Technical Report

Long Beach City College ROV Team
Long Beach City College
Long Beach CA
Team: Viking Explorers
ROV Name: Ormhildur
"Female battle serpent"

6th Annual
International ROV Competition

Celebrating the International Polar Year:
Science & Technology Under the Ice

Terry Allen	Electrical – Graduated 5/31/07
Maria Borja	Engineering – Spring 2008
Francisco Canul	Electrical – part time, maybe Spring 2017 ☺
Jon Chavez	Mechanical Engineering - Spring 2009
Cliff Colella	Physical Science – Graduated 5/31/07
Ian Jasper	Electrical – Spring 2009
Emily Morrow	Anthropology – Spring 2008
Shauna Otto	Marine Biology – Spring 2008
Jan Reside	Engineering – Spring 2008
Matt Romesburg	Undecided
Jesus Zavala	Electrical – Graduated 5/31/07
Instructor: Scott Fraser	Sage Advice: Leonard Fellman

Additional Contributions by:

Electrical Students

Noah Brandt, Simon Cade, Mark Colella, Josh Ford, Miguel Pantaleon, & Russell Watts

Engineering Students

Ven Borada, Todd Banville, Aldo Fernandez, Vincent Laura, & Carlos Villegas

Business/Anthropology Student

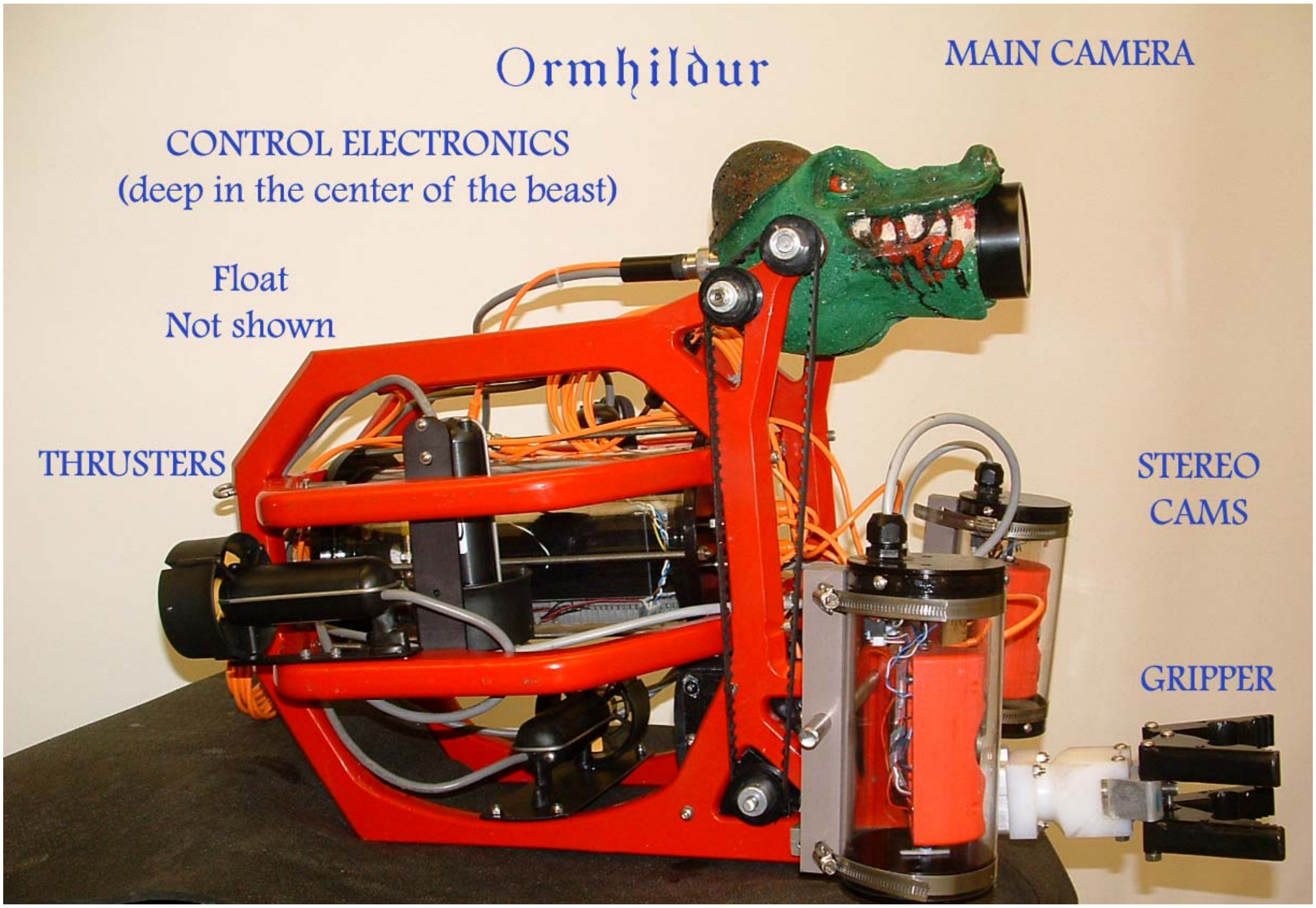
Adam Ramsey

Art Students

Kevin Boylan and Lauren Kasper

Abstract

The 2007 LBCC Robotics Program marks the Viking's return to Newfoundland with Vicky IV renamed Ormhildur, which translates to *female battle serpent* from the Old Norse Language. For this competition Ormhildur was built with two concepts in mind: compactness and power. By building Ormhildur with a small frame made of high density PVC, her maneuverability and speed is increased. Decentralized electronics systems, stereo cameras, laser/camera distance measuring system, and angularly variable grippers were all designed to be as compact as possible. Using Solidworks, the separate systems were brought together to ensure its compact size and perfect fit before physical construction. Ormhildur measures in at 50 cm in width, 52 cm in length, and 24 kg in weight, with her buoyant back (float) providing 8 kg of lift. Ormhildur is limited to 30 meters of depth because of the tether length. Her construction involves a variety of materials which include anodized aluminum, PVC, stainless steel, and polycarbonate plastic. Ormhildur carries four cameras; a stereo camera system, which gives an all-purpose distance-measuring viewing system, a single high resolution auto-focusing zoom camera and an upward looking camera for escape out from under the artic ice cap. The thrusters provide 2 kg thrust each, enabling her to be quick and powerful.



Budget/expense sheet

LBCC ROV TEAM EXPENSE REPORT AS OF 6/1/07

Item Description	Source	Donated	Cost
Travel Stipends	LBCC ASB	$ 9,700.00	$ -
Fiber Optic Video Link	Optelecom-nkf	$ 5,050.00	$ -
Main Camera & Housing	Remote Ocean Systems	$ 3,000.00	
25 Student Versions of SolidWorks	GoEngineer.com / SolidWorks	$ 2,500.00	$ -
Thrusters (5)	Seabotix	$ 1,937.50	$ 1,937.50
Printed Circuit Boards	Advanced Circuits	$ 1,485.00	
Underwater Connectors	Burton Connectors	$ 908.00	$ -
Foundation Grant	Long Beach City College Foundation	$ 700.00	
Rapid Prototype Camera Housings	Saddleback CC	$ 550.00	
Tether	PIER Institute	$ 550.00	
Waterjet Services	Standard Metal Products	$ 500.00	$ -
IP68 Rated Cabling & Connectors	Lumberg	$ 350.00	$ -
Plastic & PVC sheets	MesaWest	$ 300.00	$ -
Aluminum Hard Anodizing	Lubeco, Long Beach	$ 300.00	
16 ea PIC18F4431 Processors	Microchip	$ 132.00	
Acrylic Tubing	McMaster-Carr	$ -	$ 95.00
Batteries	Ebay	$ -	$ 76.00
CNC work for aluminum parts	LBCC Machine Tool Program	$ -	$ -
Electronic Components	DigiKey	$ -	$ 375.86
Fiber Optic Cable	LBCC CISCO Program	$ -	$ -
Foam Float Material	Plastic Depot	$ -	$ 125.00
Misc Supplies	Home Depot	$ -	$ 276.00
Motors (2)	American Scientifc	$ -	$ 15.50
O-Rings, shaft seals & sealant	McMaster-Carr	$ -	$ 35.75
Pulleys and cog belts	SDP-SI	$ -	$ 75.00
Salvage Parts - Hydraulics & Pneumatics	LBCC	$ -	$ -
Salvage Parts - Video Mixer	LBCC	$ -	$ -
Salvage Parts - Video Selector Box (2006)	LBCC	$ -	$ -
Salvage Video Cameras	LBCC	$ -	$ -
Solenoids (left over from 2006)	LBCC	$ -	
Stainless Fasteners	McMaster-Carr	$ -	$ 126.00
Travel Costs			$12,948.00
Student input to travel costs			$ 1,500.00
Student Fundraising on Ebay			$ (4,000.00)
	Total Donations	$ 27,962.50	
	Total Cost		$11,101.25

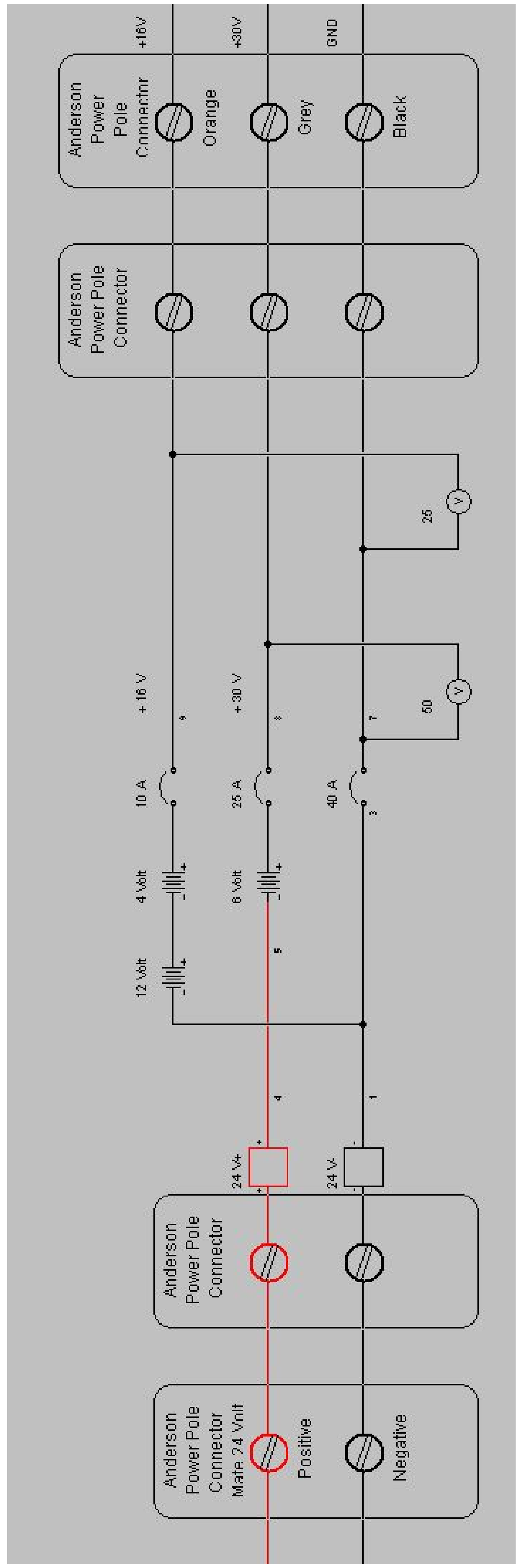
Electrical schematic – Power Connections

The power connections for the ROV will utilize the 24 volt supply provided by the competition. Then additional voltage supplies will be added to compensate for what will be lost due to voltage drop in the tether. A 6V battery is placed in series with the competition supplied 24V, providing the thrusters with 30 volts at no load and a minimum of 26 volts at full load.

The control system utilizes its own source of power, keeping the motors separate from the controls. This is made up of a 12V and 4V gel cell batteries in series with each other for a total of 16V at the ROV. Each device on the ROV utilizing the 16V bus has its own voltage regulator dropping the voltage down to 12V or 5V as needed.

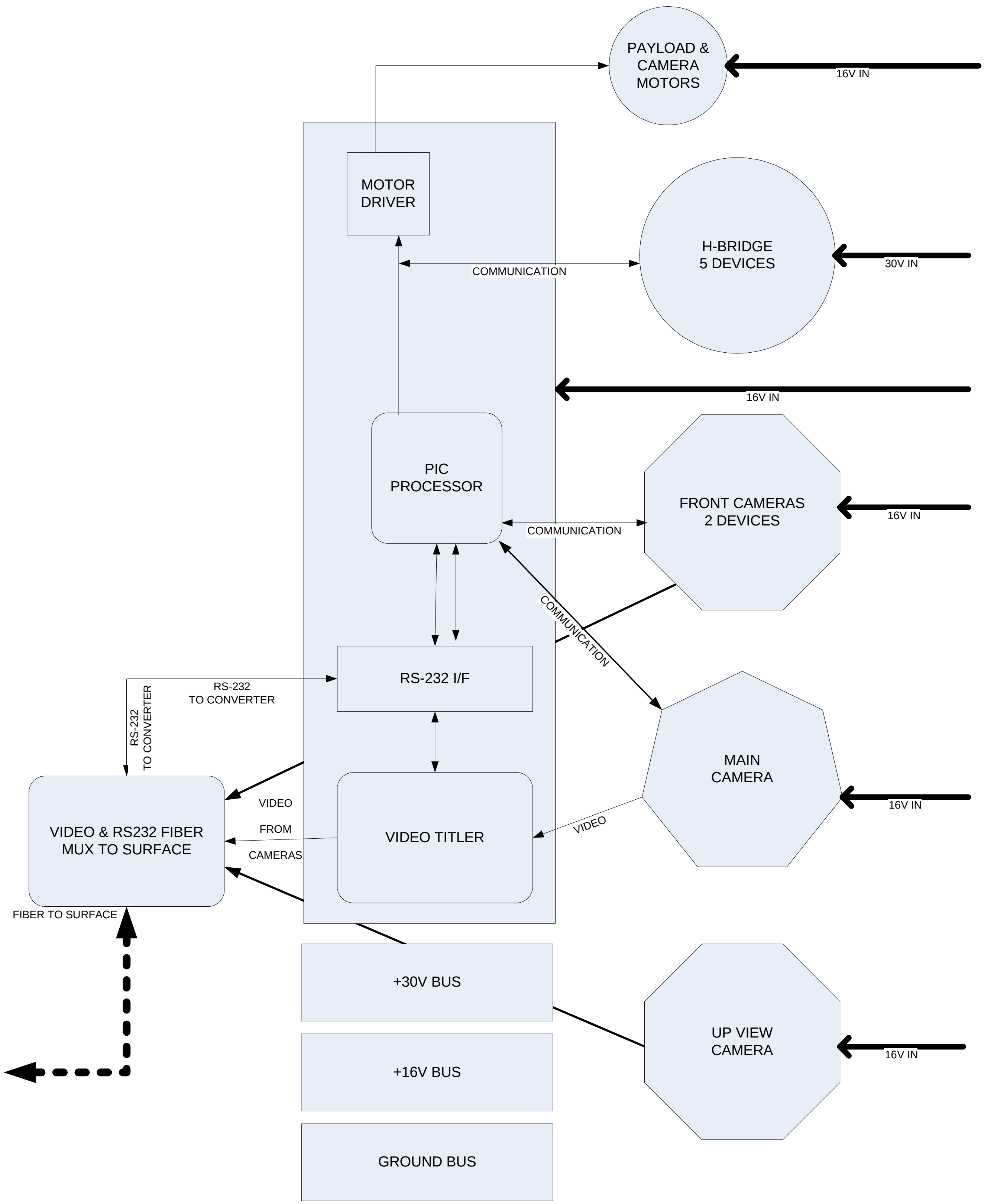
In keeping with MATE safety requirements, the return line is fused with a 40A circuit breaker/switch. This can be manually switched off or will automatically trip under over current conditions. In addition, the 16V and 30V supplies, each have their own circuit breaker/ switch. The 16V circuit breaker is rated at 10 amps and the 30V circuit breaker is rated at 25 amps.

Each supply bus has a volt meter after the circuit breakers to monitor the output before it connects to the tether. Connections to the control box and the tether are done with Anderson PowerPole connectors.



Surface Control System with Video Mixer, Video Selector, Fiber Mux, Power Supplies and PC

Electrical Schematic, Block Diagram – Power & Communications inside the ROV.



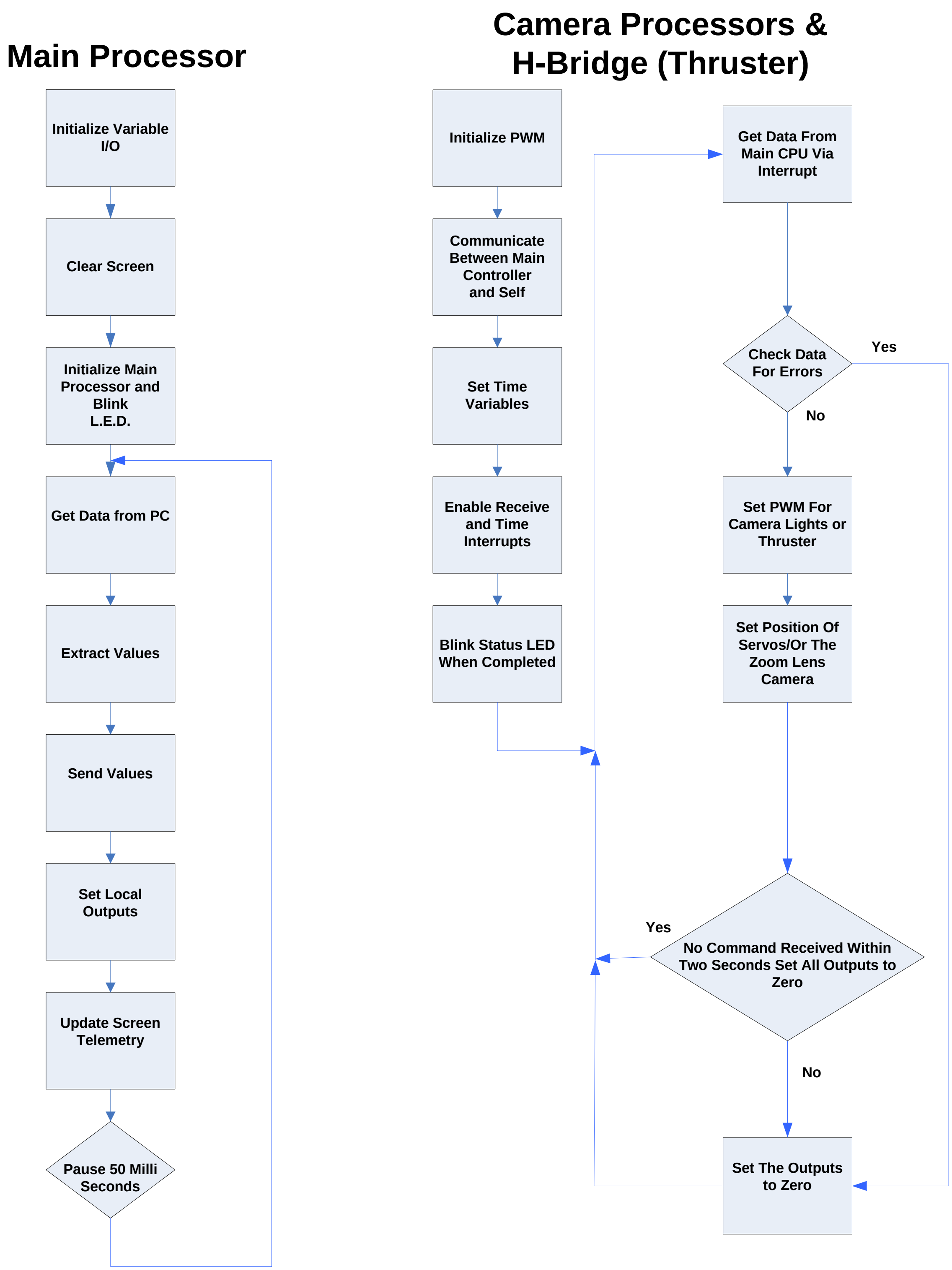
Block-diagram or flow-chart of software in the ROV

There are two levels of software on the ROV. Down in the ROV, the processors are Microchip PIC18F4431 and are programmed again with the PicBasic compiler. Much of the code was used the previous year's code as a starting point and it was modified as needed for the all new architecture implemented in this ROV.

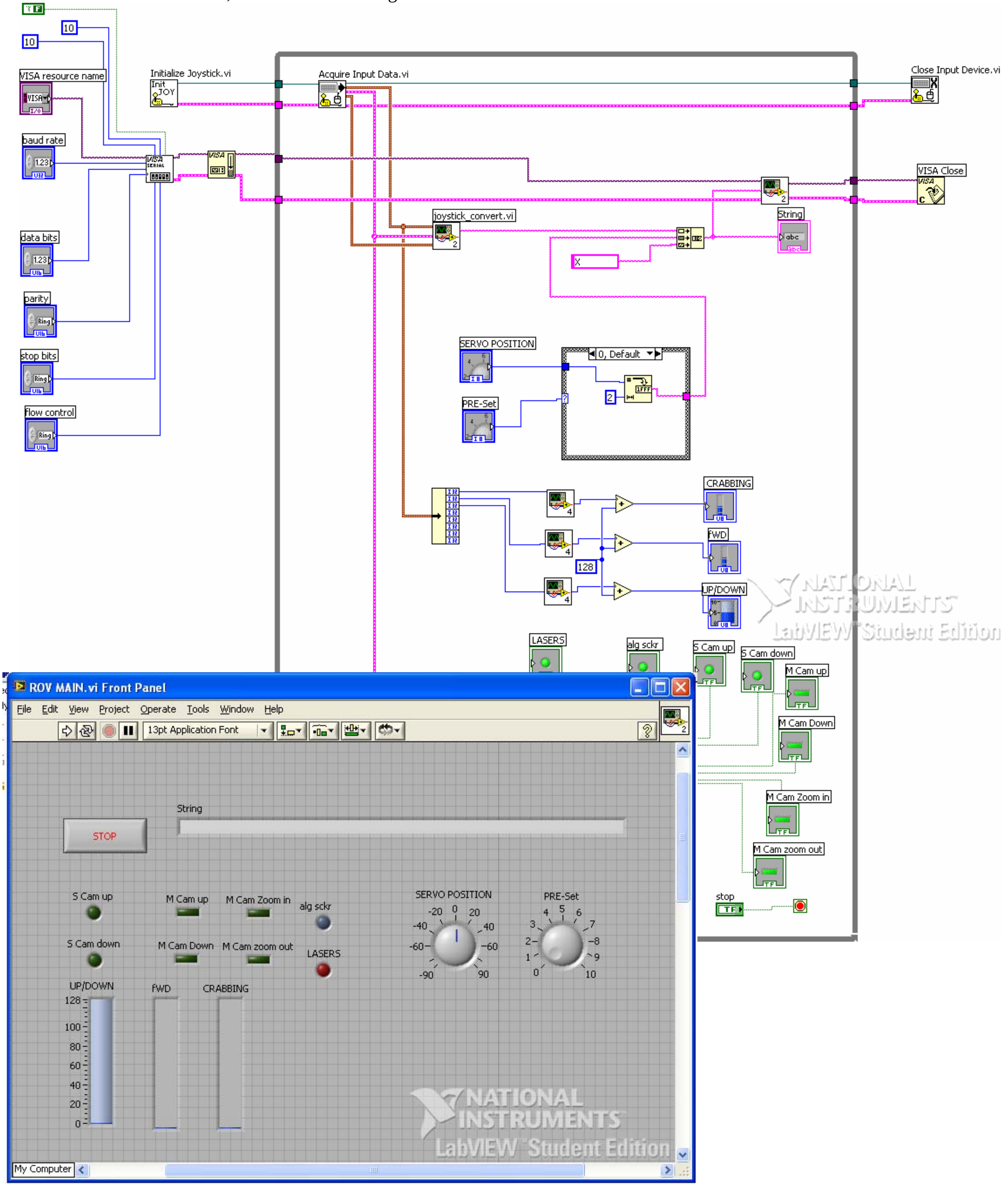
On the surface, we used the graphical programming language, LabView. This program provided us the ability to drag and drop software functions and build a surface user interface without needing to know much about programming or writing user interfaces.

In the ROV, we broke up the tasks and assigned a processor to each task. All total in this ROV, there are nine processors, the main control processor, the five H-Bridge processors and the three camera processors. The main control processor communicates with the surface control, and sends out commands to the other eight processors. In addition, it controls the two camera motors and the Harpoon solenoid/Algae Sucker.

.



Software – Surface Control; LabView Block Diagram & Screen Shot



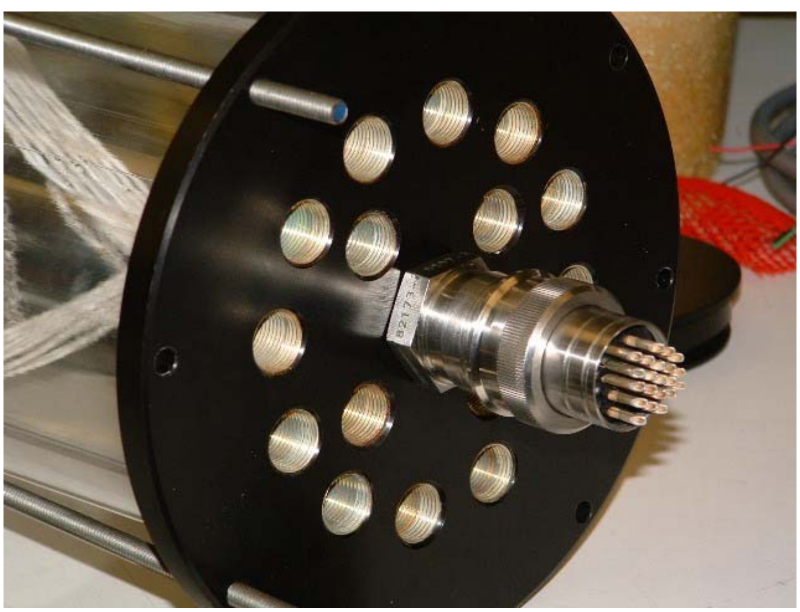
Design rationale

The design rationale will be presented in two main sections. The first section will discuss the ROV itself from the perspective of manufacturing. The second section will cover the task related items (gripper, harpoon and algae sucker).

MANUFACTURING

The fabrication and manufacturing of this year's ROV involved a wide array of materials and processes each with its own intricacies and advantages. The rational for each choice of material and how it was worked to yield the final result involved several factors. These factors include; availability and cost of materials, the tooling setups the team had access to, the performance of the materials themselves in relation to buoyancy, resistance to corrosion, and durability.

The first piece of the ROV that had to be manufactured in order to lay a foundation for everything else to come was the frame. The frame was designed to allow maximum water flow around the thrusters and allow for easy maintenance. The concept behind the design is essentially two pairs of octagons that lock together perpendicularly. The interior and exterior angles are filleted in order to create a more hydrodynamic profile. The frame itself was cut out of inch thick high density PVC on a water jet machine. The water jet machine gave us the precision we needed and allowed for the complex shapes to be cut out with relative ease. The choice to use high density PVC was agreed upon due to the material's strength, flexibility, closeness to being neutrally buoyant, and the fact that the team had a large amount readily available. After being cut out, the frame's corners were rounded off on a router table using a rounding bit. This eliminated any sharp corners and allowed for smoother flow of water around the frame. To finish the frame, it was meticulously sanded and painted with plastic bonding paint.



By far the most difficult parts of the ROV to manufacture were the aluminum caps for the electronics housing and stereo cameras. The caps were manually machined out of donated aluminum. The first process was to machine them down to the proper diameter on an engine lathe and then cut the grooves for the o-rings. This process involved the removal of a large amount of material and the need for extreme precision in order to ensure the proper sealing of the o-rings. After all of the turning processes were finished the parts were mounted on the vertical end mill on an indexing chuck. This allowed for accurate drilling and taping of the complex hole patterns needed for electrical connectors and the mounting of circuit boards. After the parts were drilled and tapped on the mill, they were deburred, cleaned, and polished. After a proper fit of all the aluminum caps was checked, they were then sent out to be anodized in order to protect them against corrosion. Also during the anodizing process the female threads were flash plated with gold for corrosion resistance. The choice to use aluminum for the caps was made because the material is relatively lightweight, easily machined, acts as a great heatsink for circuit boards, and has a good amount of resistance to corrosion even before being anodized. A number of other parts were also made of aluminum including the brackets for mounting the thrusters, the rotating clamp for the main camera, the swing arms on the gripper and the clips for holding the gripper in place. The machining of these parts followed a similar process.

Design Rational – Manufacturing (cont.)

Among other things on the ROV there is a fair amount of machined plastic. The machined plastic parts include the gear motor housings that drive the movement of the stereo and main cameras, the central bolt hub on the gripper, and the jaws of the gripper. The majority of the plastic fabrication was done on the end mill and drill press, with a few operations done on the engine lathe. The motor housings were milled out of high-density polyethylene with a two-flute end mill. The bolting holes were then drilled on the drill press. An interesting design feature in the lids for the housings is the tapered socket for the o-rings to go around the motor shaft. The taper allows for an ever-increasing crush on the o-ring as the motor shaft is pressed into the lid and the box is assembled. The central bolt hub for the gripper was mostly manufactured on the mill in the same manner as the motor housings except for a single groove that was cut into the part on the lathe to allow for the clearance of bolts to assemble the gripper. The plastic jaws of the gripper were cut out of high density PVC on the water jet machine and the milled, routed, and sanded for a smooth fit.

There were several other small processes used during the manufacturing phase of the project. One of these was the modification of the caps on the thrusters. In order to clear larger wires the old wires were drilled out of the caps. A square cup was then milled out of the potting material to allow for new epoxy to be applied around the new wires. A series of mounting cups were then milled out of wood to hold the caps level as the epoxy was applied. Once the epoxy was applied the caps were placed in a vacuum to cure. The vacuum was used in order to pull any air bubbles out of the epoxy for a more complete seal around the wires.

Another item that was paramount in the manufacturing phase of the project was the use of helicoils placed into various plastic parts which allowed things to be bolted directly to the plastic without any worry of stripping the threads. Another material we used quite successfully was polycarbonate tubing for the electronics housing and stereo cameras. This material was an ideal choice due to its strength, flexibility, and wide temperature operating range, which was a serious concern when operating in polar conditions. The use of stainless steel hardware and shafts also worked out very well because of the material's very high strength and strong resistance to corrosion.

An interesting part that was manufactured was our foam serpent head to provide buoyancy for the main camera. The serpent head design of the robot comes from the Long Beach City College mascot, the Viking. In the age of Vikings, the serpent's head was placed at the bow of a leader's ship, a symbol of wealth and power, always looking forward. This part was made by first having a student create a clay dragon head of proper size. A rubber mold was then made of the clay piece. After the mold had cured, it was then cleaned. We then poured high density polyurethane foam into the mold and let it set up. After the foam had set up it was cleaned up with a rasp and sandpaper, the necessary holes were drilled, and then it was finally painted.   While this head looks exciting, it has three real purposes.

1. Provide positive buoyancy of 1kg for the camera housing.
2. Provide a means to hold the LED lamps for the main camera.
3. Provide a means to hold the red status indicator LED lamps for the processor.

On top of all that, the team hopes it adds a certain intimidating element to the ROV.

Throughout the manufacturing phase of the project a wide range of processes and techniques were learned and explored. The end result was the gain of a wide range of knowledge about the behavior and characteristics of many different materials and their ideal applications. This allowed for a highly functional, flexible, and durable ROV. The knowledge each student gained through this process has already proven to be very valuable and is sure to serve us well in the future.

Design Rational – Manufacturing (cont.)

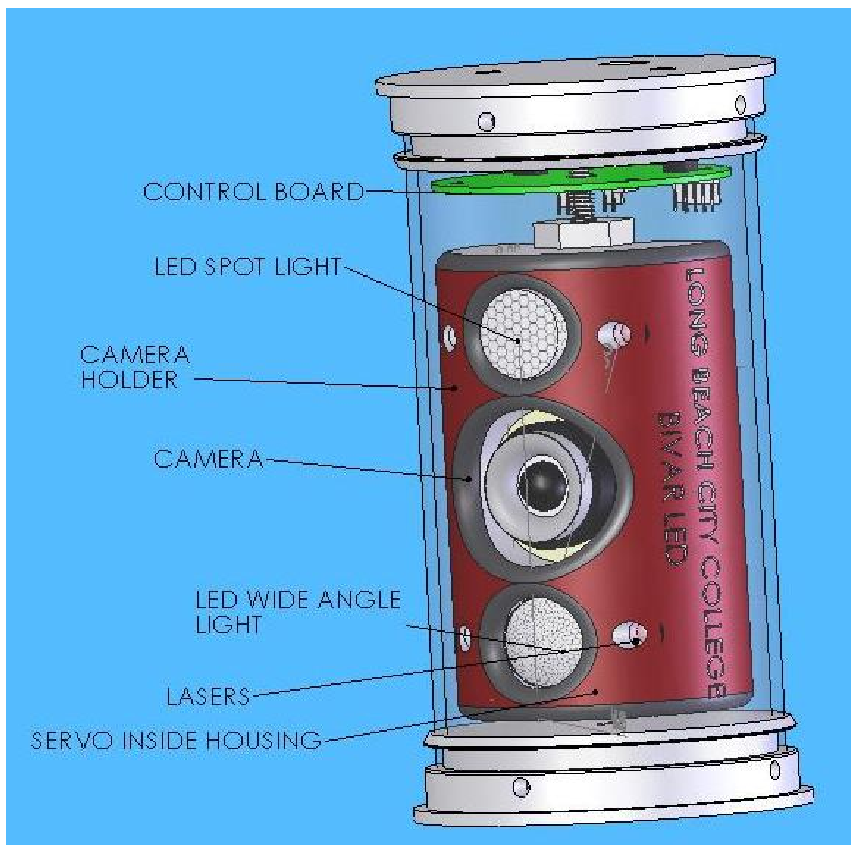
We wanted to reduce the size of our ROV significantly, do to the cost of travel. This would limit the amount of cameras we would put on the ROV. However, we still wanted the efficiency of a ROV that had all the cameras it needed. Our problem-driven research inspired us to use stereo cameras. By using stereo cameras we would be able to simulate human vision and give our ROV depth perception. The way stereo cameras work is very similar to how our eyes work. The cameras are set a distance apart. Their images overlap and provide us with an exaggerated sense of depth. The depth is determined when the images both come into focus.

Do to the accuracy of using stereo cameras, we decided to use the stereo cameras with our griper. We set the cameras to focus on the tip of the griper so that we can determine how close we are to the object that we need to grab. Viewing the object from a distance through the stereo cameras it appears that the distant object is in two places at once. This could be confusing to the operator of the ROV. However, our control board allows us to fade out one of the overlapping images to get one clear two dimensional image in order to avoid confusion when approaching the object. Once the ROV is close enough, he/she can fade the overlapping images back on the screen and approach the object so that it comes into focus and the griper is able to close in the precise spot.

In addition to using the cameras for our griper, we later created our gasket holder and cover remover (harpoon). In order to do this task with an ordinary camera, we would have needed a top view. However, this would have been a challenge considering that our gasket holder and cover remover extended far beyond our ROV frame. With the inspiration of our stereo cameras, we determined an easier and more affective way. We mounted the stereo cameras on a servo that would rotate it 180 degrees. By giving our cameras this freedom, we were able to program pre-sets to the servo so that the cameras would have a focus point on the griper and another on the gasket holder and cover remover.

We also accompanied each of our cameras with two LEDs and two lasers. One of the LEDs is used as a spot light and the other lights up the surrounding area that comes into the cameras view. Although the two lasers serve no significant purpose for this competition, they are used to measuring objects under water. We came up with this idea before we received any information about what our tasks would be. However, they were too cool to just throw away.

Design for the camera assembly was developed using SolidWorks, an engineering design computer program. First, a team of three people redesigned all the objects that where going to go into the camera assembly witch include the camera, servo, LEDs, lasers, and electronic boards. Then all the parts where carved into a cylinder using SolidWorks. Later, all excessive material was removed in the design stages. The design was sent out to be manufactured utilizing a rapid protyping machine.



DESIGN RATIONALE - ADAPTING TO THE TASKS

Once the ROV was designed, adaptations needed to be made to it to allow it to perform the required tasks. Some of the parts were used for multiple tasks and others were single use items.

Task: Threading a messenger line. In order to thread a curved U shape bolt in a buoy anchor the gripper could be used to take a "needle" down attached to a messenger line. This needle would be about twelve inches long and could be treaded through the bolt on one side. Then it would be dropped and picked up by the gripper on the other side of the bolt before returning to the surface. This would bring back the messenger line safely threaded though the eye on the bolt to allow a hoisting line to lift the anchor. The position of the gripper for this task will be parallel with the water's surface.

Task: Deploying the Passive Acoustic Sounder (PAS). In order to deploy a sensor buoy at the bottom of the ocean surface in a specific location a gripper is needed to take the buoy and anchor down. While holding the line between the anchor and the sounder in the gripper, the operator can navigate the buoy over the location given. Once over the location the gripper simply opens and drops the anchor in place. The position of the gripper for this task will be perpendicular to the water's surface to keep the profile of the ROV under the 80cm ice hole.

Task: Recovering a Jellyfish sample. The gripper will be used for this task. The ROV will locate the jellyfish and almost sit down on it. The gripper jaws will hold on to the jellyfish and return it to the surface. The position of the gripper for this task will still be perpendicular to the water's surface from the previous PAS operation.

Task: Algae Sample. This task is performed by suction. A simple bilge pump is connected to a collection cup. The cameras can be moved for watching the sample process. Once the sample cup is near the "algae sample" the pump motor is turned on, sucking the sample in. Fingers hold the sample in place, allowing the pump motor to be turned off.

Task: Inserting the Hot Stab. The final task the gripper was designed for is to insert the hot stab into the wellhead. Before starting this task the gripper must be set at the 45 degree angle position for alignment to the hot stab port. The gripper hydraulic control will give the gripper enough gripping strength hold onto the hot stab during the parts leading up to this task. Once the hot stab is inserted, it can be released and then picked up again once the insertion is verified.

Task: Removing the Well Head Cap and Inserting the Gasket. The harpoon will be utilized for this task. The harpoon is a T-channel with a notch for the cap bolt and a solenoid operated release mechanism for the gasket. It is mounted to the bottom of the ROV and sticks out far enough not to interfere with the insertion of the hot stab. The method of operation is to "stab" the well head cap and lift it off of the well head. Proceed forward and drop the gasket into the well head. Energize the solenoid to release the gasket. Back up and replace the cap onto the well head. Back up further to release the harpoon from the cap.

Closeup of Harpoon – Gasket holding solenoid.

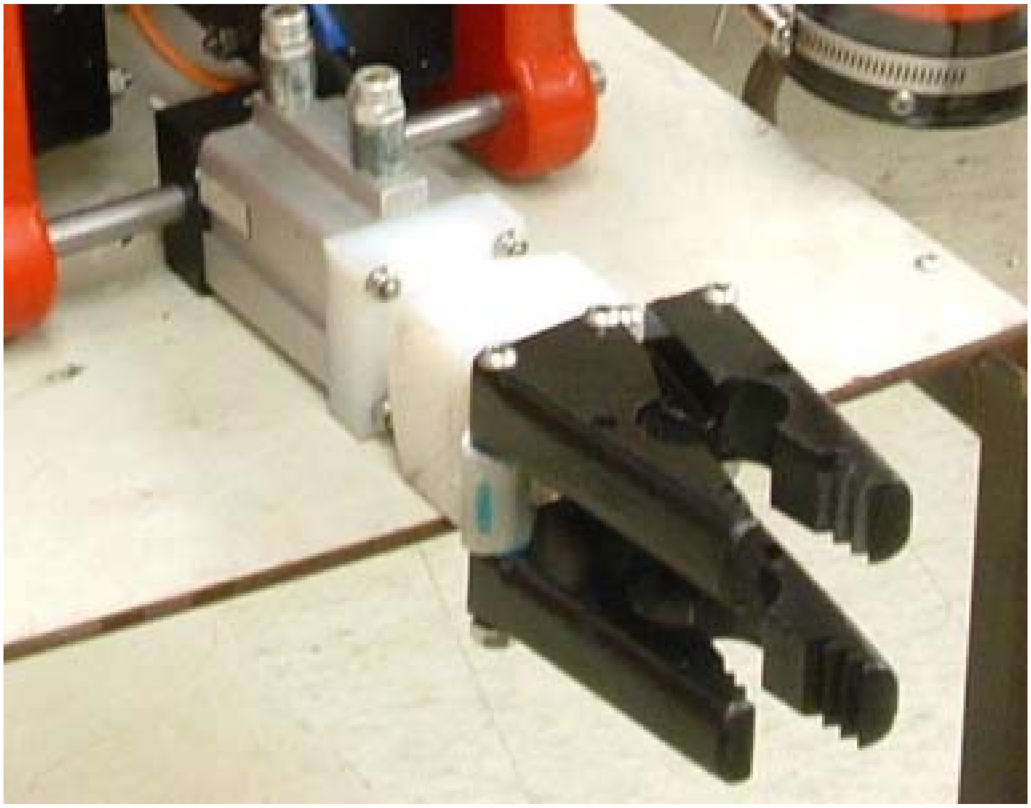
The Gripper Description

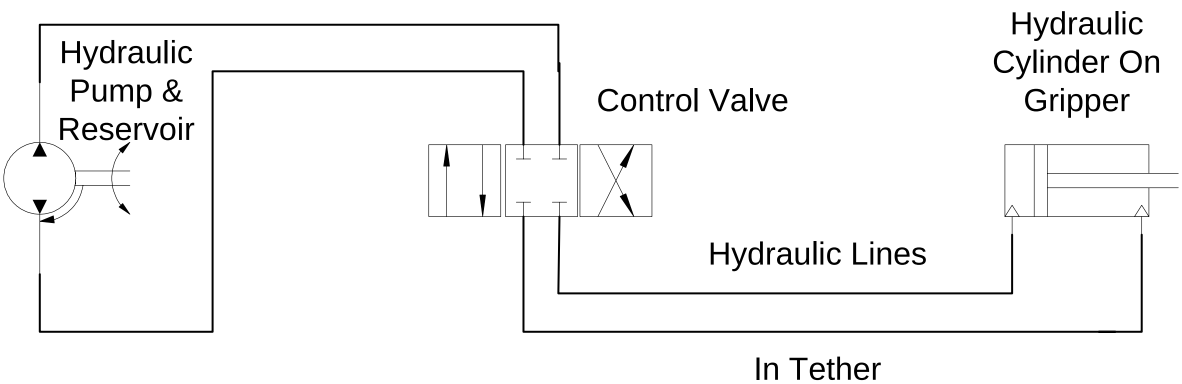
Remote Operated Vehicles or ROVs have few essentials, and a gripper is definitely one of them. The gripper allows the ROV to complete its tasks by giving it the ability to grab things or take things down and release them. Even if the ROV is doing another task like suction with a collection tube a gripper could still come in handy to help move things that the suction can not get to or work around. The gripper on the LBCC ROV was designed and fabricated for specific tasks like threading a messenger line and anchor a buoy at the bottom of the ocean, deploying a sensor buoy on the bottom of the ocean, and attempting a hot stab at a wellhead protruding from the bottom of the ocean.

The gripper was a unique design, and the fabrication process was interesting. If one looks closely they will see that the gripper was loosely based on the Jaws of Life used by rescue officials to break open severely mangled steel in car wrecks. This design allows it to open and close with four inch thick prongs. The open and closing motion of the gripper is controlled by a simple actuator that gives a back and fourth motion controlled, through hydraulics, by a lever on the surface. There are three settings for the gripper, 90 degrees straight off the front, 45 degrees down from the front, and straight down toward the bottom of the ROV. The gripper was fabricated from the same material used on the frame of the ROV in a manner that gives it a gripping surface in front of a circular opening. This opening gives clearance behind the jagged gripping surface for longer objects.

It should be noted that the hydraulic fluid used in this system is completely biodegradable and nontoxic. The fluid goes by the product name of BioFlow and its Material Data Safety sheet lists no known toxicities. We are not sure but it may even be free of Trans-Fats.

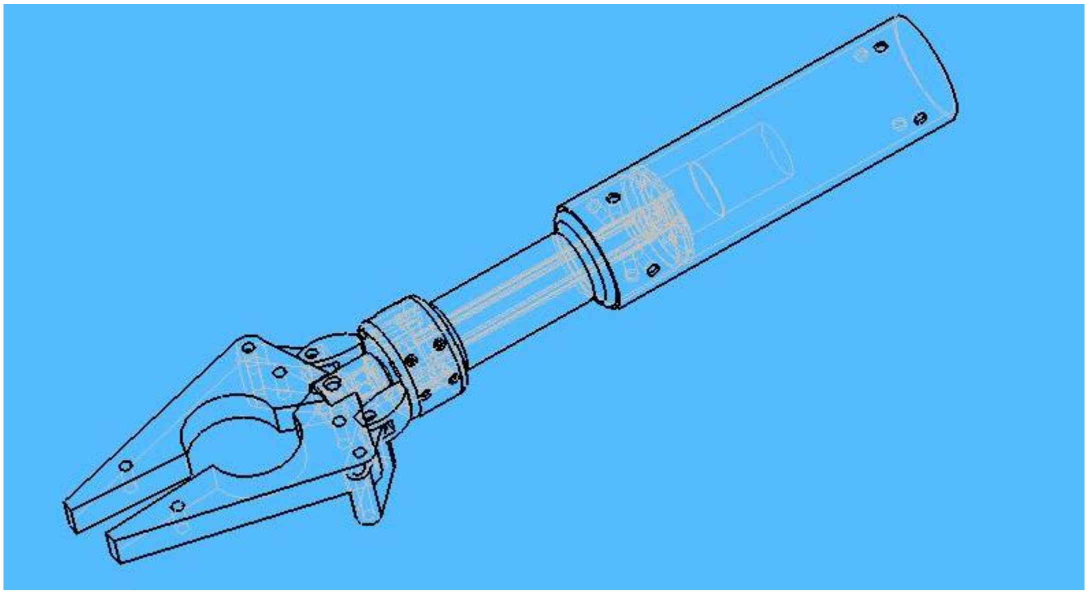
The gripper is the most important tool the ROV has. Without the gripper the ROV would be limited in its abilities. The gripper allows for the ROV to complete a multitude of tasks safely and in a timely manner with out having to change a whole lot of devices for each task. With every ROV comes new ideas and innovations, but the gripper has remained a constant for every ROV throughout their evolution.





Description of at least one challenge that your team faced and what methods were used to overcome it.

The biggest challenge we had was time and having enough of it. The original design of the gripper for the ROV never made it past the design stages. It was to be an electric gripper with multiple complex moving parts. The design was very promising because of its embedded H-bridge control and it was going to be a very versatile design. It had a gripper head that allowed for the repositioning of the fingers in multiple axis's and configurations. We could put two fingers, three fingers or five fingers as needed for the task. In the long term it proved to be too complex to be properly manufactured within the limited time restrictions. The gripper was still in the design stages in SolidWorks for several weeks after fabrication of the ROV had begun. Time had run out for this design, the ROV needed a gripper that could be designed, built and tested soon for its trial runs. A much simpler design for the gripper was proposed that called for the use of hydraulics. The team was able to design, built and test this new gripper within a fraction of the time used to design the unfinished electric gripper. More than satisfied with the results from testing, the new hydraulic design was chosen over the original due to time restrictions.



SolidWorks Rendering of Original Electrically Operated Gripper

Explanation of troubleshooting technique(s)

One of the major troubleshooting challenges faced during the construction and testing of the ROV dealt with the seals on both of the stereo cameras. During a buoyancy test both of the cameras were found to have significant leaks around their o-rings. In order to save the electronics, the ROV was quickly removed from the water and the cameras were promptly disassembled in order to remove the water. The team was then left with the problem of figuring out what had gone wrong. After careful inspection two problems were found that had caused the leaks. The first problem found was that there was too large of a gap between the o-rings, the polycarbonate (Lexan), and the endcaps. The second problem found was that the screws holding the Lexan from sliding off of the endcaps were applying uneven force onto the Lexan and causing it to distort. The solution to the first problem was solved by wrapping a layer of rubber tape around the inside of the o-ring grooves in the endcaps and thus causing the o-ring to be pushed out slightly. The type of o-ring that was used was also changed from the quad style to the simple round style. The round style of o-ring created a better seal by being slightly thicker than the quad style. The combination of these changes on the o-rings allowed for a much tighter seal. Using set screws instead of socket cap screws solved the second problem of the Lexan distorting. The set screws held the Lexan from sliding off of the endcaps but did not put pressure on the Lexan itself and thus allowed it to take the shape of the endcaps. After these changes were made the camera housings were sealed up and submerged to a depth of 3.7 meters for ten minutes and found to be completely dry on the inside. The housing was then pressurized to 0.75 bar and left for five days. At the end of that time, the housing was checked and still pressurized at 0.75 bar.

Description of at least one lesson learned or skill gained during the design and building process.
Comments from Various Students

Soldering was something I took part in. I had never soldered before. It's a technique that takes time to be master, even though it's not to hard to do. The hardest things to solder are the tiny chips with all those pins. Using the microscope was really cool I thought that microscopes were only use see microorganism at a great magnification. I found out that I was really wrong and that there really important in the making of the ROV. Looking through that microscope and seeing those small parts and knowing the function they play for the ROV, was incredible. Without these microchips the operation of ROV would not be possible.

A couple of things that I learned from this class is how to solder, designing parts with SolidWorks, how to make our tether line, and stereo vision. With the soldering I learned how to assemble circuit boards. We made circuit boards for everything. Using SolidWorks I learned how to create designs for our ROV. I worked on taking measurements from the cameras and lasers, and then creating SolidWorks parts and assemblies. We designed the housing for the cameras and lasers. The way the cameras work is through stereo vision. What that is, is our cameras will display two different types of pictures of an object. When those pictures meet we will than know that our gripper is at the point to grab it with extreme accuracy.

One skill that I learned is the technique of proper soldering. It proved to be much trickier than I anticipated at first but with some experienced guidance from my instructor as well as my classmates it became more of a challenge to overcome rather than a discouragement to be avoided. Dealing with such small parts as with this ROV; it became more enticing to get the job done and done right because it has proven truthful that the size of a part of an ROV does not determine it's importance of functionality. I have refined my skills in soldering and am all the more indispensable for it.

A much needed skill in the assembly of the ROV is the countless hours of soldering that needs to be done. All of the circuit boards for cameras, thrusters, control boards, etc. need to be made. My grandfather taught me the basics of soldering years ago in my youth, but that doesn't hold a candle to what needed to be accomplished with the ROV.

There is a great deal of patience that is required when developing a skill on the hardest circuits to solder. After soldering a component to the surface of the board we would check the integrity of the solder under a microscope. Many times in the beginning we had to correct mistakes or places where the solder might bridge to another component and cause a short.

Tether Building

Frame Assembly

Board Fabrication

Float Pouring

Discussion of future improvements

Automatic Station-Keeping & Gripper Improvements

The water is naturally a very dynamic environment. Due to this constant state of flux, it is hard, for example, to maintain a consistant heading while traveling forward, as it is also hard to maintain a fixed position relative to another object.

The environment may not be the only factor in causing the ROV to veer off-course or to inadvertently change its depth. The ROV's thrusters (actuator uncertainty), its kinematics, and physical construction can have minute imperfections that may cause one motor to work slightly slower than the other(s), or one side of the ROV is more aerodynamic or heavier than the other side. These issues make it impossible to predict with certainty the position of the ROV in the water.

We already have a human in-the-loop making adjustments to the ROV's course whenever the ocean current, temperature or normal wear-and-tear of the ROV cause small deviations to the ROV's planned trajectory. This, however, requires human intervention which not only is expensive, but also can substantially be more imperfect than a computer doing the adjusting and controlling. After all, computers are good for repetitive and highly-precise tasks! Humans, on the other hand, excel at adapting to unknown situations and environments.

We want to add the following new capabilities to the ROV but we want to leverage the computer's power to do some of the controlling:

1. We want the ability to apply a specific amount of pressure on the subject we are holding with the gripper and maintain that pressure even during environmental changes (i.e. movement of whatever we are holding, temperature and/or depth changes).
2. We want the ability to follow a consistent heading despite abrupt ocean currents, thruster imperfections or irregular voltages being fed into the thrusters.
3. We want the ability to stay stationary relative to an underwater object (i.e. the sea floor, rock, platform, etc) despite abrupt ocean currents, thruster imperfections or irregular voltages being fed into the thrusters.

In order to accomplish this we need to borrow a concept that is commonly used in real-world automation: Control Theory. Control Theory is the study of behavior of dynamic systems. Specifically, we can make use of the PID (Proportional, Integral and Derivative) controller model that Control Theory gives us. PID controllers are used in many every-day electronics: cars, robots, heart defibrillators, and the Space Shuttle to name a few. By coupling the new software with depth, compass and dead reckoning sensors, we can build a system that can be put into autopilot. This will result in a system that is accurate and takes much of the piloting load off of the human pilot.

Another improvement on some of the current hardware includes the gripper. Though not needed especially for any of our current missions, dexterity is always a plus when working under harsh conditions. With a few modifications to the current design, our gripper could be outfitted with a wrist, allowing us to inspect and manipulate objects much easier. Using the power from our front mounted solenoid, we could drive a motor. Within its own housing, mounted to two of the bars on the hydraulic piston that drives the gripper, this assembly would connect to a geared ring via belt. This ring now takes over as the mounting point for the gripper fingers and their attachment brackets. The hand of the gripper will rotate with the ring about the center piston. Depending on whether or not it would create too much friction for the motor to spin the piston with the hand, the piston may have to be modified a little. It would probably just consist of drilling a hole in the tip, inserting a bolt and using the previous hole to put a pin in to hold the bolt in place. The crossbar to connect to the fingers of the gripper would need a hole through the center to rotate around the bolt in order to allow for the rotation but also keeping the movement necessary to operate the gripper. Though more invasive than some of the other enhancements, a wrist for the gripper would give us a valuable ability.

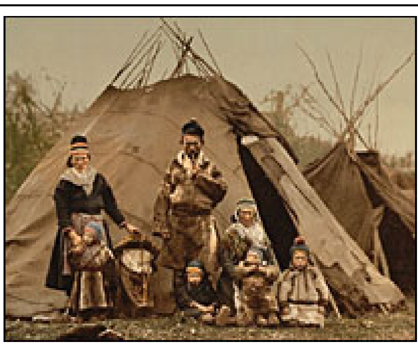
Life in the Polar Regions

The harsh climates of the Polar Regions make it incredibly difficult for human life to be sustained there for very long. It maintains cold temperatures almost all year long with long, dark cold winters with short summers that have almost continuous sunlight. Temperatures can reach anywhere from -65C degrees to a fair 21C degrees or so depending on the location. The artic regions have no fertile land for crops to be grown on nor does it have any natural resources to be mined or recovered. It does have some game species, like caribou and seals that use it as a migration passages or breeding grounds. But the only thing the artic land really does provide is just ice, or permafrost, and lots of it. One might ask themselves then what could be so appealing about this land then when it doesn't seem able to give very much? That's one thing that many of the natives to land have been able to do; take what the land has provided for them and use it to their fullest advantage.

Map of the Polar Regions

Native people, like the Inuit, Athapaskan, and the Iñupiaq to name a few, are just some of the native tribes that have inhabited the land for thousands of years. By becoming hunter and gatherer societies, the natives to the Polar Regions have been able to use the land and what little resources it has to sustain their ever growing populations.

Little is known about the exact origins of most of the tribes that live in the Polar Regions since many of their origin myths are passed down orally because there is no written language for them. Each tribe has their own origin myth of how they came to be. For instance the Inuit believe that a trickster in the form of a raven created the world. When the ground rose from the water, Raven had stabbed it to hold it in place. From that piece of land the first people settled: a father, a mother and a boy. Raven had pleaded to the father to let him play with a bladder, which was believed to contain light, and had managed to damage it while playing with it. From this bladder came light, and not wanting to have light shining all the time, the father took it back to have it more contained. This myth not only gives the origin of life for them, but also shows how the day became to be. Origin myths mainly are just tales of how the people believe their ancestors came into being. But if it is looked at geographically, there is evidence that their ancestors had migrated across the Bering Strait into the Arctic North America and spread out from there, some even expanding into Greenland. Some tribes still exist in northern Siberia, and tribes like the Saami span out over 4 different countries in Europe.



Picture of a Saami Family from the 1900's

Even though the tribes are spread out over a vast area of land, most of them are able to keep their traditions alive. The family unit is the most important social unit; this includes the immediate family and kinships. When it comes to marriages men and woman are allowed to choose whom they want to marry even though in some cases the marriages are arranged. Marriages tend to monogamous but it is not uncommon to practice polygamy in some circumstances. For instance if a woman's husband dies, she might marry into another marriage for the security of a provider, since a woman does not posses the same survival skills as men such as the ability to hunt for food. In these societies men are the bread winners while woman raise the children and do the cooking. Families are responsible for production of their own tools, usually out of bone or stone, and for making their own clothes. Everything they posses is made by someone within the family unit. Although women do the cooking there are no natural resources, mainly wood, to burn and to cook with. This means that most eat the meat raw. They do use the fat from seals and sometime even whales to burn as a light source, but there is not enough of it to cook with.

Shelters in the arctic vary in size and the materials they are made of. The most stereotypical image people think of when they think of the Inuit would be the igloo. The igloo is a hut composed entirely of ice and is used mainly during long journeys. But in most cases shelters are made out of a plethora of materials which include: stone, whale bones, skins from various animals, in some areas people even use vegetation to build their houses. Nowadays though most of the people of the Arctic have been relocated to little towns that have been built for them. The country of Canada wanted to bring them into modern technology since the environments in the Polar Regions are rapidly changing, which ultimately is affecting their way of life socially. The adaptations the natives have made to the Polar Regions are incredible. They have managed to take a land that doesn't give very much to them and turn it around to survive there for thousands of years. Granted there has been some outside contact in the recent three hundred years or so, but it hasn't really affected their cultural ways of life. Even though most of the people of the Arctic now live in larger more structured communities, they still hold steadfast to their values and traditions.

Igloo. Houses used for long journeys.

Works Cited

High Latitude People: the Human Dimension of the Polar Regions." Science Poles. 26 Aug. 2005. Science Poles. 24 May 2007 http://www.sciencepoles.org/index
"Inuit," Microsoft® Encarta® Online Encyclopedia 2007
http://encarta.msn.com © 1997-2007 Microsoft Corporation. All Rights Reserved.
"Weather in the Arctic." All Things Arctic. All things Arctic. 23 May 2007 http://www.allthingsarctic.com/weather/index.aspx

Reflections on the experience.

Reflections – Ian Jasper

My experience in taking both the electrical 230A and 230B classes this school year has been immeasurably valuable to me. I feel that I could not have gotten a better feel for what goes into an engineering project from start to finish than I did in these two classes. In the first semester I gained a very in-depth knowledge of the factors involved in designing an ROV. I learned how to use 3D CAD software, Solidworks, and began to understand the power of the software and immense capabilities that the program has. After gaining a working knowledge of the program, I was fully able to participate in designing various aspects of the ROV including the frame, caps for the electronics housing and cameras, and the placement of thrusters on the ROV. I also learned how to draw plans for parts that needed to be sent to our school's machine shop, and how to solder circuit boards.

During the second semester in Electrical 230B, I saw all of the hard work from the previous semester come together. The most valuable skill I gained during this semester was a beginning knowledge of manual machining and other manufacturing techniques. Throughout this semester I worked closely with the Long Beach City College machine shop instructor to make a significant portion of the machined parts on the ROV. I learned how to make parts on both the engine lathe and the vertical mill. I also learned about using a water jet machine to precisely cut out plastic parts. Another valuable skill I gained was a good understanding of how the crossover from design to manufacturing is not a perfect science. I developed the ability to see problems due to certain details being missed in the design phase and come up with viable solutions that could be quickly applied. Overall I found the year an incredibly rewarding one with valuable lessons learned that I will continue to apply my whole life.

REFLECTIONS – Miguel Panteleon

The experience from this class has changed my way of thinking. I was intimidated by the fact that we were going to compete against the world, but I soon realize that we had it in us to win this completion. I also know that it takes a lot of work, effort, dedication, and mostly team work.

We started off by designing the ROV. This task was very important because what we created was going to affect the outcome of our missions. We had to design the ROV to meet our demands and to complete the missions that we need to accomplish. Next came the manufacturing of the ROV parts. This process included everything from soldering, to machining parts, working with software, and troubleshooting, I can go on and on, the fact of the matter is that in order for the project to be completed it takes a lot of people's effort and dedication. The thing that sticks out in my mind is the importance of team work and respect for one another, since we all had different ideas.

Reflections – Russell Watts

Upon entering the Robotic Integration class at Long Beach City College I had no idea what to expect. The others in the class had a whole semester start on the design process for the ROV (Remote Operated Vehicle). At first it was an overwhelming feeling to know that the others had begun such a complicated project and I was coming into it in the middle of it. I soon found that I had many different fields of experience that could help out and make the ROV a success. I did not realize how complicated we were going to get in building the ROV. We made everything from scratch, from building the frame to each component and part ourselves. Since the team seemed to have most of the designs they wanted already, it was a matter of using my manufacturing experience to help fabricate what they needed. The intricate use of each camera and the stereo vision idea were wonderful.

This class gave me some invaluable experience and taught me some things I will never forget. There are many different things to keep in mind when developing an underwater vehicle. Water dynamics and buoyancy are factors that have to be kept in mind with every new development. The use of vegetable oil as a hydraulic fluid to operate the gripper was a unique idea. There were more electronics and wiring than I had imagined, and the mounting of each component proved a formidable task. Even the simple use of PVC plastic as a buoyant frame amazed me. I will take great memories of this class away with me.

REFLECTIONS – Maria Borja

This class is amazing. I'm not going to take time talking about what I have learned in class because I feel that it is evident by the quality of the ROV that we brought to the competition. Instead, I will talk about how this class has been the second pivotal step to my future. Today you see me as a student who wants to become an engineer and has hopes of attending the Massachusetts Institute of Technology to earn a PhD. However, there was a time where I wasn't so sure of myself. I was continuously reevaluating my career choice and asked myself, is becoming an engineer really worth it? I sought guidance and fell upon an invitation to travel to Santa Cruz for a Latinas in Engineering conference. I was amazed of how many Latinas attended. However, out of all the great Latina engineers, Elicia Niebla had a profound impact on me. She opened my eyes by revealing all the research and government work that she was doing in studying soil. Elivia Niebla manages the science research program on global change in forests and also worked closely on other government environmental research. This encouraged me to continue to study engineering. I now know that there is a way for me to use my knowledge to help the environment. I became excited in all the opportunities that would come from helping others by becoming an engineer. A semester later, I joined the ROV team. I learned not only how to build a ROV but what it takes to complete an engineering project with a team. As a consequence of that semester, the ocean became my soil and I, now, hope to work with the government and develop legislation that would prevent our oceans from becoming polluted.

REFLECTIONS – Carlos Villegas

My objective in taking this class was to see how a robot is assembled and how all the parts work together. I certainly learned that and more. Some of these were:

a) Solid Works is an excellent tool to design a project in a group,
b) Learning as the final ROV "brain" is constructed wire by wire is a magical experience that teaches every student how things are built.
c) Solder. I learned how to solder because students in the class were very willing to share their knowledge and patients.
d) I learned about electronics and how to order the different components online, organized them and solder them to the board.

REFLECTIONS – Emily Morrow

As a new semester began I remember the first day; showing up to class wearing the proper attire: closed toed shoes, jeans and a t-shirt. Armed with a notebook and pencil, I quickly tried to jot down everything that Scott wrote on the board. Words like resistors, connectors, pressure sensors, grippers and more kept flying out of his mouth as he drew diagrams on the board to go with his explanations. There I was, an Anthropology major, scrambling to get everything down and not understanding a word of it. After awhile, I realized as everyone else sat and listened I had been the only person taking notes. My immediate thought was 'oh my god, what am I doing here? I'm the only person who doesn't know what they are doing!' The panic somewhat subsided when the class went upstairs to work on the Solid Works program.

Underwater Robotics was a completely new field to me. I did not know anything, and even to this day there are still some concepts I don't quite understand. Scott told me at the beginning of this class that an interest in the subject, an attempt to design and build, and just plain showing up to work on the ROV will get me an A. I learned how to use Solid Works and designed what I now consider to be one of the easiest parts to design for the ROV, the end caps for the thrusters. It took me, with some help from fellow class mates, about a month and a half to design and create on Solid Works. It was a challenge for me to do it, but I sure was proud after it was all done. However the part was not even needed, but that is something that one must get used to in a class such as this. Not everyone’s part gets used due to time constraints or manufacturing difficulties. Although that doesn’t mean it won’t be used in the future.

The second semester was not as challenging in some aspects; as it was the building and assembling stage of the ROV. There were still some occasions where I would be asked to build something or asked to fetch a tool of some sort, and I would stand there with a confused look on my face asking someone to help me like a lost sheep. As an Anthropology major, I never thought I would be in a class like this. Everyday was about learning something new for me. Whether it was designing a part, learning how to use the band saw, or observing someone drill a hole and tap it with me there on the sidelines trying to do what I could. By watching experienced students use all of these foreign tools and techniques, I now have developed a better understanding of the complex field of robotics. Now I am able to retrieve, identify, and use many different tools without any hesitation or second thoughts.

Overall I love the impact this class has had on me. It was something at the other end of the spectrum for me, but I still managed to hold my own. I plan to continue on in this class by taking it next year as well. Hopefully some classes I plan on taking will better prepare me for it next time around. The next time someone says, “Emily, I need a 5.750 end cap give or take five thousandths with 12 3/8th NPT holes arranged in a 4.6 in bolt circle. Also don’t forget to use the one degree taper reamer before you tap and give me a 20 thousandths countersink far and near sides” I’ll be able to understand them.

Acknowledgements

The team would like to extend its thanks and appreciation to the following companies and organizations. Without their help, this ROV would never have gotten off the drawing board. It is through their generosity that all this becomes a reality.

Long Beach City College Associated Student Body
Optelecom-nkf
Remote Ocean Systems
GoEngineer.com/ SolidWorks
Seabotix
Advanced Circuits
Burton Connectors / Crouse Hines
Long Beach City College Foundation
Saddleback Community College Rapid Prototyping Lab
PIER Institute
Standard Metal Products
Lumberg Connectors
MesaWest
Lubeco
MicroChip Technology

SOLIDWORKS RENDERING OF ROV