LONG BEACH CITY COLLEGE VIKING EXPLORERS

Long Beach, California

EXPLORER CLASS

ROV *VIKING SHIELD*

Technical Report

9th Annual MATE International ROV Competition

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

ROV 2010 Team

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Figure 1 - Mechanical Drawing of SHIELD ROV

ABSTRACT

Long Beach City College returns for our seventh year to enter the 2010 MATE Remotely Operated Vehicle (ROV) competition with our latest ROV, the Viking Shield. The purpose of this ROV is to successfully complete an exploration of the Loihi seamount. Four different tasks are to be performed to accomplish success: Resurrecting HUGO, collecting crustaceans, sampling a vent site, and sampling a microbial mat. This year's ROV, designed in SolidWorks, is cut out of buoyant Teflon, has a mass of 22 kg, and is built to allow maximum water flow. The ROV is 35.6 cm high and 56 cm wide while both wings are open; and 48.3 cm wide while wings are folded. The major design focus was on design functionality. The ROV has, a multi-functional pneumatic gripper, six thrusters, and seven cameras covering all angles of viewing. These features allow the pilot to execute the several tasks set forth by MATE in a timely fashion. In accomplishing the design and build of this ROV, the team created well over 250 SolidWorks files, invested over 5000 student hours, and corresponded daily utilizing the team's online design forum. The entire project was heavily invested in Computer Aided Design and Manufacturing (CAD/CAM).

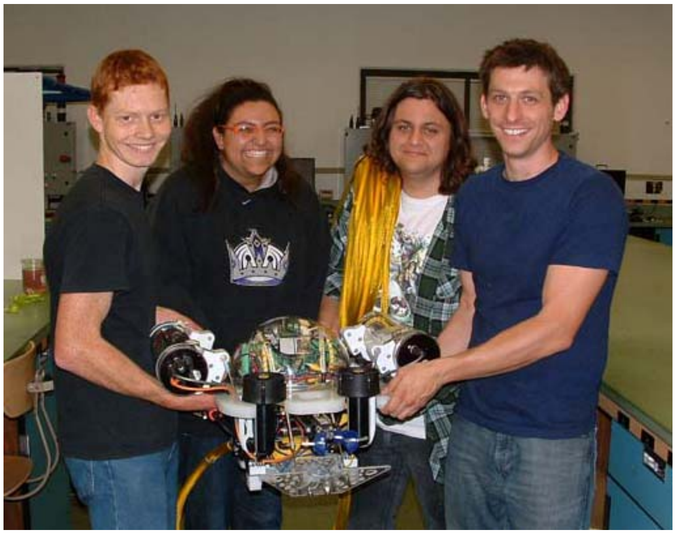

Figure 2 - Partial Team and ROV

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Design Rationale

Structure and Missions:

Mission 1-Removing the Hugo:

The purpose of this mission is to activate the HUGO monitoring station allowing seismic activity data to be transmitted to the surface. This mission requires the ROV to be able to pull out the pins, remove the High Rate Hydrophone (HRH), identify locations of seismic activity, and identify the frequency of the sound caused by the seismic activity. In addition, the ROV is to install the HRH within a 50 cm x 50 cm square, remove the cap from the port of the HUGO, retrieve the HRH power, and insert that HRH power into the port of the box. In order to accomplish all of the tasks presented in this mission, Shield will heavily employ the use of it's gripper. The gripper is designed as a multi-tool for several tasks. Many of its features are designed to work as backups should there be a failure in the primary tool. In order to accomplish parts of this mission, a very special adaptation was developed for our gripper. The adaptation involves the use of a plastic funnel, integrated into the gripper which houses a potted microphone and temperature sensor. This housing provides a focused sound sensor that extends out toward a potential noise source where a quick frequency and amplitude measurement is recorded and checked against a second microphone located in the bacterial mat samplers' camera housing. When an obvious sound positive source is identified, its position, frequency, and amplitude are noted by Pilot and Copilot.

Figure 3 - HRH Deployment

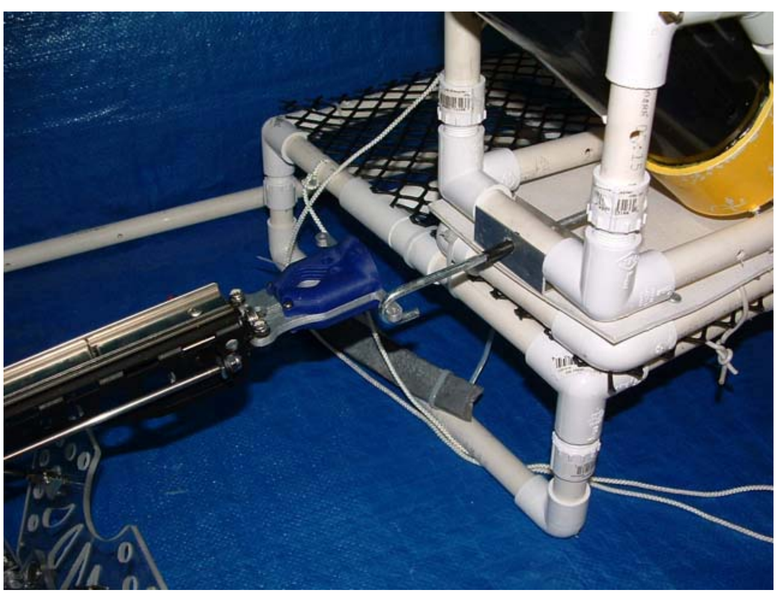


Figure 4 - Pulling HRH Pin

In order to remove the two pins used to secure the HRH to the elevator, the gripper extends approximately 25.4cm from the face of the ROV, which allows Shield to reach across the length of the elevator to remove the interior pin. The gripper head employs a fine tipped manipulator and two catch hooks that protrude from either side. The primary technique to remove the pins is to secure them with the hooks and then remove them by either retracting the gripper arm, removing the pin axially; or by rotating with the thrusters and pulling the pin out in a radial sweep. Should the grippers' hooks fail to complete the task for any reason; the pneumatic gripper can be used to maneuver the pin from its position. Once the HRH is freed from the elevator mounting, the pneumatic gripper will once again be used to move the HRH to the previously-designated, active sound. Should the pneumatic gripper fail to secure the HRH, the extended arm and hooks can also be used as an emergency backup to hook the HRH and transport it. Shield's gripper will be employed once again to remove the HUGO junction cap, through use of the pneumatic clamping mechanism, or catching it with the grippers' hooks. The pilot will maneuver the ROV back to the elevator and use the pneumatic gripper to clamp onto the HRH communication connector. Shield has the ability to vary its horizontal tilt +45 degrees. Should the Pilot and Task Operator require a slight angle or happen to drop the connector, this tilting ability can be used to aid with completing the connection or retrieving the connector.

Mission 2- Collect samples of a new type of Crustacean:

The purpose of this mission is to collect the newly discovered crustacean forms found after the seismic activity of the Loihi seamount. This mission requires the ROV to maneuver itself to the back wall of an 80cm x 80 cm cave at which point the objective is to collect three crustaceans without knocking the walls of the cave. The objective is to deliver these crustaceans to the biologists in the surface. For this task SHIELD will utilize a specially designed device called "The Crusty Scooper." Before entering the cave, the Pilot and Task Operator will prepare the tether and ROV for working in the dark enclosed space of the cave. To do this, the pilot gathers tether in front of the cave door by traveling a number of back and forth sweeps. The task operator will activate a software toggle; located on the LabVIEW interface (explained in the software section), to illuminate the ROV's headlamps. The pilot will use the game pad on his controller to retract the buoyancy tubes against the dome in order to compact the overall width of the ROV allowing for maximum maneuverability. "The Crusty Scooper" is a pneumatically actuated plate that lowers like a draw bridge and can be closed against a hard acrylic trap called the "The Crusty Catcher." Using the gripper targeting camera, and LED's, the pilot can target a crustacean and move side to side to easily center the crustacean, then softly scoop it from the wall. Once a crustacean is caught, the pilot will continue a slight upward motion, using the thrusters, while the task operator closes the scoop against the acrylic trap. This process is repeated until a sufficient number of crustaceans are safely stowed in the trap. The number of successfully trapped crustaceans can be verified by the payload camera, located on the aft portion of the gripper assembly. When the Pilot and Task Controller verify the number of contained crustaceans, the Pilot will activate another software toggle in LabVIEW, which when pressed, will reverse the controls and activate the reverse viewing camera allowing the pilot to drive the ROV in reverse. As the Pilot leaves the cave, the Copilot can turn off the external LED's, extend the buoyancy tubes for maximum stability, and return the controls to normal operation before starting the next task.

Figure 5 - Collecting Crustaceans

Mission 3- Sample A New Vent Site:

This mission requires the ROV to navigate towards the high temperature hydrothermal vents to capture accurate readings of the venting fluid along three locations of the chimney. The data is to be graphed to display the temperature vs. the chimney height. Once this information is obtained, a sample of a vent spire must be collected and returned to the surface. This task will rely heavily on the gripper and the custom plastic adaptor mounted to it. In addition to the microphone, the plastic adaptation on the gripper contains a sealed temperature sensing board that was designed by the team. When the gripper is in a closed position, the plastic adaptor's form a semi-spherical shape which creates a seal over the vent protrusion. The Pilot will align the extended gripper with the column and slowly move the ROV forward to mate the gripper with the vent. Once joined, the flowing water from the vent will be forced through a channel inside the plastic adaptor that passes over the temperature sensor. The temperature sensor constantly sends temperature data to the LabVIEW interface, where it is averaged and graphed. The graph displays temperature in C° versus chimney height in centimeters. The second part of this task is the retrieval of the vent spire, a task that will also be completed with the use of the gripper. The slot in the center of the gripper is specifically designed to securely grip vent spires and connectors of the specified size and shape laid out by the MATE mission specs. When a spire is secured the operator can to choose to open "The Crusty Scooper" door, retract the gripper arm and secure the spire in the "The Crusty Catcher." The operator may also choose to leave the spire secured in the gripper and return to the surface later for manual retrieval.

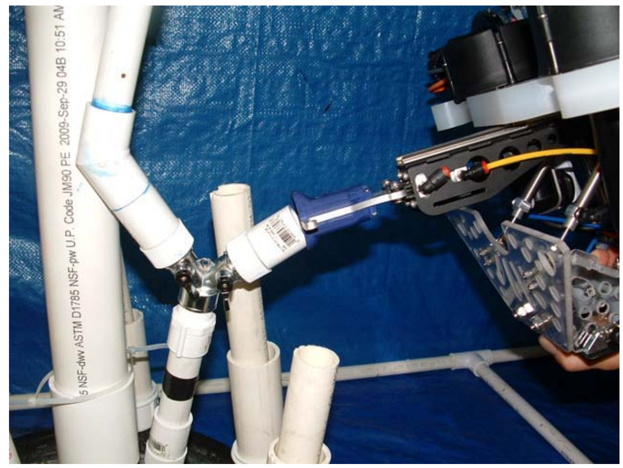


Figure 6 - Sampling Temperature

Mission 4- : Sample A Bacterial Mat:

The objective of this mission is to collect a sample of the bacterial mat formed by iron oxidizing bacteria sustained by the hydrothermal vents to the surface for further biological study. This task uses a custom designed device called the "bacteria mat sampler." The bacterial mat sampler is designed like an ice cream scoop, allowing for a precise amount of bacteria to be sampled without difficulty. The Agar sampler is a pneumatically actuated semi-sphere, with cookie cutter-like teeth for breaking the surface tension of the bacterial mat. The semi-sphere is designed to hold approximately 145mL of bacterial mat, which is in within the 101mL to 175mL range specified by MATE. When the bacterial sample area is located, the Pilot will cycle camera views using the game pad to choose the bacterial mat targeting camera. This camera is in side the sampler directly

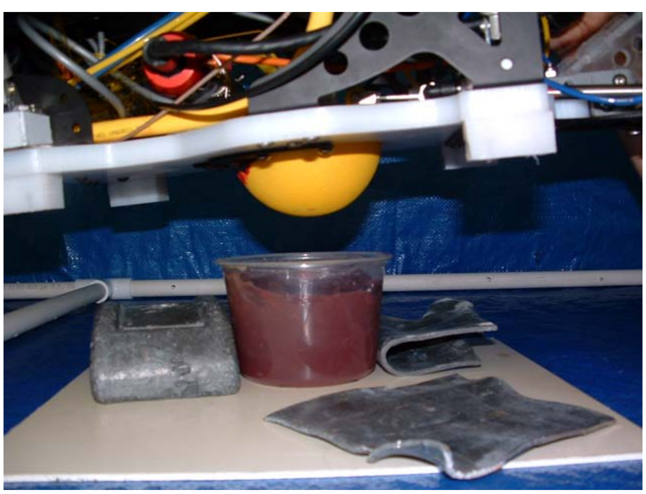


Figure 7 - 150mL Bacteria Sample Complete

over the area the sampler can sample. The Pilot will use his targeting camera and thrusters to virtually land on the sample area, at which point the Copilot will activate a toggle on the LabVIEW interface that will actuate the bacterial mat sampler to rotate in place, slicing into the bacterial mat and holding it in place. Once the Pilot and Copilot verify that a successful sample has been taken, using Payload and bacterial mat sampler cams, the Pilot can return to the surface for retrieval of the sample.

Design Rationale-ROV Components:

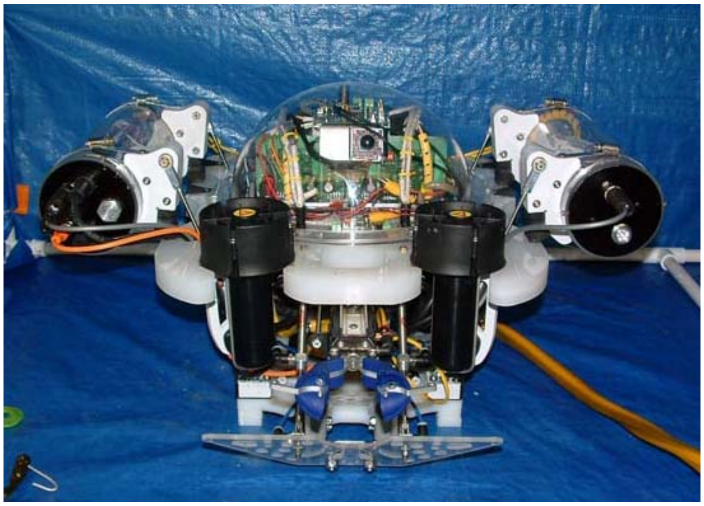


Figure 9 - ROV with Wings Out

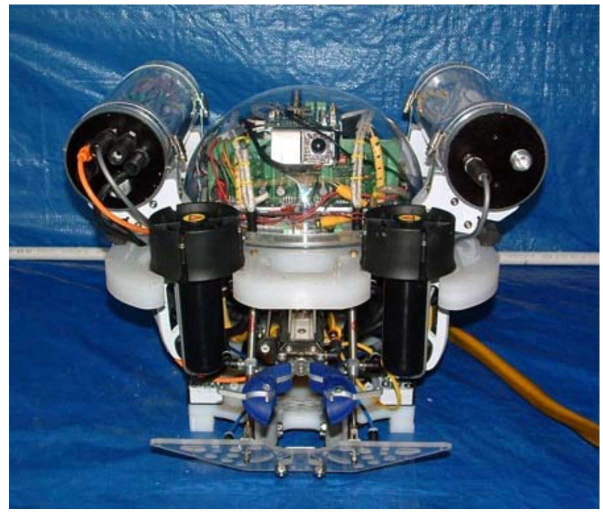


Figure 8 - ROV with Wings In

Frame:

The driving design concept of shield is to create an ROV that is as compact and stable as possible. In order to achieve this, several major design choices had to be made. The frame material had to be buoyant, the electronics enclosure was to be a dome, and lastly the ROV must be less than twenty inches wide in order to quickly maneuver around the ninety degree bend within the mission cave. Firstly, material choice is imperative. Teflon soon became the favored material, due to its superior buoyancy, its high rigidity, and low density. The structural brackets were constructed using highly corrosion resistant aluminum. The electronics dome provides a phenomenal amount of buoyancy, and was one of the greatest challenges to incorporate. In order maintain easy access to the electronics the dome would have to be lifted off without any interference. It was a forgone conclusion that buoyant tubes would have to be placed on either side of the dome. Without these stability would be jeopardized. Consequently, this pushed the design over the twenty inch goal. In order to circumvent this difficulty, the tubes were mounted on hinged brackets that could be extended outward for stability or brought inward for a minimal profile. This made the electronics very easy to access, yet kept the ROV below twenty inches wide; granting the pilot versatility within tight spaces, as well as maximum stability for ease of operation. The thrusters were mounted so that their heavy motors rested below the mass center, increasing stability. In order to make the unit as accessible as possible, a base plate was mounted directly under the main bulkhead on which the electronics were mounted. This created two sections. The top section served as buoyancy and an electronics facility. The lower served as the instrumentation bay. Here the gripper would be mounted at the top, and the crustacean collector and agar sampler would lie directly below. Two accumulator tubes could then be mounted on either side of the gripper as well as electrical connector ports. This provided the ROV components with optimal positioning, while simultaneously making all the components easily accessible for maintenance.

Camera Housing:

The cameras are essential to the ROV as they provide a way for the team to maintain sight while it is performing tasks underwater. Without eyes, none of the tasks can be accomplished effectively. When trying to maintain a certain weight and dimension, large camera enclosures present problems. In order to create a light-weight, versatile camera that can be placed anywhere on the ROV, the camera housing has to fit the camera as tightly as possible. Camera enclosures are divided into three major parts: a housing tube and two end caps. One of the end caps holds the camera and electrical connections, while the other end acts as a lense and protective cover, as seen in the figure below. The front end cap is made of lexan, giving the camera perfect visible clarity and robust protection. SHIELD is equipped with a rugged high definition underwater camera 1.9 inches in diameter and almost neutrally buoyant underwater.

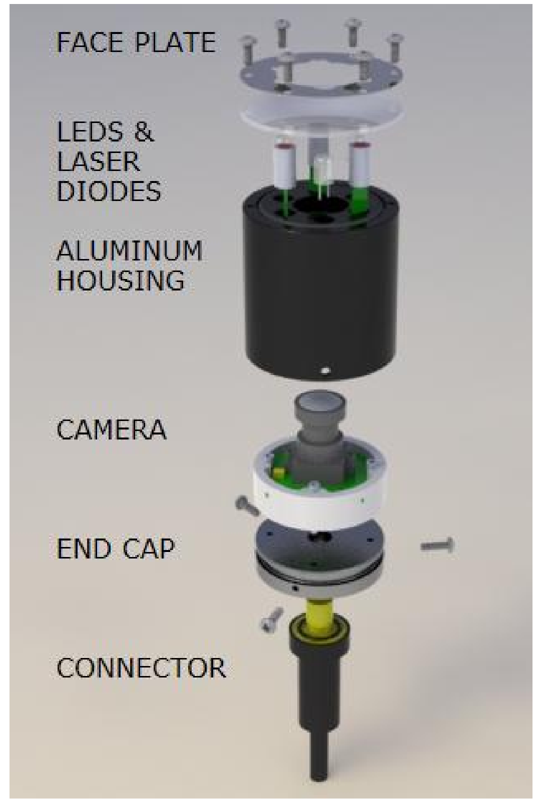


Figure 11 - Camera CAD Diagram

Thrusters:

This year the team wanted to design a more efficient thruster that could outperform commercial thrusters. We came up with a design that incorporated a three bladed prop at a 30 degree angle, an airfoil shaped kort nozzle, and a 150 watt motor. The motor housing is an acrylic tube with end caps on each side, both sealed by two o-rings. The propeller was meticulously designed to have three blades at 30 degree angles. The team designed six thrusters with different angles and number of blades, and conducted tests to find the design with the best performance. These prototypes were tested against each other, last year's design, and commercial Seabotics thrusters. The results indicated that the 30 degree props out preformed every other angle by 36-69%, and the commercial thrusters by 44% while reducing the watt usage by 28%, thus increasing the efficiency. The kort nozzle uses an airfoil shape design to further

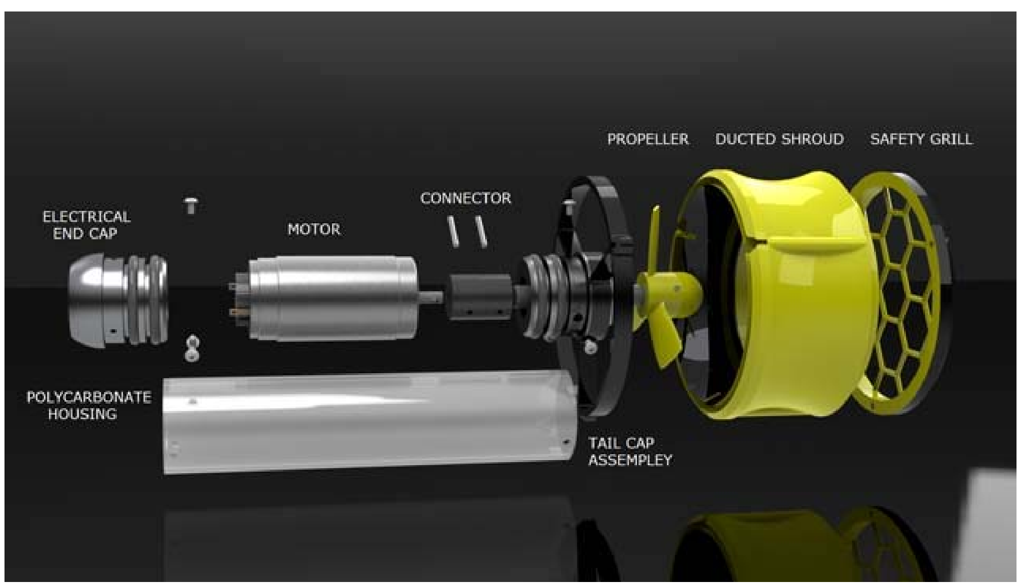


Figure 10 - Thruster CAD Diagram

increase the efficiency. As the water flows in, the diameter of the shroud is reduced, forcing the water to increase in velocity. Our tests demonstrated approximately a 66% increase in efficiency after incorporating the kort nozzle in the assembly. For safety purposes the kort nozzle also acts as a shroud, along with the hexagon grill preventing anything from contacting the spinning prop.

To test the seal of our end caps and shaft at various depths, we used a paint pressure pot. We filled the pot with water and submersed our thrusters. We then pumped compressed air into the tank to simulate water at various depths. We started at half a bar of pressure which converts to 5 meters of simulated depth. We continued to raise the pressure by half a bar, holding for two minutes then checking for leaks or damage, until we reached two bars, an equivalent of twenty meters, and held for five minutes. The thruster came out sealed in tact without leakage or damage. The shaft is sealed by o-rings. The o-rings cause friction, increasing the load on the motor. A future improvement would be to incorporate a method of sealing the shaft without decreasing the performance.

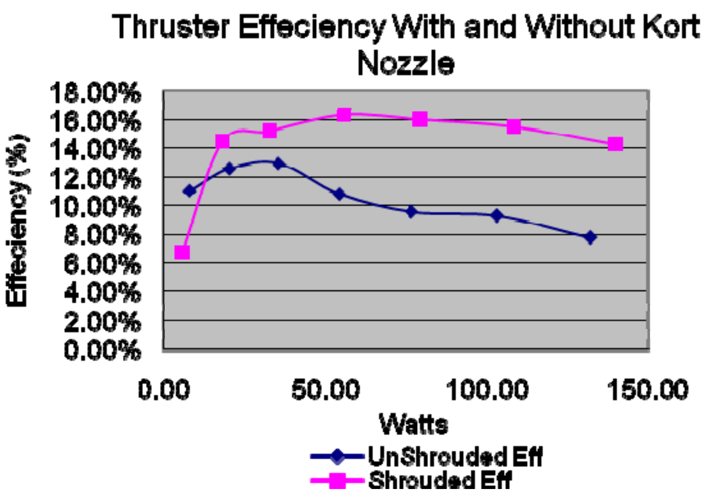


Figure 12 - Thruster Efficiency

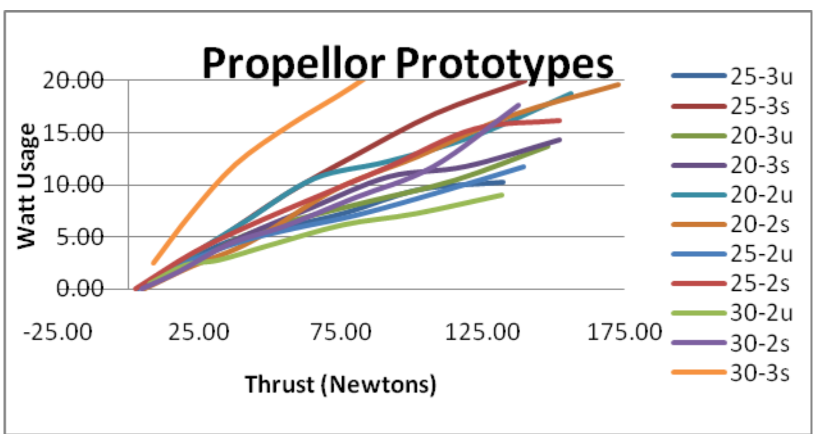


Figure 13 - Propeller Types

Crustacean Catcher:

The crustacean catcher consists of a wide scraper that can funnel crustaceans into a small vented enclosure. The scraper is operated by two pneumatic cylinders that either extend the scraping edge forward, or retract to shut the scraper against the enclosure opening for secure capture. The scraper is wide enough so that when one of its corners has reached the edge of the crustacean zone, the ROV still has clearance between its side and the wall of the cave. The scraper is also mounted low enough that when the ROV rests on the floor of the cave the top of the extended scraper will be below the crustacean zone. On either edge of the scraper is an aluminum rail that will channel the dislodged crustaceans to the center where they will be shut into a small enclosure. The enclosure also has a vent in its floor, causing any upward movement of the ROV to suck the crustaceans in. Once the desired number of crustaceans has been caught, the pneumatically operated scraper serves as a gate shutting the crustaceans within the enclosure and preventing any chance of escape.

Bacterial Mat Sampler:

The bacterial mat sampler is a rotating half dome mounted in the center of the ROV base plate. It is designed to revolve in a scooping action that will capture a calibrated amount of bacterial mat. Once actuated the scooping edge is lined with teeth so that all resistive surface tension is alleviated. This allows the sampler to carve into the bacterial mat with unmatched precision, preventing any unwanted sliding or bending of the bacterial mass that would compromise the sample quantity. The sampler is also driven by two pneumatic cylinders that supply a smooth, even amount of torque to the scoop. This insures an optimal sample every time.

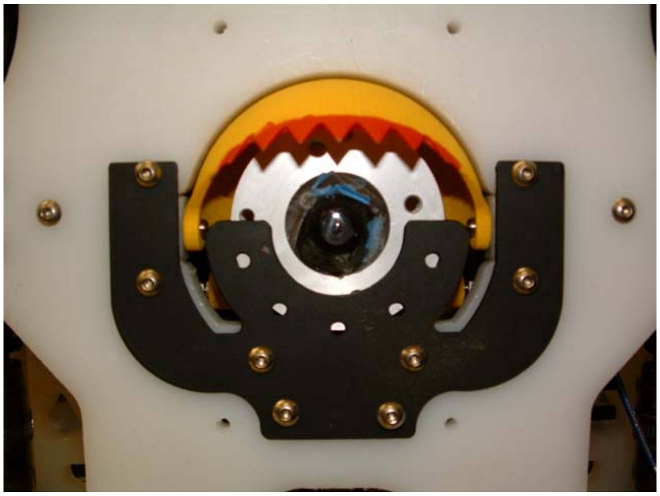


Figure 14 - Bottom View of Bacterial Mat Sampler

Gripper:

Figure 15 - Gripper in Hand

The gripper was designed to have both sides come together to form a funnel like shape. This allows the pilot to easily locate SHIELD's temperature sensor, which is housed on the back of the funnel, with the thermal vent structures. A water outlet, located just above the temperature sensor ensures the receipt of a constant flow of water from the vent. This gives us the most accurate temperature measurement possible. Also located on the back of the funnel is a potted microphone, which aids in focusing sound coming from seismically active areas. Acting as a backup in case the crustacean collector fails, small pincers were aded to the metal frame of the gripper. The two protruding arms from either side of the funnel are designed to pull the anchoring pins from the HRH in Task 1. The curved-grooved feature behind the funnel is designed to pick up volcanic spires and the HRH. The grooves were added to increase gripping action. Driving the gripping force is a pneumatic actuator. Small brackets are bolted to the face of the actuator and hold both gripper halves in position.

Software

There are two different programming environments involved for the software development: Labview, running on the surface PC, and PicBasic program on the ROV. We wanted to implement the most of the complex software with Labview instead of having it in the ROV in PicBasic code. This provides us with the ability to easily manipulate and modify the program as needed on the surface. Therefore, we kept the ROV programming in PicBasic as simple as possible giving us exactly what we need from the ROV during the mission.

Labview:

Team programmers have used the same simulator board to develop their programs concurrently with the hardware development. This year our Labview program running on the surface PC has completely changed to accommodate our new communications method. The surface control program has become more sophisticated to have a better control on the communication with the ROV during the mission. We have implemented broadcast control logic so that we can send a command to the ROV and then receive the status from each processor. Last year the surface waited for the ROV to send the message to the surface and then it replied with commands. This method allows any board to stop functioning while the remaining boards will continue to take commands from the surface. For each command sent, only one ROV processor will respond with status, which means that if there are N processors, it will take N command strings to retrieve status from all the processors.

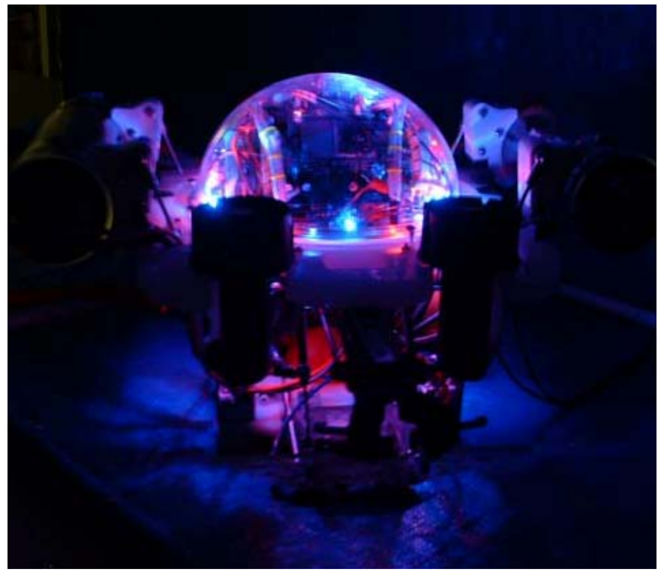


Figure 16 - ROV with Status Lights in Operation

PicBasic Software:

PicBasic is a programming environment that was used on the individual processors in the ROV. Due to size constraints of the chip, the programming on the chip isn't as complex as the software ran by Labview. In addition to the operation of the ROV, this software was used to program the status LED display inside the dome. The status display consists of fourty LED lights in a ring configuration. These LEDs turn on according to the movement of the individual payloads on the ROV. The status display program monitors the command strings and sets the outputs to reflect command status. The program continues to listen to the commands, but never sends status back to the surface.

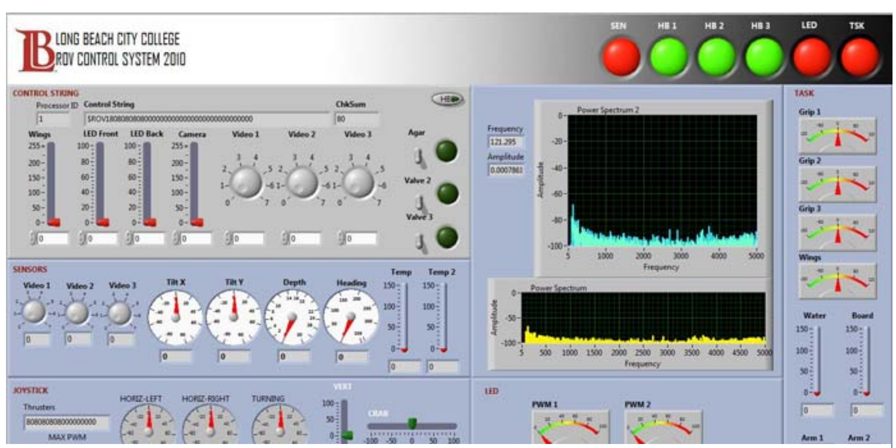


Figure 17 - Control Display in LabVIEW

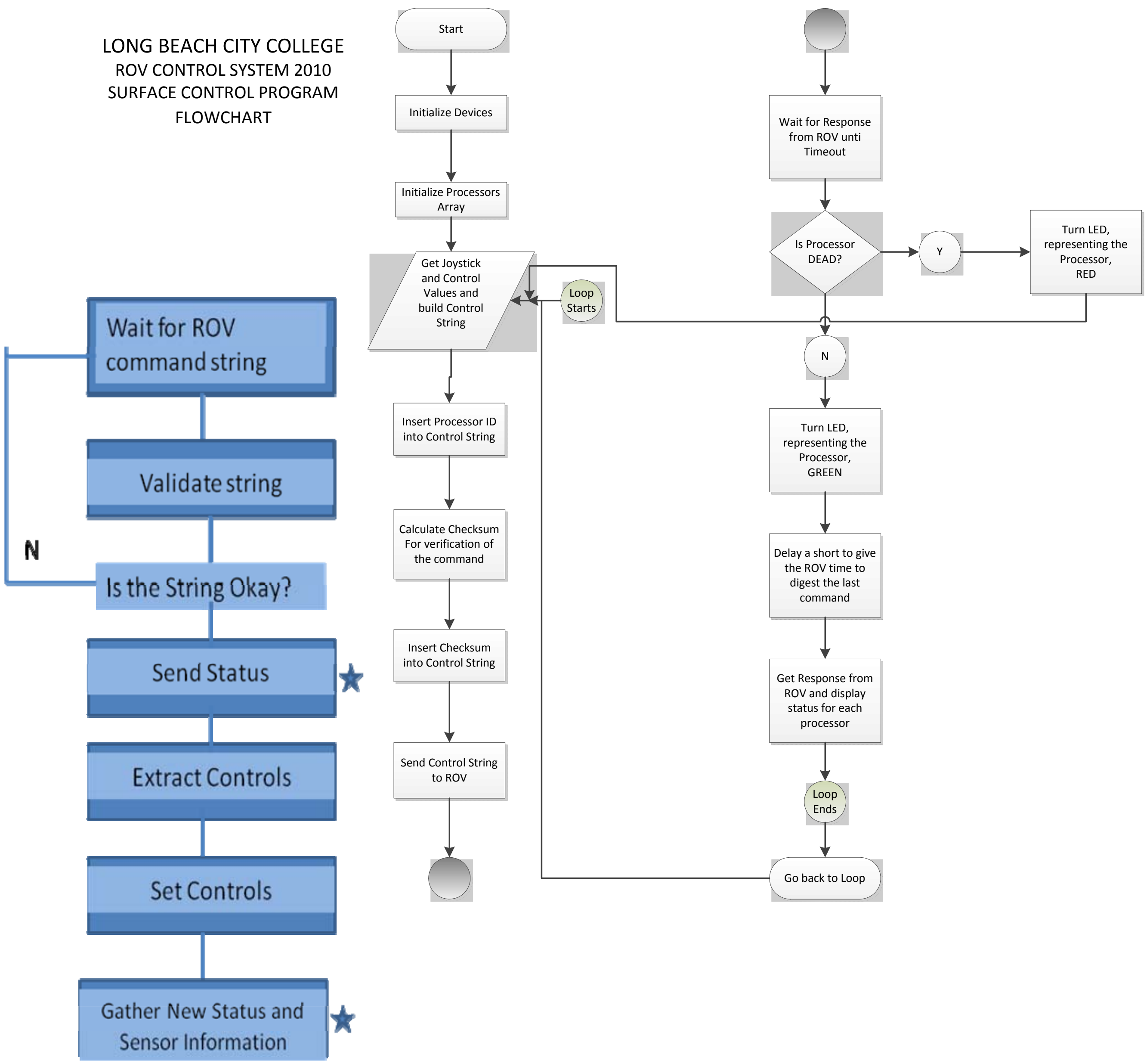
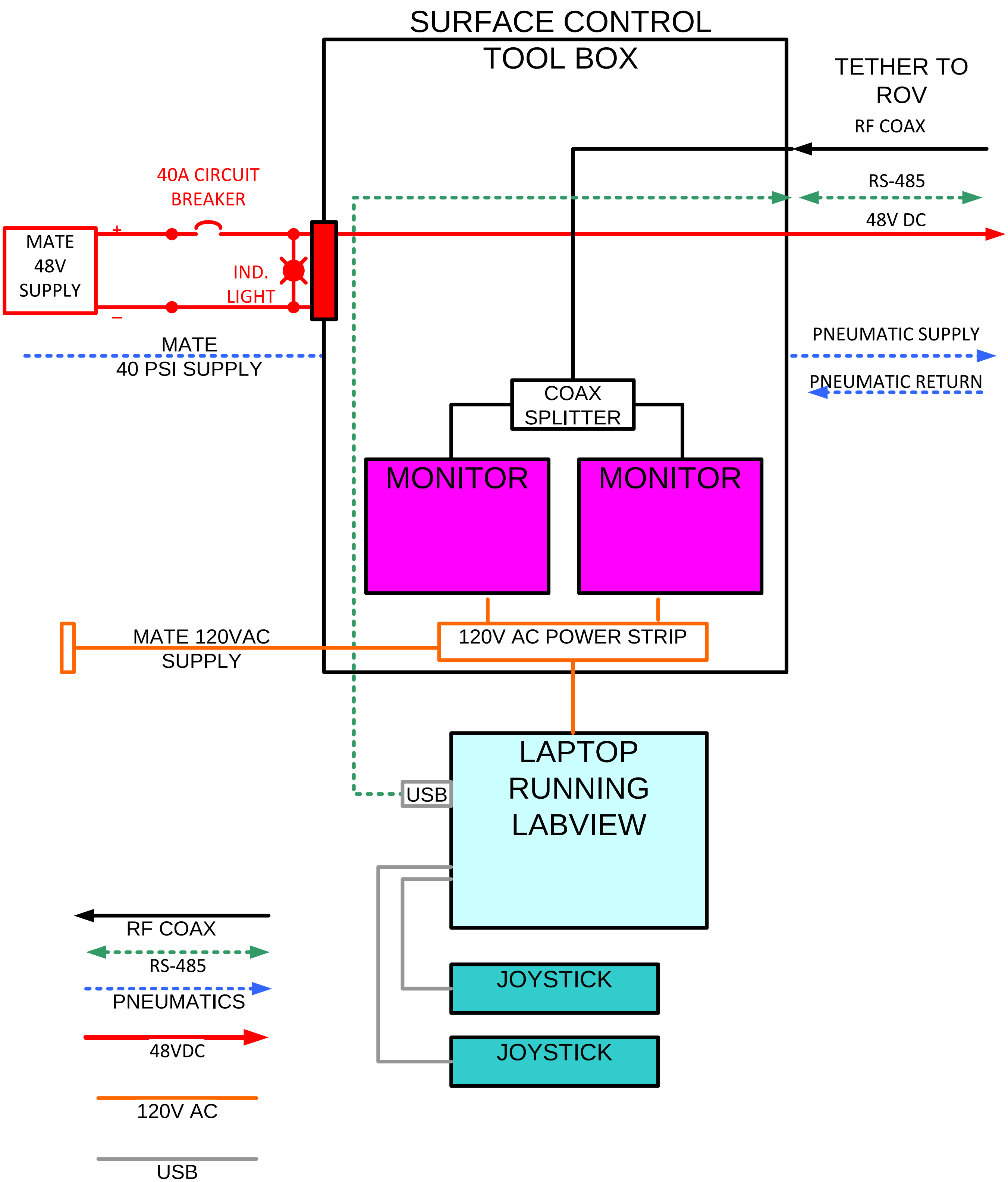
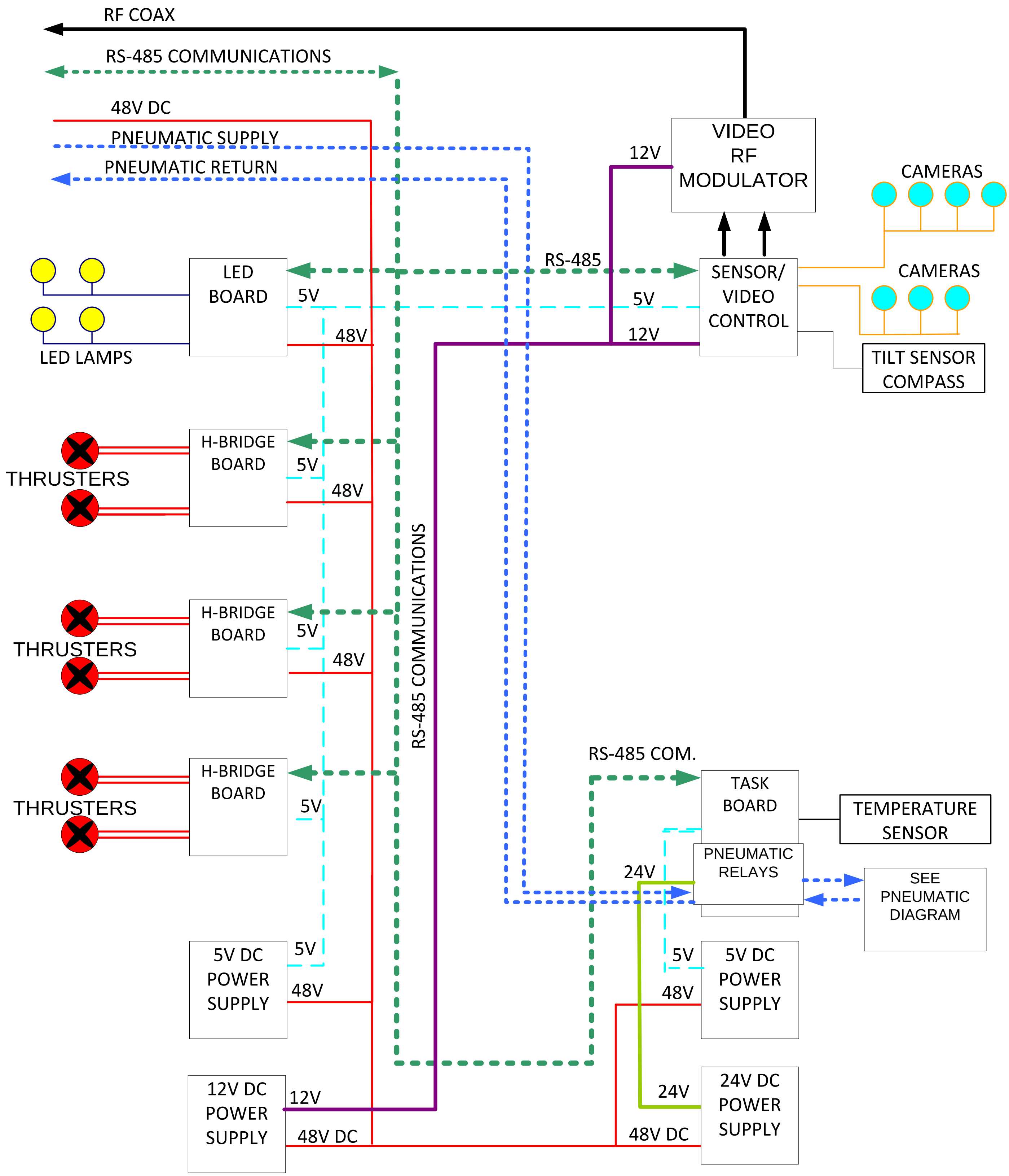


Figure 18 - ROV Software Flowchart

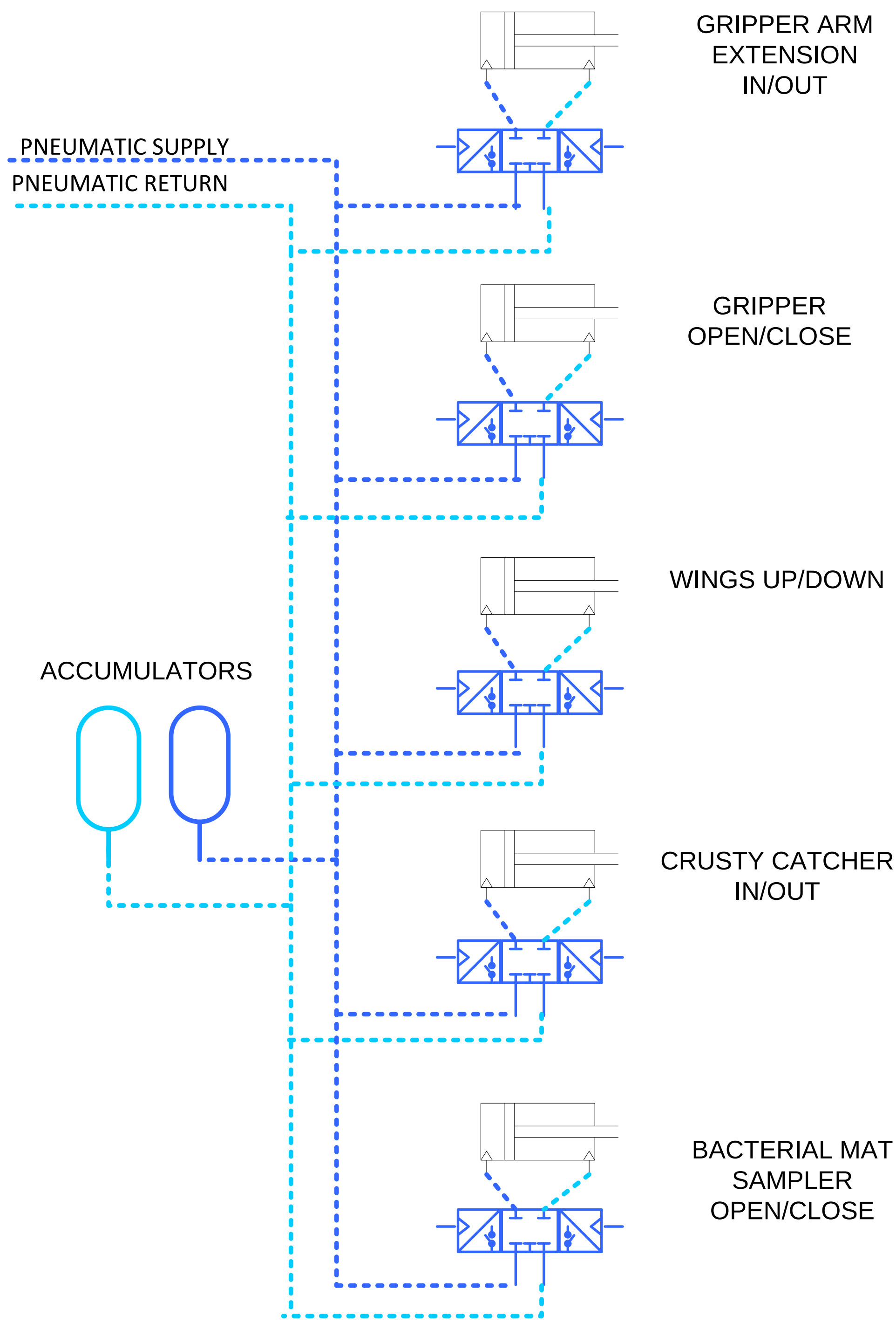
Electrical Schematic:



TETHER TO SURFACE



PNEUMATICS DIAGRAM



NOTICE: FOR CLARITY THE WIRING TO EACH SOLENOID IS EXCLUDED IN THIS DIAGRAM. EACH SOLENOID HAS A RELAY DRIVER AS PART OF THE TASK BOARD

Planning and Design:

Planning and Design is a long process that starts in early in the fall. The process begins with a brainstorm of basic design concepts. This year the preliminary design included two domes, and a task package underneath the dome that would include all of the payloads needed to accomplish the unknown missions. With these preliminary ideas, the team inspects the gripper designs, and investigates thruster designs. As the team develops these ideas, the designs are inspected and reviewed. The initial design also included two pneumatic cylinders that would provide a nearly 180 degree vertical rotation in the gripper. The team encountered a lot of problems with this design concept, and ended up deciding on a belt drive to rotate the gripper wrist which was easier to accomplish and provided that same 180 degree rotation.

Once competition rules were announced, the team was able to narrow down what was needed for the completion of the missions. The multiple dome design was instantly thrown out upon inspection of the second mission, which requires the ROV to enter a small cave. The team redesigned the ROV to include one dome instead of two, which dramatically reduced the size. By January the ROV was redesigned and reduced to 61 cm, and included a 1.3 cm Aluminum thick base plate which included mounted thrusters on both sides, two buoyancy tubes next to the thrusters, and a gripper. The team continued to work on the design until March when the design was finalized to what the ROV is today. After the design was finalized, the final frame was cut out and electronic designs were also finalized. By April, the team tested the gripper, and changed the design once more from a belt drive, that could easily slip to a chain that would provide a stronger design. The ROV was then assembled and software was uploaded.

Challenges:

Our biggest personal challenge was juggling the ROV project around problems with jobs and illnesses. We started the team with three people returning from the 2009 team. One of those was our team captain and as a result of the 2009 team's performance, he was offered a job with an underwater connector company. This had both positive and negative effects on the team. On the positive side, we now had a team member working in an underwater connector company. He was able to work with them in developing the connectors for our ROV and personally took part in building our connectors. The negative part was the time away from the team that his job required. Between going to school full time and work, our captain eventually had to pull out of his leadership role and pass to torch on to the current team captain. It was a little rough at first, but the team pulled together and pushed on.

Our next difficulty was illnesses. Our machine tool instructor contracted cancer and was taken out of the picture for a few months. He was going to have his students build camera housings and new thruster housings that we had designed for the ROV. We backed up, redesigned the thruster so that we could machine the changes ourselves on last year's thrusters. We also potted cameras rather than put them in machined housings. We used those cameras for the qualification. Right after qualification, the instructor was back and his students machined a complete set of camera housings to our design just in time to get them onto the ROV. Other illnesses made their rounds with the team and unfortunately one team member lost the last three weeks of school in the hospital. In each of the illnesses, other team members stepped in and filled in the gaps keeping the project on schedule.

Our technical challenge involved the size of the ROV. The original design for the ROV was approximately 75 centimeters wide and twenty four inches tall. When the mission specifications were released it became apparent that the design was far too large. In order to correct this, the electronics compartment was compacted into one small dome. In addition, many of the load-bearing brackets were used for multiple components to further downsize and simplify the ROV. The buoyancy tubes and task cylinders were placed on pneumatically driven cantilevers, which were immediately dubbed "The Wings", allowing the ROV to shrink it's width and easily slide into the cave.. Lastly the task control cylinders were oversized so that they could take the place of the buoyancy tubes. These choices reduced the size of the ROV to a sleek 48cm wide by 36cm tall and only 55cm long.

The original gripper was designed with 12.5 cm elbow that would allow for a wide field of vertical reach. At the end of this elbow a secondary joint was added for correcting the angle of the gripper. This presented the massive challenge of balancing the ROV when manipulating the gripper. The heavy "elbow" bracket was removed and replaced with a linear actuator. When the ROV underwent its massive downsize the secondary "wrist" actuator was eliminated. This tremendously simplified the gripper and made it far easier to operate.

Trouble Shooting Techniques:

One of the strongest tools when troubleshooting Labview software is the probe tool. The "Probe" tool looks at the output at specific locations of the code. It helps because it allows the programmer to see what comes out based on the input. This allows the programmer to retrace the code to find where the problem is. Troubleshooting for the PicBasic software was done by loading the program into a simulator called PicKit which would display debug messages that were placed at various locations in the code to provide a window into the operations.

Safety

While operating SHIELD, safety practices must always be in mind. Pilots and Copilots must be aware of divers and be mindful of operating too close. General safety features added to SHIELD and subsequent systems are: Thruster shrouds and covers to protect hands and loose clothing from contact. Bright contrasting coloring of thrusters and propellers. Light weight for easy launching. Overcurrent protection switch on ROV mainline.

Improvements

One of the biggest improvements for next year will be in our power supplies. This year we built modular power supplies that could have the voltage set with two resistors. The same circuit board was used for the 5V, 12V and 24V supplies. We were aware of the potential to put a supply into the wrong slot and the comments were made, "that's OK, we'll be careful and won't mess up". As always, Murphy struck and a power supply was swapped. The 24V supply was swapped with the 5V supply on the task board. The PIC processor instantly burned up and was destroyed. We were able to remove the processor and replace it with a new one after cleaning the board. This should not have happened. We discussed how we could keep this from happening in the future, and kicked around a number of ideas. The best one ended up being to move the two voltage setting resistors off of the power supply board and onto the target board. This way we can swap power supply modules and the location of the module sets the voltage rather than the specific board. This will result in quicker builds, a much more stable system and the ability to have a spare power supply board that can be used for any voltage.

Lessons Learned:

The ROV team has learned many lessons through out this experience. Writing this report, we can safely say that we have learned to pay close attention to dates, and to double check with each other to make sure that the information that we pass along to one another is accurate. An important message any team can learn is that communication is really something that shapes the efficiency of the team as well as the performance of the ROV.

Reflections:

Karen: One of the things that I was responsible for was the soldering many of the ROV electronics boards. We broke up into teams and each team had at least one board to solder. I have soldered before but never anything as small as our boards. My partner Al and I teamed up to work on the task board. This was the largest and most complicated board of all. We took turns soldering the components, while one soldered, the other located the next part and marked the soldered parts off the check list. We took our time and were able to solder the tiny pieces without damaging any. As our technique improved, I still found that many of the components were hard to see. I used a magnifying glass, reading glasses and a microscope. Yes a microscope! Some of the components were very tiny and the only method to solder them properly was to look through the microscope as we did our work. When we finished, the board was inspected, programmed with a test program and it worked the first time! There were high fives all around.

I really enjoyed the soldering experience and purchased a soldering station for my home so I could practice building my own boards. I am very interested in how a board is built and plan to learn EagleCad next so that I can work on laying out the boards for next year's ROV.

Yasin: I have been working on the programming portion of the ROV for two semesters now and I feel that it has paid off. Not only do I have a greater understanding of programming in real world settings; I have gained so much more understanding of creating complex algorithms to handle various tasks. I think one of my most significant accomplishments would be programming two Xbox 360 controllers to work simultaneously for the missions. I think it's great to have worked on the handling of the ROV.

Ben: This year was an amazing experience for me. I was very fortunate to be able to devote a large amount of time to this program. I worked with many of the concepts in this years' design. I was able to become proficient with five different industry standard software packages, two types of programming languages, machining techniques, circuit design, systems integration, -wrap it all up into a water tight package, and to top it off earn an at- sea internship with Dr. Ballard aboard the Nautilus this fall. A feat I would have never thought possible before I found this program.

By participating though, I have also learned a lot about myself, and how I interact and fit in a group of equally intelligent peers working towards a common technical goal. You don't get that kind of self-reflection listening to a lecture. See-ya next year!

Ferruh: I have had another challenging and very productive year with the Robotics Team at Long Beach City College. Even though I have written so many programs, I can easily say that this was the first time I felt that programming was like putting the Lego pieces together; Build the pieces one at time and put them together and watch it grow in front of eyes. It was really awarding.

We were challenged with the new idea as far as communication with the ROV. Instead of waiting ROV to send its status to us, we have changed the logic and ask the ROV to send us the status on demand. In this way, if any processor is not responding for any reason or out of synch with surface PC program, the communication won't be interrupted and ROV will keep receiving the commands from the pilots.

As I always say, the Robotics class is a great experience and prepares the team members for the industry; especially in the field of Remotely Operated Vehicles (ROVs). It challenges your skills in the field you want to gain experience and the best thing is that it teaches you how to accomplish your goals at the end of the class.

LOIHI SEAMOUT

The department of geology at the University of Hawai'i at Manoa defines Hawaii as a series of volcanoes and surrounding land formed by the hardening of the lava produced by the volcanoes over an extensive time. The Loihi Seamount, is Hawaii's "youngest submarine volcano," and is located south east of the Island of Hawaii and 30km from the shore (Lo`ihi Seamount par. 1) as seen in the figure below. The volcano rises more than 3000 meters above the Pacific and is an active volcano, though it was thought to be inactive prior to 1970. (Rubin par 2). Earthquakes of magnitude 2.0 to 4.0 are common around the Loihi area due to magmatic movement ("Loihi" par. 4), which is defined as the layering of magma resulting in rock formations (McBirney and Nicolas par. 8). These earthquakes are considered an indication of growth and activity for the volcano and were first observed from 1970 to 1975 ("Loihi" par. 5). The Hawaiian Volcano Observatory reports that the largest seismic event occurred in 1996, and was the primary event responsible for the creation of the newest crater named Pele's Pit. Pele's Pit, which is about 600 m in diameter and its bottom is 300 m below the previous surface making the Loihi seamount base about 6000 meters below surface as seen in figure 2 of the appendix (Rubin par. 1).

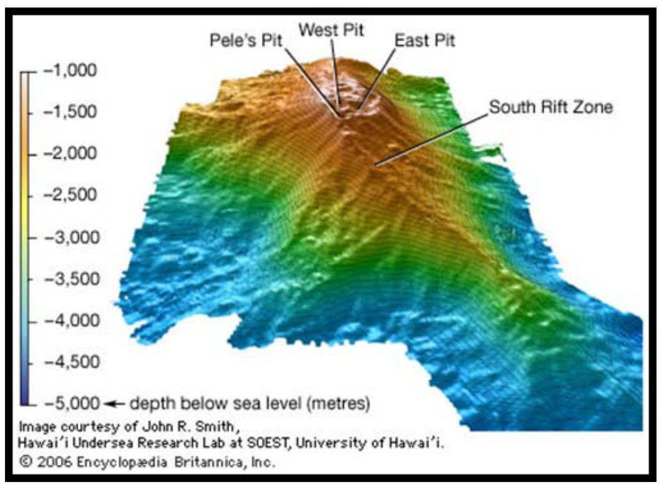


Figure 19 - Loihi Seamount Location

The earthquake activity in 1996, according to the 1996 Loihi Science Team, was the "largest swarm of earthquakes *ever* observed at any Hawaiian volcano." The massive series of earthquakes were investigated by 15 PISCES V submersible dives. A PISCES V is a three-person, battery-powered, submersibles that can travel down 2000 m (6,280 ft), and allow scientists to observe the deep sea through multiple view ports, video records, instrument placement, sample collecting, and environmental monitoring according to the NOAA, Office of Ocean Exploration and Research. 41 water-sampling operations were also performed for the investigation of the 1996 earthquake swarm. The use of the ROVs in the Loihi seamount is a revolutionary way to explore not only current marine life, but to see the development of the island, which over time will include Loihi as another volcano.

Budget/Expenses

Part	Quantity	Reused Value	Donated Value	Cost
120V AC power Strip	1	$ 5.00		
40A Circuit Breaker	1			$ 15.76
Acrylic Dome	1			$ 32.00
Acrylic Tubes	2			$ 51.82
Backpack Frame	1	$ 18.75		
Camera Housings	5		$ 375.00	
Cameras	8			$ 176.00
Connectors, Electrical	6			$ 138.00
Connectors, UWS *	1		$ 4,500.00	$ 1,000.00
Cylinders, Paint Ball	2		$ 67.65	
Drawer Slide	1			$ 23.94
Electronics Boards	12			$ 396.00
Electronics Components	misc			$ 735.00
Endcaps, Aluminum	4	$ 75.00		
Hardware, Stainless	misc			$ 237.00
Hinges, Plastic	5			$ 18.50
Indicator Light	1			$ 2.75
Paint, Powdercoat	2			$ 69.34
Pneumatic Cylinders	10	$ 216.00		$ 120.00
Pneumatic Fittings	24	$ 47.04		
Pneumatic Tubing	200	$ 72.00		
Pneumatic Valves	2	$ 350.00		
Rapid Prototype Parts	misc		$ 1,600.00	
Sheet, Aluminum	2			$ 113.50
Sheet, Plastic	1		$ 250.00	
Sheet, Teflon	1		$ 739.00	
Stainless Pipe Strap	10			$ 10.67
Tether	1		$ 220.00	
Tether Sheath	1	$ 37.00		
Thrusters, LBCC	3	$ 1,266.30		
Thrusters, Seabotix	3	$ 2,250.00		
Tool Box	1			$ 36.00
TV Connectors	misc			$ 35.00
TV Monitors	2			$ 217.00
Welding & Routing Services	1		$ 750.00	
Solidworks CAD Software Donation			$ 10,200.00	
		$ 4,337.09	$ 18,701.65	$ 3,428.28

Fundraising	$ 3,457.00
Electrical Dept Funds	$ 1,540.28
Total Budget	$ 4,997.28
Amount Spent	$ 3,428.28
Balance	$ 1,569.00

* Sponsor provided the team with deep discounts off their list prices

We apologize for the 10 point font for the budget sheet. There was no way to fit it on one page with 12 point font.

ACKNOWLEDGEMENTS

Dr. Thomas Clark	Cash Donation
ELECT 230B Robotics Students	Design Ideas & Board Soldering Team
LBCC Associated Student Body	Travel Stipends
Michael Avila & Valley College Machine Tool Students	Machining our camera housing designs
Saddleback College Rapid Prototyping Dept.	Rapid Prototype Propellers, Thruster Housings, Bacterial Mat Sampler
SolidWorks	30 student copies of SolidWorks
Standard Metal Products	Welding and material cutting
Underwater Systems, Inc	Discounted Connectors
VideoRay	55 Foot Tether won at the 2009 Competition
Our Families	Putting up with our late nights working on the ROV
Our Mentor – Scott Fraser	
MATE – Marine Advanced Technology Education	The support and all their hard work into putting this competition on.

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ROV10-TASK2brd.pdf *TASK BOARD*
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ROV10-MBbrd.pdf *MOTHER BOARD*
ROV10-MB.pdf *MOTHERBOARD SCHEMATIC*
ROV10-LEDbrd.pdf *LED DRIVER BOARD*
ROV10-LED.pdf *LED DRIVER SCHEMATIC*
ROV10-HBbrd.pdf *H-BRIDGE BOARD*
ROV10-HB.pdf *H-BRIDGE SCHEMATIC*
ROV10-CTLRbrd.pdf *VIDEO CONTROLLER BOARD*
ROV10-CTLR.pdf *VIDEO CONTROLLER SCHEMATIC*
MATE_temp_REV0Cbrd.pdf *MATE TEMPERATURE SENSOR BOARD*
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