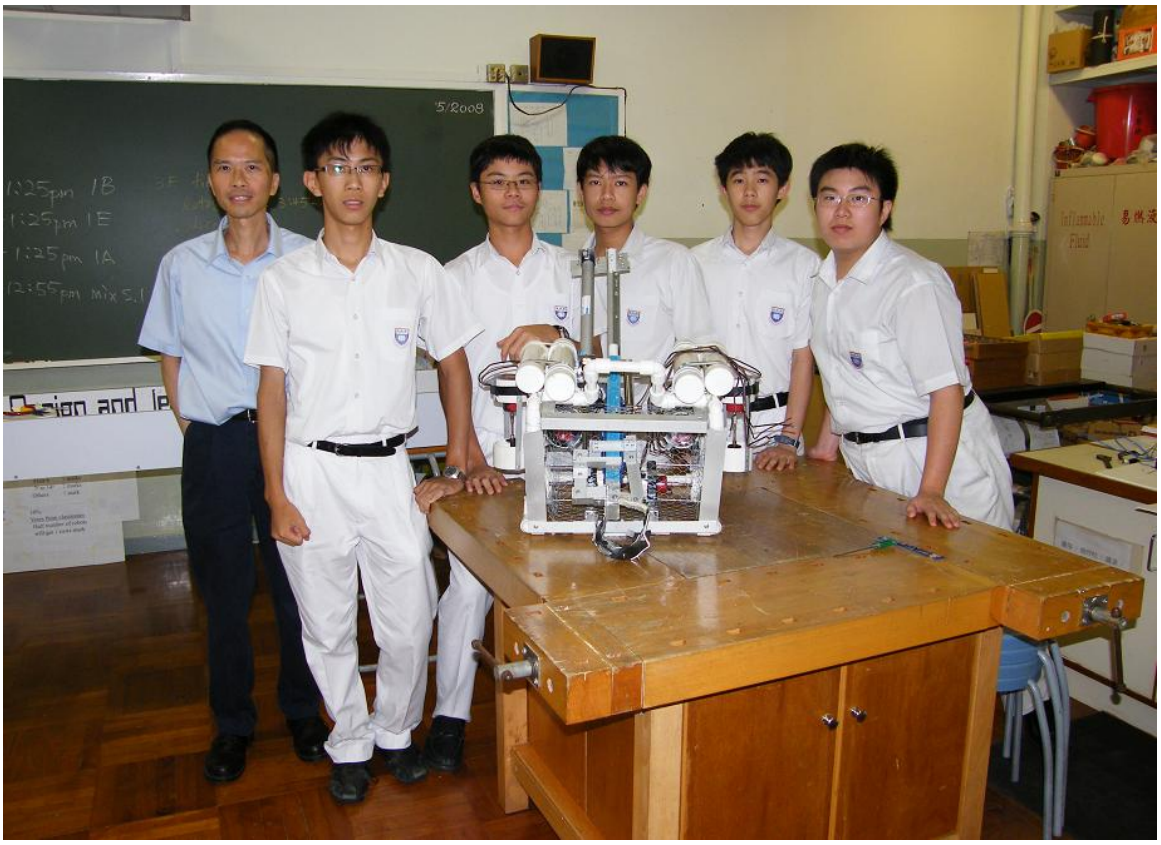


ROV:	Dolphins III
School:	Shau Kei Wan Government Secondary School
Club Name:	Design and Technology Club
Team Member:	Lee Ying Yin
	Li Tsz Yen
	Chan Ka Chai
	Yan Ho Ting
	Li Kai Ho
Instructor:	Leung Kwok Shun, Donald
Teacher:	Lo Man Wa

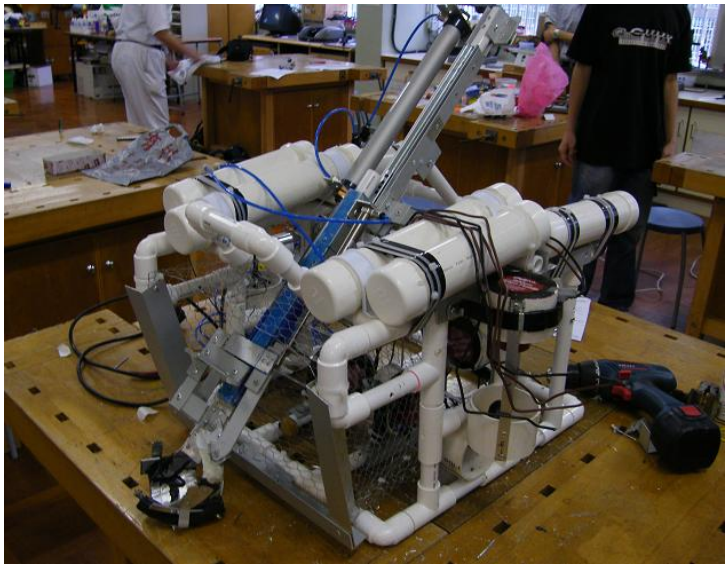
Abstract

This report introduces ROV ***Dolphin III*** (fig. 1) designed and made by the SGSS dolphin team of Shau Kei Wan Government Secondary School from Hong Kong. ***Dolphin III*** is designed to accomplish 3 missions: collecting vent crabs on the seafloor, collecting lava samples, and measuring the temperature of hydrothermal vent fluid.

The collecting system is the most important part of the ROV. We spent lots of time on designing a 'catch and store' system. This system greatly increases the efficiency of ***Dolphin III***. Another important part for completing the mission is the temperature taking system. With a laser sight, we can insert the temperature sensor accurately. Our control box was diligently designed and was built into a little control station which includes all buttons, meters and monitor. Other important parts included the observing system and moving system. The components were well positioned and installed. This can help to make ***Dolphin III*** agile and sensitive.

This competition is really a great experience to us and has given us a great lesson. So, apart from introducing you our design, we are also going to share with you what we have learnt, and the challenge and trouble we faced in the past few months.

We have paid much effort in this competition and were doing our best. For further details of above content, please read through our report. I hope you can enjoy it.



(fig. 1)

Content

Design rationale

STRATEGY

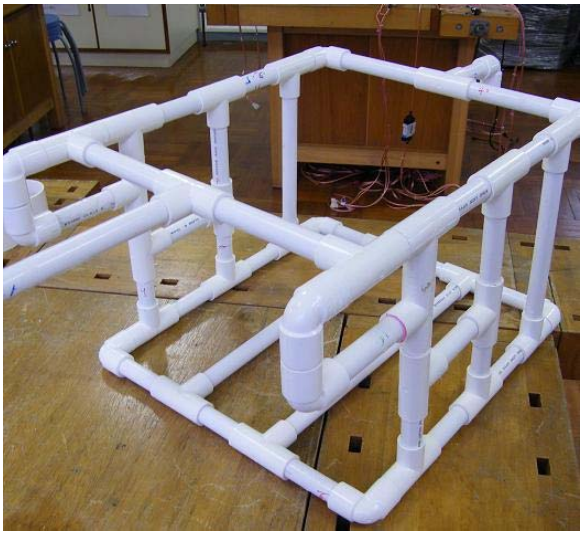
The time bonus is considered as a key factor for winning the competition. In order to finish the missions in a shorter time, we use a 'catch and store' design. Dolphin III can store collected object so all missions can be done with only a single trip to the bottom of the water tank. Time for going up and down can de saved.

The order of process of missions is:

1. Measure the temperature of hydrothermal vent fluid
2. Collect 3 samples of lava
3. Collect 3 vent crabs. Finally, Dolphin III returns to the poolside and the mission is over

I. Skeleton of Dolphin III (Frame)

The frame (fig. 2) of ***Dolphin III*** is constructed by 15mm PVC pipes, which are light in weight, strong, cheap and easy to make the frame into our ideal shape. The frame is in a box shape, which allows us to install other components of the ROV easily and increases the stability of Dolphin III. We jointed the pipes together by T and L shape joints with blind rivets to joint them together strongly.



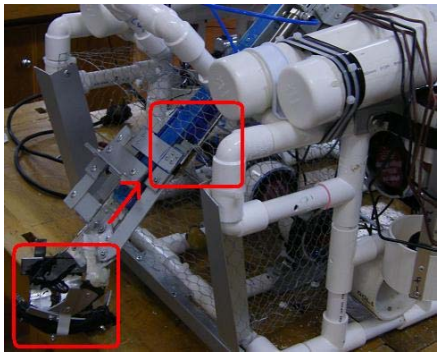
(fig. 2)

II. Collecting system

a. The beak (gripper)

The beak (fig. 3) of ***Dolphin III*** is made of flat bar and corner bar. A simple mechanic structure allows the gripper to be driven by a pen size cylinder directly. The arm of the gripper is pointing at about 45 degrees downward in order to collect both objects on the seafloor as well as from the black smoker. The arm of the gripper can extend and shorten (fig. 4) which this function is controlled by another cylinder. This function allows the gripper to drop the target object into the basket behind it.

(fig. 3)



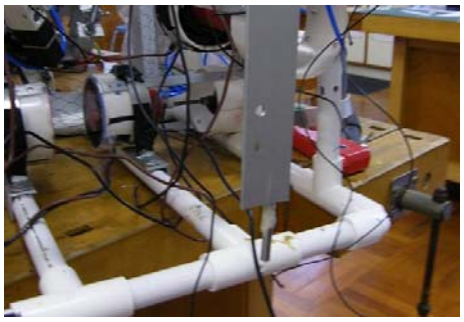
(fig. 4)

b. The stomach (Net)

The metal net used for storing collected objects is positioned behind the position of the gripper when the arm extend. When the arm shortens, the gripper moves upward and backward. Then drop the objects. The net enables ***Dolphin III*** to complete all missions swiftly with only a single trip to the bottom of the water tank.

III. The tail (Temperature measuring system)

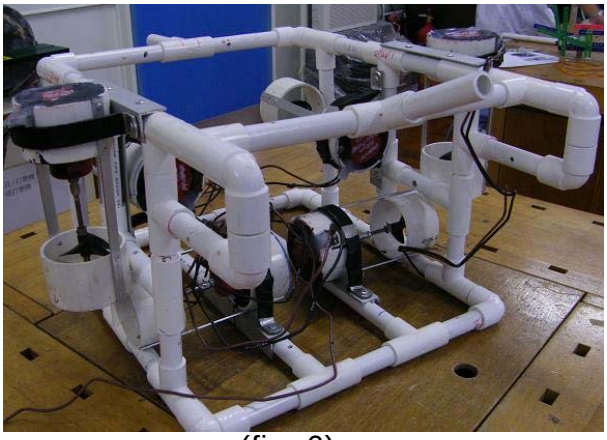
The temperature measuring system is located at the back of the ROV. Our concept is to insert the thermometer (fig. 5) into the vent flow to get the most accrete reading. The thermometer is extended out of the ROV by an L shape PVC pipe. The temperature sensor is located at the end of the pipe. A laser pointer is used to sight the target to lower the difficulty of inserting the thermometer into the vent flow.



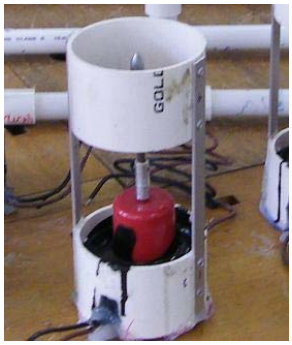
(fig. 5)

IV. The fins (Thrusters)

The ***Dolphin III*** has 6 motors (fig. 6) 2 for moving vertically, 2 for moving forward and backward, and 2 for shifting left and right). We used Rule 800gph (4,164 L/h) bilge pump motors (fig. 7) because they are waterproof and can provide sufficient thrust and with less amp drawn. We used 75mm propellers. The shaft is extended to prevent the motor from blocking the current, which greatly decreases the thrust. The thrusters are surrounded with 80mm PVC pipes in order to protect the propellers and natural surroundings from physical damages. It is very important for a ROV not to damage the habitat and marine creatures.



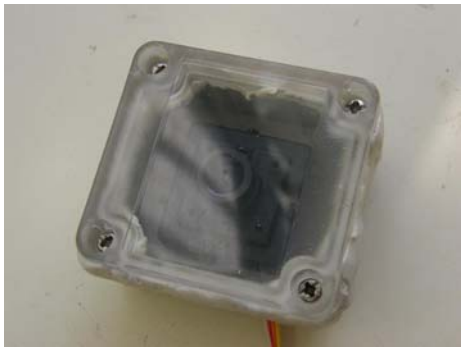
(fig. 6)



(fig. 7)

V. The eyes (Monitoring system)

There are 3 CCD cameras (fig.8) in our ROV, each of them for a specific duty. One is used for observing the front and it is positioned in the inner side of the ROV. The second one is set above the gripper, which is used for monitoring the collecting system. We can use this to identify the position of the target and whether our gripper is successful at the catches. The last one is at the back of the ROV, for observing the insertion of thermometer into the vent flow.



(fig. 8)

The CCD cameras are not factory waterproofed so we perform our own waterproof treatment. We put a camera in a plastic box and seal the container with epoxy. When they harden, the cameras are then waterproof.

VI. The life line (Tether)

The tether (fig. 9) of the ROV consists of 6 pairs of No.15 copper wire, an air tube, a 10-signal wire and 3 video cables. The tether is 20m long so that the ROV can move freely underwater. We attached 1 table tennis ball every 10cm to the tether to make it neutrally buoyant so the drag can be reduced.

(fig. 9)

VII. The swimming bladder (Buoyancy system)

The buoyancy of Dolphin III is slightly negative. The buoyancy of the ROV is adjusted by buoys constructed by 50mm PVC pipes. We made the buoys waterproof by sealing the two ends of the PVC pipes with caps and hot malt glue. The buoys are located on the upper tubes of the ROV. The floating buoyancy is evenly distributed. This makes the ROV more stable.

IIX. The brain (Control system)

The ROV is controlled through a control station (fig. 10). There are 7 buttons on the control panel. They are 4 on-off-on switches are for the motors, 3 on-off switches for 2 cylinders and 1 for the balloon and the pressure regulator for controlling the pressure of the air compressor. The monitors, amp meter, voltmeter, barometer are all installed in the control station. This design greatly shortens our set up time.

(fig. 10)

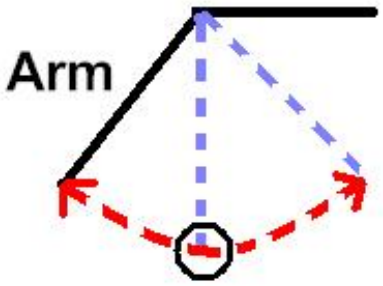
Troubleshooting techniques

I. Difficult pool testing arrangement

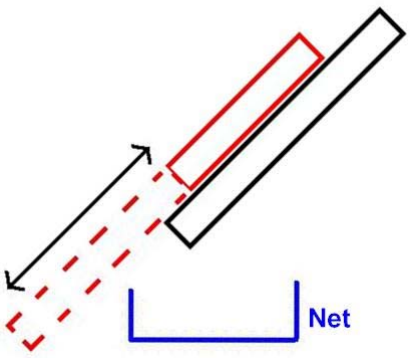
During the HK district competition, we used a small, self-built pool to test our ROV. However, the pool is too shallow about 1m deep. We can't test the buoyancy of ROV. So, we had to book a swimming pool. We found that the public swimming pool in Chai Wan is the closest to our school. As the pool is only available in a few certain dates, this resulted that we have to plan the test well and pack up all the things we need before time.

II. Gripper design

In order to improve the gripping system, we designed a new system in order to allow Dolphin III to store the collected object in his body. First, we try to let the arm of the gripper swing by using a design of a excavator's arm but there are a few problems. First of all, when the gripper swung out or swing in, the position of the gripper will be lower than the ground level (fig. 11). So every times we store an object, the ROV needs to moves upwards first. The space required for the motion is too large and will disturb the thrusters.



(fig. 11)



(fig. 12)

So, we came up with the third design. We installed the gripper laterally and allow its arm to shorten or lengthen by using a cylinder. As the arm is laterally installed, when it shortens, the gripper will move up and back (fig. 12). This allows the gripper to drop down the objects into the container.

III. Malfunctioning camera

This is a late-discovering problem. When we test our camera before attaching them onto ***Dolphin III***, we found them failing. This maybe due to the salt water remain in it after the Hoi Ha Wan Trip. We made a quick decision right after it. We decided to buy all the materials to make a new camera immediately. This also tells us that more professionally waterproofed cameras will be needed when a ROV go on a real mission.

Challenge

I. Transportation problem

The transportation of ROV, tools and belongings became a great challenge in both HK and USA. They are very bulky. In HK, whenever we have to transport them, we must spend about $100 to book a goods van. In USA, a friend of our teacher will help us to transport it from LA International Airport to San Diego.

II. Meeting arrangement

Other than putting emphasis in this competition, our members also have to do many other things, such as doing revision, attending tutorial class and joining sport competition. These always diversify our attention to the competition or made us unable to attend some of the meeting. We can hardly have all members present in a meeting.

III. Bent shaft

Another problem we faced was on the thruster. The shaft of the motor was very short .We had to extend the shaft in order to prevent the water current from being blocked by the motor. However, the shaft we used for the extension is difficult to buy. Though we got them, they would easily bend the original shaft of the motor. We had to try our best to straighten them and handle them with care.

Lessons learnt

I. Time arrangement

After learning not to waste our time in the HK competition, we found that this is not enough. Other than this, we also have to arrange our time very well because the yearly exam is approaching. On one hand, we have to build our ROV. On the other hand, the workload from the revision is heavy, especially after long working hours on the ROV. This is really a lesson which teaches us to revise everyday.

II. Work distribution

We learned the importance of work distribution among team members for efficient and effective work. One of the team members has good manipulation with tools, and most of the difficult soldering and wiring work was done by him. Another team member is good at bargaining and obtained good offers for our equipments bought in the different stores. Though, we thought we can have a more detail and elastic work distribution because we have noticed that some members may become idle in the workshop.

III. Life experience

We also learnt some new equipments and materials, such as the pneumatic system, epoxy (fig. 13) and blind rivets. Although they look simple, we rarely handled them. This is really a good experience. Also, we now know where to buy these kinds of materials in Mongkok and Sham Shui Po. This would surely help us in the future for building other robots.

(fig. 13)

Discussion for future improvements

I. More advanced control system

Because of the numerous buttons on the control box, the ROV must be controlled by at least two pilots. This greatly reduces the efficient and agility of the ROV. To improve, we can use a joystick and computer programs in the control system. This can make the control system more user friendly and increase the agility of the ROV.

II. Better monitoring system

There are a lot of blind spots in the monitoring system of ***Dolphin III***. When the ROV is blocked by something or cannot move, we may not know where the blockage is or even why. This makes it difficult to remove the obstacle and move on. We can overcome this problem by installing the cameras to robotic arms or makes them moveable. This greatly increases the monitoring angle of the cameras.

III. Thinner tether

In our design, we are using a "one-to-one" connection method to provide electricity to every thruster on the ROV. There are 6 thrusters in our ROV, which means that there are 6 pairs of 16 AWG speaker wire in the tether. This makes the tether very bulky. This adds a huge load to the ROV, which will lower its speed and agility. To improve, an electronic circuit which can control individual thrusters can be installed on the ROV. By doing so, only a pair of 20 meters electrical wire and several signal wires are required in the tether. The tether can thus become less bulky.

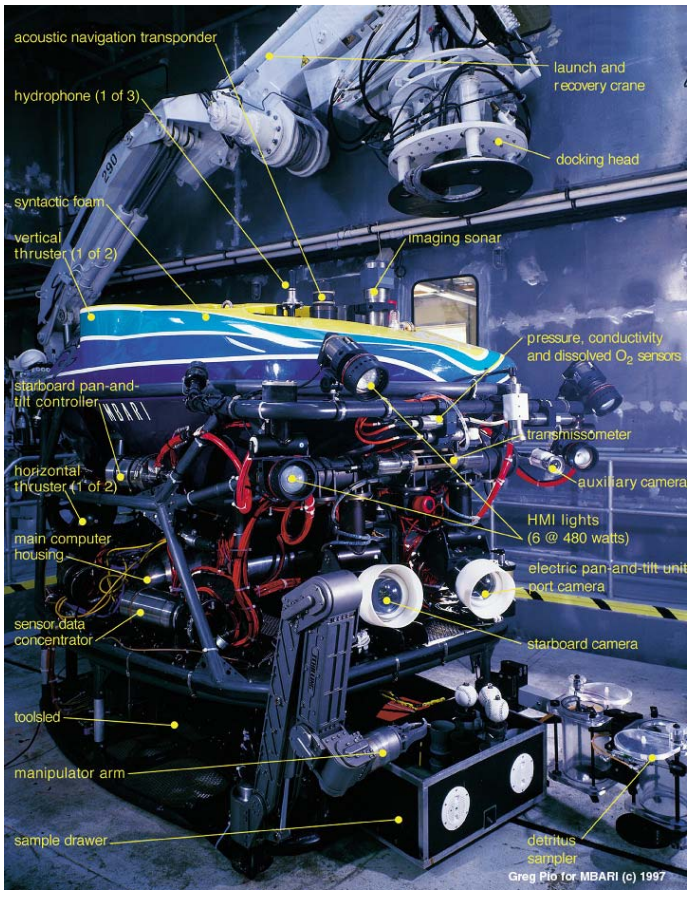
IV. Compass

A digital compass can help the pilot to know where the ROV is facing. When we do the missions, it is easy to lose the direction and go around especially during the return to the poolside. The compass can help the pilot find the target more quickly and thus the efficiency of the ROV can be increased.

Research done in Mid Ocean Ridge by ROV

ROVs are used extensively by the science community to study the ocean. A number of deep sea animals and plants have been discovered or studied in their natural environment through the use of ROVs. Many of these devices configured to work in the extreme environment of the deep ocean such as the mid ocean ridge.

A project done by **Monterey Bay Aquarium Research Institute** is to explore the explosive eruptions in mid-ocean Gorda ridge. Compositionally variable limu o Pele (lava bubble-wall fragments) occurs in widely distributed sediments collected by ROV ***Tiburon*** when it dives along the Gorda Ridge axis. The fragments were formed deeper than the critical depth of seawater so are unlikely to have been generated by supercritical expansion of seawater upon heating in contact with hot lava. Discharge of CO_2 through erupting lava is the most likely way to make such bubbles at higher than 298 bars pressure. The distribution and composition of limu o Pele fragments indicate that low-energy strombolian activity is a common,



ROV ***Tiburon***

although minor, component of eruptions along mid-ocean ridges. Combined dissolved and exsolved volatile contents of N-MORB from the Gorda Ridge with 12.8-15.6% spherical vesicles are about 0.78% CO_2 and 0.18 wt% H_2O and exceed estimates of primary CO_2 of only 0.07 to 0.095 wt% calculated from whole rock Nb concentrations. This discrepancy suggests that the magmas accumulated an exsolved volatile phase prior to eruption. The evidence that a separated volatile phase drives strombolian eruptions on the seafloor also implies that gas bubbles coalesce during storage or transport to the surface. The combination of large bubbles in otherwise dense magma suggests nearly complete coalescence of small bubbles and is most consistent with accumulation of the exsolved volatile phase, most likely near the tops of crustal magma chamber, prior to upward transport in shallow conduits to the eruptive vents on the seafloor. A portion of this CO_2-rich separated fluid phase is released in brief bursts during eruptions where it becomes part of event plumes.

limu o Pele

Reference: www.mbari.org/volcanism/Ridge/R-ExplosiveErupt.htm
en.wikipedia.org/wiki/ROV
www.mbari.org/volcanism/RovEquipment/gear.htm
www.mbari.org/volcanism/RovEquipment/tiburonLabeled.jpg

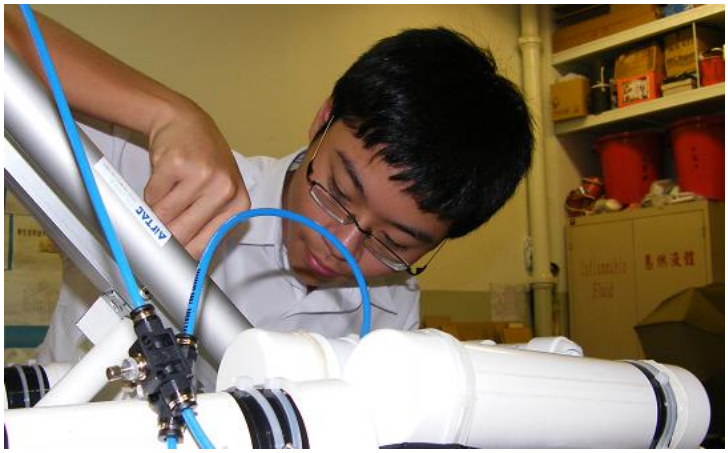
Reflection

Lee Ying Yin:

This is the first time that I join such an international competition. At first, I was a bit nervous because I though it would be much harder than the Hong Kong competition. But then, I realize if I do my job as well as I can, I will not regret. This competition also gives me a great experience. I am looking forward to the trip to San Diego. Here, I would also like to thank my teammates. They are really hard-working and we found that we can help each other very well. Lastly, I hope we can get a good result in the competition.

Li Tsz Yen:

This competition is really a memorable and rewarding experience to me. Joining an international competition is really treasured for a S4 student. It widens my eye and taught me a lot. In the competition, I found that a good management of the team members is extremely important. A good management and a detail planning a can greatly raise our productivity. Also, being the member for the thrusters, I learnt a lot about physics and raised my interest to physics. Although the preparing works are hard, I really enjoyed the competition.



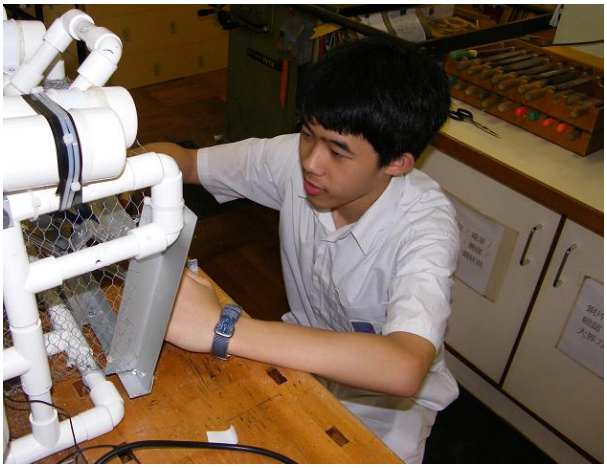
Chan Ka Chai:

In this ROV production, I leant much about the electric circuit. Compare with the first ROV we made, the remote control is more complicated, during the production, the wires always become a mess and I have to sort them. Besides the remote, I have to link the remote with the ROV and the linking process is quite difficult because the wire of the camera should be cut and join back together after putting the camera into a water prove container, the wires of the camera are so small that they seems to be easily broken but they are very short that I can't make any mistake or the whole wire will be written off. I think the robot arm is the most complicated part of our ROV, nearly all of the members took part in making the robot arm.

Yan Ho Ting:

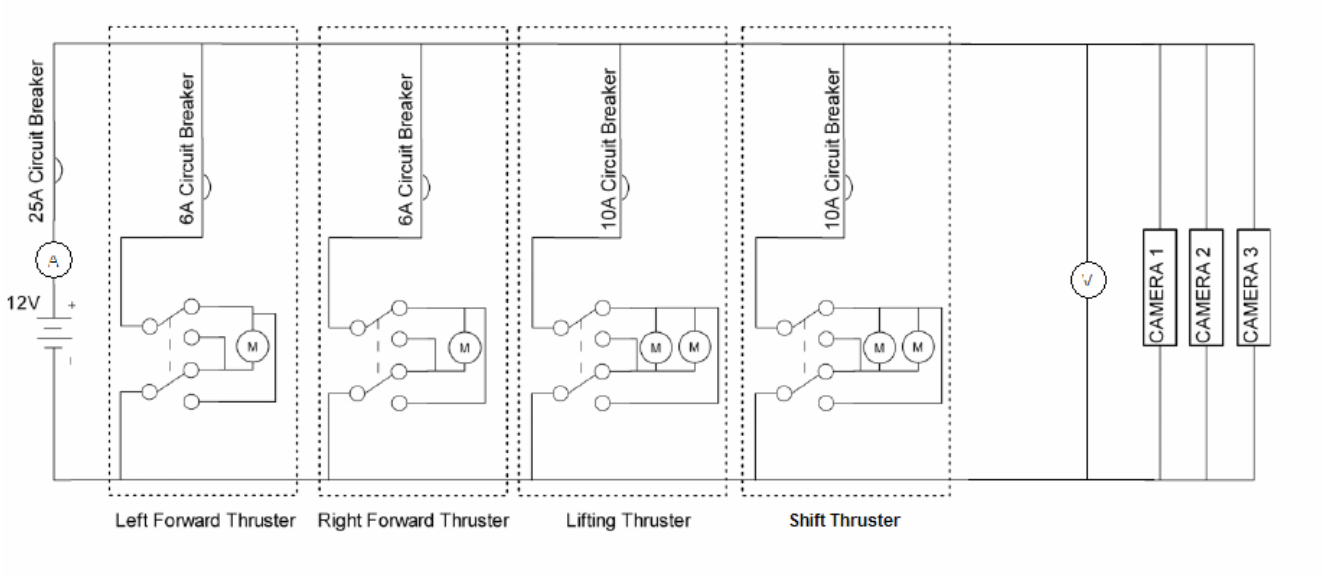
In this competition, I learnt how to think creatively. Before participle into this game, I can not think more than 2 methods to solve the problem I face and the process of creating the ROV give me a chance to try more, think more. The competition also improves my communication skills and good time management. I here thank all of my teammates, instructor and teachers for giving me such unforgettable lesson

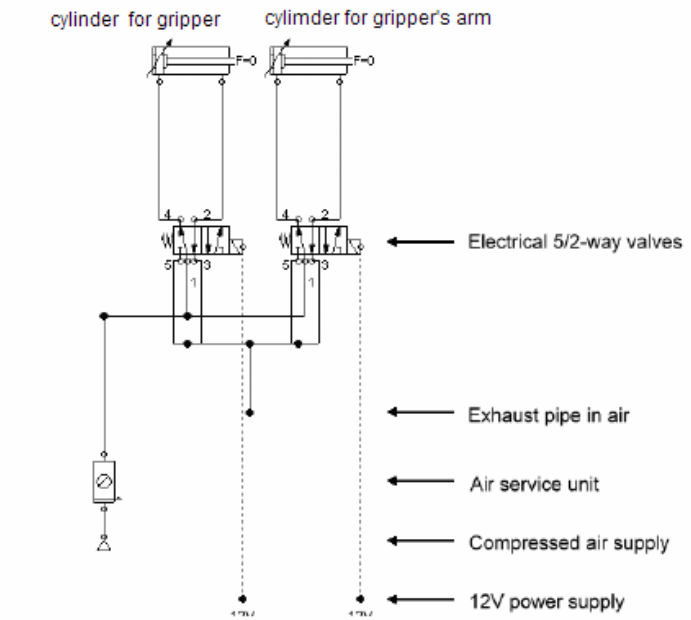
Li Ka Ho:



During the days of ROV making, I gain many valuable experiments that I could never get in normal school life. Because of participating in this competition, I have the chances to use the skills, which I have learnt, in school. In the past, I think that the things I have learnt are not so useful at all. Indeed, I study for examination only. However, joining the event changes my points of view. I soon realize that the knowledge I learnt especially in physics and chemistry are so fantastic and important. The theories in the textbooks no longer theories, it works out. It is very lucky for me to join the competition. It provides chances for me to do experiment on the theories and turn theories in reality. Although sometimes the work is quite hard for me, I enjoy solving them one by one by different techniques and new solutions. They give me the feeling of successful. I will surely treasure this experience as one of the biggest event in my life.

Electrical schematic





Budget sheet

Expense

1. ROV			
Item	Quantity	Unit Price(HKD)	Total(HKD)
15mm PVC pipes	10m	$12	$120
15mm PVC pipes T joints	20pc	$2	$40
15mm PVC pipes L joints	20pc	$2	$40
50mm PVC pipes	2m	$15	$30
50mm PVC pipe cap	15pc	$2	$30
90mm PVC pipes	1.5m	$18	$27
12mm Flat bar	1.5m	$12	$18
24mm Flat bar	2m	$15	$30
24mm Angle bar	2m	$18	$36
Rule Pump Bilge 800 GPH	6pc	$200	$1200
Extension shaft	6pc	$120	$720
Propeller	6pc	$38	$228
Epoxy	2pc	$150	$300
250mm Pneumatic cylinder	1pc	$150	$150
80mm Pneumatic cylinder	1pc	$120	$120
Air valves	3pc	$90	$270
Pneumatic speed controller	2pc	$60	$120
On-off-on Switch	4pc	$12	$48
On-off Switch	3pc	$12	$36
10A Circuit breaker	2pc	$15	$30
7A Circuit breaker	2pc	$15	$30
15 AWG speaker wire	120m	$9	$1080
10-Signal wire	20m	$8	$160
4mm Air pipe	20m	$3	$60
20m Video cable	3pc	$60	$180
CCD Camera	3pc	$200	$600
Camera base	3pc	$55	$165
Camera box	3pc	$25	$75
Electrical thermometer	1pc	$34	$34
Total			**$5868**

2. Travel	
Land traveling express	$6000
Air tickets	$45000
Accommodation	$12000
Food/beverage	$10000
Insurance + visa	$8000
Total	**$81000**

Funding

1. School fund raising	
Parent, schoolmate, staff	$31520
Parent Teacher Association	$20000
Alumni Association	$20000
WWF + City University	$15000
Total	$86520

Net balance

Expanse	$86868
Funding	$86520
Net balance	$348

Stages of work

6/4	End of HK regional contest
12/4	1st design meeting
14/4-18/4	frame
19/4	2nd design meeting
21/4-25/4	Thrusters
26/4	Collecting system design meeting
28/4-2/5	Collecting system and control system
5/5-9/5	Collecting system and control station
12/5-16/5	Collecting system and Monitoring system
19/5-23/5	Technical report and temperature measuring system
26/5-30/5	Technical report and ROV test
6/2-6/6	Technical report and ROV test
9/6-20/6	ROV test and packing
23/6	Leave HK

Acknowledgements

We would like to give thanks to all people, organizations and companies that have given us important advice and help in different aspects. Without their help, we cannot construct our excellent ROV. We would like to give thanks to the followings:

香港城市大學
City University of Hong Kong

MATE
MARINE ADVANCED TECHNOLOGY EDUCATION CENTER

WWF

AirTAC

The Knowledge Network
Institution of Engineering and Technology

PROFESSION MODEL

VINCIT VERITAS

&

SGSS graduate Mr. Donald Leung

DT teacher Mr. Lo

School workman Mr Ma