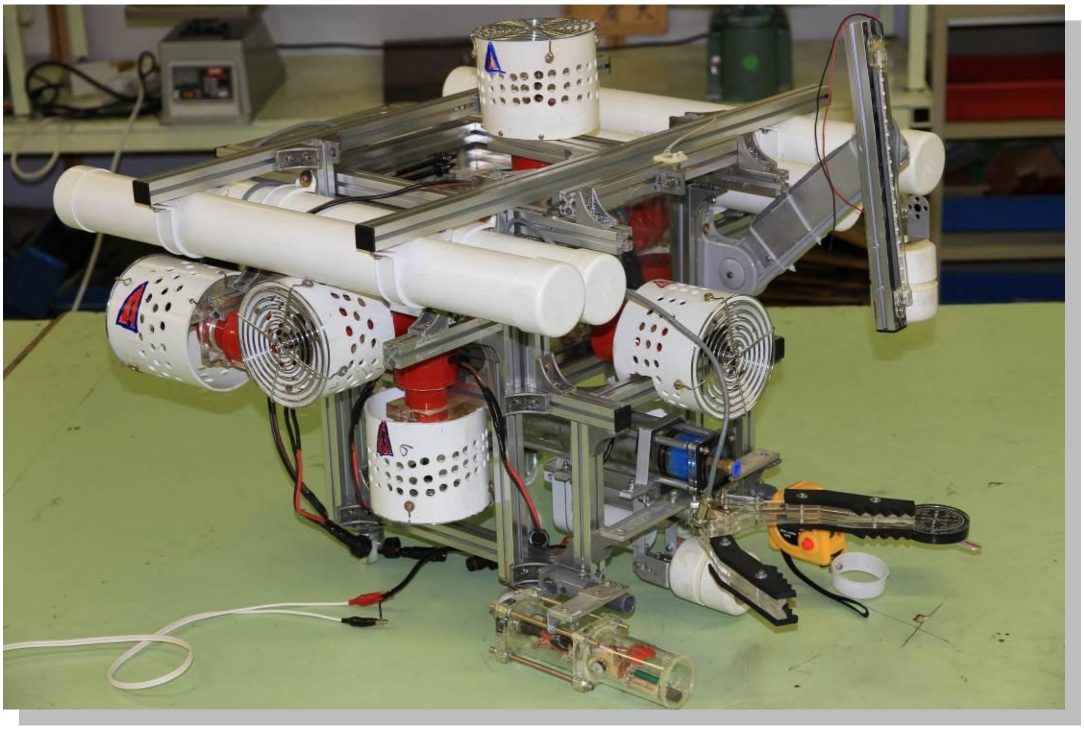
2012 MATE ROV International Competition

Company Name : CMA Underwater Expert Ltd.

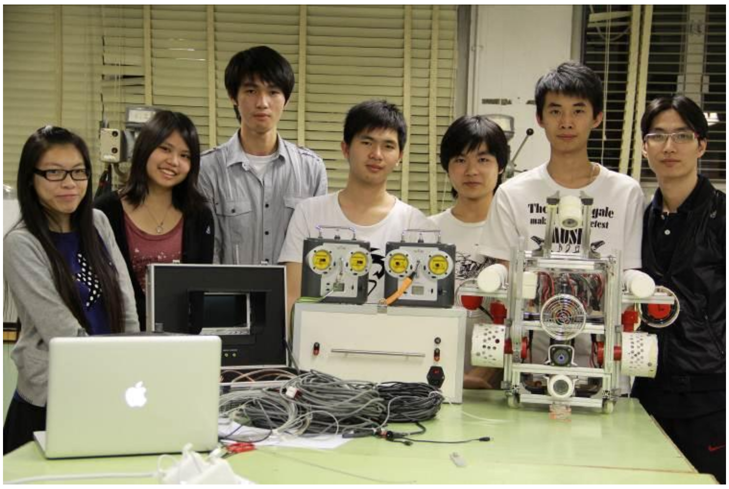
School Name: CMA Secondary School (Hong Kong, China)

Club Name : Design and Applied Technology Club



ROV Name: **Alphatar**

Team Members



Yeung Suet Yee Queenie (S7, Secretary)

Poon Wing Kee Kimberly (S7, CEO)

Chen Sen Chang (S6, Electrical Engineer)

Dang Quoc Vuong (S3, Research and Development)

Chan Cheung Hin (S6, System Engineer)

Leung Shun Kuen (S4, Mechanical Engineer)

Cheung Man Yuen (Teacher, Mentor)

Team photo (From left to right)

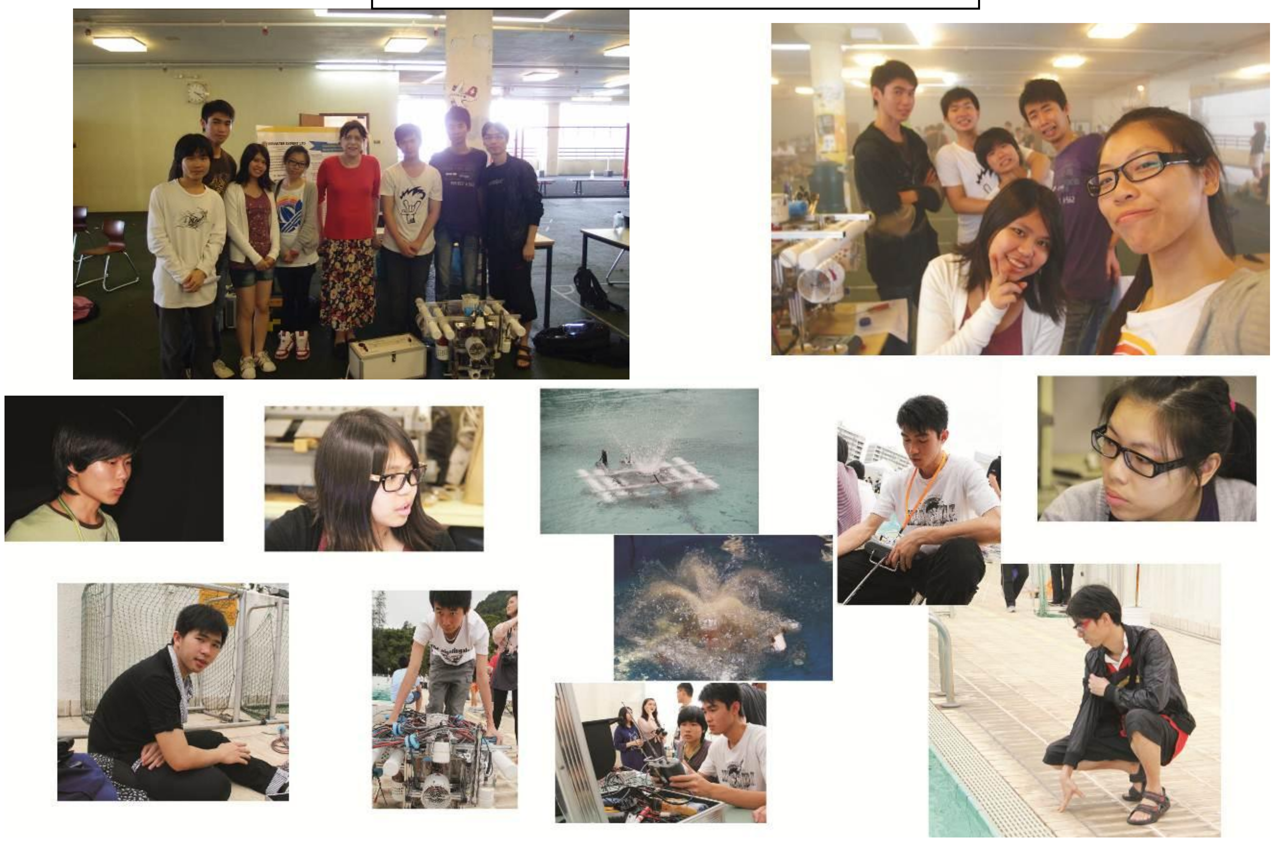
Abstract

This is the first time for our company to join the MATE ROV International Competition.

We are CMA Underwater Expert Ltd. and specializes in creating robotic offshore and intervention systems for shallow water to ultra-deep sea applications. Our company designs and manufactures autonomous and remote-controlled unmanned underwater vehicles, remote-controlled electric and manipulator arms, and inspection TV cameras for subsea intervention offshore in past five years. We have created a Remotely Operated Vehicle (ROV), named ***Alphatar***. The 2012 Marine Advanced Technology Education (MATE) ROV competition focuses on the trouble in the southwest of San Francisco of California. ***Alphatar*** was created to perform a variety of tasks including: surveying the shipwreck site and removing fuel oil from the shipwreck. The CMA Underwater Expert Ltd. is committed to delivering a reliable product and responding to underwater emergencies with professionalism and expertise.

Alphatar has the approximate dimensions of 80cm x 45cm x 50cm and is weighted 18kg. It has one multi-functional gripper, eight thrusters (three for moving forward and backward, three for rise and sink, two for turning), and three cameras, these aspects maximize functionality, thrust, and angles of viewing. In our design, we installed the manipulator arm on the bottom and in front of the ROV. We put the waterproof box inside **Alphatar's** heart for power distribution and keep it balanced when it is under water.

Activity of Hong Kong regional context



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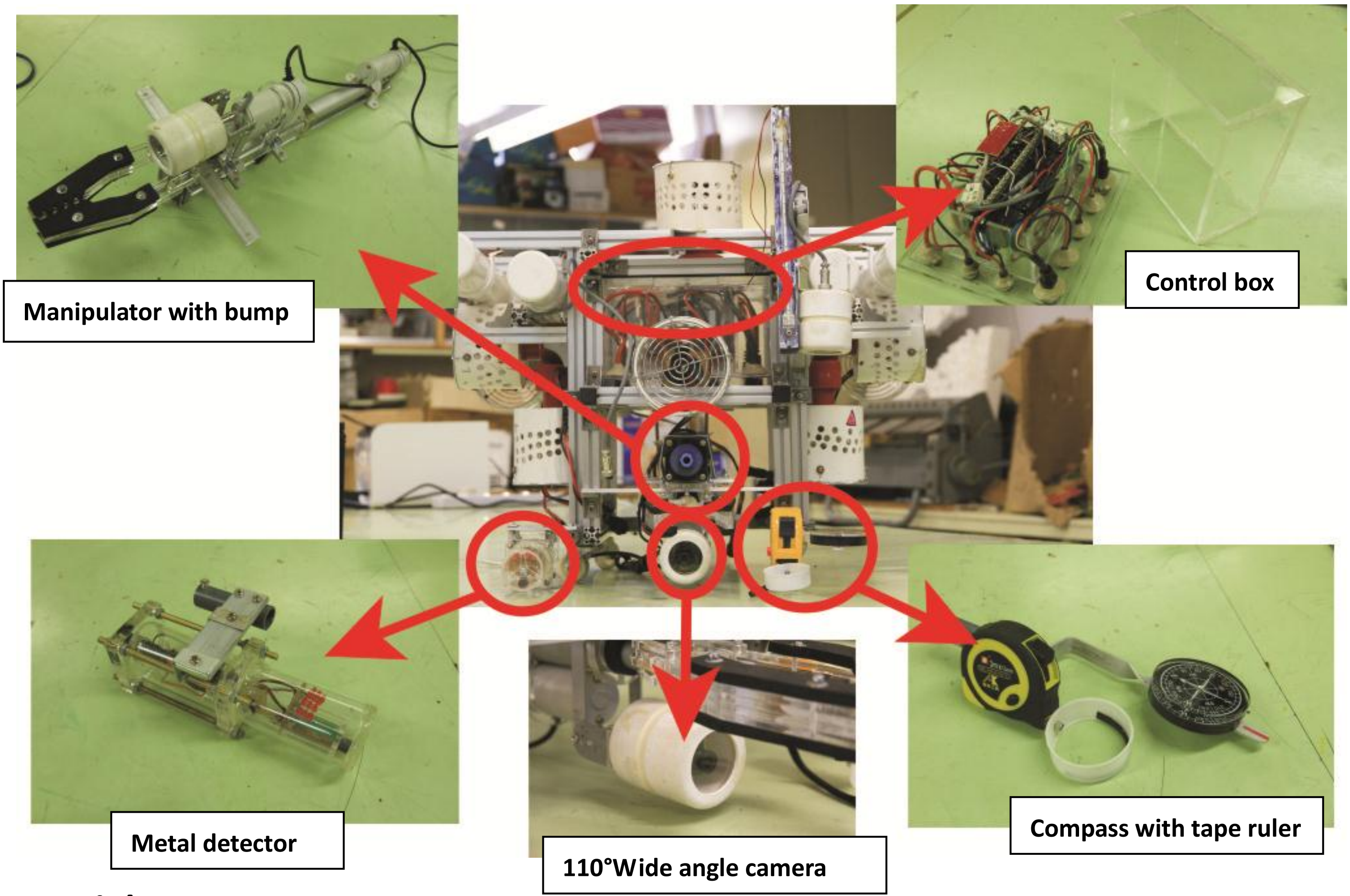
Photos of ROV

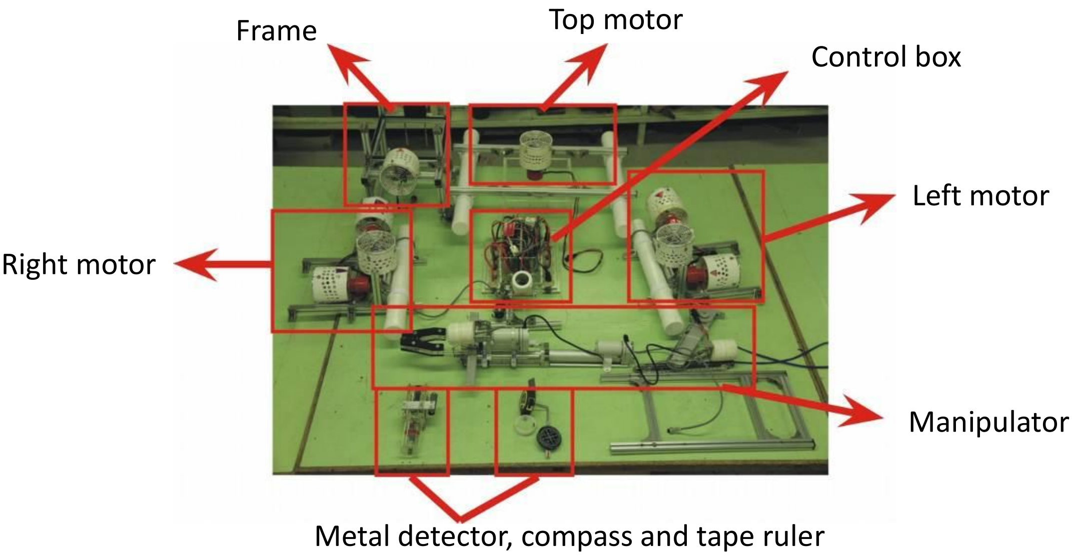


Special Feature

Modular Frame Design

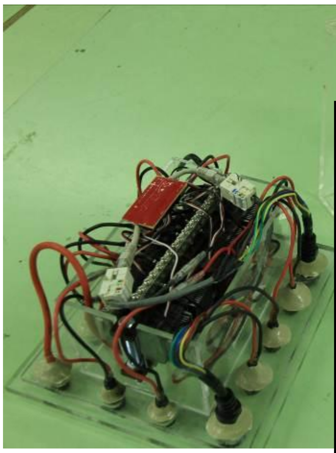
The frame of **Alphatar** has two special points. First, the frame is hand made by our group mates and is made of aluminum rods which are strong enough to protect the ROV when it is carrying out the mission. Moreover, the frame can separate into small pieces for convenient transporting.

The frame is separated into different modules. They are motor module, camera module, sensor module, manipulator module. Each module can be removed rapidly and easily.



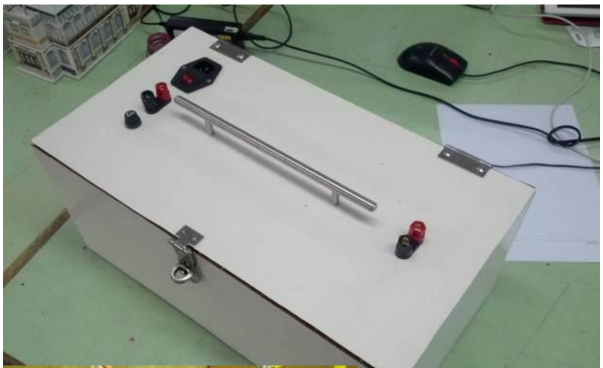
Custom Waterproofed Control Box Design

As it is not easy to make the motor drivers get into the water, a waterproof function designed. It is hand made by our group members and is made of acrylic glass.



Control box

Control box is made of acrylic glass. There are all together 14 plugs, 10 of them are used to control motors, 2 of them are used to be signal wire, and the rest of plugs are power cords.



There two resistors inside the box. Both of the resistors are 1000W 1Ω. They are used to limit the current.

1000W 1Ω resistors

Custom current limiter design

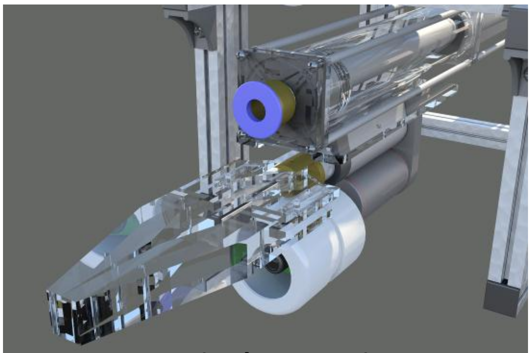
Knowing that the initial work load of the current is increased if turning on the ROV in a deep level of water, and this will cause the blown of fuse. So a current limiter is made. It can limit the current of our ROV. The 12V 25A power source is divided into 2 parts. One is 5A and another is 20A. For the 12V 5A power source, it is connected to three cameras and a controller. For the 12V 20A power source, it is connected to two 1000w 1Ω resistors in parallel then to the 8 thrusters.

Reference formula: V=IR

We paralleled two 1Ω resistors. That we can get a 0.5Ω resister. According to the formula, 12V÷0.5Ω=24A. So our limited current is 24A.

Custom manipulator arm design

Hand made by our group mates and is made of Acrylic glass and covered by EVA mat. Since EVA mat is a kind of soft plastic and its friction coefficient is high, which enables to hold the corals tightly. Manipulator can help removing corals and puts it in the grid. Also, that can reseal the drill hole.



Manipulator Design

Manipulator solid model

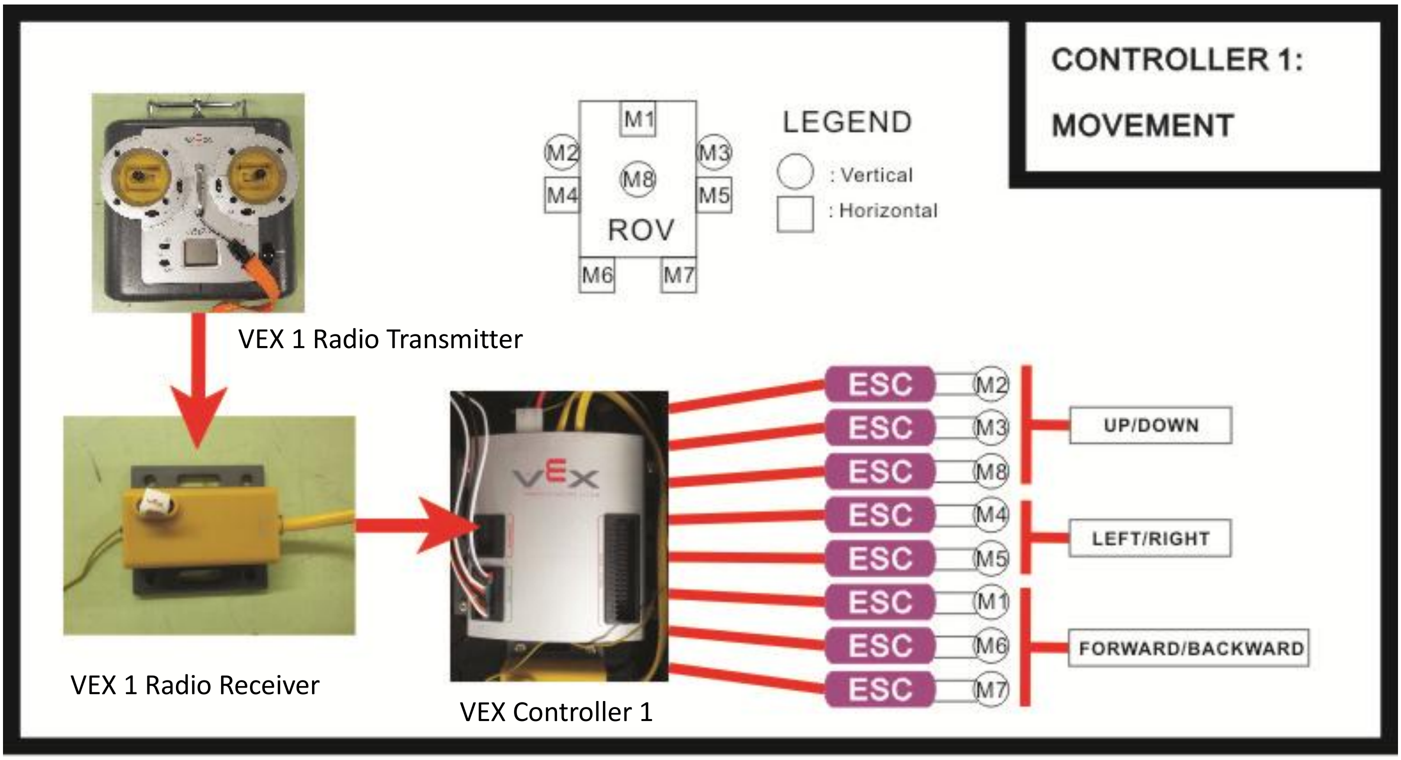
Budget

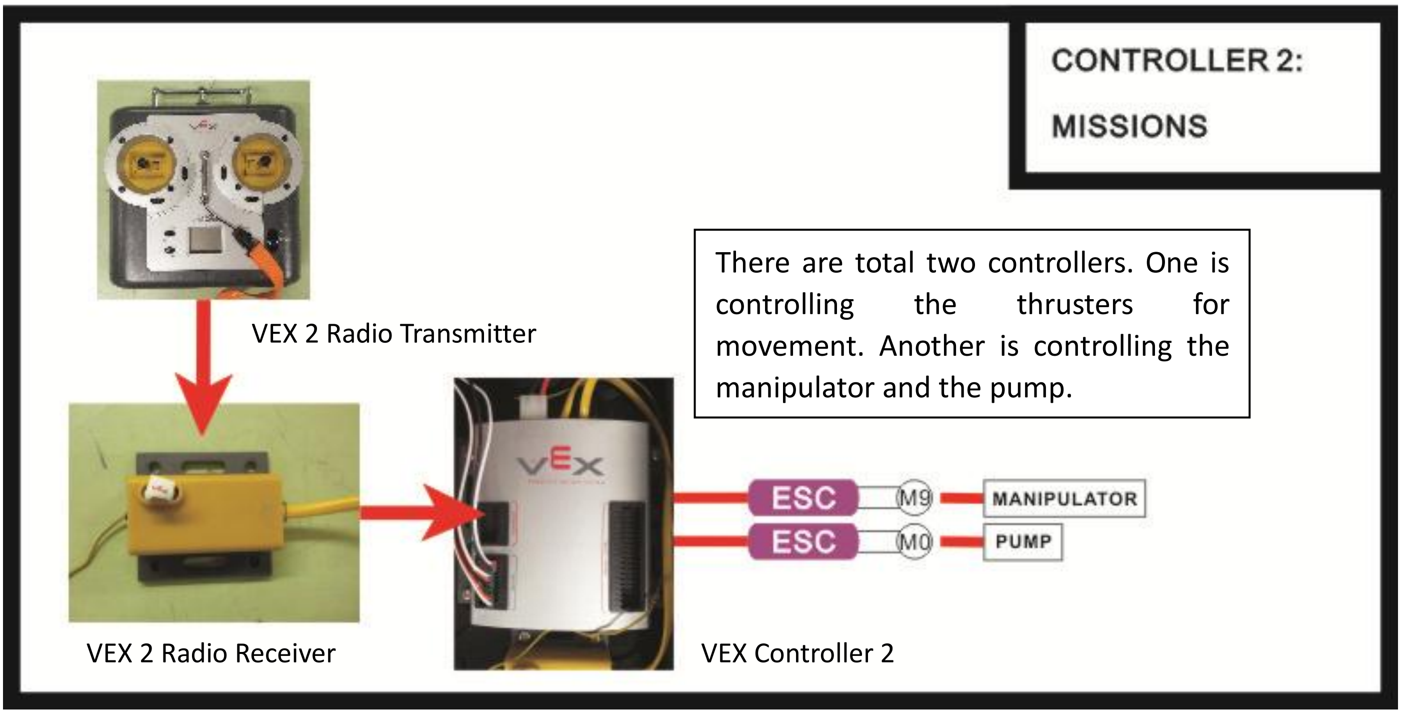
2012 ***Alphatar*** Financial Report

	Part	Quantity	Unit	Donated Value (HKD$)	Cost (HKD$)
FRAME					
1	3030 Aluminum	10	Meter		500
2	Aluminum joint	30	Ea		150
3	Stainless Steel screws + nuts	n/a		300	
4	Waterproofed plugs	30	Ea		100
5	Tap ruler	1	Ea		20
6	Compass	1	Ea		20
7	Metal detector	1	Ea		200
8	LED light	1	Ea		20
9	EVA mat 30mmX30mmX5mm	1	Ea		20
Electronics					
9	Vex Basic kid	2	Ea		4000
10	Easy C Software	1	Ea		600
11	ESC	12	Ea		840
12	1000w 1 Ω resistor	2	Ea		300
13	Fuses	8	Ea	16	
Topside electronics					
14	Vex download Cable	1	Ea	250	
Propulsion					
15	1100GPH bilge pumps	7	Ea		1400
16	Propellers	7	Ea	64	
17	Mounts (50mm PVC mount)	8	Ea		40
Payloads					
18	Geared motor for manipulator	2	Ea		100
19	6,9,10mm acrylic	n/a	Ea	500	
20	Cameras	3	Ea		1500
Tether					
21	Black and red 10WG	30	Meter		120
22	Black and red 16WG	30	Meter		600
23	Extra Flexible Cat5	30	Meter	300	
24	Wire	15	Meter		150

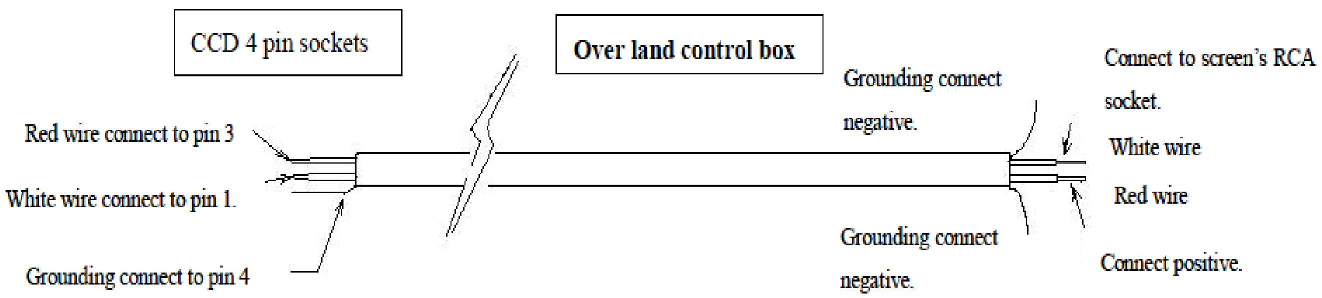
Fundraising	10680
Total Budget (Fair Market Value)	1430
Amount spent	10680
Balance	0

Electrical Schematic





110^{0} CCD Camera Circuit Diagram



Design Rationale:

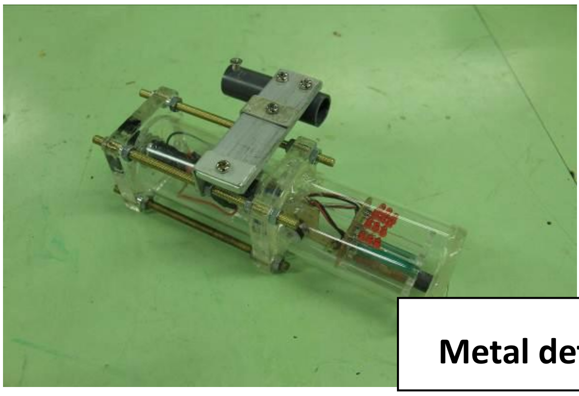
ROV Tasks

Task 1: Survey the shipwreck site

1) Tape ruler is used to measure the overall length of the wreck. The hole in front of the ruler is used to hitch the front part of the wreck. After fixing the starting point, drives the ROV to the backward of the wreck and read the measuring.
2) The orientation of the ship is determined by compass. Parked the ROV in a position which is parallel to the wreck. Then, read the orientation where the wreck points.

Tape Ruler and Compass

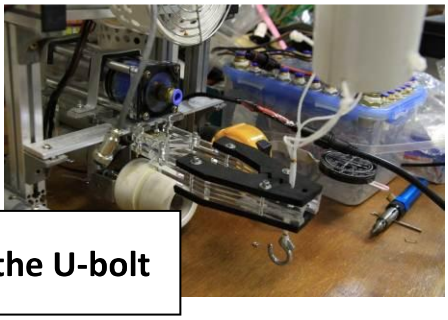
3) Metal detector is installed in ROV. It is waterproof. When a metal is detected, the red light turns on that can help us to determent metal or non-metal easily.



Metal detector

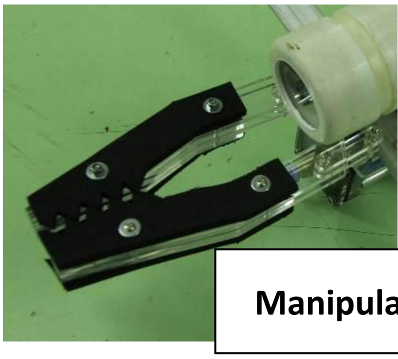
Task 2: Removing fuel oil from the shipwreck

1) The notch design in manipulator arm is used to transport the U-bolt, inflate the lift bag and reseal the drill hole.



Holding the U-bolt

2) ROV can remove endangered corals to an unoccupied space by using manipulator arm.



Manipulator Arm

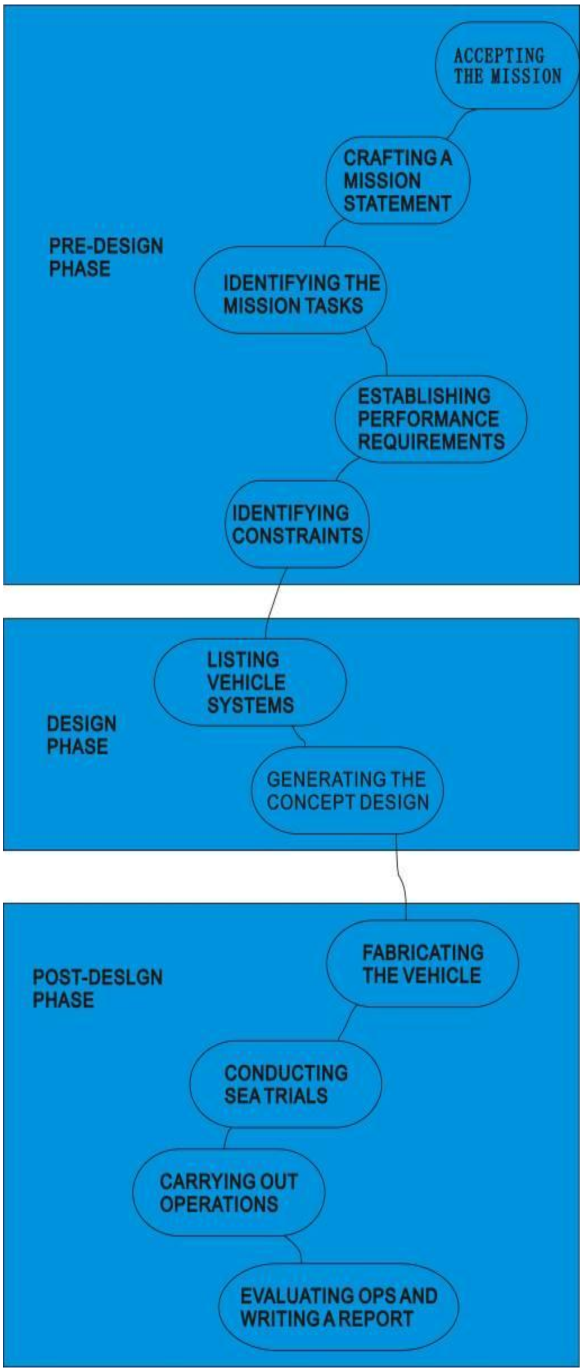
3) The sensor is used to calibrate the neutron backscatter device.

Simulated Sensor

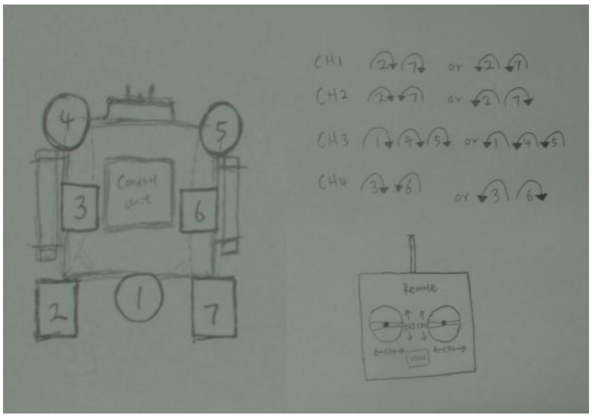
4) ROV removes fuel oil by using a big syringe.

Big syringe

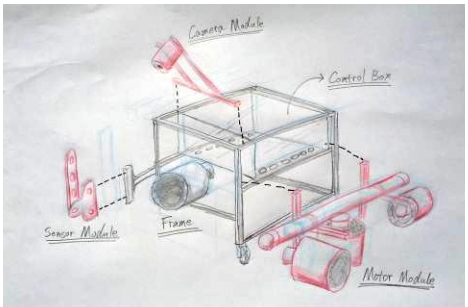
Design Methodology



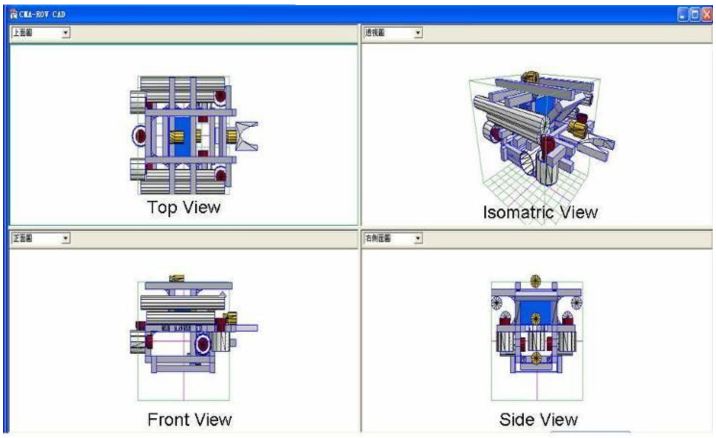
Concept design



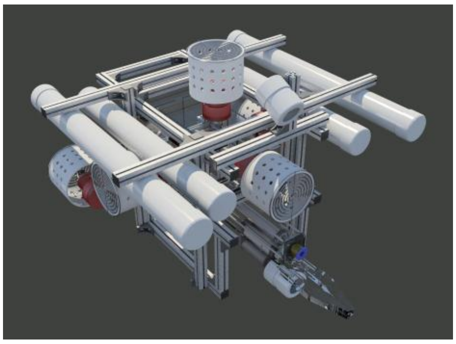
From Sketch to CAD



Alphatar Draft Design



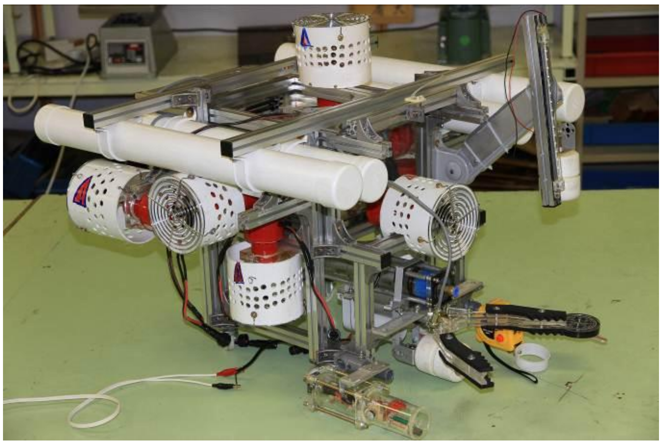
From CAD to Reality



Computer Aided Drawing

for Structure design

Final Version of CMA-ROV



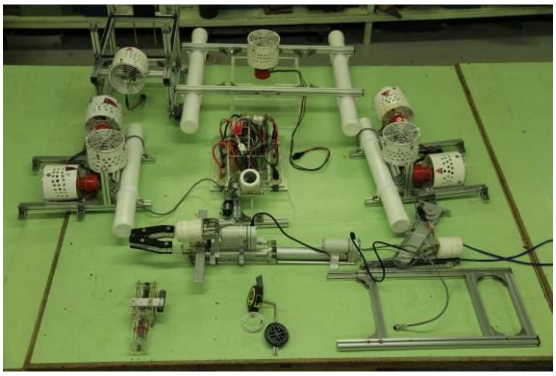
Completed model of Alphatar

Frame

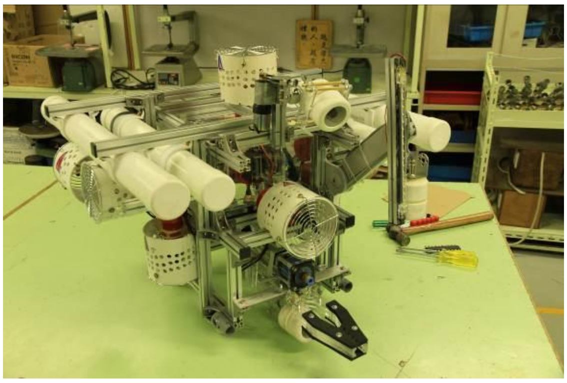
Alphatar's frame is composed of 30mm x 30mm entrusted aluminum. Compared to other structural materials, aluminum are chemically simple and it is a popular structural materials for all sorts of things (not just underwater vehicles), because of the hard, stiff, wear-resistant materials that can offer excellent strength-to-weight ratios, yet they can also be cut, drilled, bent, and also fabricated into a wide variety of useful structural components, including beams, plates, bolts, rivets, and even wire rope or cable.

Also, our frame is modular design. That can separate into small pieces. For example, the cameras and motors can be separated from the ROV easily while transporting.

The size of ROV is 80 cm long, 45 cm widen, and 50 cm high.



Different parts of Alphatar

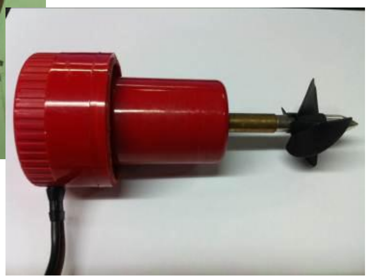


ROV SIZE 80X45x50cm

Propulsion

Alphatar can store eight thrusters. By replacing impellers with propellers, the team transformed ordinary bilge pumps into fully functional thrusters. Each thruster provides 2.5 amps of power and propels approximately 1100 GPH. Five of the thrusters are mounted in a horizontal row; this position allows a full range of motion for the ROV and permits the vehicle to travel forward, backward, and in both lateral directions. The other three thrusters are mounted for vertical motion in the water. The converted bilge pumps give **Alphatar** the power to travel.

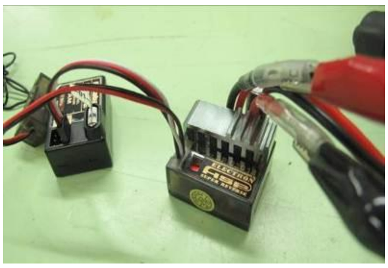
1100 GPH bilge



Electronic Speed Controller

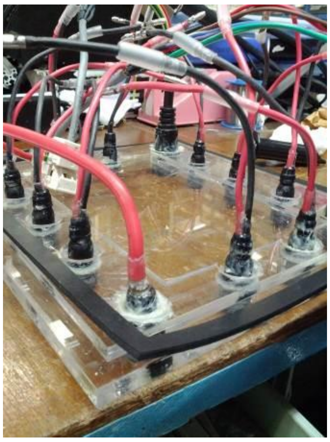
We used the MOSFET type electronic speed controller (ESC) in **Alphatar**.

For general, a single channel is able to control one actuator or one thruster on the ROV. Therefore, a deeper diving hybrid with four thrusters would need a transmitter and corresponding receiver with a minimum of four channels.



Electronic Speed Controller (ESC)

ROV Control Box

	
Made of Acrylic glass	Installation of the plugs
	
Waterproof testing	Fit into ROV

Our control box was made of Acrylic glass. It is waterproofed. ESC is built inside, they are used to control motors.

Cameras

We used 3 cameras to investigate the surrounding.(one camera for front; one camera for watching the compass and tape ruler and one for watching the manipulator)

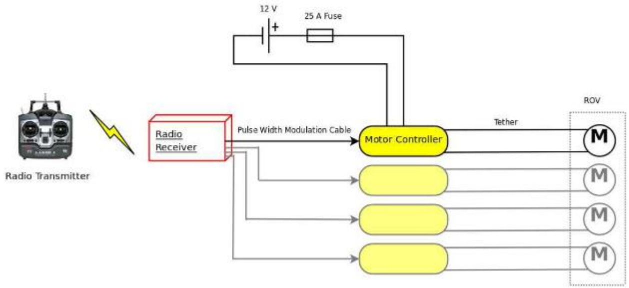
Camera Specification

Waterproofed 420 wire, 110 degree wide angle camera, focus could be preset, focus distance from 300 mm to infinity, could work under 20 meters, video cable could be over 50 meters(over 70 Ω).
Voltage: 12V DC
Current: 0.5A

Controller and Electronics

VEX Radio-control (R/C) controllers have been adapted to operate the **Alphatar**. The **Alphatar** is developed by Underwater Expert, uses two VEX 6-channel R/C controllers to control 12 electronic speed controllers. It encodes the analog control voltages from the R/Cs, queues them in the VEX controller, and sends them down to the ROV with two CAT-5 cable. The signal is modified to pass through two CAT-5 cables in the tether. The result is an elegant way to control the **Alphatar**.

These R/C controller systems consist of two 6 channel hand-held transmitter units, which store the controls, compatible receiver units and two VEX controllers, plus 12 electronic controllers separated into two groups, which reside on the water-proof box in the ROV.



R/C Diagram

Two sets of VEX controllers for Alphatar

The VEX controllers are programmable. It helps for easy control and made the design become more flexible. It would easily accommodate future expansions of ROV subsystems, such as a manipulator or a camera tilt mechanism. The ROV's thrusters require high rate of power of delivery in short time periods. Typically, the thrusters that power pull currents in excess of 2.5 amps and may peak at 4 and 6 amps for short periods of time. To meet these demands, producing small, high-capacity electronic motor controllers is used for this purpose. This is a good news for our underwater robot designers, since thrusters that pull up to 4 amps at 12 volts can be controlled by these heavy-duty R/C motor controllers.

Tether

The tether consists of two 8 AWG power cables, three coaxial cables for cameras, two CAT-5 cables for the ESC's signal, one signal cable for portable fish finder and one 1mm wire for tether protection.

The Length of tether cable - 15 m

Diameter - 20 mm Weight - 2 kg

Power Budget for the ROV

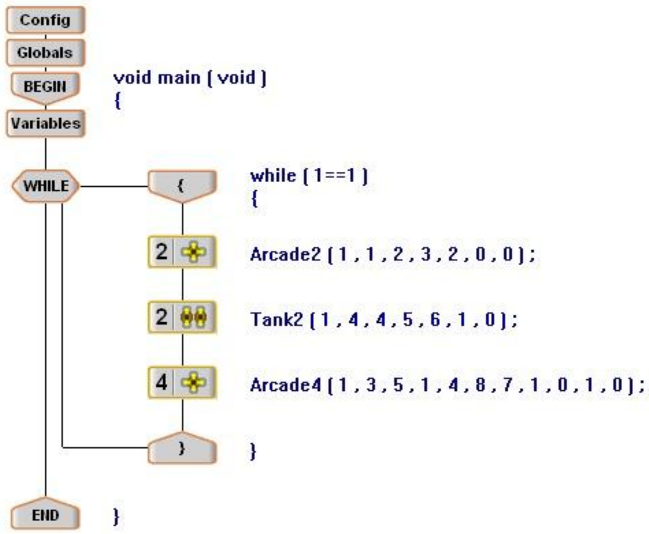
Device	Current per device	Power per device	Total power
8 Thruster	12V 6A	72 watts	576 watts
3 Motor	12V 1A	12 watts	36 watts
1 Sensor	0.2A	1.2 watts	1.2 watts
3 Camera	12V 0.5A	6 watts	18 watts
Total	-	-	**630.2watts**

Software flow

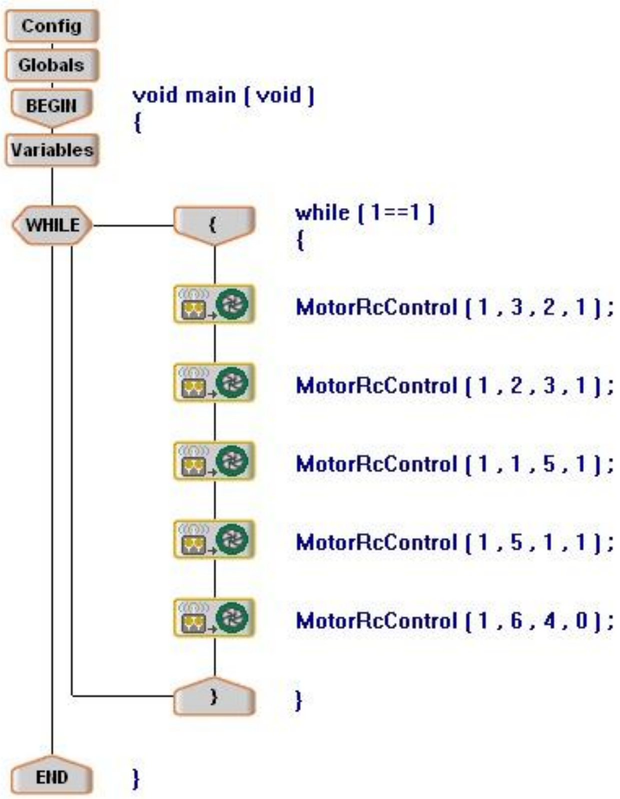
Using VEX radio control system; we used the "Easy C" software to write the program. It was GUI program software so we could write the program by graphic.

Coding for ROV

Thrusters control



Manipulator arm control

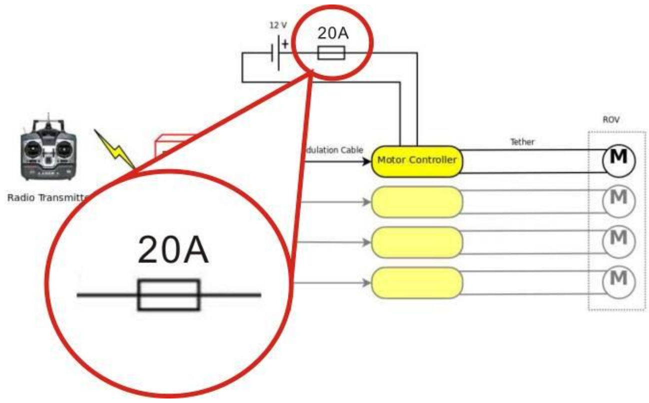


Safety

Safety feature

- **20A fuse in place**
- **Clearly labeled moving parts**
- **No sharp edges**

Power safety



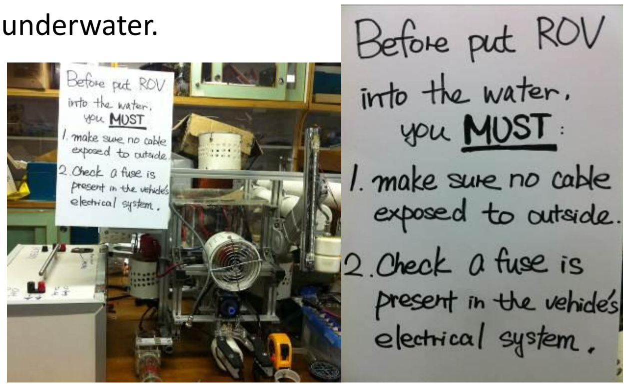
We used a 20-Amp fuse at the beginning part of the circuit to protect the motors. Also all of the wires is clean and neat, no wires or contacts are exposed.

Thrusters' safety

We used water pipe and steel mesh cages to cover the propellers and draw some safety marks to prevent any loose or someone who is unlucky and contact them with fingers accidentally.

Safety check list

We made a safety check list and check all of the safety every time before we operate our ROV underwater.



Vehicle System

Alphatar is made by ourselves. For example, manipulator, pump. Design of Alphatar, electrical, Easy C program for VEX.

Poon Wing Kee Kimberly is a CEO of our company.

Chan Cheung Hin is system engineer in change of software testing and operations.

Chen Sen Chang is electrical engineer in charge of electronic system development.

Leung Shun Kuen is mechanical engineer in charge of hardware design and material selection.

Yeung Suet Yee Queenie is company secretary respond for the writing report.

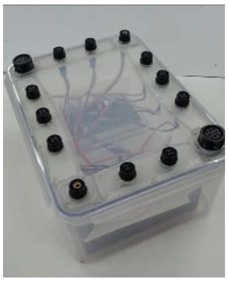
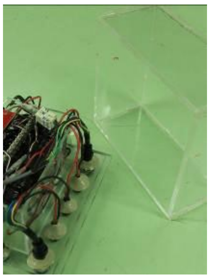
Dang Quoc Vuong is R&D engineer, studies ROV waterproof

CMA - ROV Operating and Control Crew
*Typical team members operate **Alphatar** :*
> 1 x Pilot
> 1 x Technician
> 1 x Navigator

CMA - ROV Back up technical crew
*Typical team members operate **Alphatar** :*
> 3 x pit crew members

Challenges

The first challenge we faced was our control box. We designed three boxes in total. The first version of the box was too small, so there was not enough space to put in our motor drivers. Then we developed the second version. The second version was reproduced by lunch box, but the lunch box was broken while our waterproof testing. Lastly, we decided to make the box by ourselves. We used Acrylic glass and laser cutter to build one. That was the latest version.

		
Version 1	Version 2	Version 3

The second main challenge was most of us have to prepare the public examination, so we didn't have enough time to build the ROV and finish the report as soon as possible. We had to know our job duty and finish it on time, so we could complete the project on schedule. Good management and organization is very important as a team.

Troubleshooting Technique

Checking the program of control system had spent much of our time. When we finished the program, we tried to control the thrusters at first time. But these thrusters always trembled and we could not control it. We thought maybe the signal wire was too long. So we found a shorter signal wire to try, but it still did not work. Then we checked the program again, we discovered that the program syntax was wrong.

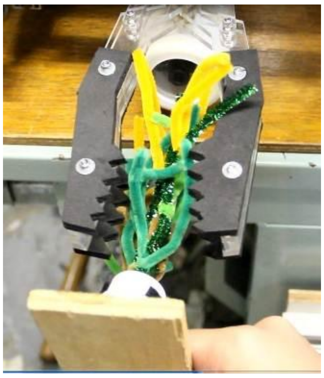
First, we used 16 AWG as the power cable. We found that the voltage drop will become signification. It means that was not enough power to give to the thrusters. So, we used 8 AWG cable to replace the 16 AWG to get enough power.

As for the waterproofed control box problem, there was not enough space for the motor drivers in side. So we built a larger box. Another problem of the box was about waterproofing. Lastly, we used Acrylic glass to build the box by ourselves and we make it successfully.

Payload Description

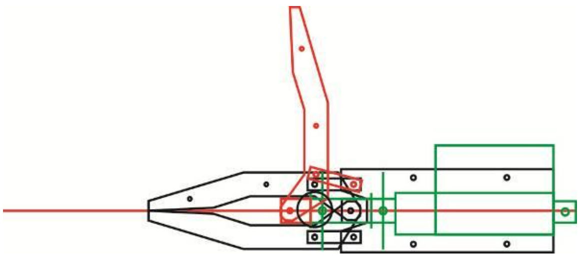
ROV Speed : Horizontal Speed – 0.588m/sec

Vertical Speed – 0.75m/sec



Manipulator Force – 25Kg

Manipulator Open Angle – 90° -180°



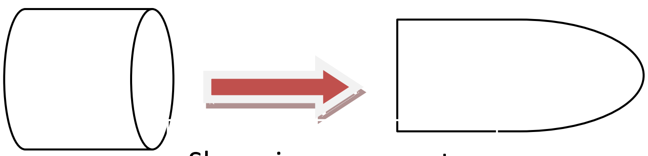
CorelDraw for Gripper Design

Future Improvement

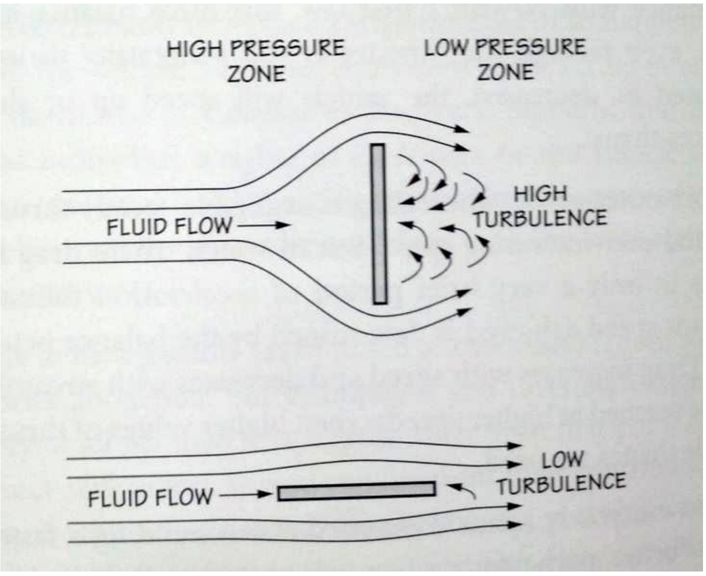
We found that **Alphatar** move slowly, while going deeper in the water. There are several ways to solve the tasks.

Improve the shape of **Alphatar** could be designed in streamlined. It can reduce the resistance when the ROV is moving in the water. The ROV can move faster.

We can also use the lighter material to replace the 3030 aluminum. It can solve the weight problem and help us to transport our ROV.



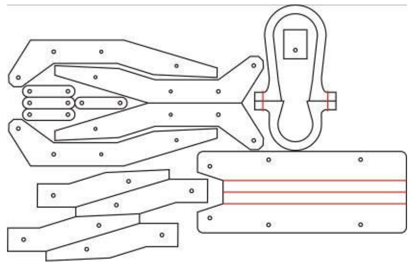
Shape improvement



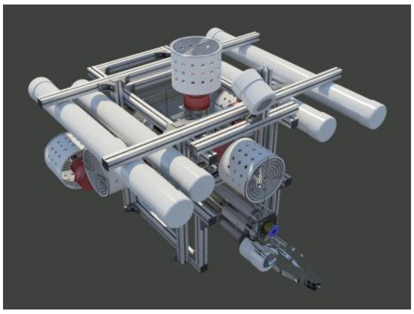
Lesson Learned

Technical Aspect

- We learned how to handle hand tools, e.g. soldering and wiring.
- Learned how to use the CorelDraw to design the manipulator and control box.



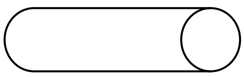
- Learned how to use the AutoCAD to design the 3D model. Using AutoCAD to design our **Alphatar**. It spent us one week to draw this graphic.



- Learned the usages of different material, e.g., EVA mat can increase the friction of the manipulator.
- Learned to use resistor to limit the current.

1000W 1Ω Resistor

- About buoyancy, learned that ballasts needed to put at a upper level. This can help the ROV become more stable in under water. Weight of displaced water column.

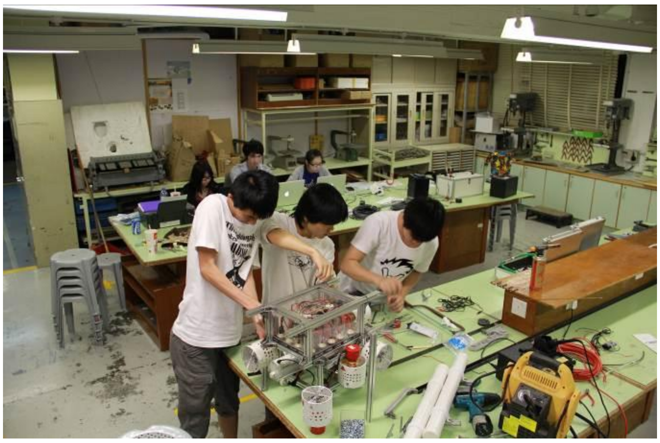


Cylinder:
$V = \pi r^2 h$

Interpersonal Aspect

- A major lesson we learned this year is time management. After discussion, we drafted a schedule for our preparation. It makes our project run smoothly.
- We know that communication among teammates is very important, so we meet regularly to discuss and plan for the project.

- By learning from fellow team members, we have grown as a team.
- All the members are important and the whole success depends on everyone's work.



Team spirit : Working hard to achieve goal

Preparing regional competition : Concentrating with committment

Reflections

This is the fifth times for our team to participate in the Hong Kong Underwater Robot Challenge. This is because of how much fun we have had building, designing, testing and eventually competing with ROV that has been created with a great team. Throughout the design and building process, our team logged over a thousand hours and learned a lot about what to do and what not to do while building an ROV. Moreover, sometimes our team had disagreement about the ROV's design or had to troubleshoot its systems. All of the members have always enjoyed all the mechanical and technical things and this competition is the perfect outlet for our creativity. In addition, the past experience has enriched our knowledge and skills about ROV. For instance, we have learned to take the design and build an ROV, how can they use, how to work with certain electronics and how to solder effectively.

Our team has learned many valuable skills this year. Through the competition, we have grown as a team. This experience has taught us that leadership and diligence are very important to us. This kind of experience can enhance my communicate skills and build up team spirit.

From our point of view, we look forward to using the lessons we have learned as we aim to pursue our degree in the field engineering. The experience of competition is invaluable to us. It lets us be more confident and extrovert. We are proud of our work.

Teamwork

<table>
<tr><th colspan="9">Schedule</th></tr>
<tr><td>Name</td><td colspan="2">November</td><td>December</td><td>January</td><td>February</td><td>March</td><td>April</td><td>May</td></tr>
<tr><td>Yeung Suet Yee Queenie</td><td rowspan="6">Planning getting to know ROV design</td><td>Research</td><td>Trouble in the WWII discussion</td><td rowspan="2">Brainstorm, Report writing</td><td>Budget</td><td>Budget, Presentation practice</td><td rowspan="2">Research for improve our Alphatar</td><td rowspan="2">Re-design poster and presentation practice</td></tr>
<tr><td>Pooh Wing Kee Kimberly</td><td colspan="2">Research</td><td>Report writing,</td><td>Future Improvement, Poster and presentation practice</td></tr>
<tr><td>Dang Quoc Vuong</td><td colspan="2">Research</td><td>Brainstorm</td><td>ROV tool packages hook</td><td>Future Improvement</td><td colspan="2">Replace new cameras</td></tr>
<tr><td>Chen Sen Chang</td><td colspan="2" rowspan="2">Shield motors,
Build ROV Frame,
Electronics programming</td><td>ROV tool Packages- brainstorm, Controller design</td><td rowspan="2">Ballast system,
ROV tool packages gripper,
ROV tool packages sampler</td><td>Flow works, Presentation practice.
Touch up ROV, Driving</td><td colspan="2">Manipulator improvement</td></tr>
<tr><td>Leung Shun Kuen</td><td>ROV tool Packages- brainstorm</td><td rowspan="2">Touch up ROV, Driving</td><td colspan="2" rowspan="2">Technical improvement</td></tr>
<tr><td>Chan Cheung Hin</td><td colspan="2">Use AutoCAD to design</td><td>Software and Electrical discussion</td><td>ROV tool packages- Hook</td></tr>
</table>

CMA UNDERWATER EXPERT Ltd.

CMA Secondary School in Hong Kong, China

Competition History :

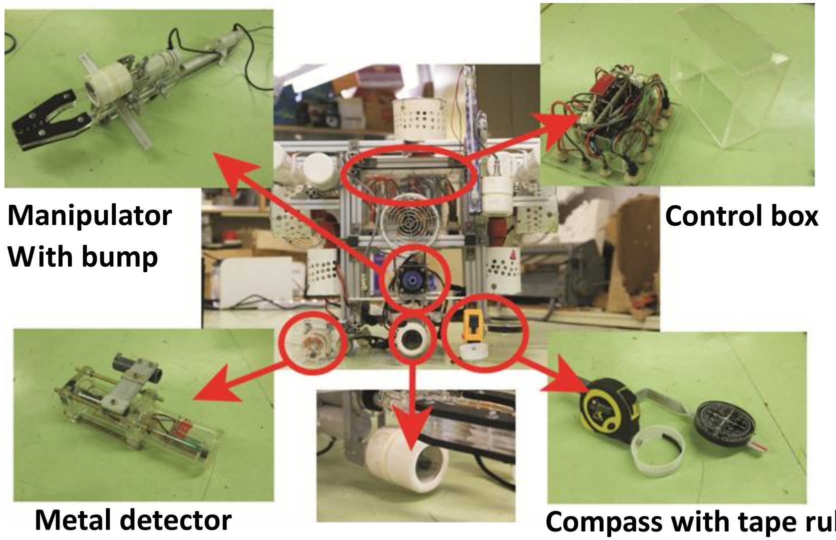
This is our fifth times participating in the HK MATE ROV Competition

Protect Environment

Always and Forever !

CMA Underwater Expert Ltd. is specialized in robotic offshore and intervention systems for shallow water ultra-deep sea applications. The company designs and manufactures autonomous and remote-controlled unmanned underwater vehicles, remote-controlled electric and manipulator arms, and TV cameras for subsea intervention offshore.

ROV : Alphatar



ROV Name : Alphatar

Cost: $10680

Material: Aluminum, Acrylic glass

Length: 80cm Width: 45cm Height: 50cm

Weight: 18 kg

Design Rationale:

- Solve the potential environmental problems and socioeconomic threats.
- Do not waste lots of unnecessary money on shipwreck toll.

The most rewarding part:

- Building, designing, testing, and competing an ROV with our teammates
- Team spirit is the most important thing when we working together
- Get enough communication with each other.

In next time:

- Design our ROV's become streamlined sharp because that can reduce the resistance when the ROV is moving in water.
- Reduce the weight of ROV because that may make the ROV move flexible

Special Features :

- Custom frame design
- Custom Acrylic waterproofed control box design
- Custom current limiter design
- Custom manipulator arm design

Acrylic control box

Challenge:

Control box and wiring

Acrylic Box design and build

Team Member Name (Form, Role)

Yeung Suet Yee Queenie (7, Secretary)

Poon Wing Kee Kimberly (7, CEO)

Chen Sen Chang (6, Electrical Engineer)

Dang Quoc Vuong (3, R&D Engineer)

Chan Cheung Hin (6, System Engineer)

Leung Shun Kuen (4, Mechanical Engineer)

Cheung Man Yuen (Teacher, Mentor)

Team Photo (Left to right)

Acknowledgements

The CMA Secondary School ROV Team would like to thank the following parties and organization for supporting us, allowing the creation of a successful ROV.

Marine Advanced Technology Education Center (MATE), for giving us this grateful opportunity to not only expand our technical knowledge, but also enrich our experience.

City University of Hong Kong, for hosting workshops, it makes us to know cleanly about the competition.

Dr. Mak Yiu Kwong, our Principal and CMA Secondary School for the school pool, facilities and financial support.

Mr. Yu from Alert Enterprises (H.K.) Ltd. for financial support (HK$10,000).

Mr. Cheung Man Yeun, our mentor, for being there when ever we needed help (CMASS Technology Innovation Club), for allowing us to use their machines and storage area and donate materials for the competition of the ROV.

All of our parents and families, for their patience, encouragement and support to our team and project.

MATE International ROV Competition

7th Hong Kong Underwater Robot Challenge (MATE International ROV Contest Regional)

Technical Sponsor

Organising Sponsors

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