# Chinese International School ROV team

## Hong Kong

## 2010 MATE ROV International Competition

## Ranger Class

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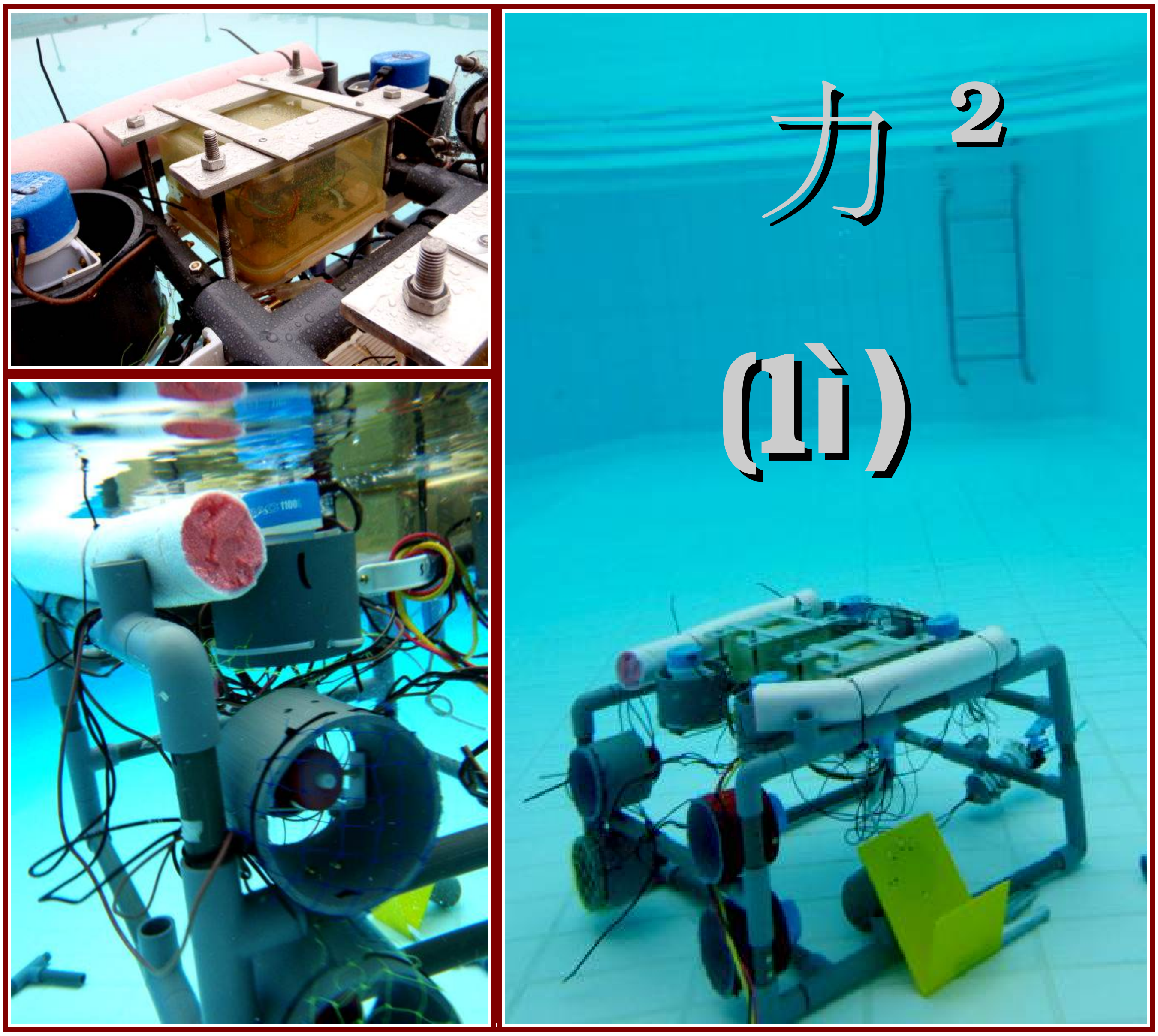

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## Abstract

The 2010 Marine Advanced Technology Education (MATE) ROV competition focuses on the resurrection of HUGO, the Hawaii Undersea Geological Observatory and a subsequent survey of the surrounding area. These two main objectives are further defined by four distinct tasks.

The 力 ² ROV is the culmination of four months' worth of investigating, designing, planning, creating and testing by a three-man team. Throughout this period our team overcame many obstacles to create a **rigid**, *polymer-aluminium hybrid frame*, a sufficiently powerful *propulsion system*, a versatile and robust *robotic manipulator*, a precise *audio-visual sensory array (*including an *underwater camera* and *hydrophone)* and numerous other *mission-specific tools* to collect agar and small plastic crustaceans. Overall, our team invested over two hundred hours, in the lab and workshop, in the field, and online (website: http://bchasnov.com/rov/wiki).

What follows is the 力 ² team's technical report of our ROV, 力 ². Within this report are detailed descriptions and illustrations of 力 ²'s components (including an expense budget, electrical schematics and software flow-charts), troubleshooting information, challenges met and their respective solutions, possible future improvements, information related to the Loihi seamount and reflections.

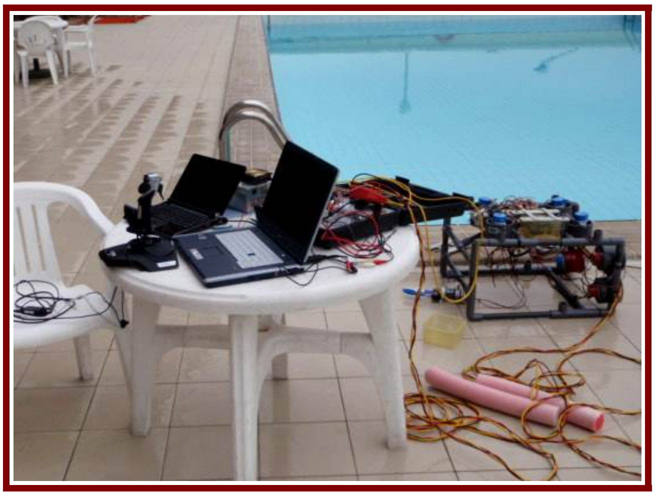


*Image 1: The entire setup, ready to launch*

## Vehicle Systems

Although we built our robot with the competition's mission in mind, we also wanted to build a technologically advanced and versatile, underwater vehicular system platform that can be modified in the future to accommodate different tasks and requirements. Also, our robot was built with a small budget of $3000HKD (excluding research costs), was easy to build and use, and included many of our own original designs.

One of these original features is the "brain" of the entire robot. Consisting of a self-made circuit board of our own design (further expanded in the design rationale), this "brain" is designed to operate the robot and send sensory information back to the software which is used by the ROV's pilots. All the software was programmed and designed by ourselves, too.

Moreover, the software being used by the pilots includes a GUI (graphical user interface) for ease of use. This is combined with an intuitive controller – a USB flight simulator joystick. Other aspects of user-friendliness is a 40-page documentation for the robot, which can assist the ROV operators with future troubleshooting.

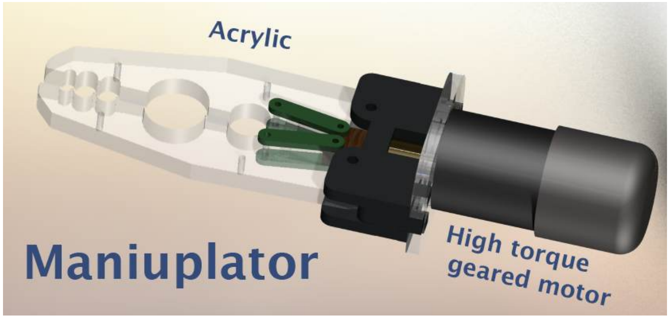
In order to keep the production costs of the robot low without compromising its overall mission-accomplishing capability, we used aluminium, PVC, stainless steel, plastics, and several other widely-available materials, all of which are relatively long-lasting and cost-efficient.

Furthermore, we seriously considered safety in our ROV and its construction process. Basic safety features include a thruster guard and fuses, and more complex features include leakage sensors, internal temperature sensors for overheating detection, digital current sensors to monitor the current flow.

## *Design Rationale – tasks*

This year, our team has decided to place heavy emphasis on the planning and designing process before the manufacturing process. By doing so, we were able to create complicated systems in less time. We used Solidworks 3D CAD to draw all of the designs before manufacturing them, ensuring that there were no errors. Following, there will be renders of each Solidworks design to show the step-by-step planning and designing process we undertook.

Throughout the competition, we must be able to pick objects up, remove objects, and sample objects. Instead of using just a rod of some sort to manipulate the objects, our team decided on an opening and closing mechanism was required to grab onto the objects. Thus, these tasks require a manipulator. Our team designed and manufactured a strong and robust waterproof claw (see Solidworks render below) that was capable of completing such tasks.




*CAD render 1: 80% laser-cut maniuplator*

*Image 2: Removing cap from port of HUGO junction box*

Aiding the manipulator in this task is a part of the ROV's sensory array – the hydrophone. Using this piece of equipment, our team will be able to pinpoint the exact site on which the HRH should be placed.

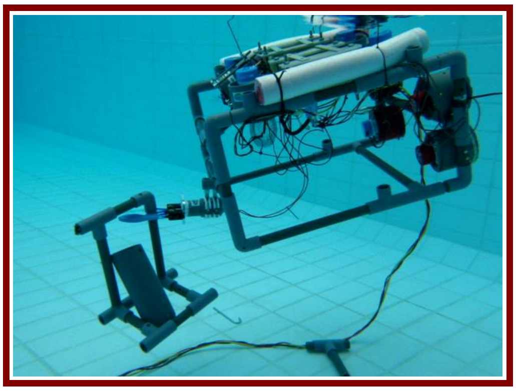


*Image 3:Moving the HRH*

### Task #1 – Resurrect HUGO

The first mission that the ROV will have to undertake is to use a manipulator to resurrect a simulated version of a certain Hawaii Undersea Geological Observatory (HUGO). To do this, our team used the ROV's manipulator to remove and relocate the target objects, including the HRH, a pin that locks it to an elevator and its power/communications equipment.

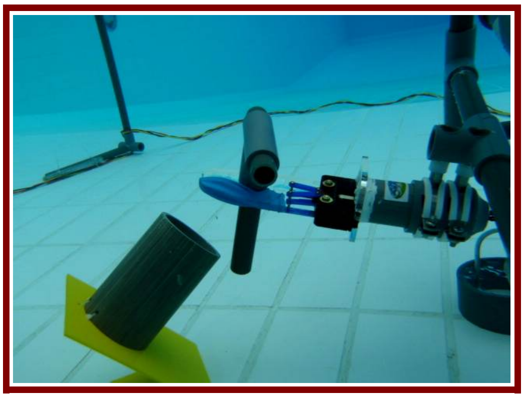


*Image 4: Inserting the HRH connector into the port of HUGO*

### Task #2 – Collect samples of a new species of crustacean

The ROV's design was influenced by the second mission, more specifically, the dimension required to enter a simulated cave. Despite it being within the limits of the cave, the ROV is still rather large (needed for its robust, solid and modular features) and the team will need to pilot it carefully through this task. As such, the ROV's camera has been modified with the addition of a wide-angle lens, to allow our team to view, from the control unit, a wider view of the ROV's surroundings. This way, our team would be much more aware of the the cave's limits and so the small movements that have to be made would be based on good, clear information.

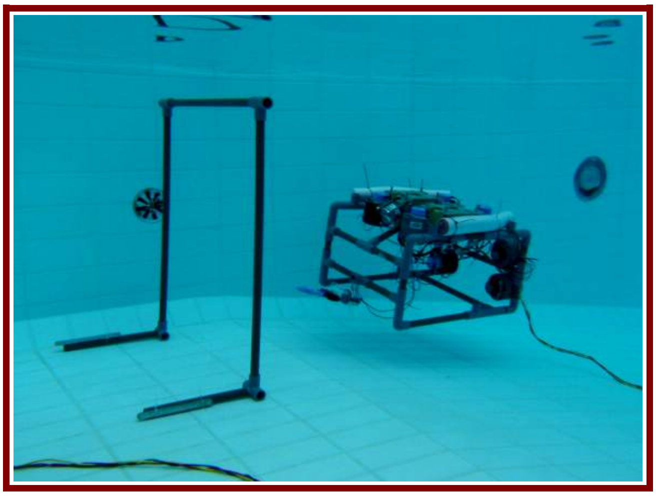


*Image 5: Entering the "cave", an 80x80cm entrance*

Just as in the first task, the manipulator will be used, except that crustacean models replace the simulated HUGO model. Our team will use the outer part of the manipulator's claw, which has been designed to grasp smaller objects. As the manipulator only features one degree of freedom (the only movements it can make is opening and closing the claw), collecting the crustaceans with an onboard compartment/storage area is out of the question. Instead, our team has modified a negatively buoyant basket that it can use to store the crustaceans. Upon completion of this part of the task, the ROV will grab the basket and return the samples to the surface.

### Task #3 – Sample a new vent site

The thermometer is used to record the thermal levels of a simulated vent site. A 1-wire digital thermometer is connected to the microcontroller that sends information to the software's GUI. Once the information has been logged, it is plotted onto a prepared graph.

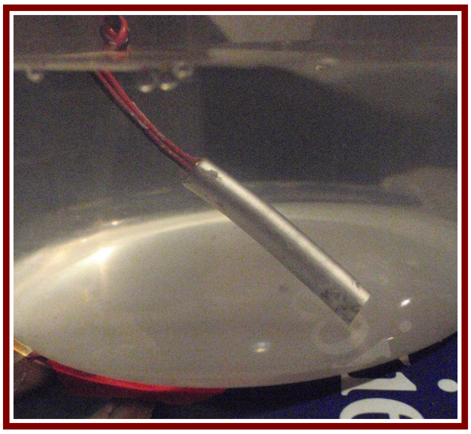
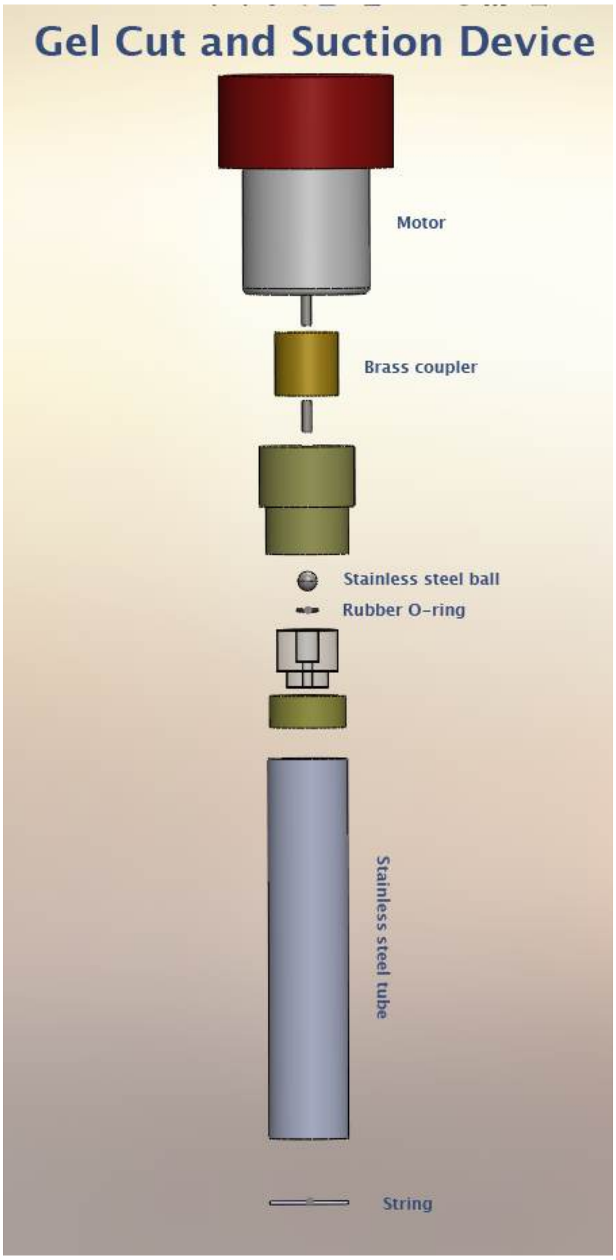


*Image 6: Waterproofed thermometer underwater test*

In this task, the manipulator is used again. Similar to removing the power/communications connector in the first task, the simulated vent spire that is needed to be removed will be done by the manipulator.

### Task #4 – Collect a sample of a bacterial mat

This final task involves the collection of simulated bacteria on the "seafloor"—agar gel in a container located at the bottom of the pool. By far the most sophisticated task of the four, our team designed and made a standalone tube with one open side which will cut into the surface of the gel, submerge and collect the sample. This is done with the aid of a home-made ball check valve, which will allow the insertion of the tube into the bacteria gel, but does not allow the connected gel to escape the tube, due to the one-way-valve. The rotation of the slow speed motor will cut the gel, which will allow easy removal of the gel.




*CAD render 2: Gel suction device*

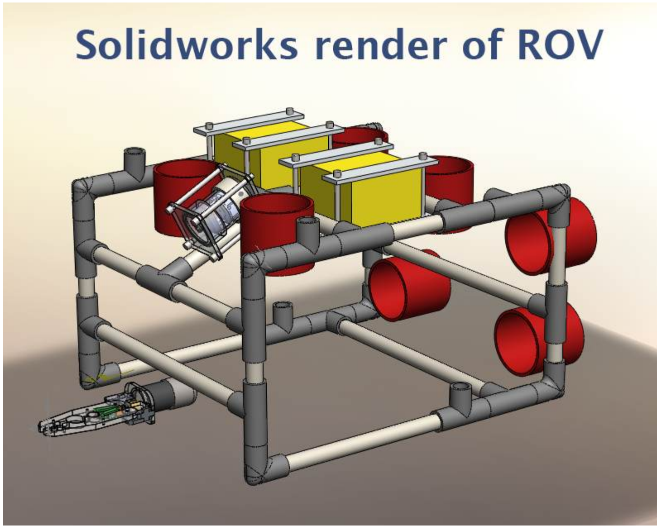
# *Design Rationale – ROV*

### The process

The process of creating this ROV is crucial to the success of the final product. Without proper investigation, planning or design, it would be extremely difficult to create something that will operate properly. This is why we used the *design cycle* as guidance throughout this project (above).


The *investigation* included using reliable sources such as the internet and books. Then follows the design and plan, where we heavily relied on CAD programs such as solidworks and eaglePCB CAD. Then, with all the designs, we manufactured all the parts to create the ROV. After, we tested the ROV and evaluated it, then made changed according to our test results. This cycle is extremely efficient and useful.

### Frame




*CAD render 3: Entire rov*

The frame design used this year is quite similar to last years', except that it is of a more simple box-shape rather than a trapezoidal-prism design from last year. This change has been made to accommodate a larger number of thrusters. Also, a box-shape is much easier to build as the angles incorporated are all right angles. The entire frame measures around ***35x50x60cm***, which leaves the robot much space to manoeuvre in the cavern. It is also big enough to allow space for different mission-specific tools and also for future modifications/additions, which extends the life of the ROV.

PVC was chosen to be used as the main material for the frame, as it is cheap, easy to obtain, easy to cut and perforate. While heavier, a thicker type of PVC has been used for this year compared to last year, enhancing the tensile strength of the frame to support the additional weight of the components.

## Electronics

There are two main circuit boards in the ROV that make it work – the control unit, and the motor controller.

All of the circuits are made by our team; everything was an original design, no commercial products were used, at all. Even the PCBs were fabricated by ourselves. Although this made the entire process much more complicated and time consuming, it was much more rewarding, as well as much cheaper.

**The control unit** is in charge of serial communications with the laptop above the water. It understands the commands sent by the laptop, and translates them into whatever it needs to do, for instance, open the manipulator, or send sensory information.

It has an atmega168 microcontroller as its "brain", running AVR-C software, which is designed and written by our team. The MAX232 chip converts 9600 baud serial signal from the tether into TTL signals.

It utilizes mostly SMD components, with occasional DIP for important ICs such as the MAX232 and atmega168 for easy replacement and debugging.

It features a hall effect current sensor and voltage divider connected to an ADC port on the AVR; a buzzer and LED for auditory and visual indication of activity, which is extremely useful for debugging; leak detection to inform the pilot when the enclosure has been breached, a 25A fuse to prevent dangerous short circuits; and capacitors to help smooth out the voltage fluctuations which prevents the AVR from resetting when there isn't enough power.

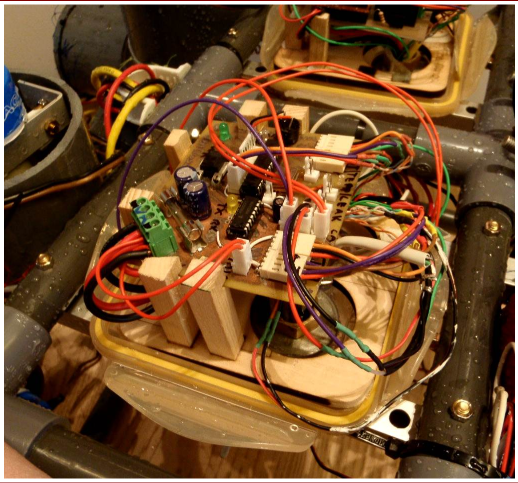


*Image 7: Control unit circuit board*

There are 6 pins of 1000hz PWM for controlling the motors, which are connected to the motor controller board. Another 3 pins are for controlling the shift register, which will be explained in a moment.

**The motor controller,** as its name suggests, is used to control the motors on the ROV. It is capable of controlling 6 motors.

To allow reverse movement, there are DPDT relays to form H-bridges. Each motor has an n-channel MOSFET, which switches PWM to control the voltage fed to the motor. A shift register connected to a ULN2003 darlington transistor array is used to switch the relays on and off. A shift register is used so only 3 pins are required (clock, data, latch) from the microcontroller, rather than wasting 6 pins.

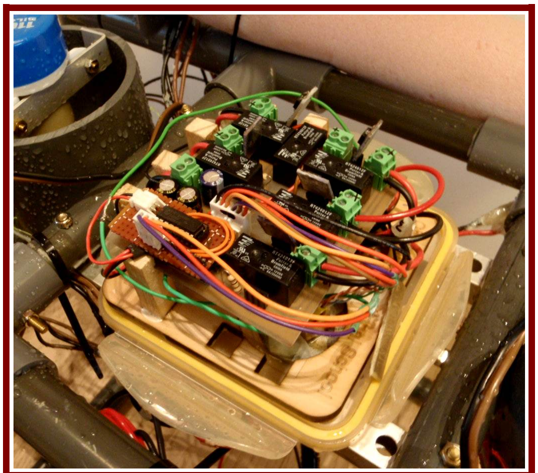


*Image 8: Motor controller circuit board*

Low Rds MOSFETS are used to reduce the voltage drop across the MOSFET, which would heat up the component. There is a 1-wire temperature monitor located in the motor controller to measure the ambient temperature, which will inform the pilot if the enclosure overheats.

The PCB has thick traces to allow large currents. The wire gauge used for the motors is 12AWG, which is suitable for 9.3amps power transmission – definitely enough.

Both of the boards' size was limited to 80mm by 100mm because we could only use the free version of Eagle PCB to design the circuit boards.

## Electronics Housings

The electronics are housed in a cheap, transparent plastic "lunch" box, sealed with a rubber gasket. Because the default closing and locking mechanism of this box is not strong enough to withstand the pressures of being underwater, a custom aluminium clamp was created to apply pressure to the rubber gasket, creating a safe, water-tight seal.

Two of these boxes are used instead of one larger box in order to distribute the pressure across a larger surface area, and to separate the motor controller board from the control unit board, for easier debugging and maintenance.

The box is flipped upside down – the cover is at the bottom – for easy maintenance (more room to fix things when it's opened). There are wood columns supporting the circuit board to raise the PCB off the bottom of the enclosure, like raised houses. If the enclosure leaks, the water will enter from the bottom, activating the leak detector, but will only wet the circuit boards when the water rises another 2.5 cm, which should give us enough time to rescue the ROV from the water.

## Propulsion System

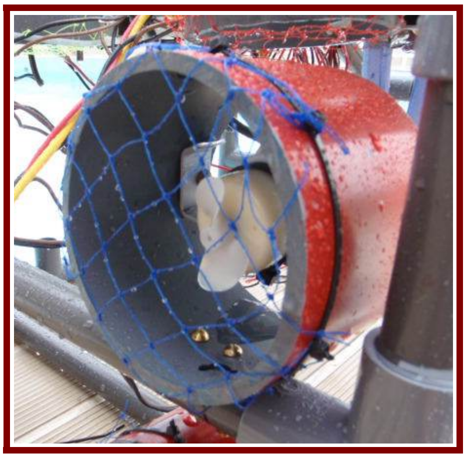


*Image 9: Thruster*

The thrusters are 1100GPH bilge pumps. They are already waterproofed, which saves us a lot of time. There are 8 thrusters, four providing vertical movement and four providing horizontal movement – two on the left, two on the right. There are only 4 channels on the motor controller to control thrusters, so each channel has two motors in parallel–two on the left, two on the right, two in the front vertical, and two in the back vertical, all for twice the power. Each motor is fused with a 6A fuse, to prevent over current when stalling.

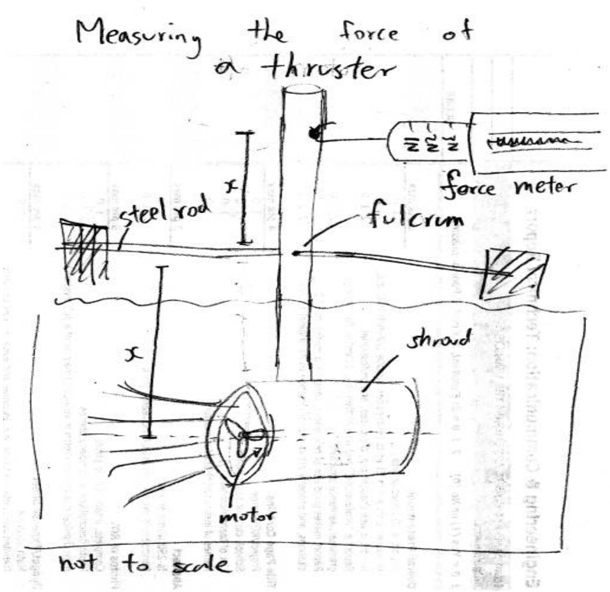



*Figure 1: How we measured the force of a thruster*

The propellers are two finned, each fin has an approximate pitch of 15 degree, and the fins are 3.5cm in diameter. A shroud is used to direct the water flow in one direction; to optimise the thrust.

Each motor requires 2.5 amps each at full throttle. 2.5*8 = 20amps (although voltage drop over tether hasn't been considered).

Each motor gives out approximately 8.5 newtons of thrust. Figure 1 is a diagram of how we measured the thrust.

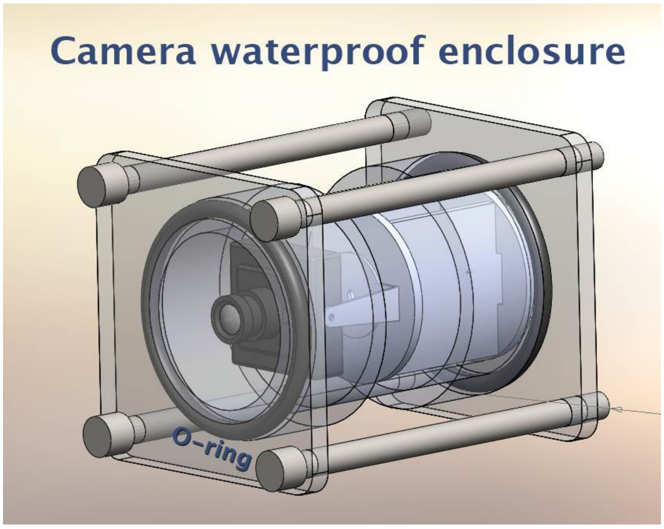
## Safety

Always, always, "safety first!" The team has decided to emphasise the safety of the ROV this year.

The ROV has many safety features to protect both the ROV and its environment from harm. Fuses are incorporated to protect the electronics from getting damaged, as well as dangers to living animals. There are nets on the thrusters to protect the propellers, as well as to protect any curious hands or divers in the swimming pool.

There are leak detector to ensure no water will damage the circuitry. There are many, many more safety features of the ROV, these were just a few.

## Camera




*CAD render 4: Camera enclosure*

The camera is a CCD color camera that works under very low light. The enclosure is waterproofed by compressing two o-rings to create a waterproof seal (see CAD render 4).

The camera needs such a complicated waterproof enclosure because the camera gets very hot when it's on. Also, we want to be able to take the camera out and replace it if it breaks. The enclosure has been tested to be waterproof at a 5m depth for 24 hours, but is expected to be waterproof at over a 20m depth.

## Tether

The 15 meter tether is 3 cables in a braid – +12v (red), ground (black), and an extra flexible cat5 cable (8 connectors).

The tether is extremely light and flexible, giving the robot less drag and more freedom.

The 8 conductors in the cat5 cable are stranded copper conductors, not the typical solid conductors, which makes it extra flexible.

One twisted pair is used for the camera so the signal is always coupled with the ground, which allows for less interference and a cleaner video.

The power cables are 10awg, fully capable of transmitting 25amps bursts. Furthermore, a thick copper cable has less resistance, which allows for the lowest voltage drop while remaining flexible.

The conductors are braided for extra flexibility, and also to eliminate the use of cable ties or other methods of bundling – which is more elegant and simplistic.

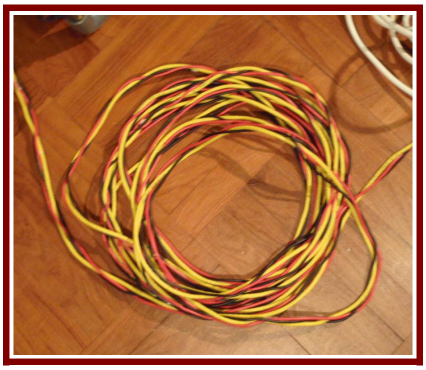


*Image 10: Tether*

Since the tether is extremely light, neutral buoyancy was achieved by evenly spacing out intervals of floatation (not pictured). Neutral buoyancy is required to reduce drag.

## Sensory

Two main modules of sensors are needed for the completion of the missions: hydrophone and thermometer for task 1 and task 3, respectively.

The hydrophone, used to listen to sound activity underwater for task 1, is a piezoelectric transducer connected to a preamp. The signal occupies two conductors in the tether. Once on the shore, another amplifier is used to amplify the signal for listening with headphones. We determined that we had to use a preamp before transmitting the signal along the tether because without the preamp, the voltage will be too low and there was too much noise and interference from the motors.

The thermometer is a 1-wire Dallas DS19B20. This digital thermometer is much preferred over any other IC thermometers because it does not need to be calibrated, does not require an ADC, and is very accurate. The thermometer is placed in a 6mm aluminium tube filled with thermally conductive paste to ensure optimal thermal transfer. It is further waterproofed using underwater epoxy, and requires only two wires, ground and signal, because we utilize the “parasite power mode”.

Other sensors include voltage, current, and internal temperature in order to provide the pilot with more information about the system.

## Surface control

On the surface, there is a USB ↔ serial dongle for communications with the ROV. There are also analog current and voltage meters (pictured below). Instead of relying on the onboard digital voltage and current meters as described above, these analog meters are here just in case the serial communication doesn't work, just in case nothing else works, it is still possible to figure out what is wrong.

There is one 25A fuse to protect the entire setup. There is also a reset switch that is directly connected to the reset pin on the microcontroller, used if something goes wrong.

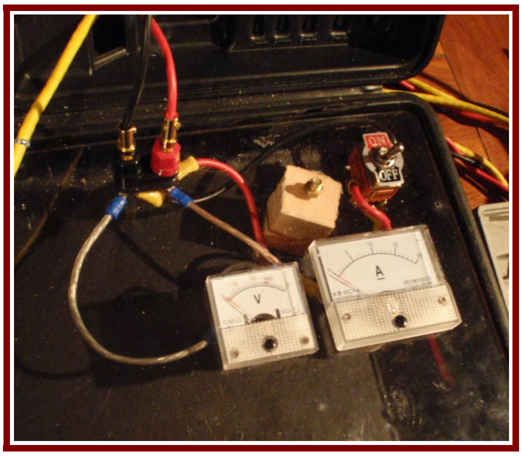


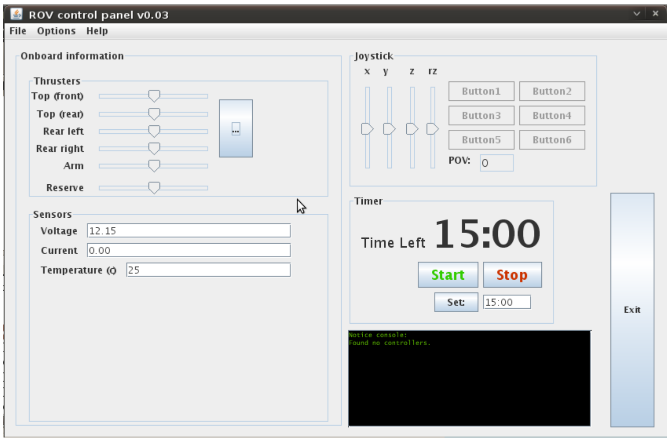

*Image 11: The topside voltage and current meters*

A large power switch is also located on the surface control panel, and is used to switch the power on and off.

Furthermore, connected to the laptop is a USB flight simulator joystick for controlling the ROV.

Please note that it is extremely dangerous to connect the power cables in the wrong way. Capacitors will blow up and chips will get fried.

## Software




*Screenshot 1: ROV Control Panel*

There are two pieces of source code in this ROV – **topside** and **onboard.**

The **topside** software is written in Object Oriented

Java, and coded in the NetBeans IDE. It features a GUI, which displays information about the sensors, the thrusters, and the joystick. A joystick is used to control the ROV.

The software is heavily based on threads. There are in total 3 main threads. First, **the joystick thread**, which monitors joystick activity, and updates the joystick information. Second, **the serial-write thread**, which checks the joystick information every 10ms, to see if anything has changed. If there is change, it will send the data as thruster speeds to the ROV. This needs an additional thread to avoid the congestion of serial data. Third, **the serial-read thread**, which is in charge of parsing serial data that has been received from the ROV and displaying the data on the GUI.

There is a mode pre-launch checklist mode/diagnostic mode, which the pilot is required to execute before the launching the ROV. It checks the motion of the thrusters (direction and speed), and checks the validity of the sensory information. Once these checks are satisfied, the pilot can continue with the operation.

The joystick used is a USB flight simulator joystick, very accurate and precise, perfect for controlling a vehicle that needs precision for its missions.

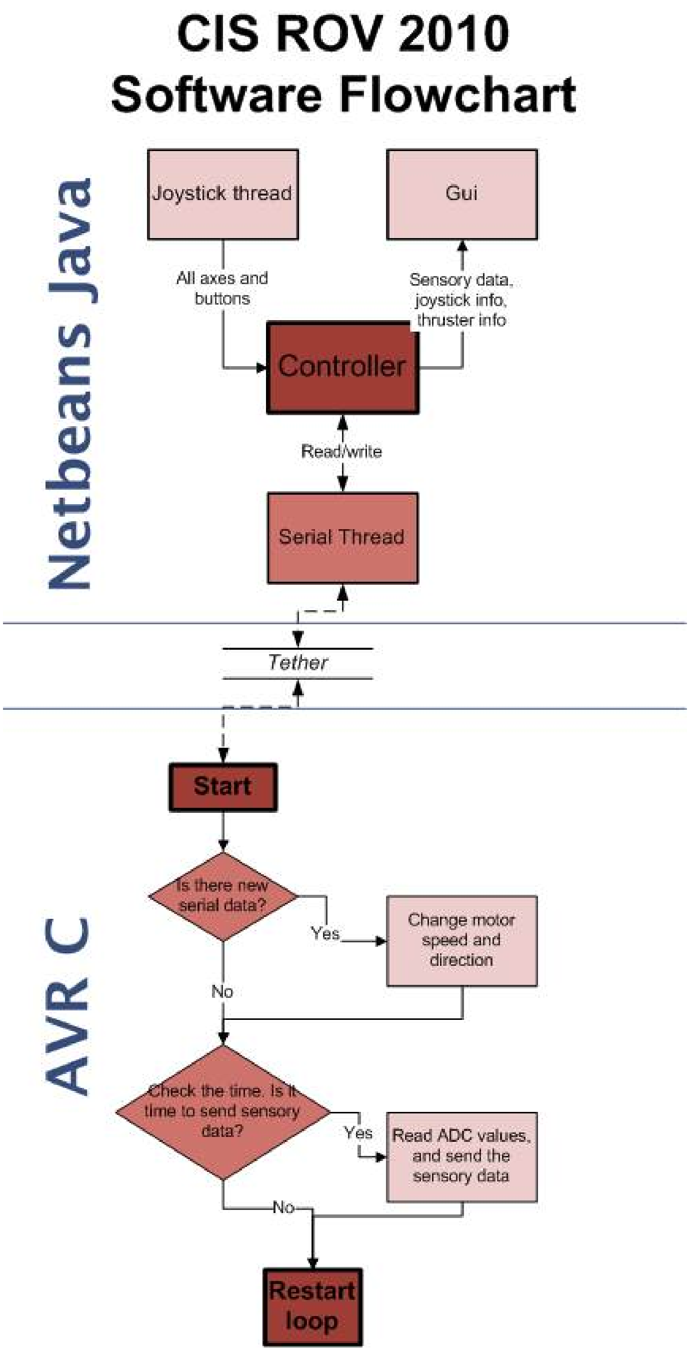



*Figure 2: Software flowchart that describes the software flow*

The other part is the onboard program–code on the AVR microcontroller. This piece of software is significantly less complex. It is in charge of listening to the topside serial communications, and acting accordingly. When the Java program says "turn thruster 1 on", the AVR microcontroller will turn thruster #1 on.

Every 500ms, the AVR microcontroller will read all the ADC and 1-wire values, and send all the sensory information to the Java program.

Throughout all the serial communications, a Pearson hash is used for every transfer to insure error-free data transfer. CRC could have been used, but when data is being transmitted every 10ms, CRC would be too slow.

All software is entirely coded by the students in the team; the only code that was used that was not coded by us are the libraries that control serial communications: RXTX, and joystick input: JINPUT.

### Manipulator and Accessories

The manipulator (see Solidworks render in a previous page) is laser cut, consisting of mostly 3mm, 6mm, and 9 mm acrylic, some pvc, and a high torque gearbox motor.

*Image 12: The high torque gearbox motor*

The gel suction tube includes a home made cheap check valve that is made from lathed acrylic, an o-ring, and a stainless steel 6mm ball. When water is forced up and out of the tube (while the tube is being inserted into the gel), the ball is lifted off the o-ring, allowing the flow. But when water tries to enter to tube (sucking the gel out of the container), the ball is sucked into the o-ring, forming a tight water seal.

## *Future Improvements*

One huge annoyance and problem we had this year was the lack of proper electrical connectors. The current connections are complicated and time consuming. If we had bought waterproof connectors, instead of creating them ourselves, troubleshooting would have been much easier as it would have been simpler to remove the circuit boards from the enclosure.

Another improvement we could have done is to have thicker power lines in the tether. Even though this would increase the weight and decrease the flexibility of the tether, there would be less voltage drop across the tether, allowing more power for the thrusters.

Another improvement we could make is to add multiple cameras. During testing, we discovered that one camera was not enough to confidently complete the missions. However, there wasn't enough time to manufacture another camera before the competition, and we did not leave extra conductors in the cat5 cable for another camera signal anyway.

## Troubleshooting

The making of the ROV has provided us with many opportunities to develop our electrical troubleshooting skills. Because the electronics were designed and built ourselves (especially the copper circuit board), we knew that this would greatly increase the likelihood of errors.

Initial testing of whether the circuitry can "live" (indicated by a flashing LED) was successful, but when we began to program the microcontroller to communicate using the serial port, problems occurred. It was discovered that the uC could transmit data, but it couldn't receive data. The first step we took to solve this problem was to diagnose each section of the circuit to figure out where it went wrong. First we tried replacing the MAX232 serial driver with a new one, suspecting that the current one was faulty. However, that did not solve the problem. Then, we removed the microcontroller from the circuit board and placed it on a solder-less breadboard to test the TTL communication ports with a oscilloscope – no problem. Then, using a oscilloscope, we traced the pins on the MAX232. This is when we gained a suspicion – the -10 to 10 volts signal from the RS232 side was correct, but when it was converted to TTL, the signal switched between 0 to 2.5 volts, not 5 volts. Ah ha! We then read over the schematics and deduced that the LED connected to the RX pin on the MAX232 is draining too much current. To verify this hypothesis, we downloaded the MAX232 datasheet, and it says that the pin is very high impedance and can only source a maximum current of 3mA (an LED needs 20mA). The LED is the cause of the voltage drop; de-soldering the LED fixed the serial communications.

After having soldered every part of the circuit board and tested every aspect of it, we were ready to place it in the ROV and connect the real thrusters to the motor controller. However, when we did a dry test of the ROV, it worked for a while until a fuse burned. At first, we thought that the problem was that we were increasing the motors' speed to quickly, resulting in a rush of current, causing the fuses to break. We replaced the fuse and told the pilot to increase the speed slowly. This is when a team member noticed that there was one motor that could move forward, but not backward. This is when the fuse blew again, raising our suspicion. While investigating the circuit board, a team member accidentally burnt his finger by touching a MOSFET. It turns out that the MOSFET was short circuited when the h-bridge was switched to reverse. By using the continuity test on a multimeter, we could easily find the solder bridge, and we de-soldered it.

The camera is connected to the 12 volt power that comes from the tether, instead of a battery. Initial testing showed that everything worked properly out of the water. However, when we placed the ROV into the water and operated it, the camera would spuriously turn into a black screen when the motors were operating. After observing the voltage measurements on the software's GUI, we realized that the voltage dropped to about 7 volts! Further investigation also showed that the voltage fluctuation (drops and spikes) caused by the PWM motor control signals greatly affect the camera, because when the motors are at 100% duty cycle (no fluctuation), there was less interference. Then, a member of the team suggested that we place a low ESR capacitor as near as possible to the camera to smooth out the voltage fluctuations. This solution worked and now the camera works perfectly, without impaired vision.

Through these experiences we have learned to troubleshoot electrical systems by signal tracing using an oscilloscope, voltage and continuity testing with a multimeter, and using non-technical methods– observing, noting patterns, and reading schematics and datasheets.

## *Challenges*

One huge challenge for us was that we manufactured our own circuit boards, a lot of problems occurred because of the PCB itself. There were solder bridges, conductivity problems, problems with the boards getting dirty from the accumulation of flux, etc. All these challenges had to be debugged one by one, a very time consuming process.

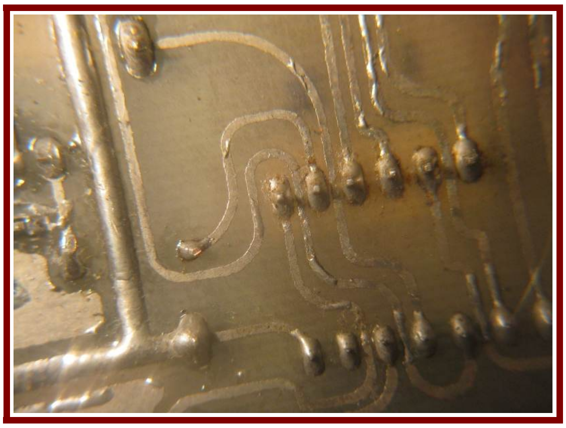


*Image 13: Can you see the poor connection? Neither could we!*

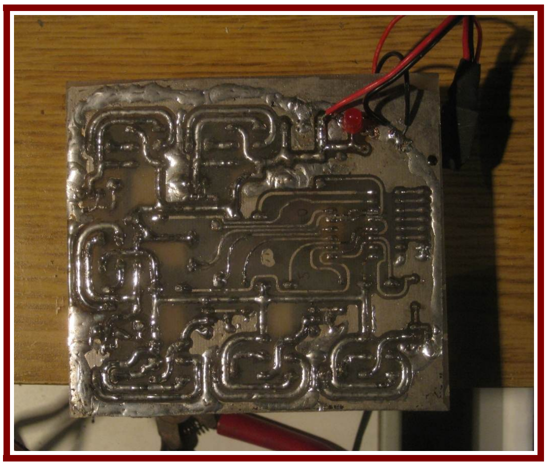


*Image 14: The backside of the motor controller board–an example of how messy it can get.*

Eventually, we overcame this major problem by using a method that utilizes the conductivity tester on a multimeter. With time, all problems were eliminated.

Although all this was time consuming and very challenging, we all agreed that it was worth it, as we are proud to say “we made all of it ourselves”, rather than purchasing them from another company. In other words, it's very self-satisfying.

By going through the entire process of fabricating a PCB out of copper clad board, to the final stages of testing, we have gained an enormous amount of skill and experience.

Another big challenge we had was prioritising: this is not limited to the time that was needed for completing our ROV, but also prioritising our student lives. We are students from high school that demands lots of work. Our problem was trying to fit the ROV into our busy schedules of sports, music, and most importantly, school work. In order to build our vehicle, we developed a schedule that suits everyone's personal schedule. We ended up staying in the machine shop everyday after school when we did not have any other activities, went to the lab every recess and lunch time for the last 2 months. That way, we could finish the ROV on schedule.

We learned how to manage our time properly, especially with a busy schedule. We learned how to prioritize by placing the most important tasks first, and least important task later. This will definitely become extremely handy in the coming years when we start college, or even in the coming decades when we apply for jobs and enter the “real world”.

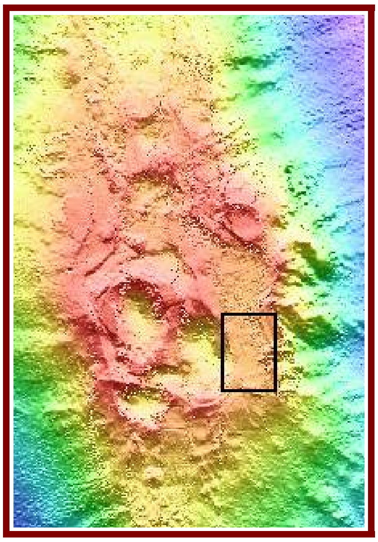
## About the Loihi Seamount

The Loihi Seamount is an active undersea volcano located around thirty-five kilometres off the coast of Hawaii. It is the youngest of the Hawaiian-Emperor seamount chain, a chain of volcanoes stretching over 5,800 kilometres around Loihi and the island of Hawaii.

Its significance lies in its relatively recent activity. Despite it being known to be the newest member of the Hawaiian-Emperor seamount chain, it was presumed to be an inactive volcano until 1970, when it catalysed a series of earthquakes (though apparently its activity had begun in 1959, before it was monitored by scientists). Since then, several more series of earthquakes (known as earthquake swarms) have been attributed to the Loihi Seamount, the most notable of them being the 1996 earthquake swarm. From the 16th of July till the 9th of August that year, a total of 4,070 earthquakes were recorded, a record unsurpassed for a Hawaiian volcano in both its amount and intensity—of the 4,070 quakes, more than forty reached a magnitude of 4 or 5 on the Richter scale and almost none fell below 2.

Such an event does not go unnoticed. Scientists were already on the scene almost immediately when the seismic activity was detected, though the expeditions made during this time were bogged down by the aftermath of the earthquakes—visibility was greatly reduced due to the high concentrations of displaced minerals in the sea and floating mats of bacteria floating in the water. However, samples were taken from the sea floor and hydrothermal vents were probed with the aid of the Hawaii Undersea Research Laboratory's *Pisces V*, an ROV.

However, the information gathered during the earthquake swarm was not enough, and in 1997 Hawaii's School of Ocean & Earth Science & Technology deployed HUGO (Hawaii Undersea Geo-Observatory). Installed on the summit of the Loihi Seamount, it is connected to the surface via a 47 kilometre-long fibre optic cable donated by AT & T. Since its first deployment, HUGO's main experimental features included a seismometer, a hydrophone and a pressure sensor, in order to monitor undersea volcanic eruptions, geology, geophysics, biology, hydrothermal vents and other phenomena. Thanks to the then-recent volcanic events and HUGO's advanced equipment, it became an important part of the international laboratory for the study of undersea volcanism in Loihi.



*FigureQ 1: The location of HUGO on the Loihi Seamount http://www.soest.hawaii.edu/HUGO/images/map2.gif*

HUGO's fibre optic cable was, unfortunately, broken in October 1998, just after a year of operation. It was repaired by the aforementioned *Pisces V*, only to operate for another four years before it failed again 2002. HUGO has not reached operational status since.

This ROV competition is essentially based on these real life happenings. Task #1 requires us to devise a method to resurrect HUGO—which is needed in the real world. Additionally, the other tasks require the ROV to be able to collect samples of newly discovered crustaceans, vent spire, and bacterial mat. All of which is located in the Loihi seamount. Although rather unrealistic, the ROV competition allows us to experience the technical difficulties experienced by the professional ROV engineers, and allows us to advance our knowledge about the Loihi seamount and ROVs in general.

# Reflections

## Benjamin Chasnov

Before signing up to the MATE competition a year ago, I have to admit I knew very little about electronics and software engineering. The MATE competition allowed me to further develop my knowledge and understanding of electronics and software.

The competition forced me to learn more about my passions. Even though I haven't taken any courses about electronics or programming, I was still able to learn a lot from books and from the internet.

A huge improvement of this team from last year's team is the development of specific assignments for each team member to design or build the ROV. Last year, we did not organize it properly. But this year, each member had a personalized "to-do list", agreed on by the entire team. This way, everyone will always have something to do.

I will most likely be pursuing robotics or electrical engineering in college, purely due to the fact that I found this competition very fun.

However, I have accomplished much more than just gaining knowledge and understanding. I accomplished a habit of time management, teamwork, communication between team members and the mentor. This, I believe, is far more important than knowledge and can only be learned from experience, and not books. Everyone has to learn it, and it's better to learn it now than to learn it later.

## Jonathan Chan

Though being a MATE ROV Competition veteran (I participated last year), this year's competition is in no way less rewarding than the last. In fact, I have found this year's experience to be more rich and more fulfilling experience. Not only were the mission objectives just as challenging as last year's (or even slightly more), the knowledge I gained from this year's competition is simply ineffably larger.

The MATE ROV Competition teamwork is a unique one—the sheer amount of cooperation and communication it requires between team members is an experience that is not seen anywhere else in school or in any other accessible extra-curricular activities. The contributions of the entire team from the initial design to the final testing stages are simply amazing.

It was also with this strong team bond we had that enabled us to overcome the many problems that came up throughout the project, especially the issues concerning the agar gel-extraction task and those concerning the propulsion system.

While working as a team, all of us made our own individual accomplishments. For me, the most major accomplishment was designing the successful water-proofing systems that are in use with the on-board control boxes (containing the "brain" of the ROV) and those in use with the camera. Other than this, I had many other smaller accomplishments, one of them being learning the right method to coil and braid cable. This may seem like a very small piece of knowledge but I believe that this skill will come in use many times in the near future. Overall, working with the team on this great journey has been a life-enriching experience.

## Joe Hwong Pang

During the creation of the ROV, I have learned great deals about different materials and their strengths and limitations. I learned how to accurately manipulate the materials and furthermore how to join them. The construction of the ROV has taught me a great deal on working with metals and learning the different methods and way of water proofing and how to counteract various mechanical problems. I also learned a great deal from my teammates as they introduce me to new ways of fabricating various parts for the ROV.

The MATE competition has also allowed me to flex my technical design muscle, and furthermore allowed me to think and act independently during the course of creating the ROV. The MATE competition has given me an opportunity to see where my true skills lie and where I can improve, furthermore it has taught me to appreciate these machines as they perform tasks that usually would be dangerous and life threatening to man.

# *Financial Report*

## 2010 CIS ROV Financial Report

| | Part | Quanitity | Unit | Resued Value (HKD$) | Donated Value (HKD$) | Cost (HKD$) |
|---|---|---|---|---|---|---|
| | ***Frame*** | | | | | |
| 1 | 1" OD PVC pipe | 5 | m | | 100 | **d*** |
| 2 | PVC joints | 20 | ea | | 100 | **d*** |
| 3 | Stainless Steel screws + nuts | 12 | ea | | 40 | **d*** |
| 4 | Scrap Aluminum | n/a | | | 0 | **d*** |
| 5 | Scrap PVC | n/a | | | 0 | **d*** |
| 6 | Plastic box | 2 | ea | | | 50 |
| | ***Electronics*** | | | | | |
| 7 | Atmega168 | 1 | ea | | | 37 |
| 8 | RS232 chip | 1 | ea | | | 12 |
| 9 | DPDT relays | 6 | ea | | | 96 |
| 10 | N-channel mosfet | 6 | ea | 42 | | |
| 11 | Allegro hall effect current sensor | 1 | ea | | | 57 |
| 12 | Fuses | 8 | ea | | | 16 |
| 13 | Copper clad board | 2 | ea 80x100mm | | | 8 |
| 14 | Misc components (resistors, capacitors) | | | | | 400 |
| | ***Topside electronics*** | | | | | |
| 15 | Analog voltmeter and ampmeter | 2 | ea | | | 90 |
| 16 | USB – serial | 1 | ea | | | 14 |
| | ***Propulsion*** | | | | | |
| 17 | 1000GPH bilge pumps | 8 | ea | | 1040 | **t*** |
| 18 | Propellers | 8 | ea | | 64 | **c*** |
| 19 | Mounts | 8 | ea | | 16 | **d*** |
| | ***Payloads*** | | | | | |
| 20 | Geared motor for manipulator | 1 | ea | | | 30 |
| 21 | 3,6,9mm acrylic | | ea | | 50 | **d*** |
| 22 | 500 gph bilge pump motor | | ea | 180 | | **c*** |
| 23 | Camera | | ea | | | 210 |
| | ***Tether*** | | | | | |
| 24 | Black and red 10AWG | 30 | meter | | | 246.06 |
| 25 | Extra flexible Cat5 | 15 | meter | | | 147.64 |

| | |
|---|---|
| **Fundraising** | 1930 |
| **Total Budget (Fair Market Value)** | 3045.7 |
| **Amount spent** | 1413.7 |
| **Balance** | 516.3 |

***Sponsors:**

**t:** *Trac-Marine*

**d:** *Design Technology Deparment,*

*Chinese International School*

**c:** *City University, Hong Kong*

# Acknowledgements

The Chinese International School ROV team would like to thank the following people and organizations for supporting us, allowing the creations of a successful ROV.

**Trevor Harris** – our teacher supervisor, for being there when we needed help.

**Chinese International School Design Technology Department** – for allowing us to use their machines and storage area, and for donating materials (scrap and new) for the construction of the ROV.

**CIS DT technicians** – for offering moral support, and occasional advise with technical difficulties.

**Trac-marine.com** – for sponsoring us with bilge pump motors.

**City University of Hong Kong** – for hosting workshops and the competition, for donating propellers for our motors.

**Chien He, Ronald Wu, Alina Luk and Boris Lee** – for helping us with the pizza sale at school to raise money for the ROV.

*And last but most certainly not least...*

**MATE Marine Advanced Technology Education Center** – for giving us this wonderful opportunity to not only expand our technical knowledge, but also to teach us real life working skills such a teamwork, to hopefully strengthen our knowledge and prepare us for a better life after high school!

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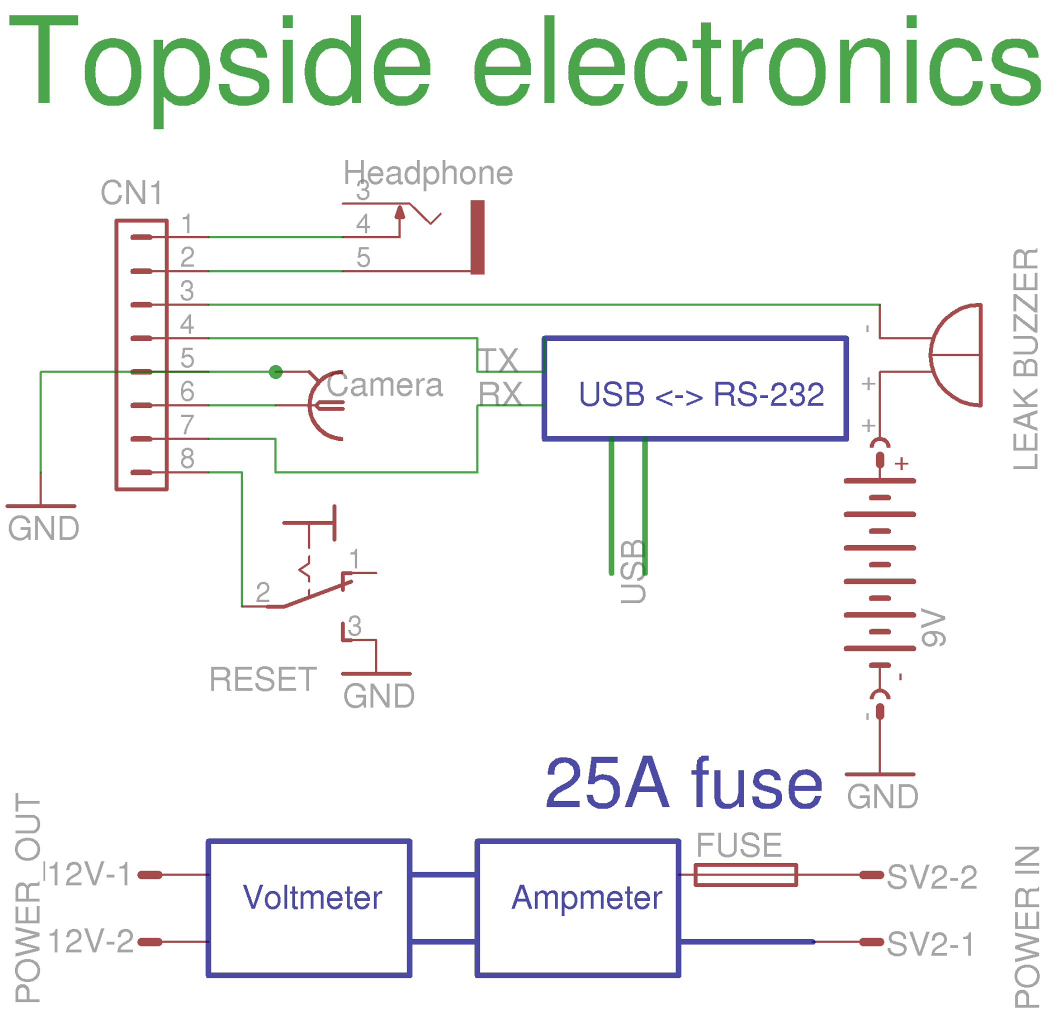
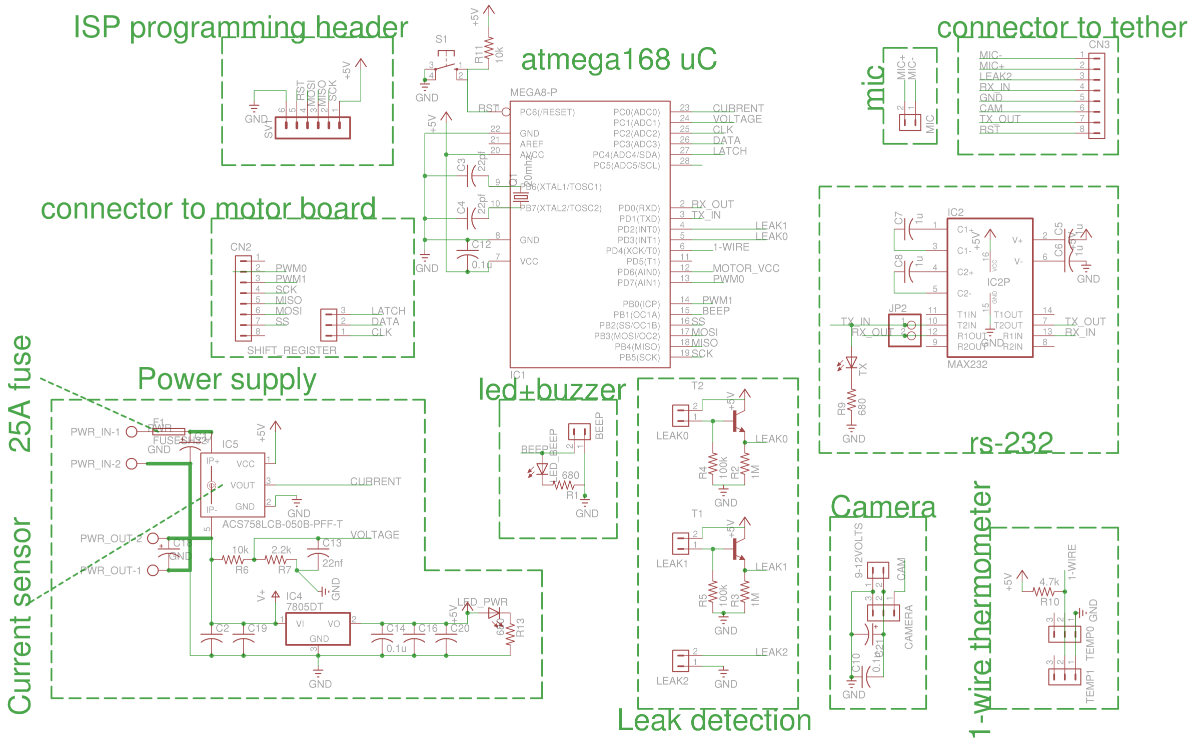
# *Appendix*

## Electronic / electrical schematics



# Control Unit Schematics




# Motor controller schematic