

# Technical Report

## Surfrider Robotics Team

The International MATE Center  
ROV Championships 2007



**Kohola Kuainu**  
(Humpback Whale)

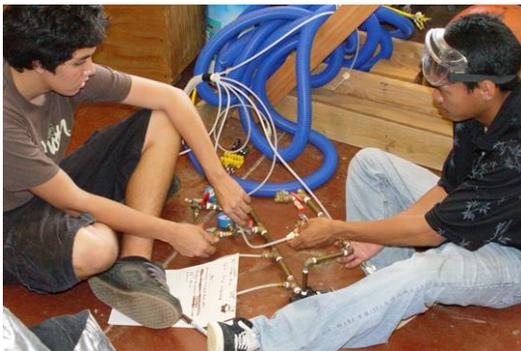
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**Alex and Sen working on the air system**



**Nick welding the stainless steel portion of the frame**

## Societal Impact of the Melting Polar Ice Caps with Regards to the Indigenous People of the Arctic

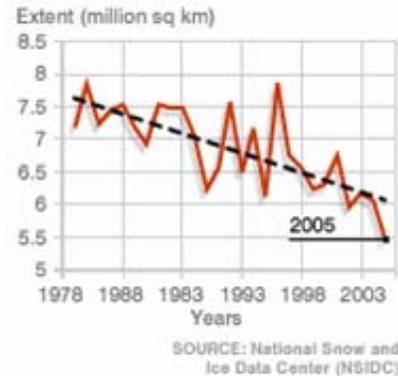
One degree Celsius or two degrees Fahrenheit, could your body feel this small change in temperature? Yet, over time it is enough to cause catastrophic changes in the world's climate by melting massive pieces of frozen bodies of land made from ice. It is hypothesized by the year 2050 the large masses of ice will have depleted thousands of miles inward. The impact of the melting ice caps will affect the diversity of the indigenous Arctic people as well as many species of biological life forms.

Many of these people depend on wildlife for their livelihood. Clothes, shelter, food, and religion are all deeply influenced by this cold and barren environment. People of this region have lived off the resources of land and sea for thousands of years. With each passing year they will have to further adapt to the environment, survive massive changes to their hunting grounds and available food, and to their spiritual beliefs which are deeply rooted in the worship of animal spirits.

These people inhabit Arctic land in areas such as Greenland, Norway, Serbia, and Canada. There are an estimated 4 million people with diverse cultures and ethnic background. Almost 80 percent of the indigenous Arctic people are in Greenland, the other 20 percent is split among Norway, Serbia, and Canada. They are called Inuits, Aluets, Athapaskans, Chukchi, Inupiaq, Nenet, Saami, and Yup'ik.

Although the main culture has survived thousand of years without interruption, many of the people are adopting western cultures and making societal changes. The number of outsiders who are arriving are mainly those seeking various natural resources (oil, and natural gases), explorers, and scientists are also influencing wide spread change. The host culture is being assimilated into western societal norms and mores. Traditionally a deeply rooted religion strongly believed and depended on the spiritual nature of animals where the environment provided sustenance and the bartering for goods is currently quickly being replaced with the monetary value of goods. As hunting becomes scarce for these people, they will resort to other means of survival.

In closing, will the continued melting of polar ice caps further force the indigenous Arctic people into becoming a part in our global community?



**The straight line tracks a more than 8% decline per decade**

### I. Abstract

The Kohola Kuainu, our ROV, was assembled with basic design processes in mind. This procedure includes brainstorming, making a rough sketch, prototype, testing and re-testing. The result, a hybrid frame composed of stainless steel and carbon fiber.

The Kohola Kuainu is propelled, determined through vigorous testing, by remote controlled boat propellers angled inward at 30 degrees. The power behind the propellers is provided by bilge pump motors from Piranha.

To accomplish the missions we have installed various apparatuses:

1. A “*Happy Hooker*” used in boating to retrieving moorings, to latch onto the mooring.
2. Double actuating pneumatic cylinders built from scratch. The arms that are connected to them are specialized for specific mission tasks. One arm is built to lift the PAS, mission 2, while the other is for precision, placing the gasket in Mission 3.
3. A fabricated variable ballast system allows us to compensate for the different water density in the different tanks, and the added weight of the PAS.
4. Installed are two CCI Infrared cameras mounted strategically to optimize full vision of the pneumatic arms.
5. To insure smooth operation of our ROV, we are utilizing two “*Ultimate Joysticks*” with DPDT “*Happ*” switches.
6. Encasing our tether line is 5.08 cm vacuum hose to hold all the pneumatic hoses, camera wires, and power wires together.

## II. 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 stated it is comprised of stainless steel and carbon fiber. However, it is far different from our previous hybrid frame, in the regional, which was made of stainless steel and aluminum. On the first frame, we noticed that there was corrosion on both of the metals. This is due to the fact that stainless steel and aluminum corrode when joined. 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.

The stainless steel provides strength for the pneumatic arms, 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 .952 cm rod. We cut it and bent it to the dimensions of: 63.5 cm (l) by 43.18 cm (w) by 3.18 cm (h). It was welded together with an 110V MIG welder from Miller. Because of the thickness of the metal, the settings on the welder were maxed out. Otherwise, there would not be enough penetration and the welds would break under strain.

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



The Kohola Kuainu with out payload

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, I 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 / m<sup>3</sup>, water= 100 kg / m<sup>3</sup>). 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 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, which is fixed to have a equal radius, progressive/regressive pitch is were it decreases along the radial line from leading edge to trailing edge, variable pitch and controllable pitch.

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 R.O.V. Negative rake sucks water in the opposite direction



**Rear Horizontal Propulsion**

and in results in a reverse movement. Skew is the blade center line that is curvilinear sweeping back from the direction on rotation.

The team did a comparison test on different types of propellers. Tested were 15.2 cm wood propellers, 15.2 cm plastic airplane propellers, and four types of brass boat propellers with different rakes, blades and pitches. We looked at each of the propellers performance and decided to go with two brass 8.25 cm propellers per motor. The decision to use the brass propellers was based on the overall speed and performance as compared to the rest. On each motor, one of the propellers is fixed to have a positive rake and the other a negative rake. The team found both propellers, on each of the four motors; have a cup to increase the thrust. By inverting one of the propellers, we found it actually increased the thrust by increasing surface area and the amount of water which is being pushed through the propellers.

In addressing the motor position, we decided to angle them inward thirty degrees after a trial and error tests on different angles. Tests in varying degrees from ninety to forty-five were tested. We didn't want to compromise straight in line speed, but needed a better turning axis. In the end at thirty degrees, it enabled us to turn better and although we lost straight away speed it was enough to satisfy our needs.

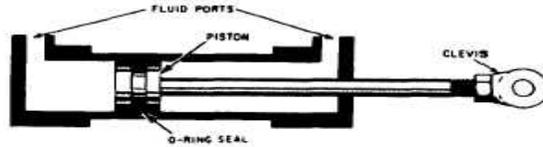
### **Pneumatic Arms:**

The Kohola Kuainu, our ROV is equipped with two pneumatic arms which are located on the bottom- front left and right corners. The pneumatic arm is cycled by double actuating



**Double Actuating Cylinders with Arms Attached**

cylinders with a compressed rubber stopper and metal rod acting as a piston. This cylinder is made of 1.27cm polyvinyl chlorate (PVC). The actual grabbing mechanism of this system is made of aluminum flat-bar, aluminum channel, and molded PVC. The PVC was molded by dipping it in boiling water then shaping it to fit our needs. The PVC pieces were then coated with Plasti-Dip to add extra grip. We constructed two different arms because the missions called for both stability and precision. One arm was designed to have a wide claw because it was designed to be able to hold onto the object in a fashion where it would not be easy for it to accidentally slip out. On the opposing arm two metal rods were riveted onto the claw to extend it and make it easy to be able to pick up smaller items. The pneumatic arms run off of 2.8129 k/cm.



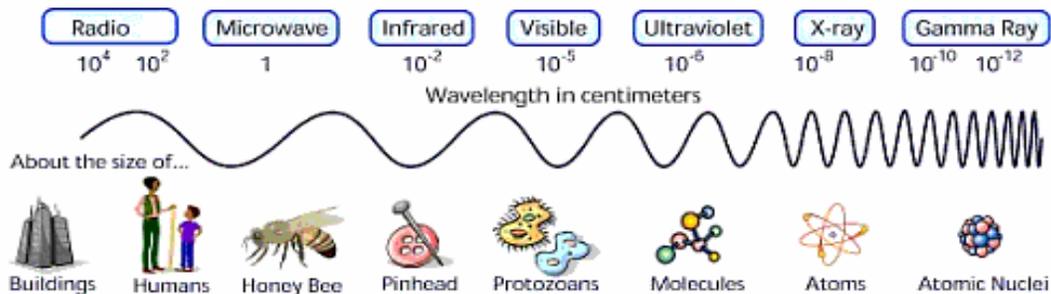
Cross section of a pneumatic cylinder

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 two CCI Water Proof cameras. 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 and certain depths, it may seem that the density of water might also affect the wavelengths and spectrum of IR cameras. The only hazard that faced us in the water issue was the electronics, but since the cameras are waterproofed, it saved us time and the hassle of waterproofing a camera system. 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* ( $\lambda$ ).

#### **Camera Specifications:**

**Dimensions** 5.08 cm L x 3.81 cm W x 3.81 cm H **Electronic Shutter:** Auto 1/100 – 1/1000,000 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:**

Polypropylene is one of the materials that we used for our ROV. Polypropylene is a very light-weight thermoplastic resin, similar to Styrofoam.

Another challenge in our flotation 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 of the displaced fluid. We solved this challenge by creating our own buoyancy formula:

$$R+F=W+D$$

"R" represents the mass of our ROV in grams. "F" represents the mass of the flotation in grams. "W" represents the mass of the water displaced by just the ROV. "D" represents the mass of the water displaced by the flotation.

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 11,158 grams or 111.58 N. The mass of the water it displaces was 10.77 liters, or 107.7 N. Then we found the floatation mass to mass ration displaced was, for 125 cm<sup>3</sup> of floatation, the mass was 4 grams and it would float 1.269 N or roughly 75 grams. From there it was a matter of algebraic reasoning to determine that our ROV needed 10645.779 cm<sup>3</sup> of floatation to be theoretically neutrally buoyant. This calculation made the mass of the ROV with the floatation 11.498 kg. (114.98 N) neutral, and the mass of water displaced was 10.645 kg (106.45 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.

$$100 \text{ g} = 1 \text{ Newton}$$

### **Ballast:**

The ballast systems are used to bring our ROV up without using the motors. They can be made differently depending on the objective they need to carry out. The ballast system we chose to use is simple and best suited the mission requirements. The ballast system on our ROV is in the shape of a cylinder with holes for rapid breeches and dives;

the ballast tanks are distributed within the frame. The ROV has four ballasts; two vertical, in the front and two horizontal, in the rear area of the ROV. When fully inflated, each offers 6.4 Newtons of buoyant force. They are made of thin 7.62 cm PVC and were drilled with a step bit to the size of 1.25 cm. To enclose the PVC we



**Front left independent ballast**

used two 7.62 cm caps. One cap on each cylinder was drilled with a .635 cm bit through the center, and was later threaded to accommodate the compression fitting. The balloon sits on the inside of the cylinder on the compression fitting. Since the fitting has barbs which would puncture the balloon, we used .635 cm of polyurethane tube to cover the fitting so the balloon won't pop. We used punching balloons as a bladder because of their thickness and durability. To mount the ballast on the carbon fiber rod we used plastic cutting board and cut it into a crescent shape. Then we used a special application glue called marine goop to fuse the cutting board and the cylinder together; it is waterproof and only small amounts are needed for it to work properly.

The ballast system was design to take on water, be neutrally buoyant and then fill the balloon with air to displace the water, thus making the Kohola Kuainu positively buoyant. The front left ballast is independent from the rest of them. Independent meaning that particular ballast tank has its own dedicated air line. The ballast is independent because it is meant to cancel out the weight of the Passive Acoustic Sensor

(PAS). If all four tanks were supplied by the same airline it would bring up the ROV unevenly because the weight of the PAS is only being subjected to one corner. Also in mission 2, where we are to retrieve at least one ping pong ball, we want to raise just the front of the Kohola Kuainu. The other three are to be used to bring our ROV up and out of the water.

### **Copper Air Lines:**

For our air system in our robot, we used copper tubing rather than macro lines because previous tests showed us macro lines would kink and contort when pressurized, which would disable the pneumatic cylinders and ballast

To bend the angles in the copper lines we first used bare hands. Bending the line was uncontrollable, which would make the line pinch. Having pinches in the lines caused restricted airflow. The next thing we tried was using a spring to bend the angles; unfortunately this also did not work. To finally solve our problems, we turned to a hand tool bender, which is similar to a hydraulic pipe bender. The tool gave us the ability to bend the copper lines 90 degrees without pinching them. Having this tool makes the copper tubing more symmetrical and neat.

Each copper line was designated for either a pneumatic cylinder or a ballast tank. For the arms to operate two lines are needed; one to push the rod inside the cylinder one way and the other to return it, thus opening and closing the arm. The front-right ballast tanks and the two rear ballast tanks are all connected to a central line by two T-splitters, so that the air would be equally distributed to each balloon. The front left ballast is independent to cancel out the P.A.S.'s weight which we have to deploy in one of the missions. All of the copper air lines are directed to a stainless steel plate in the rear of the robot. The copper lines are capable of holding well over 70.323 kg/cm, but we are only using only 2.8129kg/cm. To connect the polyurethane tubing to the copper line we used .635 cm compression connectors.

### **Tether:**

The tether's sole purpose is to provide the ROV with electrical power and air supply. To protect the lines from fraying, splitting, or from being severed we use a vacuum hose with a diameter of 5.08 cm. We contemplated using a wireless system but the radio waves from a transmitter to the ROV can only travel 1.524 m. underwater, if we go any deeper, we are dead in



**Tether with the air lines and electrical lines**

the water. The 15.24 m tether line consists of 10 electrical wires and 6 polyurethane air lines. Eight wires go to the Piranha bilge pump motors. The other two wires are for the Infra-red LED cameras. Four of the six

polyurethane air lines are for the two pneumatic cylinders. One of the other lines is for the individual ballast tanks and the remaining line is split amongst the other three ballast tanks.

## Control Systems

There are several wires that are connected to the plug and fuse box. Four sets of these wires connect the switches on our joysticks to the positive fuse box and the negative plugs. Connected to the underside of each joystick are four single pole double 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 switch. Located on one single pole double throw switch are three brass electrical ports, two of which are connected to the negative and positive power sources, but the third port is connected to the motors. Coming out of a hole drilled on the back side of the box are eight motor wires that have been gathered together in a plastic plug. This makes it so each plug wire will be fused to the corresponding wire. 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..



The "Ultimate Joysticks"

## III Missions

### Mission 1

The first mission in the flume tank is based off the scenario that a ship collided with a weather buoy. The cable connecting the buoy to its anchor was severed. The mission description requires us to have a device that will thread a messenger line through the buoy anchor ring, and then proceed to return the line to the surface.

We fastened a device called a "happy hooker" used in boating, to retrieving moorings onto the Kohola Kuainu. The front end of the device opens up as the forward motion of the ROV and the u-bolt pushes against it, the ROV continues forward as the u-bolt goes through a cavity of the happy hooker. Then the u-bolt pushes against the back of the device, which opens and releases the u-bolt. In this process, the messenger line is threaded through the u-bolt. The line is attached to the tether and up to the surface. As the robot returns, it brings the line with it, enabling us to complete the mission with both ends of the messenger line.

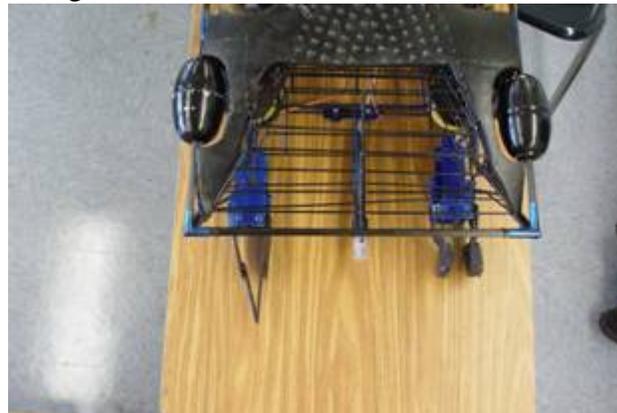
### Mission 2:

The second mission takes place in the Ice Tank. This scenario was based on the retrieval of information about the benthic jellyfish, an unknown alga, which resides on the underside of the ice, and the bowhead whale. The mission description requires us to bring down a Passive Acoustic Sensor (PAS), which will monitor the calls of the bowhead whale. In addition to deploying the PAS, we are to retrieve a benthic jellyfish, which floats near the seafloor, and to collect an algae sample from the underside of the ice.

To deploy the PAS and to retrieve the benthic jellyfish, we mounted the two pneumatic arms on the Kohola Kuainu. We mounted two arms because we need to have the gripping capability in the first part of the mission while being able to have pin-point precision in the second half of the mission.

One arm has a very wide grabbing mechanism while the other has two metal rods protruding out of it which act similar to tweezers. Once the PAS has been deployed and the benthic jellyfish has been apprehended, we will navigate the Kohala Kuainu to the underside of the ice to collect sample of the algae with the cage, which was fabricated out of 1.5 millimeter steel wire that is mounted on the top of the Kohola Kuainu. This cage will be pushed up and dragged along the ice, thus gathering the algae sample. There were many other options we devised to capture the algae.

Some of the options brainstormed were to use a mesh netting to retrieve the algae, use suction to hold onto the algae specimen, or to make a cage that would scoop the algae from the bottom of the ice. After all things considered, making a cage was the best looking and most functional remedy to this mission.



Cage made of steel rod and two pneumatic arms

The cage was designed with holes small enough that the algae wouldn't float through thus losing the specimen. This cage is used when the Kohola Kuainu is navigated up to the ice so the cage is touching the ice. The Kohola Kuainu is then driven forward while dragging the cage along the underside of the ice, thus picking up the algae specimens.

The cage was welded with a 110 volt MillerMatic 135 welder which is made by Miller. The settings were set at Voltage-3 and Wire Speed-5.

### **Mission 3:**

The third mission consists of two tasks having to do with an offshore location called Hibernia oil production platform. Hibernia has called upon us to deliver and install an object called a Christmas Tree. The Christmas tree is a configuration of many valves, spools, and fittings. But in order to have the wellhead prepared and ready for the

Christmas Tree we need to insert a gasket for a proper seal. Then cover it with the wellheads protective cover. As soon as were done with that task we move on to the second part which is to insert a hot stab into the wellhead to complete the seal.

To perform these different tasks we needed to use the pneumatic arms once again and a steel rod fabricated to act as a hook. The hook is to remove the cap from the wellhead. The precision arm is to place the gasket. The other arm is to finish the mission by inserting the hot stab into the wellhead.

#### **IV. Challenges**

The missions in the MATE International Competition are complex and realistic which make the building of the Kohola Kuainu more complex and more realistic. During the construction we ran into many situations where we needed to stop go backwards and either redesign or rebuild to find the best solution for our problem. The biggest problem we ran into was creating a ballast system which fulfilled our needs for each mission. We continuously encountered obstacles from the design process to the assembly of the ballast itself.

We put our minds together to brainstorm the best design possible. We were going to use just PVC and end caps, however simple, this proved to be unstable in the water. Another problem was that we wanted to be able to move up and down freely without the motorized power, as well as being keeping the ballast continually variable. In order to compensate for all the challenges that were occurring we decided to keep the idea of PVC and end caps for the foundation, and utilize balloons as a bladder. Designing was finished and now came the next step, constructing and forming of the ballast system.

Another problem that required much planning was the air supply system. The fittings for each line, the conversion of polyurethane tubing to copper tubing, the bending of copper tubing, and the configuration of the central air distributor all created unique obstacles. Designing the layout required linear thinking; while implementing it required hands on skills. We had to keep the entire system compact, while not sacrificing any function.

#### **V. Troubleshooting Techniques**

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

##### **Define the problem:**

- The motors aren't working

##### **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 became a self-directed learners.

Looking back on this past year I can see a lot of areas where we had to trouble shoot. I hadn't realized we were troubleshooting; when questions such as: why are the arms taking on water, why do the balloons keep popping, why is the cage not working like we planned, etc. 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.

## **VI. 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. In turn 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. This brought physics along with it, where and how much force is being subjected to one area of the ROV, which may render it immobile or nimble.

**Professional Attitude:** The team enhanced their professional attitude to suit the different working environments. The team learned that using the right attitude in the right place can get them the respect that they need. These are the types of skills that are needed to succeed in the profession world.

**Importance of Communication:** Communication among team members and mentor is important because if a leader's directions aren't clear, it leads to the job being done incorrectly. Not only did we lose time, but we lost materials and money due to our errors.

**Responsibility:** One of the unheard of but important skills is responsibility. The team learned that responsibility for your wrong doings shows a sense of character.

**Character:** Character is another great skill that is small but goes a long way. Someone who has good character usually makes it in the real world. All of this will be added to our knowledge base. Upon that base we have grown wiser.

## **VII. Future Improvements**

There were many places where we could have improved the structure of the ROV. Since the competition is only months away we have to use our ideas that we came up with for next years design. Next year we were talking about changing areas of the ROV like the frame, propulsion, and floatation.

### **Frame:**

- The frame this year was based on the design using two different materials to make our ROV light and sturdy in the Regional Competition. To use past knowledge in a new situation, we thought we should implement .952 cm carbon fiber rods for the entire ROV rather than just the upper portion. This would lighten the overall weight of the ROV. Also we would contemplate downsizing for more speed and maneuverability.

### **Propulsion:**

- To improve upon our current propulsion system we would use larger propellers of the same design as this year. For one, they have already proved to be the best in our testing, and two, more surface area would mean more thrust.

### **Floatation/ Ballast:**

- In the situation with our floatation we started out thinking that the ROV would be lighter then ever but it was gained more weight than we expected it to. Next year we are hoping to use less floatation and more ballast. So that we are able to dive and breach on command. Also we wanted to cut back on surface area from floatation so that the ROV is quicker in the water. The greater the surface area, the less hydrodynamic we are in the water which in turn slows us down.

## **VIII. Hind Sights**

**Dalfred Kaipo**

I was introduced to the field of engineering during an awards ceremony. I'm currently a junior at Kailua High School in my first year of robotics. Most memorable experiences are the differences in the purpose of specific tools, the importance of communication, and leadership.

Using the right tools in the right situation is very important to avoid damaging the tool, the object being worked on, and hurting yourself. Communication is important. If the message is not communicated effectively and efficiently, wasted materials and time will make us fall behind schedule. The most important quality that I developed this year was how to become a leader among my peers. As the captain of the team, I encountered many challenges and through trials and tribulations I matured from being just another teenager into a young adult. I realized just how much work it was to keep on top everything.

### **Nick Poleshaj**

After reflecting on the robot, and this past build, I realized that I learned several valuable skills and concepts. First, I learned how to be an effective leader. I saw the importance of having everyone working simultaneously. I was able to take note of what needed to be done, and assign it to someone with the capability to do so. I also learned some chemistry because of the ROV. In the previous competition, we used stainless steel and aluminum for the hybrid frame, but we noticed corrosion on the two metals. So I researched and learned that it is because of electrolysis. The interactions of electrons from the two metals cause them to corrode. So rubber was used on the frame to separate the aluminum from the stainless steel to prevent electrolysis.

I also learned the importance of precision as well. This was especially true with the stainless steel sleeves that I made to join the carbon fiber rods together. I had to make the cuts and angles as precise as possible; otherwise, the entire frame would be warped.

If I could go back and change anything, I wish I had more time to practice welding, because welding the thin stainless steel was very difficult. Just by looking at the ROV, it is evident that the ROV is student made, but had I been able to spend more time practicing, the welds would have looked more professional. I also wish that I had been a team leader earlier on in the build. If I had done so, by this time I would be much more proficient at being a leader.

### **Alex Vallejo-Sanderson**

During this past season in robotics, I have learned about the process electrolysis and the extra electron floating around which causes corrosion between aluminum and stainless steel. I also learned the different shapes and design of a propeller which are pitch, rake, skew, and cup. I learned how each of these elements affects the performance of the propeller as a whole. Because of this year, I also learned about the chemical reaction needed in the process when two materials are epoxyed together. Upon looking back at this year, if I could "re-do" anything I would ask more questions about the welder

and the plasma cutter so I could use these machines more effectively. Another thing I would “re-do” is I would pay more attention to detail. I would do this because I do not want to cancel out my work because of poor quality.

### **Kahue Kaopuiki**

The most I learned in the first year of robotics was about neutral buoyancy. To be neutrally buoyant means that an object will not float when pushed underwater. If the object is at surface then it will not sink. So in layman’s term, the object that is neutrally buoyant won’t sink or float unless force is applied to it.

Another thing that I learned in robotics is what a pneumatic arm is. At the beginning of robotics I only knew of hydraulics so when we decided to make pneumatic arms. I learned that pneumatic is the same as hydraulic but instead of liquids being pushed through the lines, air is. Lastly I had the privilege of welding. I didn’t know how to weld or the fact that if two metals aren’t the same it’s next to impossible to get a good weld. The molecular ions in the two metals won’t bond with the weld very well. Since the welder in the shop doesn’t work, my team member brought his MIG welder to shop. After all the welding for our ROV was completed, I had the opportunity to practice tacking and making a bead. What I would like to change for next year is get more time to practice welding. There are a lot of jobs that include welding and I would like to pursue it. Also I would take more initiative in my work. Instead of rushing through the work, I would measure twice and cut once. I will also take more ha’aeo (pride) in my work. I feel that these changes would make next year much better.

### **John Trueman**

This past year in robotics I learned a lot about teamwork because I found out if someone did not work or not show up to class, it can affect the team in many ways. Another thing that I learned was propulsion and propellers such as the different parts of a propeller like the rake, pitch, cup, and skew. The other thing that I learned a little about was welding such as how to make a good weld by gradually moving down until the metal glows orange.

I need to learn is good communication and responsibility because in the past I did not call in to report my absence. The other thing that I need to learn is respect because in the middle of the year I left the team and returned when they were almost done with the new robot, which was wrong. My goal in this is to be a better team member.

### **Noah Park**

Throughout the time I have spent within this team, we have come across many challenges and obstacles that of which have stood in our way of completing our task. Through hardship I learned many lessons. When we first started out, a lot of us didn’t know each other. As time progressed, we came to realize in order to get this going; we

would need to unite as a team, and work together to accomplish our goals in completing this ROV.

Another lesson well learned which ties into teamwork is communication. Communication is one of the lessons I had the hardest time to learn. I always had problems with public speaking and talking with strangers. To be an efficient team, communication is a key quality all its members need to be connected. Dedication is the most important lesson I've learned throughout this experience. When we first started out, I dedicated myself to the team. I came everyday, did my job, helped around where I could. When I didn't show up, work piled up and others got stuck with the work I was supposed to do. As I reflect on this project, I would improve on my lack of dedication and communication that I've had in the last few weeks. I haven't been there for the team, my dedication had been lacking, I kept out of touch with my team and most importantly my teacher.

### **Sen-Katsu Takata**

Through my time spent in robotics I have gained a lot and have had a hard time in it as well. I know it has been a really good experience, I learned a few things in class, like Archimedes principal. We used this formula to determine the amount of flotation we would need to make our ROV neutrally buoyant. I furthered my math skills by using ratios and algebra as well. I learned about the ballast system and how it plays an important role on our flotation.

I also learned about the camera system and the tether, and how sensitive they are. They require delicate care as we don't want to break them. We were taught this the hard way of learning from our own mistakes. We accidentally cut the camera lines and had to delicately splice them back together. And we also cut a few air lines from carelessness.

I wish I could improve on a few things such as my dedication to the class. I haven't always been there for the team, and I really do regret it. I only wish I could take back all the negative actions and poor decisions that I've made in the past. Feeling shameful, I have learned from experience how it feels to quit on something like a team. It feels like the whole world is resting on your chest. I would also like to improve on meeting responsibilities, communication and meeting deadlines.

### **VIII. 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.

- **Mrs. Francine Honda, Principal of Kailua High School** - For her support in both the monetary type but most importantly moral and administrative.
- **Mr. Derek Minakami, Physics teacher/CTE Coordinator** - For technical support in the copulation of our technical report, and his ability to handle our travel itinerary and finding that tiny needle in the giant haystack.
- **Mrs. "Aunty" Lorraine Asano, Account Clerk** - For gathering and compiling all the necessary forms and doing all the calculations in assuring our travel would be as trouble free as possible.

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- **Ameron International/Linda Goldstein** - We have ten thousand reasons to thank them for the support in easing the stress of fundraising and concentrate on expanding our educational foundations.
- **Lights Camera Action** - for helping us see in the dark. Your camera scholarship, what can we say? We wouldn't be able to see our futures without it.
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- **Pools Hawaii** - Your donations insured us we wouldn't drown in our own sorrows by keeping us afloat.
- **Genuine Auto Parts** - Assisting with the stainless steel collars and tapping.
- **Mark Rognstad, HURC Director** - Thank you for making this all possible. Your assistance with the happy hooker, motors, and cameras is why we're here. Mahalo nui loa!
- **All the Parents:** Mahalo nui loa for all the food, drinks, and snacks. Your moral and spiritual support will help us to explore our futures, and fulfill our dreams. We hope we make you proud, and all the trouble you had to put up with will pay off big (time) in our lives.
- **Mr. & Mrs. Leonid Poleshaj** - without your administrative support we'd be up the creek without an ROV, starving and broke. Without your generous donations we'd just be all over the place blowing bubbles.
- **Mr. & Mrs. Dale Vallejo-Sanderson** - You fed His sheep and supplied the bread—pudding that is. And other very sustainable yum-yums? Not to mention our ROV would be stuck in Hawaii. Thank you for the hook-ups.
- **Mrs. Maile Kaipo** - Assisting in the chaperone duties in Canada.
- **Mr. & Mrs Kaopuiki & Jennifer Kaopuiki** - For our designer sweaters, ono loa mea'ai (very delicious food).
- **Ms. BJ Field, Vice Principal** - We are greatly in your debt. What other person would want to subject themselves, as our chaperone, to our constant talking, making fun of each other, countless arguments which go no where or mean anything, or just basically all the insanity we offer. Not only for the eighteen hour flight, but throughout the whole competition. We also thank you for all your moral support and just being there when it mattered the most.
- **Mr. Rodney "Break Everything" Tabiolo & Mr. David Izumi** – Slave Driver, Coach, & Advisor. Their advice and encouragement helped us strive to build our robot to the caliber that it is. Your motivation skills are what have kept this team on track. Without your our aid has greatly helped us expand our knowledge and make our high school experiences that much better. The knowledge that you have shared with us has improved our understanding of industrial engineering. Thank you again for preparing us for situations outside of high school.

### VIII. Budget Sheet

Date	Donation or Expense	Description	Reason	Debit	Credit	Balance
05-06	Donation	Carry over from 2006		\$114		\$114
10/5/06	Donation	MATE	Misc. supplies, Travel		\$1000	\$1114
2/23/07	Expense	Hardware Hawaii	Shooter Supplies	\$16.03		\$1097.97
2/28/07	Expense	Hardware Hawaii	Floation Device	\$0.00		\$1097.97
3/10/07	Expense	Hardware Hawaii	Hardware	\$60.17		\$1037.80
3/12/07	Expense	Genuine Auto Parts	Thread Steel Rods x2	\$20.00		\$1017.80
3/15/07	Expense	Genuine Auto Parts	Drill holes in steel plate	\$92.86		\$924.94
3/20/07	Expense	Hydra-Air Pacific	Ball Valves	\$34.74		\$890.20
3/21/07	Expense	Hardware Hawaii	Air lines	\$44.75		\$845.45
4/3/07	Expense	Hardware Hawaii	Pneumatic Cylinder	\$28.05		\$817.40
4/ 5/ 07	Expense	Hardware Hawaii	Control Box supplies	\$39.56		\$777.84
4/ 6/ 07	Expense	Hardware Hawaii	Aluminum channel	\$15.68		\$762.16
4/ 8/07	Expense	Genuine Auto Parts	drive shaft collar	\$20.00		\$742.16
4/10/07	Expense	Buck's Pool & Spa	Floation	\$0.00		\$742.16
4/11/07	Expense	Hardware Hawaii	Spray Paint	\$37.11		\$705.05
4/18/07	Expense	Hardware Hawaii	Spray foam	\$11.34		\$693.71
4/23/07	Donation	Genuine Auto Parts	Thread Stainless Rod x2	\$0.00		\$693.71
4/24/07	Donation	Advantage Carpet Care	50 ft vacuum	\$0.00		\$693.71
5/ 3/ 07	Expense	Hardware Hawaii	Copper tubing	\$28.64		\$665.07
5/17/07	Expense	Hardware Hawaii	Miscellaneous	\$122.42		\$542.65
5/17/07	Expense	Hydra-Air Pacific	Ball Valves	\$56.89		\$485.76
5/21/07	Expense	Hydra-Air Pacific	Ball Valves	\$50.07		\$435.69
5/23/07	Expense	Hardware Hawaii	Ball Valves	\$5.74		\$429.95
		<b>Total Spent/Balance Remaining</b>		<b>\$684.05</b>		<b>\$429.95</b>