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I. Abstract

This is a Technical Report written and compiled by the students of Kailua High School's Surfrider Robotics team to record the processes of the construction for the ***Pilikua O'ma'o Nui***, or the Green Monster. The building of a remotely operated vehicle, *ROV*, was to be developed to mimic an exploration of the following:

1) Endeavour Segment of the Juan de Fuca Ridge – an intermediate-spreading ridge with a high density of hydrothermal venting.
2) East Pacific Rise (8° - 11° N) – a fast-spreading ridge where a seafloor volcanic eruptions have been detected in 1991 and 2006.
3) East Lau Basin Spreading Center site of the first coordinated study effort of a back-arc spreading centera mid-oceanic ridge.

The mission tasks include the observation and documentation of the various biological and geographical environments. We are also required to record temperatures, and collect samples.

During the production Surfrider Robotics worked together resourcefully and competently to produce an ROV that can complete the designated tasks of this year's International ROV Competition. New friends, experiences, and life lessons were gained as a result. We were stretched, and pushed far beyond what we thought we could ever accomplish. The result is the ***Pilikua O'ma'o Nui.*** The Green Monster was designed and built over a period of nine months to complete the mission specifications of the 2008 Marine Advanced Technology Education (MATE) International Underwater Robotic Competition.

II. Mid Oceanic Ridges

A mid-oceanic ridge is an underwater mountain range formed by plate tectonics. The uplifted sea floor results from convection currents which rise in the mantle as magma at a linear weakness in the oceanic crust, and emerge as lava, creating new crust upon cooling. The mid-ocean ridges of the world are connected and form a single global mid-oceanic ridge system that is part of every ocean, making the mid-oceanic ridge system the longest mountain range in the world. The total length of the system is 80,000 km.

Hydrothermal vent releasing high-temperature, sulfide-rich fluids from�the Earth's crust�on the Endeavour Seg ment of the Juan de Fuca Ridge. http://images.google.com/imgres?imgurl=http://www.mbari.org/

There are two processes, ridge-push and slab-pull, thought to be responsible for the spreading seen at mid-ocean ridges, and there is some uncertainty as to which is dominant. Ridge-push occurs when the weight of the ridge pushes the rest of the tectonic plate away from the ridge, often towards a subduction zone. At the subduction zone, slab-pull comes into effect. This is simply the weight of the tectonic plate being pulled below the overlying plate dragging the rest of the plate along behind it. However, there have been some studies that have shown that the asthenosphere is too flexible to generate enough friction to pull the tectonic plate along. Moreover, mantle upwelling that causes magma to form beneath the ocean ridges appears to involve only the mantle above about

400 km depth, as deduced from seismic tomography and from studies of the seismic discontinuity at about 400 km.

Thirty years ago, scientists made an interesting discovery at the bottom of the Pacific Ocean. They found seafloor vents spewing hot, mineral-rich water into the cold, dark depths, and they found that the vents contained life. Hydrothermal vents are found along the ridges of the seafloor where the plates that make up the earth's crust are either spreading apart or being pushed together. The dynamic movement of these plates creates cracks and fissures through which seawater travels into the vents where it is heated and goes back up as super-hot springs. Temperatures at these sites can go as high as 403°C (757°F), and the water is filled with minerals and chemicals acquired during its sub-seafloor journey. It is the uprising of the minerals, such as copper, iron, and zinc sulfides, as the extremely hot water collides with the cold ocean water that creates black smokers, which are the tall, chimney-like structures seen so often near hydrothermal vents. The biology associated with hydrothermal vents is just as unique and intriguing as the geology, geophysics, and chemistry. The four are inevitably tied together; it is the chemicals found in the hot vent fluids that support the oases of life found at these sites. Specialized microbes acquire hydrogen sulfides supplied by the vent fluids as an energy source to manufacture food, and it is these microbes and the food they create that sustains the life of the vent communities.

Vent microbes use the hydrogen sulfides as an energy source to transform carbon dioxide dissolved in the ocean water into food during the process of chemosynthesis. The sulfur-oxidizing microbes are found at vent sites in both free-living and symbiotic forms. In the free-living form, mats of these microbes are the first organisms found at new vent sites. As symbiotes, these microbes are part of a mutual relationship with the superior organisms of vent communities. The giant, blood-red tubeworm holds the microbial symbiotes within a special organ called a trophosome. The tubeworm takes in hydrogen sulfides, carbon dioxide, and oxygen through its bright red, gill-like plume and delivers these compounds to the symbiotes that use them to create food. This food nourishes the worm and allows it to grow at phenomenal rates, up to 85 cm per year, making it the fastest growing marine invertebrate alive today.

Image of **Tubeworm** Plumes www.itee.uq.edu.au

The clams, mussels, and a few gastropod species at vent sites also harbor microbial symbiotes within their tissues, where they can ensure a sufficient supply of hydrogen sulfide, carbon dioxide, and oxygen for their guests. Vents are also home to other, "non-chemosynthetic" organisms, organisms that do not contain symbiotic microbes within their tissues, but rather feed on, living or dead, tubeworms, clams, mussels, and gastropods. For example, crabs and several kinds of fish make their homes at vent sites. While these organisms do not rely directly on the microbes for food, they are benefiting from the microbial food chain near the vents.

The importance of this in our opinion is to understand how these organisms are able to live in their extreme environments and flourish. Then maybe we can understand how the adaptation of different species might insure not only our existence but also provide answers to many other health related problems or concerns we have. Also if we are able to understand the mobility of the plates, maybe we can predict earthquakes and other geological phenomenon, such as climate changes and storms.

III. Design Rationale

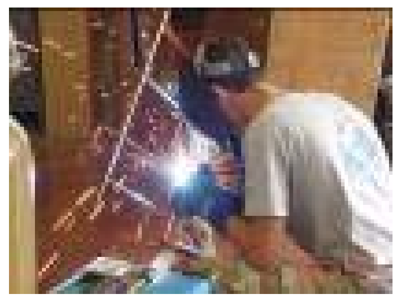
Frame

The past teams' experiences assisted us in improvements on design and material choice, saving precious time. From past years we observed that other teams used polyvinyl chloride (PVC) which had limitations on what we wanted to accomplish during the missions. PVC also didn't possess the hydrodynamic characteristics we were looking for.

Past teams had adequately demonstrated and hypothesized, the thinner frame provided less resistance in the water. To check their conclusions we tested two different frames, stainless steel and PVC. Confirming their conclusions, we also tested the same hypothesis using two different frames, a hybrid of stainless steel and carbon fiber verses PVC.

Identical weights were attached to both frames and ran in the water. At the time of testing both frames were made to be neutrally buoyant. The results, although not as drastic, showed the hybrid stainless carbon fiber frame maneuvered just slightly better. Given the other benefits of strength and stability of the stainless steel and carbon fiber's lightness, we decided to use the hybrid frame.

Also justifying of our choice to use a hybrid frame was the ability to reap the benefits of two different materials. As previously stated, it is comprised of stainless steel and carbon fiber. We would have liked to use aluminum because of its light weight characteristics, malleable traits, and its easy accessibility, however we are not able to weld aluminum in-shop because we don't have a TIG welder. Also the stainless steel and aluminum components will corrode when combined. The corrosion, caused by the difference in standard reduction potential, the electron transfer, the ions separate from the metal and oxidize, is the process known as electrolysis. To prolong the life of the frame and aluminum components, we installed a piece of zinc, as a sacrificial anode. The zinc will dissolve over time, and be replaced as needed because it is stripped of electrons, and conducted to the metal that is being protected. To facilitate this, we ran wires throughout the frame to allow the zinc to protect the more isolated areas of the ROV as well.



The frame was welded in shop with a 110V MIG welder made by Miller.

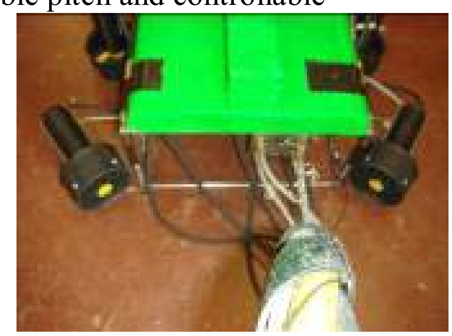
Stainless steel frame bottom keeps the majority of the weight on the bottom the result is increased stability.

The stainless steel provides strength, and helps with the ability to alter it and manipulate the frame to fit our needs, such as welding mounts to accommodate the apparatuses needed to complete the missions. The stainless steel is a .635 cm rod. We cut it and bent to the dimensions of: 33.0 cm (l) by 30.5 cm (w) by 3.8 cm (h). The frame was welded in shop with a 110V MIG welder made by Miller.

We used carbon fiber on the upper portion of the ROV for several reasons; its unmatched strength to weight ratio, its lightness, and its lack of interference with the stainless steel. The carbon fiber is unbelievably light, and yet very strong, so we saw it as a practical material for our ROV. Its tensile strength ranges from 5,650 MPa, to 531 GPa which is far superior to that of aluminum. We needed a light material for the frame because we did not want excess weight. With extra weight, to be neutrally buoyant, a lot of flotation would be needed, which creates a lot of surface area. The surface area creates large amounts of drag, in turn drastically slowing down the ROV. To connect the carbon fiber rods together, we cut and welded .952 cm stainless tubing to make the joints. This proved to be a tedious task because the metal was so thin it would burn through very easily, even at low settings. The angles needed to be precise; otherwise, the frame would not fit together properly. However, the carbon fiber and stainless steel do not interfere with each other. Therefore, we chose carbon fiber as the light upper portion of our frame.

Propulsion:
Thrust, as Newton once said, "actio es reacto". It means a device accelerates air or water in one direction and moving in the opposite direction. To find thrust we used the thrust formula which is (air= 1.225 kg / m3, water= 100 kg / m3). Thrust is important to our R.O.V. because that is how our robot accelerates through the water. Propellers work by accelerating air particles or water molecules to the rear and thus applying a force on itself which is called thrust.

The four parts on a propeller are the rake, pitch, cup and skew. The pitch is the linear distance that the propeller will move in one complete revolution. The different types of pitch are constant pitch, progressive/regressive pitch, variable pitch and controllable pitch. Constant pitch is fixed to have an equal radius. Progressive/regressive pitch is when it decreases along the radial line from leading edge to trailing edge.


BTD 150 Motors Angled Inward at 30

The area located at the edge of the blade is the cup. The cup helps reduce slip, thus increasing the pitch and usable thrust. Rake is where the blade is slanted forward or aft from the blade center axis (BCA). The two types of rake are positive rake, where the blade is slanted towards the aft end of the hub, and negative rake, where the blade is slanted towards the forward end. Positive rake on a propeller sucks in water which results a forward movement to the ROV Negative rake sucks water in the opposite direction and in results in a reverse movement. Skew is the blade center line that is curvilinear sweeping back from the direction on rotation.

In previous years we knew a shroud around the propellers would increase thrust, and we always yearned to create a shroud, however we were never able to achieve the precision to do so. This year we purchased four BTD150 motors from Seabotix. These motors have the shroud we have desired, and create more thrust than any other motor we have ever had. They peak at 2.9 KGF (6.4 Ft/Lbs) and draw 4.24 amps.

In addressing the motor position, we decided to angle them inward thirty degrees after a trial and error tests on different angles. Varying degrees from thirty to forty-five, both inwards and outwards were tested. We didn't want to compromise straight in line speed, but needed a better turning radius. In the end at thirty degrees inward, it enabled us to turn better and although we lost straight away speed it was enough to satisfy our needs. At the 2007 MATE international competition, our tests were confirmed when we were told that real ROV's use the same vectors as we do. This year we reevaluated and ran those tests again for the new members on the team. This helped them to understand and strengthen our knowledge for the dynamics of the ROV moving in different vectors, levers (pivot points and its fulcrum to explain the turning efficiency), and basic design.

Pneumatic Arms

The nature of the missions called for a more advanced grabbing mechanism than ever before. We followed through, and met the demands of the missions by creating a 3 claw-grabber, with the ability to tilt up and down.

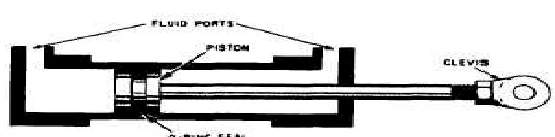
Three possible arm designs

The arm this year was modeled after the 3 claw grabbers seen in arcade games where the player is trying to win a stuffed animal. We thought that by adding a third claw, it would give us more versatility, now that we had to pick up items off of the ground, and a vertical surface, as opposed to previous 2 grabber arms we have fitted our ROV with in the past.

This arm took much planning and revising. I had to be conscious of the various force vectors being subjected to the arms, and change the placement of pivot points and fulcrums accordingly to prevent binding.

This arm was designed to keep the stress of the pneumatic cylinder within the system, rather than transferring it to the frame of the ROV. This made for a cleaner, more compact and precise final product. This arm is equipped with a double actuating pneumatic cylinder which is tied into the base of the arm, which utilizes a series of levers to then open and close the arm.

We decided to add the tilting feature of the arm rather that use two separate arms. We contemplated and decided that in the long run, having a more versatile, multi-purpose arm would be more beneficial than two single-purpose arms. The arm offers 24 degrees of travel, allowing us to complete the missions efficiently. It operates by a double actuating pneumatic cylinder push or pull on the rear of the arm, which causes the front to tilt up or down. We used a .952 cm aluminum rod with self-centering springs as the fulcrum, which acts as a first degree lever.



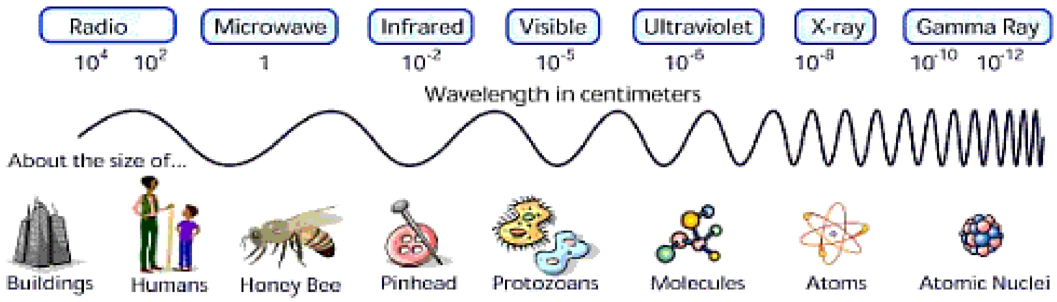
Cross section of pneumatic cylinder

A double actuating pneumatic cylinder operated by using a compressed rubber stopper acting as a piston. There is a port on either end which allows for movement in both directions. We chose to use double actuated cylinders over a single actuated one because that would rely on a return spring to restore the arm to its original position, which was less reliable and operated slower when compared to a double actuated cylinder. Over all the double actuating system would be heavier and more costly because of the added air line but for the reliability and speed, we decided as a team, using double actuated cylinders was worth it.

The non-electrical sources of power used meet safety guidelines:

- Pneumatic, such as compressed, inert gases up to 413.685kPa
- Generated from approved, tested and inspected pre-pressurized containers. These containers have a safety relief device.

Infra-red Camera System:
Our ROV supports one CCI Water Proof camera, and two underwater cameras, from *Lights Camera Action*, model LCA 7700C. Each camera is equipped with ten infra-red LED lights. A Led is a light emitting diode. These LED emit infra-red light, just below the lowest frequency of visible light. Infrared, IR radiations, electromagnetic radiation of a wavelength longer than visible light, but shorter than microwave radiation. The name means “below red” (from the Latin infra, “below”), red being the lowest color of visible light and the longest wavelength. This basically means with the naked eye is virtually invisible, but with our ROV being tethered to a monitor, it enables us to see the effects of the IR lights. IR radiation spans three orders of magnitude and has wavelengths between 700nm and 1mm.



All reflected light that we *can* see with the naked eye represents a fractional portion of the electromagnetic spectrum, which is infinite. We refer to this section as "visible light". All around us light is reflected which the human retina cannot detect, such as ultraviolet and infra-red radiation.
The visible part of the spectrum falls between the wavelengths of 430nm~690nm. (1nm=10^{-9}m) Infrared rays have much larger wavelengths than this. They are divided into "Near Infrared Rays" (690nm-4,000nm) and "Extreme Infrared Rays" (over 4,000nm).

Unlike ultraviolet and visible rays, infrared rays tend to penetrate any medium rather easily because of their rather large wavelengths. This also means that infrared rays are not refracted significantly when passing from one medium to another. Considering that radio waves are ineffective under water at shallower depths, it may seem that the density of water might also affect the wavelengths and spectrum of IR cameras. But it seems the longer wavelengths enable the IR light to move throughout the water without the interference. Radio waves being longer than the IR waves may be too long and may experience more disruption. This explained why we may not be able to see color underwater, as color is the reflection of light being reflect by ultraviolet light (which is the normal in which we see objects).

The only hazard that faced us in the water issue was the electronics, but since the cameras are waterproofed, it saved us time of waterproofing a camera system—time in which we were able to spend fine tuning our design.

The manufacture's spec sheet states the waterproofing has a maximum depth of 82.296 meters, yet recommends an operation depth of 15.24 meters. 36.576 meters of waterproof wire provides the signal to be transported up to the monitor, and the power for the system.

The wavelength is the distance between repeating units of a wave pattern. It is commonly designated by the Greek letter *lambda* (λ).

Camera Specifications:
Dimensions 5.08 cm L x 3.81 cm W x 3.81 cm H **Electronic Shutter:** Auto 1/100 – 1/1,000,000 sec.**Housing: Brass** black in color **Humidity:** Within 95% RH
Image Device: .846 cm b/w CCD image sensor **IR Led:** 10 IR LED **Lens:** 3.6mm, Hor. 72° Vert. 53°**Minimum Illumination:** 0 lux **Number of Pixels:** 512 horizontal x 492 vertical **Operating Temperature:** 265k – 325k **Outputs:** Video – RCA with BNC adapter, power –DC Jack **Power Consumption:** 100mA **Power Requirements:** regulated 12v DC power supply included (UL and CSA listed) **Resolution:** 420 lines
Scanning Frequency: horizontal 15.75 kHz vertical 60 Hz **Scanning System:** EIA standard 525 TV lines 60 fields/set **Video Output Level:** 1.0 Vp.p 75 ohm
Video S/N Ratio: Greater than 46 dB **Weight** 209.7 grams

Flotation


Polyisoproplyne with

Pourable Polyisoproplyne foam is the main floatation material that we used for our ROV. It has extremely beneficial characteristics for our needs. It is 95-98% closed cell, meaning it is resistant to absorbing water, however over a long period of time it will take on water and reduce its buoyancy. So creating a barrier between the floatation and the water is vital to maintain neutral buoyancy during a long term mission, so achieve this we covered the floatation with a laminating resin which we added Q-cell and milled fibers to make the resin lighter and stronger. Another challenge during our floatation process was adding just enough "floatie" to follow Archimedes Principle to make our ROV neutrally buoyant. Archimedes Principle states that a body immersed in a fluid is buoyed up by a force equal to the weight if the displaced fluid. We solved this challenge by creating our own buoyancy formula: **R+F=W+D**
"R" representing the mass of our ROV in grams.
"F" representing the mass of the floatation in grams.
"W" represents the mass of the water displaced by just the ROV.
"D" represents the mass of the water displaced by the floatation.

So basically, the mass of the ROV and the floatation has to equal the mass of the water that they both displace in order to become neutrally buoyant. The mass of our ROV was 6350 grams or 63.5 N. The mass of the water it displaced was 6.48liters, or 64.8 N. Then we found the floatation mass to mass ration displaced was, for 113 cm^3 of floatation, the mass was 5 grams and it would float .18 N or roughly 18.1 grams. From there it was a matter of algebraic reasoning to determine that our ROV needed about 5200 cm^3 of floatation to be theoretically neutrally buoyant. This calculation made the mass of the ROV with the floatation 7.6kg (76.2 N) neutral, and the mass of water displaced was 8.574 kg (85.74 N). We were able to get an estimate and a starting point from our calculations. Without Archimedes formula, finding neutral floatation would have been a tedious procedure.

Tether

The tether is one of the most important parts of the ROV, as it is the life line. It provides it with the electrical power and air supply. We used a 2.54 cm black vinyl hose protector to keep the lines from fraying, splitting, or from being severed. All the lines together come out to an amount of 12 electrical wires, and 4 polyurethane air lines. The yellow cable made and donated by SoundOcean contains the 8 wires which power the SeaBotix motors. The remaining 4 wires are for the video feed and power for the Infra-red LED cameras. The polyurethane lines provide air for the pneumatic cylinders. We thought of using a wireless system, but the radio waves could only travel about 2.5 m. If we tried to go deeper, the ROV would be dead in the water.

Control Systems

Ultimate Joy stick

There are numerous wires that are connected to the plug and fuse box within the control box. Four sets of these wires connect the switches on our joysticks to the positive fuse box and the negative terminals. Connected to the underside of each joystick are four single pole single throw switches. These joysticks aren't like regular joysticks, in that these joysticks don't control the speed of the motors' rotation, they allow vertical and horizontal movements by activating each desired motor. Located on one single pole single throw switch are three brass electrical ports, two of which are connected to the negative and positive power sources, but the third terminal is connected to the motors. Coming out of a hole drilled on the back of the box are eight motor wires that have been gathered together with a quick connect device. This makes it so each plug wire will be connected to the corresponding wire with ease. According to the multi-meter, the voltage passing through each circuit that powers each of our individual motors is roughly 12.0 volts. Then there is about 4.5 ohms of resistance between each individual circuit and switch. Also connected to the fuse box inside the control box are the wires that power our infrared camera connected to a DPDT switch. In the ranger class there is a maximum of 25 amps and 12 volts. We have installed a safety fuse on the positive lead coming into the control box with 15 amp fuses per circuit and the DC electrical power is run topside next to the control box and monitors.

IV. Missions

In the 2008 international competition our missions that we have to accomplish are, retrieving samples from black smokers (rocks), collecting vent crabs, and taking a temperature from hydrothermal vent fluid.

Our first mission will be done by navigating our ROV through the terrain of the Mid-oceanic ridges, drop off our collection basket on the sea floor, then find and identify a black smoker. Once identifying a black smoker we will then scrape the side of it and collect a rock sample. We will then drop the rock into our collection basket. Our collection basket is made up of a wire mesh so that it is more hydrodynamic. It will allow water to flow through it, therefore creating less drag on our ROV.

The second mission will be similar to the first all we have to do it find a vent crab and pick it up with our arm and drop it off in our basket. We will then leave our basket on the sea floor and do our 3rd mission before returning our samples to the surface. We as a team decided that it would save more time if we completed all the missions first instead of do one mission and bring the samples up and doing the 2nd and returning to the surface again.

The 3rd and last mission will be taking a temperature reading at a hydrothermal vent. Our ROV is equipped with a thermometer and we have to insert our thermometer into that vent and take the temperature reading. Hydrothermal vents can reach temperatures up to 403 degrees Celsius.

As previously stated in section II "Mid-Oceanic Ridges, the importance of doing these missions is to further our understanding of the living organisms which live in these intense environments. By studying them we can learn about how organisms adapt to their different environments and the dynamics of plate tectonics.

V. Challenges

In life there are always challenges. While building our robot we also had our share of problems. We faced long nights, slow days, even arguments. Through out the building process we encountered challenges such as debating on the one multi tasking arm or using two specialized arms. During testing the robot would have a hard time trying to pick up the vent crabs and the rocks with the one arm. Yet adding another would add more weight to the ROV. To fix this problem we added a shovel like apparatus to scoop the items we were having problems with.

We also encountered floatation problem, the most difficult part was to obtain exact neutral buoyancy. We were finding out through the calculations on how much polyisopropelyne to use. When we would make a mix we would let it set up and run the ROV. It would be pretty close to perfect. The problem came when we needed to coat it with laminating resin and paint. Both added weight and therefore affected our buoyancy enough to make it negatively buoyant. When mixing the resin, Q-cell, and milled fibers we found it to be inconsistent in weight. To mend this problem we weighed every part of the mix down to the catalyst and paint to insure accuracy in the overall product. With all of this insurance we were still a few grams of the mark. We added an additional flotation device to compensate for the negative buoyancy.

This year for the tether we decided to make an easy connection using a plug in system near the ROV, hopefully this would make connection and disconnection faster then using the usual electrical connectors. . The dilemma we were up against was trying to get continuity through the wires and finding an eight to ten pin plug and its female counter part. We were finally able to find one at radio shack and successfully add it to the ROV's tether.

As with the missions the retrieval samples and returning them back to the surface proved to be most challenging. Including an on board basket as our payload was tested and found not to be an option. It added too much weight and instability as the retrieved were free to move in the basket. We therefore decided to use a basket that is autonomous from the ROV.

VI. Troubleshooting Techniques

A systematic check list was used while building our ROV. This checklist is commonly called a "Design Process". An example of the process is as follows:

Define the problem:

- The non-functioning motors.

Where to start?

- Check the source; the battery using the multimeter.
- Check the motor check if power is flowing through with a multimeter and continuity tester. Examine the tether for any cut wires.
- Check the control box where the motors wire comes in for a flow of power with a multimeter.
- Check the fuses make sure they're in good working order.
- Check the switches and joysticks see if electrical current is running through them using the multimeter.
- Check to see if there are any wires lose or stripped.

What to Do?

After checking everything systematically and not finding the cause of your problem, check again—sooner or later we found the problem on the way to this last step on the checklist, we used problem solving and in turn learned the meaning of becoming a self-directed learner.

Looking back on this past year I can see a lot of areas where we had to trouble shoot and solve the many problems which arose. I hadn't realized we were troubleshooting; when questions such as: why do the pneumatic cylinders take on water? Why is the ROV sinking? How can we avoid the propellers from canceling the others' thrust? All these questions came about and we used a simple way to solve them using the design process: going over every step possible and using a checklist.

VII. Skills Gained

When we sat down and actually thought about everything we've been through we realized we learned and accomplished so much throughout the whole process.

A Better Understanding of Engineering: We developed the best design for our ROV using the scientific application and the design process. We also learned to work with tools in a shop. Thinking outside of the box, expanding our minds played a major part in the entire process. As result, our ROV should perform every mission with no complications.

Mechanics and Physics of a ROV: We asked and found assistance to help them understand the mechanics and physics in building an ROV. The mechanics had to do with the idea of having our ROV move like a fish so we found the best solution for this proposal. With the idea of moving like a fish, we developed a system where the ROV can pivot, allowing it to turn with ease. To do so, we turned ROV's rear motors and propellers inward at thirty degrees. This brought physics along with it, where and how much force is being subjected to one area of the ROV, which may render it either immobile or nimble.

Professional Attitude: The team took on a more professional attitude to suit the different working environments. We learned look at the entire project as if it were in a real work place. Punctuality and promptness were on the top of the list along with following HIOSH rules and regulations. These were determined to be types of skills that are needed to succeed in the professional world.

Importance of Communication: Communication among team members to leaders and from leaders to advisor and teacher is important because if the leader's directions are vague to the team, or they aren't sure of exact procedures to their teammates, it leads to the job being done incorrectly or inefficiently. Not only did we lose time, but we lost materials and money due to our errors.

Responsibility: One of the most important skills is responsibility. We all learned responsibility as a sense of character and integrity. This means since we took on a job, quitting is not an option—nor is letting your teammates hang over something you did or didn't do. We came across some of these problems early. After taking charge we the captains were able to change the behavior of most of the team in not showing up to class or arriving late. We had to also talk to the team in putting tools away and cleaning the shop area is vital to a safe work environment and demonstrates responsibility.

Character: In life what is my legacy? What will I be known for? A person of good character integrity can always look back and be happy in knowing they tried their best, and always learn given any situation. A person of good character will always succeed in the real world.

VIII. Future Improvements

In the future, the team would like to research and experiment with electrical actuators rather than pneumatic cylinders. We think this would save weight, be a smaller overall system, and in turn create a more agile ROV. The integration of electrical actuators would be another challenge that the team is willing to take on next year.

Also, refining our ballast system would be very advantageous for the team. We would like to be able to dedicate more time to creating a more efficient and reliable ballast system. Its not that it can't be done, but to have a perfectly neutrally buoyant ROV, is a very time consuming process because of a very small margin of error.

IX. Hind Sights

Dalfred Kaipo

I've learned a lot over the last two years, about what things will and won't work, with regard to designing and fabricating. At the beginning of last year I walked into this program thinking I was going into business after graduating. I didn't know anything about how to work in a shop, or how to use any of the tools. Now I have a better understanding as what to do and the proper use of the tools. I am more confident in myself and know the limitations of my knowledge and talent. I feel empowered by this competition in the knowing that stretching oneself and their boundaries is the only way to grow and gain wisdom. This year things are being done faster and more efficient because I applied things I learned last year. For example, the importance of communication, respect, trust, and teamwork is the basis of all relationships. This year teaching others was at the forefront of learning. I found it isn't as easy as it seems, but very important in the cycle of learning.

Communication is important. If the message isn't perceived correctly, wasted materials and time will make us fall behind schedule. Being a leader isn't, leadership calls for a lot of responsibility and having the respect of your team shows a sign of success. Since it's my second year in this class I had to teach the new students this year. Teaching other students proved to be the hardest thing to do this year because last year our team was all on the same page. I realized that being the captain of anything can be a trial.

Nick Poleshaj

This build has been totally different from the past builds I have been a part of. Previously, I did the majority of the fabrication, however this year, I tried to take a step back and focus more of my efforts into managing the team members, and allowing them to step in and get some fabrication experience. It was hard to take the time and teach them the process and the techniques, even to do the simplest of tasks. But it was for the well being of the team by shaping the next generation.

It was very had to be more of a leader. I had to work on explaining myself in an understandable manor. So that my teammates would be able to follow my instructions, and think for themselves while working a challenging tasks, and come up with their own solutions.

The stress from robotics was reduced this year mainly because of my change of management techniques. I did more delegating of tasks and overseeing of the project. This was largely due to the much busier schedule outside of robotics. I had three AP classes, enrolment in English 100 at the local Community College, and all of the applying for my future education and scholarship stuff seniors go through. If I could go back I would change my schedule and return robotics as the priority. I didn't need to take the English at the college but thought I would to keep busy, stay out of trouble, and get a requirement out of the way.

John Trueman

I learned that driving into telephone stability wires will get me grounded. Therefore I must drive with greater care and caution. This year, returning I was faced with different challenges than just building. For the most part me, Dalfred, Nick, and Kahue, took on a new role as project leaders. We taught the "newbies" of what we learned last year. From design and fabrication, to running the same tests for propulsion and buoyancy, it was challenging to have them see and learn what we were taught last year from Mr. Izumi. Going over the various aspects a second time I was able to learn a little bit more by teaching it to them. With the experience from the previous year I would've like to have found a way to use carbon fiber for the entire frame.

Kahue Kaopuiki

The most I learned in the second year of robotics was about commitment. To be committed means to be in class and try to be a positive role-model

for the underclassmen. Being a senior was hard due to senioritis and the breaking of my leg.
I also had the privilege of learning how to weld using a MIG. I didn't know how to weld or the fact if two metals aren't the same it's next to impossible to get a good weld. At the molecular level the ions in the two metals won't bond with the weld very well. After all the welding for our ROV was completed, I had the opportunity to practice tacking and making a bead. I tried this year a whole lot more on being a team player and helping out more, not only when crunch time is here. For the most part I succeeded with some momentary lapses of brain freeze. There are also a lot of jobs which include welding, fabricating, or designing and building I'd like to pursue after graduating. Most importantly I learned to take more initiative and pride in my work. Instead of rushing through the work I'd measure twice and cut once—having more ha'aheo (pride) in my work. Knowing what's got to be done and doing it!

Andrew Ikeda
This being my first year in robotics, I've learned many new things. The main thing that has stuck out is teamwork. Teamwork is a huge part of our team. We would have made very slow progress if we did not have each other. When we got stuck in a hairy situation, we could always rely on one another to help us overcome the issues. I have learned so much about the electrical aspect of our robot, which, to me is very complex. The basics of which are Ohms law, resistance, the different circuits, and switches. If I could change one thing on the ROV, it would have to be the flotation. It took a lot of time to make what we have and get it right. The foam took a little getting used to and having it come out consistent. At times we would have some really dense spots and in the same mix it would come out very light. Sometimes letting the "new guys" do and learn proved to be, at times, costly. We have realized what areas we should take time in doing, so that we can get it right the first time.

Oranna Davis
This is my first year and robotics and it has been real interesting. I started to help with the building of the control box for the ROV. During the short amount of time I have been in robotics I have learned key information, the basics, any engineer should know. Electron flow is from negative to positive. I helped rearrange the wires inside and learned about where things go and determined the total resistance, and current, using Ohms Law and a multi-meter. This proved to be useful when we were wondering if we could run a fifth motor or one additional camera. The hardest part was figuring out the density and volume of Green Monster. Submerging it into the tank and finding out how much water was displaced by using the ruler, sort of like a giant graduated cylinder. It was kind of confusing because once we had the numbers we plugged them into the formula I got a little confused especially because math isn't one of my greatest subjects.

Ashlyn Seda

This is my first year being in robotics, I wanted to try something new and challenging. While being on the team there is so much I learned in such a short amount of time. Using the MIG welder and plasma cutter proved to be the most fun and challenging. Setting aside typical stereotyping I don't feel intimidated by any of the tools or machines in the shop. I also built a prototype of the ROV for my science fair project focusing on weight, buoyancy, and Archimedes' principle. Archimedes' principle focuses on density, which is hard to find on some objects, our ROV for example. To find the our density we filled a tub with water, with a ruler on the side to measure the displacement, placed the robot in, read the measurement, and figured out the weight of the displaced water. This was done to find the volume and density of the ROV

If I could change one thing about the robot it would be the arm. The placement of the arm is too far to the left of the robot therefore, I think, it disrupts the stability.

Rachel Chang

This year I learned many invaluable things on the robotics team. The first is the importance of teamwork. I learned from the start teamwork is needed to make it possible in building the ROV. Having the team we were able to bounce ideas off of each other. If we didn't help each other, and contribute, then the ROV wouldn't have been built. Working on this team has forced me to ask questions, and learn new things. Since being on the team is a privilege, I tried to get the most out of it. Some of my friends and other students in the school think this is something a girl shouldn't do. "It's a guy thing", or "girls shouldn't work with power tools," is all I heard at first. It got to me in the beginning then I just figured hey I can do this, at times better than some of the guys on the team. The ROV has given me a new confidence in myself.

Willson Scott

There are many things I learned from this program in a short amount of time. Some of the things I learned were how to use the many tools in the shop and practicing good safety habits while doing so. These were very important to what needed to be done for the ROV. A plasma cutter needs to be used when it's difficult to drill something. I never had the chance to weld before, but I learned the basic concept to it with robotics. Teamwork was imperative to learn as we need it to get many things done. The teamwork and collaboration was needed to decide on certain things. "How should this camera on the tether be placed? At what angle? How much flotation is needed?" Communication makes everything go much smoother. What I would want to change about the ROV is the material we used to make the frame. I think its pretty original using carbon fiber rods. Some of pictures I've seen on other international teams didn't incorporate it into their designs, but I was told there were some which did. I feel it would have been more aqua-dynamic if we could have used it exclusively. Robotics has been a great learning experience for what I plan to do in the future. I also learned more about Archimedes principle, and Ohms Law—not that I didn't know about it but it helped to actually use what I learned in other classes. As with some of us, I would like to have spent more time on the project. Other commitments have kept me from spending more time and contributing more.

X. Acknowledgements

As Newton's first law of motions states, "an object at rest will remain at rest: and an object in motion will remain in motion until a net external force is applied." We, the students of Surfrider Robotics would like to recognize the following for getting us in motion, kept us moving toward our goals, offering redirection and motivational advice when needed.

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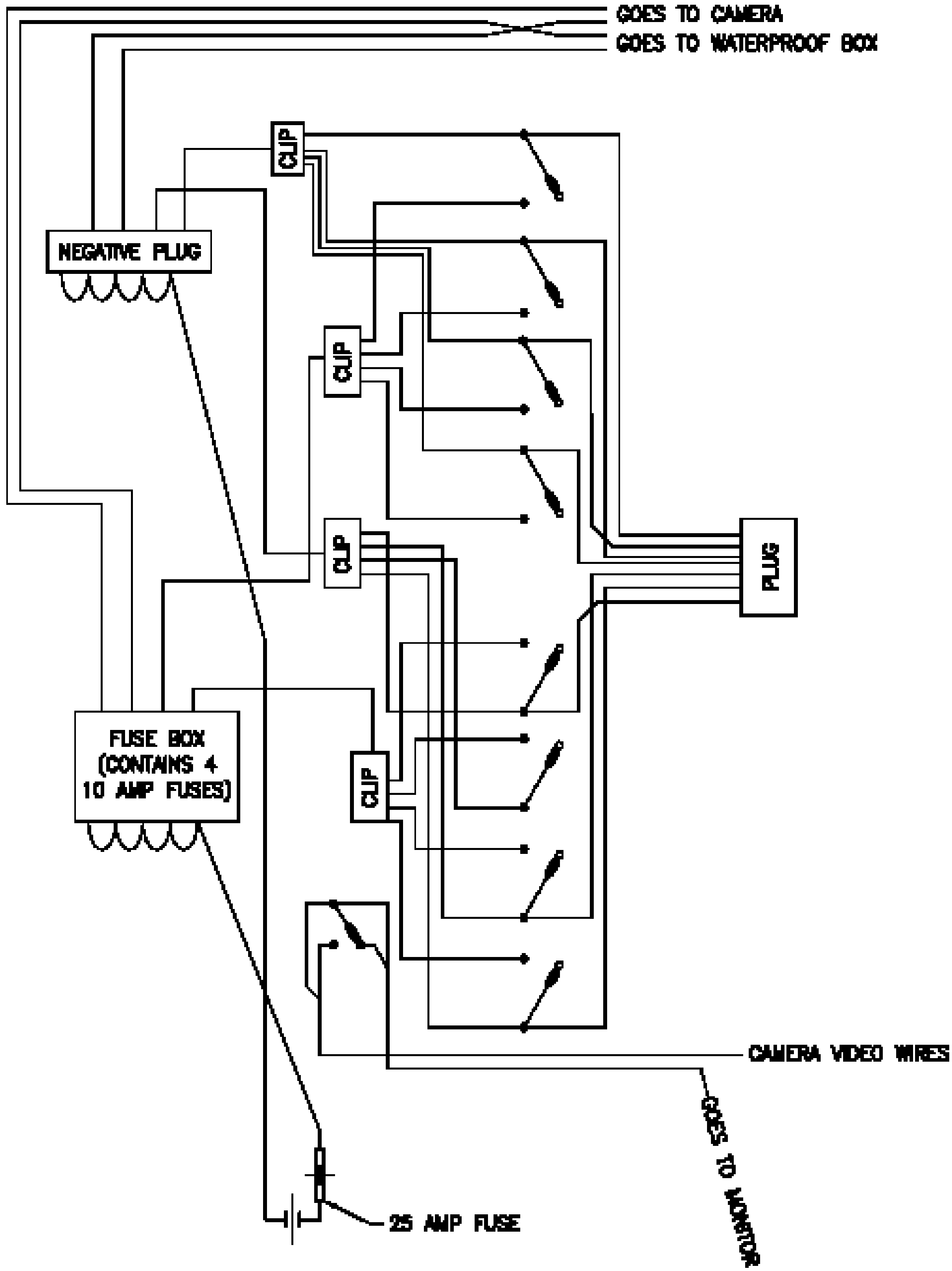

KAILUA HIGH SCHOOL

Schematic Diagram For R.O.V.

XII. Budget Sheet

Date	carry over from last year or expense or donation	Description	Reason	Debit	Credit	Balance
6/07	Carry over	Last years left over	Misc. supplies, Travel		$2000	$2000
3/12/07	Carry over	Genuine Auto Parts	Thread Steel Rods x2	$0		$2000
3/15/07	Carry over	Genuine Auto Parts	Drill holes in steel plate	$0		$2000
3/20/07	Carry over	Hydra-Air Pacific	Ball Valves	$0		$2000
3/21/07	Carry over	Hardware Hawaii	Air lines	$0		$2000
4/3/07	Carry over	McMaster double actuated cylinder	Pneumatic Cylinder	$0		$0
4/18/07	Carry over	Hardware Hawaii	Spray foam	$0		$0
4/23/07	Carry over	Genuine Auto Parts	Thread Stainless Rod x2	$0		$0
5/17/07	Carry over	Hydra-Air Pacific	Ball Valves	$0		$0
5/21/07	Carry over	Hydra-Air Pacific	Ball Valves	$0		$0
7/23/07	Expense	Sea Botix DC motors	Motors	$1300		$700
		Total Spent/Balance Remaining		**$1300**		**$700**