Mintlaw Academy

Peterhead Scotland

Technical Report

Subsea Technical Services

Team members

CEO/Designer – Liam Forbes
Pilot/CFO – Kieran Yule
Machinist/CAD – David Finnie
Co-pilot – Gareth Swinney
Electrical/umbilical – Douglas Leel

Thanks to:

Mentors

Ali Hynd, Teacher
Neil Stagg, BP Mentor

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Tel: 01779 473608
Fax: 01779 472755
sales@buchanpowertools.co.uk
www.buchanpowertools.co.uk

Duthie Motors Ltd
55 Main Street, Longside, Peterhead, Aberdeenshire, AB42 4XJ

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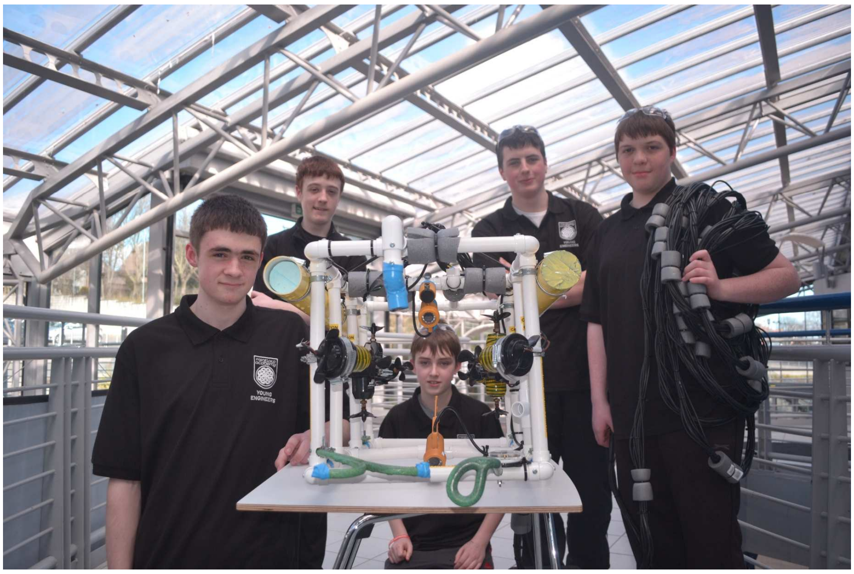
Introduction...

At Subsea Technical services (STS), we primarily work with the off shore oil and gas industry and the renewable sector.

Our primary business is dealing with ROV's which we design and build and use to offer a large range of services ranging from inspecting well heads to installing and removing critical components. We employ highly trained staff and look to maintain an efficient and safe work place and are constantly training and improving our staffs skill sets. We also offer competitive prices for the sector and are always looking to improve it.

The Team

CEO/Project Manager – Liam Forbes
CFO / Pilot – Kieran Yule
Head Machinist – David Finnie
Head Electrician – Douglas Leel
Co-pilot – Gareth Swinney



All of our team are looking to peruse different careers in the oil and gas sector of engineering.

Abstract...

Subsea Technical Services (STS) is an ultramodern company which explores and pushes the boundaries of ocean observing systems

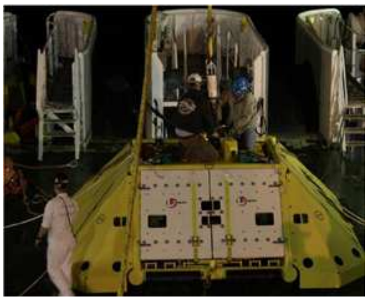
Our task was to design and construct an ROV (Remotely Operated Vehicle), which would be capable of carrying out the tasks for the client. The team spent a total of 7 months designing and constructing the ROV, which was named ROV 13. As this was our first year competing at such an event, the design process was particularly challenging.

This year's task focused on observing the ocean bottom. There were four main tasks in which we designed specific tools on the ROV to carry these out. The four tasks included:

- Completing a primary node and installing a scientific instrument on the seafloor.
- Installing a temperature sensor over a hydrothermal vent opening.
- Replacing an ADCP on a mid-water mooring platform.
- Removing bio fouling from structures and instruments on the seafloor.

ADCP without Biofoul

ADCP withBiofoul



Example of BIA

Specification list

Our ROV must:

- Must have 8 fields of movement
- Must run from 12v DC
- Must have a 25A fuse in line with the battery
- It must comply with all of Mates ROV safety regulations
- Must be able to complete the set challenges

Prototypes

We first of all built a prototype, we used 50mm PVC pipe, we found this shell to be quite large and weak in places. Extra support had to be placed in the final frame to fix the motors in place and to support the front bar,

We used this to get a basic design shape for our current ROV, We encountered several design problems with our prototype e.g.

- The overall size— it was to large to complete the tasks
- The design of the frame—insufficient strength
- Weight—too heavy affecting the buoyancy

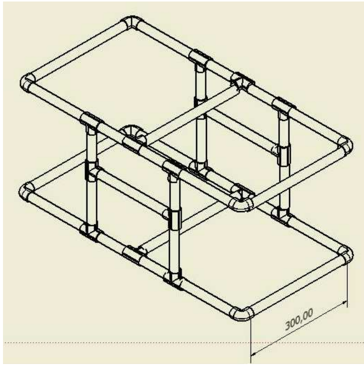
We used the information gathered to design and build the final ROV.

Design Rationale ROV...

Frame

Our frame is built from 21.5mm PVC pipe, this gives us strength, durability at the fraction of the weight. The ROV has been depth tested to 4 meters.

-This is our CAD drawing of the Frame, we created this to give us a guide to work from.

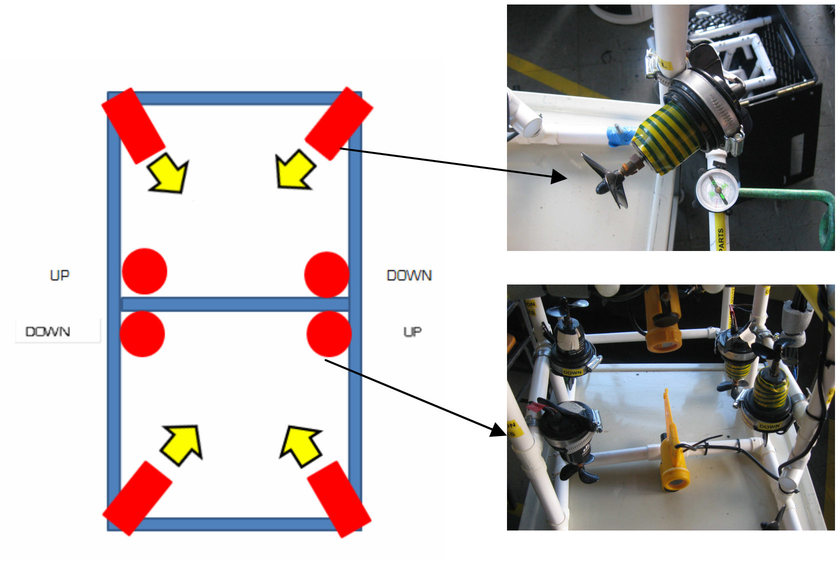


CAD Design

Thrusters

The Thrusters are 650 Gallons per/hour, we have positioned them like this so that we can have 8 directions of control:

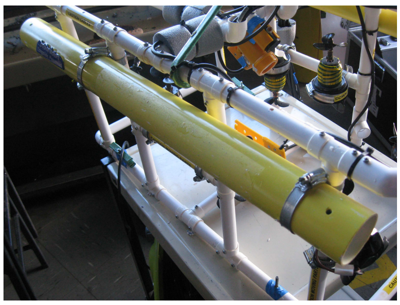
- Forward
- Reverses
- Rotate Left
- Rotate Right
- Strafe Right
- Strafe Left
- Up
- Down



Motor Arrangement

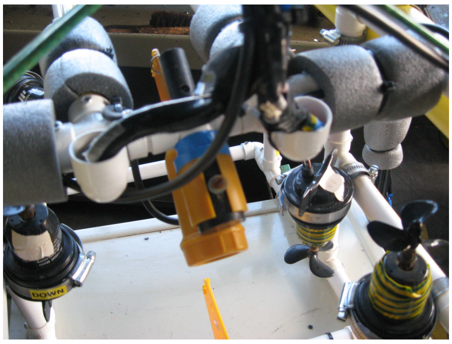
Buoyancy

Our ROV's buoyancy is mostly contained in the two large 50mm pipes, they are filled with high density foam, this gives us his buoyancy using very little weight and space, the rest of the ROV's buoyancy is covered by pipe insulation in the necessary parts that require it, we can compensate by adding small steel weight on the four corners.



Buoyancy tanks

Umbilical/tether



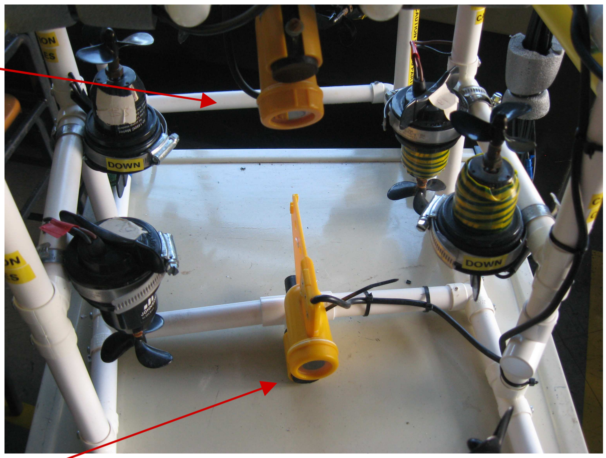
Our ROV's umbilical cable comprises of 12 cables that are permanently attached to the ROV by waterproof cable crimps, this has its advantages and disadvantages, the cables that go down to the ROV are…

- 8 cables for motors
- 3 camera cables
- I cable for the electro magnet

Camera placement

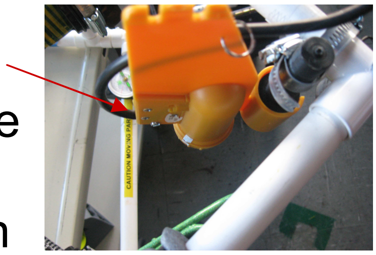
Our ROV has 3 cameras that we have placed in specific places for different tasks/roles.

Camera 1 is mounted at the centre of the upper frame pointed forward and angled down slightly. It is used as the main navigation camera and also gives a view of the tools.

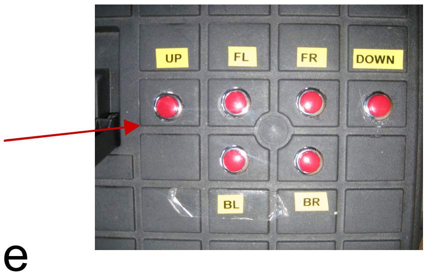


Camera 2 is mounted at the centre of the lower frame giving a straight forward view. It is used mainly for operation using the tools.
Camera 3 is mounted at the very front of the upper frame pointing downwards. It is situated above the electromagnet and is used to place the thermistor and as a means of depth perception.

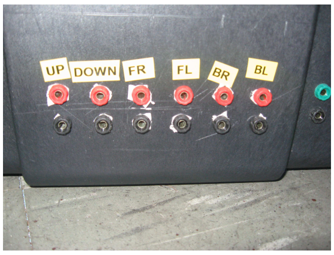
Electronics



The ROV 13 is piloted using six push to make switches. The two motors that provide up thrust are connected together to one switch, as are the motors that provide down thrust. The other four motors are activated by a single switch to each motor. This was found to give a great range of manoeuvrability by activating different combinations of motors.



The wiring for the pumps is hidden inside the frame of the ROV to ensure there is no risk of snagging on external objects.



We also had the idea of using joysticks to pilot the ROV. Pushing the joysticks in different directions activated different combinations of motors. This was achieved using diodes which prevented current flowing to any motor which was not wanted to be on. However the joysticks which we were using were found to overheat after long periods of constant use. After testing both methods of control our pilot found the push switches easier to use, so we decided to use those instead of solving the overheating problem.

Design Rationale Tasks...

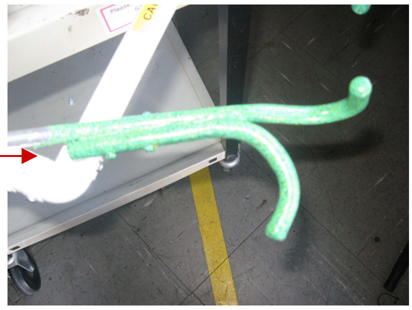
Our ROV was designed in order to carry out a series of subsea tasks set by MATE, we have tried to established the most simple and efficient way as possible to solve the problems. We decided on our final shape on the task specification. Many other ideas were discussed, but it was decided that this was the most optimal solution.

<u>Task 1</u>

The first task involved ten individual steps, which had to be carried out in the correct order to achieve full points.

Step one was to transfer the Scientific Interface Assembly (SIA) to the seafloor. In order to do this, we had to design a grappling hook to hold it. The second step involved installing the SIA within the Backbone Interface Assembly (BIA).

RANGER mission photo #10: SIA inside of BIA. Door open.



The next two steps involved removing the Cable Termination Assembly (CTA) from the sea floor and inserting it into the bulkhead connector. We found these steps particularly easy thanks to our eye on the front which made it easy to pick up the CTA.

In step five, we had to pull a pin which would release the Ocean Bottom Seismometer (OBS) from the elevator. We then had to remove it from the elevator and place it in the

RANGER mission photo #22: OBS in designated area.

designated area on the seafloor. For these steps, we used our grappling hook, which was positioned perfectly for ease of use.

The last three steps of task 1 were slightly more challenging. We firstly had to open the door of the SIA, return to the elevator, pick up the OBS cable connector, and then insert it into the bulkhead connector behind the door.

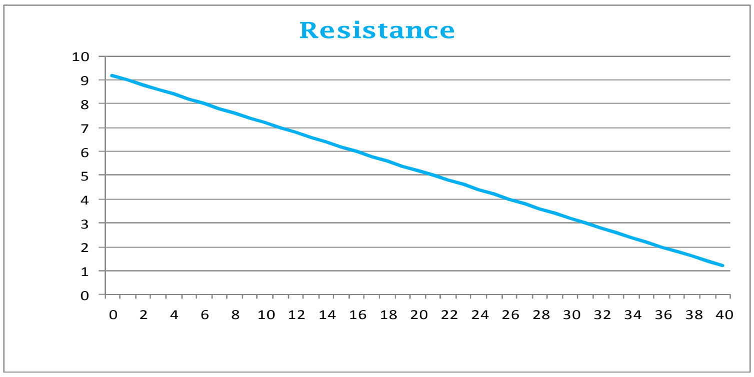
Task 2

Task 2 was to design and install a temperature probe and insert it into the hydrothermal vent on the seafloor to record the temperature of the water flowing from it. It was crucial that it was monitored closely in order to prevent any harm the eco-system and living organisms around it.

RANGER mission photo #23: Vent structure (5-gallon bucket).

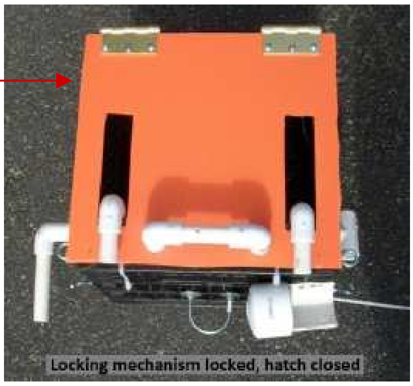
Our solution to this problem was constructing a simple temperature probe which consisted of a thermistor. By measuring its resistance, we created an accurate graphing system to determine the temperature of the water coming out of the hydro thermal vent. Our graph is shown on the next page.

We installed the temperature probe by using an electromagnet, which is controlled by the Co-Pilot. We attached a small piece of steel to



the top of the probe, so it could be fixed on and easily adjusted to suit the pilot's requirements. The electromagnet was the easiest solution to the complex problem. The electromagnet is mounted at the front of the ROV along the top rail directly above the eye and grappling hook.
Our recently added third camera which looks straight down on the tools, helps insert the probe into the vent by giving the pilot a 'birds-eye-view' to aim it in the correct place.

<u>Task 3</u>
Task 3 involved replacing an Acoustic Doppler Current Profiler (ADCP) on a mid-water column mooring platform. This task was also split into 8 different steps which had to be followed in order.

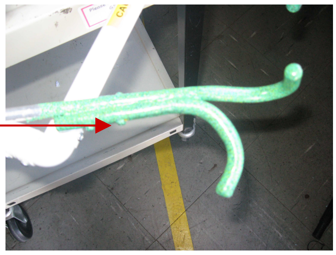


The first step was disconnecting power from the platform. To do this, we used the eye to hook on the plug and remove it. Steps two and three involved turning a handle and opening a hatch. For this step, we used the grappling hook to push up the handle from the side and then to nudge the lid up, and then push it open.


RANGER mission photo #30: ADCP inside cradle inside mooring platform.

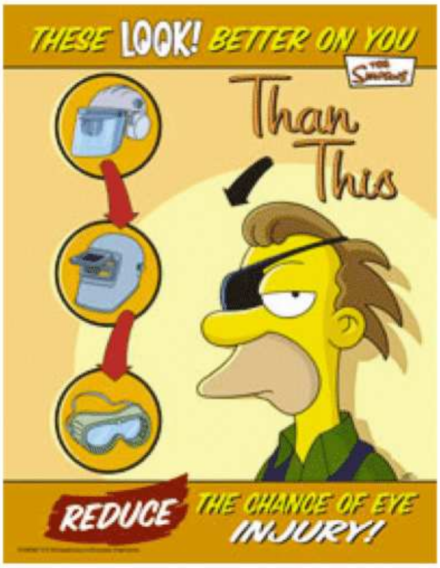
For the next steps, we used our third hook in the middle, which can be guided on the ADCP using the camera at the front which looks down on the tools.
To close the lid, the grappling hook was used to nudge it up and the handle easily rotated again to lock it. The eye was then used to plug the power back into the platform.

Task 4
Task four was to remove bio fouling from the scientific instruments at the bottom of the pool. For this task, we used the grappling hook which could be easily guided on with help from the front camera.



Safety...

Safety was one of our largest concerns, due to the fact that serious injury would have most likely stopped the team to stop taking part in the ROV competition.



It was then crucial that all safety precautions were always taken when building any part of the ROV. When using solvents, soldering or painting, it was always made sure that the room was well ventilated. At the beginning of the build various posters were made, which were placed in the correct areas of the work shop. We used humour as a technique to draw attention to health and safety but it was no laughing matter. When handling the ROV, a checklist was created to make sure that all possible safety hazards on the ROV were checked before use. Examples of what this list included I

- making sure that the propellers were free of debris,
- that there was no exposed wires coming out of the control box,
- all wiring was secure and that no one was present in the pool when the ROV was being used.

There have been no injuries during the build of the ROV we put this down to the extensive and intricate precautions that were put in place.

Future Improvements...

In order to improve the manoeuvrability/stability of the ROV, if we had more time we would investigate the use of a gyro positioned centrally on the ROV. The Gyro would be connected to a computer at the surface. The computer would be able to determine any changes from the norm (i.e. movement not intended by the pilot) and would send appropriate feedback to the motors to correct the movement.

In order to improve safety and performance of the pumps, an improvement may be to design motor housing. This would remove the swirl effect produced from the propellers and would direct more of the flow into thrust. The drawbacks of this idea are that the bulkiness of the housings would reduce camera visibility and add more drag.

An improvement to the umbilical cable next year would be to only have one power cable and 3 camera cables cutting down on weight and space, the only drawback would be that all electronics would be underwater leaving the susceptible to water damage that could un repairable.

Another improvement to the visibility of the ROV could be to design cameras with the ability to rotate on their axis by making waterproof servos. This would Improve visibility and could potentially reduce the number of cameras.

Future improvements...

Another improvement to the frame could be to experiment with other building materials.

We could also continue to design and improve the joystick concept that we have been working on, or even develop a totally different control concept.

Liam Forbes (CEO)

This is our first year competing in the mate competition, and the honour of competing in the international competition. I really appreciated the opportunity to be part of the team which was focused on designing and building a working ROV capable of completing real life tasks. The challenge presented by the competition has not only led us to build a great ROV it has also strengthened friendships.

Kieran Yule (Pilot & CFO)

As this was our first year competing in the MATE competition, winning it was all the more rewarding. When we first started building the ROV, I had very little knowledge of the industry and the jobs available, but since winning the competition, it has broadened my knowledge of the ROV industry. It was also a great pleasure to pilot our first ever ROV, I feel that being part of the team has improved our team working skills and built our friendship!

Douglas Leel (Electrical Engineer & Umbilical management)

Having been the first year we have competed in the MATE competition it felt extremely rewarding having won the regional contest. I found the building of the ROV challenging having tested all my and the group's knowledge, while also being extremely enjoyable. I am very happy with the final ROV and the build has inspired me to pursue a career in the oil and gas engineering sector, hopefully directly to do with ROVs.

David Finnie (Machinist)

I have really enjoyed making the ROV and making the different tools for the challenges we had tackle at the competition. The challenges we encountered were quite hard like the buoyancy and getting the joysticks operational but overall I am really pleased with the Final ROV and I am really proud that we manage to get into the international competition.

Gareth Swinney (PR/Co-Pilot)

This competition has been very exciting and has opened my eyes to the opportunities available in the ROV and Subsea industry. I have found the overall experience very interesting, getting to meet the other teams from the competition. It has proven to be a very good team building exercise.
I have found the designs other teams have developed very interesting and has inspired me for future years.

Acknowledgements...

We would like to thank the following companies for their support, sponsorship and generosity for our project…….

Organisers and Sponsors

Marine Advanced Technical Education Centre
Robert Gordon University, Aberdeen

Competition Sponsors

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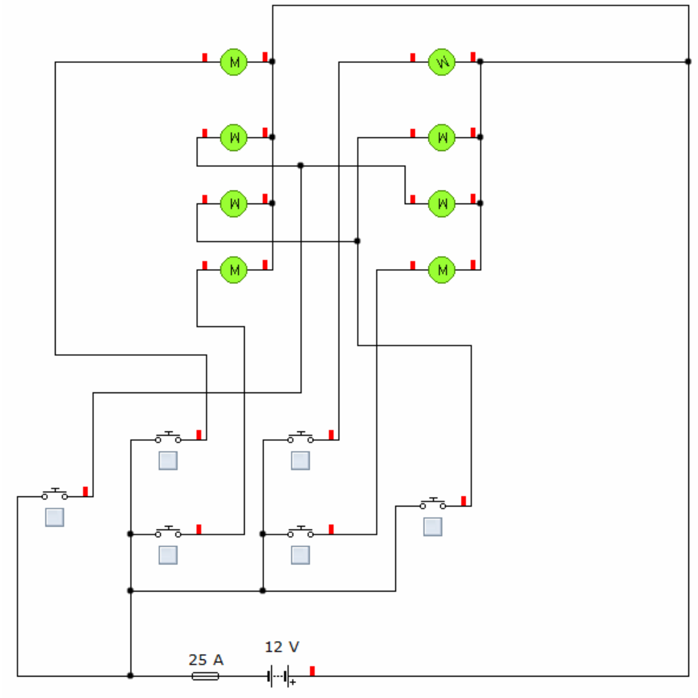
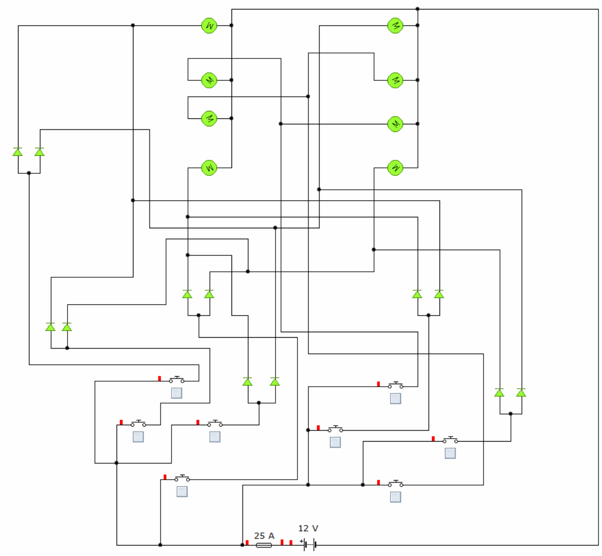
Appendix A

Wiring Schematic for Push to make control Switches



Appendix B

Wiring Schematic for Joystick control box



Appendix C

Finance Sheet

ROV 2013 Budget…

Income		
Dragons Den		£ 250.00
RGU Sponsorship		£ 400.00
Bill Mackie Engineering		£ 250.00
Plumbcentre		£75
Duthie Motors		£45

Expenditure		
Framework		£ 75.00
Bilge Pumps		£ 224.00
Jubilee Clips		£ 15.00
Screens		£ 63.00
Control Box		£ 9.98
Electronic Components		£ 96.00
Tether Reel		£ 24.99
Pipe fittings		£ 45.00
Electro Magnet		£5.00
Cable for Tether		£ 61.18
Propellors and fittings		£ 37.63
T-Shirts		£ 75.00
Pool Time		£ 40.00

Total	£ 1,020.00

Total	£ 771.78

Balance	£ 248.22

Appendix D

Camera Wiring Schematic