Vethos ROV technical Report
Robert Gordon University

for **MATE competition June 22-24, 2007**
Memorial University
St. John's, Newfoundland, Canada

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Abstract

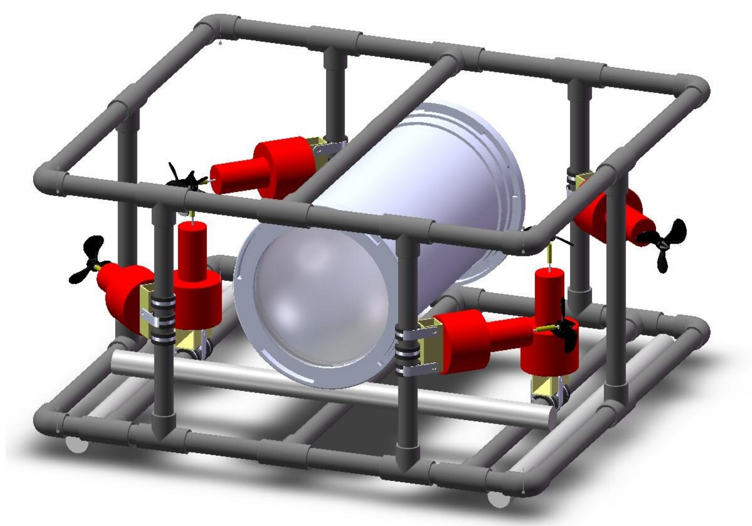
The team's task was to research, design and develop a submersible ROV, that will compete on three different missions of the MATE competition conducted in St. John’s, Newfoundland and Labrador, Canada in June 2007. All research and development operations were performed within Robert Gordon University's laboratories. Some other facilities outside the university, such as Subsea 7 in Aberdeen, were used to perform various tests.

Along with the three mission specifications, the team realized that the ROV should feature maximum maneuverability in order to reduce the time needed to complete missions. To achieve this features the team utilized vector thrusting along with specialized tools for each mission.

Radio control technology was used for the system control. The system was redesigned from scratch to transmit multiplexed servo signals down a two line cable, while still providing analogue control for the vehicle's movement.

This is the first time the team had taken part in the competition and only got to start designing at the end of January. This forced a fast to assemble and test design, with inexpensive parts. The team resulted in ingenuitive methods, where parts meant to be used for other environments and tasks, where adopted and customized to be used on an ROV.

Vethos ROV will be used to increase the awareness and draw attention of schools and other universities over the competition in the North East of Scotland.



Index

1. Design Rationale

When considering the design for the ROV it was obvious that there were several factors that would determine the various aspects of the design. Primarily it has to perform the various missions as put forth by the competition committee and still remain maneuverable enough to perform the required tasks in a set period of time, with the aim of doing them as fast as possible. The most critical factors were time and funds and due to the late start, time was very much against the project. This short period of time also meant that there wasn't a lot of time to find sponsors to help pay for the construction and development of the ROV so the whole robot had to be made to a budget and as fast as possible. Its for these reasons that many 'off-the-shelf' parts were used in the construction of both tooling and the ROV itself.

The frame was designed to be as 'flexible' as possible so that the positions of tooling, motors, cameras and the pressure vessel can be placed where they need to be to suit any particular challenge. It was for this reason the frame was made of round tube so that parts could be mounted to it easily. Being made from standard PVC tubing also kept the costs down and allowed for quick assembly, as standard fittings could be used to make the shape of the ROV. The overall dimensions of the robot were determined by the tooling and the drive motors, as adequate space was required but at the same time the ROV couldn't be too large either. The size of the ROV would dramatically affect the performance, the bigger the robot, the slower it would be to move around and so it was made as small as it could be with consideration for the tooling and motors.

2. Expenses

MATE ROV Costing

Item	Name	Type	Qty	Unit Qty	Price @	Cost	Supplier	Stock Code	Description/Application	Req. by	Budget	Purchaser	Date ordered	Date Arrived
1	Table tennis balls (6)		1		£3.00	£3.00	John Lewis		Mission 2		donation	GD	30-Mar-07	30-Mar-07
2	Oball		3		$USxx	£20.71	Rhino Toys		Mission 2		donation	GD	30-Mar-07	10-Apr-07
3	Oball		1		£5.00	£5.00	eBay		Mission 2	Jeff	donation	Jeff Tapp		arrived
4	Webcam		1		£7.00	£7.00	Amazon.co.uk		Cameras		donation	GD		arrived
5	Ripmax Futaba R/C kit	6EXA	1		£116.95	£116.95	RGU Lab stock		Control		loan		30-Mar-07	30-Mar-07
6	40 mm x 45 deg ultra ABS tee		2		£1.79	£3.57	Drain Centre	F27440	Mission 2		petty cash	Ian	01/04/2007?	01/04/2007?
7	CB tin solvent cement	250 ml	1		£4.88	£4.88	Drain Centre	F16200	Mission 2		petty cash	Ian	01/04/2007?	01/04/2007?
8	Rule 1100 GPH pump		10		£29.95	£299.50	Force4 Chandlry	830271	Thruster		EN298 126	GD	09-Apr-07	26-Apr-07
9	Viper Marine 15 boat speed controller		10		£21.99	£219.90	Mtroniks Ltd	VIPMarine15	Thruster control		EN298 126	GD	10-Apr-07	17-Apr-07
10	Servo Mixers		2		£14.95	£29.90	Mtroniks Ltd	WTAILWP	Thruster control		EN298 126	GD	10-Apr-07	26-Apr-07
11	Electromagnet		2		£39.25	£78.50	RS Components	346-104	Mission 1	Allart	EN298 126	GD	10-Apr-07	13-Apr-07
12	USB Extender 4 port hub		1		£59.99	£59.99	Maplin Electronics	A22FJ	Cameras		EN298 126	GD	10-Apr-07	12-Apr-07
13	Electrolube Silica Gel Dessicant 10g	SGL010	20		£0.52	£10.40	Farnell	890698			EN298 126	GD	11-Apr-07	17-Apr-07
14	Araldite rapid		2		£3.39	£6.78	RS Components	314-9675			EN298 126	GD	11-Apr-07	17-Apr-07
15	Araldite Precision		2		£2.87	£5.74	RS Components	314-9653			EN298 126	GD	11-Apr-07	17-Apr-07
16	Araldite Putty		1		£3.89	£3.89	RS Components	483-5945			EN298 126	GD	11-Apr-07	17-Apr-07
17	Mastic Sealant		2		£8.53	£17.06	RS Components	264-1215			EN298 126	GD	11-Apr-07	17-Apr-07
18	P-clips 20mm plated steel		30		£0.60	£18.12	RS Components	186-5397	Motor mounts		EN298 126	GD	11-Apr-07	17-Apr-07
19	Equip Wire 50/0.25 2.5mm^2 25A		1	100 m	£20.85	£20.85	RS Components	544-1822	Umbilical		EN298 126	GD	12-Apr-07	17-Apr-07
20	Georg Fischer 20mm PVC-U pipe		9		£2.52	£22.68	RS Components	437-4917	Frame		EN298 126	GD	12-Apr-07	17-Apr-07
21	Georg Fischer 20mm elbow		20		£1.19	£23.80	RS Components	279-0569	Frame		EN298 126	GD	12-Apr-07	17-Apr-07
22	Georg Fischer 20mm Tee		25		£1.29	£32.13	RS Components	279-0711	Frame		EN298 126	GD	12-Apr-07	17-Apr-07
23	Tangit PVC-U Cement		1		£12.55	£12.55	RS Components	214-4506	Frame		EN298 126	GD	12-Apr-07	17-Apr-07
24	Futaba training lead square to DIN		1		£14.99	£14.99	Sussex Model Centre	SMC-RE-P-TC-FM	Control		EN298 126	GD	13-Apr-07	17-Apr-07
25	Y junction servo lead - Futaba		3		£5.99	£17.97	Sussex Model Centre	SMC-RE-P-AL0731	Control		EN298 126	GD	13-Apr-07	17-Apr-07
26	Triple servo tray - Futaba		1		£3.50	£3.50	Sussex Model Centre	SMC-RE-P-AB0721	Control		EN298 126	GD	13-Apr-07	17-Apr-07
27	Single base mount servo tray - Futaba		1		£2.50	£2.50	Sussex Model Centre	SMC-RE-P-AB0720	Control		EN298 126	GD	13-Apr-07	17-Apr-07
28	Battery lead - Rx 200mm		1		£1.35	£1.35	Sussex Model Centre	SMC-RE-P-XFT210.200	Control		EN298 126	GD	13-Apr-07	17-Apr-07
29	Hitec 4.8V 600mAhr Nicad Rx pacl		1		£4.50	£4.50	Sussex Model Centre	SMC-RE-P-H57401	Control		EN298 126	GD	13-Apr-07	17-Apr-07
30	Hitec HS-311 servo		4		£6.99	£27.96	Sussex Model Centre	SMC-RE-P-HS311	Mission	Jeff	EN298 126	GD	13-Apr-07	17-Apr-07
31	Clear acrylic tube	50mm dia	1	1 m	£12.28	£12.28	K&M	ACTUBECL-50mm	Mission		EN298 126	GD	13-Apr-07	19-Apr-07
32	ABS square tube	25.4 mm sq	4	760 mm	£5.48	£21.92	K&M	FPH-32	Thrusters		EN298 126	GD	13-Apr-07	19-Apr-07
33	Fly Line Backing	30 lbs	1	75 m	£3.50	£3.50	Sloans, Inverurie		Mission (messenger line)		petty cash	GD	14-Apr-07	14-Apr-07
34	Piano wire		1		£1.25	£1.25	Models Unlimited, Inverurie		Mission (servo coupling rod)		petty cash	GD	14-Apr-07	14-Apr-07
35	K&S Brass tube	1/8 x 0.014	1		£2.15	£2.15	Models Unlimited, Inverurie	1213	Mission (servo coupling rod)		petty cash	GD	14-Apr-07	14-Apr-07
36	Marley access cap - grey	82 mm	6		£16.23	£97.38	Plumb Centre	SE30	Camera and servo housing		EN298 126	GD	18-Apr-07	24-Apr-07
37	Marley access cap - grey	160 mm	2		£44.97	£89.94	Plumb Centre	SE62	Pressure pod		EN298 126	GD	18-Apr-07	24-Apr-07
38	Marley PVC-U pipe	160 mm	0.1	3 m	£40.00	£4.00	RGU Lab stock	SP603	Pressure pod		donation	GD	18-Apr-07	18-Apr-07
39	IP68 glands		100		£0.19	£19.00	Rapid Electronics	04-1920	Pressure pod		EN298 126	GD	20-Apr-07	23-Apr-07
40	2182Y white 2 core round cable,0.75sq.mm		0.1	100 m	£22.95	£2.30	RS Components	126-3561	Thruster Cable		RGU Stock	GD	19-Apr-07	19-Apr-07
41	In-line coupling	3mm-3mm	10		£2.55	£25.50	Rapid Electronics	43-1052	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
42	Tamiya battery connector	male	10		£1.56	£15.59	Maplin Electronics	JG04E	Speed controllers		EN298 126	GD	25-Apr-07	27-Apr-07
43	Heatshrink		2	1m	£1.70	£3.40	Rapid Electronics	03-0600	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
44	Heatshrink		2	1m	£1.95	£3.90	Rapid Electronics	03-0605	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
45	Heatshrink		3	1m	£2.30	£6.90	Rapid Electronics	03-0610	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
46	Heatshrink		3	1m	£2.90	£8.70	Rapid Electronics	03-0615	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
47	Heatshrink		3	1m	£3.20	£9.60	Rapid Electronics	03-0620	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
48	Heatshrink		2	1m	£5.95	£11.90	Rapid Electronics	03-0625	Thrusters		EN298 126	GD	25-Apr-07	27-Apr-07
49	CB 2" screwed Acc.Plug		1		£1.43	£1.43	Drain Centre	F15300	Mission 3	Ian	petty cash	Ian	24-Apr-07	24-Apr-07

50	CB 2" knuckle bend 90D		2		£1.43	£2.86	Drain Centre	F15292	Mission 3	Ian	petty cash	Ian	24-Apr-07	24-Apr-07
51	Bullet crimp connector	10 A	50				Farnell	150-346	Thrusters		RGU Stock		24-Apr-07	24-Apr-07
52	Electromagnet		1		£39.25	£39.25	RS Components	346-104	Mission 1		EN298 126	GD	27-Apr-07	30-Apr-07
53	Model Boat Propeller	65 mm RH	3		£2.75	£8.25	Wesbourne Model Centre	H-2308/55	Thrusters		EN298 126	GD	01-May-07	03-May-07
54	Model Boat Propeller	65 mm LH	3		£2.75	£8.25	Wesbourne Model Centre	H-2308/55	Thrusters		EN298 126	GD	01-May-07	03-May-07
55	RS-422/485 driver	ADM485	4	1	£2.48	£9.92	RS Components	523-6737	Control		EN298 126	GD	04-May-07	04-May-07
56	Cat 5 cable		20				RGU Lab stock				Donation			
57	Buccaneer IP68 Connector	2 pole	5	1	£2.48	£12.40	Rapid Electronics	23-2210	Tooling		EN298 126	GD	28-May-07	30-May-07
58	Buccaneer IP68 Connector	2 pole	5	1	£3.70	£18.50	Rapid Electronics	23-2220	Tooling		EN298 126	GD	28-May-07	30-May-07
59	Buccaneer IP68 Connector	2 pole	5	1	£2.82	£14.10	Rapid Electronics	23-2260	Tooling		EN298 126	GD	28-May-07	30-May-07
60	Futaba 9.6 V 700 mAhr Tx pack		2	1	£17.50	£35.00	ServoShop		Control		EN298 126	GD	01-Jun-07	
61	Universal Mains Travel Adapter		2	1	£9.99	£19.98	RS Components	484-1170	Laptop/camera		EN298 126	GD	01-Jun-07	
62	Buccaneer IP68 Connector	6 pole	3	1	£5.89	£17.67	Rapid Electronics	23-2205	camera		EN298 126	GD	01-Jun-07	
63	Buccaneer IP68 Connector	6 pole	3	1	£4.60	£13.80	Rapid Electronics	23-2194	camera		EN298 126	GD	01-Jun-07	
64	Buccaneer IP68 Connector	6 pole	3	1	£4.90	£14.70	Rapid Electronics	23-2218	camera		EN298 126	GD	01-Jun-07	
65	Buccaneer IP68 Connector	2 pole	5	1	£2.65	£13.25	Rapid Electronics	23-2186	Tooling		EN298 126	GD	01-Jun-07	
66	Buccaneer IP68 Connector	2 pole	5	1	£3.45	£17.25	Rapid Electronics	23-2218	Tooling		EN298 126	GD	01-Jun-07	
67	Shipping of ROV					£0.00	Subsea 7							
						£1,681.48								
					VAT	£294.26								
					Total	£1,975.74								

3. Electronics

The electronics were divided into two systems. One is control and power which was designed and developed by Stavros Polymenis, and the other is the vision which was designed and developed by Michael Galt.

3.1 Power

The ROV and its control station are mainly powered by 12 V. The only exception is the laptop used as a display, which has a separate power supply. The minimum current draw of the whole system (laptop excepted) is about 5A, while the maximum is around 25 A. The power is transmitted to the vehicle, using two cables.

3.2 Control

The control system is defined as the part of the electronics responsible for the user input for movement, the encoding/transmission/decoding of the signal, and finally its output to the thrusters and tools.

Initial ideas involved multiple lines, with analogue signal that would control the thrusters and digital for the tools. The idea was soon abandoned since it increased the size of the tether system dramatically. A second idea involved the use of a couple of micro controllers, one at the control station and one on the ROV, connected with a serial line. Again this involved several lines going down the tether, and a very sensitive system that could jeopardize the missions. It was finally decided to use model aircraft technologies, to control the ROV.

The first challenge was modifying the electronics to transmit the signal over a cable instead of radio waves (radio waves cannot be transmitted within water). The second challenge was to transmit the signal over a 20 meter cable with out any loss due to noise and other signal degeneration effects.

Analyzing the design from the top to bottom (input to output), the first subsystem encountered is the controller. The controller accepts the user input from two joysticks (with two degrees of freedom each) and a rotational analogue switch. Since the radio transmitter could not be used, the buddy box output was used to transmit the input. Every degree of freedom or function, is translated into a square wave, were the HIGH width (time) is proportional to the degree the stick is rotated, which is the standard encoding method for servo signals. Each function requires a channel. All channels are then multiplexed into a signal line, with time division. The frames are separated by a long LOW section at the end of each cycle. The multiplexed signal is then send to a RS422 line driver, which boosts and transmits the signal down the tether over two balanced lines.

On the receiver end, an RS422 receiver accepts the signal, and reverts it back to a single ended signal. A de-multiplexer separated the channels and sends each channel to each respective motor driver or actuator. Some of the channels are mixed before the signal is sent to the motor drivers or actuators. The motor drivers are all Mtroniks “Viper Marine 15”, and the actuators standard servos.

3.3 Vision

The aim of the optical system was to devise a way of delivering imagery of up to four cameras, back to the control station. The cameras had to be able to work at least 15 m away from the ROV. The system had to be robust as there was no way of committing hardware changes while the ROV is undertaking a challenge.

The decided camera system had to be able to solve three issues. Possible incompatibilities between UK and Canada power and video systems, the inability due to rules to use more than 3 displays, and transporting a lot of equipment. All these issues were solved by using digital USB web cameras. The drawback of the web cams was the limitation on the length of the USB cable. This cable can only be 5 m long for the device to work. As a 15 m range required another way of connecting the cameras from ROV to the computer was needed. This was done using a USB extender. This device takes the signal from a camera and converts it into a signal that can be passed down a cat 5 networking cable, after traveling down the cable the device then converts the signal back to USB for linking up to a computer. This device meant that the cameras could be up to 50 m away from the computer.

There were several different USB extenders available from different companies. All these devices worked the same way and were pretty much the same. The one that was used was slightly different; instead of an input of one USB port it had four. This made it perfect for our use, since it allowed multiple web cams and it reduced the amount of equipment required inside of the ROV.

The web cams that were used had to be from different companies. If two of the same web cams were used the system would get conflicts as the same driver would be used for both, resulting to failure. The cameras used have all the same specifications. They all have a resolution of 640 x 480 pixels and a frame rate of 35 frames per second. This gave and adequate size of picture that was also fluid so every movement could be seen instantly.

The software used to create the program was C++ Builder. An add-on was had also to be included this was called “VideoLab”. This add-on allowed C++ to input videos from many different sources and to manipulate these videos in a number of different ways. This set-up was chosen for its simplicity to use and develop software and the and because of prior knowledge of using it for this type of task.

The original concept was to have all four web cams displayed on the monitor at the same time and be able to enlarge one of the displays at once. After some experimenting with the USB hub and the cameras it was discovered that the bandwidth of the system only allowed two cameras to work simultaneously and one camera had to be completely shut down before the other could be started or the system would crash.

The program utilizes a windows based GUI (graphical user interface) which makes all tasks a lot simpler. This will be done with the use of buttons that the user can click on. Each button will enact a separate part of the program.

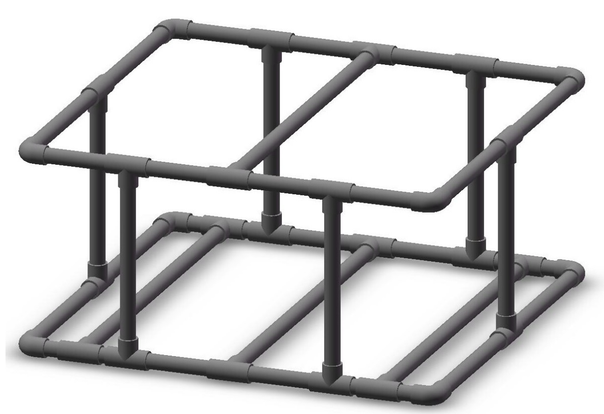
There can be a maximum of two cameras displaying at one time. One camera display is the camera located inside of the ROV. This camera will be started using a button that will enable it and make this display screen visible. This camera will be the only one available for that window. The other three camera will be used for tooling and will be all displayed individually in the same window. The camera that is viewed at a specific time will be selected by the user using one of three buttons. Each button will denote a different camera. Pressing a button will close down any other cameras and make all other screens not visible. It will then turn on the camera selected and make the screen for it visible.

The interface layout has two windows for the camera outputs and the buttons for controlling the cameras. The camera 1 button enables the camera and enables the display for it. Camera 2 button disables camera 3 and 4 and makes there displays not visible it the enables camera 2 and makes its display visible. The buttons for the other two cameras do the same task just for different cameras being enabled and disabled. The stop all button disables all cameras and displays. The only difference from the original design was the input of setting buttons. This was added to allow the system to be compiled and run independent from the programming software. There is a settings button for each of the cameras. When pressed this button displays a separate form. On this form the camera that is to be used for each display can be selected from a drop down list.

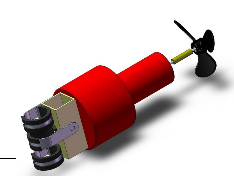
4. Frame

The main frame of the ROV is made from Georg Fischer 20 mm PVC pipes joined together with PVC connectors and glued using solvent cement, it was decided to use this material mainly because of the ease to work with PVC. The effect of external pressure on the PVC pipes at the working depth of the ROV was taken into consideration before choosing the material of construction so as to prevent implosion of any structural members of the ROV. The frame is sealed and is not free flooding. It was anticipated it might be difficult to remove all air bubbles in the free flooding frame in the heat of the competition.

Critical distortion pressure of the PVC pipes, acrylic dome and electronic housing was also calculated over a range of different temperatures which the ROV is likely to be used in, by the use of appropriate de-rating factors. To mount the propellers symmetrically relative to each other we came up with a cuboid shape for the final structure of the ROV. The ROV measures 560 x 530 x 260 (mm).



4.1 Thrusters



The choice of thrusters was down to selecting thrusters that were easily modifiable and fitted the power budget. The ROV uses a total of 6 type 'Rule 1100 GPH' bilge pumps. Two vertically mounted pumps help the ROV in its vertical motion and the other four pumps mounted horizontally provide motions in all directions horizontally.

4.2 Propellers

The basis of choosing propellers was purely experimental. Aircraft type propellers and PC fans were tried out initially but they were found to slow the pumps down, causing the pumps to draw excessive current. A source of model boat propellers were found.

The propeller diameter to be used with new pumps was calculated using observations made from experimentation using type 'Rule 500 GPH' bilge pumps with propellers of 60 mm diameter providing optimum thrust output without overloading the pumps. Thus propeller diameter suitable for the power output of the new pumps was calculated by scaling the sizes from the earlier experiment and using a similar propeller pitch.

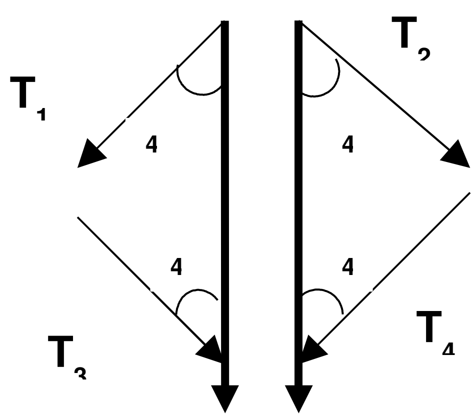
4.3 Propulsion

The ROV uses vectored thrust for its horizontal movements in different directions in order to attain maximum thrust from the given set of motors, assuming that the thrust is equal in both the directions, i.e. the pull of the thrusters is equal to their push.

This design feature provides the total thrust, in any direction, which is greater than the thrust which can be provided by a pair of the motors acting in the same direction by a factor of $\sqrt{2}$.

Moreover the Propellers used in the ROV are out turning each other so as to avoid any sideways drag and thus making the ROV highly maneuverable. The rate of ascend and descend of the also calculated upon calculating the vertical thrust of the propellers.

$$T_1+T_3=\sqrt{|T|^2+|T|^2+2|T|^2\cos\theta}$$
$$\Rightarrow\sqrt{2|T|^2}\quad(when\ \theta=90°)$$
$$\Rightarrow|T|\sqrt{2}$$
therefore sum of thrust
$$\Rightarrow 2|T|\sqrt{2}$$
where T is thrust



4.4 Buoyancy

The frame of the ROV with all the electronic components such as motor drivers and thrusters were made neutrally buoyant by a series of calculations and experiments. During initial calculations the ROV was found to be positively buoyant. In order to make it neutrally buoyant the ballast required to be taken was calculated. The ROV was weighed on a spring balance to get its total mass, the volume of each structure and component was calculated independently and the necessary calculations were done to obtain an approximated value of the ballast required.

The calculated ballast required by the ROV was confirmed experimentally by adding sufficient weights to the ROV in the form of 3 mild steel bars of density 7860 kg/m^3 and 438 mm in length. Whilst establishing the stability of the ROV the transverse and longitudinal metacentric heights (the distance between the center of gravity and center of buoyancy) were calculated.

All the other tools were made neutrally buoyant and fitted on the ROV so that the stability and buoyancy of the ROV remained unaffected.

4.5 Water-proofing

The pressure vessel of the ROV is constructed from Marley Plumbing and Drainage 160 mm diameter PVCu pipe and SE62 Access Caps with pressure plugins which use very reliable rubber O-rings and are capable of withstanding the pressure encountered by ROV during its operations.

The cap on the bow end was modified to take a 150 mm acrylic dome (from K&M Wholesale Supplies). The cable penetrators on the stern end are waterproof IP68 rated cable glands.

The force of drag experienced by the ROV was calculated experimentally to confirm the theoretically calculated value by towing the ROV at a given speed using a spring balance. The reading on the spring balance multiplied by 9.81 N (force gravity) would give the value of drag in Newtons.

$$F_D = \frac{C_D \times \rho \times V^2 \times A}{2}$$

where CD = Coefficient of drag, p = Density of fluid, v = Velocity, A = Area, F = Force of drag

It was noted that the vehicle slowed down when moving sideways and this was due to an increase in surface area of the ROV experiencing drag which leads to the drop in velocity.

N.B. In all the calculations due consideration was given to the density of water at different temperatures for different missions.

5. Tools

5.1 Mission 1 (Allart Parish)

The tool for mission one has to be designed to tread a line through an anchor ring. It also has to do this with the minimum movement needed from the ROV. A way of doing this, is to keep a hold of the line at all times. This means the tool has to thread the line through the anchor ring and grab the line from the other side before letting go of the first side.

To achieve this a mixture of electromagnets and Velcro is used. The reasons for using these components are the reliability and the ability to use them underwater without any modifications. The electromagnets are going to be used for two functions: One is to use the actuators for the arms. To do this we pace the magnets at opposite poles to attract and close the arms. Therefore reversing the direction of the current on one of the magnets and thus flipping the pole and causing repulsion between the two magnets and opening the arms. The other use for the electro magnet is to hold the end of the messenger line to one arm until it can be passed to the other arm at which point the line will be held by Velcro. This means there has to be a metal disk with a side of Velcro attached to the end of the messenger.

The tool is neutrally buoyant so when attached to the ROV there will be no need to adjust the buoyancy or the ballast of the ROV. To do this, the tubing that is the basis of the tool is filled with foam.

5.2 Mission 2 (Martin Pinner & Ian Burns)

5.2.1 Bethnic jellyfish collector

This part of mission 2 involves the collection of a simulated Jellyfish which has been represented by a child’s toy called an Oball. This Oball is around 110 mm in diameter and is full of large diameter holes. Instead, a way of physically moving the ball into a net was decided the best way of collecting it as this method would be a much more secure way of stopping the ball from falling out from all of the maneuvers the ROV has to do to complete its other tasks for that mission. For this reason, hooks were not widely considered.

The inspiration came from a vacuum cleaner for this particular tool. A beater brush from a Dyson Vacuum cleaner was used and joined to a modified 500 GPH bilge pump via a belt. The motor has been connected to a motor controller inside the ROV. The framework is made of aluminum plating and 6 mm “thick plastic to hold the moving parts together. To keep the Benthic jellyfish ball from escaping, a hole was cut in the bottom of the tool and a net was placed in it as well as placing plastic tubing at 50 mm intervals along the rear of the tool. This is to allow the use of the main on-board camera to sight the ball. The tool is designed to fit on the front of the ROV enabling the ROV to sit on the bottom of the pool deck and then as the ROV drives forwards it will pick up the Jellyfish as they come into view of the camera.

5.2.2 Algae collector

As part of another task in mission 2, simulated algae have to be collected from the underside of a floating ice sheet. This algae is being simulated by ping-pong balls which float underneath the ice and this poses a challenge to collect.

This new tool utilizes the "Venturi Effect" where it creates suction underwater capable of pulling the ping-pong/ Algae balls down a tube and then trapping them. One piece of pipe had too large of a diameter so another pipe was inserted into the first one by cutting it along its length to decrease the internal diameter. This created a narrow enough tube for the Venturi effect to be effective. A "U" bend was then added to keep the ping-pong balls from escaping and a "Y" joint was fitted to hold the bilge pump in place with a removable end piece so the balls are easily accessable.

5.2.3 Sonar Placement

In this last task, a sonar sensor has to be accurately placed in a fenced off area in the tank. The original idea was to use an already existing tool made to complete a different mission. The idea behind this is that it would save time and money during the construction and development phase in the design of a new tool. This tool would have been the same one that is used to thread a string through a 'U' bolt in mission 1. The idea was dropped however for two important reasons. The first being that this tool would have required extensive modification and would have taken the same amount of time as developing a new tool. Another important factor in the decision was reliability, should this tool stop working and was rendered unfixable, that would mean potentially two out of three missions that would not have been possible to complete fully. Instead a new very simple tool was decided on as being the most reliable way of completing this particular mission. The idea is to simply hang the senor off a hook with a shallow bend in it. This bend would allow the sensor to stay on the hook by threading the hook through the chain of the sensor device. When the senor is placed in the fenced off area the ROV would simply reverse to release it (as the sensor would be resting at the bottom of the tank and the tension of the chain would be slack).

5.3 Mission 3 (Andrew Reid & Martin Pinner)

An important element of this mission is orientation, without some way to anchor the ROV around the wellhead it would be very difficult to accurately land the gasket and wellhead cover in place. With this is mind the first piece of tooling designed was a clip to be mounted on the front of the ROV allowing it to attach, rotate around the wellhead, and also move vertically while keeping the wellhead in reach of the rest of the tools.

Originally for this mission, electrical solenoids were to be used to pick up and drop the gasket and wellhead cover, however once the tool was built, the solenoids proved themselves to be unreliable. Consequently, since time and manpower were both in short supply, a system of hooks was designed, one hook to carry down and drop the gasket, another to pick up and replace the cover.

Since an additional degree of freedom was required to effectively use the hooks, the clip at the front was connected at a pivot, allowing the ROV to twist around the wellhead. With one hook carrying down the gasket, the other beginning empty. First, the ROV must fly down and attach the clip to the wellhead, use one hook to catch and lift (by using vertical movement still centered on the wellhead) the cover, twist the ROV about the pivot, use the second hook to drop the gasket, twist back and replace the cover.

The hot stab release works in a similar way, the clip is used to center around the insertion point, a one shot release mechanism is used, a bilge pump motor used to shoot out the hot stab, which will be attached by a string, so when the ROV flies away the stab follows, keeping the system as simple as possible.

6. Challenges & Experiences

During the course of the project, the team was met with a variety of challenges ranging from software to hardware and from electronics to finance. These next few paragraphs discuss these issues in greater depth and what was done as a team to overcome them.

By far the biggest hurdle was simply the very short period of time we had to plan, prepare, get funding, construct, test and develop the ROV. However, this was tackled by breaking each problem down in to goals that each team member had to reach. Once reached, (some sooner than others), the members then joined the other tasks to help complete them faster. With this structured approach we were able to complete the challenges as they arose.

One such problem that was tackled was the decision of what to use for the drive motors. Bilge pumps were the first choice as these were already water tight and were small enough to fit comfortably in the ROV. As these had been used successfully in other ROVs the decision was made to use them, 1100 GPH pumps were chosen for there optimum performance for power and current draw.

This then gave the team a bench mark as to what size the ROV was going to be when designing the chassis with only the tooling (needed to complete each challenge) yet to determine the final size. The chassis was designed open plan (no side panels and built around a frame) which allowed easy access to various areas should they need to be accessed for maintenance and it also allowed for easy attachment/detachment for tooling and reduced the drag as much as possible. It wasn't until a prototype of the largest tool (the ping pong ball collector for mission two) was made could the final height be determined. This tool was the longest therefore the chassis had to be tall enough to encapsulate it. Most of the other tools were designed around sizes of the chassis where possible.

The challenge that took the longest to solve was the electronics. As there wasn't enough time to make a fully custom control system, the decision was made to use a hobby Radio Control (RC) transmitter and adapt it for umbilical use (as it's receiver can't be used underwater as the radio waves are absorbed by the water and by other contaminants). The controller has what's known as a Trainer Cord socket which is used by the hobby RC community to connect two RC transmitters together in a slave/master configuration so that a novice flier can be 'backed-up' by an expert so they don't crash their vehicle. The signals coming from the master controller override those of the slave controller and control of the vehicle is regained (in theory). This 'signal' is sent in a multiplexed form down the cable and can be used to control RC equipment such as speed controllers and servos. With the use of a circuit on-board the ROV which separates the signals (using a de-multiplexer) and translates them in to something the RC equipment can understand. One issue that arose during the testing of the control circuitry was that it was highly susceptible to interference, especially with the length of umbilical needed for the ROV. To get around this, line drivers are used at each end of the control lines of the umbilical to filter out and boost these sensitive control signals.

7. Troubleshooting

The team had to face several problems that were not foreseen in the design process. Most of these problems occurred during the test runs and the experimenting.

One of them was the camera located inside the pressure vessel. During the test run the pilot was having difficulty understanding what the camera was viewing due to the very limited angle and resolution of the camera. Thus the camera had to be replaced with a better one, which features bigger resolution and viewing angle.

Another issue discovered during the test run was that the control system was resetting at constant intervals with a certain input. This took the ROV back to the electronics labs for further tests, which proved that the issue was caused by bad grounding. The problem was quickly resolved.

8. Lessons & Skills

Throughout the research and development stage, and during the testing runs, the team had important lessons only real life engineering applications can give, and acquired useful skills.

To begin with most of the team members have never worked in such a large scale group, where so many people are involved, with limited budgets, timing schedules, reports etc. This is what real life engineering jobs are like thought, and it is extremely useful for an engineer to acquire skills such as communication and cooperation during their academic time. The crew members had to keep in touch in person and over IT services (like emails, forums, etc), organize meetings, lab sessions and transfer and share data.

Further more team members had a unique opportunity to apply the theoretical knowledge they have gather so far. It is normal and expected that an engineer will not get to learn about little details during their training, which really make the difference. These details are only faced and tackled once an engineer gets a real life tasks. Examples of such details are the materials used and the reasoning for that, what connectors were chosen for a specific application, their features etc.

But the most important skill acquired, is creative thinking. All team members had to perform researches, design and experiment, for the various problems that had to be tackled. The team members had to learn about Radio Control technologies, the Venturi Effect, buoyancy and hydraulics and other theories and techniques. These were then analyzed, tweaked, experimented, and applied to result into a suitable choice for the task.

9. Future Improvements

As mentioned above, this ROV was developed over a tiny period. This makes this first version only a testing one, through which important information will be gathered during this years competition in order to find in which fields the team is on the right track and in which fields the team had to revise or change the specific system.

So far the team knows that a definite change for next year is to improve the quality and the design standards of the electronics. If the current technologies prove effective and efficient, they will be improved in order to become more robust and easier to use.

The current thrusters are likely to change as well, as more efficient and powerful ones can be designed or bought provided there is enough time for the team to research the subject.

Finally the chassis will have to change to support new functions and modules that will be introduced in next years version.

10. Life at Poles

Aberdeen and Scotland have a long-standing relationship with the Inuit of the Canadian Arctic. The following is about the adventures shared by a Scotsman William Perry and an Inuit, Inuluapik in the 1800.

William Penny born in Peterhead Scotland located a few miles north of Aberdeen in 1809. He became a mate before 21 and by the time he turned 26 he was commanding his own whaling vessel. Between 1821 and 1864 he sailed between Scotland and the Arctic whaling and sealing ground often sometimes twice a year. It was in 1839 that William Perry met and befriended a young Inuit man named Inuluapic. Inuluapik was exceptionally familiar with the area and impressed by this local knowledge, Perry convinced Inuluapik to travel with him to Aberdeen to spend the winter, in exchange for Inuluapik's helping to find and map Cumberland Sound. Perry did have an ulterior motive with inviting the young Inuit to Scotland in that he hoped to gain publicity and public support for the exploratory voyage. After a ceremonial goodbye from his mother and family Inuluapik set off with Penny for Aberdeen sometime in October 1839. The ship arrived at Aberdeen harbour on November 8 but almost immediately Inuluapik caught a potentially life threatening lung infection. Only a few days after his arrival, and still being ill from the lung infection, Penny managed to convince Inuluapic to make a public appearance. Dressed in Full fur dress, Inuluapik gave a kayaking demonstration in the River Dee which resulted in a recurrence of Inuluapic's infection confining him to bed for 14 days and hampering his health for the remainder of his stay in Scotland.

Failing to get any government funds to pay for his expedition Penny and Inuluapik set off aboard the Whaling Ship Bon Accord, for the Davis Strait on April 1st, arriving on May 5th. Penny and his intrepid Inuit companion first made there way to the Melville Bay to earn money Whaling to pay for the expedition, and by July had earned enough to begin making there way south to look for the inlet to Cumberland Sound. It was on July 27, 1840 that William Penny and Inuluapik found Cumberland sound though at first he thought that it was an unknown channel and named it Hogarth's Sound, it took a few years for the error to be recognized and fixed.

They followed the north-east shoreline until they were able to cross the sound to Inuluapik's birthplace Qimmiqsut where they were greeted by a party of Inuit, 2 of which were cousins of Inuluapik. Inuluapik talked a little of his travels but kept his discussions mostly to the Greenland Coastline and peoples and demonstrated the gun that Penny had given Inuluapik as a present in Scotland, most likely because Inuluapik knew that these things would be of more interest to his fellow Inuit then his travels to Scotland. Not long after this Inuluapik and Perry parted ways and Perry returned home empty handed thinking that his exploratory mission was a failure. Yet in the years following Inuluapik and Perry's adventures together, Cumberland sound was to become one of the most important whaling grounds in the Canadian artic.

Life at Poles bibliography:

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