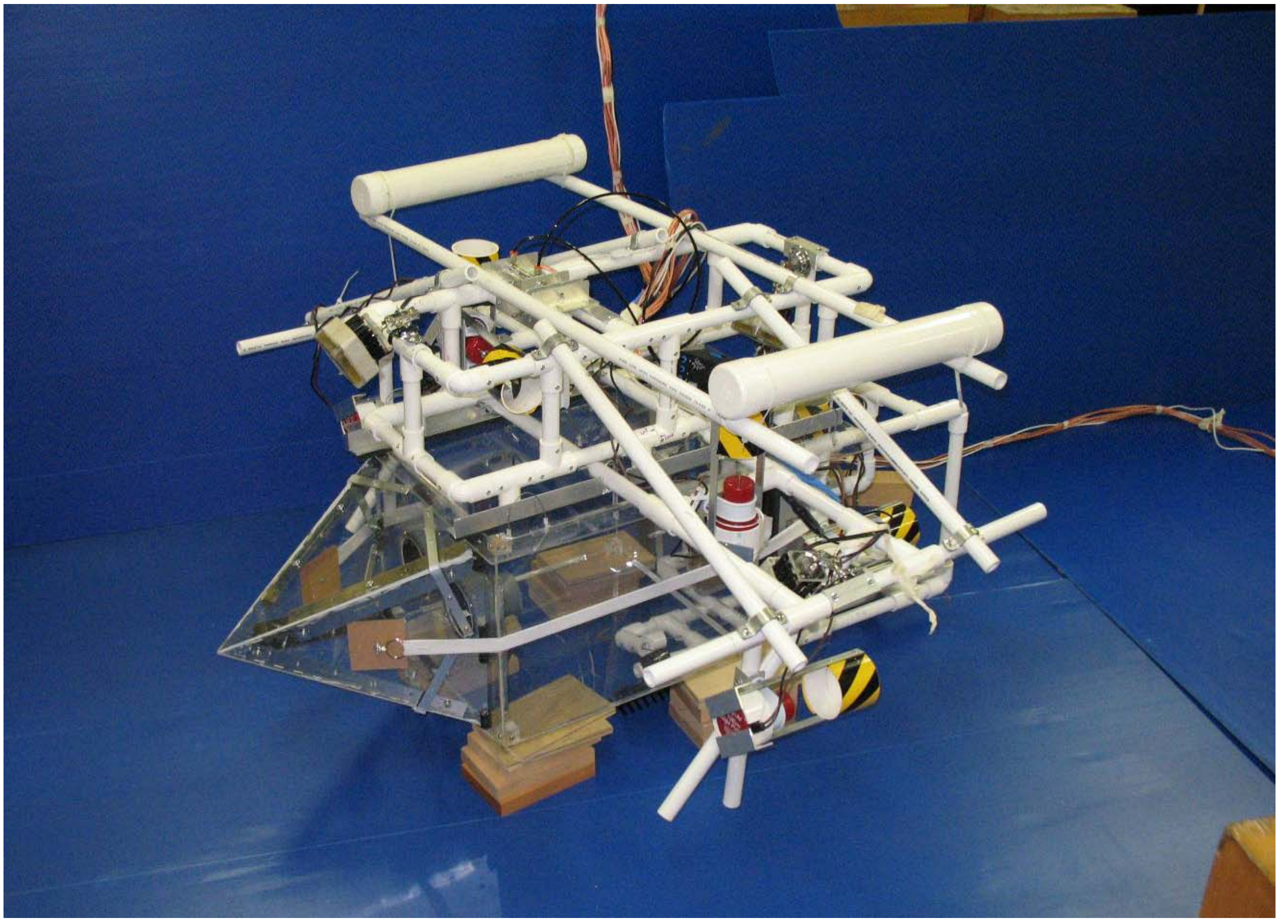
Shau Kei Wan Government Secondary School
Design and Technology Club

Dolphins



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Abstract

Dolphins is the team representing HONG KONG in the international ROV competition which is held by MATE at Johnson Space Center's Neutral Buoyancy Laboratory in Houston, the USA. As this is the first time for Hong Kong students to take part in this competition, everything is new, but delightful for us. The team did everything to get well-prepared. To finish the missions as fast as possible, two ROVs are prepared and will work together simultaneously during the competition. Both of them possess specially designed features so that they are capable of operating at water depth of 5 metres with the modifications made on the cameras. The cameras are modified so that they are water proof and can withstand a high water pressure. The cameras are set at different angles to provide a three dimensional view. Thrusters are precisely positioned so that shifting, turning actions can be achieved. Both the ROVs are highly manoeuvrable with the carefully positioned cameras and thrusters. They are able to complete all the tasks. The larger one is the module carrier which carries the module with a rubber band which can be loosened by a pneumatic system. While the smaller ROV pulls the key and opens the door of the frame with a row of hooks of suitable size.

We present all details of our ROV, including the ideas of designing the ROV, the process of making ROV and our reflection, in this technical report.

Design Rationale

A) <u>STRATEGY:</u>

The time bonus is considered as a key factor for winning the competition. In order to finish all the missions in the shortest time, we designed two ROVs for the missions. The larger one, the module carrier, is mainly responsible for carrying the electronics module. The other one has to remove the release loop, open the door of the frame, retrieve and insert the cable.

The electronics module is first fixed on the module carrier. Then, a pyramid, made of acrylic sheets, will be placed at the front and the small ROV will be placed at the back of the module. These three components are combined together with two rubber bands which can be loosened by a pneumatic system on the small ROV later on. To speed up the ROVs, four thrusters (two on the module carrier and two on the small ROV) are switched on at the same time to produce the greatest forward thrust.

When the combined ROVs get near to trawl-resistant frame, the rubber band is released by the pneumatic system, and the three parts separate. The pyramid made of inert materials is left behind in the water. The module carrier starts to place the electronics module in the right position carefully. At the same time, the small ROV removes the release loop, retrieves the cable, open the door of the frame and finally, inserts the cable into the appropriate hole.
The module carrier will finish the task earlier and will return to the water surface. After finishing all its missions, the small ROV will go back the pool side. The mission is over.

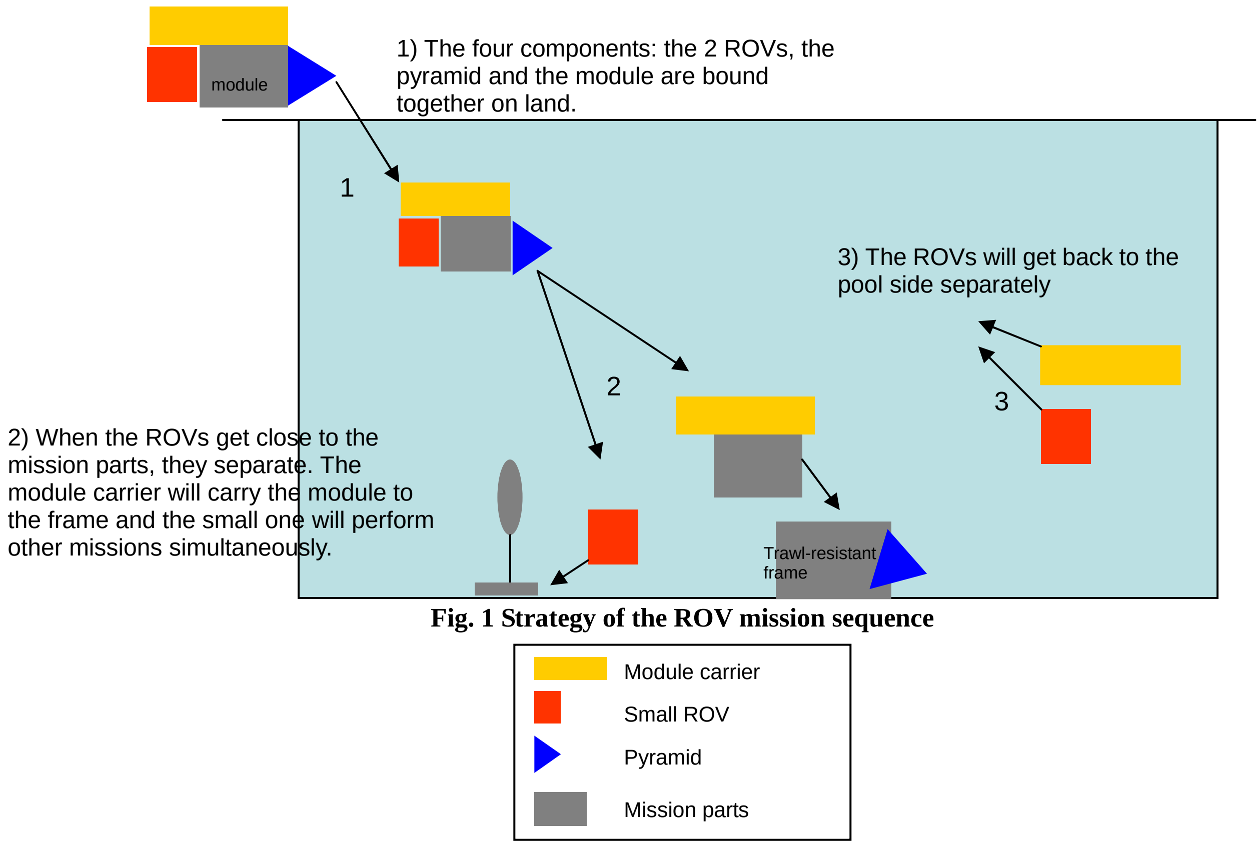


Fig. 1 Strategy of the ROV mission sequence

B) THE DESIGN OF EACH ROV TO SOLVE THE PROBLEMS OF THE MISSIONS

1)Module carrier

i) Specifications:

No. of thrusters:	5
Properties of Thrusters:	4164 LPH Bilge Pump with 2 blades propeller of 80 mm pitch, 57mm diameter
No. of cameras used:	3
Properties of cameras:	420lines, 1LUX
Electrical Wires used:	16AWG
Length of the tether:	20 m
Weight in air:	3.2kg
Dimension (height x width x length):	0.18m x 1.06m x 0.66m

ii) Role of module carrier:

The module carrier is responsible for carrying the module to the trawl-resistant frame and placing it in the frame. There is a pneumatic system in the module carrier for releasing the module. A strong rubber band is used to hold the u-bolt at the centre of the module and is loosen by the action of a pneumatic cylinder, the module can then be released.

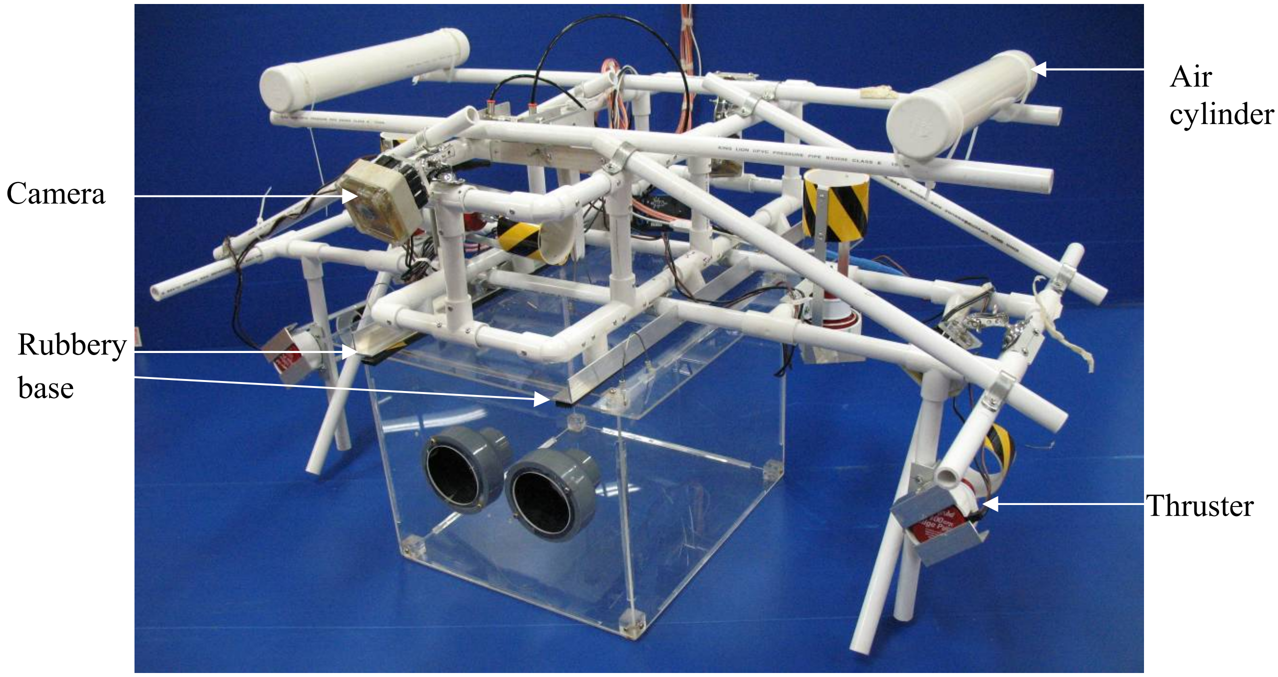


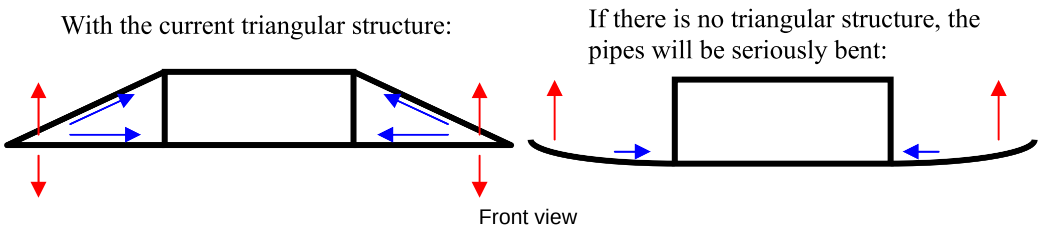
Photo 1 Main ROV design

iii) Structural properties of ROV on module carrying:

To hold the module stably, there are two parallel and strong aluminium strips with a rubbery side facing down at the bottom of the ROV. When the u bolt at the centre is held tightly by the rubber band on the ROV, the module is pressed against the rubbery base of the ROV. The force provided by the rubber band is evenly distributed and the rubbery base provides a large frictional force to make the module stable. The rubber band provides a large force so that the friction between base and the module can be larger. This is shown by the equation $F = \mu R$.. The length of the rubber band was calculated after several experiments to find out its elastic constant, by $F = ke$.

The design of the structure of the ROV also enables the motor to exert their thrust fully on the ROV. (Figure 2.) .There are two thrusters on each side of the ROV for the up and down thrust. The structure is strong as it is of simple triangular and rectangular shape. The transmission of force is made efficient

Photo 2. Front view of the main structure of the module carrier



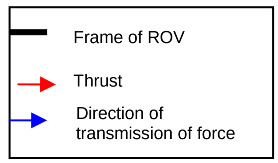


Fig. 2 Showing the action of the triangular structure

iv) Position of thrusters:

To maintain accuracy and stability of movement, two motors in the ROV for up and down movement are employed, one at each side of the ROV. This is to provide a balanced, symmetrical force across the centre of gravity (CG) of the ROV.

Both upward thrusters are connected to the one switch instead of two to increase manoeuvrability. They are placed at a distance from the body of the ROV to prevent its thrust from being blocked by the module. The thrusters for forward and backward movement are positioned as far as possible from the body of the ROV so that the greatest possible moment is generated by them to turn the ROV. Also, a thruster is positioned horizontally on the middle line of the ROV for shifting.

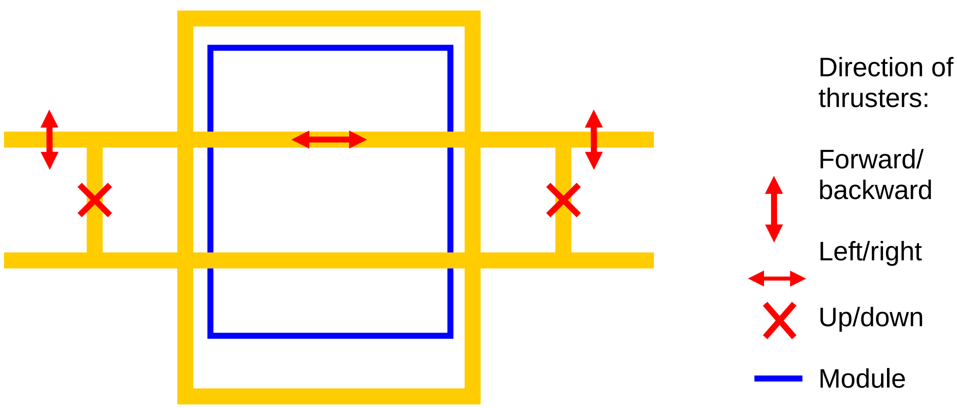


Fig 3 : The positions of thrusters in module carrier (top view)

Moreover, thrusters are positioned close to the bottom so the distance between the CG and the floatation is maximized to increase the stability of the ROV.

v) Position of the module:

The module is placed under the ROV such that the CG of the combined unit are vertically in line. The ROV can then turn about the CG. an the moment can then be maximized. The module is also between the two forward and backward thrusters for better differential drive.

vi) Rationale on module releasing:

To free the module from the rubber band, a pneumatic system (Photo 3) is used as it is very reliable when compared with geared motor which may be burned or blocked. Another big advantage is that it does not draw any current from the 12V, 25A power supply. More power can be reserved for the thrusters. An air compressor which has a maximum pressure of 60PSI is used. Electric valves are employed to control the action of the pneumatic cylinder as they give nearly no time lag when it is switched on and turned off. If manual valves are used, there is a long time lag of about 2.5 second for pressure to build up in the long 20 meter air pipe. Only one u-bolt is held so that the module can be released more easily and the chance of occurrence of errors reduces.

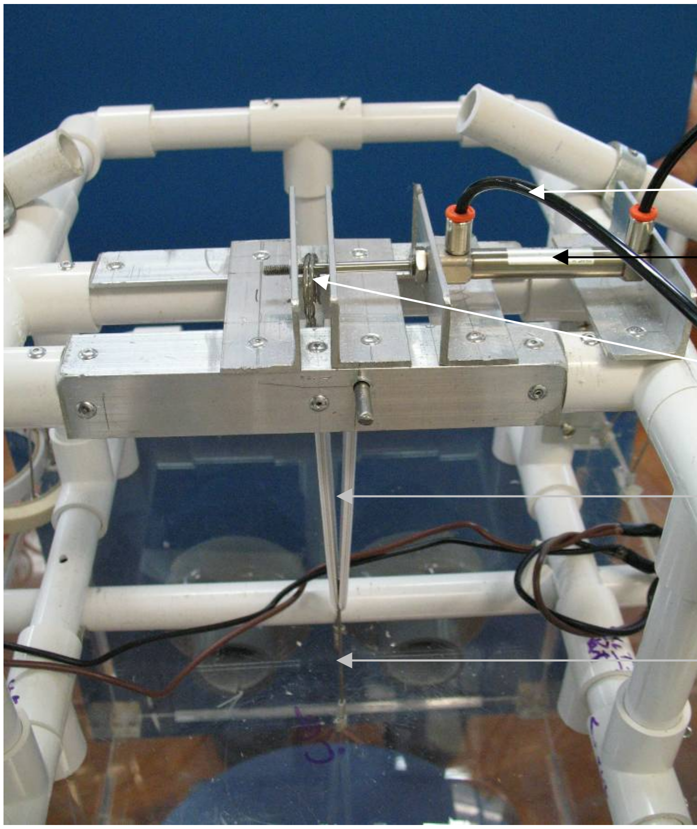


Photo 3 The pneumatic cylinder in the Module carrier for releasing module

IMPROVEMENTS MADE ON ROV COMPARED TO THE HONG KONG REGIONAL COMPETITION

In the former ROV, geared motors were used to release the rubber band. It was not reliable as the motor burned easily. So instead of a motor , a pneumatic system is employed in our new ROVs

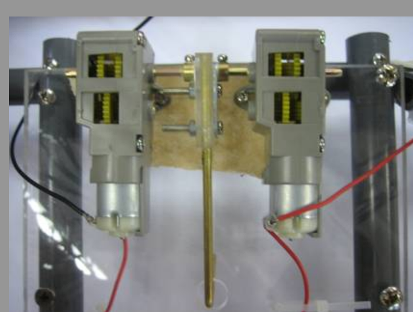


Photo 4: Motor system for releasing rubber band in the former ROV

vii) Buoyancy:

When the module carrier is built, we decided to install two floating pipes on it with the similar length as the body. Using two long pipes for floatation makes the ROV more stable as the upward force is evenly distributed over the body. We put the whole ROV into the water and used a spring balance to measure its weight in water after all the air inside it had come out. We found that it weighed 3.0 kg. so we decided to have 2 cylinders with a total volume of $0.0032m^3$ to provide extra floatation. Each cylinder is 0.6m long, which is slightly shorter than its body length. Each cylinder is has a volume of $0.0032m^3 \times 0.5=0.0016m^3$. The cross-sectional area = volume/height $=0.0016m^3/0.6m=32.4cm^2$. By $A=\pi r^2$, r=0.0319m (3.19cm). So, we bought PVC pipe of diameter of about 0.064 m. Lastly, we put the module carrier with the floatation system installed into water, and we added some mass on it until it is naturally buoyant.

2) Small ROV

i) Specification:

No. of thrusters:	4
Properties of Thrusters:	4164 LPH Bilge Pump with 2 blades propellers of 80 mm pitch, 57 mm diameter
No. of cameras used:	3
Properties of cameras:	420lines, 1LUX
Electrical Wires used:	16AWG
Length of the tether:	20 m
Weight in air:	1.5kg
Dimension (height x width x length):	0.32m x0.33m x 0.41m

ii) Role of the small ROV in the mission:

After the separation of the pyramid, the module carrier and the small ROV, the small ROV will:

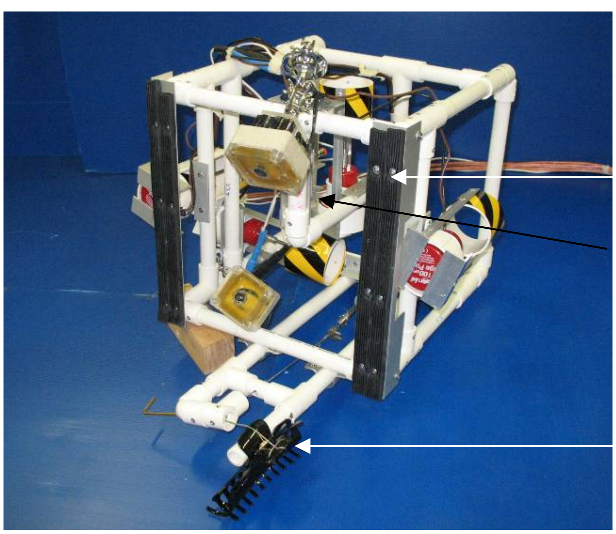
-Locate, attach and remove the acoustic transponder's release loop

-Retrieve the submarine power/communication cable connector from the seafloor

-Open the door of the trawl-resistant frame adjacent to the submarine cable, and

-Insert the power/communication connector into the appropriately labelled open port on the electronics module

This schedule is specially planned so that the small ROV would be able to finish all its task within the shortest period of time.



Rubbery surface

Pneumatic system for releasing pyramid

Hooks and clamp

Photo 5: Small ROV

iii) Properties of the Small ROV:

a) The hooks

There are hooks to attach and remove the release loop. The hooks are designed to be inserted into the release loop and pulled. There are multiple hooks in order to make inserting hooks easier. (Photo 6)

b) Pneumatic Clamp

To retrieve the submarine power/communication cable connector, a pneumatic clamp is used in order to hold the cable firmly. A pneumatic cylinder (Photo 6) instead of motor is used as the cylinder gives a larger force than motor does, and the motor spends more time on opening a clamp than cylinder does. In this system, when the cylinder is shortened, the clamp is opened. When the cylinder extends, the clamp is closed. The cable can be picked up and released easily by this system. We use a pneumatic cylinder with 0.027m diameter, which is quite large, to provide a large force to open the clamp. For the clamp, we have chosen one which fits the cable perfectly. (Photo 7).

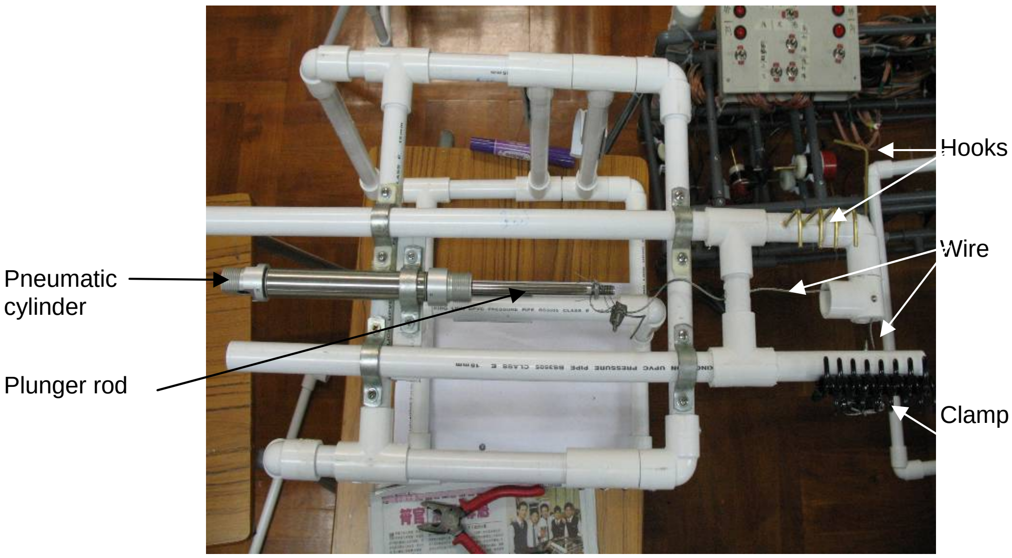


Photo 6: The pneumatic system and hooks on the small ROV (bottom)

Photo 7: Close up of the clamp on the small ROV for clamping cable

IMPROVEMENTS MADE ON ROV COMPARED TO THE HONG KONG REGIONAL COMPETITION

In the former ROV, hooks were used to hold the cable(Photo 8), which is not reliable, as the cable fluctuates a lot when the ROV moved. So we employed a pneumatic system (Photo 9) to clamp the cable in the new ROV which makes the transporting and inserting of the cable much easier.

Photo 8: The hooks on the former ROV

Electric valves are employed as they give nearly no time lag when it is switched on or off. When manual valves are used, there is a long time lag for pressure to build up in the long air pipe. Also, the cylinder will extend slowly and the impact is greatly reduced.
The air compressor we used for the pneumatics gives a pressure of a maximum of 60PSI, which is legal under the contest rules.

Photo 9: Air compressor

c) Release of Pyramid

When the trawl-resistant frame is reached, the ROVs will separate from each other. This is triggered by the small ROV with a pneumatic cylinder. Normally, the pneumatic cylinder is extended to hold the 2 rubber bands, so the pyramid and the small ROV will be fixed on the module tightly. When we release, the cylinder is shortened and the 2 rubber bands are released. The small ROV is then freed from the module.

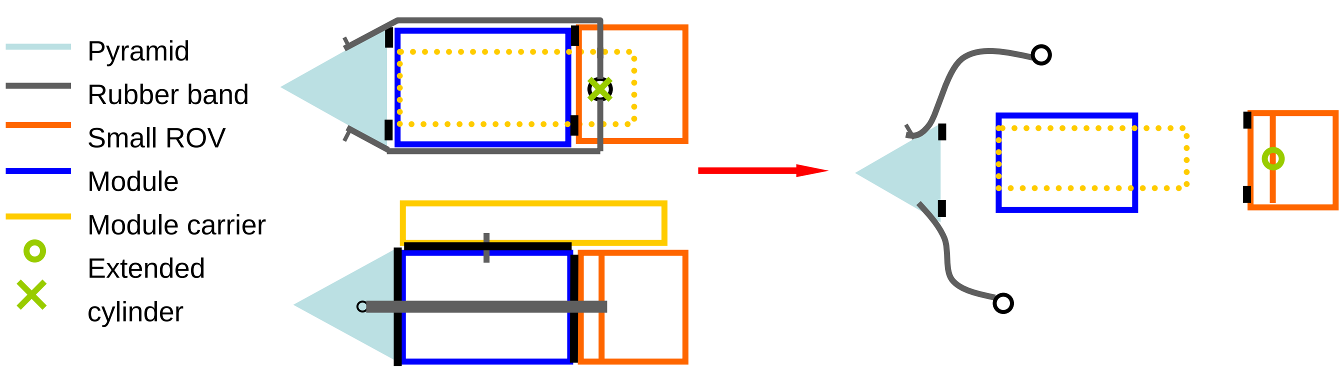


Fig 4: The release of the pyramid

d) Position of thrusters

The position of the thrusters are carefully planned in order to provide the ROV the greatest stability and manoeuvrability. The two forward motors are set on the left and the right of the ROV, and this enables a differential drive control. As motors are the most massive component of the ROV, they are put as low as possible. This maximizes the distance between the weight and the floatation. Also, there is a thruster which is placed horizontally to enable the ROV to have a lateral movement.

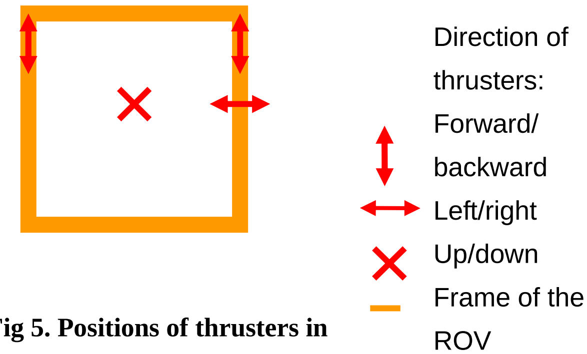


Fig 5. Positions of thrusters in small ROV

e) Floatation of the small ROV

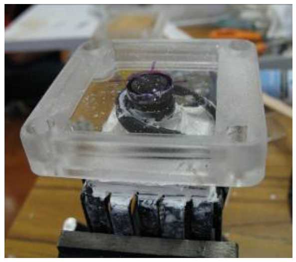
After having the small ROV built, we had to decide volume of the floating pipe to be installed on the small ROV. To decide its size, we put the whole ROV into the water and shook it slightly to prevent air being trapped in the ROV. Then, we used a spring balance to measure its weight in water. We found that it weighed 1.5kg. In order to have a little excess floatation, we decide to have two cylinders with a total volume of $0.00175m^3$. In order to fit the 2 cylinders into the small ROV properly, each cylinder is 0.27m long. Each cylinder is of volume of $0.00175m^3$ x $0.5=0.000875m^3$. Cross-sectional area=volume/height = 0.000875 $m^3/0.27m=0.00324m^2$. By $A=\pi r^2$, r=0.032m (3.211cm). So, we used a PVC pipe of a diameter about 6.4cm diameter. Lastly, we put the small ROV with the floatation installed into water, and added mass on it until it is neutrally buoyant.

C) COMMON PROPERTIES IN BOTH ROVS:

1) Visual:

CCD cameras were employed in our ROVs to provide a high image quality (420 lines, 1 LUX). However, they consume a lot of power (P=VI=400mA x 12V=2.8W). A considerably large amount of heat is produced by the cameras and trapped in the poor heat-conducting potting epoxy. To enable the cameras to perform well even for long operation time, heat sinks and heat transferring compound are added to the cameras. They provide a good conductive medium and large surface area for the conduction of heat away form the cameras. The heat sink conducts electricity, so there should be no direct contact between it and the circuit board of the camera. To ensure a good contact, non-silicon heat-transferring compound is sandwiched between them. Heat produced by the camera can then be effectively conducted away. (Photos 10 -12)

After applying heat transferring compound between the heat sink and the camera, potting epoxy is used to fill the modified boxes with cameras carefully fixed inside. Even under very deep water, the box will not be compressed and deform, and give an excellent protection to the cameras against high water pressure as it is compensated with potting epoxy. Stands which can be freely rotated to set the cameras to desired angles were employed. They are bridged to the camera by a carefully positioned thick acrylic board.

Photos 10 and 11: Procedure on modifying cameras

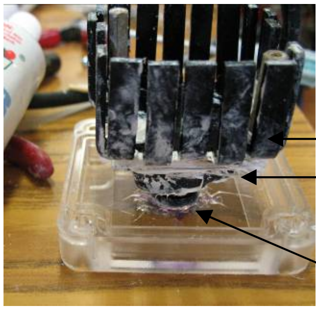


Photo 12: camera heat transmitting components

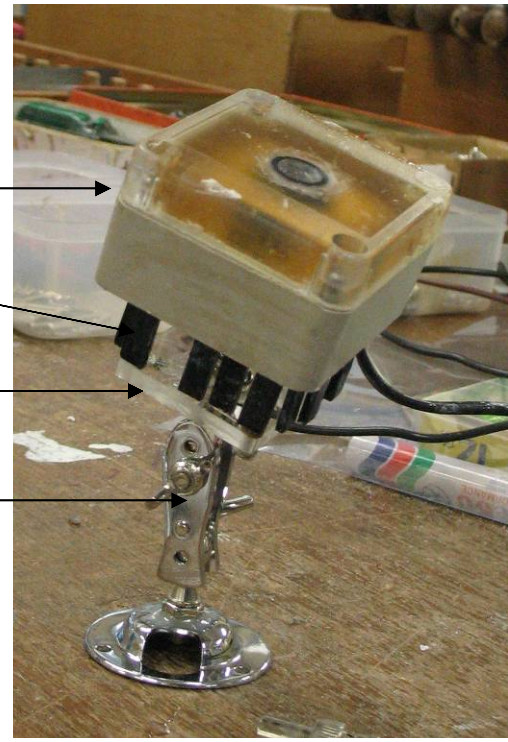


Photo 13 : modified camera

IMPROVEMENTS MADE ON ROV COMPARED TO THE HONG KONG REGIONAL COMPETITION
The cameras in the former ROV(Photo 14) are incapable of withstanding a high water pressure. The water resistant box was filled with air instead of potting epoxy we now employ in our new ROVs (Photo15). Gas (air) is compressible so that if the ROV operates in deeper water, the high water pressure will compress the air inside the camera box and the box will deform. The camera inside is damaged.

Photo 14: Camera in the former ROV

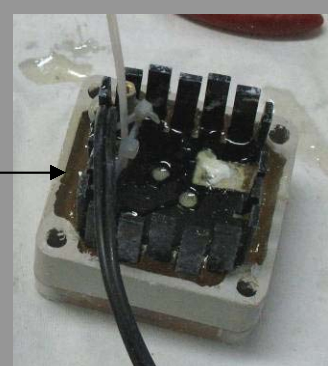


Photo15: Camera in the new ROV with potting

In addition, there are totally six carefully positioned cameras (three on each ROV) and three monitors. The controllers are able to view from different angles at the same time, to obtain a 3 dimensional picture. The manoeuvrability greatly increases.

2) Control boxes

Each motor draws about 5A when operating in water. A maximum of two motors are switched on for each ROV at the same time so that the maximum current drawn by the motors is only 20A. The circuits in the control boxes are all parallel (Photo 16) to reduce the current through each wire as a safety measure. It also reduces the power loss in the wires in the control boxes. Switches and sockets with high current rating are chosen to withstand the high current.

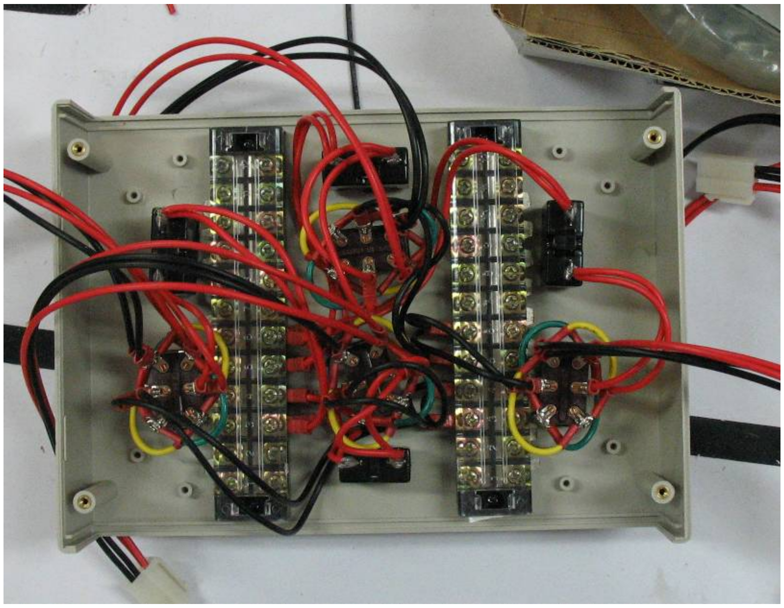


Photo 16: control box

3) Thrusters:

Each thrusters was modified to give maximum thrust. The distance between the body of the motor and the propeller was increased by fixing a stainless steel rod between them. This modification doubles both the forward and backward thrust as water current flows more smoothly. A pointed copper fitting is added to reduce the water resistance. Protector with warning labels is also added to make the operation safer.
As chlorinated water is conducting, we have to insulate the junction between the thrusters and the tether wire from water, epoxy was first applied to the junctions. The junctions are then sealed by heat shrink tube and the epoxy was allowed to dry. The completely sealed junctions give no chance for short circuit at all.

IMPROVEMENTS MADE ON ROV COMPARED TO THE HONG KONG REGIONAL COMPETITION
The motors of the former ROV were also modified such that the distance between the propellers and the motor is increased (Photo 17) However, the fixing method was not strong enough. We used epoxy to fix the lengthening rod in the former one. We improved it by using screws which is much stronger and reduces the trembling of the propeller. (Photo 18)

Photo 17: Former thrusters

Photo18, 19: New thrusters

4) Pipe parts

Each T-shape pipe parts were modified by drilling through the top to increase the diameter so that the PVC tube can go straight through the pipe parts. There are a few big advantages in doing so: the ROV is structurally stronger; the dimensions are much more accurate with fewer errors on junction points; the positions of the pipe parts along the tube are more easily changed and finely adjusted.

5) Tether wire

i) Buoyancy

Air pipes were used to greatly reduce the water resistance on the tether. This minimizes the drag as the tether wire is made more stream-lined and the cross sectional area is greatly reduced. The most suitable thickness of the air pipe was found by calculation to save time and money on trial-and-error. The tether wires were firstly weighed in water with spring balances. The weight on the wires in water is found to be 0.143kg per metre.

Assuming 0.1 litre water weighs 0.1kg and equivalent to $0.0001m^3$ in volume, the volume of the pipe used to buoy the wire would be $0.000143m^3$ per metre. $V = \pi r^2 L$, r = 0.0067m (diameter of pipe =0.013 m)
We chose a pipe with the diameter of 0.015m, to make the wire slightly positively buoyant and the buoyancy is then finely adjusted by adding small standard masses.

IMPROVEMENTS MADE ON ROV COMPARED TO THE HONG KONG REGIONAL COMPETITION
Floating elements *(photo 13)* were use for the buoyancy of the tether wire in the former ROV. They produce great drag and lower the speed of the ROV. We improved it by using air pipe to reduce water resistance to the tether wire.

Photo20: Floating elements in the old ROV

ii) Tether Management

The tethers used in the ROVs are very long and bulky. If we don't manage to get them tidy, the tethers may be twisted and cause trouble while operating the ROVs. We designed a stand which allows us to wind up the tethers on it easily.
The way we achieve this is coiling the tether in an "8" shape so that they look tidy and can be easily loosen without twisting. The wires can be pulled out straight.
The whole stand is made of plastic pipe. It is designed in a way that resists bending, thus it can hold the bulky tethers.

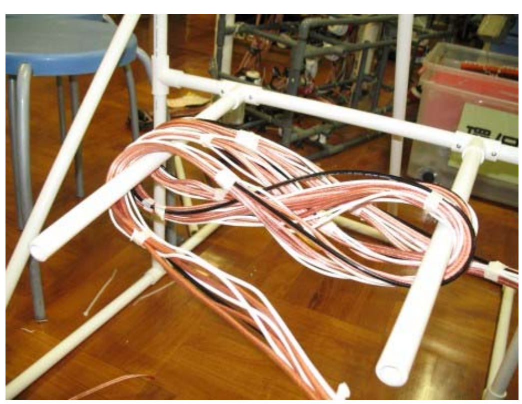


Photo21: Tether Management Stand

Electrical Schematics:

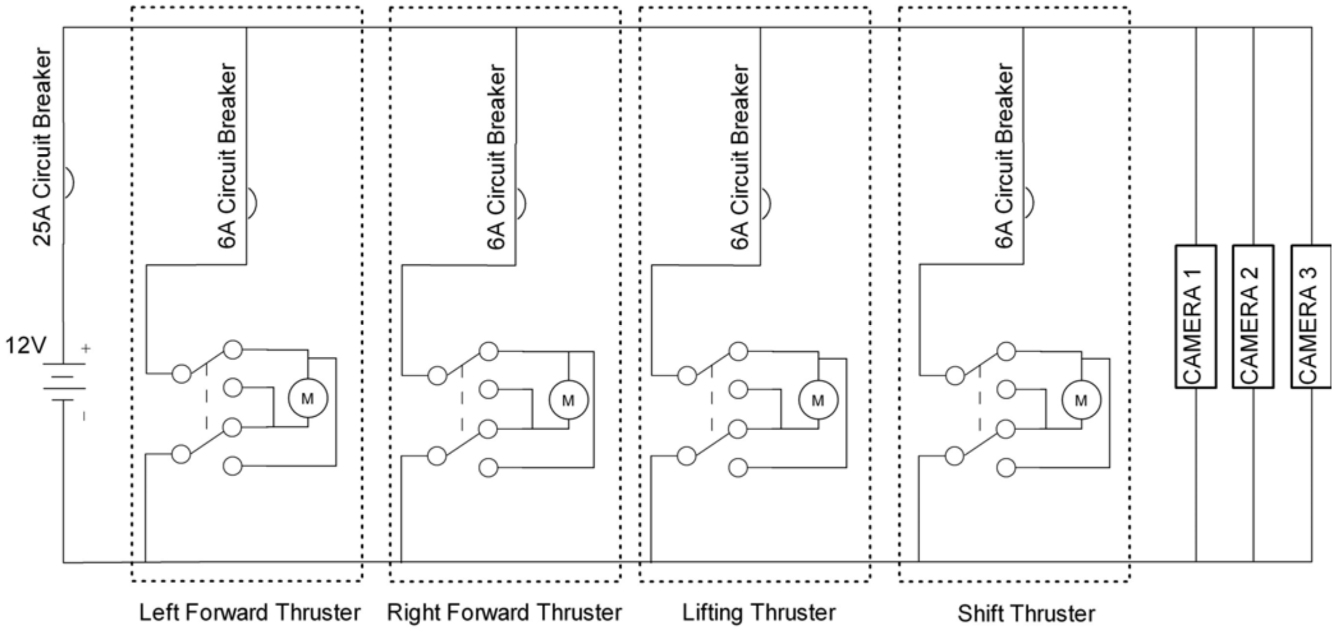


Fig 6 Electrical schematics of the small ROV

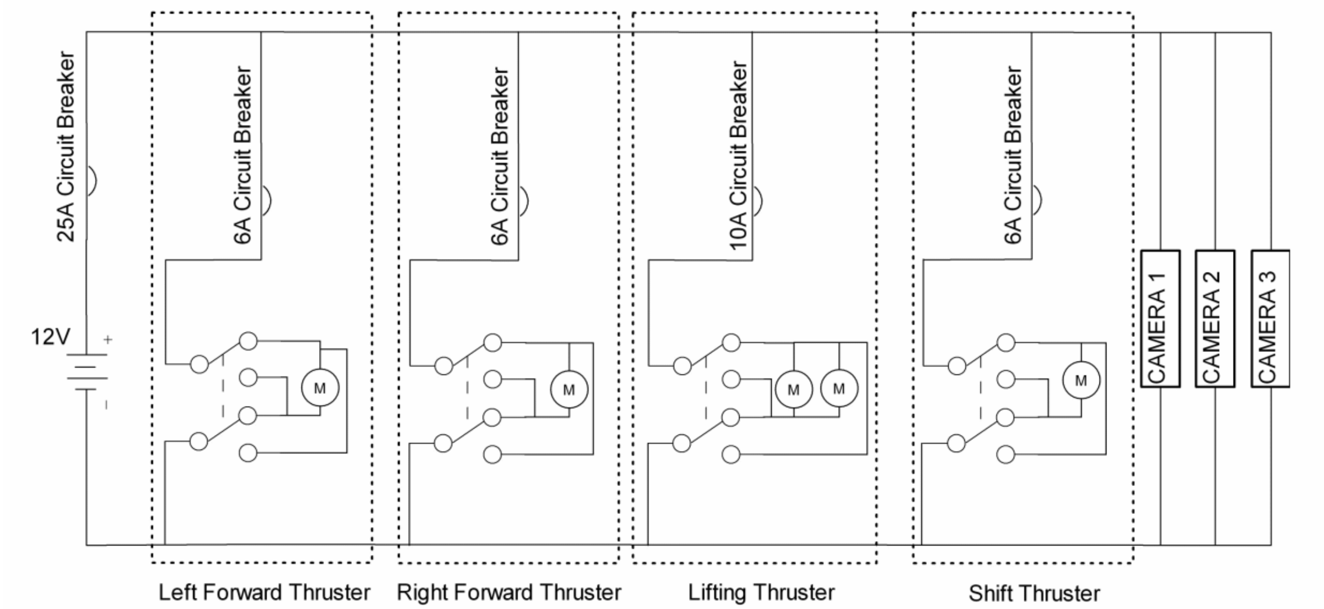


Fig 7 Electrical schematics for the module carrier

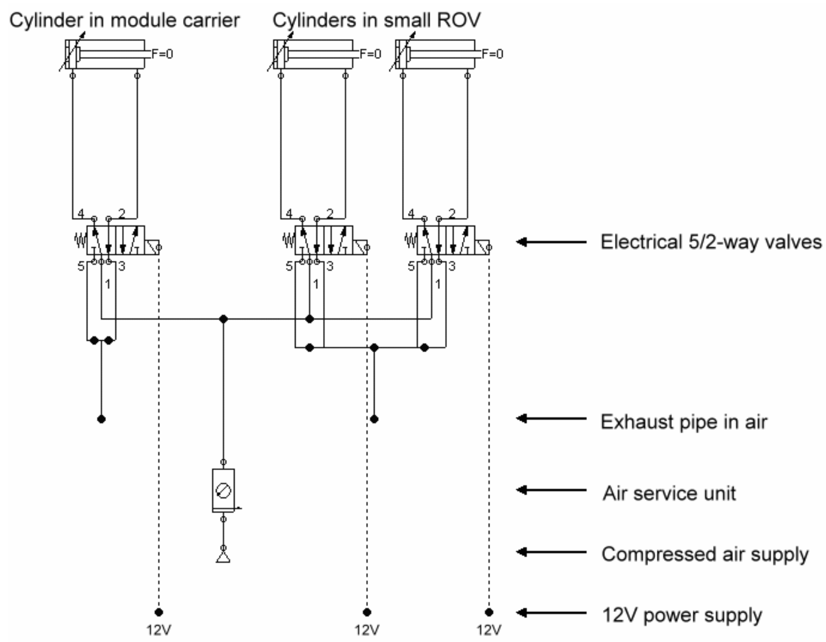


Fig8 Pneumatic systems schematics

D) OTHER SPECIAL DESIGNS:

i) Monitors

There are totally three monitors for the controllers. They can be switched to any of the six cameras on the ROVs. The controllers can view at different angles at the same time to have a three dimensional picture. The manoeuvrability greatly increases.

ii) Voltmeter and ammeter and circuit breaker

An ammeter and a voltmeter were installed in the control boxes. The ammeter enables the two controllers to monitor the total current consumptions and the voltmeter shows if the battery is fully charged or not. A 25A circuit breaker was also installed to protect the circuit. The voltmeter, ammeter and a 25A circuit breaker are held in a box such that the controller can refer to the readings easily.

Trouble Shooting Techniques

This is the first time for Hong Kong students to take part in this competition. Lacking experience is also a problem to us. We don’t have much help on the competition, nobody can share experience with us. It is also not easy for us to find industrial materials, like potting epoxy. How do we solve the problem? We ordered the potting epoxy in the internet, and we ordered the pneumatic cylinders from Japan by the help of a shop.

As the USA is thousands of miles away from Hong Kong, we have to take planes to the USA. The shipping of the ROVs will be a big problem. Hiring logistic companies like DHL or UPS are expensive and we are lacking funds. So we decided to bring them with us. But before that we need to break up our ROVs in smaller parts, mark the numbers on each pipe and then packed them well. We shall handle the boxes with great care; otherwise, something may be broken inside the boxes. We decided to arrive at the USA two days before the competition to reassembly the ROVs. The need for disassembling also dictated the overall design of the ROVs. Also we need to bring a transformer to the USA in order to step down the voltage because of the difference in the mains voltage between the USA and Hong Kong.

Challenges:

One of the problems we faced was lack of time. We won the competition in early April, although it seemed that there was enough time for us to prepare well for the US international competition which is to be held in late June. But because the whole team is going to have school examine in July and will sit in a public examination in the coming year, we have had face to loads of schoolwork at the same time. We can only spend after-school hours at the school to make the ROV. What we do to deal with this is to study till late night and to seize every minute in the school to make the ROV, including break and lunch hour. Although we all face such great stress, we all think that it is a good chance for us to improve time management skill.

In the beginning, there is no suitable venue for us to test our ROV. There is no swimming pool in our school and the City University of Hong Kong does not offer us a chance to test our ROV at its swimming pool because of safety reasons. Finally, we send a letter to the director of Leisure and Cultural Services Department, whose department is a government department managing all the public diving pools in Hong Kong, to ask for the use of those public diving pools. Fortunately, we are offered two chances to test our ROVs at the diving pool of water depth at 4.6m.

Future Improvements

In our design, we are using a "one-to-one" connection method to provide electricity to every thrusters on the ROV. That means every thrusters require a pair of individual wires to connect with. In our ROVs, each motor is connected with a pair of 16 AWG, 20 metres long tether. And there are 5 thrusters in the module carrier, you can imagine how bulky the tether is. This adds a huge load to the ROVs, which will in turn lower their speed. To improve, an electronic circuit which can control individual thrusters can be installed on the ROVs. By doing so, only a pair of 20 metre electrical wires and a signal cable are required in the tether. The tether can thus become less bulky.

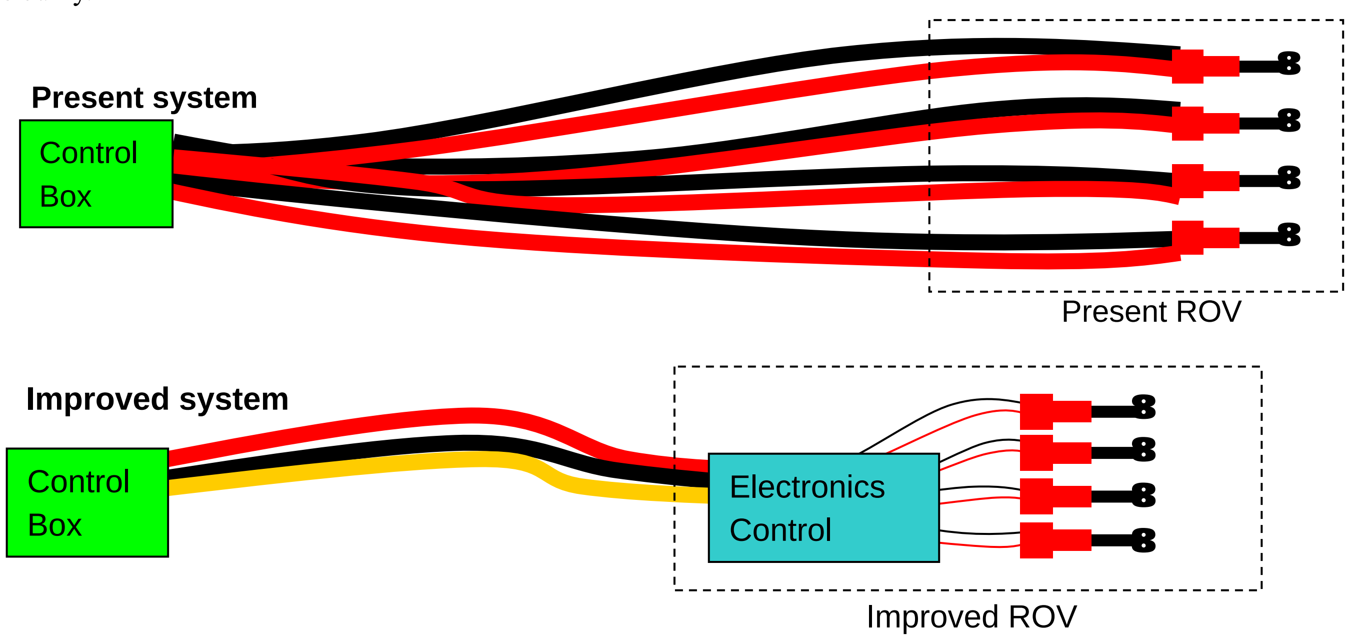


Fig9 The graphical presentation of the present system and improved system

Second, although the ROVs are designed to be very stable underwater, positioning underwater is anyway a difficult job. Transporting the module, pulling the release loop, etc, require the controller to be very skilful. To improve, we can make a ROV which can land on the pool bottom so that it can move by sliding. Operating the ROV would be something just like driving a car! Controlling the ROV would become much easier and the motion can be more precise. So, the ROV can work underwater more effectively.

Other than technical improvements, future improvements on time management can be made. We will set up a better schedule of work and make better planning in the future.

Lessons learnt:

We learnt lots of things during planning, designing and constructing our ROVs. The most important thing that we learnt is the importance of efficiency. During the preliminary round, we decided to make only one ROV to complete the tasks; as a result, we did not have adequate time to complete the mission successfully. To make our ROV become competitive in the international competition, we finally made a decision that we should separate the former All-in-one ROV into two, so that they can try to complete different tasks at the same time. This is more or less the same as the economic principle of the division of labour. In fact "efficiency" is very important in our daily life, just like our former ROV, it can surely complete all the tasks without the limit of time, but its efficiency is not very high. Apart from the efficiency of the ROVs, the team efficiency also imports on the performance of the ROVs. We had only limited time on constructing them while we have so many ideas. To higher the team efficiency, good cooperation and communication between team members are vitally important. In designing and constructing the ROVs, members worked better and better together. We were able to work efficiently together and did our best. Our ability is, of course, very important, but if we want to become competitive when getting into the society, we have to higher our efficiency, which is being emphasized very much, not only in the ROV competition, but in all aspects of our lives.

Ocean Observing Organizations:

i)WET LABS:

WET Labs is a company dedicated to developing and manufacturing underwater instrumentation to detect vital biological, chemical and geological parameters and processes of the earth's oceans, lakes and streams.

Integrated ocean observing systems that address the diverse needs of the aquatic scientific community are expected to be the core tools in aquatic research for the foreseeable future. Over 40 pilot ocean observatories are presently operating within U.S. and Canadian waters. Major initiatives such as the NSF-sponsored Ocean Research Interactive Observatory Networks (ORION) and the contemplated Integrated Ocean Observing System provide broad templates for the future development of research and operational observatories with organizations such as Ocean.US, providing scientific and organizational guidance to their formation and governance.

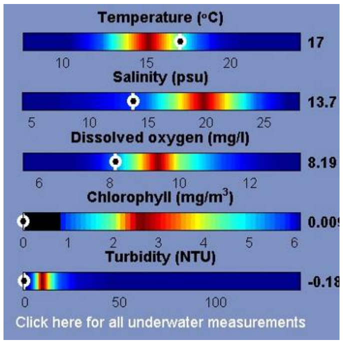


Photo 22, 23, 24 Information collected by the Great Bay Coastal Buoy at 43.0715 degrees N and 70.8678 degrees W, near Portsmouth, NH

ii)THE GLOBAL OCEAN OBSERVING SYSTEM:

The Global Ocean Observing System (GOOS) is an international programme with the primary goal of providing practical benefits to society. The main elements are the sustained collection of ocean observations and the timely distribution of those data and derived products, including analyses, forecasts, and assessments. Additional elements are the development and transfer of technology and building capabilities. The system design is scientifically based and subject to continuing review.

The two systems are both dedicated on working for the environment and the society. The development in underwater ROV is essential for their work.

Sources:
http://www.cooa.unh.edu/buoydata/buoy.jsp
http://www.wetlabs.com/index.html
http://www-ocean.tamu.edu/GOOS/

Acknowledgements:

We would like to thank the following people and organizations for their generous supports in all sorts of resources.

Mrs. Lilliana Kung, the school principal, helps us seek funds from the alumni, teachers and schoolmates, make special arrangement of the school examination for us and gives us a lot of encouragement.
Mr. Poon Ting Cheong, our class teacher, helps us make arrangement for the USA trip and sacrifices his family time to accompany us to the USA .
Mr. Lo Man Wah, the in-charge teacher of Design and Technology Club, gives us a lot of encouragement and provides facilitate and venues for us to make the ROVs.
Mr. Eric Chan, our physics teacher, comments on our technical report.
Mrs. Yung Chan Shuk Fan, our English teacher, proofread the technical report.
Ms Robin Sarah Bradbeer , Associate Professor of City University of HK, gives us the ideas on making the ROVs and also comments on our technical report.
Mr. Cyrus Wong, the coordinator of HK competition, arranges the laboratory for us to test ROVs and make arrangement for the USA trip.
Jordon Lee and **Cheung King Tai,** our schoolmates, who sacrificed their leisure time to work together with us.
The World Wide Fund (WWF) and **The City University of Hong Kong**, the organizing body of Hong Kong ROV Competition, provide funds for our trip.
The City University of Hong Kong, also provides us with the laboratory to test the ROVs
The Leisure and Cultural Services Department provides us a public diving pool for us to test the ROVs.for free!!
The Marine Advanced Technology Education (MATE) Center and **the Institute of Electrical and Electronics Engineers, Inc**.,(**IEEE)** provide funds to subsidize our expense.

Lastly, we would like to extend our special to **the school alumni**, **all the teachers** and also **all the schoolmates** for their generous donation and encouragement.
Without your support, we shall not receive such big success in this project.
Thank You All Very Much!

Budget:

EXPENSE

	Date	Description	Quantity	Unit Price	Amount	Remark
	Pump					
1	21/04/2006	Bilge Pump 4164LPH	9	$180.0	$1,620.0	
2	21/04/2006	Propeller	9	$45.0	$405.0	
3	22/04/2006	Steel Shaft	9	$70.0	$630.0	
4	22/04/2006	16AWG speaker wire	250m	$3.5/m	$875.0	
	Cameras					
5	01/05/2006	CCD Camera	5	$200.0	$1,000.0	
6	01/05/2006	Camera Stand	5	$32.0	$160.0	
7	01/05/2006	Video Cable	5	$30.0	$150.0	
8	01/05/2006	Camera Case	5	$10.0	$50.0	
9	12/05/2006	500g Plotting epoxy	1	$150.0	$150.0	
	Pipes					
10	06/05/2006	PVC Pipe	20m	$4.0/m	$80.0	
11	06/05/2006	Pipe conjunction	40	$3.5	$140.0	
12	06/05/2006	Buoyant Pipe	5m	$5.0/m	$25.0	
	Control Set					
13	08/05/2006	Control Box	2	$40.0	$80.0	
14	08/05/2006	Circuit Breaker	8	$10.0	$80.0	
15	08/05/2006	DPDT Switch	8	$20.0	$160.0	
	Pneumatics					
16	10/05/2006	cylinder	2	$108.0	$216.0	30mm ranged
17	10/05/2006	cylinder	1	$150.0	$150.0	100mm ranged
18	10/05/2006	Gas Tubing	80m	$3.5/m	$280.0	
19	10/05/2006	cylinder adapter	10	$5.0	$50.0	
	Others					
20	10/05/2006	Cable Tie	4packs	$20.0	$80.0	In different sizes
				Sub-Total:	**$6,381.0**	**US$807.7**
	Travel					
22	23/05/2006	Airfare	6	$4,900.0	$29,400.0	round-trip
23	29/05/2006	US Visa	6	$500.0	$3,000.0	
23	21-26/05/06	Hotel	6nights	$3,232.0	$19,392.0	4 rooms reserved
24	21-26/05/06	Van Rental	-	-	$3,500.0	
				Sub-Total:	**$55,292.0**	**US$6,999.0**
				Total:	**$6,1673.0**	**US$7,806.7**
				Sub-Total:	**$6,381.0**	**US$807.7**

DEPOSIT

	Date	Description	Amount	Remark
1	29/05/2006	Donation from School Alumni	$10,000.0	
2	29/05/2006	Donation from Schoolmates and Teachers	$11,220.0	
3	07/06/2005	Expected Sponsorship from the City U of Hong Kong	$5,000.0	
4	07/06/2005	Expected Sponsorship from WWF	$3,000.0	
5	23/06/2006	Expected Funding from MATE	$7,900.0	US$1,000.0
6	23/06/2006	Expected Funding from IEEE	$7,900.0	US$1,000.0
		Total:	**$46,020.0**	**US$5,825.3**

NET BALANCE

Description	Amount (HK$)	Amount (US$)
Expense	$6,1673.0	$7,806.7
Income	$46,020.0	$5,825.3
NET	**-$15653.0**	**-$1981.4**

REMARKS:

1. Our fundraising activities are still in progress, thus the figures in the income part are not yet confirmed.
   The figures were updated on 1st June.
2. Currency Exchange Rate: UD$1 = HK$ 7.9