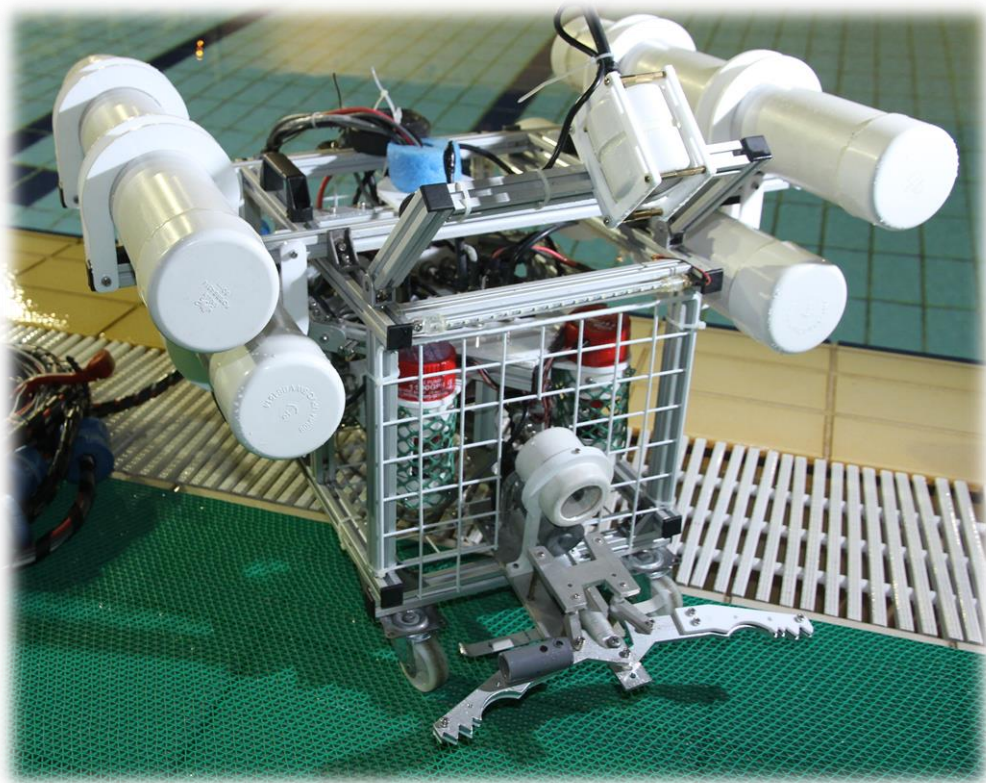


# The 12th Annual MATE International ROV Competition

Company Name: CMA Underwater Expert Ltd.

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

Club Name: Design and Applied Technology Club



ROV Name: **Beta** 【佩珊號】

## Team Members



## Consultant Team



## Abstract

This is the second times for our company to join the MATE ROV International Competition.

We are CMA Underwater Expert Ltd. and specialize 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 **Beta**. The 2013 Marine Advanced Technology Education (MATE) ROV competition focuses on launching a new era of ocean science & discovery. **Beta** was created to perform a variety of tasks including: completing a node and installing an instrument on the seafloor, using a temperature sensor to measure temperature over time in a hydrothermal vent opening, replacing an Acoustic Doppler Current Profiler (ADCP) on a mid-water column mooring platform and removing bio-fouling within the observatory. The CMA Underwater Expert Ltd. is committed to delivering a reliable product and responding to underwater emergencies with professionalism and expertise.

**Beta** has the approximate dimensions of 79cm x 68.5cm x 49.5cm and is weighted 19kg. It has a multi-functional manipulator, a temperature sensor, eight thrusters (four for horizontal movement and four for vertical movement) and three cameras, these aspects maximize functionality, thrust, and angles of viewing. We put four Electronic Speed Control boxes (ESC) inside **Beta** for driving motors and two monitor signal collection box.

### Last Year MATE contest



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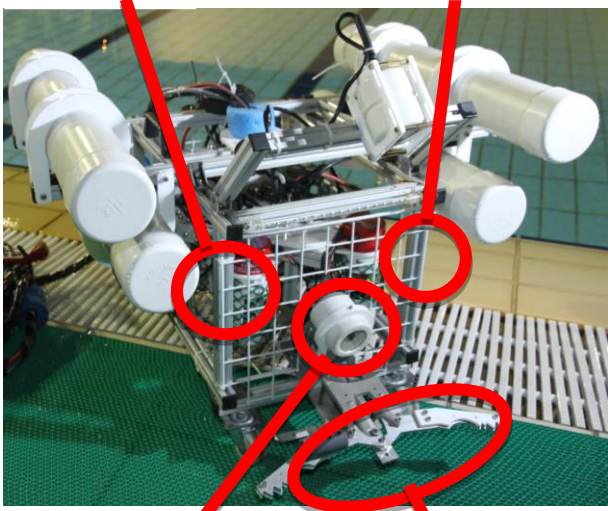
## Photos of Beta



Thruster



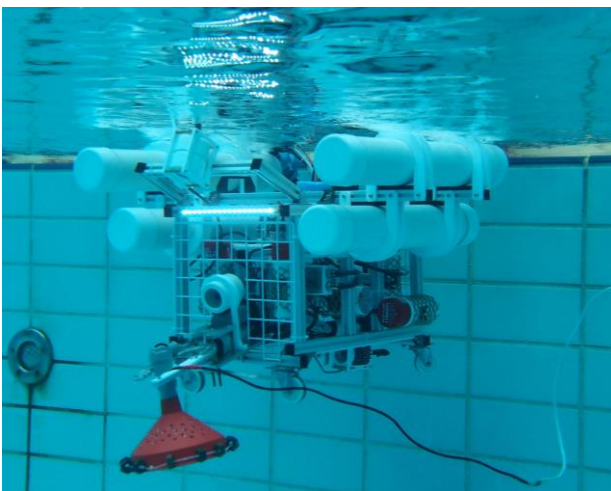
Electronic Speed Control Box



110° camera



Manipulator



Remote Operated Vehicle Detail

## Special Feature

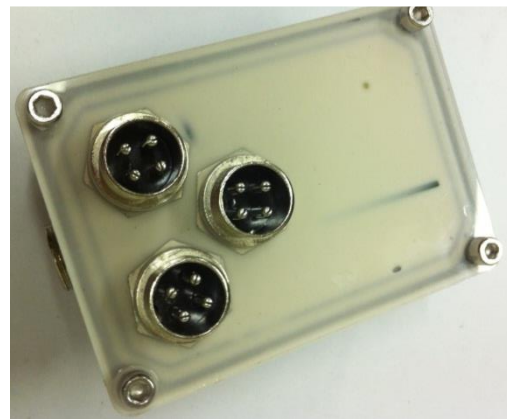
### Modular Frame Design

The frame of **Beta** 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.

### Waterproofed Electronic Speed 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 and epoxy.



### Electronic Speed Control Box

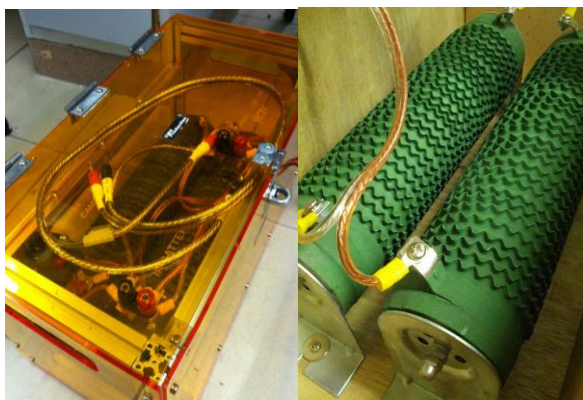
Control boxes are made of acrylic glass. There are all together 4 boxes. And all of them have 2 two-way E.S.C. for thrusters. Some of the E.S.C. are used to be spears.

## 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, we would step down it to 7.5V 7A for each motor. It is connected to two 1000w 1Ω resistors in parallel then to the 6 thrusters.

### Reference formula: $V=IR$

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

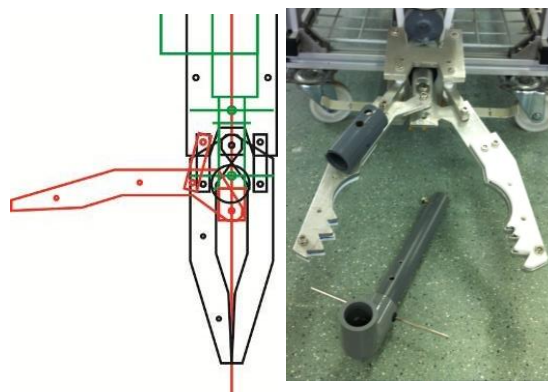


### 1000W 1Ω resistors

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

## Manipulator Arm Design

Knowing that in the concerning situation this year, the manipulator is used and important for finish a lot of missions, so we focus on it and test different types of manipulator. At first, VEX's manipulator is used, as we found that it do not have enough force to hold things, a new manipulator which is handmade by our members instead the old one. We modify the manipulator to have 2 dimensions movement. Also, an appurtenance is designed to increased reliability.



### Simplified Diagram and Manipulator Detail

The VEX manipulator arm can afford to take the heavy things to the seafloor or pick the tinny things, such as, SIA, a pin, etc. After revised, an optional tool is designed for turning the handle, and picking up the ACDP.



### New Design of Manipulator Detail

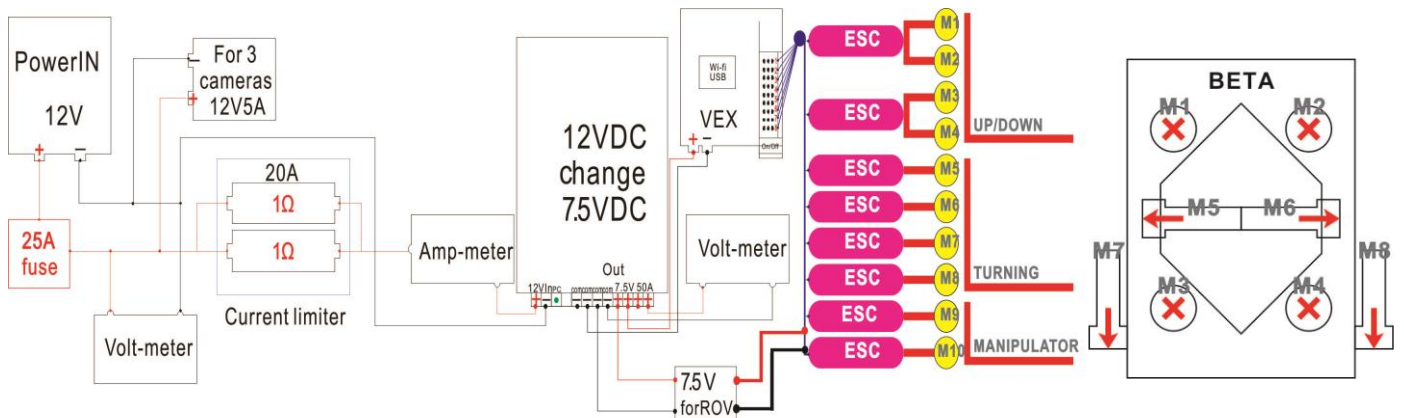
## Budget

### 2013 *Beta* Financial Report

	Part	Quantity	Unit	Unit price (HKD\$)	Cost (HKD\$)
FRAME					
1	2020 Aluminum	10	Meter	25	250
2	Aluminum joint	30	Ea	5	150
3	Stainless Steel screws + nuts	1	Ea	300	300
4	Waterproofed plugs	20	Ea	5	100
5	Temperature sensor	1	Ea	10	10
6	EVA mat 30mmX30mmX5mm	1	Ea	20	20
Electronics					
7	Vex Basic kit	1	Ea	2000	2000
8	Electronic speed controller	10	Ea	70	700
9	1000w 1 $\Omega$ resistor	2	Ea	150	300
10	Fuses	8	Ea	2	16
Propulsion					
11	1100GPH bilge pumps	8	Ea	70	560
12	Propellers	8	Ea	8	64
Payloads					
13	Geared motor for manipulator	2	Ea	50	100
14	6mm x 25mm x 500mm aluminum plate	1	Ea	50	50
15	Cameras	3	Ea	300	900
Tether					
16	Black and red 10WG	30	Meter	4	120
17	Black and red 16WG	30	Meter	20	600
18	Extra Flexible Cat5	30	Meter	10	300
19	Wire	15	Meter	10	150
					<u>6,690</u>

CMA Technology Funding	HKD\$5,000
Public donate (Fair Market Value)	HKD\$1,690
Amount spent	HKD\$6,690
Amount spent	US\$861.97

# Electrical Schematic

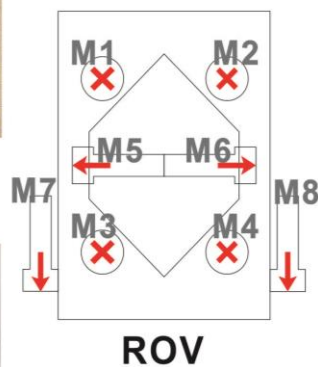


## Power and Monitor System

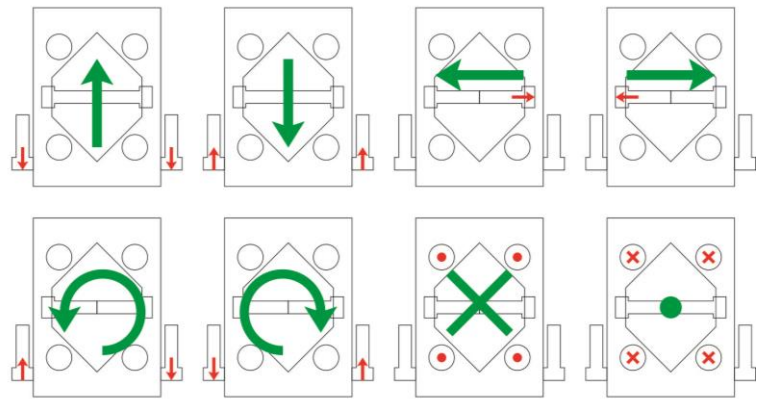
### Controller



Joytick



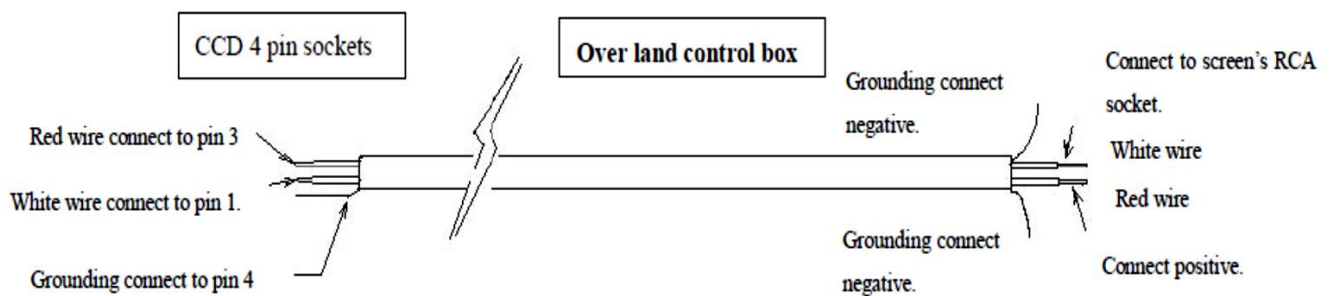
ROV



↑ Directions of ROV

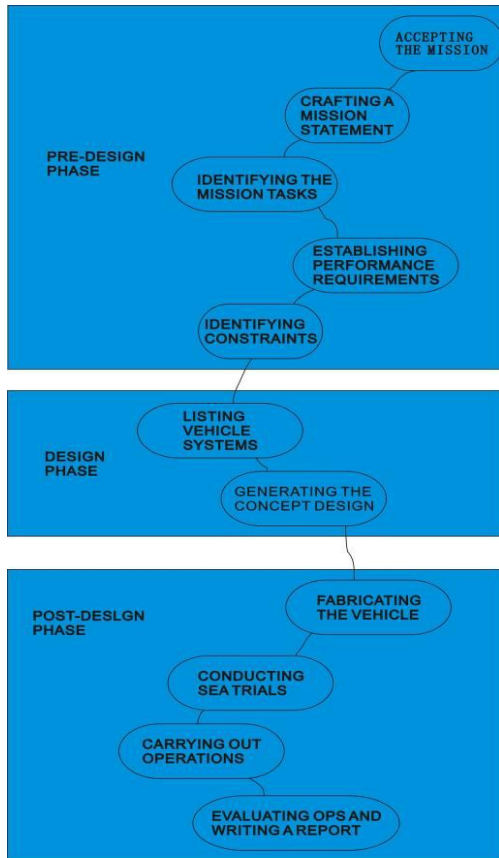
## Thrusters Setting and Movement Detail

### 110<sup>0</sup> Camera Circuit Diagram

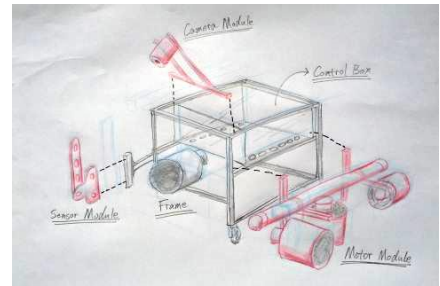


# Design Rationale:

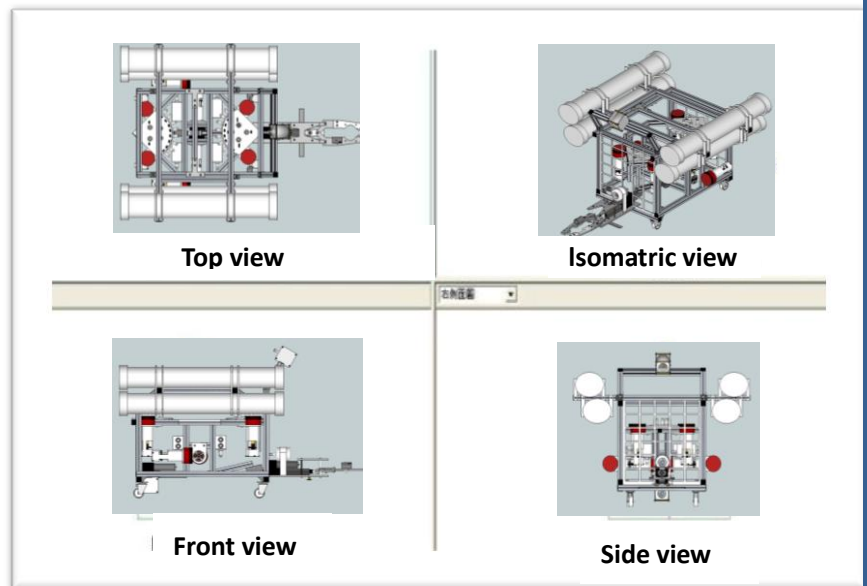
## Design Methodology



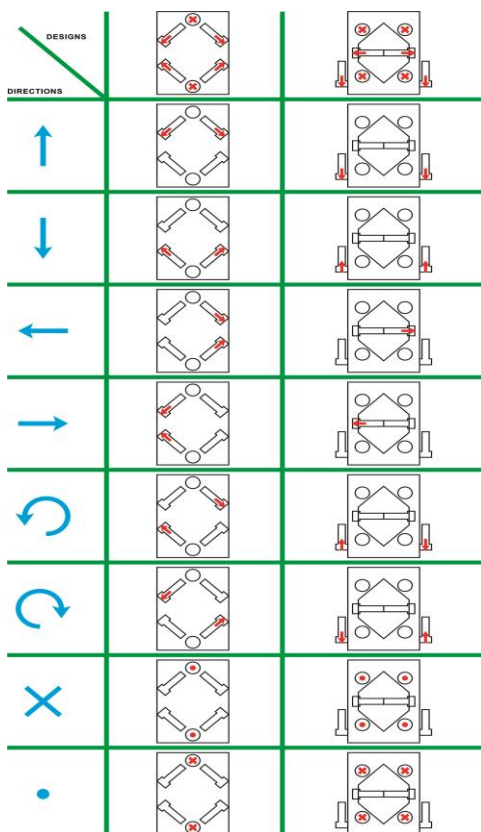
## From Sketch to CAD



Beta Draft Design

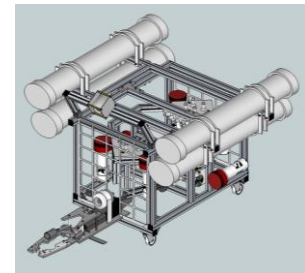


## Concept design



Analysis of a more elaborate thruster arrangement

## From CAD to Reality



Computer Aided Drawing for Structure design



Final Version of Beta



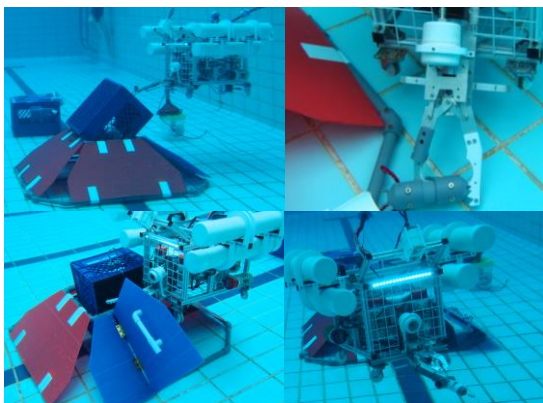
## Missions Tasks

### Manipulator Arm Functionality

One manipulator arm is used. Besides, there is an additional tool. As there is an appurtenance, the tasks would be done easier by a little movement of the ROV.

For Task 1,

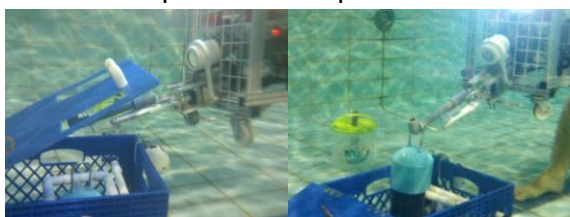
- take the SIA to the seafloor and install the SIA into the BIA.
- insert the CTA into the bulkhead connector on the BIA.
- remove the OBS cable connector from the elevator after pulling the pin to release the OBS and opening the door of the BIA.
- remove the OBS cable connector from elevator and insert it into the bulkhead connector on the SIA.



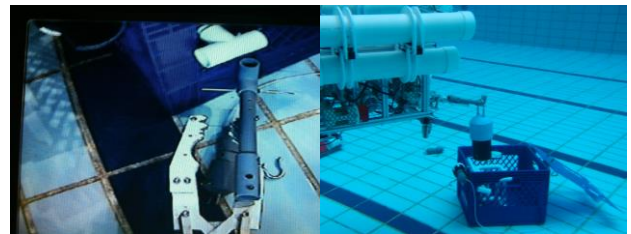
**Mission Task 1 Training**

For Task3,

- Disconnect power to the platform.
- Turn the handle to unlock the hatch.
- Open the handle.
- Remove the ADCP from the mooring platform.
- Install the new ADCP into the mooring platform.
- Close the hatch.
- Turn the handle to lock the hatch.
- Reconnect power to the platform.



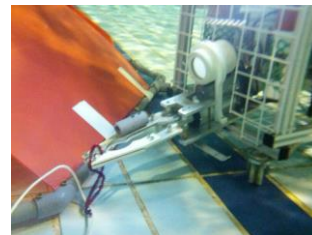
**Mission Task 3 Training**



**Mission Task 3 Training**

For Task4

- locate and remove bio fouling from structures and instruments within the observatory.



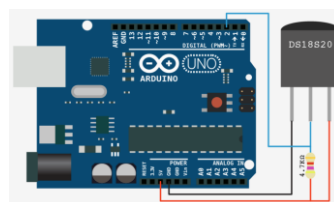
**Mission Task 4 Training**

### Temperature Sensor

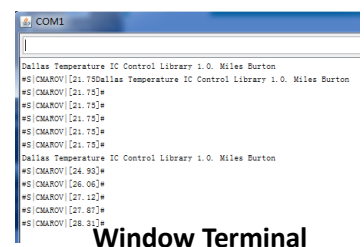
Temperature sensor is used to collect the temperature data over an extended time period. The data would, then, transfer to the Arduino board. Arduino board is used to receive the data and display the temperature value to the number.

For Task 2,

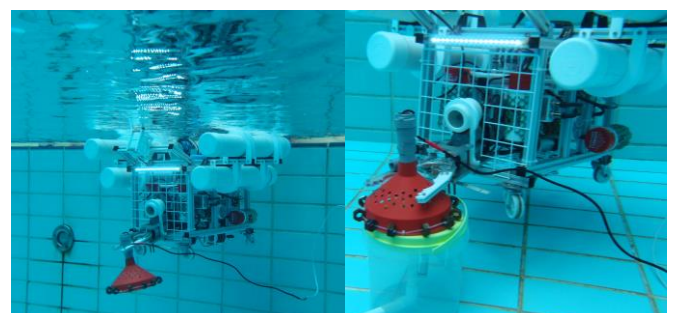
- Designing and constructing a temperature sensor prior to the competition
- Installing the temperature sensor over the vent opening
- Measuring temperature over time
- Graphing all five data points (temperature versus time)



**18B20 Temperature Sensor**



**Window Terminal**



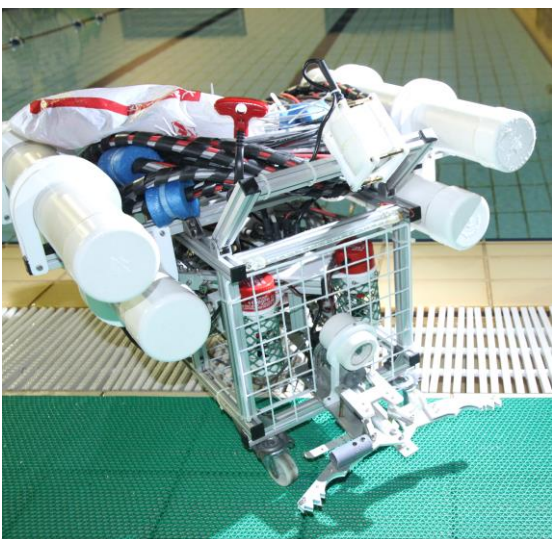
**Temperature Sensor Testing**

## Frame Feature

**Beta's** frame is composed of 30mm x 30mm extruded aluminum. Compared to other structural materials, aluminum is chemically simple and it is a popular structural material 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 75 cm long, 60 cm wide, and 40 cm high.



**ROV SIZE 75cm x 60cm x 40cm**

**Overall weight 12kg**

## Thruster Feature

**Beta** features four vectored horizontal thrusters. These Under-water Thrusters specially designed for ROV with high efficiency, large thrust, small size, use flexible and easy to control of features.

1. Meet the 50m water depth work environment.
2. The 50mm diameter 2 blades ducted propeller provides thrust 720g.
3. Control propeller rotating direction can effectively provide thrust of forward or reverse.



Underwater Thruster

## Electronic Speed Controller

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

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)

## Underwater Electronic Control Box



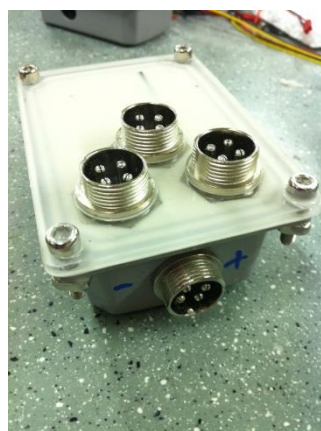
Aluminum box



Installation of the plugs



Waterproof testing



Fit into ROV

Our control box was made of aluminum box. 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 observation; one camera for top observation, and one for observing manipulator operation.)

### 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 controllers have been adapted to operate the **Beta**. The **Beta** is developed by Underwater Expert, uses 2 VEX controllers to control 8 electronic speed controllers. This control system consists of two joysticks with Wi-Fi transmitter units and compatible receiver units. Eight electric speed controllers separated by two groups, which resides on the waterproof bow in the ROV. The software code is designed by our members. Also, it has a good command of the software flow because we used a graphical programmer to write control codes. Moreover, electrical power system was placed the fuse on the positive side of the main power system because this is a safety protection of it.



### One set of VEX controllers for Beta

We used one VEX controller to control 8 electronic speed controllers. This control system consist of two joysticks with Wi-Fi transmitter units and compatible receiver units. The VEX controllers are programmable, and the programme is designed by our company. It helps to control easier 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 7.5V 6A and the total power consumption for thrusters is 180 Watt.

### 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

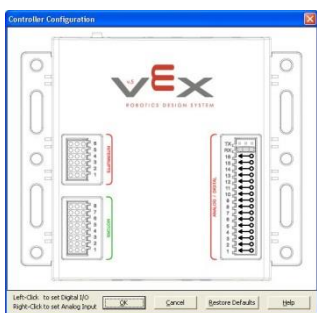
Diameter - 20 mm Weight - 2 kg

Power Budget for the ROV

Device	Current per device	Power per device	Total power
8 Thruster	7.5V 6A	45 watts	360 watts
2 Motor	7.5V 2A	15 watts	30 watts
3 Camera	12V 0.5A	6 watts	18 watts
<b>Total</b>	-	-	<b>408watts</b>

### Software flow

We have a good command of software flow because we used a graphical programmer to write control codes. Using VEX Wi-Fi 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.



### Thruster's control

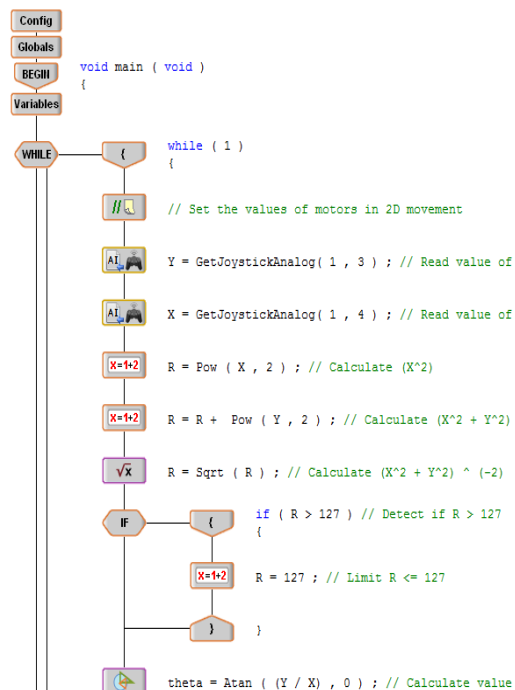
The analogue joystick readings naturally come back in cartesian coordinates.



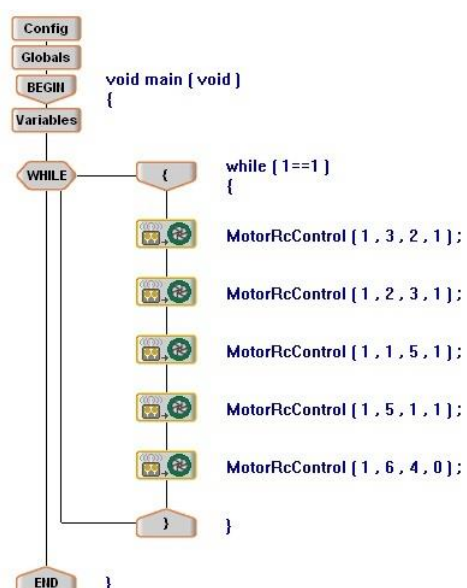
$$v = \sqrt{v_x^2 + v_y^2}$$

$$\phi = \arctan \left[ \frac{v_y}{v_x} \right]$$

### PROGRAMMING - Rectangular coordinates to Polar coordinates conversion



### Manipulator arm control



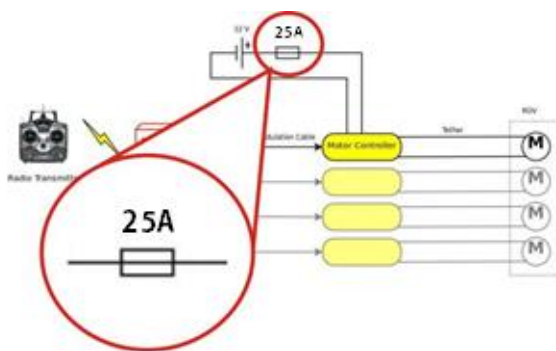
# Safety

CMA Underwater Expert Company is focusing on safety issues. When we design and develop the ROV, ensure that it does not contain sharp edges, expose the cable to outside and carry the cover of the thruster.

## Safety feature

- Cable joint tidy
- Steel wire for prevent tether's tension stress
- Clearly labeled moving parts
- Aluminum frame do not sharp edges
- Volt-meter and Amp-meter monitor

## Power safety



We used a 25-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

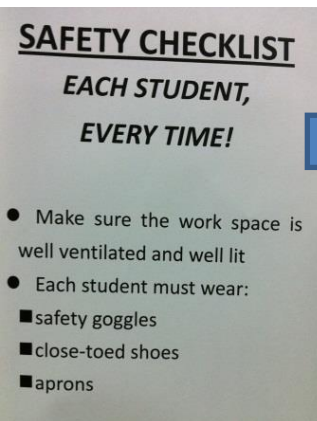


When we choose which type of thrusters is more safety, we decided to choose it already contain the cover of thruster. We think that will increase the safety level than use water pipe and steel mesh cages to cover the propellers.

Moreover, 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 for vehicle, electrical and system of pre-drive and post- drive to make sure that check all of the safety details every time before we operate our ROV underwater.



## Vehicle System

Beta is an original design by our company.

Mechanical department is tailor-made design and builds the ROV's frame and gripper.

Electrical department use Arduino controller and 18b20 temperature IC to design and build temperature sensor.

Software department is responsible to write the vehicle control and manipulator arm operation program.

### Role of each member

**Dang Quoc Vuong** is a CEO of our company.

**Cho Lee Man** is software engineer in charge of software testing and operations.

**Li Yin Sing** is electrical engineer in charge of electronic system development.

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

**Chan Kwok Fung** is company secretary respond for the writing report.

**Leung Hei Long** is CAD engineer, sketching CAD model.

All the components and the materials is new in this year. We have not re-use the component and materials from last year. It is because these consumed already. That is the reason why the Beta costs around HK\$20000.

#### Operating and Control Crew

*Typical team members operate **Beta** :*

> 1 x Pilot

> 1 x Technician

> 1 x Navigator

#### Back up technical crew

*Typical team members operate **Beta** :*

> 3 x pit crew members

## Technical Challenges

As there are some new members, they usually made some wrong decisions when building the ROV. Our team member make a mistake to burn the ESC and mixing a wrong ratio of epoxy, so it cannot be curdled completely, and they need to remove it from the E.S.C. and mixed another glass of epoxy.

To solve this problem, our team member should read the related menu or instruction before they use the electronic device or mix the epoxy.

### Lower Water Resistance

By the last years' experience, knowing that a big waterproof box placing in the center of the ROV would cause a high water resistance, so we distribute the big waterproof control box into four waterproof boxes. For the absent of the big waterproof box, our ROV would move faster in a lower power distribution.

### Interpersonal challenge

Our team members are come from different form. It is difficult for us to know what the others had done. Also, there are four new members join our team. As we do not know their strength, it is difficult to arrange our works.

Finally, we know that communication among teammates is very important, so we meet regularly to discuss and plan for the project.

### 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 significant. 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 inside. 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 made it successfully.

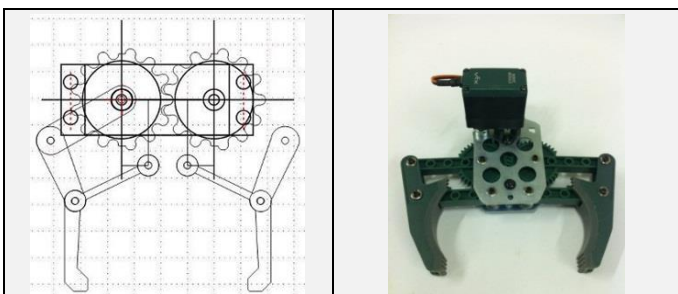
## Payload Description

ROV Speed : Horizontal Speed –1m/sec

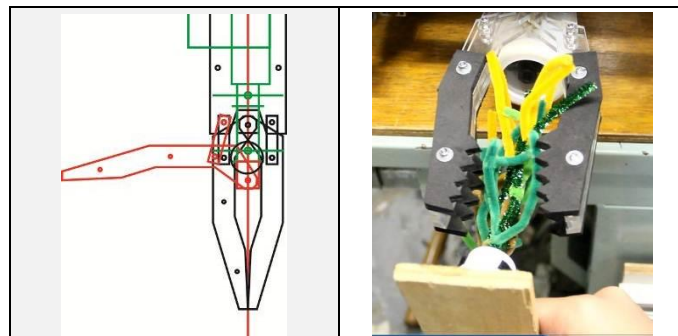
Vertical Speed – 1.3m/sec

### Manipulator Arm

Manipulator is the most important for ROV to complete the mission tasks, so we focus on it and must design and build a simple operate and reliable manipulator. We found that the manipulator arm which made by ourselves cannot use for heavy work. After the modification, 2<sup>nd</sup> prototype manipulator arm is able to take things about 15 kg and clip things more easily. Also, we had waterproofed the motor of VEX's manipulator to prevent the water get into the motor. VEX's manipulator arm is simplified its design and increased reliability. But it cannot turn the handle in task 3, so we make a couple joint to extend a U-bolt to turn the handle.



Manipulator 1<sup>st</sup> Prototype



Manipulator 2<sup>nd</sup> Prototype



Manipulator Final Prototype

Manipulator Force – 15Kg

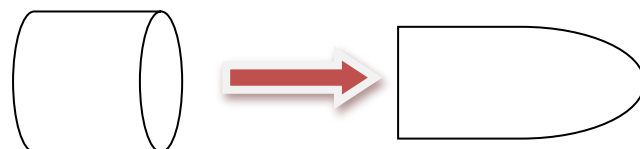
Manipulator U-Bolt Turning Angle – 0° -90°

## Future Improvement

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

Improve the shape of **Beta** 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 2020 aluminum. It can solve the weight problem and help us to transport our ROV.

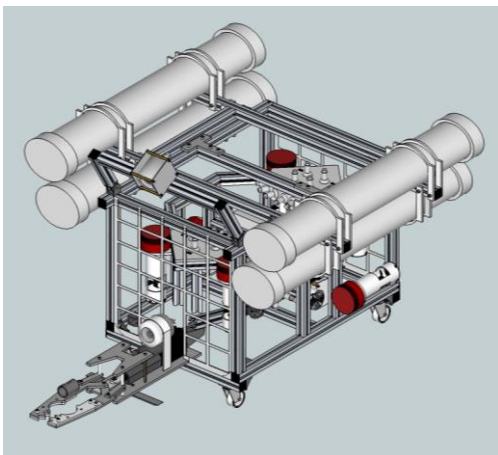


Shape improvement

## Lesson Learned

### Technical Aspect

- In our design, we use the four vectored horizontal thrusters. The thrusters are arranged with one at each corner pointing diagonally. This can create four pairs of vectored thrusters (one pair in front, one at the back, and one on each side), which can be used alone or in combination to coordinate a truly impressive range of motion. The motors are put in radial shape. It makes our ROV move smoother. But it became a challenge that ROV cannot rotate left and right. So the design has to change. In our second design, the motors are placed in four corners and faced the center of the vehicle. Then the rotation problem solved. If the four horizontal thrusters in the corners have independent speed and direction control, they can be used to move the ROV in any horizontal direction. This is an extremely versatile thrusters arrangement.
- Learned how to use the Sketchup to design the 3D model. Using Sketchup to design our **Beta**. It spent us one month to draw this graphic.



**Beta CAD model**

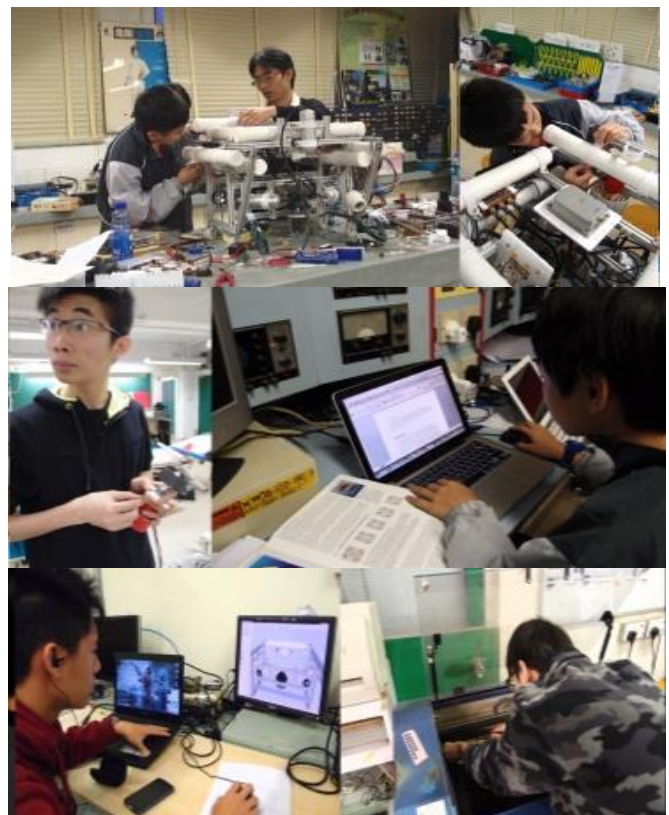
- About buoyancy, learned that ballasts needed to put at a upper level. This can help the ROV become more stable in under water. Weight of displaced water column.



$$\text{Cylinder: } V = \pi r^2 h$$

### Interpersonal Aspect

- A major lesson we learned this year is time management. Some of the members need to out more time in their study to prepare the public exam. After discussion, we drafted a schedule for our preparation. It makes our project run smoothly.
- 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**



## Reflections

This is the sixth 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.



Photo of Last Year Hong Kong Ranger Classes and Explore Class in the International Competition

## Teamwork

Schedule									
Name	November	December	January	February	March	April	May		
Leung Hei Long	Planning/ getting to know ROV design	Research	Discussion of Ocean Observing Systems	Brainstorm, Report writing	Budget	Budget, Presentation practice Report writing			
Chan Kwok Fung		Research			Report writing,	Poster display Presentation practice Report writing			
Dang Quoc Vuong		Prepare the safety checklist		Brainstorm	Temperature sensor and Arduino		Rebuild cameras and wires		
Li Yin Sing		Build ROV Frame, Electronics, programming		ROV tool Packages- brainstorm, Controller design	Ballast system, ROV tool packages gripper, ROV tool packages sampler	Flow works, Presentation practice. Touch up ROV, Driving		Manipulator improvement	Redesign poster and prepare the presentation
Leung Shun Kuen				ROV tool Packages- brainstorm		Technical improvement			
Cho Lee Man		Use Sketchup to design		Software and Electrical discussion	ROV tool packages camera	Touch up ROV, Driving		Use AutoCAD to design	Redesign poster and prepare the presentation

## 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 and The Hong Kong University of Science And Technology, for hosting the workshops, it makes us to know clearly about the competition.

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

Ms. Chow Pui Shan, our Golden Sponsor. Mr. Fung Kwok On, Dr. Tse On Ki, our Silver Sponsors.

Mr. Hung Hing Lun, Mr. Jason Cheung, Mr. Jeffrey Yung, Mr. Lau K C, Dr. Peter Tong, Ir. Peter Wong,

Mr. Victor Cheung, Mr. Albert Lo, Mr. Calvin Tang, Ir. Chang C S, Ms. Eagle Mo, Ms Li To Seung,

Mr. Wong K Y, Mr. Yuen P L, Mr. Cecil Man, our Bronze Sponsors.

Mr. Cheung Man Yeun, our mentor, for being there whenever 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.

Mr. Chan Sen Chang, Mr. Chan Cheung Hin, Ms. Yeung Suet Yee Queenie, Ms. Poon Wing Kee Kimberly, our mentors, for giving advices to help us.

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

### MATE International ROV Competition



### Organizing Sponsors



### Financial Sponsor



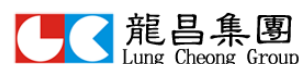
### Venue Sponsors



### Media Sponsors



### Equipment Sponsors



## References

1. Steven W. Moore, Harry Bohm, Vickie Jensen, Underwater Robotics Science, Design & Fabrication, Marine Advanced Technology Education (MATE) Center, Hong Kong, 2010
2. Harry Bohm, Vickie Jensen, Build Your Own Underwater Robot and Other Wet Projects, New Man Printing International Co. Ltd. , Hong Kong, 2010
3. Eddie Norman, Joyce Riley, Syd Urry, Mike Whittaker, Advance Design And Technology, Longman Group UK Limited, 1990

## Appendix I

### SAFETY CHECKLIST

*EACH STUDENT, EVERY TIME!*

- Make sure the work space is well ventilated and well lit
- Each student must wear:
  - safety goggles
  - close-toed shoes
  - aprons

#### **Pre-dive checklist**

##### A. Vehicle Inspection

1. Check thruster shaft seals for oil loss
2. Inspect camera port for cracks or signs of condensation
3. Inspect/ secure hull end caps for full engagement
5. Lubricate and replace camera vent plug
6. Inspect/ adjust vehicle position within crash frame

##### B. Electrical Hook-up

1. Check that the main power switch on the console is off
2. Remove vehicle and tether connector dummy plugs and store safely
3. Bring umbilical OVER hook onto lifting eye
4. Protect all unused connectors with dummy plugs
5. Mate other end of umbilical to console as labeled
6. Ensure the input line voltage matches the setting
7. Use a heavy-gauge (14 AWG or less) extension cord to reach the power source

##### C. System Checkout

1. Ensure that the thruster and light switches are in the off position
2. Center trim adjust knob
3. Switch on power to control console
4. Switch on video on monitor
5. Check for video monitor
6. Turn thruster switch on
7. Briefly toggle joy sticks
8. Double-check that all vent plugs are installed. Lower vehicle into water and adjust trim if necessary by adding weights or floats
9. Check video picture
10. Confirm light operation
11. Confirm thruster operation
12. Confirm temperature sensor

## Post-dive checklist

1. Inspect camera ports for cracks and condensation. Cover lens ports immediately after drive.
2. Check thruster oil filled chambers to ensure no collapsing occurred during drive
3. Inspect and rotate thruster shafts to ensure no debris was collected during dive and that shafts are turning freely
4. Rinse vehicle down with fresh water
5. Remove and replace both vent plugs to equalize pressure
6. Secure all equipment to deck
7. Once ROV operations are complete, remove all electrical connections. Rinse all exposed plugs and sockets with fresh water. Grease terminals with lubricant and fit dummy plugs on vehicle and tether connectors.
8. When ROV operations have been completed, disconnect all cables, install dummy plugs and pack in crate.

## Appendix II

### Media Outreach

10 **youngpost** Monday, May 13, 2013

# roll call

## CMA to compete again in ocean robot finals

While the idea of secondary school students building robots for fun may seem like something from a science fiction movie, the pupils at CMA Secondary School showed that this idea isn't so strange after all.

Students from all over Asia took part in the Eighth Hong Kong Underwater Robot Challenge. The event, organised by the Marine Advanced Technology Education (Mate) Centre, took place at the Tseung Kwan O swimming pool,



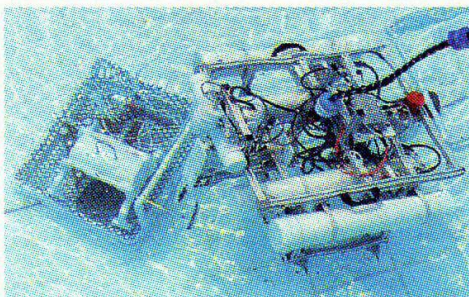
with 25 teams from Hong Kong, Macau, Thailand, Shanghai, India, Indonesia and Singapore taking part.

CMA won for the second year in a row, and will go to the 12th Mate International Competition, from June 20 to 22, in Seattle, in the United States.

The competition asks top regional qualifiers from all over the world to show off their skills. They have to design and build remote-control vehicles to work in the ocean.

Students also get to take part in Mate programmes, which teach technical skills, problem solving, critical thinking and teamwork.

The Challenge also promotes ocean conservation among young people, asking them to consider how modern technology can be used to help the ocean be a healthier home for animals and plants.



**CMA's robot in the regional event.**

South China Morning Post – Young Post (13rd May, 2013)



文：MT01 設計：Ca

鳴謝：廠商會中學

## 水底機械人——保育海洋生態

廠商會中學，設計與應用科技

由香港工程師學會主辦的 MATE ROV 潛水機械人比賽香港區賽在4月14日於將軍澳游泳池順利舉行。今年比賽吸引了來自亞洲8個國家共33隊的大學組和中學組隊伍參加，分別競逐所屬組別到國際總決賽的出線權。

廠商會中學繼去年以港區冠軍身份出戰美國，奪得國際賽全球第七名後，今年成功衛冕，再次以冠軍身份，代表香港區前往美國西雅圖參加由6月20日至22日的國際總決賽。



▲ (左上起) 導師：張之亮 學生：梁順權、陳立恩、鄧利文、陳德峰、梁駿茵、李高強 (左下起)：馮詠琪、陳梓軒、劉德王、楊雪儀

### 比賽規則

參加者須模擬一家公司，由行政總裁、工程師、設計師等虛擬職位組成，並完成水底機械人的設計、撰寫報告書、口頭匯報和任務控制工作。比賽總分共計560分，其中報告書、海報設計和口頭報告部分佔260分，水底任務控制部分則佔300分。

同學在報告內需詳細介紹機械人的設計及解難過程、設計特色以及如何能針對比賽任務要求而作出設計和改良。

此外，工程匯報部分須以精闢明瞭的方式向比賽評判介紹「公司」。在任務控制方面，同學須控制潛水機械人在模擬海底養殖場中，用溫度感應器探測及記錄指定位置的溫度變化、移除指定儀器裝置、採集微生物樣本等。



▲ 同學設計的水底機械人



▲ 同學正進行工程匯報

### 作品介紹

圖中是修讀新高中設計與應用科技科的同學，花了數月時間製造的水底機械人，其中大部分零件均是同學自行設計製造及編寫程式，出色的手工藝贏得了評判的高度評價。

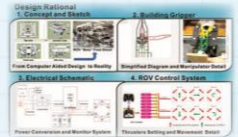


▲ 製作中的水底機械人

▲ 同學下課後努力製作水底機械人

### 特色設計

- 機械手：**為了在任務中採集微生物樣本，同學用鋁材和直槓推進的原理加工設計出上圖的機械爪。透過機械運動的設計而製造出堅固的機械手，而且在機械手上的 PVC 膠喉，可以快速裝配任務所需的組件。
- 推進器：**同學利用 PVC 膠喉和 12V 船用水泵等，設計出這款體積迷你的推進器，既能降低水底機械人的造價，亦藉此鍛煉同學的動手能力。在設計過程中，同學都不忘安全的重要性，在推進器的末端安裝了電腦風扇的防護網，防止因人手誤觸馬達內部危險部分而造成不必要的傷害。
- 操控方法：**為了讓水底機械人的動作更靈活，同學嘗試將馬達以45度擺放，配合 VEX 控制器和出色的編寫程式能力，機械人能以矢量的方式作出前進、後退、左右平移和旋轉的全方位動作。



### 同學的感想

從參加比賽的過程中，同學認識了更多科技上的技術，例如怎樣改善防水的技術，以避免弄壞控制系統；怎樣把推進器放在不同的位置，以達致活動上的最佳效果。除了在科技上的進步外，同學在團體合作方面亦不錯，雖然偶爾會產生意見分歧，但都能透過溝通達成最後共識。同時，同學亦明白香港區的比賽獲勝只是比賽的開始，他們將更努力在科研比賽取得好成績，為港爭光。



▶ 烈日下展現團隊合作精神



▶ 賽後大合照

## Chinese Technical Press – 機械人之家 (June, 2013)

This article was named “Underwater Robot – Conservation of the Marine Ecosystem”. Rules of the MATE ROV International Competition, our team’s ROV – Beta’s special features, our team members’ feelings on this competition.