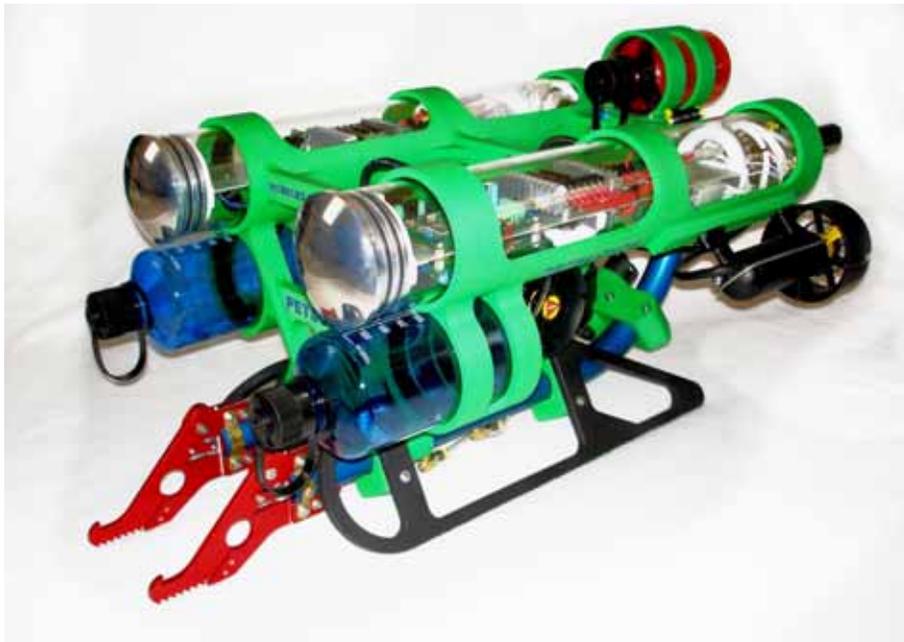




**TECHNICAL REPORT**  
**For**  
**MATE 2008 International ROV Competition**  
**Prepared by**  
**Flower Mound High School ROV Team**  
**Flower Mound, Texas**

**PETSUCHOS**



**Team FloMo Members**

Collin Cragin

Luke Cragin

Nathan Georges

Sung Ho Park

**Mentors**

Trent Cragin – Mechanical Mentor, Harry Lewis – Electrical Mentor, Doug Hamerman –  
Machinist



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## Pictures of PETSUCHOS



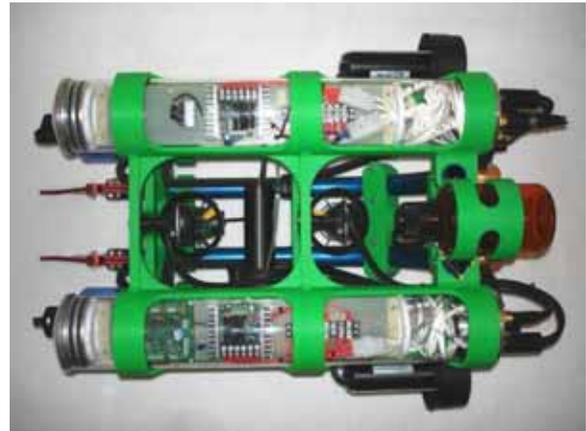
Front View of PETSUCHOS



Rear View of PETSUCHOS



Side View of PETSUCHOS



Top View of PETSUCHOS



## **Abstract**

The 2008 MATE Competition will be Flower Mound High School's second attempt at ROV robotics. Our primary goal this year was to take the knowledge gained from last year, as a "first time" Ranger team, and build a new and improved version that would be competitive in the Explorer class. Our secondary goal was to approach the construction process differently. This effort involved spending more time in design and development and integrating those designs with third party manufacturers. This direction was chosen because the exercise represents the real-world engineering/manufacturing process.

The design process for our team began with establishing a schedule and identifying team member responsibilities. Using the MATE Competition guidelines, we then determined all elements required to build an ROV with the mission tasks in mind. The process included selecting the number of thrusters and cameras, type of control system, type of payload attachments and frame construction materials. Once these decisions had been made, we started the design and development process. We began with hand sketches, which were eventually transformed into CAD drawings. Using CAD (2D and 3D) helped us evaluate and visualize different design scenarios without wasting construction time and money. We could view the design quickly and make adjustments as desired.

Once our basic design had been well established, we found third party vendors to help with the miscellaneous fabrication of key components. After several months of hard work and interesting challenges, PETSUCHOS was finished. Underwater testing soon followed along with mission performance evaluation.

During the testing process, we also turned our attention to the Technical Report, Poster and Engineering Evaluation. Using our notes, sketches and testing experiences, we prepared for the show-down in La Jolla.

## **Petsuchos**

Petsuchos was the name given to the living crocodile at Crocodilopolis in Ancient Egypt. This creature was worshiped as the manifestation of the Egyptian god "Sobek". The name Petsuchos means "son of Sobek". Crocodiles were deeply feared by the Egyptians who constantly navigated the Nile River. His worship began as an attempt to pacify the crocodile. Our ROV, PETSUCHOS, cannot be pacified!



## 1. Team “FloMo”

Team “FloMo” is made up of one sophomore and three seniors from Flower Mound High School in Flower Mound, Texas, a suburb of Dallas. Last year was our first year to compete in MATE and we enjoyed the competition immensely. We gained valuable experience and became hooked on the competition. All of our team members are interested in science and math and want to pursue careers in engineering in the future. In Fact, three of our graduating team members will be attending the engineering schools of The University of Michigan, The University of Texas and Kansas State in the fall. This will be our last competition together as a team. It has been a great ride. As we each embark in a new direction this fall, we will carry this same enthusiasm to our new schools and hopefully spark an interest in the formation of new MATE teams. The members of Team “FloMo” are Collin Cragin, Luke Cragin, Nathan Georges and Sung Ho Park.



Team “FloMo: (left to right) Nathan Georges, Collin Cragin, Luke Cragin

### Team Responsibilities:

- |                            |  |
|----------------------------|--|
| Luke Cragin (Team Captain) | - Project Organization<br>Electronic Assembly<br>3D CAD/Stratasys Interface<br>ROV Construction and Final assembly<br>Programming<br>Technical Report/Poster |
| Collin Cragin              | - Ballast Control System<br>Claw Design and Construction<br>ROV Construction<br>Graphic Design and 2D CAD<br>Technical Report/Poster                         |
| Nathan Georges             | - Electronic Assembly<br>Tether Design<br>Frame Assembly<br>Technical Report/Poster  |



Sung Ho Park

- Programming  
Technical Report

## **2. Budget and Expense**

With our new design approach this year, involving some outside fabrication, we knew that the cost of PETSUCHOS would exceed that of last years Ranger project. Unfortunately for us, due to budget constraints and other issues, our high school was not able to provide any funding for our project this year. However, with a couple of timely, parent and vendor, donations and income earned from odd jobs during the school year, we managed to fund the entire project.

This year, we estimated that we could build PETSUCHOS for around \$4500.00 using many of the existing parts form our 2007 Ranger machine. Ultimately, we incorporated the control system, motors and cameras into the 2008 ROV. Not only was this a savings for us, but these components had served us well last year. We used Stratasys, Inc. for the fabrication of our frame and Heritage Machine for the fabrication of a few miscellaneous parts. Using these outside fabrication vendors added a new dimension to our learning curve. Our production drawings had to be correct the first time. Paying for rework was not an option.

For the final list of expenses, donations and reused equipment values, refer to Appendix A.

## **3. Design Rationale**

Our main focus in design was to concentrate on the completion of mission objectives, while keeping in mind the competition schedule, limitations of our knowledge, the availability of materials and cost. We began our project this year with the desire to build a more advanced machine. At the very least, this meant the elimination of any PVC frame construction and large watertight boxes. Furthermore, we wanted to reuse products that were successful for us last year and enhance their capabilities where possible. With these concepts in mind we defined four areas of design where we needed to focus our concentration:

- 1) Maneuverability, power and speed
- 2) Size, machine profile and weight
- 3) Mission Specific Tasks and Attachments
- 4) Modular construction with quick disconnect ability for transport and serviceability



Without an ROV that could maneuver accurately and with speed, there would be no hope of completing any mission in a competitive time. For this reason, we chose to use a joystick type control system. This system would allow us to have proportional control and motor mixing for better efficiency. As for speed, we wanted the most powerful motors/thrusters we could find to overcome any potential current and minimize mission completion time. This year, we are taking advantage of the increased voltage offered in the Explorer class. Using a DC/DC converter donated from the Vicor Corporation, we can take the 48VDC supply and transform this into a 12VDC and 28VDC split supply. We use the 12VDC supply for the operation of the electronic control components, air solenoids and cameras. The 28VDC supply is used to power the motors and motor controllers.

One of our main goals in design was to keep the ROV profile small and fluid dynamic. We have seen many projects that have large surface profiles. This is not a good design characteristic for subsea operation where strong currents are involved. This was a lesson we learned from watching the Explorer class competition last year. Bigger is not necessarily better. With more profile, more power is required. A smaller profile would result in less drag and more efficiency with the thrusters. Reducing weight, by using as many naturally buoyant elements as possible, would also help to improve thruster efficiency.

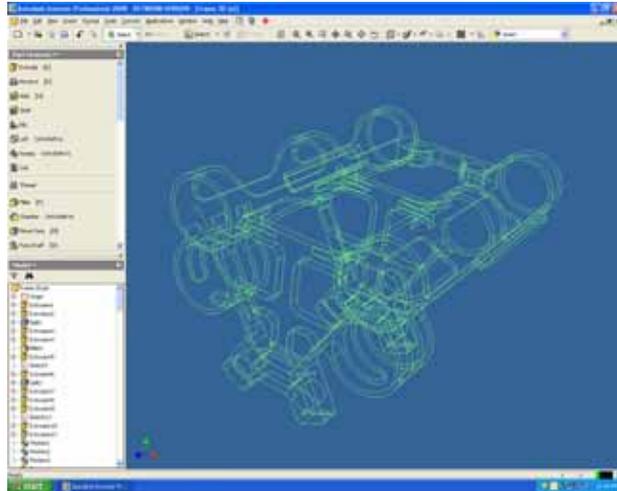
The exact placement of objects underwater for all missions was a major unknown. Without the “gadgets or tools” to help ROV positioning and operation, each mission specific task would become extremely difficult. We focused on making the robot frame adaptable for different attachments, specifically the claw manipulator and temperature probe. Because heavy lifting was involved this year, pneumatic ballast was definitely going to be required.

Last, but not least, we wanted to concentrate on modular design. We wanted to construct a frame that was monolithic and reduce the number of pieces and joints. We wanted to be able to have quick disconnect ability for each major component. This would be helpful if we ever needed to replace or service individual parts without dismantling a large portion of the machine.

Looking at the big picture and stepping back from detail, we had to constantly remind ourselves to keep it simple. Sometimes “simple” is the best solution.

### 3.1 Frame Construction

With our new approach toward design this year, we concentrated on monolithic frame construction using ABS plastic, which has a specific gravity of 1.05, a tensile strength of 22MPa and a flexural strength of 41MPa. After several weeks of research, we discovered that FDM technology, Fused Deposition Modeling, would work best for us and selected Stratasys, Inc./RedeyeRPM to be our manufacturer. This process is a type of rapid prototyping or manufacturing commonly used in engineering design for preliminary part design. This process works on an additive principle by laying down materials in layers. A plastic filament or wire supplies material to an extrusion nozzle which can turn on or off the flow. The nozzle heats the material and deposits the layers. This process has an accuracy of .0015 in. per in. Several materials can be used in this process including ABS and Polycarbonate. Both thermoplastics offer properties that would work well with our design. Although Polycarbonate has stronger strength properties, ABS was more economical and more buoyant. For these reasons, we chose to use ABS.



Screenshot of the frame in CAD



Rendering of CAD drawing

A large portion of our project effort was concentrated on design and development of the PETSUCHOS frame. Using 3D CAD design software, we were able to produce a frame that was exact and allowed for the incorporation of all ROV accessories, such as claws, motors, ballast tanks, electronic and buoyancy modules, end caps, cameras, temperature docking funnel and tether interface. The great benefit of 3D CAD software is that the process allows us to position all

accessories on the frame to check weight and balance, center of thrust, center of buoyancy, camera line-of-site and potential physical conflicts without spending



any time on actual construction. Problem areas are discovered and revised quickly.

During the entire design process, we stayed in close contact with Stratasys, Inc./RedeyeRPM engineers to make sure that we were coordinated and could produce the final CAD file for production. Knowing that this was the most expensive part of our project, we could not make any mistakes. We were now ready for the manufacturing process. This was the real world experience we were waiting for. After one week of waiting we received our package from Stratasys. Everything was perfect. The entire FDM process had taken about five days and the final frame weighed just over 1.81 kg.



Stratasys Frame

### **3.2 Thrusters**

The Seabotix thrusters used last year for the 2007 Ranger competition worked so well that we decided to use the same thrusters again this year. Our Ranger machine had four motors powered by a 12 VDC battery source. With the tether voltage drop, the Ranger machine motors were operating at only about 8.5VDC. We had great success, even with this low voltage. The Seabotix motors were designed to operate at a voltage as high as 28VDC. Since the maximum potential of these motors had hardly been tapped, we saw an opportunity to utilize much more power and speed this year by moving to the Explorer class. The power requirements for the Explorer class are limited to 48VDC and 40A. Using our Vicor DC/DC converter and reduced voltages, we could more than double our voltage from last year to the motors.



With our calculated voltage drop(2-14GA stranded wires with 22.8m length) of 8.5VDC, our motors would run at 19.5 VDC and 4.5A each. The thrust for each motor is approximately 2.2kg at a continuous 4.25A. Surge currents do not exceed 4.6A

We also decided to add an additional vertical thrust motor this year to give us more lifting power and vertical speed. The final configuration for thrusters is as follows:

- A) Two vertical thrust motors providing up and down movement
- B) Two horizontal thrust motors providing forward, backward and turning movement
- C) One horizontal thrust motor to provide sideways movement

All motor whips were specifically selected for the required length and connection into the ROV electronics module. In an effort to reduce possible water leaks at bulkhead penetrations and to provide independent quick disconnect for all motor whips, we chose Seacon and Subconn wet-mateable connectors. The connectors are specifically designed for this purpose and all have o-ring seals.

### **3.3 Lights and Cameras**

Knowing that the MATE 2008 Competition was going to be held in an outdoor pool environment, the need for lights was eliminated. As for cameras, we had great success last year with the waterproof infrared LCA -7700 cameras sold by Lights Camera Action. This company specializes in underwater cameras. Using their half-price discount offered to any interested team, we purchased two more cameras for our machine. These cameras were perfect for our mission. They are waterproof, have infra-red LEDs for low light conditions, small in size – 3.5 cm diameter x 10 cm long, operated on 12VDC, have a current draw of .15A and came with 30.48 m of cable.

Continuing the theme of “quick disconnect” and modular construction, we ordered special Seacon wet-mateable whips to modify our cameras and eliminate the need for multiple 7.0 mm diameter cables running to surface along the tether. We used 3M - 2130 Splicing kits to hard wire the whips to the existing shortened camera cables. The 3M kits provide for a waterproof connection. These modified camera whips, now only 46 cm long, can now be plugged into our rear end cap bulkhead Seacon/Subconn fittings for quick disconnect and servicing.

The positioning of all cameras was critical to performing our mission tasks. We placed one LCA -7700 camera in the bottom front of the frame, looking straight forward. This camera gave us a full view for general steering, mission prop



location and activation movement of the claw. We placed a second LCA – 7700 camera at the rear of our machine, at 45 degrees down view, to provide a view of the docking temperature funnel. Our only complaint with the LCA – 7700 cameras is with their limited depth perception. Two internal board cameras were also positioned inside the acrylic electronic tubes, both looking down, to provide positional cross-referencing for the docking funnel. All camera cables were connected to our ACQ-4 quad mixer. The quad mixer allows us to send four views, simultaneously through the tether and up to the surface control box with only two conductors.

### **3.4 Control System**

The main ROV control system is separated into two packages (1) the surface system and (2) the ROV underwater system. Our goal was to build a control system with readily available electronic components, learn PBASIC programming skills and utilize analog controllers for proportional motor control. With our modular approach to design this year, the connections between the surface control system, the tether and ROV underwater system make for quick assembly.

The surface unit includes our analog joystick controllers, Vicor DC/DC converter, Parallax Board of Education (BOE) with BS2 Basic Stamp microcontroller, Parallax AppMod/Transceiver board, a 15A ammeter, a 50A ammeter and two 12 pole power blocks. In an effort to avoid the use of standard on-off toggle switches for motor control, we chose to use the standard analog joystick. The joystick provides much better control and allows for proportional mixing of motors for the forward, backward and turning movements. The joystick position is determined by potentiometers, or variable resistors, attached to the joystick gimbals. Varying the resistance of the potentiometer alters the electrical current and sends the analog resistance readings to the AppMod board and then to the BOE, the ROV brain. All surface components have been placed in a watertight laptop box for quick connection to the tether. The functions of each individual component are outlined as follows:

The Parallax Board of Education (BOE) Functions:

- 1) Provides platform for the BS2 Basic Stamp microcontroller.
- 2) Provides serial connection between computer, BASIC Stamp Editor and BS2 for PBASIC programming
- 3) Converts the resistance readings from joystick potentiometers into servo values using RCTIME instructions (PBASIC Language) and sends this information back to the AppMod/Transceiver board.



#### The Parallax AppMod/Transceiver Board Functions:

- 1) Provides connection between joystick and BOE.
- 2) Receives 12VDC power from battery, powers BOE, and sends power to underwater ROV.
- 3) Receives signal data from BOE and transmits to underwater ROV Co-Processor board.
- 4) Separates serial data going to and back from the underwater Co-Processor board. This is necessary because the Co-Processor (servo controller function) requires separate wires for the data in each direction, but allows us to use one data wire to limit tether size.

The ROV underwater system includes our Blue Bell Design Transceiver/Driver board, Blue Bell Design Co-Processor board, two double Dimension Engineering motor controllers, one single Dimension Engineering motor controller, one QVC Video quad mixer, two Sizto Tech solenoids, two miniature board cameras and two 14 pole power blocks. All electronic components of the ROV are placed within two 90 mm diameter x 558 mm long acrylic clear tubes (electronic modules).

#### Transceiver/Driver Board Functions:

- 1) Receives serial data coming from the AppMod surface unit and sends data to Co-Processor board.
- 2) Separates serial data going to and back from Co-Processor board.
- 3) Drives reset to Co-Processor which stops the servo signals to motor drivers.

#### Co-Processor Board Functions:

- 1) Receives commands from the BOE, through Transceiver/Driver Board, and converts them to servo pulses to the motor drivers. The Co-Processor chip converts serial data signal into a high level pulse from 1 to 2 ms in length. Servo pulses repeat every 20 ms. A 1.5 ms pulse will cause a motor driver to stop. A 1 ms pulse will cause the motor to go full speed in one direction. A 2 ms pulse will cause the motor to go full speed in the opposite direction.
- 2) The board also has other features not used, like bumper sensors, voltage measurement and timers.

#### Motor Driver Functions:

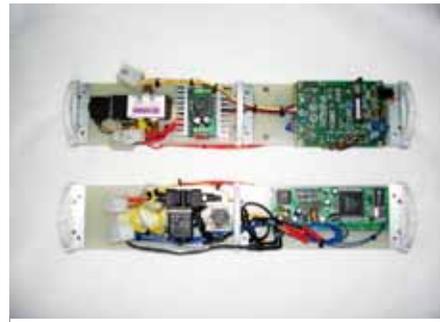
- 1) The Dimension Engineering Syren 25 motor controller is rated to 15A continuous/25A peak and 30VDC max. The Dimension Engineering 2 x



25 Sabertooth motor controller is rated to 25A continuous/50A peak and 30Vmax. .

- 2) A signal servo wire is connected from the Co-Processor board servo port to each motor controller. Power to each motor controller is supplied directly from the power block in the electronics module.
- 3) Uses Pulse Width Modulation (PWM) to control motor speed.

Our ROV electronic modules are made from two 90 mm diameter x 558 mm clear acrylic tubes, which also serve as the main buoyancy elements. Each end of the acrylic tubes is sealed by a machined aluminum end cap. These end caps were designed with double radial o-rings and tight tolerances to prevent water infiltration. The rear end cap permits all penetrations and bulkhead connections for the electrical and air supply. All bulkhead connections are either Seacon or Subconn wet-mateable style. Reference Appendix E and F for rear end cap penetration diagrams. All electronic components are supported on linear trays, which slide in and out of the tube for quick access. This modular concept was adopted for ease of serviceability. Molex connectors are used between all Seacon/Subconn bulkhead connectors and electronic tray components.



Electronics trays

During the testing phase of PETSUCHOS, we never encountered leak problems with the acrylic tubes. One benefit, and perhaps the only, of increasing depth is increasing pressure. As the ROV moves deeper, the end caps are pushed in with increasing pressure as well. The only concern we had for the electronic module was heat generation from motor controllers. We specifically selected motor controllers that had much higher voltage and current capacities than required to reduce potential heat effects. Through our testing so far, heat generation has not been a problem. Possible adverse effects of heat generation would be component overheat and water leaks from expanding air pushing out on the end caps.

### 3.5 Electrical Schematics

Schematic diagrams for both the surface control system and ROV control systems are shown in Appendix C and D.



### **3.6 Tether**

Our goal for tether construction this year was to eliminate as many conductors as possible and to use a commercially available tether with quick disconnects. We also realized that a thick and stiff tether would add drag, weight and decrease maneuverability. Fortunately, the Storm/Teledyne Company is located in Dallas and we contacted them for help. After meeting with the Storm personnel and defining our conductor and power requirements, we selected a cable. Using our pre-selected Seacon connector whips, Storm provided the molded connection between whips and cable. The cable selected provided us with dual power transmission, 12VDC and 28VDC, at a voltage drop we could tolerate. The 12VDC source was for the operation of all onboard electronics, cameras and solenoids. The 28VDC was for the operation of the Seabotix motors and Dimension Engineering controllers.

Unfortunately, none of the cable choices made available to us were neutrally buoyant and flotation is required. Since the tether umbilical has negative buoyancy characteristics, we added foam flotation segments, purchased from Memphis Net and Twine, about every four feet to provide neutral buoyancy. The flotation elements are doughnut shaped polyurethane. The positioning and length of foam flotation was resolved by trial and error. Although these foam doughnuts were extremely dense, crushing and loss of buoyancy was never an issue at contest depths specified.

This length of the cable was chosen based upon the maximum vertical and horizontal distance to the mission prop location (2.5m down and 10m out from the wall). This gave us a total length of 12.5 m at the pool shell surface. We added another 82% for maneuvering around the competition props. The total length of the tether is now 22.8 m. Reference Appendix B for tether diagram.

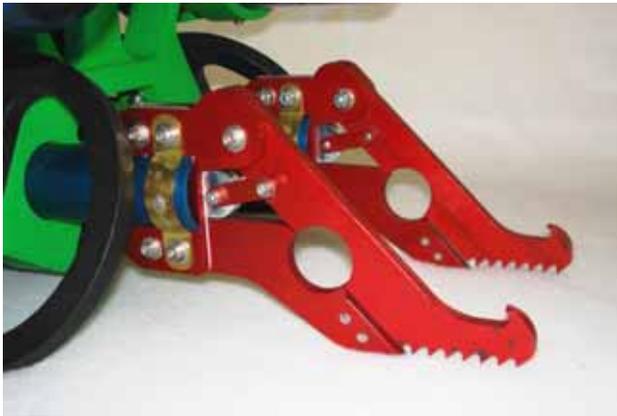
### **3.7 Payload Lift and Mission Tools**

PETSUCHOS is very maneuverable and fast, but placement of critical mission specific tools is essential. This years mission can basically be broken down into three tasks; (1) Collect diver soft weights to release the OBS and (2) lift and bring back three of the diver soft weights back to the pool start platform and (3) Read water temperature at vent stack. From our experience last year, we knew that lifting any significant weight would require variable ballast adjustment. We did not have enough motor thrust to complete the heavy lift task, so a pneumatic control system was developed.

We designed our pneumatic control system to have enough buoyant capacity to lift all three soft diver weights (2.72 kg) totally, without the aid of the thrusters.



This was important, because the net effect of the lift would not change the center of gravity of PETSUCHOS. An out-of-balance machine would not be maneuverable. After calculating the minimum volume of air required for the lift (2126 cubic cm), we chose two commercially available 32 oz. Nalgene bottles for the main ballast. All supply air for the system was supplied at the surface and sent down the tether line to the ROV. To increase the ballast, we used a two-way valve (joystick operated) to introduce air into the initially flooded main ballast tanks. To reduce ballast, we also provided an air release valve into the main tanks. This system works reasonably well, but establishing equilibrium for each ballast condition occurs with a delayed response. Reference Appendix G for pneumatic control diagram.



The two crocodile-shaped claws on PETSUCHOS

In order to reduce mission time, we decided to carry all weights with one lift. Since this could not be achieved with a single claw, we chose to use a small basket, transported to the mission prop, to carry all weights. For greater stability, we chose to use two claws to support the basket handle during the lift. Our claw is air actuated, using a double acting Clippard air cylinder. Open and closed positions are controlled by a five-way solenoid valve (joystick operated).

As a backup precaution, we have designed the claw to have a hooked nose for lift support in case of claw failure. As our claw was developed, it seemed to take on a life of its own. With the crocodile appearance, the naming of our ROV PETSUCHOS became an obvious choice.

For the temperature measurement task, we utilized a plastic funnel, mounted inverted on the frame, to dock with the vent stack. Inside the funnel, we placed an Onset HOB0 12 temperature probe to collect temperature readings. The funnel not only provided positioning help, but provided an enclosure for water isolation at the stack source for amore accurate reading.

## 4. Challenges

During the course of this project, our team encountered many challenges and learning opportunities. We approached every challenge as a team and resolved some issues quickly and others with more deliberate thought. Our most significant challenges were:



- 1) Developing a monolithic frame out material that would float and have sufficient strength.
- 2) Developing a design for machined endcaps for our acrylic tubes that would provide a waterproof seal using radial application o-rings.
- 3) Developing all CAD files to work with third party vendors.
- 4) Developing a voltage reduction plan and selecting the proper DC/DC converter to maximize our motor output and work with lower voltage electronics.
- 5) Improve PBasic programming skills to provide more flexibility with control applications.

We learned how to bring together several components, made by different manufacturers, to make a complete control system. Our Mentor, Mr. Lewis, created our first joystick program and helped us learn PBASIC programming. Our team organized and installed all of the wiring and component placement, and soldered circuit boards for "PETSUCHOS".

## 5. Trouble Shooting

During the course of the project we resolved several unexpected problems. Most of our challenges were simple and were resolved quickly. Some examples of these problems and solutions are as follows:

- 1) Problem - The Aluminum end caps used to seal both ends of the electronics module had the tendency to rotate out due to bulkhead fitting weight and tether movement.  
Solution - Provide aluminum retaining compression rings and cable ties between end caps.
- 2) Problem - The air actuated claw will not close or return completely. The one-way acting air inlet to the cylinder permits water Infiltration. Water destroys lubrication of the o-rings.  
Solution - Use double acting air cylinders which have a closed system. No water infiltration. Add oil periodically.
- 3) Problem - The tether sinks creating drag on the ROV.  
Solution - We provided doughnut shaped PVC sponge floats along the tether at about 122 cm O.C.
- 4) Problem - The ROV buoyancy changed from original calculations. The machine was slightly negative and tail heavy.



Solution - We designed another Stratasys, Inc. part to hold an additional Nalgene bottle to be placed at the rear of the machine.

## 6. Future Improvements

With more time, investigation and money, we could definitely make improvements with our current ROV. Our goal to design and build a machine that could meet the basic requirements for the competition and keep the cost as low as possible were met. Our goals for next year will be to improve the following:

- 1) Use larger diameter acrylic tubes for buoyancy and electronics storage. Additional space for added components should be available.
- 2) Add more internal board cameras within the acrylic tubes. Mount the cameras on rotating platforms to provide viewing flexibility. These cameras are lighter and work well through clear polished acrylic tubes.
- 3) Add a more sophisticated ballast system to allow for variable payload weight.
- 4) Refine mission specific payload attachments.
- 5) Select tether cable with buoyancy characteristics, smaller diameter and less stiffness.

Our list of improvements was created from our experience gained this year during construction and underwater testing.

## 7. Lessons Learned/Skills Gained

We feel we experienced a huge learning curve this year. Our knowledge of electronics grew incredibly. We have a much better understanding of power, current (constant and surge), voltage, voltage losses, wire sizing and component selection. We became very proficient with our use of 3D modeling using CAD. Our CAD skills improved immensely. This was a tremendous help in the development of our ROV design. Time and material were saved. This is a great engineering tool..

As with our machine last year, we had to be creative in the selection of off-the-shelf components that we could bring together to build a complete project. Finding “things” that fit into other “things” or that could be modified easily became our driving objective. What would we do without Home Depot? We learned what tools worked better than others for specific tasks and developed hands-on skills. Working with your hands and your mind is extremely rewarding.



Team organization and scheduling are essential to a successful project. Without a schedule for task completion, we would have never been ready for the competition. We established a schedule early in the project, which was followed with very little deviation. Dividing project tasks among team members helped distribute the workload. Research is a key component of success. Many hours were spent on the internet by all, looking up related links for materials and ideas. We have really enjoyed this process and this is what drives us all to become engineers.

## 8. Reflections

The 2008 MATE Regional Competition has become another great learning experience for our entire team. We took the successes and challenges experienced from last year, our first year, and focused on improving our entire approach toward this year's competition. Maybe the most important lesson learned from last year, was that there is never enough time and there is no substitution for preparation. As a result, we started working on PETSUCHOS two months after the competition in Newfoundland.

The MATE competition itself, with each different mission challenge, is extremely interesting. The fact that these missions incorporated real life undersea tasks made our experience seem even more important. Relating to this year's theme of "The mid-oceanic ridge and hydrothermal vents", we can see how the use of the unmanned ROV can help with the scientific exploration in extreme environmental conditions. Eliminating the need for manned submarines, requiring human conditioning, will help make exploration much more economical and safe.

## 9. Mid-oceanic Ridges

The exploration and discovery of these hydrothermal vents and their surrounding habitat could not have been possible without a deep-sea submersible such as Alvin. Alvin, the world's first deep-sea submersible, was introduced in the 1960's to help scientists observe the process of seafloor spreading. Unlike ROV's, this vessel can house three people, giving scientists the chance to travel to depths up to 4,000 meters deep.



The ROV, Victor, at sea

It is more practical to send an ROV to explore these ocean depths however. The use of manned submersible requires a pressurized and oxygenated vessel that



needs to be environmentally safe for passengers. By using an ROV, scientists and engineers can explore hydrothermal vents and their surrounding environment while staying above water, thus minimizing safety hazards. Victor 6000 is a deep sea Remotely Operated Vehicle that was created by the French. This modular remote-controlled vehicle has numerous capabilities. With a depth rating of 6000 meters, Victor is able to explore both shallow and deep waters. Victor 6000 has been used for various research projects. One such project, the IRIS Cruise, includes the exploration of the Mid-Atlantic Ridge. From this project, scientists were able to study the hydrothermal processes that take place on the oceanic ridge. One discovery made by this research expedition is the abundant amount of hydrogen produced by the hydration of mantle rocks. Hydrogen serves as the base for the creation of organic compounds. The inorganic reactions that take place are believed to be responsible for the formation of prebiotic molecules. The molecules are responsible for the population of bacteria in the extreme environments such as the areas where hydrothermal vents exist. This research mission was executed with a total of 16 dives and a traveled distance of 121 kilometers on the sea floor. Within the 195 hours of Victor's use, Victor was used to sample hot hydrothermal fluids as well as collecting sediment cores, chimneys, and rocks. With water sampling capabilities, Victor was able to map the methane concentration near the sea floor. This project was able to give geophysicists, chemists, geologists, and microbiologists an accurate magnetic map of the hydrothermal fields as well as bettering their knowledge of the Rainbow hydrothermal reactor as well as the microbiological and chemical processes that take place.

Hydrothermal vents are important in many aspects and continue to provide for the deep ocean environment. The bursting water that comes from the vents contains numerous minerals that various living creatures thrive upon. These creatures, such as giant tube worms, clams, and spider crab, depend on these hydrothermal vents to sustain their unique ecosystem. The hydrothermal vents are very important to the ecosystem. The water that spews from these vents contains hydrogen sulfide, which is the base for this ecosystem's food chain. The energy for this ecosystem does not come from sunlight, but from the energy released in the chemical reaction of sulfate in the water.

Sources:

<http://pubs.usgs.gov/gip/dynamic/exploring.html>

<http://www.ocean.udel.edu/deepsea/level-2/geology/vents.html>

[http://www.amnh.org/nationalcenter/expeditions/blacksmokers/black\\_smokers.html](http://www.amnh.org/nationalcenter/expeditions/blacksmokers/black_smokers.html)

[http://www.ifremer.fr/flotte/systemes\\_sm/images/nautilie/1002p007.pdf](http://www.ifremer.fr/flotte/systemes_sm/images/nautilie/1002p007.pdf)



## 10. Acknowledgements

We would like to thank the following people and companies for their help, support and donations:

Matt Stenoien – Sratasys, Inc./RedeyeRPM  
Doug Hamerman – Heritage Machine  
Tom Perkins – Vicor Corporation (Donation)  
Trent Cragin – Mechanical Design Mentor  
Jane Cragin – Team Coordinator  
Harry Lewis – Electrical Mentor  
Lights Camera Action  
Seabotix, Inc.  
Lockheed Martin Aerospace  
The Core Group (Donation)  
MATE Center

Without this group, this project would not have been possible. Our mentors were incredible.



## Appendix A: Project Budget Sheet

### Part Expenses

Expense Item	Part Description	Usage	Quantity	Vendor	Cost
1	Frame Attachment 1	Front Camera Attachment	1	Stratasys RedeyeRPM	\$ 232.34 *
2	Frame Attachment 2	Rear Camera Attachment	1	Stratasys RedeyeRPM	\$ 397.72 *
3	Frame Attachment 3	Rear Ballast Attachment	1	Stratasys RedeyeRPM	\$ 558.00 *
4	Aluminum Front End-caps	Acrylic Tube Closures	2	Heritage Machine	\$ 200.00 *
5	Aluminum Rear End-caps	Acrylic Tube Closures	2	Heritage Machine	\$ 200.00 *
6	Aluminum Rings	End-cap Compression Rings	4	Heritage Machine	\$ 125.00 *
7	1/16" Stainless Steel Cable & Fittings	Compression Ring Ties	4	Lexco	\$ 53.96 *
8	72" x 3.25"OD Diameter Acrylic Tubes	Electronics Module & Main Ballast	1	Nationwide Plastics, Inc.	\$ 119.83 *
9	HOB012	Temperature Probe/Software	1	Onset	\$ 105.78 *
10	120mm Funnel	Temperature Docking Cone	1	SKS	\$ 4.67 *
11	#233 Buna O-ring Seals	End-cap Water Seal	6	Porter Seal	\$ 7.03 *
12	12" x 2 1/2" x .125" Aluminum Plate 2024	Claw Parts	2	McMaster Carr	\$ 26.72 *
13	12" x 3/4" x .25" Aluminum Plate 2024	Claw Parts	2	McMaster Carr	\$ 25.50 *
14	12" x 3" x .25" Aluminum Plate 2024	Claw Parts	1	McMaster Carr	\$ 29.50 *
15	12" x .50" x .0625" Brass	Claw Parts	2	K & S	\$ 1.25 *
16	1.25" OD x 1.125 ID T4 Aluminum Tube	ROV Camera Frame	2	Wolf Aircraft	\$ 250.00 *
17	48" x 3" x .0625" Epoxy Board	Electronics Tray	1	Polymer Plastics Corp.	\$ 67.49 *
18	24" x 24" x .375" HDPE Board	ROV Skids	1	Industrial Plastics Supply	\$ 41.40 *



Expense Item	Part Description	Usage	Quantity	Vendor	Cost
19	.25" x 9" x 15" HDPE Cutting Boards	Electronics Tray Bulkheads	2	Walmart	\$ 15.98 *
20	.062" x L.50" x L.50" Aluminum Angle	Electronics Tray Connectors	72"	Home Depot	\$ 3.56 *
21	.062 x L.75" x L.75" Aluminum Angle	Claw Parts	72"	Home Depot	\$ 4.37 *
22	Soft Dive Weights	Mission Props	8	Scuba Toys	\$ 43.30 *
23	MCBHM3/15F	Bulkhead Fitting	1	Seacon	\$ 252.28 *
24	MCILM3/15M	Male Pie Wedge In-line Fitting	5	Seacon	\$ 163.25 *
25	MCDCM3/15M	In-line Fitting	1	Seacon	\$ 26.82 *
26	BH6FS	Male In-line Whip	1	Seacon	\$ 75.00 *
27	IL6MP	Male In-line Whip	1	Seacon	\$ 40.81 *
28	BH10FSX	Male In-line Whip	1	Seacon	\$ 102.57 *
29	IL10MPX	Male In-line Whip	1	Seacon	\$ 67.00 *
30	FAWM8PMP0061/ FAWM8SBC3/4	Male Link Whip	1	Seacon	\$ 180.20 *
31	AWQ	Bulkhead Fitting	1	Seacon	\$ 42.50 *
32	FAWM8SBC3/4	90 Degree Bulkhead Fitting	2	Seacon	\$ 281.60 *
33	BH4F	Bulkhead Fitting	2	Subconn	\$ 153.80 *
34	MCBH2F	Bulkhead Fitting	1	Subconn	\$ 48.60 *
35	Dimension Engineering SyRen 25	Motor Control For Seabotix Thrusters	1	Dimension Engineering	\$ 85.20 *
36	Dimension Engineering Sabertooth 2 x 25	Motor Control For Seabotix Thrusters	2	Dimension Engineering	\$ 55.98 *
37	ACQ-4	Video Quad Board	1	Quality Video Components	\$ 109.36 *
38	SPD-22548 Cable	Tether Umbilical Power/Signal	75 Ft.	Storm Cable	\$ 1,135.47 *
39	4V110-1/8-G	5 Way Air Valve	1	Sizto Tech	\$ 56.75 *



Expense Item	Part Description	Usage	Quantity	Vendor	Cost
40	2P025-1/8	2 Way Air Valve	1	Sizto Tech	\$ 34.34 *
42	Double Action Air Cylinder	Claw Actuator	2	Clippard	\$ 50.82 *
43	22 GA Strand Wire	Data Wiring Between Surface and ROV	100 Ft.	Jameco	\$ 4.65 *
44	20 GA Strand Wire	Miscellaneous Wiring	100 Ft.	Jameco	\$ 7.69 *
45	18 GA Strand Wire	Motor Wiring	100 Ft.	Jameco	\$ 9.65 *
46	14" Servo Extension	Motor Controller/Co-Processor Data Wiring	4	Parallax, Inc.	\$ 5.16 *
47	6 Pole Double Row Terminal Blocks	Wiring Terminals	2	Radio Shack	\$ 5.17 *
48	8 Pole Double Row Terminal Blocks	Wiring Terminals	2	Radio Shack	\$ 5.39 *
49	Pelican 1470 Black Case	Control Box	1	Pelican	\$ 121.75 *
50	Eye Connectors 16-22 GA	Wiring Connectors	100	Radio Shack	\$ 12.40 *
51	1.25 O.D. x 0.058 Aluminum 6061 Tubing	Claw Housing	6 ft.	Metal Supermarkets	\$ 51.01 *
52	1.125 Dia. x 12" Delrin Rod	Claw Bushing	6 ft.	Interstate Plastics	\$ 135.47 *
53	Miscellaneous Stainless Steel Hardware(screws, washers, nuts)	Frame, Claw and Thruster Connections	-	Ace Hardware	\$ 30.00 *
54	Nalgene 32Oz. Plastic Bottle	Buoyancy and Ballast Control	2	Nalgene - Outdoor	\$ 19.31 *
55	Nalgene 16 Oz. Plastic Bottle	Buoyancy and Ballast Control	1	Nalgene - Outdoor	\$ 10.38 *
57	PQM-EU05	Air Tee Union	2	Clippard Instruments	\$ 7.89 *
58	PQM-CC05P	Air Male Connector	5	Clippard Instruments	\$ 17.50 *
59	PQM-SU05	Air Strait Union	1	Clippard Instruments	\$ 3.95 *
60	PQM-CC05N	Air Male Connector	11	Clippard Instruments	\$ 38.50 *
61	MQC-3S	Air Bulkhead Fitting	7	Clippard Instruments	\$ 39.97 *



<b>Expense Item</b>	<b>Part Description</b>	<b>Usage</b>	<b>Quantity</b>	<b>Vendor</b>	<b>Cost</b>
62	PQ-YU05	Air Y-Union	1	Clippard Instruments	\$ 5.42 *
63	15004 Fitting	Female Hex Coupling From Air Cylinder	2	Clippard Instruments	\$ 3.89 *
64	15010 Fitting	Air Cylinder Inlet/Exit Extension	2	Clippard Instruments	\$ 4.58 *
65	Seabotix BDT150 Thrusters	Directional Control Thrusters	1	Seabotix, Inc.	\$ 410.00 *
Total Cost					\$ 6,425.48 *

### Donations

<b>Donation Item</b>	<b>Part Description</b>	<b>Usage</b>	<b>Quantity</b>	<b>Vendor</b>	<b>Cost</b>
1	VA-E Converter	DC/DC Converter	1	Vicor Corp.	\$ 600.00 *
2	Main Frame	ROV Frame	1	Stratasys, Inc.	\$ 3,300.00 *
Total Cost					\$ 3,900.00 *



**Parts Used from Last Year Last year**

3	Blue Bell Design Transceiver Board	ROV Underwater Control Unit	1	Blue Bell Design	\$ 145.95 *
4	Blue Bell Design Co-Processor Board	ROV Underwater Control Unit	1	Blue Bell Design	\$ 264.95 *
5	Parallax Basic Stamp	ROV Microchip	1	Parallax, Inc.	\$ 49.00 *
6	Analog Joysticks	ROV Manual control	2	EBAY	\$ 10.00 *
7	Parallax Board of Education	ROV Interface Surface Control	1	Parallax, Inc.	\$ 65.95 *
Total Cost					\$ 2,625.85 *

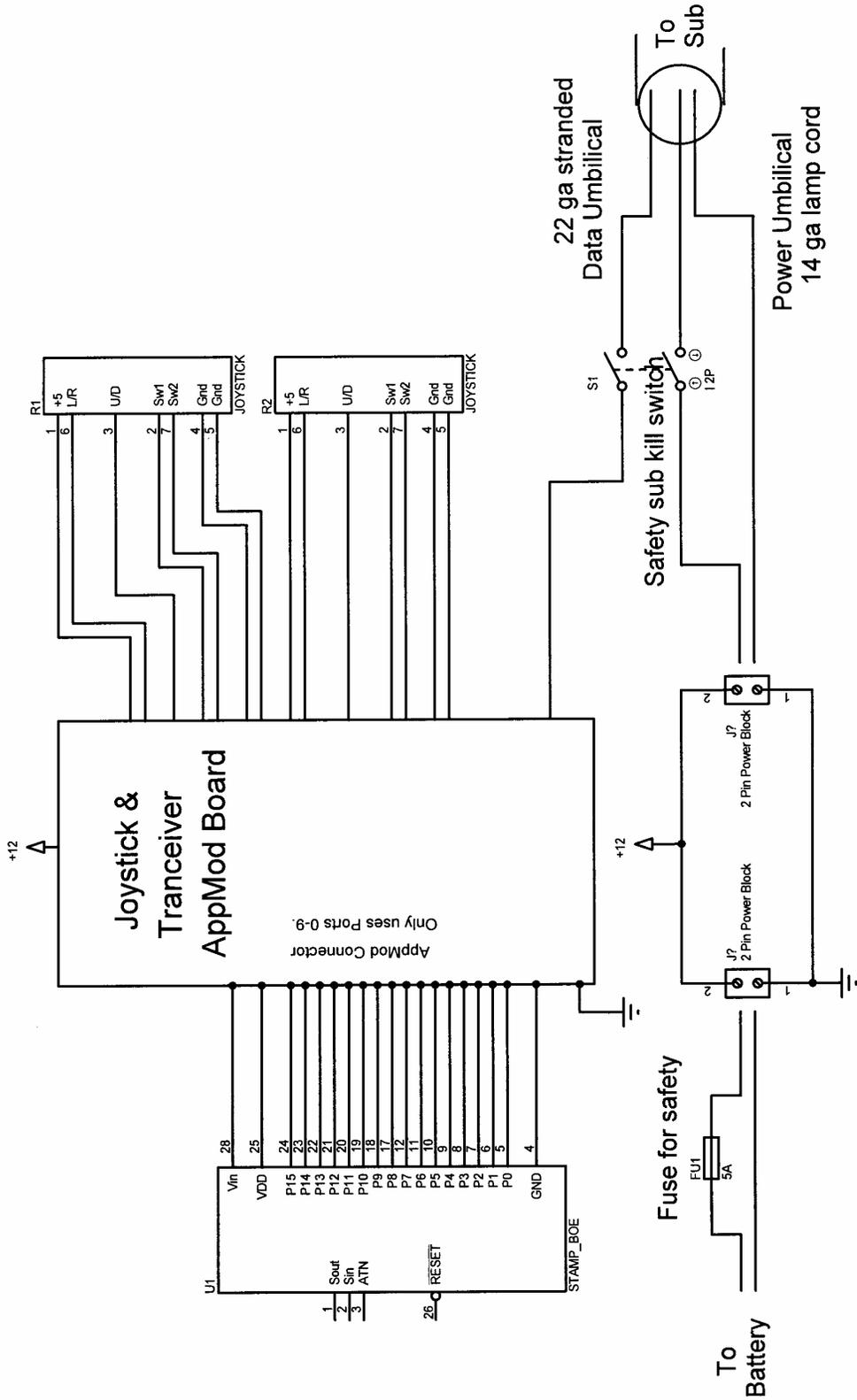
**Trip to La Jolla Expenses:**

Car Rental	\$ 1,400.00
Hotel	\$ 1,750.00
Food	\$ 1,100.00
Gas	<u>\$ 700.00</u>
 Total	 \$ 4,950.00





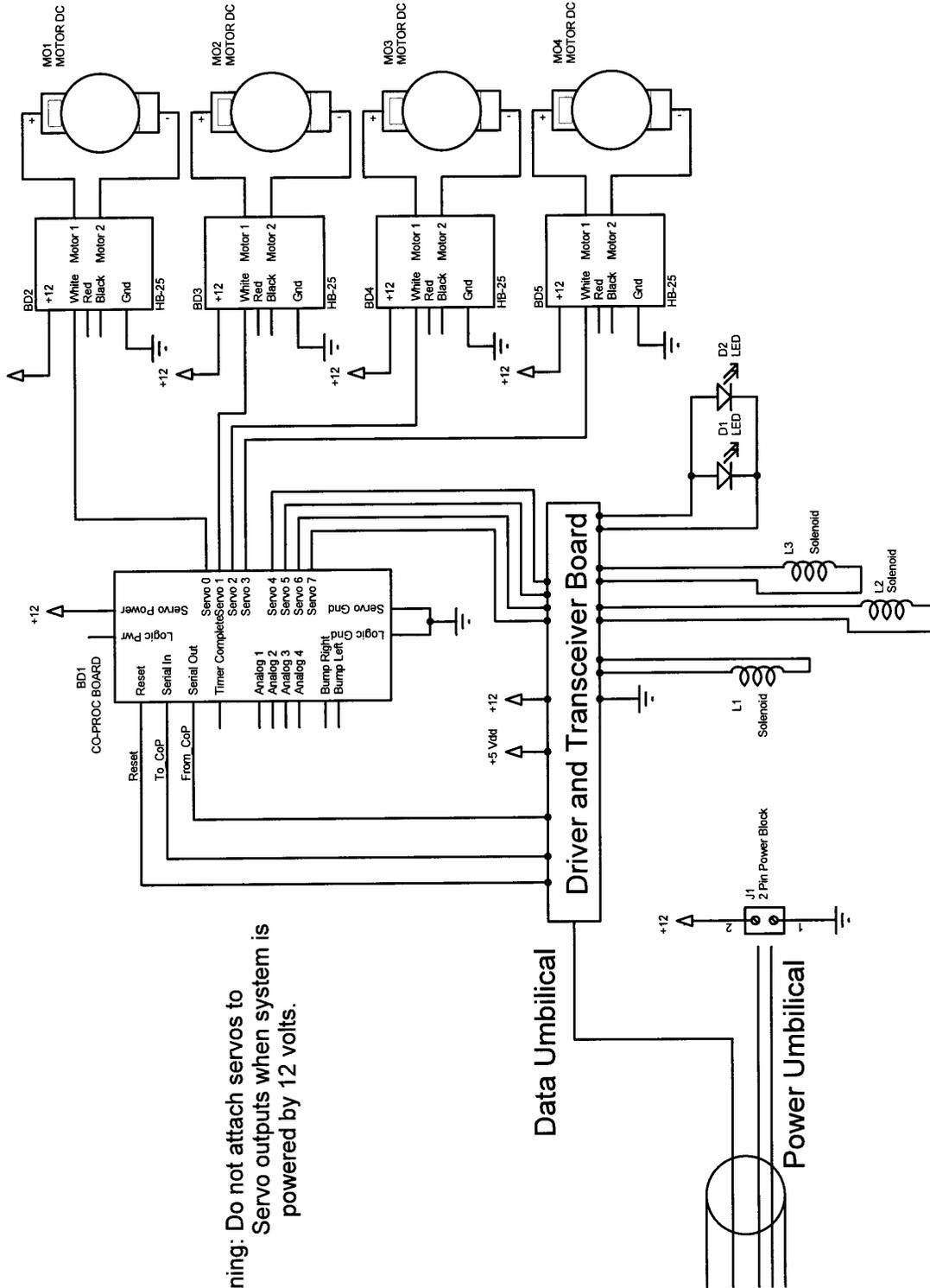
## Appendix C: Surface Control Schematic



Note: Battery is not shown. Be sure to install a fuse in series with the battery for safety



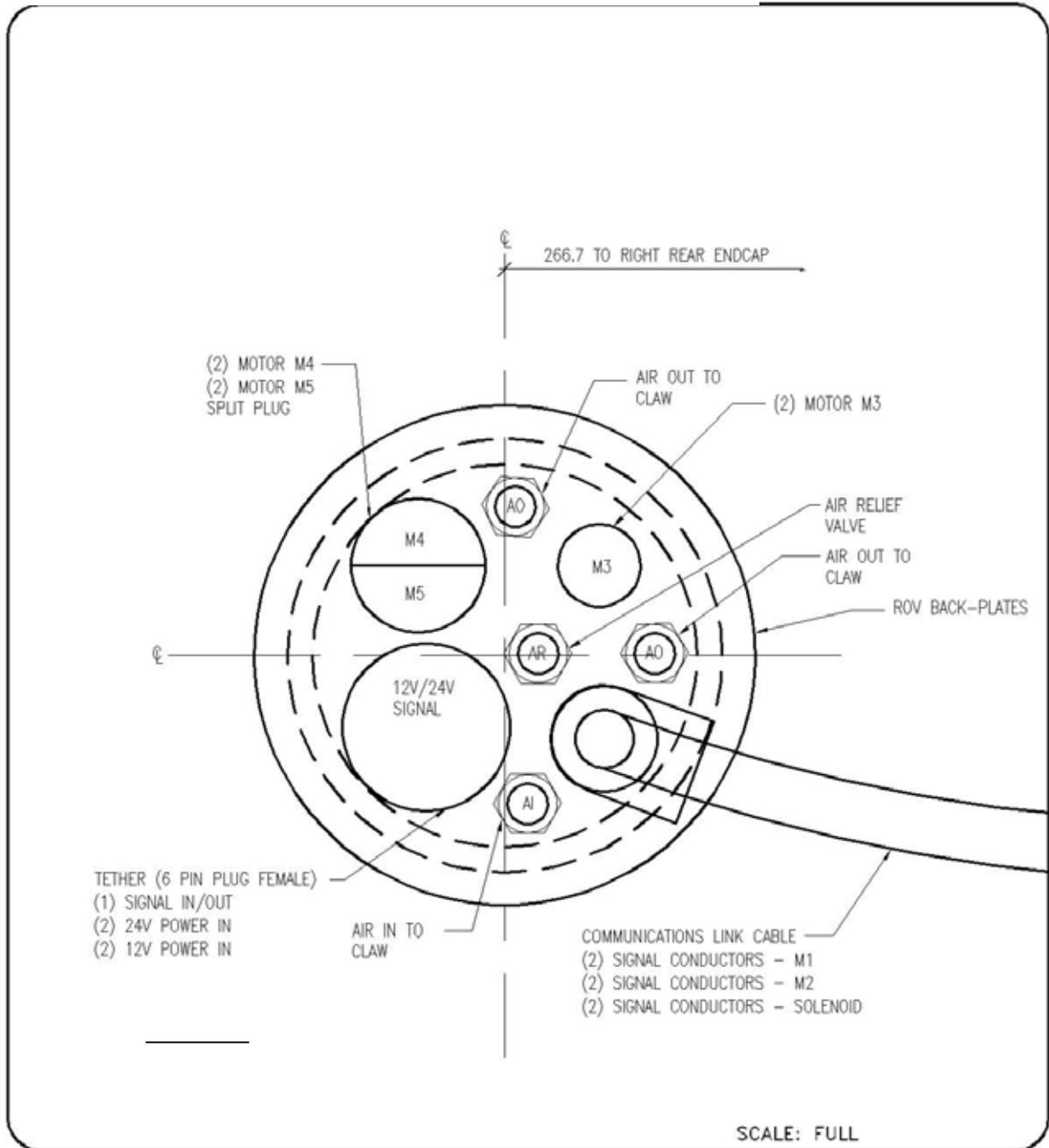
## Appendix D: ROV Control Schematic



**Warning: Do not attach servos to Servo outputs when system is powered by 12 volts.**



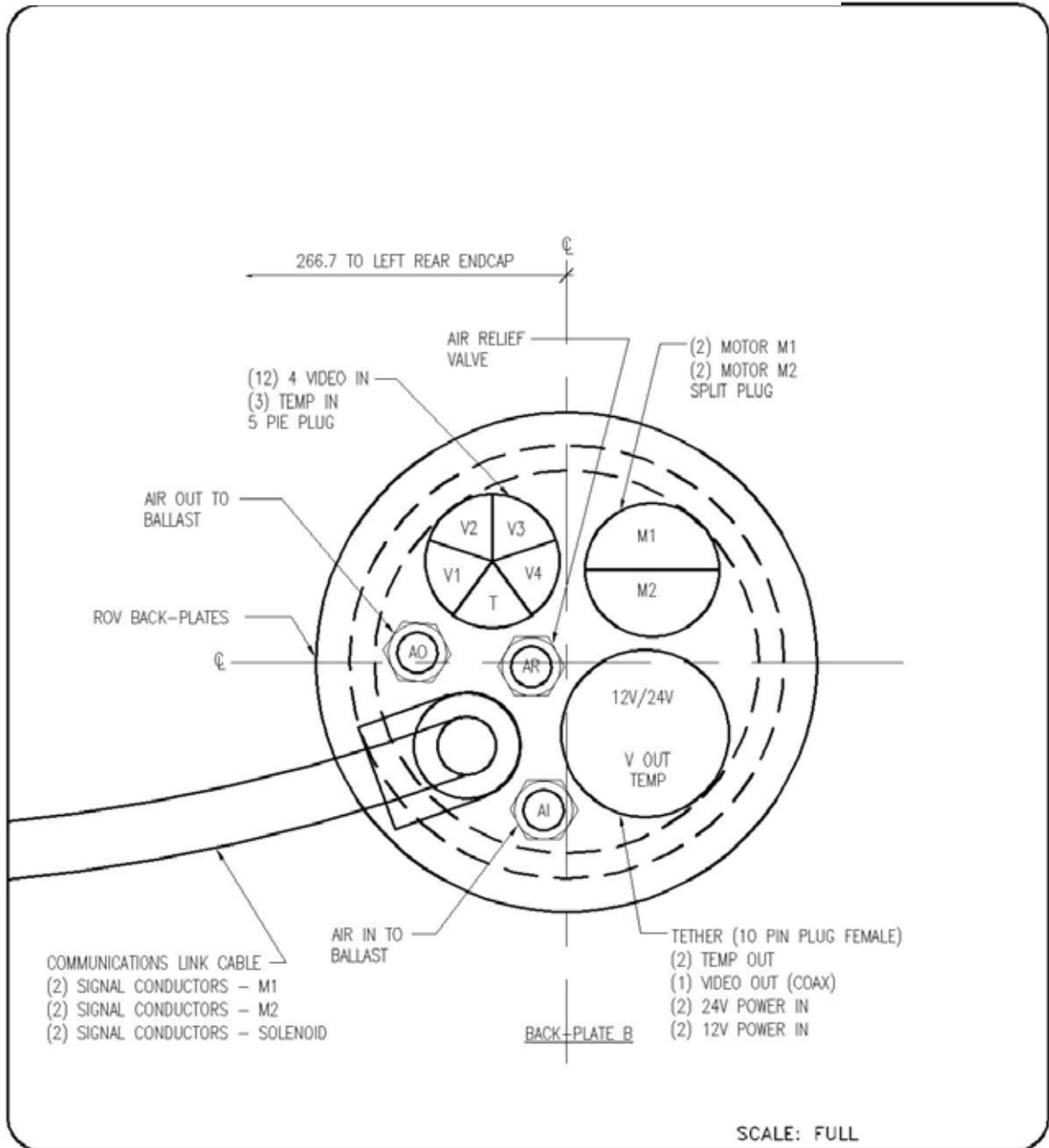
## Appendix E: Left Rear Endcap Drawing



TITLE LEFT REAR ENDCAP - CONNECTOR FUNCTIONS		TEAM FLOMO "PETSUCHOS" FLOWER MOUND HIGH SCHOOL FLOWER MOUND, TEXAS
PROJECT MATE 2008 COMPETITION - ROV "PETSUCHOS"		
DATE: 3/28/08	SHEET NO.	
REVISION:	D7	

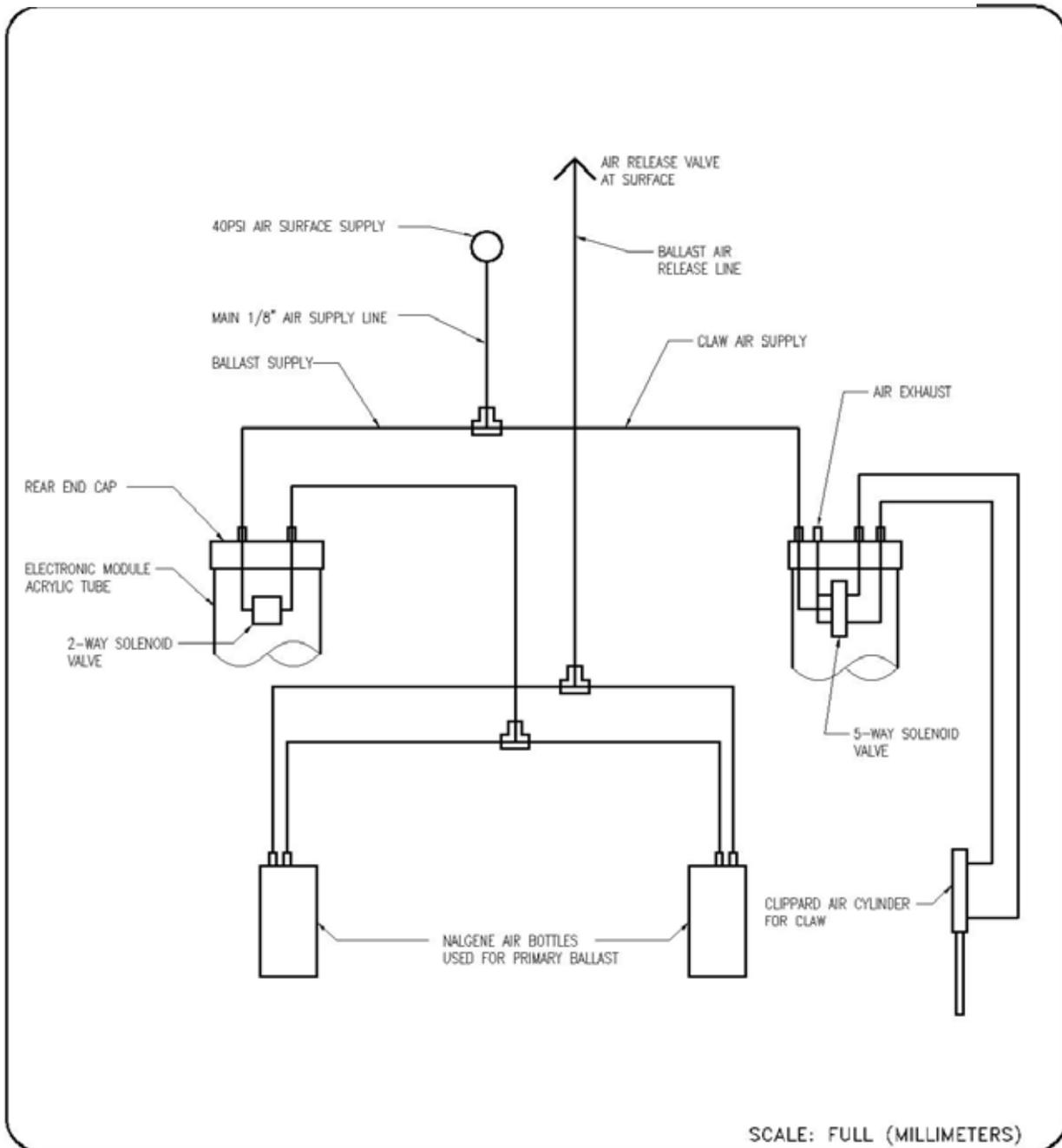


## Appendix F: Right Rear Endcap Drawing



TITLE RIGHT REAR ENDCAP - CONNECTOR FUNCTIONS		TEAM FLOMO "PETSUCHOS" FLOWER MOUND HIGH SCHOOL FLOWER MOUND, TEXAS
PROJECT MATE 2008 COMPETITION - ROV "PETSUCHOS"		
DATE: 3/28/08	SHEET NO.	
REVISION:	D8	
REVISION:		

## Appendix G: Pneumatic Control System Drawing



TITLE PNEUMATIC CONTROL SYSTEM		TEAM FLOMO "PETSUCHOS" FLOWER MOUND HIGH SCHOOL FLOWER MOUND, TEXAS
PROJECT MATE 2008 COMPETITION - ROV "PETSUCHOS"		
DATE: 3/28/08	SHEET NO.	
REVISION:	D9	