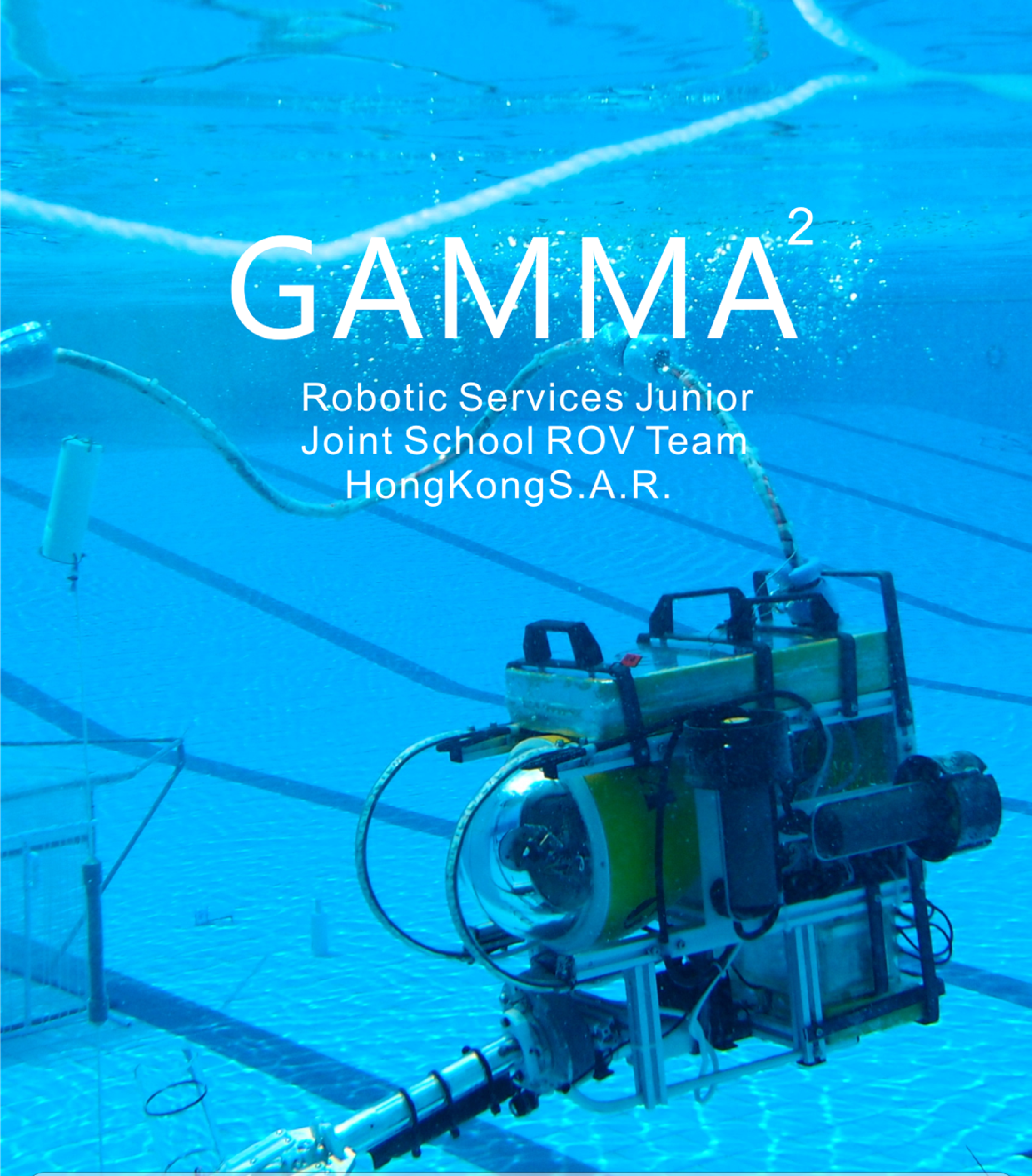


GAMMA²

Robotic Services Junior
Joint School ROV Team
HongKongS.A.R.

Company Members:
CEO - LI FENG SEN
CTO - IP TAK MING
Secretary - TAM KI MING
Logistics engineer - TAM KA YAM
Mechanical Engineer - TAM KI MING
Mechanical Engineer - IP TAK MING
Mechanical Engineer - WONG CHI KIN
System Engineer - NG MAN YIN
System Engineer - THAI THANH LONG

Mentors:
HO LI WAI

HONG KONG

B. Table of Content

C. Abstract

Robotic Services Junior (RSJ) is a startup marine technology services company. In this year, it is a very valuable experience and memories for the all RSJ staffs that have a joint venture project on ROV training and development with CMAss.

The goal of our company is to build an ROV (Remotely Operated Underwater Vehicle) that focus on cost effectiveness, customer satisfaction, safety, and environmental protection. Also, we want to use this opportunity to prove that ROV can realize the concepts of recycling and reusing without trading off any of our strictest safety and performance requirements.

Gamma² with a small size (610mm x 380mm x 410mm), reasonable weight (10kg), stable video signal transmission and manipulator which makes our ROV capable to tackle a variety of tasks under water including operation, observation, measurement, installation, as well as maintenance work. What makes ***Gamma²*** 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.

This technical document details the development process and the design details of ***Gamma²***, including the safety issues it entitles. Records on troubleshooting techniques, obstacles encountered, lessons learnt as well as the project budget are also carefully illustrated.

D. Mission Theme

Remotely operated vehicles (ROV) are essential for the polar science community and the offshore oil and gas industry to deal with the extreme environment at the Arctic region. For the scientists that they needs to conduct scientific activities, for example sample collecting that includes counting species and sampling organisms, deploying an instrument, and collecting data about an iceberg; For the oil and gas industry, subsea pipeline inspection and repair that includes replacing a corroded section of oil pipeline and preparing a wellhead for delivery of a Christmas tree. On the other hand, ROV helps to operate offshore oilfield production and maintenance that includes testing the grounding of anodes on the “leg” of an oil platform, measuring the height of a wellhead, and controlling the flow of oil through a pipeline.

Polar researchers and offshore oil and gas companies use the facilities at MI and the OCRE to test the equipment that supports their science and operations before heading out to sea. A number of scientists who work in polar environments are based in St. John’s or use it as a starting point for their research in the Arctic. Similarly, several companies involved in oil and gas operations on the North Atlantic continental shelf are headquartered in St. John’s, while a number of others have offices there.

We designed and built an ROV that can pinpoint and sample counting in species and sampling organisms, deploying an instrument, and collecting data about an iceberg from the surrounding areas. Our ROV uses cameras, manipulator and mission tools to achieve subsea pipeline inspection and facilities repairing. For the offshore location, our ROV also provide essential services for the oilfield in operating maintenance duties.

II. Design Rationale

A. Aim

Robotic Services Junior 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 standards and 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.

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 1: Supervisor and all engineer discuss the placement of thrusters

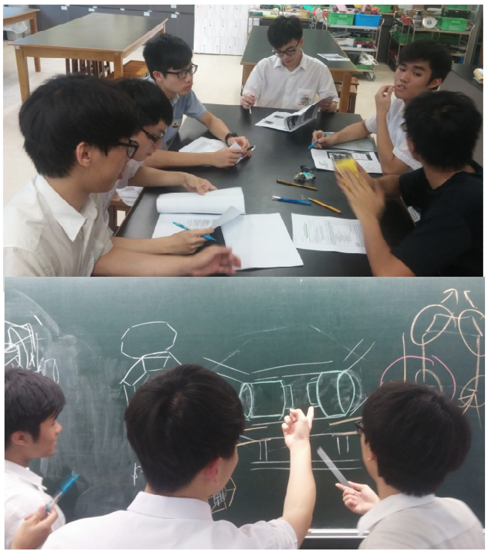


Figure 2: The team brainstorms ideas on the design of ROV and the accomplishment of mission tasks

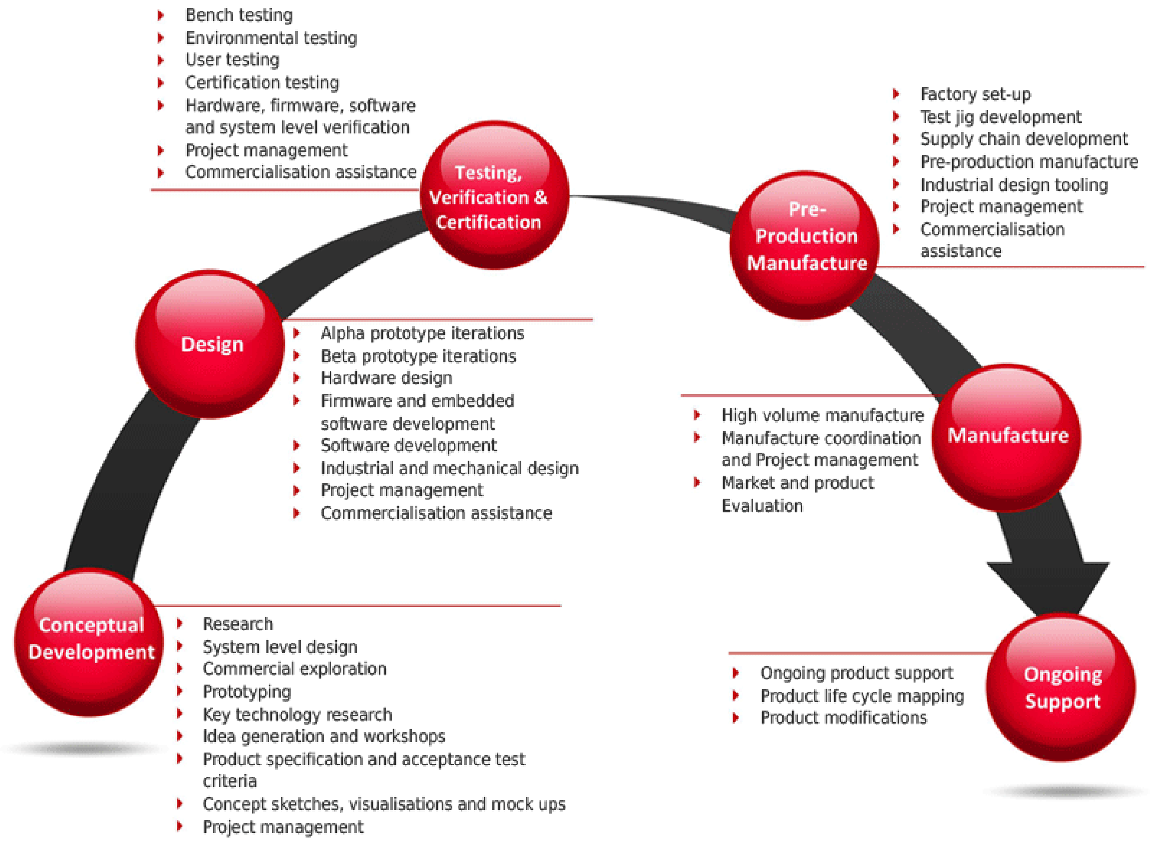


Figure 3: Gamma[2] Design process

C. Overview of Gamma^2

Gamma^2 is recently improved ROV by Robotic Services Junior. This design takes CMA Gamma as the base and modify. This under water robotic system mainly divided into two sections – on surface and under the water. These two parts is connected by our tailor made tether.

For the on land section, this electrical distribution control box which contains video system, safety monitoring devices and ROV controlling system. Video system is made up of 24" monitor optical transceiver and 4 in 1 video box that make the pilot have clear vision in driving the ROV without disturbance. Safety monitoring devices includes voltmeter, ammeter and emergency stop button that help keep safe during operation. The twin VEX controller set up a separate driving duty protocol for two pilots. It is easier for the pilot to control the motion of the ROV and the manipulator during missions.

For the under water section, cameras provides video signal to the pilot to drive the ROV and operate the manipulator and mission tools to finish mission tasks. With the command from the pilot, the ESCs control the thruster to drive the ROV to task point for mission. While the floating material controlling the buoyancy of Gamma^2.

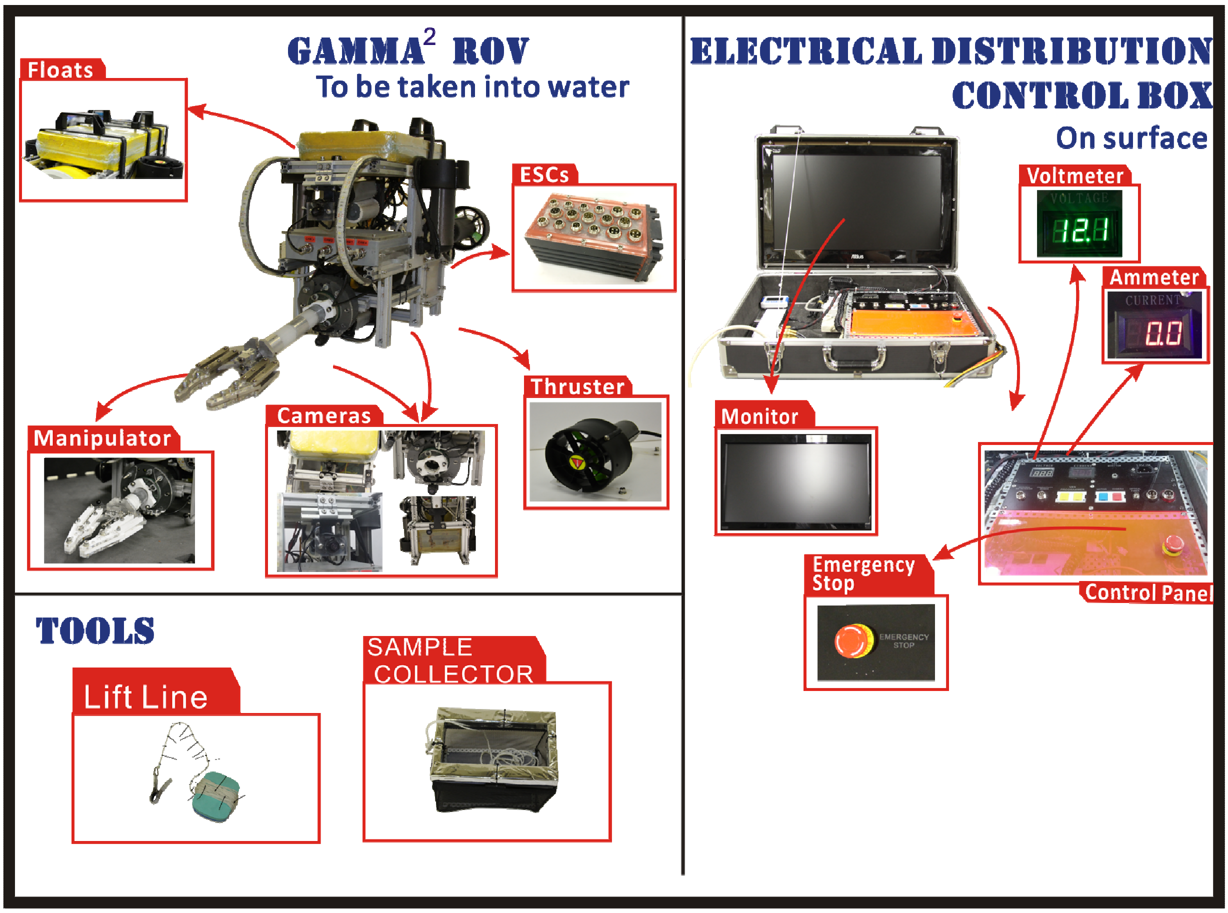


Figure 5: Overall parts of Gamma^2

Before the final version of ***Gamma^2*** had been designed, we seriously consider the size, the shape and maneuverable of our new ROV. With reference to different ROV design, ***Gamma^2*** is based on the former generation of ROV - Gamma to keep the size as small as possible in order to increasing the possibilities to pass through everywhere under the water. Also, for the shape of ***Gamma^2,*** it keeps the rectangle shape. It is not only easy transportation, but also allows our customer to make some modification, to attached different play load tools on it. The more important is that customer can adjust the buoyancy of our ROV after their modification.

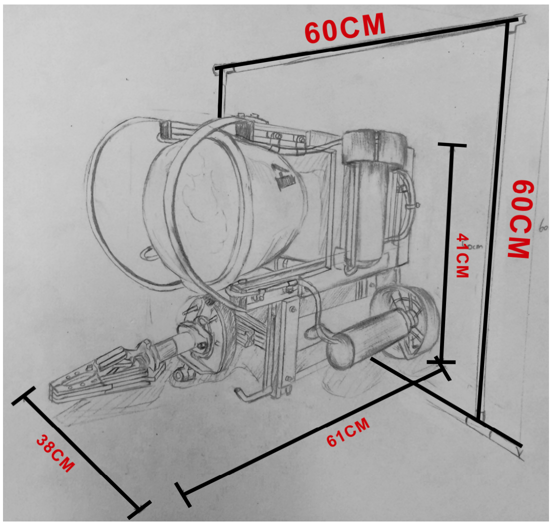
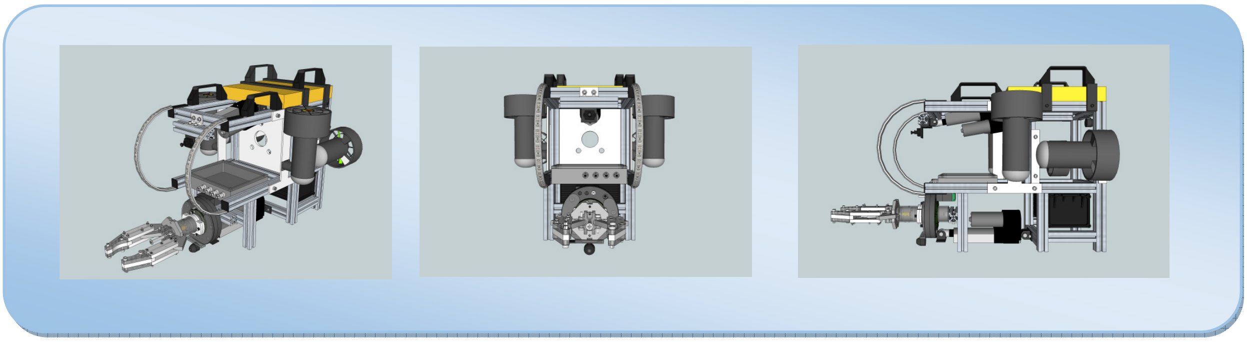


Figure 6a: concept drawing of reference ROV - ***Gamma***



Isometric View   Front View   Side View

Figure 6b: CAD design of **Gamma^2**

Gamma^2 have made a great change to meet our goal of cost – effective. In this generation, our ROV reduce the number of the thruster from Five to Four. As per our design, with advantages of small in size and light in weight, **Gamma^2** just use four thrusters that 2 for lateral movement and 2 for vertical movement. With pool trial for ROV testing and documentary studying, we found that there is less chance to use horizontal movement at St John area. As a result we decided to reduce the number of the thruster for the horizontal movement.

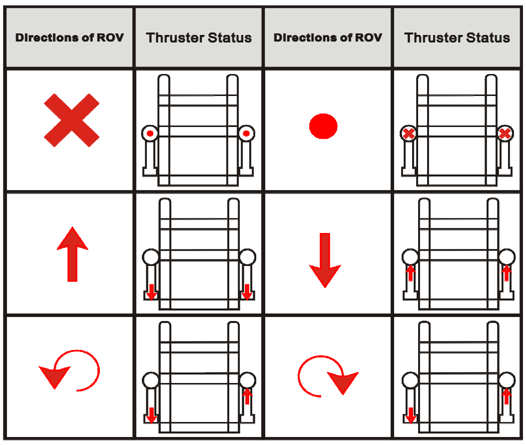


Figure 7: Motion of Gamma^2

D. System Integration Diagram(SID)

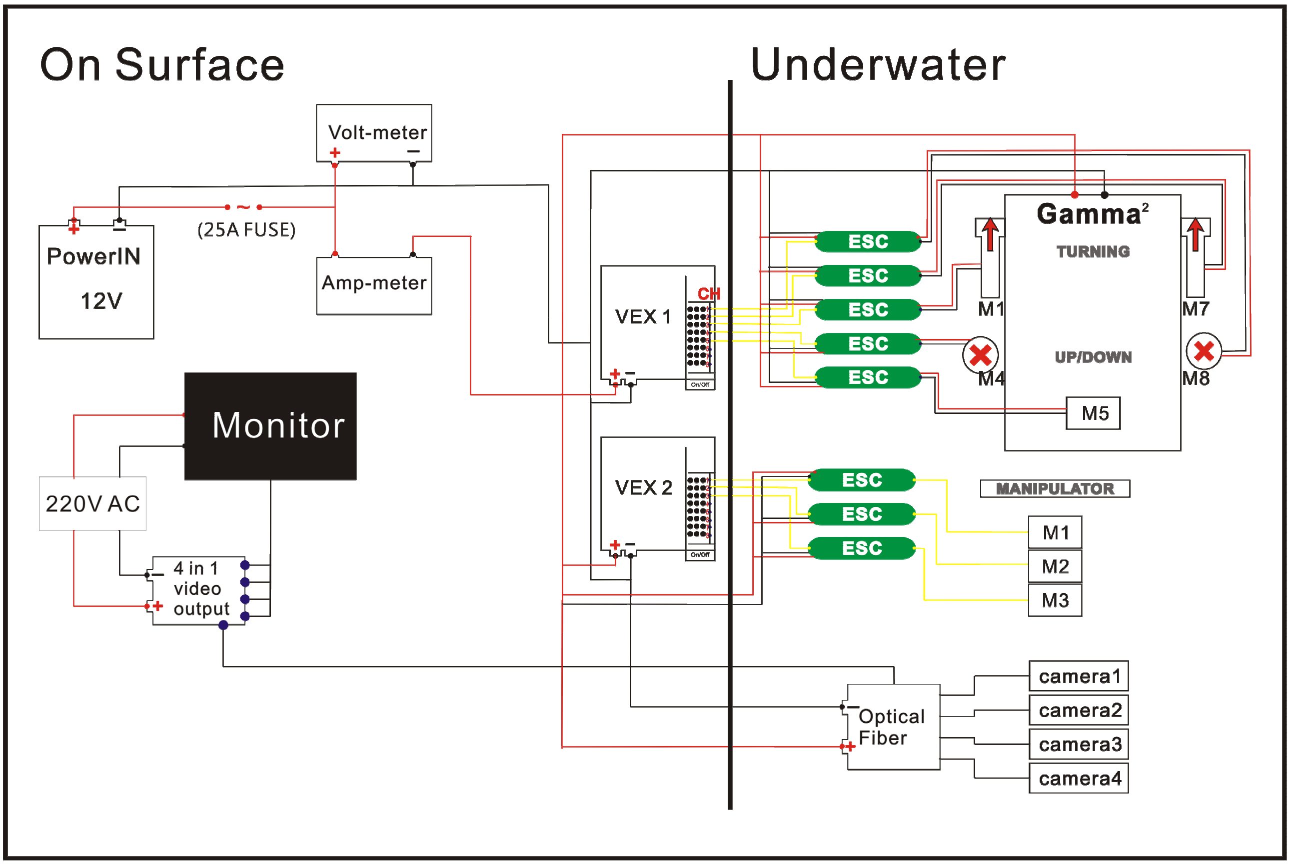


Figure 4: Gamma² System Integration Diagram (SID)

E. Tether

The tether connects the ROV to the Electrical Distribution Control Box. It consists of two 10AWG power cables, one optical fiber 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 fiber 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.

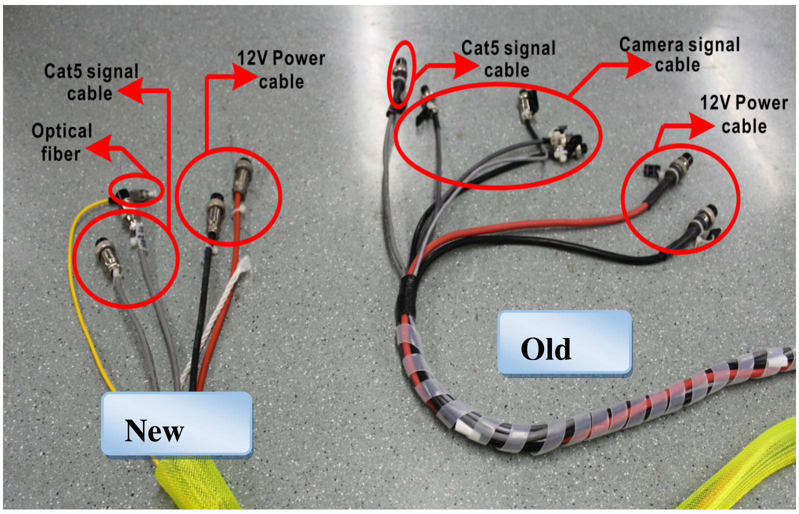


Figure 5: Comparison of the content of old and new tethers

F. Frame

Robotic Sercices Junior decided to construct the frame of Gamma^2 by make use of 2020 aluminum extrusions. Its sturdy yet light nature offers an excellent strength –to-weight ratio for the support of the ROV. Aluminum extrusion is also rust-resistant, making ROV maintenance less frequent and less costly. The reason of use 20mm X 20mm aluminum extrusions is the consideration of the weight and the space for installation of ESC box and optical fiber transmission box.

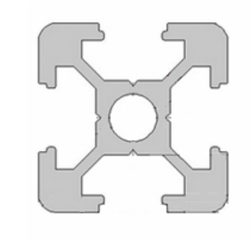


Figure 6a: cross section of 2020 aluminum extrusion

The aluminum frame, with a dimension of 610mm X 380mm X 410 mm, is made up of smaller aluminum extrusion rods. (It allows the ROV to enter the ice berg hole through the 750mm X 750mm 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.

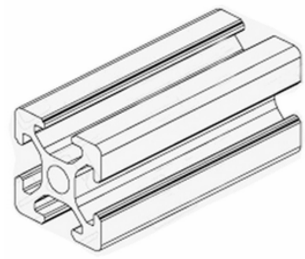


Figure 7b: isometric view of 2020 aluminum extrusion

Apart from the mechanical advantages, aluminum extrusion also has its advantages in attaching play load tools and other extra equipments on to the ROV easily. The slot on the 2020 aluminum extrusion, it is easier for the engineers and the customers to tune the buoyancy after attaching different external equipment.

G. Electrical Distribution Control Box

A highlight of ***Gamma²*** ROV is its Electrical Distribution Control box (EDC), which is made up of a VEX controller kit, a customized panel stage and a 24"monitor.

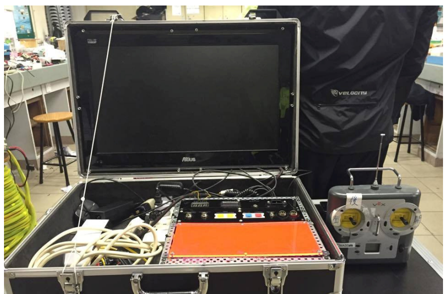


Figure 8: Electrical distribution control box with monitor

The main function of electrical distribution control box is to distribution power and signal to Gamma^2. The power supply provides 12V 25A power to the electrical distribution control box. The box will distribute 12v to the ROV for operation and power to the vex controller. In order to reduce the weight of the tether, we collect all the vex controller signal and transmits by cat5 signal cable. The 12V power cable also link into the ESC box that distributes enough power to four thrusters and motors within the manipulator.

H. VEX Controller Kit

Our VEX Controller kit is used to control the 7 ESCs, which in turn control the motions of the ROV and the performance of the manipulator. The control system consists of two 75MHz 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.

I. Electronic Speed Controllers

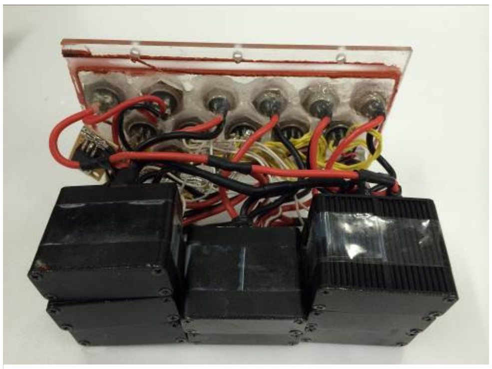


Figure 13: Electronic speed controllers

Gamma² contains seven ESC (Electronic Speed Controllers), these seven ESC are divided into two sections which packed within a waterproof box. The first section is designed for the movement of ***Gamma.*** Our four SeaBotix thrusters are controlled by four waterproofed ESC. 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. The rest of three ESC is to control the manipulator. These three ESC allows the manipulator become adjustable not only for the widening of the gripper, but also provides the manipulator have the function of self-turn in 360 degrees, and the upward and downward movement of the manipulator.

J. Thrusters

Our engineer team decided to use commercial thruster for the reason that Robotic Sercices Junior currently does not have the expertise to build their own 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 ***Gamma²*** 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.

Figure 14: Engineer checks the buoyancy system

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

L. Software Flow

The software code is designed by our system engineer. 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.

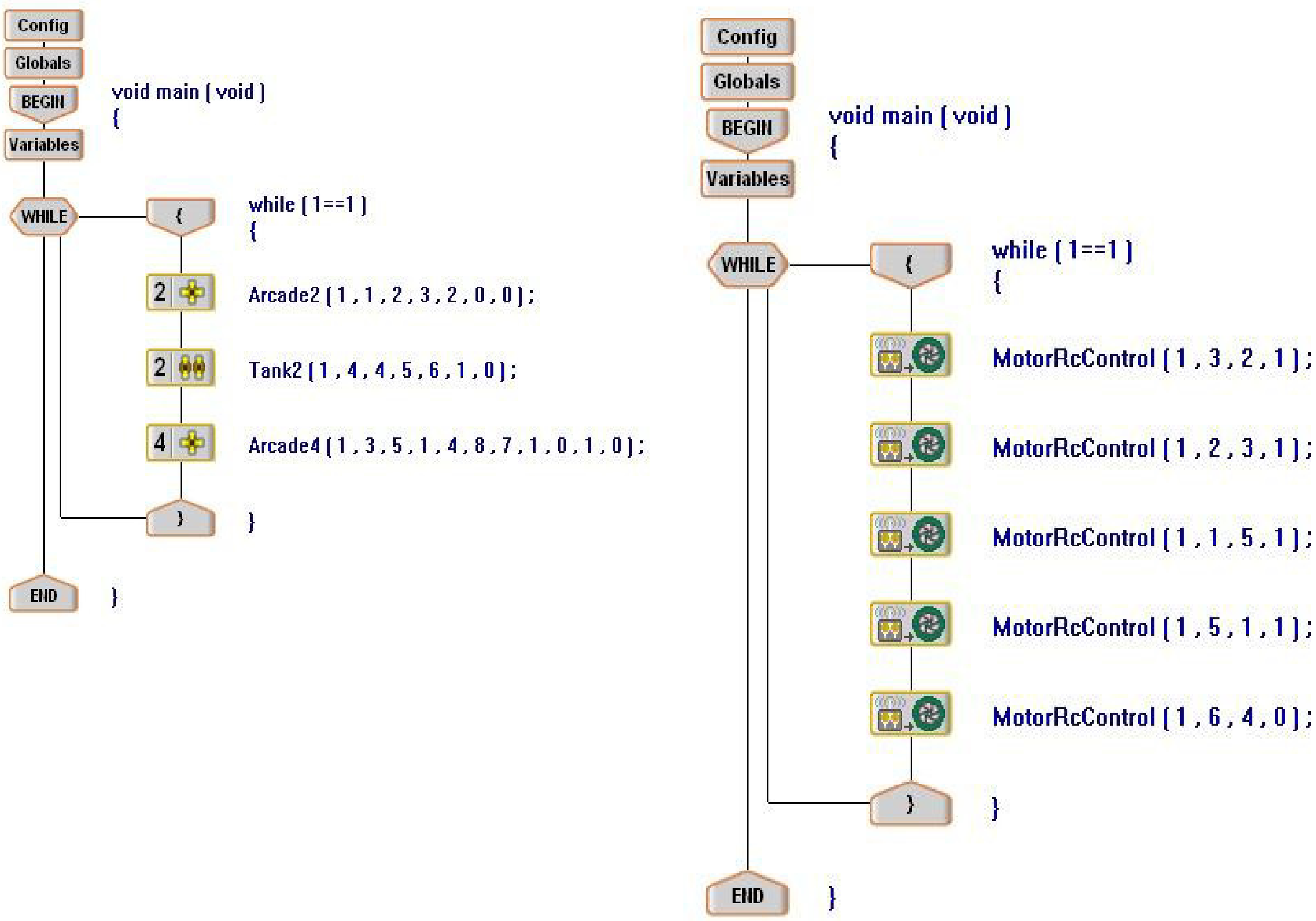


Figure15: Software Flow of Gamma^2

M. Cameras

Camera selection, positioning, and functionality are most important for the pilot to be able to effectively deal with the missions. For the Gamma^2, we choose the camera which is used for vehicles. A total of four cameras are attached to ***Gamma²*** to provide the operators on shore the maximum knowledge of the ice berg and its surrounding environment.

Three 170-degree cameras all function to observe of the ice berg region, 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.

Figure16a: Wide Angle Camera

Among the three wide-angle cameras installed in ***Gamma²***, 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 can be found at the front of ***Gamma²,*** it provides the full picture under the water for the pilot to motion the ROV. it helps to locate four different point of the ice berg and helps to measure the volume of the ice berg.

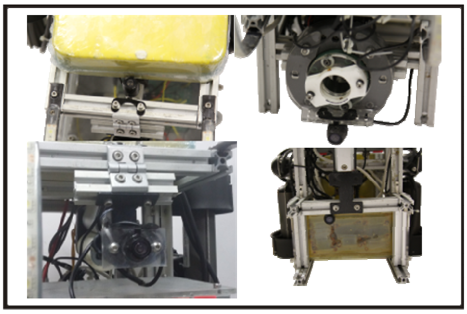


Figure16b: Positioning of Camera

The last one is seen at the bottom of ***Gamma²*** to give operators an overall picture of the surface ***Gamma²*** is moving on. It generally aid us to identify the stars and calculating the volume of the ice berg.

One camera is placed under the manipulator to monitor closely the condition of the manipulator in task performances. As our manipulator is designed have three degree of freedom that can move nearly all rounded. This camera is very helpful for the pilot to control the manipulator to accomplish the missions.

N. Manipulator

Our tailor-made, unique manipulator is quick, simple and strong, and can deliver its best performance. To ensure safety, the team waterproofs the motor.

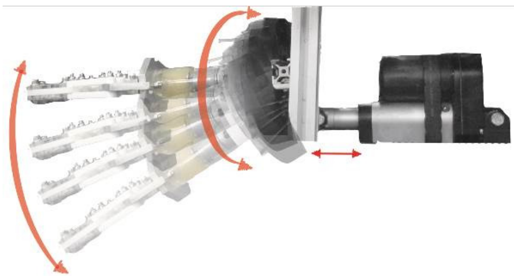


Figure17: 45-degree of freedom

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 with actuator can incline 45^{o} vertically and increases its flexibility in reaching targets even in wavy situations. We are certain that the performance of ***Gamma²*** in task 2 will be enormously strengthened when compared to that of our past ROV.

With the function of 360^{o} clockwise or anti-clockwise rotation of the manipulator, it will reducing needs of installation of second manipulator on ***Gamma²***. The pilot can adjust the manipulator to correct angle and allow the pit crew to install props on it for the mission.

O. Mission Specific

Sample collector

Due to the needs to collect samples of algae and sea urchin from the underside of the ice sheet, a sample collector is created. It has a metallic design with metal and acrylic plastic as the main materials. ***Gamma²*** will be operated to retrieve samples and put them into the net from the sample collector. The sample collector has magnets so that we can dismantle it quickly and conveniently once completed the tasks.

Figure18: Sample Collector is used for retrieving the samples.

Lift line

The lift line has a 3 meter string attached to a floating board and a zip tie is attached to every 5cm starting from the end. Each zip tie indicates the length of the string and help us to measure the corroded pipe when clip is gripped to it. The buoyancy board will be attached on to the ROV when pulling the lift line to measure the corroded pipe.

Figure19: Liftline used for mea corroded pipe.

Measuring rob

The measuring rob is to measure the angle well head during Mission 3. Our play load engineers design a play load tools for this task. By make use of PVC pipe and connector, double "L" shape stand to measure the distance and height that related to the angle wellhead. With mathematic calculation, task man can calculate the angle of the well head and length of it.

Figure20: Play load engineers the structure of double "L" measuring rob

III. Safety

A. Our Philosophy

Safety has always been our company's primary concern. With the training and help of CMAss, 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 staffs 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 21: CMAss safety training workshop

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

Figure 22: Staff members are introduced to the first-aid kit

should always follow the dress code strictly, which restrict the wearing of lengthy accessories and open toed shoes. 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 ***Gamma²*** to keep the ROV itself and its operators safe.

Figure 23: 25-Amp fuse to prevent overloading of power

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.

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.

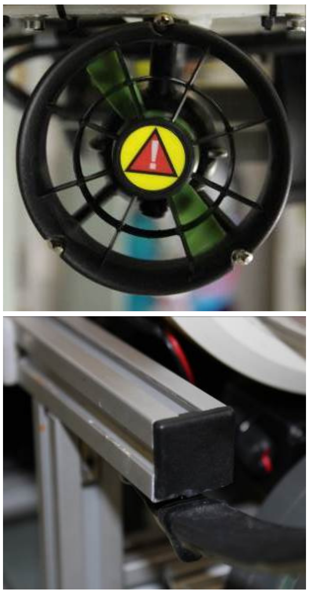


Figure24: Safety caps and safety labels are put up

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.

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.

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.

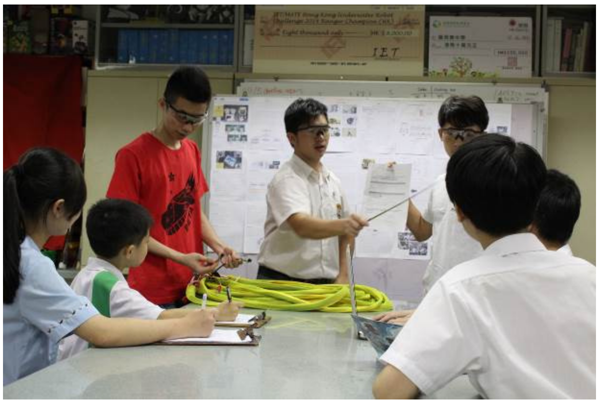


Figure25: Staff members are taught how to check the

<u>Safety Checklist</u>

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.

<u>Pre-dive Checklist</u>

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.

<u>Post-dive Checklist</u>

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.

All the specific item and standard of these Check List please refer to Appendix I, Appendix II, Appendix III.

IV. Logistic

A. Scheme of Work (Teamwork)

<table>
<tr><th>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="7">Plan / get to know ROV design (All depart-ments)</td><td rowspan="2">Research the St. John’s region (Administration)</td><td>Brainstorm & write the Technical Document (Administration)</td><td colspan="2">Calculate the budget & Write the Technical Document (Administration)</td><td colspan="2" rowspan="2">Solve the problems found out of the ROV (Mechanical Department and Electrical Department)</td><td rowspan="2">Design poster (Administration)</td></tr>
<tr><td rowspan="3">Build ROV frame (Mechanical Department)</td><td rowspan="3">Design and construct Mission tools</td><td>Design Marketing Display (Administration)</td></tr>
<tr><td>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 colspan="2">test and rehearse the missions with ROV in water (All departments)</td><td>Test and rehearse the ROV in water (All departments)</td></tr>
<tr><td>Use Sketchup to create initial design of ROV (Mechanical Department)</td><td>Finalize the Technical Document (Administration)</td><td>Finalize the Technical Document (Administration)</td><td>Practice presentation (All departments)</td></tr>
<tr><td>Discuss the electrical software (Electrical Department)</td><td colspan="2">Design and develop the program of control system (Electrical Department)</td><td>Practice presentation, design Marketing Display,</td><td rowspan="3">Compete the regional competition (All departments)</td><td>Test and rehearse the ROV in water (All departments)</td><td>Join the international competition (All departments)</td></tr>
<tr><td colspan="2">Safety Training (All Department)</td><td colspan="2" rowspan="2">Find out the problems of the ROV (CEO, Mechanical Department and Electrical Department)</td><td colspan="2" rowspan="2">Fund Raising for International Competition</td></tr>
<tr><td colspan="2">Prepare safety checklists (All departments)</td></tr>
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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 ***Gamma²***, both electrical and software.

B. Financial Report for 2015 ***Gamma²***

		2014-2015 Expense		2014-2015 Income
	QTY	**Unit Price (HKD)**	**Subtotal(HKD)**	
Items				
ROV Construction				
Aluminum Frame	10m	20	200	
SeaBotix BTD 150	4pcs	6,000	24,000	
Silicone Cable	60m	25	1,500	
Optical Transceiver	2	125	250	
ESC	7	150	1,050	
LCD Monitor	1	1,100	1,100	
VEX Controllers	2	1,600	3,200	
Cameras	4	45	180	
Camera Box	1	100	100	
Distribution Box	1	700	700	
Miscellaneous	nil	5,000	5,000	
Total Robot Costs			**37,280**	
Travel / Competition				
Flight tickets	**8**	**12,000**	**9,6000**	
Hotels	**8**	**2,000**	**16,000**	
Transportations	**8**	**1,000**	**8,000**	
Meals	**8**	**2,000**	**16,000**	
Rental of Swimming Pool for ROV tests	**15hrs**	**200**	**3,000**	
Sponsor from St Joseph’s AC school				**60,000**
Sponsor from NWSS Alumni				**10,000**
Sponsor from TWG Education Funding				**12,000**
IET Prize for Regional Qualification (Ranger Class)				**8,000**
Total			**139,000**	**90,000**

The Balance of 2014 – 2015 is (-HKD84,480)

The team, together with its supervisors and mentors, has contributed an approximate 1,700 hours on the project.

IV. 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, ***Gamma²***, comes to place.

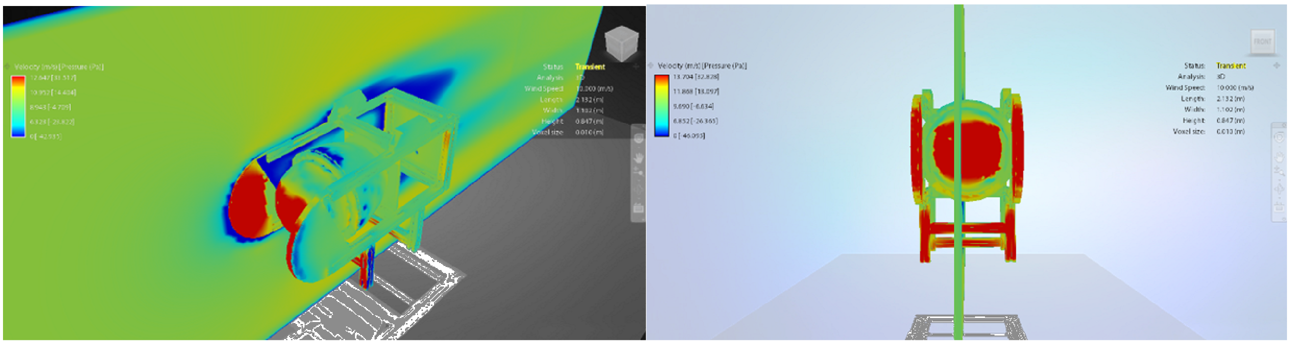

Figure26: Simulation of the design of the ROV

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 Technical Document, 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, Technical Documenting 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 ***Gamma²*** to function. In case of abnormal ROV performance, the ROV could be called to a stop by the operator by pressing the emergency button. The reason that we did not use the Arduino board is due to the reason that VEX controller kit contains less system error than the Arduino contains, thus it eventually simplify the entire system of the ROV and it even reduces time and resources for fault detection. The emergency has been installed for safety issues if any electrical system error happens within the ROV.

Figure27: Emergency stop button for troubleshooting

C. Lessons Learnt

The team as a whole has benefited 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 competitions. 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 Technical Document, 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 ***Gamma²*** 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 Android system graphic caculation, hoping that we could custom our own application like what we did in ***Gamma²*** system software to measure the volume of the ice berg. This research process shall sharp reduce the cost of purchasing software at this aspect. 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 2 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."

-- LI FENGSEN (Year 9)

"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. Also, thank you for CMASS Robotic team, they held three workshops for the team member who first time deal with ROV. 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."

--- THAI THANH LONG (Year 10)

"It has been, indeed, the most eye-opening experience I have ever encountered in my life. 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 first time participation in ROV project. With the help of my teammate, I learn a lot from it. This project provides me a chance to take part in engineering. After joining this project, I decided to become a engineer for the robotic field"

--- WONG CHI KIN (Year 10)

F. References

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- https://lx-group.com.au/lx-design-process/LX Group (Australia)

Acknowledgements

Robotic Services Junior would also like to thank:

All the judges of the MATE Competition

MATE Centre for organizing the competition

CMA Secondary School ROV team for providing training and workshop

MATE International ROV Competition Organizer

The IET/MATE Hong Kong Underwater Robot Challenge 2014 Organizer

Co-organizer

Tung Wah Group Sponsor

St Joseph's AC School Sponsor

NG Wah Secondary School Sponsor

CMASS Robotic Team Technical Support

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.

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

Should you encounter any inquires or if any of the above conditions is not met, you should immediately contact the

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:		

respective departments for help. NEVER HANDLE OR OPERTE THE ROV UNLESS ALL CONDITIONS ARE MET.

Sign of the first staff:	Sign of the second staff:
________________________________	________________________________
____________________(Name in full)	____________________(Name in full)
____________________(Date and time)	____________________(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

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:		

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

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.

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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.

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

	√	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:	Sign of the second staff:
________________________________	________________________________
____________________________(Name in full)	____________________________(Name in full)
____________________________(Date and time)	____________________________(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.