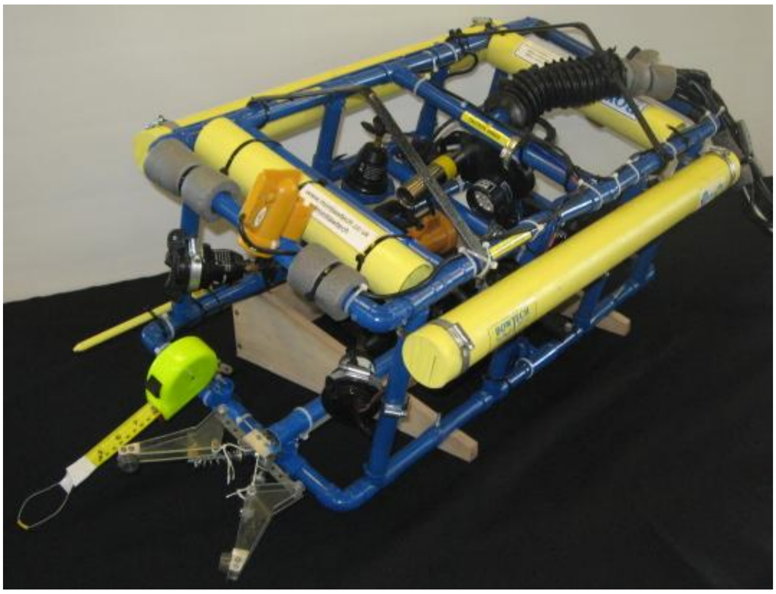
Technical Report

Mintlaw Academy

Aberdeenshire

Scotland



Our Team

Kieran Yule – *Chief Mechanical Engineer, Pilot*

Douglas Leel – *Chief Electrical Engineer*

Liam Forbes – *CEO*

David Finnie – *Machinist*

Scott Turriff – *Chief Machinist*

Gareth Swinney – *Mechanical Engineer, Co-Pilot*

Mentors

Ali Hynd – *Teacher*

Neil Stagg – *BP Mentor*

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1.0 Abstract

Subsea Technical Services (STS) is an innovative company, which designs and manufactures underwater ROVs specifically to meet customer requirements. Our latest project is Poseidon, an ROV particularly suited to exploring shipwrecks.

The Poseidon project has taken the team a total of 10 months to complete, after extensive designing and testing of the vehicle. This year's ROV is a complete rebuild of last year's vehicle, with many new modifications to help improve performance. Poseidon also features many innovative tools, which have been carefully designed to carry out the tasks for the client. It features a fully functioning manipulator, Shipwreck Measuring Device, a detachable Groundwater Conductivity Sensor and detachable Agar Retrieval System. To use these detachable tools, three carefully positioned electromagnets have been attached to the ROV. Together with four carefully positioned underwater cameras, these features allow Poseidon to:

- Explore, document and identify an unknown shipwreck;
- Collect microbial samples, measure the conductivity of groundwater, deploy a sensor and estimate the number of zebra mussels found on a shipwreck;
- Remove trash and debris from a shipwreck and it's surrounding area.

2.0 Introduction to the Team

Kieran Yule 16 | **Chief Mechanical Engineer** | **Poolside - Pilot**

2nd year competing at the International Final

Leaving school for University | Career Goal – Mechanical Engineer

"This is my second year competing at the International Competition. My job as Chief Mechanical Engineer this year brought many new challenges for me. This year I was responsible for designing many of the mission tools, which include the Groundwater Conductivity Sensor and Shipwreck Measuring Device. I was also responsible for designing the Manipulator, which was definitely the most challenging and rewarding part of the whole experience. Competing in the MATE competition has also helped me decide on my future, as it has inspired me to go to University next year to study a Master's degree in Mechanical Engineering."

Douglas Leel 17 | **Chief Electrical Engineer** | **Poolside – Co-Pilot's Assistant**

2nd year competing at the International Final

Leaving school for Apprenticeship | Career Goal – Electrical Engineer

"The project has been a great experience to be involved in over the past two years. It has been a great challenge and has allowed me to apply much of the things I have learnt about in school in a more fun and rewarding way. For me personally while working on the ROV I have learnt that many problems take time and effort to overcome, and has developed my team working and technical skills. Balancing my time spent on the ROV and on my school studies has also helped with my time managing skills."

Liam Forbes 16 | **CEO** | **Poolside – Team Coordinator**

2nd year competing at the International Final

Leaving school for Apprenticeship | Career Goal – Mechanical Engineer

"As this is my last year competing in the MATE ROV competition, it was an honour competing at the regional competition and progressing to the international final in Alpena. I am very grateful for having the opportunity to be part of a winning team for the second year running. The challenges presented by the competition have not only led us to build a great ROV, but it has also strengthened friendships. I would also like to thank MATE for running the competition"

Gareth Swinney
17

Mechanical Engineer

Poolside – Co-Pilot

2nd year competing at the International Final

Returning for 6th Year

Career Goal – Mechanical Engineer

"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 experience very interesting, especially getting to meet the other teams from the competition. It has proven to be a very good team building exercise."

David Finnie
17

Machinist

Poolside – ROV Launch/Recovery

2nd year competing at the International Final

Returning for 6th Year

Career Goal – Mechanical Engineer

"This is my second year competing in the MATE ROV challenge. It has been a really great experience for me, as it has inspired me to further my education in the field of engineering and have a career in the oil and gas industry when I leave school."

Scott Turriff
16

Chief Machinist

Poolside – Tether Management

1st year competing at the International Final

Returning for 6th Year

Career Goal – ROV Pilot/Technician

"It's my first year in the Mintlaw Academy ROV team. My job as chief machinist, in this role I fabricated the metal supports for the ROV and also made some metal tools for the ROV including the bottle retriever or as its also known as the spike. In this role I also made prototype for the manipulator. Although my job was mainly to-do with metal work I'm also responsible for the design and manufacture of the agar retrieval system (ARS). The ROV competition has really made me want to work in the ROV sector in the future and has given me an insight to a whole new job world."

Feb 5th 2014 – Team attend Subsea UK Industry Dinner and described their experience competing in the MATE competition to the local offshore industry attendees.

3.0 Safety

During the Poseidon project, safety was our top priority, as any serious injury would have prevented us from competing in the competition. Our primary goals during the development of Poseidon were to ensure that:

- There was no harm to people;
- No damage was done to equipment;
- There was no harm to the environment (Particularly around the shipwreck site).

To prevent any injuries while working in the workshop, all team members had to follow a strict safety protocol. This included:

- Wearing safety goggles at ALL times when using power tools.
- Wearing closed toed shoes in the workshop at ALL times.
- Removing jewellery and tying up any lose clothing/hair when using machines.

When building Posiedon, many solvents and paints were also used, so it was always made sure that the room was well ventilated before work commenced. Gloves and aprons were also worn to prevent any harm to skin from the solvents.

Before the vehicle is placed in the water, the pilot must go through a Pre-Flight Safety Checklist (See Appendix) to ensure that the ROV is safe to enter the water. This allows us to identify any problems and address them quickly before the vehicle is launched.

The vehicle itself has many safety features this year as well. Our most innovative safety feature this year is the heatshrink sleevling we added to the ends of the jubilee clips. Each and every one has been covered this year to prevent any scratches when working inside the frame. This was particularly important this year as there is limited space to work inside the frame due to the added motors for the manipulator.

All wires for the propellers are also housed within the PVC pipe to prevent damage from external objects. This also helps improve the overall asthetics of the vehicle as there are only a few wires which are visible. A 25A fuse has also been added to the positive lead of the main power connection to comply with the rules and also to prevent any damage inside the control box due to excessive currents.

4.1 Frame

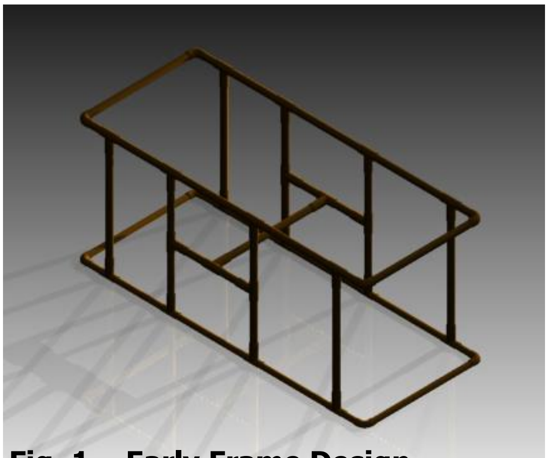
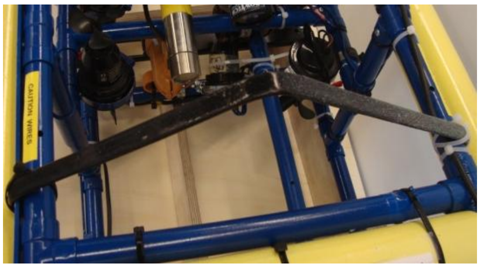


Fig. 1 – Early Frame Design

Poseidon is primarily constructed from 21.5mm PVC pipe, much like its predecessor ROV 13. This material was chosen for it's strength, and allows us to keep all wires from the bilge pumps internal to prevent snagging on any objects around it. The general layout of the frame is similar to previous designs, but a number of extra members have been added this year to strengthen the frame, and accommodate motors to control the manipulator.

On the top of the frame, an extra member has been added, 100mm in from the front bar. The front of the ROV has also changed, as both the top and bottom are now square, unlike last year's triangular front. By design reviews, it was decided that this was no longer necessary as it was only needed for placing the temperature probe with the electromagnet. The advantages of the two extra members on the front, are that they provide a facility for camera placement and to attach buoyancy.

The overall dimensions of the frame this year are 900mm X 350mm X 300mm. This means the ROV has approximately 125mm clearance at each side when entering the shipwreck through the 60x60cm opening. To Lift the frame of the ROV, we designed two handles which are attached at the front and back of the frame. Each handle is manufactured from mild steel that has been plastic dip coated. This provides excellent corrosion protection for shipwreck intervention.



4.2 Propulsion

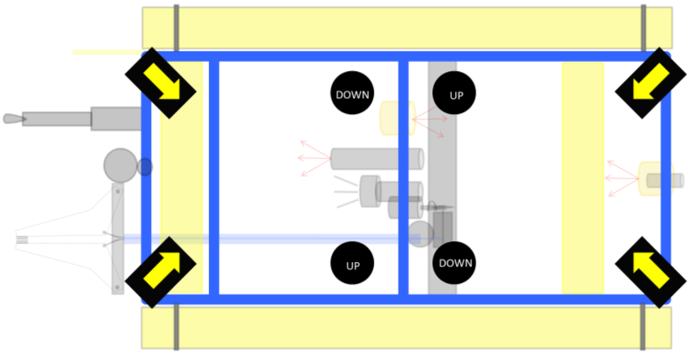


Fig. 2 – Thrust Vector Diagram

Poseidon is equipped with 8x2800 litres per/hour Johnson bilge pumps which give the vehicle 8 degrees of movement; forward, backward, crab left, crab right, rotate left, rotate right, up and down. Each bilge pump has been stripped down to the pump, with a plastic model boat 3-blade propeller added. Each propellor is screwed on to a threaded bar which is secured to a brass coupling by a split pin. A small grub screw is then tightened until the brass fitting is secured to the shaft of the motor.

Initially, we had developed our own bracket to fix the motors onto the frame, but these were found to be weaker than expected. The brackets also left the horizontal motors sticking too far inside the frame, therefore decreasing the manouverability of the vehicle, as the two front and two back motors were very close to each other. To resolve this, we fixed each bilge pump to the frame using two jubilee clips for each motor. This allows the pitch and vectored angle of the motors to be easily set for optimum thrust efficiency, and each motor can be easily removed from the vehicle if there is a problem. A small jubilee clip is tightened around the PVC pipe on the frame, and a larger one is secured around the bilge pump.

Motor shrouds were also developed early on in the project to cover the motors. They were constructed from mild steel, and were spot welded together. As we progressed to the testing stage with the vehicle, we discovered that they were too heavy, and that they would need to be manuafactured from a different material in order to work effeciently. As the vehicle was already heavier than our design intent, we decided not to use them.

4.3 Buoyancy

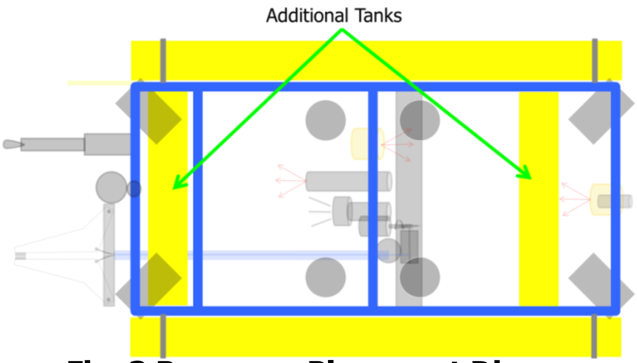
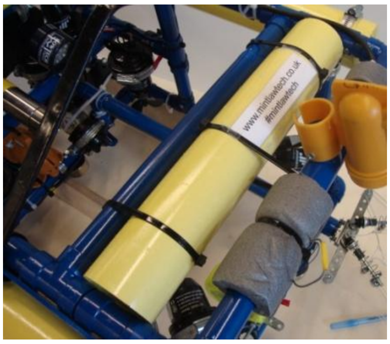


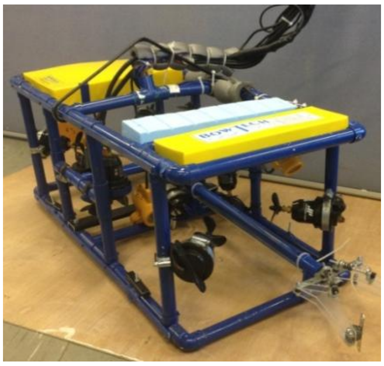
Fig. 3 Buoyancy Placement Diagram

Poseidon's buoyancy is contained inside four 50mm diameter pipes much like last year. Two of which are attached along the full length of the vehicle, and the other two placed inside the frame at the front and back. The positioning of the buoyancy gives the ROV a high degree of stability, and makes any adjustments easy to make. The extra tanks were added this year as Poseidon weighs considerably more in air than last year's vehicle. This is due the addition of the manipulator and Shipwreck Measuring Device on the front of the vehicle.



To make Poseidon as close to neutral as possible in water, we used our 1000 litre test tank for concept trials to achieve the required in-water performance. A trial and error approach was taken, and buoyancy was either added or taken off depending on whether it was positively or negatively buoyant. Once the buoyancy was almost neutral, we used small dive weights, which we manufactured ourselves. The weights and made from 8cm long strips of mild steel which were plastic dip coated to prevent corrosion. Each one weighs approximately 25g in air, and is attached using a 4mm bolt on one of the four corners of the vehicle depending on where the vehicle requires trim.

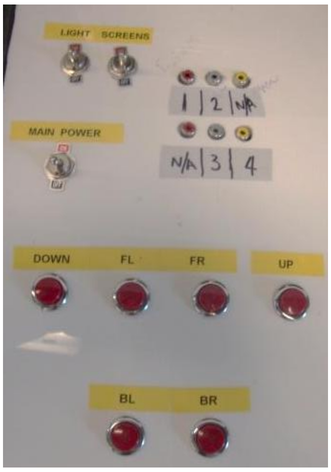
This year, we also trialled with a different buoyancy design. We initially had three slabs of buoyancy across the top of the frame to help with stability. Unfortunately during test we found that this was causing too much drag vertically, therefore causing the vehicle to take considerably longer to travel to the top or bottom of the pool. This, along with the increased drag due to its weight, made us decide to switch back to the buoyancy tanks used last year, which allow the vehicle to travel faster through the water.



4.4 Electronics & Control System

Poseidon's control system has been carefully designed to make the ROV easy to fly and maximise its manoeuvrability. Our control box was also carefully planned out to optimise user dexterity, with each button and switch positioned exactly where the pilot needs it.

All of the screens and controls are now neatly fitted into one case, which helps save storage space and aids speedy mobilisation to the site. Inside the box, are three TFT Colour Monitors which display the outputs from the cameras. The bottom screen is wired to two different cameras; the reversing camera and the rear camera. When entering the shipwreck, the co-pilot can easily switch between the two cameras by pressing the AV1/AV2 button. Each camera has its own LED Light which assists navigating in low light areas of the site. A 1amp fuse is also fitted in line with each camera to help prevent damage if a short circuit were caused by a fault.



The controls for Poseidon are much like last years, but with added switches for the manipulator and screens. The two up and two down motors are wired in parallel, and activated by the up or down button as shown. The four horizontal motors are controlled individually, by pressing each individual button. Each combination of buttons being pressed will make the ROV move in a different way. For example, if Poseidon is required to move forward, the pilot presses the buttons for both the front left and front right motor. For more accurate manoeuvres, the pilot can activate one motor at a time.

The manipulator controls are slightly different. Because the manipulator is controlled using the same specification motors as incorporated in the thruster units, this means the manipulator controls are very fast. To prevent overshooting the desired position every time, a Double Pole-Double Throw switch is wired to both the rotate and open/close buttons. A push button is also wired in series. For arm rotation, the pilot must first select the direction to turn using the DPDT switch, and then to activate the motor, must press the push button. Having this configuration means the co-pilot can tap the button quickly if he is trying to line it up at 90°. This is also used as a safety feature for the claw, to prevent it being accidentally switched on and winched in too far which would damage the mechanisms and the motor.

For excitation of the electromagnet, a simple toggle switch is used to switch the electromagnet on or off. Three other toggle switches have been added in addition. For safety, a main power switch has been added to cut off power to all motors. Another has been added to switch off the TFT Monitors when not in use to save the battery, and a third one has been added to switch the LED light on or off when required.

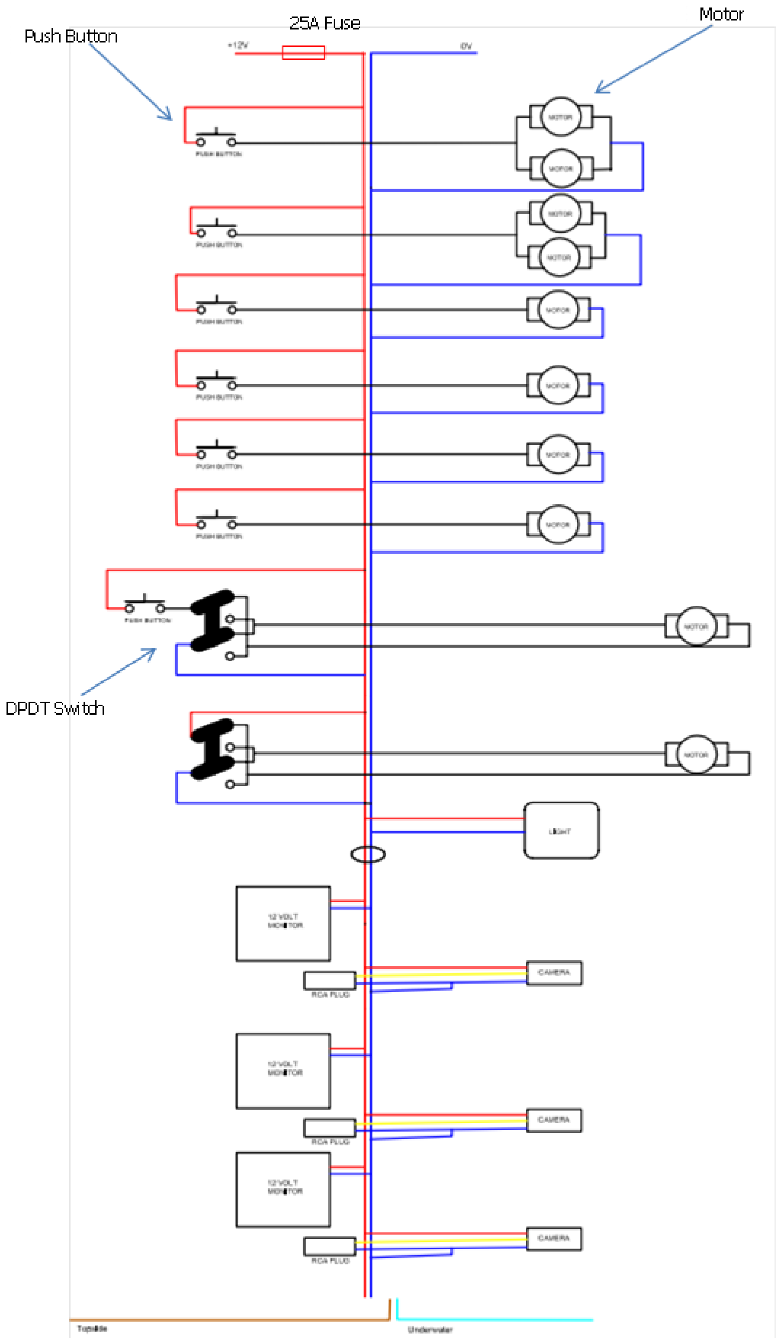


Fig. 4 System Integration Diagram

Additional Development

This year, STS began trials of a different kind of control system. We were initially going to have a Joystick control system, which would be run off Arduino programming boards. Because Arduino was new to our team, our electrical engineer Mr Douglas Leel had to acquire expertise in the language of Arduino in order for us to use it. After several months, a phase 1 program was written. Unfortunately, the STS team incurred problems with the power output from the boards. Although the program worked well, the Arduino motor drivers were not supplying the motors with enough current, therefore slowing the vehicle down. Further development is planned by STS for future campaigns.

4.5 Tether

This year's tether consists of 10 multi-core wires, 4 camera wires and 1 coaxial cable.

The multicore wires are used to drive the motors for flying and control of the manipulator, as well as the electromagnets. The main ROV camera has a separate power line from the other cameras, so requires a separate coaxial cable for the camera feed.

The wires from each motor run through the PVC pipes in the frame, and exit at the top of the frame through a T-piece. The wires are then attached to the tether. The connections are protected from contamination and interference using heat shrink crimps, which means the tether is permanently attached to the vehicle. The tether is approximately 20 meters long, and is retro fitted using plugs into the control box using 3 7-pin power connectors, and multiple banana plugs. This allows us to disconnect the tether from the control box in a quick and safe manner at the end of the mission time.

4.6 Cameras & Lighting

Poseidon is fitted with four underwater cameras and a single LED light. Each camera has been carefully positioned to optimise its zone of coverage in order to provide the best work scene for the pilot. Since only 3 monitors are permitted in the control box, we have to switch between camera 3 and 4 on one of the monitors, depending on which one is more useful for the task in hand.

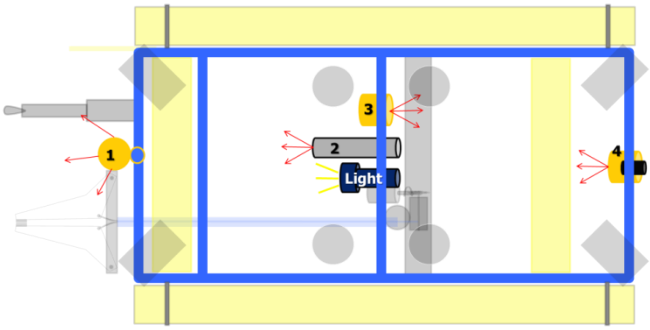
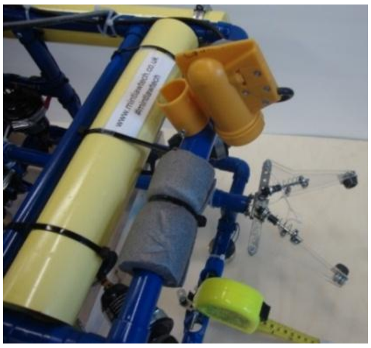


Fig.5 Camera & Light Placement Diagram

Camera 1

Camera 1, is positioned on the front top bar of the ROV, facing down on the manipulator and Shipwreck Measuring Device. This view allows the pilot to see the claw from above and help judge when to close it when grabbing an object. This camera is also used to attach the Shipwreck Measuring Device to the shipwreck, and read the two horizontal measurements. In addition, this camera can be used to position the quadrat over the shipwreck, count the mussels inside it and place the replacement sensor string in the designated area.

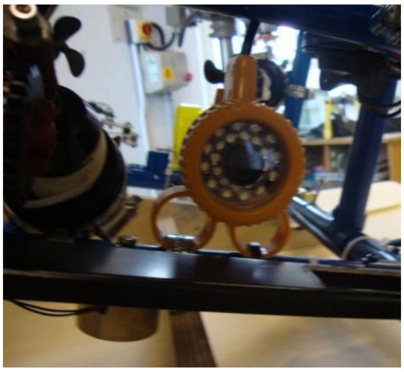


Camera 2

Camera 2, is positioned centrally on the top middle bar of the ROV, and is used as our main navigating camera. This is an industry specification ROV camera, and gives us a much sharper image in comparison to the other three cameras. Camera 2 is the most used camera on Poseidon, as it can be used for multiple tasks. These include determining the cargo and type of ship, attaching objects to the manipulator and obtaining the vertical measurement from the Shipwreck Measuring Device.

Camera 3

Camera 3, is positioned on the bottom middle bar of the ROV, just to the right of the manipulator mechanism. This is our reversing camera, which is particularly useful for navigating out of the shipwreck and scanning the three targets, as it is the only camera on the vehicle positioned horizontally. This camera also provides additional benefits for monitoring the tether behind the ROV. The pilot can easily observe any tether interference or obstructions.



Camera 4

Camera 4, is positioned centrally on the top rear bar of the frame facing down towards the manipulator mechanism and the central electromagnet. This camera angle is used to attach the Agar Retrieval System and Groundwater Conductivity Sensor to the electromagnets, and guide them over their specific areas. In addition, the camera also gives the pilot a clear view of the manipulator mechanism, which could be useful when identifying any problems with the manipulator while in operation.

ROV Light

This year's tasks require our vehicle to be able to work in low light environments, so we added an LED light to our ROV. The light is industry specification (Bowtech), and gives out 800 Lumens. The light is switched on by a toggle switch in the control box, so the pilot can choose when to use it. The light is intended for navigation inside the shipwreck, as the light level inside is considerably lower than outside the ship.

4.7 Mission Tools

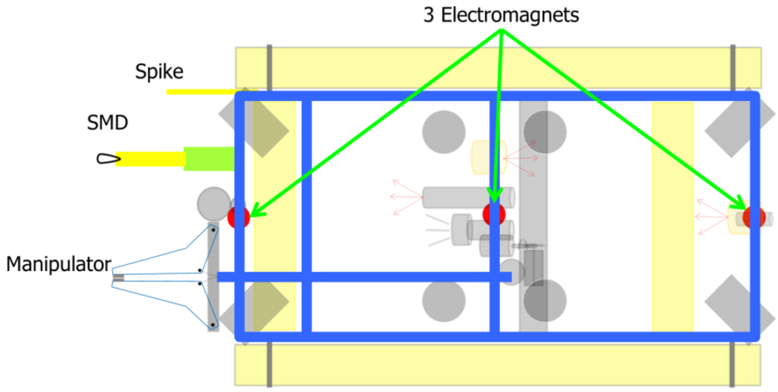


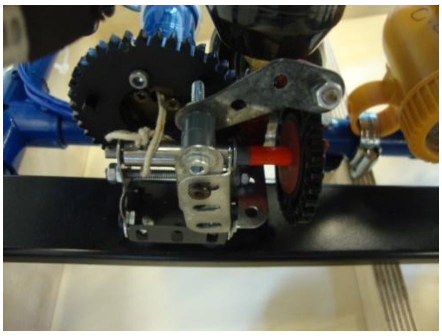
Fig.6 Payload Tool Placement

Manipulator

Poseidon features a multipurpose manipulator, which can grab objects and rotate 360°. One of ROV 13's design shortfalls was that it featured five different hooks of different shapes to carry out the various tasks. So when designing Poseidon, building a manipulator was top priority, as it would allow us to complete multiple tasks using the one tool.

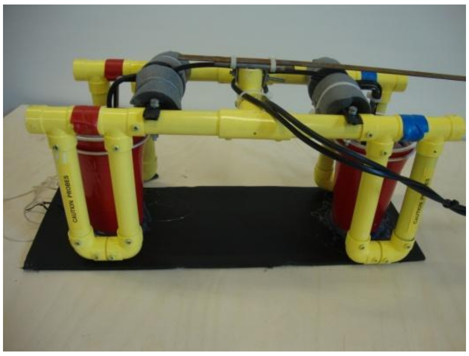
The manipulator can be used to – remove and retrieve the rope debris from the shipwreck opening, recover the ceramic dinner plate, retrieve the Agar Retrieval System, replace the sensor string and place the quadrat.

When designing the manipulator, we designed multiple prototypes and tried many different designs. After many attempts, we finally developed the concept of using string to close the grabber. This was the only solution which allowed us to rotate the arm without having the motor which closed the arm move with it.

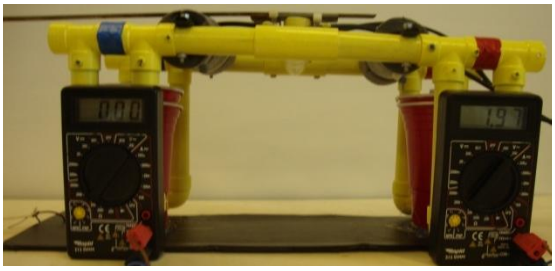


The manipulator was designed and built beginning with pencil concepts, and is constructed from clear acrylic, Meccano and angle aluminium. After trials, two rubber feet were added to each arm to provide a good grip when closed. The manipulator is bolted onto a round bar of plastic which is fixed inside a T-Piece, and screwed to a length of PVC Pipe which extends to the centre bar of the frame. The mechanisms for the arm are housed in the centre of the frame to help balance the ROV, and prevent it being front heavy. To open and close the manipulator, a bilge pump with a worm wheel winches in the string which runs through the PVC pipe back to the two arms. The motor can then be reversed, and the springs on each arm open the manipulator as the string is paid out from the winch. To rotate the manipulator, another bilge pump with a worm wheel turns a gear wheel which is bolted to the plastic bar. This plastic bar is also screwed onto the PVC pipe which is fixed to the manipulator, so when the gear wheel turns, the whole pipe and manipulator rotate too.

Groundwater Conductivity Sensor (GCS)



One of Subsea Technical Services most innovative tools is the Groundwater Conductivity Sensor (GCS). The GCS is constructed from ¾" PVC pipe and features two probes which can simultaneously measure the conductivity of the groundwater from each sinkhole. Each probe consists of two cable connectors from which two 50mm panel pins are secured, and are designed to penetrate through the cling film to take a reading. The two probes are connected to separate multimeters on the surface, from which a resistance reading is obtained by the co-pilot. In actual shipwreck intervention activities we expect to detect differences between sinkhole and seawater salinity levels, so the resistance of the water from the sinkhole should be considerably lower than the resistance of the seawater. Therefore, the co-pilot can easily identify which is venting groundwater.



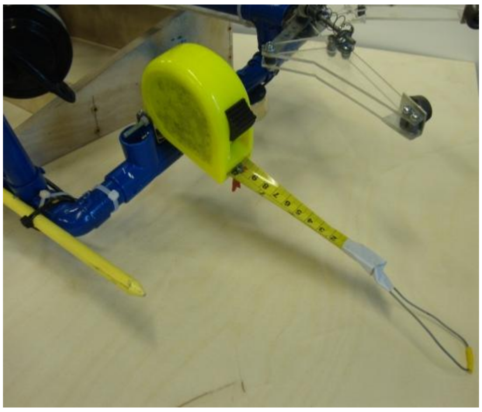
To deploy the sensor, a mild steel bar on top of the GCS is attached to two of the three electromagnets underneath the ROV to prevent it rotating when the ROV rotates. This allows the GCS to be easily positioned over the two vents using the back camera to navigate. By having the GCS attached underneath the frame, the downwards thrust from the motors also help the probes to penetrate through the cling film. Once the sensor is in place, the co-pilot can switch off the electromagnet so that the pilot can move on and complete other tasks. The use of the electromagnet also allows the pilot to retrieve the GCS quickly and efficiently after the mission time during the demobilisation period.

Agar Retrieval System (ARS)

Another one of Subsea Technical Services innovative tools is the Agar Retrieval System (ARS). The ARS consists of a 500ml measuring cylinder which has been cut in half, and can hold a maximum of 250ml of agar when full. The device was designed to be used upside down, and has a small hole drilled under it. A small single acting spring return valve is fitted over the hole to allow water and air to escape.

To pick up the ARS, an electromagnet underneath the frame is attached to the top of the device, and the ROV flies directly over the cup. To take the sample, the device is pushed down into the cup under the power of the ROV. When the ARS is pushed below the surface of the agar, the air/water begins escaping through the spring return valve forming a vacuum between the agar and cylinder. The electromagnet is then turned off, and through the use of the manipulator, the ROV can grab the ARS and the sample can be easily retrieved from the cup, and returned to the surface.

Shipwreck Measuring Device (SMD)



To measure the dimensions of the shipwreck, Poseidon features a simple but effective measuring tool. The shipwreck measuring device is constructed from a basic 8m tape measure, and is attached to a Meccano bracket which is held by two T-pieces. A shaft which runs through the back of the tape measure, holds the tape between the two brackets, and allows the tape to tilt up and down so the ROV can take measurements both horizontally and vertically. The SMD can also be stowed in the upright position when not in use to avoid interference with any of the other tools.

To take a measurement, a wire on the end of the tape is looped around one of the four screws located on the corners of the shipwreck. To measure horizontally, the ROV must reverse away from the corner along the length or width of the ship. Once the tape has been extended past the next screw, a reading in inches is obtained on the front most camera which faces down on the SMD and manipulator. The co-pilot then uses our inches to meters conversion chart to convert the measurement to meters as required by MATE. We chose to use the inches measurement because the numbers on the tape were easier to read, and continued increasing rather than the meters scale which only went up to 99cm then returned to 1m and 1cm ect.

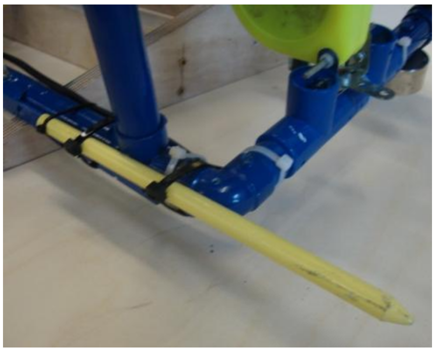
To measure vertically, the wire is again looped around the screw, but this time the ROV must fly straight down until it reaches the pool bottom. As the tape is quite high up on the ROV, the co-pilot has to add an extra 6 inches to the measurement obtained on the main camera. Again, this is converted into meters on the conversion chart. Once these measurements are obtained, the co-pilot can then calculate the surface area of the ship, so the number of zebra mussels can be estimated. To easily calculate the number of mussels, STS also created a step-by-step calculations sheet (see appendix), which allows a member of the team to quickly substitute in the measurements and do the calculations.

Electromagnets

Poseidon also features three electromagnets positioned centrally on the front, middle and back bottom bars. Two of these electromagnets can lift up to 25kg each in air, so are more than capable of lifting objects under water. The electromagnets are used to deploy the Groundwater Conductivity Sensor and Agar Retrieval System at the site of the shipwreck. Having three electromagnets also gives us flexibilty, as the front or rear camera can be used to position objects under the water.

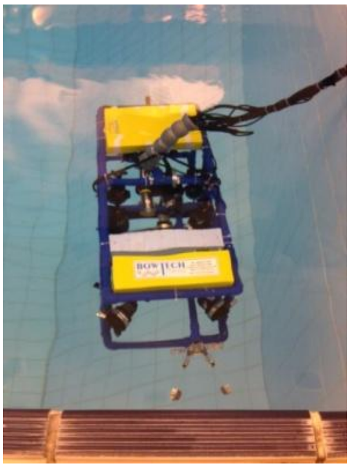
Spike

To retrieve the two bottles from the bottom of the pool, STS also added a simple spike to the front of Poseidon. The spike is made from a 10mm diameter rod of aluminium which is attached to the right side of the frame. All that the pilot has to do is guide the spike inside the open end of the bottle, and lift the bottle up. The pilot can then fly to the surface where the bottle can be easily grabbed by a member of the team.



4.8 Testing & Troubleshooting

To prepare Poseidon for Michigan exploration campaigns, we have so far had around 30 hours of vehicle testing. To test the vehicle, we were given regular access to our local community diving pool. The diving pool provided a means to test both the control system and to improve the performance of the vehicle. This year, we also attempted to construct all of the mission props, so we could test all of our payload tools as soon as they were added to the vehicle.



During our first test, we discovered that the vehicle was extremely slow moving in the water. Initially, we thought that it was just the increased drag from the vehicle that was slowing it down, but it wasn't. To solve the problem, we worked through a process of elimination. We firstly checked that none of the motors were turning in the opposite direction from each other. We then went back to basics, and bypassed the programming boards and wired the motors straight to the supply. It was found that the vehicle was moving considerably faster; therefore, it would appear the Arduino motor drivers were not supplying a high enough current to the motors. New trials used a transistor and relay circuit to power the motors, and the Arduino only needed to supply a small current to the base of the transistor. Unfortunately we found that there was still a lack of power being supplied to the motors, so the decision was made to return to a hardwired control system that we knew would work.

Testing of the manipulator was also crucial early on during the project, as we discovered that the string was easily snapped when the manipulator was closed. We trialled over 20 different types of string, ranging from bike brake cable to fishing wire. In the end, we found a string which was both flexible and strong, and which doesn't stretch or break when put under any strain.

5.0 Finances

Costs in USD				
Category	**Description**	**Company**	**Value of Materials & Services**	**Amount Spent in 2014**
Frame	PVC Piping & Fittings	Plumb Centre	$116.36	$116.36
Propulsion	4x Bilge Pumps	Bill Mackie Engineering	$155.23	$155.23
	8x Bilge Pumps	Bill Mackie Engineering	$310.46	Re-used
	Propellers & Fittings	Cornwall Model Boats Ltd.	$63.49	Re-used
	Jubilee Clips	Buchan Power Tools	$25.31	$25.31
Control System	Arduino Controllers	Rapid Electronics	$188.98	Donated
	Joystick		$67.49	Donated
	Control Case	Trojan Cases Ltd.	$422.00	Donated
	Electronics Components	Maplin Electronics	$84.36	$84.36
Cameras	3x CNM Underwater Cameras	Robert Gordon University	$430.00	Re-used
	Industry Spec. Camera	Bowtech Products Ltd.	$2,500.00	Donated
	Industry Spec. LED Light	Bowtech Products Ltd.	$1,300.00	Donated
	TFT Monitors		$106.30	Re-used
Tether	Cable for tether	Rapid Electronics	$141.73	$141.73
	Buoyancy For tether	B & Q	$31.64	$31.64
	3x 7 Pin Cable Connectors	B & Q	$12.65	$12.65
	Industry Spec. Tether*	Hydro Group Plc.	$435.00	Donated
Payload Tools	Components for Manipulator		$8.44	Donated
	Tape Measure	B & Q	$3.37	$3.37
	2x 25kg Electromagnets	Rapid Electronics	$47.24	$47.24
	10kg Electromagnet	RS Components	$8.44	Re-used
Miscellaneous	4x Paint Cans	B & Q	$40.50	$40.50
	Cost of trip to Alpena*	Robert Gordon University	$14,342	Provided as a stand alone entity
		Project Total Value	**$6,498.99**	**$658.39**
		Including Travel	**$20,840.99**	

* Denotes estimate of future expense.

Income	
Income	**Amount**
Rollover from 2013	$418.82
Donations from members of the local community	$168.73
Subsea UK	$1,265.47
Round Table	$419.97
Total	**$2,272.99**

Total out of pocket expenditure	$658.39
Total Income	$2,272.99
Balance	**$1,614.60**

6.1 Future Improvements

In order to provide a reliable and safe service to our customers, it is important that Subsea Technical Services continues to innovate and make improvements to it's existing designs. Even though **Poseidon** is a huge step up from ROV 13, there are certain areas that STS consider, given more time, could be developed further to improve Poseidon's performance.

The first of which is the control system. Now that we know more about Arduino programming boards, we would like to develop the joystick concept further and make it our primary control system. This is STS's primary goal for next year. It would also move us closer to having all of our electronics on-board, which would help reduce the size of our tether considerably. This is another area we would like to improve on. Our current tether has 15 cables in it, which causes excessive drag and in turn slows the vehicle down. By having all of the electronics on-board, we would only have a main power cable and the camera feeds running down the tether therefore reducing the weight of it in air.

6.2 Lessons Learned

STS will continue to reap the benefits of a development team with a strong broad skills base, and is highly committed to making future improvements. The teamwork involved in the development of Poseidon has stimulated new skills of teamwork and commercial appreciation. Our rigid safety policy also ensured no one was injured during development works.

6.3 Challenges Faced

The team developed a strategy for fitting the Arduino programming system into the Poseidon for testing. The development required in-water tests to assess the responsiveness of the vehicle. Unfortunately through in-water trials, the vehicle thruster units were found to be delivering insufficient hydraulic effort. By process of elimination, each thruster was checked out in turn and a relay board trialled. During the development, the team also held regular design reviews using a whiteboard and sketch pads to discuss a possible solution and way forward. We found that by holding entire team reviews for a full engagement in the problem, we were able to discuss and eliminate non-contributing factors to establish that we were still incurring in-line resistance and insufficient current draw by thruster units rather than a direct fault of the Arduino boards.

7.0 Acknowledgements

STS would like to thank the following companies and individuals for their kind support and sponsorship throughout the Poseidon project-

Our Mentor, Neil Stagg from BP
Our Teacher, Ali Hynd

Competition Sponsors

Our Team Sponsors

8.1 – Appendix A

2014 International MATE ROV Competition
Pre-Flight Safety Checklist

Item	✓	✓
All Moving parts clear of debris and hands.		
Camera + Light Checks		
Camera 1 (Front) on and positioned correctly.		
Camera 2 (Main) on and positioned correctly.		
Camera 3 (Reverse) on and positioned correctly.		
Camera 4 (Back) on and positioned correctly.		
Bowtech Light operating correctly.		
Motor Checks		
Up motors operating.		
Down motors operating.		
Front Left motor operating.		
Front Right motor operating.		
Back left motor operating.		
Back right motor operating.		
Electromagnet Checks		
Electromagnet switched on and operating.(Test with strip of metal)		
Manipulator Checks		
Claw opening and closing without interference.		
Claw Rotating both directions without interference.		
Shipwreck Measuring Device		
SMD unlocked, tape free to move and SMD stowed correctly.		
Final Checks		
Tether secured to table and laid out neatly.		
ROV placed in water.		
ROV buoyancy close to neutral.		
START PROCEDURE		

8.2 - Appendix B

2014 International MATE ROV Competition
Task Info – Calculations for Task #2

Task #1 – Dimensions of the Shipwreck

Length(L) ______m	Width(W) ______m	Height(H) ______m

Task #2 – Estimating the number of zebra mussels on the shipwreck.

Using the dimensions from Task #1, first calculate the surface area (SA):

Two Sides	2 x L ____ x H ____	=	________m^2
Front & Back	2 x W ____ x H ____	=	________m^2
Top	L ____ x W ____	=	________m^2
	Total Surface Area (SA)	**=**	________m^2

Now count the number of mussels inside the quadrat, and calculate the number of mussels per m^2:

No. of Mussels in Quadrat **(M)** = ______

No. of Mussels per m^2 **(N)**= **M** ____ x **4** = ______ per m^2

Finally, calculate the number of mussels on the shipwreck:

No. of Mussels = **SA** __ x **N** __ = ____ **Mussels**

8.3 – Appendix C

Poseidon Development Schedule