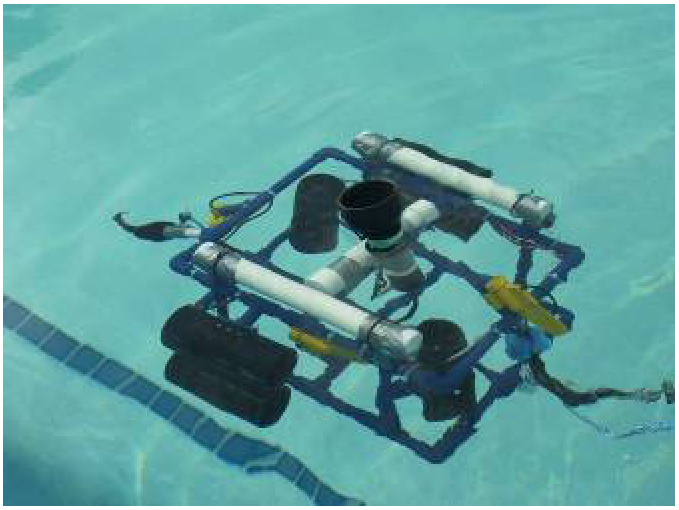


Subzero ʻIo

Kealakehe Intermediate School ROV Team

Kailua-Kona, Hawaii USA

Seventh Grade Student Team Leaders:
Ileana Argyris (12), Jonathan Kutsunai (13)

Seventh Grade Student Core Team members:
Kela Hauck (12), Koloa Kalavi (13), Alayna Machacek (13), Ariana Matthews (13)

Mentors:

Lisa Diaz, Mike Hauck, Jeannie Kutsunai,

Gretchen Matthews, Andrew & Terry Argyris, Garrett Frost, Aivale Nu'usolia

Abstract

Subzero ʻIo was designed by Kealakehe Intermediate's ROV Team specifically for the 3 missions required in MATE's 2007 International Competition. The name, *Subzero ʻIo*, references extreme polar temperatures plus our school mascot, the Hawaiian hawk.

Subzero ʻIo measures 72 cm. x 77 cm. x 47 cm. We have six thrusters: two for ascent & descent, and four thrusters for left & right that double for forward & reverse movement. All our thrusters are surrounded by custom-made cowlings for safety and to direct power in a steady stream. The frame is made of PVC. To stabilize & adjust our ROV to neutral buoyancy, we used 5.08 cm diameter PVC tubes as pontoon floats, and clip-on fishing weights.

We were innovative by creating simple, low cost, low maintenance tools for complex mission tasks, including:

A Velcro threading sleeve, three custom fabricated hooks, a jellyfish collector, and an algae vacuum collector. For mission #1: a threading sleeve is used to thread a messenger line through a mooring, & our Velcro-wrapped, J-hook brings the line to the surface. For Mission #2: the jellyfish collector is used to collect the jellyfish without harming the organism. A vacuum retrieves the algae sample from beneath the ice. The S-hook deploys the PAS unit. For Mission #3: The S-hook, J-hook and double hook service the wellhead.

The beauty of Subzero ʻIo is its simplicity. We created a low maintenance/low cost, environmentally friendly, stable submersible ROV to accomplish MATE's missions with speed and accuracy.

ROV Budget & Expenses

Items:	Category:	Amount:
PVC pipe, T's, elbows	Frame	37.38
PVC, T's, elbows, Coupler, Wire, Velcro, Msgr. Line, Bilge pump, vacuum hose, wire strainers, knee high sock	Mission Tools	64.97
Toggle switches, wire, cable, solder, shrink wraps, Electrical tape, control boxes, alligator clips, silicon	Electrical	69.03
1000 GPH marine bilge cartridge motor w/shipping Marine Tex patching compound for motors	Propulsion Motors	49.95
1 Harbor Freight u/w Camera/Monitor kit w/shipping	Sensors	129.89
Pool Noodles, Foam Pipe Insulation, tie-wraps	Ballast System	23.79
ACTUAL ROV NEW '07 OUT OF POCKET EXPENSES	**SUBTOTAL**	**375.01**

MISSION PROP SUPPLIES: (Kona practice)

PVC, elbows, T's, chain, shackle, U-bolt, cement, ping pong balls, Couplers, end-caps, ABS pipe, gasket, line, weight, tie wraps, cable	Mission Prop supplies	102.95

TOOL BOX

Wire cutters, soldering iron	Tool Box	37. 72

TOTAL '07 PROJECT EXPENSES: $515.68

DONATED ITEMS:	Donors /Grantors:	Estimated AMT:
2/ 500 GPH Mayfair Marine cartridge bilge pump motors, Propellers, adapters, drive dogs, CAT 5 wire	HELCO '07 grant	~ 100.00
Pool cover, AC power supply, PVC pipe, meter stick	Parents/Mentors	~ 50.00
'07 DONATIONS TOTAL:		**~ $150.00**

RE-USED ITEMS from '06 ROV Project:		ESTIMATION:
2/500 GPH Mayfair Marine cartridge bilge pump motors	Larry Rice '06 Grant	~ 95.00
1/100 GPH Mayfair Marine cartridge bilge pump motors	Larry Rice	
12 volt Marine Battery		
2 Harbor Freight u/w security cameras, 1 Harbor Freight monitor, 12 V battery, cables, charger	Purchased '06	~150.00
Tool box & basic tools	Larry Rice '06 Grant	~100.00
TOTAL RE-USED ITEMS		**~$345.00**

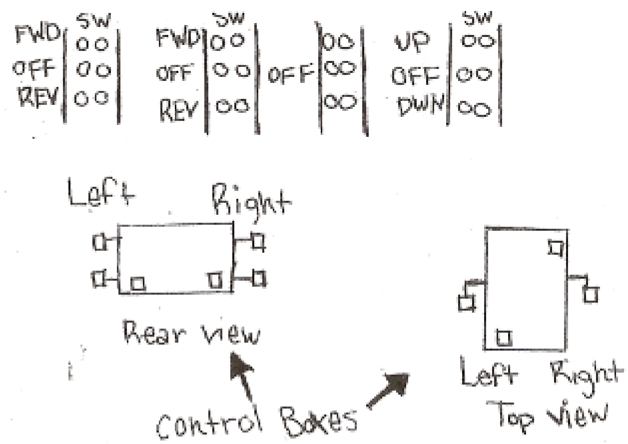
STUDENT HOURS:

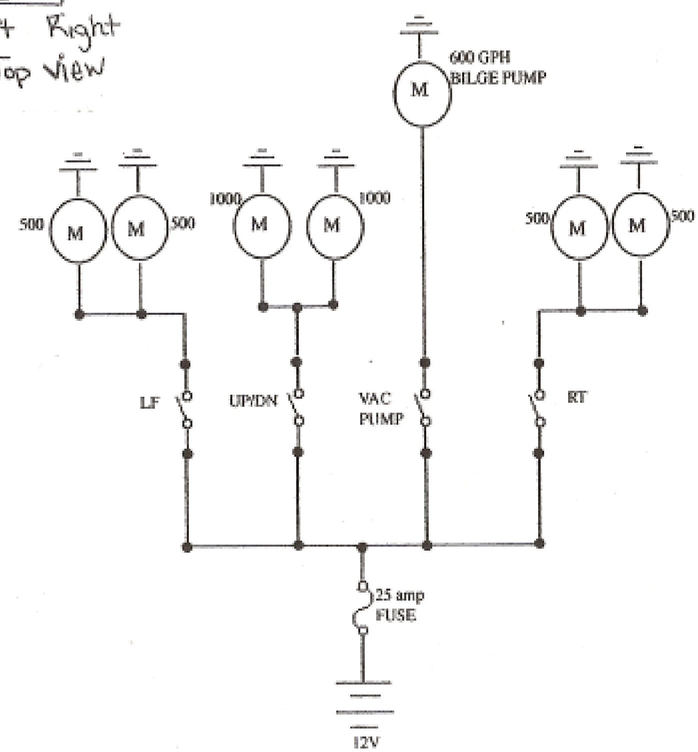
TOTAL ESTIMATED STUDENT (12 STUDENTS) DESIGN/CONSTRUCTION	HRS:	500
TOTAL ESTIMATED STUDENT (10 STUDENTS) RESEARCH/TECH REPORT/DISPLAY	HRS:	60
TOTAL ESTIMATED STUDENT (6 STUDENTS) POOL PRACTICE HOURS:		180
TOTAL STUDENT HOURS:		800

ADULT HOURS:

TOTAL ESTIMATED MENTOR (2) /PARENT (4) (Shopping/safety supervision) HOURS:	100
TOTAL ESTIMATED TEACHER (1) (Shopping, supervising) HOURS:	150
TOTAL ESTIMATED ADULT HOURS:	250

Electrical and Control Box Schematic





LEGEND

500/ 3 amp

1000/ 4 amp

Bilge/ 3 amp

Design Rationale:

We designed *Sub Zero ʻIo* specifically to accomplish the MATE Center 2007 International ROV competition mission tasks. Our goal was to create a simple, low maintenance/low cost, yet very stable, environmentally friendly, submersible ROV that could accomplish the MATE missions with speed and accuracy. We designed our ROV frame to fit through the 80 cm ice hole in mission #2. We constructed our frame, camera and motor mountings plus our payload tools to accomplish the mission tasks. For example, all camera mountings are adjustable to function in all three missions and each of our payload tools are designed to accomplish specific mission tasks, as explained in detail below.

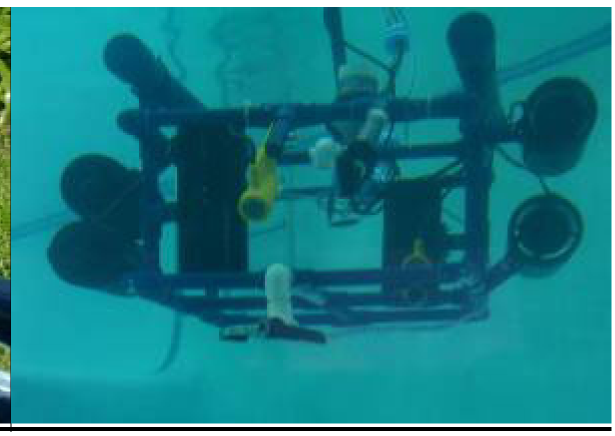
Structure:

We got ideas for our frame by researching ROV websites, examining past Kealakehe Intermediate School ROV models and by interviewing the 2006 ROV team. We brainstormed on ways to improve the frame. We decided to build a large ROV frame, to improve stability. We kept the size under 80 cm, to fit through the ice hole. We built the PVC (polyvinyl chloride) frame, customized tool fittings and camera and engine mountings around the 2007 MATE competition mission tasks.

Design Specifications:

Due to the tether length, *Subzero ‘Io* is limited to a depth of 15 meters. Our cameras have a certified depth rating of up to 18 meters & our heavy-duty bilge pump motors can function at depths of 8 meters. *Subzero ‘Io* weighs 7.7 kilograms and measures 72 cm. x 77 cm. x 47 cm.

Propulsion:



We used submersible Johnson Mayfair Marine bilge pump replacement cartridge motors for our thrusters. We have six thrusters all together, configured as follows:

Ascent/Descent Motors:

Two center-mounted thrusters serve as ascent and descent power. Each ascent/descent motor draws four amps under a full load and spins at a rate of 3,785 LPH (liters/hour). We surrounded the ascent/descent motors in sturdy ABS (Acrylonitrile Butadiene Styrene) pipe cowlings for safety and to direct propulsion in one steady stream to increase power. We centered our most powerful ascent/descent motors for mission #1 and mission #2 (Task 3: PAS deployment), which require a considerable amount of lift power. Our ascent/descent motors are fitted with two propellers for more power. We used a custom trimmed model airplane propeller and a standard model boat propeller.

<u>Forward, Reverse, Left and Right Propulsion:</u>

Four motors act as forward, reverse, left and right 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).

<u>Electrical & Control System:</u>

Left - Propulsion control box; Right - Algae Vacuum collector control box

Bottom Left - Algae Vacuum collector control box; Bottom Right - Propulsion control box

Our control system utilizes two control boxes: a gray box that controls the propulsion and a black box that controls the vacuum pump tool.

The grey propulsion control box has four switches. We used heavy-duty toggle switches so we could simplify our controls and wire in two motors per switch. Switch # 1 controls the two ascent/descent motors: this switch is moved forward to descend down and back to ascend up.

Switch #2 controls our two left motors and switch # 3 controls the 2 right motors. If you flip the second switch & third switches forward together, the ROV propels forward and if you switch them backwards, the ROV thrusts backwards. Our team worked hard on soldering the two control boxes & waterproofing our electrical system with silicon, two way tape, shrink-wraps & triple wraps of electrical tape, so we could ensure safe, reliable and easy to use electrical controls. We have 20 conductors in our tether. For safety, we installed a 25-amp fuse. We have two heavy-duty male banana clips to connect with the 12-volt marine battery we are required to use for power.

Ballast System:

Our ballast system is made up of PVC pipe pontoon floats with end caps, plus 36 kilograms of clip-on lead fishing weights to neutralize the Rov's buoyancy. Because the weights can be easily clipped-on or taken off, we can adjust the buoyancy needed for each mission. We added cut pool noodles & foam pipe insulation to the tether to achieve neutral buoyancy.

Payload Tools:

We were innovative with creating simple, low cost, low maintenance tools for complex mission tasks.

The threading sleeve and rope

For Mission 1, we designed a Velcro threading sleeve, to thread the messenger line and a custom welded J-shaped hook wrapped with Velcro to hook the messenger line and transport it to the surface.

Benthic Jellyfish collector

For Mission 2, we designed three special tools. For task 1, we designed a benthic jellyfish collector, which consists of a 5.08-7.62 centimeter rubber pipe adapter, a 5.08-2.54 centimeter PVC pipe adapter and a 2.54-1.27 centimeter pipe adapter that connects to the ROV. For Mission two, task 2, we designed an algae vacuum collector, which contains a strainer inside of a 7.62 cm. diameter pipe connected to a bilge pump vacuum. We designed both of our collection tools so that our biological specimens would not be damaged. For Mission two, task 3, we designed a custom S-hook to bring the Passive Acoustic Sensor down to the 80 cm. square.

The S-hook

The double hook

For mission 3, task 1, we re-used our s-hook from mission 2 to take the gasket down to the well head, take the cap off the well head, place the gasket into the well head and put the cap back onto the well head.

For mission 3, task two, we designed a double hook to hold the hot stab and to insert it into the port.

Camera System:

We chose to purchase a camera system to be cost effective and to ensure reliability. We purchased a Bunker Hill Security underwater camera system on sale from Harbor Freight for $99.00 that included 2 black and white monitors and 3 waterproof cameras. The camera specs are: 12-volt, 2 watt, 270,000 pixel, 0-LUX minimum illumination, 70 viewing angle and a certified depth rating of 18 meters. We configured the 3 cameras as follows:

- Camera #1 is on the top front of the frame to view the hooks.
- Camera #2 is on the bottom middle to view the tools.
- Camera #3 is on the top back of the frame for a wide-angle view. #3 also can be adjusted to focus on our Algae Vacuum Collector.

Each camera is adjustable for specific mission tasks.

This photo shows our 3 cameras

Challenges:

One of the challenges that we faced was figuring out how to design our tools. Mission #1 was the most challenging mission. For Mission #1 we had to redesign the messenger line treading sleeve 4 times to successfully complete the mission. We used the process of trial and error, by experimenting with different lengths of PVC pipe, different size loops, wire and Velcro. When things went wrong it was sometimes hard not to blame each other, but in the end, we came through to bond as a team & produce a successful ROV. Another challenge we faced was trying to make the ROV neutrally buoyant. We spent hours testing buoyancy, adding weights and experimenting with different pontoon sizes.

Trouble Shooting:

Sometimes solutions were easy, such as checking switches, using a multi-meter to check current flow, or tightening propeller screws. At other times, the solutions were more difficult. We attempted to *Dremel* channels into the motor housings to secure them within cowlings. We ended up compromising 3 of our waterproof housings. We solved this by researching marine epoxy products and filled the holes with Marine Tex. When the thrusters malfunctioned, we opened control boxes to check connections, re-wired and re-soldered.

Future Improvements:

In the future, we plan to use 12-volt marine dimmer switches instead of toggle switches, which will control individual motor power levels, to improve precision and maneuverability. We would like to try waterproofing SERVO motors to make robotic arms or hands to accomplish missions.

We learned that next year, we need to improve time management and start our ROV project much earlier. We only had five weeks to prepare for the regional competition and four weeks between regional and international competitions. We need more time to test our ROV and to practice missions.

Lessons Learned:

The important skills we have gained during the ROV project are soldering, configuring electrical systems, hydrodynamics, and public speaking. The major lessons that we learned, as 12 and 13 year olds, were project management, teamwork, and to work through new ideas. Scheduling helped us to better organize what needed to be done on a daily and weekly basis. We became better listeners and communicators.

History, Culture & Importance of the Earth's Polar Regions:

It is important to study the Earth's Polar Regions because of their critical influence on Earth's global climate, fisheries and fresh water supply. Global Warming is causing the Greenland Arctic Ice sheets to melt at a rate of 239 cubic kilometers per year- if Greenland's ice sheet melts away, global sea levels could rise 7 meters. Antarctica holds 90% of Earth's ice and 70% of Earth's fresh water. If the Antarctic ice sheets completely melt away, global sea levels could rise an estimated 61 meters. Of more concern to us is the potential increase in global ocean temperatures, plus changes in seawater density and salinity that could affect the global ocean current systems, marine food webs and global climate.

Left - Inuit man making a spear; Right - Inuit man and sled dogs

The **Inuit** have lived in the Arctic for many centuries (over 18,000 years). Inuit artifacts discovered date from 325 B.C. Scientists think that early Arctic inhabitants migrated from Northern Asia across ice and land bridges from what is now Russia and China to Alaska, & Northern Canada. Genetic studies examining mitochondrial DNA show a close genetic link between modern Inuit and Northern Asian inhabitants.

The Inuit adapted to the extremely cold temperatures by hunting & using Arctic animals, eating a high fat/high calorie diet, using furs, skins & bones for clothing, sleds, boats and shelters. They also used ice blocks to create igloos.

Building an igloo

Sources for Polar Regions Section:

http://www.ipy.org/
http://www.south-pole.com/
http://www.allthingsarctic.com/exploration/index.aspx

Arctic Ocean Map

Antarctica Map

http://geology.com/news/images/arctic-ocean-map.gif

http://www.niu.edu/polar/southpole/photos/ANDRILL/antarctica-map.gif

Exploration of Polar Regions:

The first European Arctic explorer was Greek navigator, **Pytheas**, who sailed to northern Iceland & Greenland, approximately 330 BC. **Vikings** began living in Iceland around 850 AD. **Sir Henry Hudson**, (U.K.) led the first expedition to survive an Arctic winter in 1610. In 1831, **Sir James Clark Ross** (Scotland) made the first successful expedition to the Magnetic North Pole. The Northwest Passage was discovered in 1845, by **Sir John Franklin** (U.K.), and navigated by **Roald Amundsen** (Norway) in 1903. **Robert Peary** (USA) was first to reach the geographic North Pole in 1909. **James Cook** (U.K.) crossed the Antarctic Circle in 1773. **Roald Amundsen** (Norway) was first to reach the South Pole in 1911.

Humans have explored Antarctica over the last 125 years. Antarctica is the only continent not owned by any nations. The only human inhabitants are scientists, representing 44 nations under the **International Antarctic Treaty** at 16 international research camps in Antarctica. The first **International Polar Year** (IPY) was created in 1882 with 11 nations agreeing to establish 15 observation stations in the Arctic and Antarctic. The second **International Polar Year** (IPY) was in 1932. 2007 is the **3rd International Polar Year** enacted by scientists to encourage polar research and build environmental awareness.

Polar Animal Adaptations:

All polar animals have evolved to adapt to extremely cold conditions (as low as - 40 degrees Celsius) and a lack of light during polar winters lasting up to 4 months. Whales, seals, & birds have thick insulating layers of blubber, plus specialized skin, fur or feathers to protect against harsh winds and icy cold air. Antarctic penguins have a compact body to help retain heat. Polar birds are born w/ waterproof plumage & downy insulating feathers to keep hatchlings from freezing. Insects, fish, cnidarians and crustaceans, have special chemicals in their blood that act like anti-freeze. We need to protect polar region habitats so that these specially adapted animals continue to exist.

Reflections

Building the ROV was an opportunity for us to learn about innovative ocean technology and to work together to create something that we could be proud of. From competing in the Big Island Regional ROV competition, we networked with other students and shared future design ideas.
We cannot wait to meet the international students in Canada to share ideas and our unique Hawaiian culture with them. We will learn a lot from them.

We have learned many important skills that will last a lifetime.
Team leader Ileana Argyris reflects, “I have acquired more experience in engineering, and leadership.” Team leader, Jonathan Kutsunai reflects, “We learned the true meaning of teamwork. We also improved our communication skills and learned patience and respect.”

Teamwork:

From this competition, we learned to work together, set aside our differences, and solve the problems that came up during practice and workshop sessions. We learned to stop blaming others and deal positively by solving problems that came up. Working together at practices helped us to learn different piloting techniques to accomplish the mission tasks. We also became good friends, almost like a family.

Acknowledgements

First, none of this would be possible without the wonderful support and funding from the MATE Center and the hospitality of Memorial University. We received generous support from our local community, family members, teachers and classmates. We appreciate the guidance from our teacher Lisa Diaz, our mentors Andrew & Terry Argyris, Vic Gomez, Garrett Frost, Mike Hauck, Jeannie Kutsunai, Gretchen Matthews, Aivale Nu'usolia and Steve Page. We thank our sponsors HELCO, Jack's Diving Locker, Kealakehe School PTO, Buccaneer Plumbing, Wal-Mart, Hawaii Dredging Company, Hawaiian Seafood Producers, Coldwell Banker Realty, Windmere Properties, Marjorie & Dewayne Erway and Rep. Josh Green.

We would also like to give special thanks to Jill Zande of MATE, Cynthia Fong, BIRR, Kona Classic Judges, KECK Observatory, Larry Rice.

The ROV team members (Left to Right)
Kela Hauck, Koloa Kalavi, Ileana Argyris, Alayna Machacek, Ariana Matthews, Jonathan Kutsunai