Tiki Technologies
Keakakehe High School

Company Specs: Returning Team since '10

Location: Kailua-Kona, Hawaii USA: 4795 Miles from MATE International

CEO: Kela Hauck (12th)

CFO: Adam Agpaoa (12th)

Pilots: Kela Hauck (12th)

Dana Jennings (12th)

Design Engineers:

Niko Cabutaje (12th)

Mark Lopez (10th)

Electrical Engineers:

Dana Jennings (12th)

Michael Rangasan (11th)

Adam Agpaoa (12th)

Tether Managers/Safety Officers: Michael Rangasan (11th) Adam Agpaoa (12th)

Mentors: Justin Brown, Mike Hauck, Nem Lau, and Chris Ibarra

Primary Materials: PVC and VEX Metal Cost: $926.78 USD

Dimensions- Frame: 37cm x 48cm x 28cm

Weight: approx. 10kg

Safety Features: Motor mounts, Caution Tape, Safety-Certified Operators, and Main Safety Fuse

Special Features: 4 full range tools, 10 meter tether, DPDT drive, Omni-directional movement

Abstract:

The Kealakehe HS Tiki Techs would like to present its 2012 remotely operated underwater vehicle for MATE's Remotely Operated Vehicle (ROV) Competition. This year our ROV was tasked with simulating taking the pulse of the ocean and finding solutions to many of the problems and tasks associated with it. The Tiki Techs worked collaboratively to design, model, create, test, and refine this ROV to ensure the successful completion of all of the tasks and challenges. The challenges required a submersible vehicle that could drive quickly between tasks and have smooth access to all of the tools. The Tiki Techs specifically engineered each tool for this year's tasks. Tool design was tested in isolation and then incorporated into the whole ROV. The team parallels industrial practices through creating weekly working group with project managers that organized human resources and ensured timely competition of each stage. Each week the Tiki Techs meets for 10 hours collectively while individual project managers often call for additional small group meetings to complete a limited task. On Fridays, the team conducts a thirty minute debrief to recap the previous week's progress and make an action plan for the next week. This process allowed the team to work through many challenging situations and create a fully functional and tested ROV. The team also worked to ensure educational synergy through community outreach/education, technical writing, and media relations.

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ROV Budget & Expenses

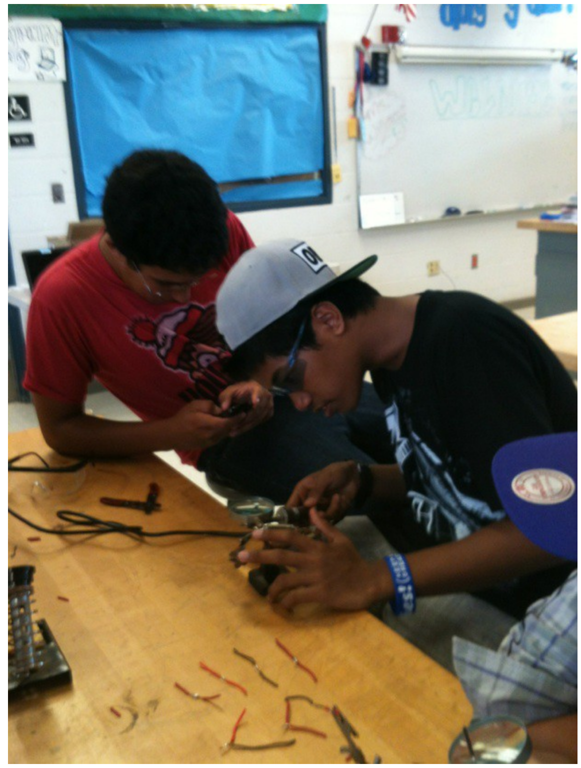
Item	Category	Amount
1/2 " 10 ft. PVC Pipe (2 @ $1.36)	Frame	$2.72
1/2" PVC - T's (15 @$0.36)	Frame	$5.40
½" PVC – 4 Way (2 @ $ 0.42)	Frame	$0.84
3" 5 ft. ABS – Motor Coupler (1 @ $ 5.49)	Frame	$5.49
½" PVC – 3 Way Corner (10 @ $ 0.40)	Frame	$4.00
½" PVC – Male Adapter (10 @ $0.33)	Frame	$3.30
Propellers (4 @ $4.99)	Propulsion	$19.96
Drive Adapter (7 @ $.59)	Propulsion	$4.17
PVC Electrical Box with lid 26.5 cubic inches (2 @ $10.51)	Propulsion & Tools	$21.02
DPDT Center Off 10 - Amp Toggle Switch (4 @ $5.99)	Propulsion & Tools	$23.96
Cherry Switch Joyce Stick	Propulsion	$34.95
Bilge Pump Motor Cartridge (500 Gph. / 1890 Lph.) (2 @ $17.15)	Propulsion & Tools	$34.30
4- 1250gph motors- $30 Each	Propulsion	$120
Octura 2" Propellers (4 @ $ 19.95)	Propulsion	$79.80
100 ft. 16 gauge Wire – Red, Black, Blue	Electrical	$13.99
100 ft. 20 gauge Wire – Blue	Electrical	$13.95
Cable Ties (Bag of Various Sizes)	Electrical	$7.95
Silver - Bearing Solder 1 oz. (2 @ $5.49)	Electrical	$10.98
1/2" Heat Shrink Tubing Black (3 pack)	Electrical	$10.00
66 ft. 3/4" Super - Strength Electrical Tape	Electrical	$3.99
10 amp relays (11 @ $12 Each)	Electrical	$132
Aluminum Bar – Vex Type	Mission Tools (Task One/Two)	Recycled
VEX Claw	Mission Tools (Task One/Two)	$14.95
50 ft. Category 5 Network Wire	Mission Tools (Task One/Two)	$25.00
3'' Carabineer	Mission Tools (Task One/Two)	$3.95
Aluminum Plate (7.5" x 2.5") – Vex Type	Mission Tools (Task Two)	Recycled
Water Bottle	Mission Tools (Task	Recycled

	Three)	
Metric Dive Watch	Mission Tools (Task Three)	$39.99
1/4” All Thread Bar	Mission Tools (Task Four)	$3.95
¼’’ x 24’’ x 36’’ Plexiglass	Mission Tools (Task Four)	$24.99
2’’ 10 ft PVC	Ballast System	$7.99
Pool Noodles (9 pack)	Ballast System	$36.99
Frost King 3/4" x 6' Self Seal Foam Pipe Insulation (10 @ $5.86)	Ballast System	$58.60
1/2" 10 ft. PVC Pipe	Mission Props	$1.36
1" 5 ft. PVC Pipe	Mission Props	$2.07
Donated SOSI Tether (Shipping)	Connection	$48
	Total:	$720.61
Donations	**Category**	**Amount**
Bunker Hill Security Underwater Camera with Two Black and White Monitors	Electrical	$129.99
Blige Pump Motor Cartridge (500 Gph. / 1890 Lph.) Four Total ($17.15 each)	Propulsion & Tools	$68.60
Project Boxes (2 @ $3.79)	Propulsion	$7.58
	Total:	$206.17

Student Hours (18 Students)	Total Hours	Adult Hours Mentor (4) /Parent (3)	Total Hours
Design/Construction	450	Shopping/Cultivating Donations And Work Space	1000
Research, Technical Report, and Display	50	Safety Supervision And Team Management	200
Student Pool Practice	50	Transportation, in-home work time, and research	50
Student Hours	550	**Adult Hours**	**350**
		Student and Adult Hours	**900**

Design Rationale:

The Tiki Techs specifically designed *Aqua-Tiger* to accomplish the MATE Center 2013 ROV competition mission tasks. The goal for this robot was to create a simple, low maintenance, low cost, environmentally friendly, submersible ROV that could safely accomplish the MATE tasks with efficiency, reliability, and accuracy. Before *Aqua-Tiger* was created, design engineers began designing the ROV, they spent three weeks researching the mission tasks and developing an action plan for construction.



Aqua-Tiger's frame, camera, motor mountings and payload tools were purposefully constructed to accomplish the specified mission tasks as quickly as possible. For example, the Hooked claw on *Aqua-Tiger* was designed to help complete the first mission; transferring the CTA to the BIA connection. The camera mountings were designed so that they could be used in all mission tasks. Using each of the payload tools, *Aqua-Tiger* is able to accomplish many different tasks.

Structure:

The design engineers developed the initial action plan for the ROV while researching ROVs, examining previous ROV competition models, and interviewing the 2007-2011 ROV team members. During the time spent on brainstorming for ideas, the Tiki Techs had to look for different ways to improve the frames of the previous ROVs. This allows *Aqua-Tiger* to complete tasks from the mission report with speed and efficiency. We collaboratively constructed the PVC (polyvinyl chloride) frame, customized tool fittings, camera and engine mountings to simulate the types of technologies we could use in future ocean careers.

Design Specifications:

The Tiki Techs tether allows the *Aqua-Tiger* to dive to a depth of 15 meters and the cameras posses a certified depth rating of up to 18 meters; however, the heavy-duty bilge pump motors used for propulsion can only function at depths of 8 meters. *Aqua-Tiger* weighs an approximated 10 kilograms and measures 37 cm x 48 cm x 28 cm . There is an extension on the top of the ROV that goes up 12.5 cm because of two pontoons and a camera mount extension 41 cm from the upper frame. Along with these additions for the height of the robot, *Aqua-Tiger* has a 23 cm tool extension on the length and also has a 23 cm extension on the width of the robot for motor mounts. With the main structure of the ROV, there are also three Lemensco Underwater Cameras. The design engineers chose this camera system because it has RV8 ports which conveniently plug into most consumer grade television sets. They discovered this camera system uses less energy and can draw its power directly from the tether and in conjunction with the battery system. With full view of the outer limits of the structure, the design engineers positioned the cameras above the ROV facing the front and back of the frame.

The design engineers wanted to decrease the drag a large tether adds to an ROV so it was decided to use a tether with smaller wires connected to a relay system in the top-middle of the ROV. To ensure even submersion and to assist with buoyancy, holes were drilled into calculated portions of the PVC frame. This helps the *Aqua-Tiger* from tipping and listing. All wires from motors and tools are tethered to the frame to prevent the wires from catching on the motors and unintentionally hooking course props to our ROV. All appendages added to the frame were designed to create a center of gravity as close to the geographical center of the ROV as possible.

Propulsion:

The Tiki Techs underwater robot has submersible Johnson Mayfair Marine Bilge Pump Replacement Cartridge Motors. There are four thrusters all together, configured as following: Two ascent/decent motors placed diagonally across from each other on the inner portion of the frame and two directional motors positioned outside of the frame by PVC joints and mountings.

Ascent/Descent Motors:

Two center-mounted thrusters serve to ascend and descend the ROV. Each ascent/descent motor draws two amps under a full load and spins at a rate of 1,892 LPH (liters/hour). Using pipe clamps, we surrounded the ascent/descent propellers in sturdy ABS (Acrylonitrile Butadiene Styrene) pipe couplings for safety and to direct propulsion in one steady stream for increased propulsion. The ascent/decent motors are centered to maximize power output. This ensures *Aqua-Tiger*'s efficiency when accomplishing tasks that require a considerable amount of lift power. *Aqua-Tiger*'s ascent/descent motors are fitted with two propellers to increase water flow and vertical speed. Tiki Techs decided to use a custom trimmed model RC boat propeller 5.4 cm diameter.

Forward, Reverse, Left and Right Propulsion:

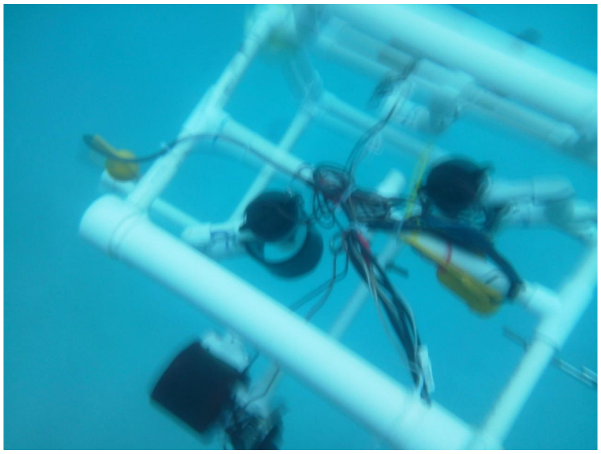
Two motors allow *Aqua-Tiger* to propel forward, reverse, left and right. The team decided to use DPDT (Double Pull Double Throw) Switch. This new system is allowing *Aqua-Tiger* to have easy ability for making the R.O.V. move left, right, backwards, and forwards. The Tiki Techs implemented hose clamps on the robot for safety and to direct propulsion in one steady stream to increase propulsion. The left, right, forward and reverse thrusters draw three amps each under a full load and spin at a rate of 1,892 LPH (Liters per hour). The forward, reverse, left, and right propulsion thrusters are centered to maximize the efficiency of the output.

Electrical & Control System:

The *Aqua-Tiger* control system utilizes one control box for propulsion. The control box has three double pole, double throw, center off switches. Using a heavy-duty toggle for up and down commands, *Aqua-Tiger* was able to have a simpler and much more effective control system. Switch # 1 controls the left motor and Switch # 2 controls the right motor. These switches are moved forward together to move forward and back together to drive backwards. Switch # 3 controls ascent/decent. This allows *Aqua-Tiger* to move left, right, forwards, and backwards. Tiki Techs worked hard on soldering the two control boxes & waterproofing our electrical system with, candle wax, silicon, two-way tape, shrink-wraps & triple wraps of electrical tape, in order to ensure safe, reliable and easy to use electrical controls.

For safety, we installed a 25-amp main fuse and two 2 amp fuses after the main fuse for additional protection for the camera system. There are two heavy-duty male banana clips to connect to the 12-volt marine battery that is allowed to use for power.

Ballast System:



The ballast system is made up of two 2.54 cm PVC pipe pontoons to neutralize the R.O.V.'s buoyancy and list. The Tiki Techs continue to work with cut pool noodles and foam pipe insulation added to the tether to achieve neutral buoyancy. This helps keep the tether behind the ROV and allows a clear vision line for the cameras. Additionally, using these recycled pool noodles helps keep the costs down and decrease the overall environmental impact. The Tiki Techs have started to work with weights in order to impede the buoyancy of the Temperature Probe. Fish weights are placed in the base of the temperature system to allow a constant docking system while smaller pool noodles are placed every 1-2 feet along the cord to the laptop reader on deck.

Payload Tools:

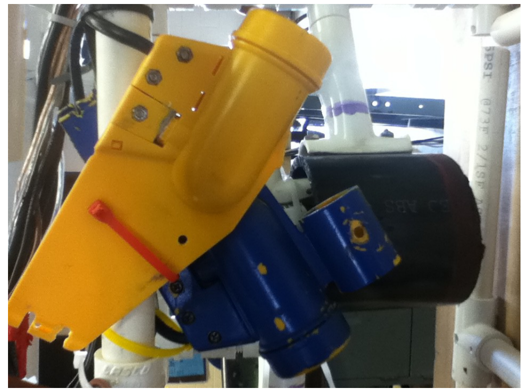
Tiki Techs prioritize innovation and creativity when creating simple, low cost, low maintenance tools for the mission tasks. For task one and three, we designed two tools: an SIA Transport and CTA Holder. These tools are used for different parts of both tasks. The SIA Transport is a hook attached to the bottom of the ROV designed to transport the SIA and the OBS. It secures the object in its move to the designated area. The CTA Holder, located in the front of the ROV, is a multipurpose hook designed to encompass the CTA and to move other parts. It is used to: transport the CTA, release the OBS from the elevator, open the door of the BIA, and transport the OBS cable connector.

For task two, we designed the Temperature Probe located at the front of the ROV. This tool is used to measure the temperature of the Hydrothermal Vent over the span of six minutes. The tool uses HOBOware Pro Software to graph the information.

Our last tool, the Bio-foul Collector, located at the back of the ROV, is used to amass Bio-foul. It also has the ability to transport the OBS, unlock the locking mechanism on the mooring platform, open the mooring platform hatch, and transport the ADCP.

Camera System:

Multiple cameras were donated for use on *Aqua-Tiger* ROV. *Aqua-Tiger*'s motors were reused from a previous ROV. The camera specs are: 12-volt, 2 watt, 270,000 pixel, 0-LUX minimum illumination, 70 degree viewing angle and a certified depth rating of 18 meters. We configured three cameras as follows:



–Camera #1, the drive camera, is located at the front of the robot. It looks upon the Temperature Probe and the CTA Holder.

–Camera #2 is located at the center of the robot and looks upon the SIA Transport.

–Camera #3, the reverse drive camera, is located at the back of the ROV. It looks upon the Bio-Foul Collector and allow the robot reverse driving ability.

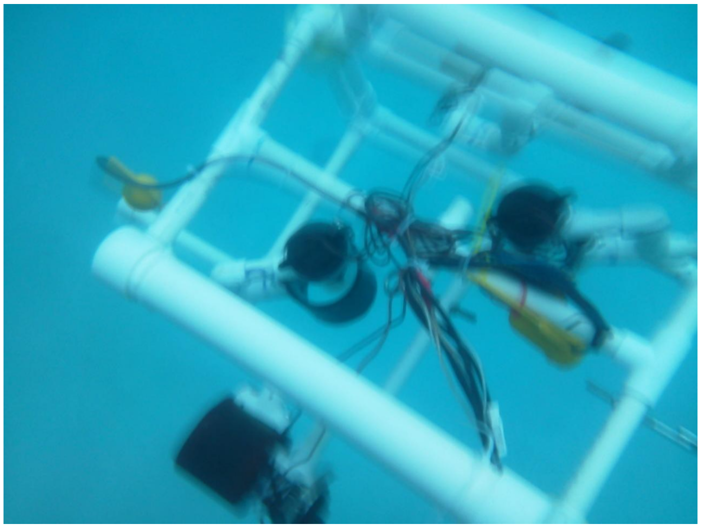
Challenges:

The greatest challenge Tiki Techs faced was prioritizing time. Many of the challenges Tiki Techs overcame stemmed from the fact that the team was crunched for time. Many of the members of the team were occupied preparing for other robotics competitions which left a small amount of people working on the ROV, this lead to a month of crunch time. The Tiki Techs had the great fortunate of winning the Hawaii Vex and the Hawaii FIRST

competition which at times diverted human capital and financial resources away from the project. Because of our work to increase our team efficiency and ensure a strong product, these circumstances did not preclude our participation and success at the MATE ROV Big Island Regional.

Another challenge faced was trying to make the ROV neutrally buoyant. The team spent hours testing buoyancy, adding weights and experimenting with different pontoon sizes. The team was pleased the relay system allowed a skinny dual cord tether to be used, but wanted to make sure that a lack of neutral buoyancy would not steal the added effectiveness.

Trouble Shooting:



Sometimes solutions were easy, such as checking switches, using a multimeter to check current flow, or tightening propeller screws. At other times, the solutions were more difficult and hard to correct. When the thrusters malfunctioned, the team checked the connections in the control box, re-wiring and re-soldering when necessary. The time spent training and understanding how the ROV functioned helped the team collaboratively solve many problems as they arose. Careful record keeping of the drive system also assuaged difficulties when fixing electrical errors. When the PVC was glued incorrectly, the team banded together to solve the issue.

Future Improvements:

In the future Tiki Techs would like to try waterproofing SERVO motors to make robotic arms or hands to accomplish missions. Another improvement would include switching the outdated control system that is already in place to a programmed circuit board system. This new system is actually similar to the control system that real ROVs operate. The slow start this year reminded the team to improve time management and start the ROV project earlier in the school year. Tiki Techs only had a few weeks to prepare for the regional competition.

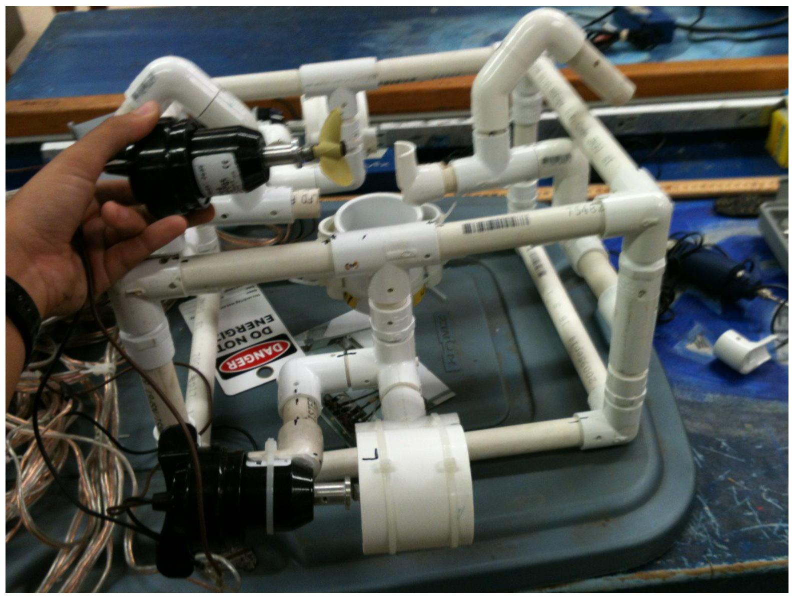
Next year, Tiki Techs would like to have a practice tank located at school to test the waterproof nature of the ROV starting 8 weeks from the regional competition. This would allow the deck crew more time to test the ROV and to prepare for the assigned missions.

Along with getting a head start on the ROV, Tiki Techs would also like to increase our community outreach programs to help inform and inspire the community in ROV work and the role of underwater robotics on our island. Eight members of the team have enrolled in a metal and welding program for next year. The Tiki Techs plan to experiment with an aluminum framed ROV next year to better parallel modern industrial models.

Lessons Learned:

The main lesson the Tiki Techs learned was the importance of communication. Weekly emails are sent out to the team detailing updates and dates and times of additional work sessions. Every Friday the team has a thirty minute debriefing on what had been accomplished during the week and what still needs to be done. The team also addresses any problems that have arisen so they can be solved effectively and efficiently.

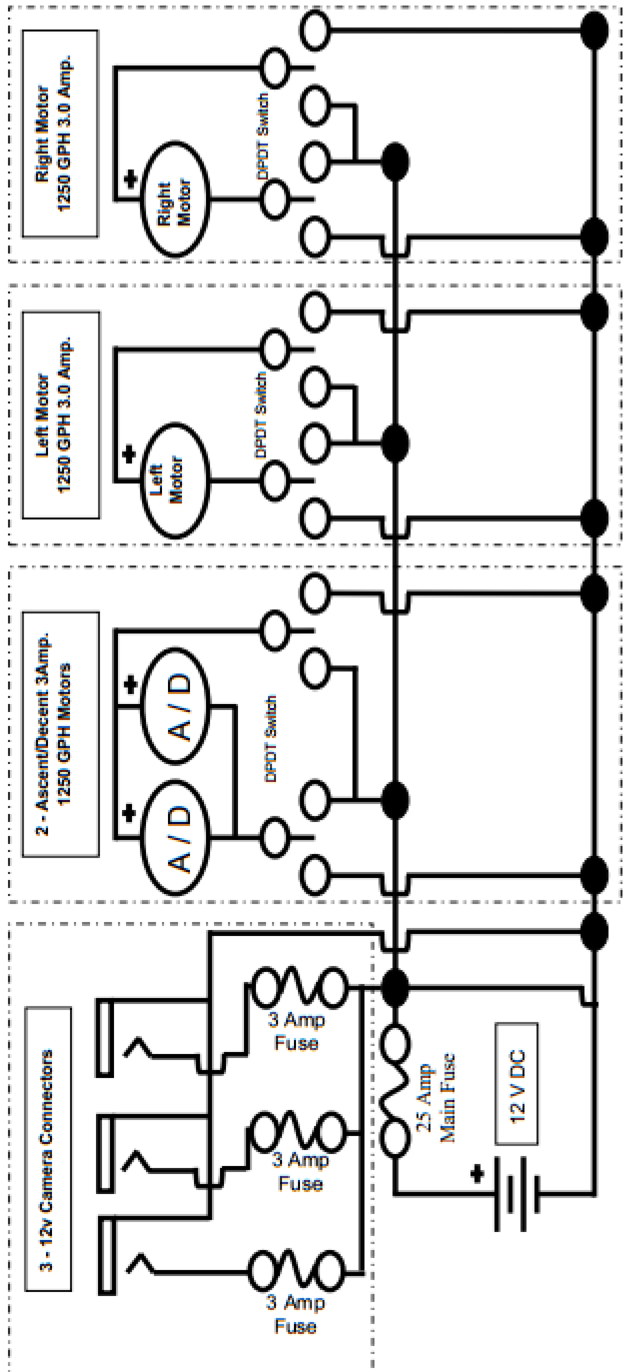
The Tiki Techs team also learned many valuable skills that can be used throughout life. Some of these skills include fund-raising, public speaking, team work, soldering, electrical configuration, wiring systems, problem solving, divergent thinking, innovation as well as many others.



Another important system the Tiki Techs has learned about was the oceanographic systems. A theme for the 2013 ROV Competition is addressing the significant role of ROV's in real world situations. The reasoning for this choice was to better understand the natural phenomena of earth's largest ecosystem, the ocean.

The ocean has drastically changed over the past few decades due to humanity's disruption of the ecosystem. As time progresses, weather patterns begin to change because of human activity. As a result of these changes, the ecosystem has taken irreversible damage. Droughts, floods, and fires have begun to appear in regions where these events are unexpected. In retaliation to these events, technology has expanded in order to increase our capability to understand the “Pulse of the Ocean”. We have learned how to improve the accuracy of predicting weather and ocean conditions. Society has created robots able to travel to inhospitable areas, giving us the opportunity to understand how the underwater ecosystem has changed and how it effects the planet.

Electrical Schematic:



Sources:

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>http://www.oceaneering.com/rovs/rov-faq/<

Acknowledgements:

The team would like to thank our ROV mentors, Mr. Justin Brown, Mr. Mike Hauck, and Mr. Chris Ibarra. This is Mr. Browns' fourth year of teaching and, with his busy schedule of graduate classes and instructing Model United Nations; he agreed to mentor Kealakehe High School's robotics program. Mr. Mike Hauck and Chris Ibarra are our technical advisers and answer any technical related question that arises. Without this support, the program would cease to exist.

The Tiki Techs also want to thank their generous sponsors Nan Inc, Ace Hardware, Hawai'i Community Foundation, Robotics Organizing Committee (ROC), Mike-Ro-Tech, Thirty Meter Telescope (TMT), Akamai Machine, ABC Stores, and Mark & Carol Solien. They would also like to thank the judges and volunteers as well as MATE. Without these important people, the ROV competition would not be as successful as it is.

Mahalo nui loa. Aloha kakou,
Kealakehe Tiki Techs