GAMMA

CMA Underwater Expert Ltd.

CMA Secondary School

Hong Kong S.A.R.

Company Members:

Dang Quoc Vuong - CEO

Leung Shun Kuen - CTO

Chan Kwok Fung - Secretary

Lai Ka Chun - Assistant Secretary

Shi Mingjie - Assistant Secretary

Cho Lee Man - System Engineer

Li Yin Sing - Electrical Engineer

Lum Chun Ho - Software Engineer

Fang Wei Yue - Mechanical Engineer

Ho Cheuk Tung - Mechanical Engineer

Mentors:

Chan Cheung Hin

Poon Wing Kee

Wong Wing Hang

Yeung Suet Yee Queenie

Supervisors:

Cheung Man Yuen

Chung Hiu Lam Janet

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Abstract

It is the seventh year the CMA Underwater Expert Ltd participates in the MATE ROV Competition. We are committed to build professional rangers of the highest safety and efficiency standards at the most reasonable cost. After months of research and experiments, we now proudly present to you our remotely-operated vehicle (ROV), ***Gamma***.

Gamma is capable of tackling a variety of tasks under water including observation, measurement, installation, operation as well as maintenance work. The 610mm x 380mm x 410mm ***Gamma*** weighs 10kg, and is equipped with a manipulator, a conductivity sensor, a microbial retriever, and four cameras.

What makes ***Gamma*** more powerful and extraordinary is that except for our thrusters and the VEX controllers, all our components are self-designed, and if possible, made of authentic materials. It has always been our company's mission to conserve and protect the marine environment. We want to take this opportunity to prove to the world that our company is not satisfied with simply producing an ROV that helps achieving our missions, but we also go far as to make the ROV itself a realization of the concepts of recycling and reusing without trading off any of our strictest safety and performance requirements.

This report details the development process and the design details of ***Gamma***, including the safety issues it entitles. Records on troubleshooting techniques, obstacles encountered, lessons learnt as well as the project budget are also carefully illustrated.

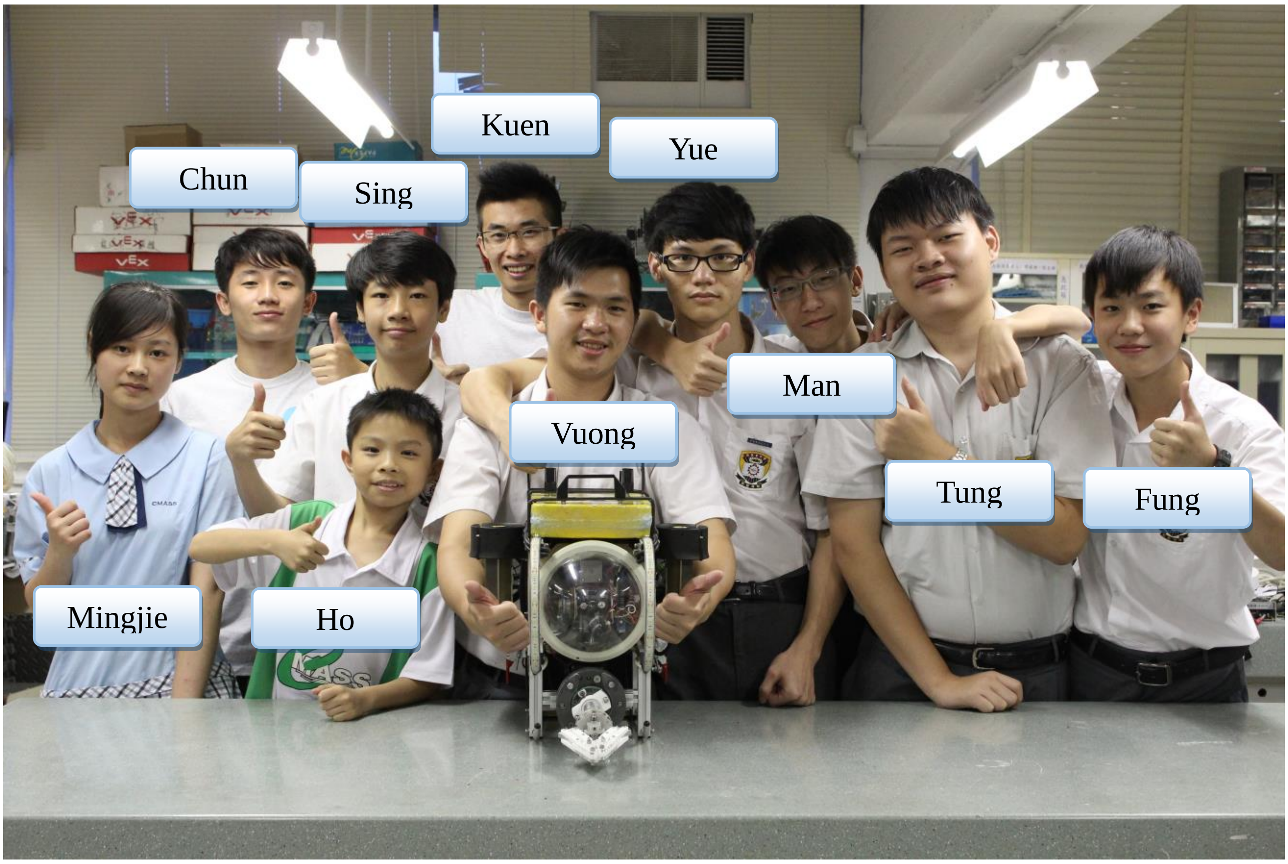


Figure 1: Team photo

Design Rationale

A. Aim

CMA Underwater Expert Ltd. aims at designing an ROV that is not only capable of completing all mission tasks as specified by MATE, but is also reliable, cost effective and safe to operate. This year, the team takes a remarkable step into using as many original and authentic components in the building of ROV as possible. The specially-tailored materials give more precise answers to the requirements of MATE, while promoting the ethical concept of recycle and reuse to the community.

B. Design Process

The team wants to create an ROV that best suits the requirements of MATE while aligning with the company's priorities, namely cost, effectiveness, sustainability and safety. Therefore, a list of conditions were written down and thoroughly discussed at the multiple brainstorming sessions. The designers, with reference to such conditions, then gave suggestions to the size, shape, number, material, etc. of the different components of the ROV. Critical comparisons and contrasts were done before narrowing down to what you may find later in our final product.

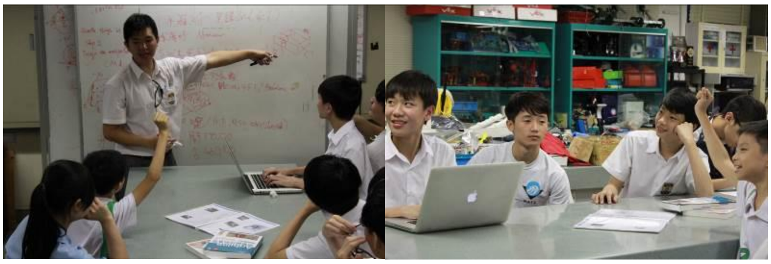


Figure 2:The team brainstorms ideas on the design of ROV and the accomplishment of mission tasks

Thanks to the advancement of technology, computer simulation helps the team in refining its design to its best. However, as the Chinese saying goes, "Practical experience is more useful than theory". Pool trials were conducted from time to time to check on the ROV's reliability, as well as to look for issues that have not been previously encountered in simulations.

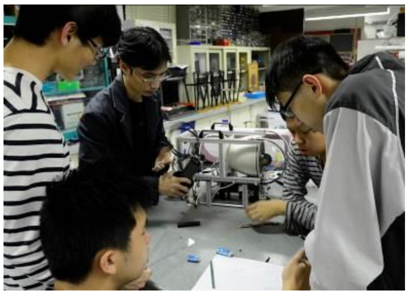


Figure 3: Vuong, Man, Yue and Yuen discuss the placement of thrusters

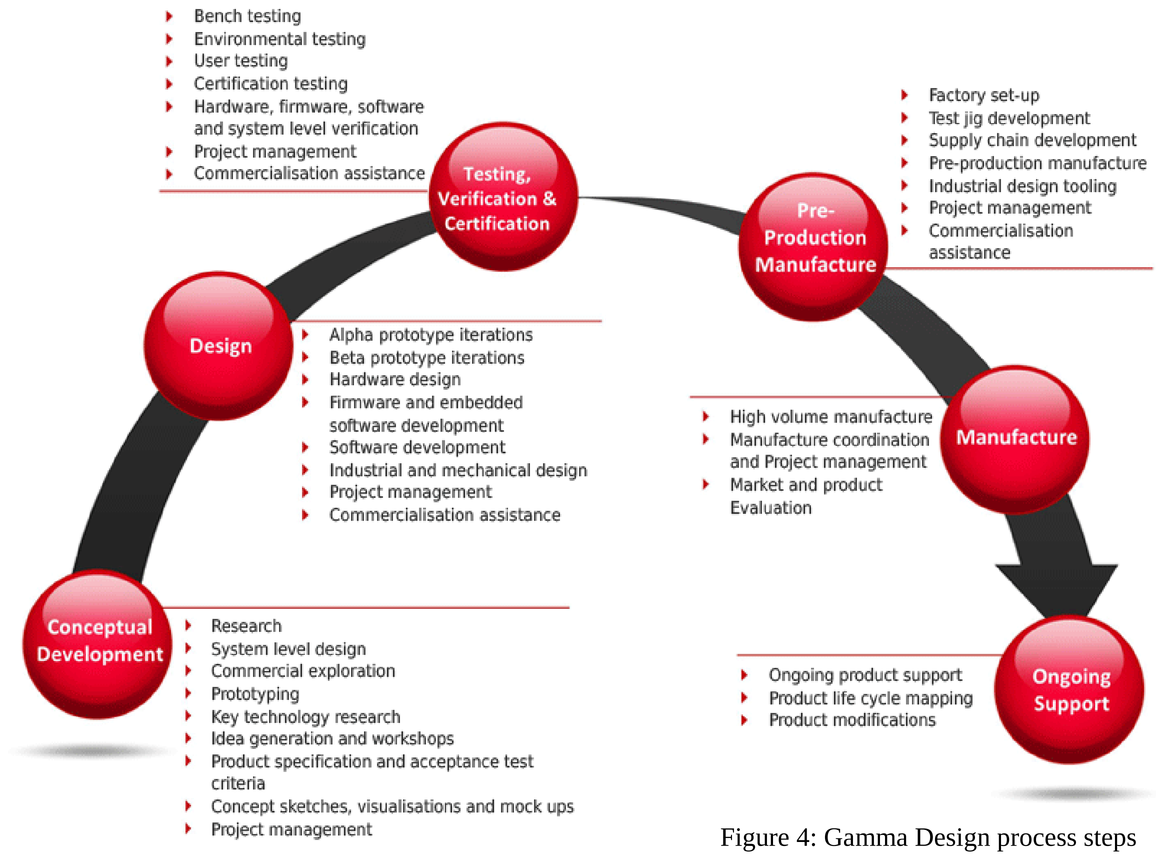


Figure 4: Gamma Design process steps

C. Overview (Photos of the ROV)

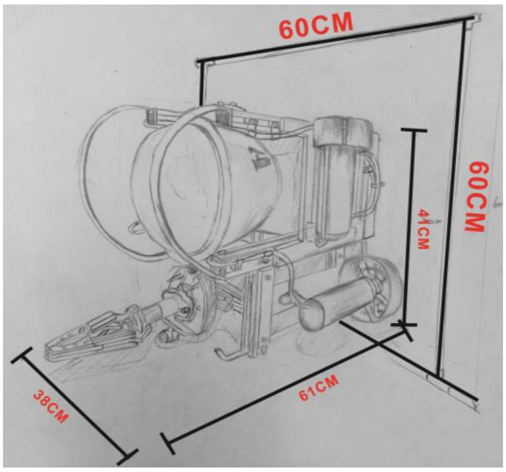


Figure 6: Concept drawing

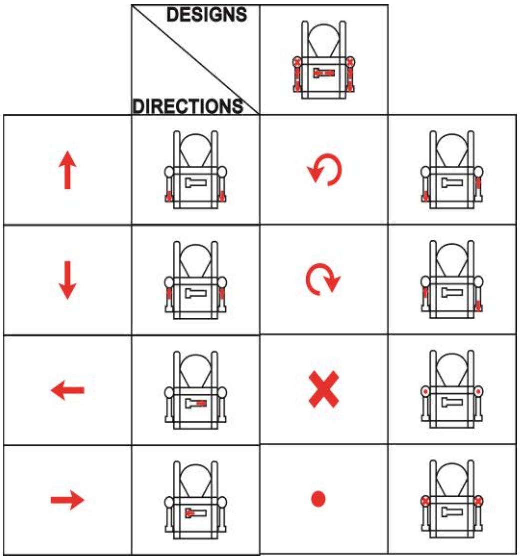


Figure 5: Motion of Gamma

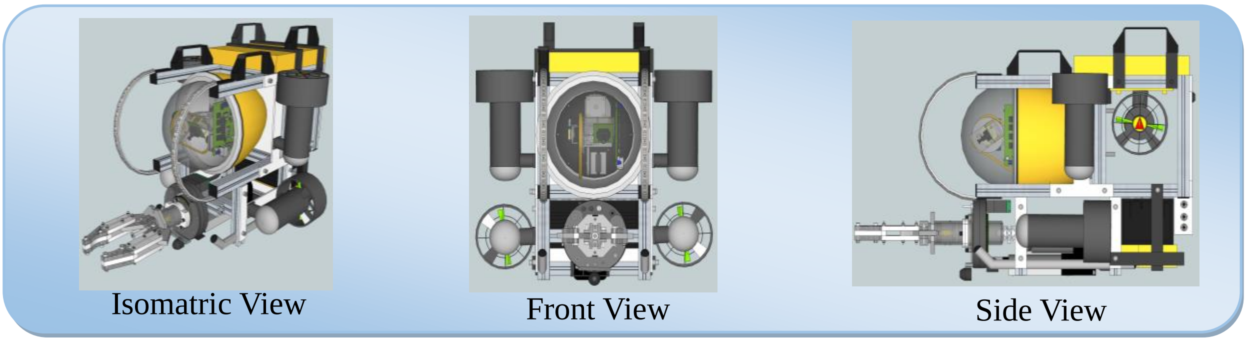


Figure 7: CAD design of Gamma

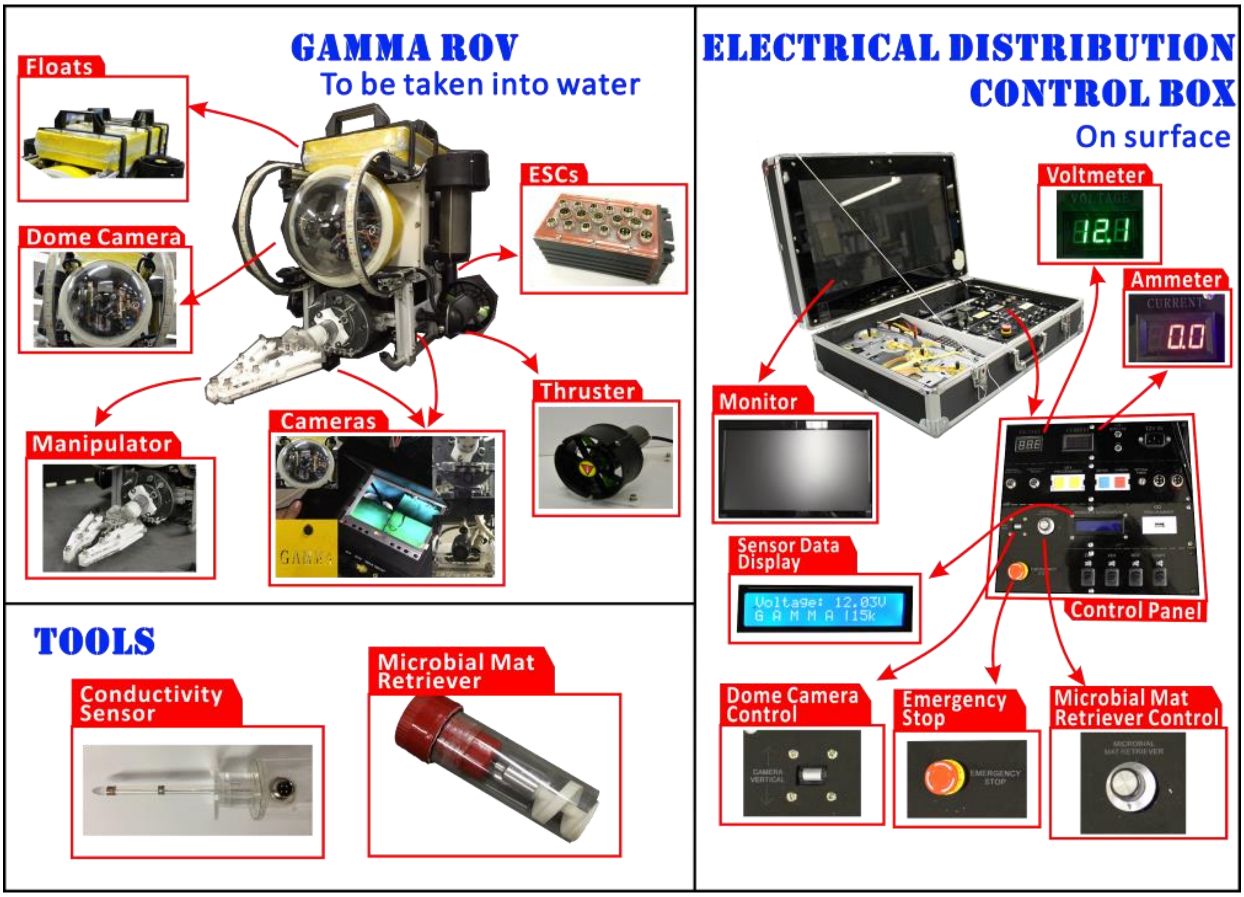


Figure 8: Overall parts of Gamma

D. System Integration Diagram(SID)

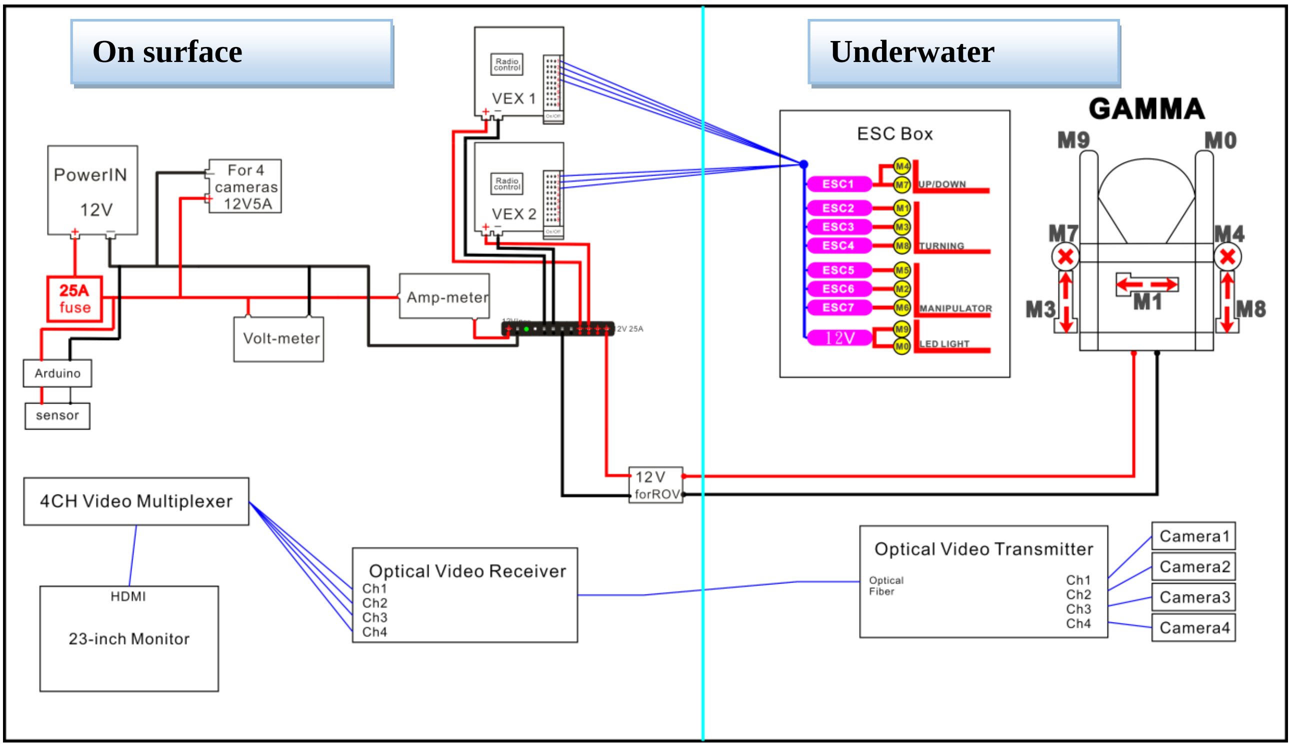


Figure 9: Gramma System Integration Diagram (SID)

E. Tether

The tether connects the ROV to the Electrical Distribution Control Box. It consists of two 10AWG power cables, one optical fibre cable for cameras and one CAT-5 cable for ESC's signals, protected by a 1mm wire. It controls power and signals operations of the ROV system.

One of the breakthroughs of this year's ROV is the use of an optical fibre to replace 4 coaxial cables of the cameras. This significantly reduces not only the cross-section of the tether but also its weight. You may see Lessons Learnt for more of our sharing in this aspect.

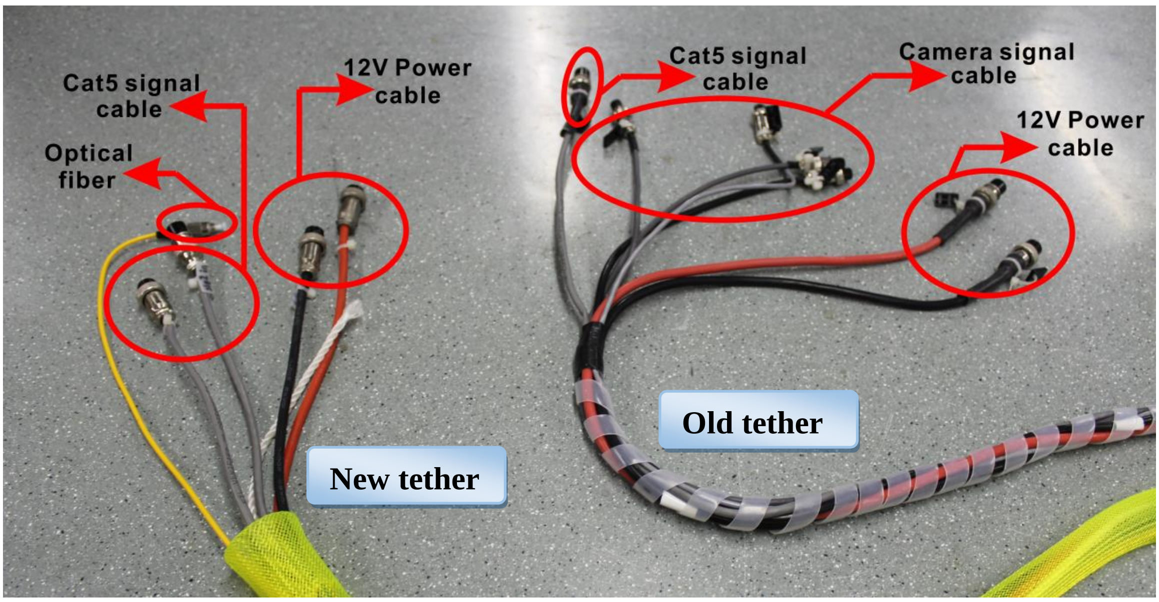


Figure 10: Comparison of the content of old and new tethers

Prototype	1st prototype of tether	Final prototype of tether
Diameter (mm)	17	12
Length (m)	15	30
Total weight (kg)	7	5
Weight pre meter wire(kg/m)	0.23	0.33
Cables included	2 of 12V power	2 of 12V power
	1 of cat5 signal cable	2 of cat5 signal cable
	4 of camera signal cable	1 of optical fibre
Protection material	Twis-les	Polyethylene terephthalate

Figure 11: Data comparison of old and new tethers

F. Frame

The frame of the ROV is constructed from 2020 aluminum extrusions. Its sturdy yet light nature offers an excellent strength –to-weight ratio for the support of the ROV. 2020 aluminum extrusion is also rust-resistant, making ROV maintenance less frequent and less costly. The aluminum frame, with a dimension of 610mm X 380mm X 410 mm, is made up of smaller aluminum rods. It allows the ROV to enter the shipwreck through the 600mm X 600mm hole for further observational and operational tasks, and can be disassembled afterwards for easier transportation. In order to minimize water resistance of ROV, which in turn promises a faster moving speed, an open frame is designed. Furthermore, a hemispheric housing is added to ***Gamma*** to help strengthening the streamlining effect, enabling it to move quicker under water than the other ROVs.

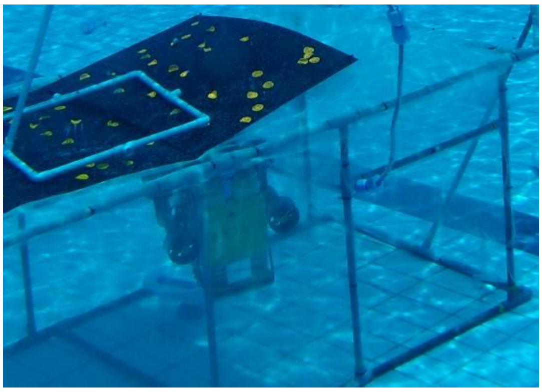


Figure 12: Gamma enters a 600mm X 600mm hole

G. Electrical Distribution Control Box

A highlight of ***Gamma*** ROV is its Electrical Distribution Control box (EDC), which is made up of an Arduino board, a VEX RC controller kit, a customized panel stage and a 24”monitor.

Figure 13: Electrical distribution control box with monitor

H. VEX Controller Kit

Our VEX Controller kit is used to control the 8 ESCs, which in turn control the motions of the ROV and the performance of the manipulator. The control system consists of two 750MHz transmitters and a receiver remote control with two radio transmitter units and compatible receiver units. The availability of such units allows easier accommodation for future expansions of the ROV subsystems.

What’s worth introducing is that the VEX controller joysticks are among the small number of components purchased from commercial companies. The decision is made purposefully since VEX controller joysticks are widely found in remote controlled toys and models, thus the resources spent on pilot training for the operation of the ROV can be lessened.

Figure 14: Tung and Vuong, our trained ROV operators

I. Electronic Speed Controllers

Our four SeaBotix thrusters are controlled by seven waterproof Electronic Speed Controllers. These controllers not only give power to the thrusters, but they also give signals for thrusters speed control. They allow operators to have a more accurate control of the direction and the moving speed of the ROV through a more effective thrusters' management. These controllers can be controlled with our VEX controllers. They are waterproof with the cover of an acrylic plane stuck with epoxy.

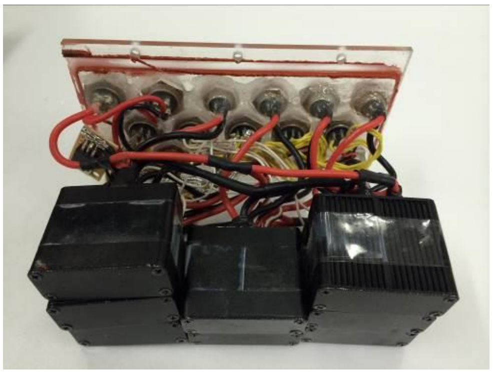


Figure 15: Electronic speed controllers

J. Thrusters

Each of our four SeaBotix thrusters provides a maximum of 2.2 KGF of thrust and with a continual thrust of 2.2 KGF. They are strategically placed on the wall mount brackets of the ROV to keep the thrust in consonance with the centre of buoyancy.

The wall mount brackets on the sides of the ROV are made of an old chopping board. It was precisely cut to and placed on the sides of the ROV for the mounting of the thrusters.

K. Buoyancy

Two buoyancy floats are attached to ***Gamma*** to give positive buoyancy. The net weight of the ROV in water is 3.5 kg. The floats, made of Styrofoam at the dimensions of 312mmX186mmX51mm and 185mmX123mmX23mm, are placed on the top of the ROV to provide 3.5 kg of buoyancy.

To fabricate the floats, our engineers first draw the contour profiles, and then carefully cut the Styrofoam block with a laser cutter. The foam blocks are then fibreglassed with bandages and epoxy, and are painted bright yellow for safety.

Floats are also installed on the tether to give buoyancy to ensure effective tether management and stable operational performance.

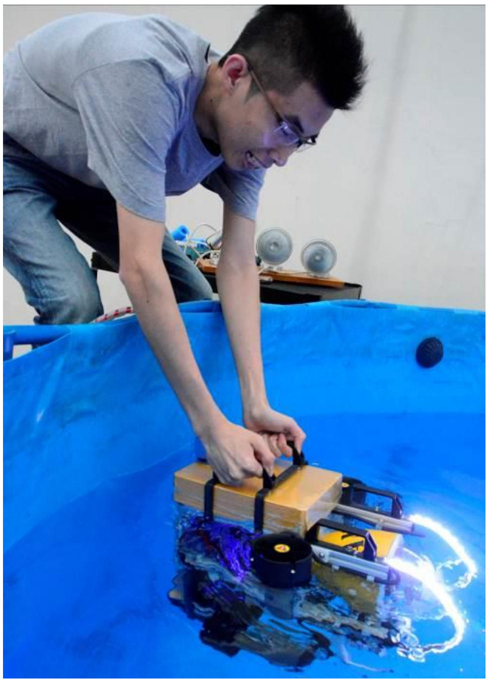


Figure 16: Kuen checks the buoyancy system

L. Software Flow

The software code is designed by our members. Also, it has a good command of the software flow because we used a graphical programmer, which is easier than the other programmes we used, to write control codes. We used the "Easy C" graphical programmer to write the VEX Radio-Control control system. It is GUI program software so we can write the program by graphic.

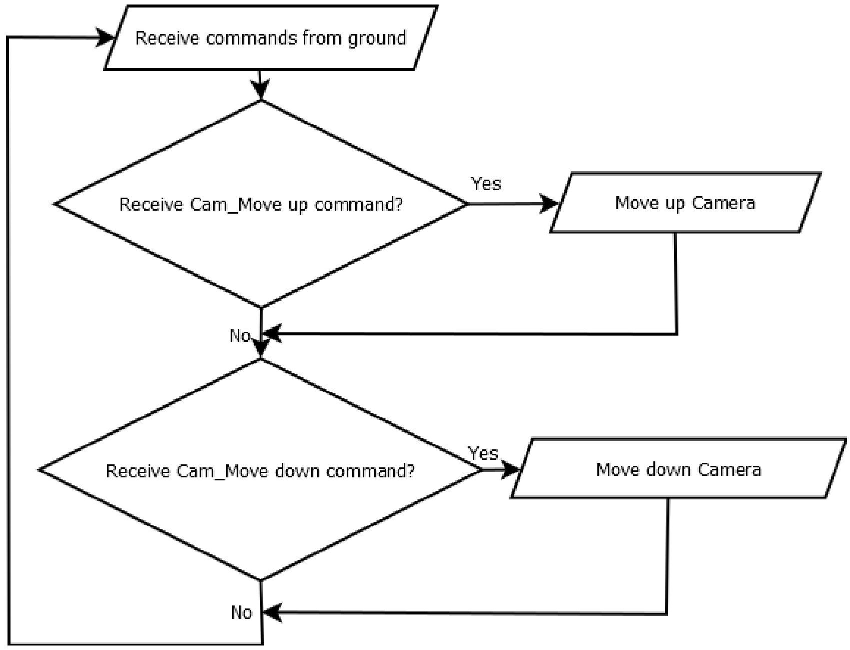


Figure 17: Underwater Arduino Diagram

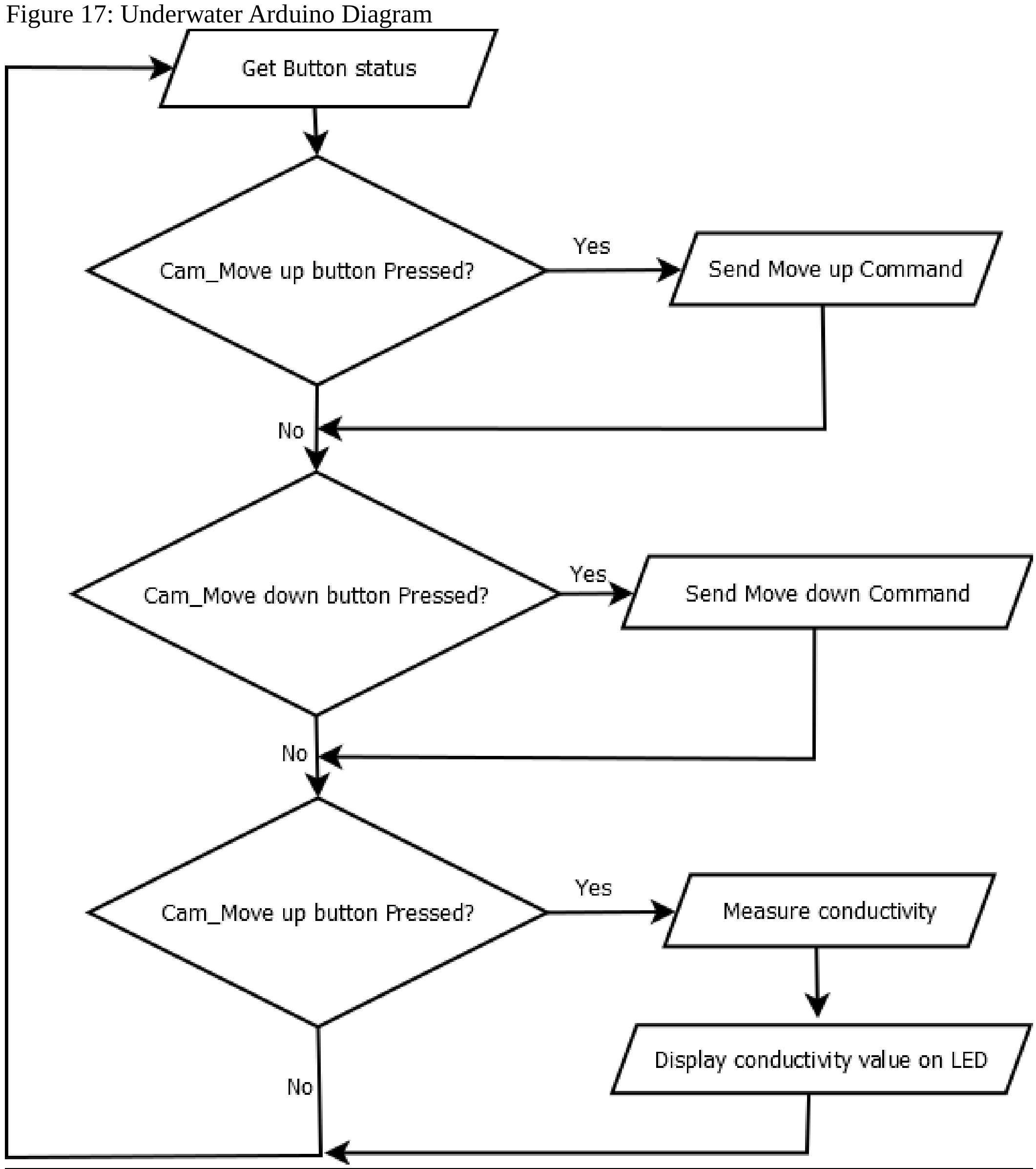


Figure 18: Ground Arduino Diagram

M. Mission-specific

Cameras

A total of four cameras are attached to ***Gamma*** to provide the operators on shore the maximum knowledge of the shipwreck and its surrounding environment.

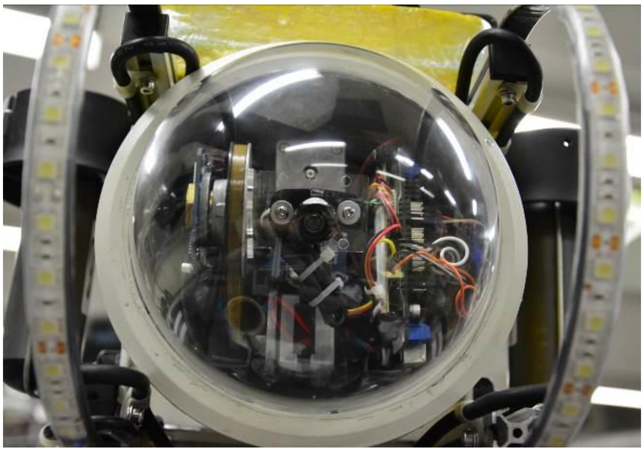


Figure 19: Dome Camera

A dome camera, which used to serve as the surveillance camera in a residential building and was discarded afterwards, was housed in a hemispheric housing placed at the front of the ROV. This movement of this camera at the front of the ROV can be remotely controlled, thus assists ***Gamma*** in its most precise and accurate positioning in water before its execution of missions.

Figure 20: Wide Angle Cameras

Three 170-degree cameras all function to capture photos of the shipwreck, as well as its surrounding environment. The wide angle of freedom of these cameras grant the ROV operators the ability to scan a wide scope of area without having to turn the ROV left and right and causing turbulences. In other words, measurement of the shipwreck and the number of zebra mussels can be very easily done with minimal disruptions. Apart from these, among the three wide-angle cameras installed in ***Gamma***, one can be found at the back for the purpose of checking the tether condition, and to prevent accidents that may be caused by the tangling of tether with floating obstacles. One camera is placed under the manipulator to monitor closely the condition of the manipulator in task performances. The last one is seen at the bottom of ***Gamma*** to give operators an overall picture of the surface ***Gamma*** is moving on.

Manipulator

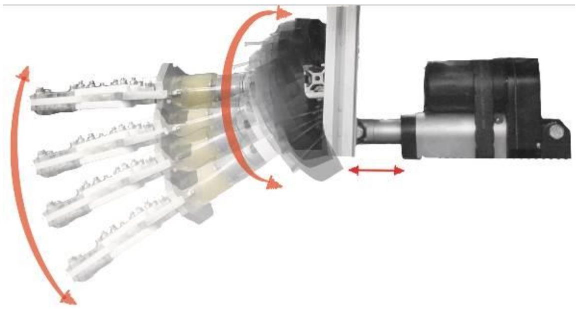


Figure 21: 45-degree of freedom

Our tailormade, unique manipulator is quick, simple and strong, and can deliver its best performance in mission tasks 1.4, 1.7, 2.3, 3.1 and 3.2. In only 2 seconds time, the manipulator is able to complete the whole set of opening and closing movements. It enables quicker tasks completion. Furthermore, it is able to clip up things which are up to 15 kg very steadily. In addition, a Turntable Bearing Kit is inserted into the manipulator to allow 360^{o} clockwise or anti-clockwise rotation. It is a 1st time design of the company as a result of reflections and innovations from our engineers. The manipulator can incline 45^{o} vertically and increases its flexibility in reaching targets even in wavy situations. We are certain the performance of ***Gamma*** in the mission task of recovering a ceramic dinner plate from inside the ship (i.e. mission task 1.7) will be enormously strengthened when compared to that of our past ROVs. To ensure safety, the team waterproofs the motor.

Conductivity Sensor

For the purpose of accurate measurement of water conductivity (i.e. mission task 2.1) as requested by MATE, the team has done a lot of researches and readings before we design our conductivity sensor. It was our original plan to use a multi-meter to measure water conductivity. However, it requires a 30-meter wire for data transmission, which means the error in readings could be big. Therefore, an Arduino board is adopted to measure water conductivity. First of all, a specially-designed probe is used as an input (see Figure 18). Then, the measured data is displayed at real time in the 1602 LED display installed in the EDC box. Through the use of voltage divider technique developed by our CEO, our engineers can get hold of analog signals to report real time data at 0.025 volts per kilo-ohms. The conductivity sensor we developed is our proud achievement because it is a perfect example of how the team develops a better and more accurate instrument to replace a commercial design. It marks a great milestone in the company's research and development (R&D).

Figure 22: Vuong tests on Analog Conductivity Sensor

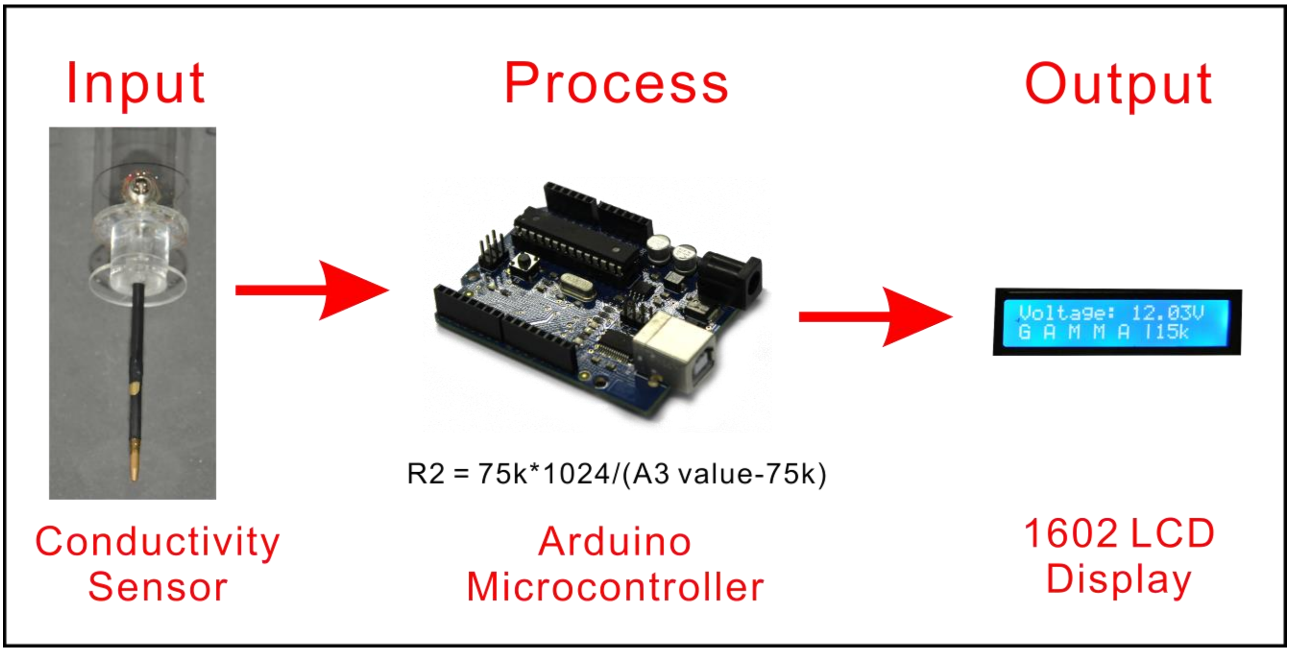


Figure 23: Conductivity Sensor

Microbial Mat Retriever

Our engineers initially adopted a bilge pump to collect samples of microbial mat. During our first trial in the regional competition, our team failed to complete the mission of retrieving the samples. Therefore, the team further analysed the microbial mat and redesigned the retriever. We looked for a screw-like tool that can guarantee a successful drilling into the mat and extraction of samples. The extracted sample is then stored within a 46mm diameter tube, which also serves to prevent the contact of the sharp edges of the drill from the marine environment. FDM 3D printing technique was used to manufacture the retriever.

Figure 24: A screw-like retriever for the task of retrieving samples of a microbial mat

III. Safety

A. Our Philosophy

Safety has always been our company's primary concern. Our company has established strict safety codes for pre-, during and post-handling and operating our ROV. They are enforced at all times in all places to minimize the risks of accidents and injuries.

B. Training

All our staff are thoroughly trained with all procedures of handling and operating the ROV. New members are required to attend at least 8 hours of training before they can be entrusted to deal with the ROV. Training takes place in the form of PowerPoint presentation prepared by department heads, as well as hands-on experience under the supervision of at least one senior member. Regular safety assessments are conducted to raise staff's awareness of safety and to ensure ROV is only operated by those who are qualified.

Figure 25: Training workshop for newcomers

C. Lab Protocols

Our staff members are well aware that under no circumstances should the ROV be handled or operated by one staff member. Our company reinforces the importance of the presence of a partner, if not more colleagues, when the ROV is to be handled and operated so that no accidents would be dealt alone. Furthermore, safety glasses have to be worn by all members at all times. Staff members should always follow the dress code strictly, which restrict the wearing of lengthy accessories and open toed shoes.

Figure 26: Staff members are introduced to the first-aid kit

Proper shields and enclosures are properly placed around all machinery. Warning signs are posted to warn operators of the safety issues. A first-aid kit is placed at an easy-to-spot location that is known to all members. Its stocks are regularly checked, refilled and, if necessary, replaced. Finally, it is strictly forbidden by our company that the ROV to be left unattended.

D. Safety Features of ROV

6 safety features are added to ***Gamma*** to keep the ROV itself and its operators safe.

To begin with, a 20-Amp fuse is chosen to be placed at the beginning part of the circuit to protect the overpowering of the electrical system. All of the wires are carefully wrapped to prevent any exposure.

Figure 27: 20-Amp fuse to prevent overloading of power

Besides, the frame of our ROV is free with sharp edges. All corners of the ROV are protected with plastic caps to keep our crew from possible cuts.

Furthermore, all our thrusters come with their own safety shields to prevent the contact of the blades to other materials, including human hands. All the moving parts of the ROV are clearly labelled with warning stickers.

Figure 28: Safety caps and safety labels are put up

To avoid the previous experiences of messy cables and possible trips, cables are put inside our Electrical Distribution Box in an organized manner. Not only does cables transport become easier, but fewer cables are also exposed at mission sites which may have caused slipping, tripping and even falling of objects.

A volt-meter and an amp-meter are installed in the Electrical Distribution Box to allow operators to closely monitor the input voltage to and the power consumption of the ROV.

Last but not least, an emergency button is installed in the Electrical Distribution Box which can bring the whole system into a halt in less than one second.

E. Safety Checklists

Several checklists are developed by our professional mechanical and electrical departments for the safety of our members and the conditions of the ROV.

Safety Checklist

This is a checklist to be completed every time the ROV is taken out of and put back into the flight box. The presence of at least two operators and the authorization of a senior engineer are needed every time for filling in and handling the ROV.

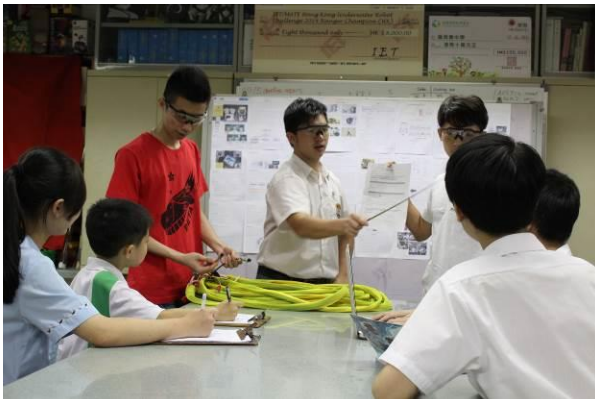


Figure 29: Staff members are taught how to check the status of components and fill in the safety checklists

Safety Checklist

Staff names (in full): ________________________________ and _________________________________

Date and time: _____________________________________

Purpose of handling: ____

Please go through every single line of this safety checklist. Put a tick in the box if the condition is met. Jot down any remarks for our mechanical and electrical departments for reference.

WARNING: Never handle the ROV unless all conditions are met.

Safety Checklist	√	Remarks:
Mechanical Aspect		
All items attached to ROV are secured.		
Hazardous items are identified and protection to moving parts are present.		

No sharp edges are found on the ROV frame.			
Other Remarks:			
Electrical Aspect			
A single Inline 20 amp fuse is present and is in good condition.			
No exposed copper or bare wires are found.			
No exposed motors are found.			
All wirings are securely fastened and properly sealed.			
Tether is properly secured to the surface control point and to the ROV.			
All wiring and devices for surface controls are secured.			
All control elements are mounted inside an enclosure.			
Other Remarks:			

Should you encounter any inquires or if any of the above conditions is not met, you should immediately contact the respective departments for help. NEVER HANDLE OR OPERTE THE ROV UNLESS ALL CONDITIONS ARE MET.

P.T.O.

Sign of the first staff: ___________________________________

___________________________________ (Name in full)

___________________________________ (Date and time)

Sign of the second staff: ___________________________________

___________________________________(Name in full)

___________________________________ (Date and time)

Sign of a senior Engineer (Authorizer): ___________________________________

___________________________________(Name in full)

___________________________________ (Date and time)

Completed forms should be signed by a senior engineer. All forms will be kept for recording and referencing purposes for up to 6 months.

Pre-dive Checklist

This is a checklist which has to be completed, again by at least the presence of two staff members and the authorization of a senior engineer, before the ROV is brought to the water for missions.

Pre-Dive Checklist

Staff names (in full): ________________________________ and _________________________________

Date and time: _____________________________________

Purpose of handling: ____

Please go through every single line of this safety checklist. Put a tick in the box if the condition is met. Jot down any remarks for our mechanical and electrical departments for reference.

WARNING: Never handle the ROV unless all conditions are met.

	√	Remarks:
Vehicle Inspection		
Check thruster shaft seals for oil loss.		
Inspect camera port for cracks or signs of condensation.		
Inspect/ secure hull end caps for full engagement.		
Lubricate and replace camera vent plug.		
Inspect/ adjust vehicle position within crash frame.		
Other Remarks:		
Electrical Hook-up		
Check that the main power switch on the console is off.		
Remove vehicle and tether connector dummy plugs and store safely.		
Bring umbilical OVER hook onto lifting eye.		
Protect all unused connectors with dummy plugs.		
Mate other end of umbilical to console as labeled.		
Ensure the input line voltage matches the setting .		
Use a heavy-gauge (14 AWG or less) extension cord to reach the power source.		
Other Remarks:		
System Checkout		
Ensure that the thruster and light switches are in the off position.		
Center trim adjust knob.		
Switch on power to control console.		
Switch on video on monitor.		
Check for video monitor.		
Turn thruster switch on.		
Briefly toggle joy sticks.		
Double-check that all vent plugs are installed. Lower vehicle into water and adjust trim if necessary by adding weights or floats.		

Check video picture.		
Confirm light operation.		
Confirm thruster operation.		
Confirm conductivity of the venting ground.		
Other Remarks:		

<u>In case of emergency, press the red emergency button (as labelled) on the front side of the Electrical Distribution Box IMMEDIATELY.</u>

Should you encounter any inquires or if any of the above conditions is not met, you should immediately contact the respective departments for help. NEVER HANDLE OR OPERTE THE ROV UNLESS ALL CONDITIONS ARE MET.

Sign of the first staff: ______________________________

______________________________ (Name in full)

______________________________ (Date and time)

Sign of the second staff: ______________________________

______________________________(Name in full)

______________________________ (Date and time)

Sign of a senior Engineer (Authorizer): ______________________________

______________________________(Name in full)

______________________________ (Date and time)

Completed forms should be signed by a senior engineer. All forms will be kept for recording and referencing purposes for up to 6 months.

Post-dive Checklist

This is a checklist which has to be completed, again by at least the presence of two staff members and the authorization of a senior engineer, after the ROV is brought back to the surface from water.

Post-Dive Checklist

Staff names (in full): ______________________________ and ______________________________

Date and time: ______________________________

Purpose of handling: ______________________________

Please go through every single line of this safety checklist. Put a tick in the box if the condition is met. Jot down any remarks for our mechanical and electrical departments for reference.

<u>WARNING: Never handle the ROV unless all conditions are met.</u>

	√	Remarks:
Inspect camera ports for cracks and condensation. Cover lens ports immediately after drive.		
Check thruster oil filled chambers to ensure no collapsing occurred during drive		
Inspect and rotate thruster shafts to ensure no debris was		

collected during dive and that shafts are turning free.		
Rinse vehicle down with freshwater.		
Remove and replace both vent plugs to equalize pressure.		
Secure all equipment to deck.		
Once ROV operations are complete, remove all electrical connections. Rinse all exposed plugs and sockets with freshwater.		
Grease terminals with lubricant and fit dummy plugs on vehicle and tether connectors.		
When ROV operations have been completed, disconnect all cables, install dummy plugs and pack in crate.		
Other Remarks:		

Should you encounter any inquires or if any of the above conditions is not met, you should immediately contact the respective departments for help. NEVER HANDLE OR OPERTE THE ROV UNLESS ALL CONDITIONS ARE MET.

Sign of the first staff: ___________________________________

___________________________________ (Name in full)

___________________________________ (Date and time)

Sign of the second staff: ___________________________________

___________________________________(Name in full)

___________________________________ (Date and time)

Sign of a senior Engineer (Authorizer): ___________________________________

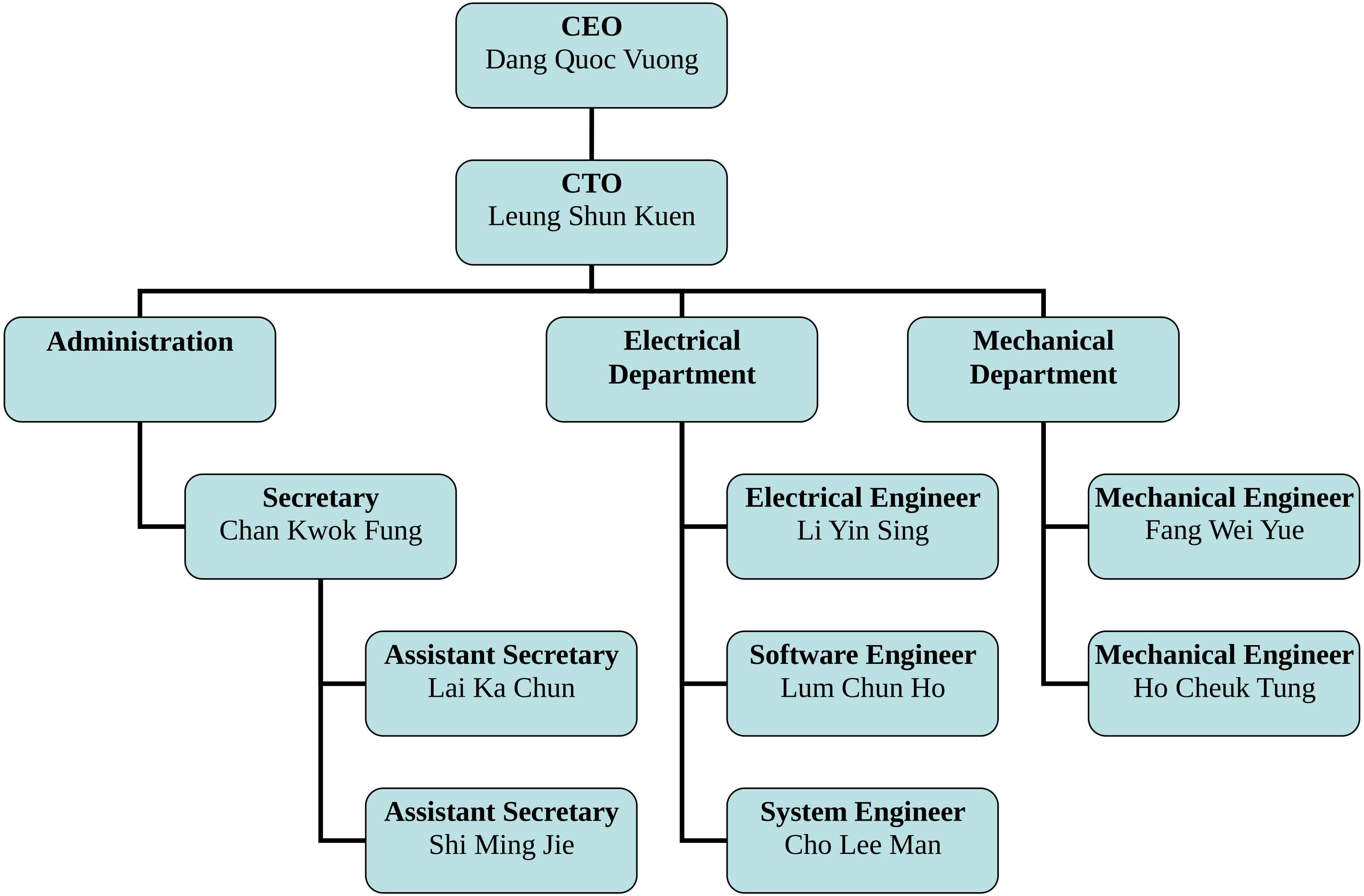
___________________________________(Name in full)

___________________________________ (Date and time)

Completed forms should be signed by a senior engineer. All forms will be kept for recording and referencing purposes for up to 6 months.

IV. Logistics

A. Company Structure



B. Scheme of Work (Teamwork)

<table>
<tr><th colspan="2">November</th><th>December</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th></tr>
<tr><td rowspan="5">Plan / get to know ROV design (All depart-ments)</td><td colspan="2" rowspan="2">Research the Thunder Bay National Marine Sanctuary (Administration)</td><td>Brainstorm & write the report (Administration)</td><td colspan="2">Calculate the budget & Write the report (Administration)</td><td rowspan="3">Practice presentation, design poster, set the future improvement of the ROV, test and rehearse the missions with ROV in water (All departments)</td><td rowspan="2">Solve the problems found out of the ROV (Mechanical Department and Electrical Department)</td><td>Practice presentation (All departments)</td></tr>
<tr><td rowspan="2">Build ROV frame (Mechanical Department)</td><td rowspan="3">Design and construct the microbial samples collector, the manipulator, the conductive sensor (Electrical Department & Mechanical Department)</td><td>Design poster (Administrati on)</td><td>Design poster (Administration)</td></tr>
<tr><td colspan="2">Design ROV structure and build camera positions (Mechanical Department)</td><td rowspan="2">Attach the Styrofoam and thrusters on the ROV (Mechanical Department)</td><td rowspan="2">Finalize the report (Administration)</td><td rowspan="2">Test and rehearse the ROV in water (All departments)</td></tr>
<tr><td colspan="2">Use Sketchup to create initial design of ROV (Mechanical Department)</td><td>Prepare safety checklists (All departments)</td><td>Compete the regional competition (All departments)</td></tr>
<tr><td colspan="2">Discuss the electrical software (Electrical Department)</td><td colspan="3">Design and develop the program of control system (Electrical Department)</td><td>Find out the problems of the ROV (CEO, Mechanical Department and Electrical Department)</td><td>Test and rehearse the ROV in water (All departments)</td><td>Join the international competition (All departments)</td></tr>
</table>

The work of scheme was carefully planned and strictly enforced by all departments. Special thanks go to the CEO and CTO for the extremely remarkable leadership in guiding the team in designing and building ***Gamma***, both electrical and software.

C. Budget

Financial report for 2014 ***Gamma***

Items	Qty	2013-14 Expense (HKD)	2013-14 Income (HKD)	Donated?	Carry-Over?
ROV Construction					
Aluminum Frame	10m	120			yes
SeaBotix BTD 150	4	24,000			
Silicone Cable	60m	1,500			
Optical Transceiver	2	250			
ESC	7	1,050			
LCD Monitor	1	1,100			
VEX Controllers	2	3,200			yes
Arduino	2	200			yes
Cameras	4	180			
Camera Box	1	100			
Distribution Box	1	700			
Miscellaneous	nil	5,000			
Total Robot Costs		37,400			
Travel / Competition					
Flight tickets	16	272,000			
Transportations	16	10,000			
Meals	16	50,000			
Visits	nil	25,600			
Rental of Swimming Pool for ROV tests	21Hrs	4,200		yes	
Total		361,800			
Others					
Souvenirs		1,000			
IET Prize for Regional Champion			8,000		
Total		1,000			
Grand Total		400,200	8000		
Cost this Year		384,480			

The team, together with its supervisors and mentors, has contributed an approximate 11,700 hours on the project.

V. Conclusion

A. Challenges

The biggest challenge the team faces is to overcome the big water resistance brought about by the square design of the ROV. To help tackle this, the team has come up with many alternative designs. Autodesk Flow Design has been used to help simulate their performances in reducing water resistance. It is also through the data analysis provided by Autodesk Flow Design that the team is able to conduct numerous tests, experiments and refinements until the ultimate design, ***Gamma***, comes to place.

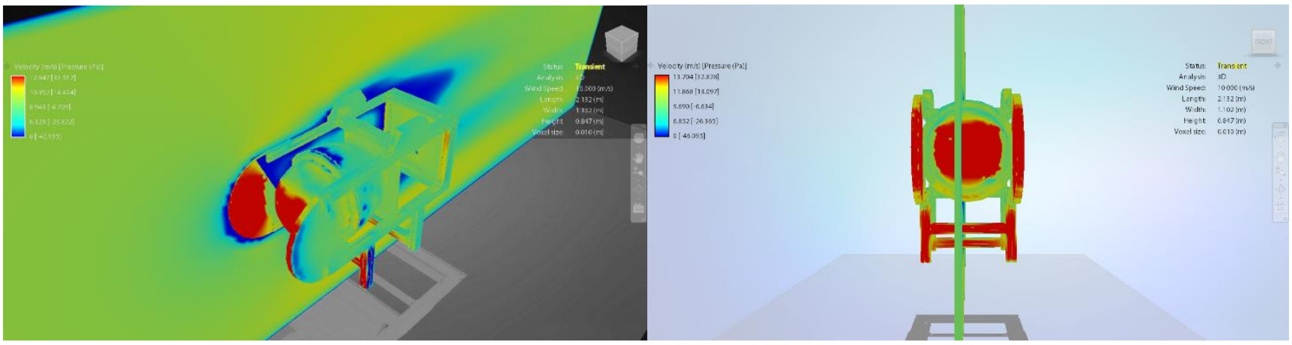


Figure 30: Simulation of the design of the ROV

There are of course challenges beyond the technical aspect. Similar to the previous years, the team's competency in English language has again greatly affected the performance of the report, and foreseeably, the presentation. Since none of our members learnt about robotics in English, the team has huge difficulty in translating, and at a later stage, reporting and presenting the details of the creation of the ROV in a foreign language. An English teacher has been added to the team to help out. Regular English sessions were conducted to equip students with the common robotic vocabulary in English, as well as to raise members' awareness of the use of English in the workplace. Students generally found the sessions useful and felt that they have greater confidence in acquiring more skills and knowledge about Robotics in the future since they now show less fear about reading international robotic journals and articles, which are most likely written in English.

B. Troubleshooting Technique

The power cable and the tether have to be plugged to the Electrical Distribution Control Box in order for ***Gamma*** to function. In case of abnormal ROV performance, the ROV could be called to a stop by the operator by pressing the emergency button. What used to happen in the past was that when ROV performed abnormally or when meters detect abnormalities, the operator has to unpower the ROV completely and the team has to look into the Arduino board, the VEX system as well as the ROV for fault detection, which often took up a large amount of time and resources. Now, four switches have been added to the Electrical Distribution Control Box for easier and more precise fault detection. By switching on and off the switches, the operator can make fault finding and fault detection more specific, focused and quicker.

Figure 31: Emergency stop and the four independent switches

C. Lessons Learnt

The team as a whole has benefitted a lot from working on the project. A major triumph shared by the team is the discovery of using one optical fiber, instead of four coaxial cables, in the transmission of video signals from the cameras to the shore. This discovery is the result of the professional team's reflections of past experience in dealing with robots as well as their exposures to the robotic work of others in various international robotic competition. Not only has the tether become thinner and lighter, the movement of the ROV becomes more flexible

All members of the team recognize the learning of different interpersonal skills while working together as a team for the competition, with the most significant one being time management. Similar to the past years, all team members have other work duties in addition to those entitled to their role in the company. What's more, the team has to receive English training arranged for them this year. However, this increase in workload has brought more good than harm. The team has learnt a great deal in managing their time in accordance to their priorities as well as their responsibilities to the team. Overall, the team has enjoyed a fairly harmonious relationship.

D. Future Improvements

As reinforced in our report, the team has a mission of creating an ROV that is composed of original and authentic components so to fit every unique requirement stated by our clients. Due to technical and time constraints, one can still find the thrusters and the VEX controllers of ***Gamma*** devices commercially designed. It is the goal of the team to, one day, replace all commercial devices with open source hardware. At present, we have staff members doing research and study on Arduino boards, hoping that we could custom our own microcontroller board like what we did in ***Gamma*** sensor system for data collection of water conductivity. This replacement shall bring about a sharp drop in ROV manufacturing cost. More importantly, an ROV made entirely of open source materials can be used as training material for other companies, thus making robotic technology more accessible to the world. We even go further as to believe this replacement can make robotic competitions more keen and cut-throat, hence leading robotic development to an unprecedented level.

Regarding staff development, the team aims at developing its own ROV curriculum and make ROV technology and knowledge more accessible to all staff members. At present, some of our members are exceptionally specialized at certain aspects of the ROV development while others do not, thus creating an imbalance in workload distribution and, at times, overreliance on a few members. Through developing our own ROV curriculum, all members are given the chance to acquire knowledge of all aspects of ROV technology. Not only can skills and knowledge be generalized to all members and the overall standards of the team be raised, but the growth and development of the company is also to become more healthy and sustainable.

E. Reflections

"Having taken part in the MATE competition for 4 years, I still find myself acquiring new knowledge and new skills about robotic development. As a senior member of the team, I think I am not only obliged to nurturing junior teammates but also promoting robotics to members of the community. I am proud to say that the team has appeared in many schools and public events to introduce robotics. I felt so touched every time when people in the crowds raised their hands and asked us questions related to our ROV or our work. They gave me recognition on what I have been devoted to and they gave me energy to go on. In my opinion, ROV technology development is a never-ending journey. I am very interested in exploring more in this field upon high school graduation."

--- *Dang Quoc Vuong (Year 11)*

"I am glad to see new members joining us in the MATE competition. We have faced a lot of challenges together since building an ROV demands a lot of technological skills, as well as technical and mechanical knowledge. However, we are lucky to have our mentors organizing lessons and helping us a lot throughout the project. I would say our group has a wonderful time working together. I belong to the sandwich class in the team, and at my position I saw tremendous and effective communication among teammates. Whatsapp and Facebook have been the major platforms for us to discuss matters when we are out of office. They have also been the platforms for the exchange of support and comfort. I cannot wait to take part in next year's competition so that we can stay together and strive together as one team again."
--- Chan Kwok Fung, Jayden (Year 8)

"It has been, indeed, the most eye-opening experience I have ever encountered in my life. I have not been in most parts of Hong Kong, let alone the U.S.A. At the very beginning stage, I was very doubtful about my ability and my contribution to the team because I had not received any previous professional training before and I was just a girl. Brought up in a traditional Chinese society, I have been told that robotics is a men's field. However, my family has been thoroughly supportive and the team has given me extra care and attention. At present, I am the only female member of the team. However, I look forward to having more girls joining me, and exploring more of their potentials."
--- Shi Mingjie (Year 8)

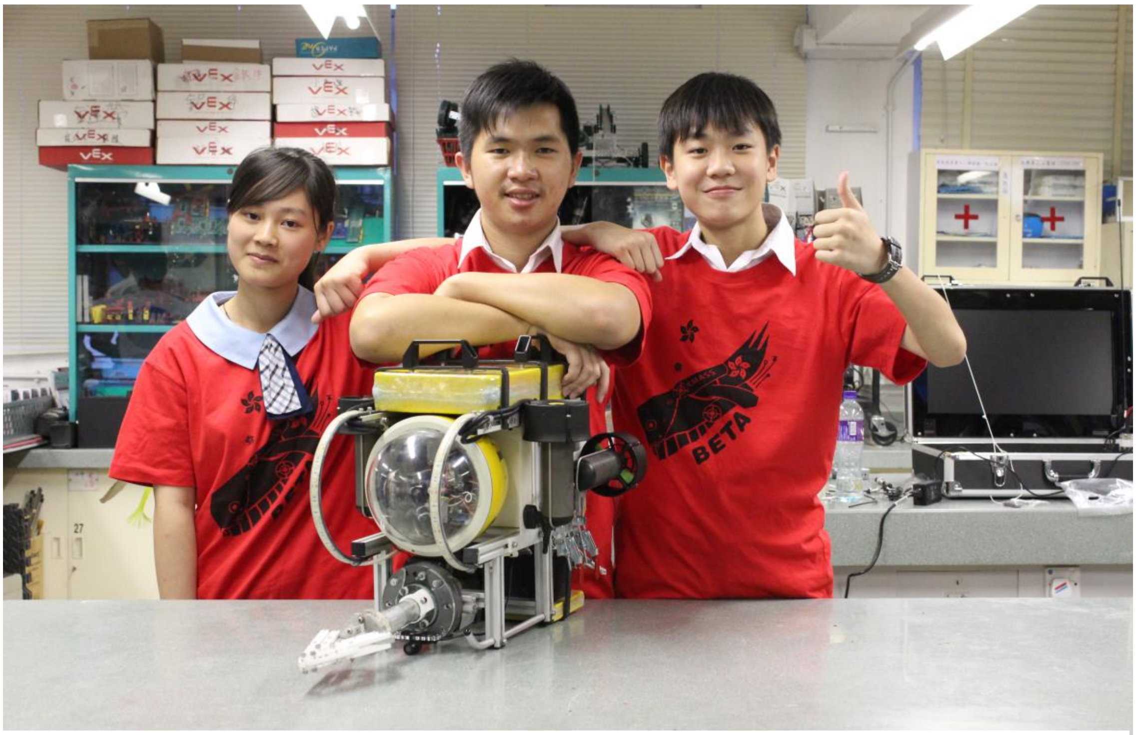


Figure 32: (From left) Jie, Vuong and Fung

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