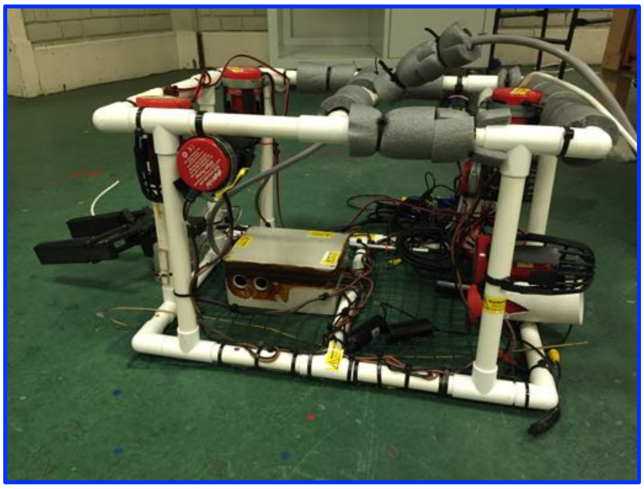
Technical Documentation
Blue Toon ROVers

Peterhead Academy
Aberdeenshire
Scotland



Team Members:
Jamie Fenty – CEO & Marketing Team Leader
Ian Buchan – Pilot & Control/Tooling Team Leader
Callum Christie – Co-Pilot & Design/Structure Team Leader
Sean Whyte – CFO & Structural Engineer
Daniel Mehigan – Electrical Engineer
Aaron Reid – Safety Consultant
Stuart Hope – Company Communications
Lauren Godfrey – Research and Development
Ewan Marr – Electrical Technician
Kieran Ritchie – Frame Technician

Mentors:
Steve Summers (DOF Subsea)
Fiona Loudon (Teacher)

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1.0 – Blue Toon ROVers Introduction

1.1 – Abstract

Blue Toon ROVers are a company who strive to provide maximum satisfaction to all of their clients by creating innovative Remotely Operated Vehicle's (ROV's), which carry out their desired tasks in a safe, cost-effective and environmental friendly manner. The versatility of experience and specialisations within our company allow us to create a vehicle with unique abilities based on our clients' requirements.

This year's clients are MATE Center, Polar Scientists and Offshore Oil and Gas Industry Executives who require our latest model, "Njord", to specialise in subsea exploration in polar areas with icebergs. The intricate design and maneuverability of Njord allows our company to meet the desired needs of our clients.

Our company endeavours to design and improve our vehicle to become the best available on the market. Njord is controlled by a two proportional movement joysticks, which put the Pilot in full control of the ROV and allows the Co-Pilot to analyse the surroundings and advise the Pilot on each mission. Our multiple onboard cameras provide an excellent first-person view of the vehicle in operation heightening the Pilot's control and the efficiency of the task at hand.

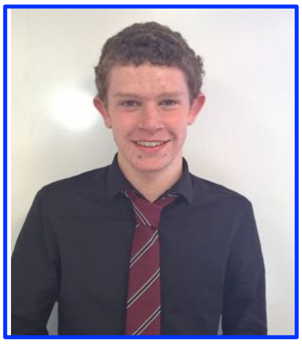
ROV Njord is constructed in a simple manner allowing our engineers to fine-tune the vehicle and make any adjustments quickly and efficiently. The safety of our employees is paramount therefore we ensure that the working conditions are the safest possible and all of the components of the ROV have been safeguarded in the correct manner protecting the working environment of Njord.

1.2 – Mission Statement

The main of objective of the Blue Toon ROVers is to provide the best service to our customers and fully satisfy their given specifications. Our ROV's must be cost-effective and environmentally friendly in order for our product to be the best available. We strive to self improve our company's structure along with our products to suit the needs of our clients. Blue Toon ROVers continue to research new control methods and payload tools that we could invest in and develop to make our ROV as versatile as possible. We ensure that Project Njord is best suited for the tasks involved in this year's competition. We abide by our company motto of "taking engineering to new depths" whilst creating the best marketable vehicle for our clients.

1.3 – Meet Our Team

Jamie Fenty – 17 (6th Year)
Company Role: CEO/Safety and Marketing Team Leader
Poolside Role: CEO and Communications
MATE Competition: 2nd Year in team, 1st International Final
Area of Expertise: Company Marketing
Current Plans: Leaving school for University
Career Goal: Chemical/Process Engineer



Ian Buchan – 16 (4th Year)
Company Role: Control and Tooling Team Leader
Poolside Role: Pilot
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Electronics
Current Plans: Staying on for 5th Year at school
Career Goal: ROV Pilot/Technician

Callum Christie – 17 (6th Year)
Company Role: Design and Structure Team Leader
Poolside Role: Co – Pilot
MATE Competition: 2nd Year in team, 1st International Final
Area of Expertise: Designing/Frame
Current Plans: University to study Mechanical Engineering
Career Goal: Mechanical Engineer

Sean Whyte – 17 (5th Year)
Company Role: CFO/Structural Engineer
Poolside Role: Tether Management
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Frame design and construction, Budgeting
Current Plans: Leaving school for an Apprenticeship
Career Goal: Mechanical Engineer

Daniel Mehigan – 16 (4th Year)
Company Role: Electrical Engineer
Poolside Role: ROV Launch/Recovery
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Control System
Current Plans: College (Mechanical PEO)
Career Goal: ROV Industry

Ewan Marr – 16 (5th Year)
Company Role: Electrical Technician
Poolside Role: ROV Launch/Recovery
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Electronics and Control
Current Plans: Leaving school for an Apprenticeship
Career Goal: Engineering/Instruments

Lauren Godfrey – 16 (4th Year)
Company Role: Research and Development
Poolside Role: Tether Management
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Mission Research
Current Plans: Staying on for 6th Year at school
Career Goal: Various Engineering Disciplines

Kieran Ritchie – 16 (5th Year)
Company Role: Frame Technician
Poolside Role: Tether Management
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: Structure design
Current Plans: Leaving school for job/apprenticeship
Career Goal: Engineer

Stuart Hope – 16 (5th Year)
Company Role: Company Communications
Poolside Role: Tether Management
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise: ROV research and communication
Current Plans: Either staying on at school or apprenticeship
Career Goal: Instrumental technician

Aaron Reid – 16 (5th Year)
Company Role: Safety Consultant
Poolside Role: Tether Management
MATE Competition: 1st Year in team, 1st International Final
Area of Expertise; Safety Regulations
Current Plans: Looking for an Apprenticeship
Career Goal: Employment in the Oil & Gas sector

1.4 Company Structure

Blue Toon ROVers is a company, which started out in Autumn 2013, with the aim of designing and manufacturing an ROV suitable for last year's MATE competition. Therefore we had some level of experience in the ROV business from competing at the Scottish Regional's in April 2014.

Two of our company members were part of last year's project therefore our company's latest project started up based on their previous experience. Our team of 10 pupils sat down together and discussed our performance in the company's 2014 project and came up with a plan for the Njord project.

We collectively decided to utilise everyone's skills and potentials by splitting our company into three separate divisions. These are the Design and Structure Team, Control and Tooling Team and the Safety and Marketing Team. Following this decision to separate the company into these sub-teams we discussed the outline of tasks and deadlines each team would have as we felt this would allow the Njord project to be completed to the highest standard and most efficiently. Based on each individual member's skills we appointed them specialized roles within the company that shared the workload evenly.

The Design and Structure team were responsible for constructing and analysing different frame structures using different materials in order to identify the best combination for the iceberg and oilfield exploration. They felt that Njord needed to be durable and compact in order to carry out the missions efficiently. The team carried out an extensive design process, which allowed them to look at all the variables that could affect the frame structure and how this structure could impact tooling, motor and camera placement. The Design and Structure team were also responsible for sourcing materials that would provide high buoyancy for our project, which they adjusted and tested in the test pool.

With regards to the Control and Tooling team, their main tasks were to improve our control system through the use of relays allowing us to control using joysticks. They also studied the missions in order for them to design appropriate payload tools which add to the marketable features of Project Njord. This involved them continually testing the ROV in order to adjust motors and cameras and also to make improvements to their tooling ideas.

The Safety and Marketing team had the role of studying the competition guidelines and advising the other two divisions on the rules and regulations. This is a vital part of ensuring that Njord is the safest and most environmentally friendly it can be. The team also designed the Marketing Display and other supplementary items such as business cards for the company, the Company Spec Sheet, Systems Integration Diagram's (SID's) and this Technical Report. For such documents to be created this team had to collect and collate information from each and every team member in order to provide the most accurate information possible. Most importantly, the team ensured that all construction was completed safely and that the ROV met the competition safety requirements. The team also drafted a safety checklist, which was used at any testing or product demonstration point (Appendix 1) along with a workshop safety checklist (Appendix 2). The team also took charge of the media outreach attempts after the Regional victory along with the fundraising organisation.

2.0 Safety

2.1 Safety Precautions and Considerations

As aforementioned on the previous page, it was the role of the Safety and Marketing team members to ensure that Project Njord was completed in the safest manner possible and thrived to guarantee that Njord was the safest possible ROV for use in underwater exploration.

ROV Njord has many safety features both onboard the vehicle and within the onshore equipment required to carry out the missions at hand. Such onboard features include all power connections safely secured in a waterproof box, which has been further waterproofed by sealing the lid with Scotchcoat Adhesive. This ensures that all wires are protected from water damage, which could cause major problems to the working environment of Njord. Also all metallic components are galvanized to protect them from corrosion whilst in the working environment – this adds to the environmentally friendly aspect of Project Njord. With regards to metal components, we have taken every precaution to guarantee that there are no sharp edges that could cause potential harm or snagging whilst working underwater and when the vehicle is under maintenance. We achieved this by covering the ends of metal components with heatshrink (Figure 1). As per the MATE safety instructions for this year's competition all of our propellers have been shrouded using pipe guards, which allows a safe water flow to the propellers but still prevents the propellers catching on anything. Our 6 onboard cameras have been positioned to give the Pilot and Co-Pilot a full view of the operations of our ROV and its surroundings in order to have the least impact on the environment as possible. Finally, ROV Njord has waterproof safety labels onboard, which highlight the hazards associated with the onboard components and identify the electrical connections (Figure 2).

Figure 1 – Jubillee clips protected using heatshrink. (S.Hope 2015)

Figure 2 – Warning labels used by our company (S.Hope 2015)

Our onshore safety features include a 25A fuse fitted to the tether, which is connected to our main onshore control system via a detachable plug for safe and easy transportation. (Figure 3) Our control box has been neatly laid out and labeled which allows our electrical engineers easy access and identification for maintenance related issues. The poolside teams have been fully briefed on the operations of ROV Njord ensuring that any problems can be attended to with the correct methods and with the correct level of safety.

Figure 3 – 12 pin connectors, which make our tether detachable (S.Hope 2015)

3.0 Design Rationale

3.1 Blue Toon ROVers Design Process

Our company strived to make Project Njord as marketable as possible and therefore decided to follow the 'Engineering Design Process' (Figure 4) in order for us to produce the highest quality vehicle. Following these steps allowed the team to plan, build, test and improve ROV Njord over several months until we were fully happy as a company that it was the most effective model that we could engineer. Our lengthy design and planning process highlights our commitment to creating the very best ROV for our clients. The constant testing and evaluation of ROV Njord gave us the opportunity to identify the strengths and weaknesses of the vehicle. We could then acknowledge the areas of excellence and improve those areas that required some troubleshooting.

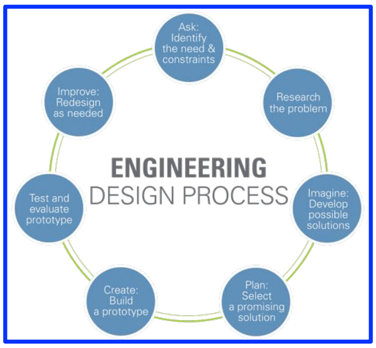


Figure 4 – Njord project design process (teachengineering.org)

Our company utilised everyone's strengths to their full abilities through the different departments within the company, this meant that each and every detail was given the correct amount of time and attention along with the required skill level to solve any problems.

3.2 Frame Design

During the design and planning phase of Project Njord the Design and Structure team sketched several potential frame structures before finally deciding on the structure and dimensions for ROV Njord (L.450mm, B.400mm H.250mm). Based on regional competition experience from the 2014 project the team decided that ROV Njord needed to be of smaller size and constructed from a lighter material. Therefore the team decided that 21.5mmØ PVC pipe should be used to construct the initial frame. This material was deemed to be durable yet lightweight enough that it would have little effect on the maneuverability of ROV Njord. Additional members were added to the frame, two at the front and one at the rear, to allow components and tooling, such as cameras and motors, to be added to the frame easily and safely. In addition, there was a strut across the top centre of the vehicle, which allowed ideal positioning for a camera to provide a view of the tooling operations within the vehicle. This strut also acted as a handle to carry the ROV with ease, which helps with regards to transportation. It also allows the poolside crew to deploy and recover ROV Njord safely and efficiently, which allows the team to avoid wasting time during product demonstration periods.

3.3 Motors/Propulsion

ROV Njord has the ability to move in 8 different directions: forwards, backwards, left, right, up, down, pitch up and pitch down. 8 bilge pumps (Figure 7) of varying output (gallons per hour (gph)) provide our vehicle with these directions of movement (Figure 8).

Figure 7 – One of the bilge pumps that equips ROV Njord. (S.Hope 2015)

Forward/Back – 800gph
Up/Down – 750gph
Left/Right – 500gph
Up/Down Pitch – 500gph

Figure 8 – Output provided by each set of bilge pumps.

As can be seen (Figure 9) our pumps have been stripped back to the motor shaft and a 45mm model boat propeller has been added to each motor. The addition of a propeller allows the motor to provide more thrust than just the bilge pump on its own that gives ROV Njord better and quicker maneuverability during flight periods. However the design team originally tested several different propellers and decided that the 45mm model boat props provided the best water flow.

Figure 9 – Modified bilge pump with propeller (S.Hope 2015)

After a series of tests the team decided which directions required more powerful pumps, in order to provide ROV Njord with the best maneuverability possible allowing our pilot to have all that he needs to complete the missions to the best of his ability.

The Control and Tooling team carried out several tests on the voltage and current drawn by each pump to give an overview of how efficient both the motors and tether are. It was vital for the team to understand how much voltage and current was drawn by the motors in terms of safety and product demonstration (mission) purposes.

As safety is one of our largest company values, the Design team planned a suitable method for shrouding our propellers, they decided to use pipe guards (Figure 10) – which allowed a good water flow whilst still protecting the propellers from damaging the environment whilst in product demonstration periods and also protected the engineers whilst testing ROV Njord. The use of propeller shrouds was also one of MATE's safety regulations for the 2015 Competition, highlighting the importance of such protection.

Figure 10 – Propellor shroud made by the Design Team (S.Hope 2015)

3.4 Control System

The control system of ROV Njord is a highlight of the 2015 project and was subject to a lot of planning, construction and troubleshooting in order to create the perfect control system for our vehicle. Although the system comes across as complex the use of joysticks for control gives ROV Njord a user-friendly aspect and provides easy handling of the vehicle. The 2 joysticks (Figure 11), which offer proportional movement in 6 of the aforementioned 8 directions, are wired through a series of relays, which allows each motor to be used bi-directionally for maximum movement capabilities. The proportional movement has been achieved through the use of proportional motor drivers (K166) connected to each bilge pump. The other two directions of movement (Up/Down Pitch) are provided through the use of a two-way switch and allow the ROV to pitch itself for easier access for the manipulator. All electrical connections are housed in a waterproof, sealed onshore case connecting to the 12V battery and onboard connections are housed in a waterproof junction box. Within the control case there is another two-way switch, which allows a 9th motor to be used for forcing water through the pipe series in product demonstration 3 (Figure 12). This motor can also function as a suction device for collecting algae samples. As per the MATE safety instructions contained within the banana plug battery connection is a 25A fuse (Figure 13). Another feature of the control case is that all 3 monitors used for ROV Njord are within 1 case; this gives the Pilot an overall view of the underwater operations all in 1 place. The pilot can switch each monitor to a 2nd feed by using an DPDT switch; the use of a switch presents fast switching between our 6 onboard cameras allowing all areas of the vehicle to be observed. Also within the control case are the switches, which operate the manipulator – allowing it to rotate and open/close through the use of servo-motors. The LED lighting hosted by ROV Njord can also be switched on and off through the use of another switch contained within the case. This function permits the lighting to be used only when needed, which saves the LED strips drawing any current.

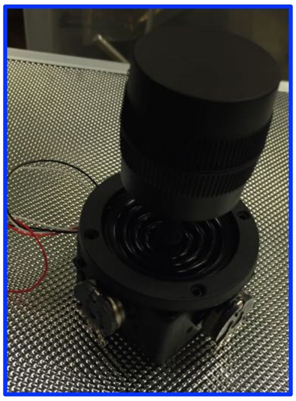


Figure 11 – Joystick, which controls ROV Njord's movements (S.Hope 2015)

Figure 12 – SPDT switch used to operate the water pump (S.Hope 2015)

Figure 13 – 25A fuse fitted to the main power connection (S.Hope 2015)

Our Control and Tooling team decided to use a hardware approach over a software approach due the skillsets we had available in the team. This included some of our team members enjoying learning about electronics at home and in school therefore they had the necessary knowledge to effectively use a hardware system. We also felt that hardware is less confusing and easy to use as opposed to software.

3.5 Buoyancy

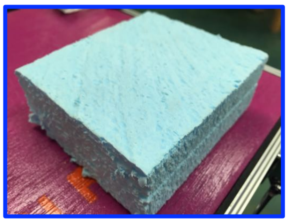


Figure 14 – High density foam used to provide buoyancy to ROV Njord.
(S.Hope 2015)

The buoyancy of ROV Njord is provided using high density foam (Figure 14). The foam was attached to the top section of the frame in the areas, which required it the most. With every adjustment made to the components onboard ROV Njord we tested and adjusted the buoyancy to ensure that we provided the correct level of buoyancy. The main aim from the company was to achieve, neutral buoyancy during Project Njord. Being neutrally buoyant meant that the vehicle could remain steady without any applied power in the absence of water currents. The tether bouyancy was provided at regular intervals along the tether, through the use of 22mmØ pipe lagging, to ensure that the tether didn't sink and cause the vehicle to be dragged with it. With regards to the environment, we attached the foam/lagging using tie wraps to ensure that no debris could fall off of ROV Njord and pollute the working environment. The use of a commonly found household item to maintain buoyancy added to the cost-effectiveness of our 2015 project.

3.6 Tether

All of our electrics were wired through the use of two tether cables; one 20-core cable and one 12-core cable. These were both detachable from the onshore case. Using only two cables gave ROV Njord much more capabilities due to the lack of weight added from our tether. Overall in length the tether measured 11m, which allowed ROV Njord full maneuverability whilst performing tasks. Our poolside team attended to the length of tether provided for each tasks in order to ensure that our vehicle never became tangled in its own tether. The onboard connection was housed in 2 waterproof enclosures – 1 for each tether cable. The tether was attached to each housing through the use of watertight glands, which were further coated with Scotchguard.

For maximum safety when transporting ROV Njord the tether was contained on a cable reel that ensured that the tether was safely stored and could cause no harm which moving it around.

Figure 15 – 12 & 20 core tether cables used for ROV Njord
(S.Hope 2015)

3.7 Cameras and Lighting

In order to provide the best first-person onboard views for the pilot we chose to utilise 6 onboard cameras wired to 3 7" dual-channel monitors. As mentioned on page 10 in the "Control System" section of the report, the pilot can switch to view different cameras through the use of DPDT switches housed in the control case. 4 of the 6 cameras are reversing cameras (Figure 15), which due to their size weigh very little and are easily attached all over the vehicle for onboard views such as reading the measuring device and surveying the iceberg. The other 2 cameras, have been homemade by the Control and Tooling team (Figure 16). Using the lens from an outdoor CCTV camera and housing this along with the wiring inside a PVC pipe achieved this. Each of these cameras is detachable through the use of a 5-pin plug and socket, which allows them to be moved around and repaired easily. The cameras are held together using plastic, steel rods and bolts - which have been protected against corrosion. These cameras give a high quality view of the underwater operations and during testing were found to be 100% waterproof in comparison to other tried and tested cameras such as fishing cameras used by many other companies. We also tested our homemade cameras in the local bay to test their ability to withstand depth-related pressure and found that they were fully functioning for up to, at least, 17m.

Figure 16 – Cameras used onboard ROV Njord (S.Hope 2015)

Figure 17 – Homemade camera made by design team (S.Hope 2015)

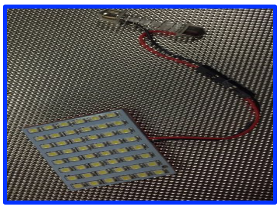
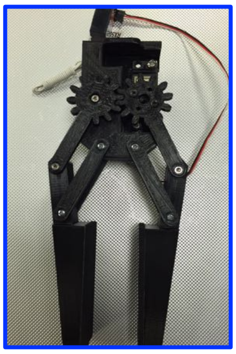


Figure 18 – LED strips used for onboard lighting (S.Hope 2015)

Due to the nature of the missions, it was highly important that our ROV had self-contained lighting in order to improve visibility in the water. This lighting was provided by LED strips (Figure 17), which were sealed and waterproofed using clear potting resin. These lights were relatively cost-effective and drew very little current from the supply adding to their marketability.

3.8 Payload Tools

Manipulator



One of the most versatile tools on the ROV is the robotic gripper. The manipulator was designed and 3D printed using plastic to maintain the vehicles buoyancy and to reduce development costs. The gripper consists of two servos – one of which rotates clockwise and anti-clockwise, providing maximum angles for easy access to objects like the Oball; minimising time wasted trying to retrieve the Oball with a hooked rod. This provides more time to be allocated to other, more time consuming tasks like calculating the volume of the iceberg. The other servo allows the gripper to actuate and collect objects to be returned to the surface.

The servos are controlled by an external controller at the surface by the Co-Pilot, allowing the pilot to concentrate on positioning the vehicle.

Neoprene padding was added to each finger to maximise grip and to allow heavier objects to be gripped firmly by less powerful servos. Power is provided by a step down transformer, which is vital for supplying voltage to the servos in the gripper - each servo requires approximately 5 to 6 volts of power while our battery supplies 12 volts.

Anode Tester

In order to complete one of the missions in product demonstration 3 our tooling team modified a small multimeter by extending the wires and running them up the tether and attaching the multimeter screen to the case that also contains the monitors. One of the probes was attached to the frame and left to sit in the water, which acted as the common ground instead of using the common ground on the pipe. The other probes was gripped by the manipulator and used to determine if there was any current present at each test point, in turn showing a reading to the pilot and co-pilot.

Measuring Device

All three missions require the measuring and recording of various objects, ranging from dimensions of an iceberg to measuring the length of a corroded pipeline. These tasks require a solution, in this case a stainless steel tape measure was mounted to the ROV. The Measuring Device has metal wire attached to the tip of the tape, allowing the device to latch on to any protruding surfaces. The device was calibrated for the increase in length and a camera was securely fastened on to the tape measure to allow the Co-Pilot to record the readings.

Water Pump

In product demonstration 3 the companies are required to force water through a pipe series to simulate oil flow, in order to achieve this we attached a section of 50mmØ PVC pipe over a bilge pump with propeller, and cut holes in the pipe to allow the 'pump' to force water through the pipe system. This was controlled by an onshore switch that allowed the pilot to only utilise this tool when necessary, therefore the water flow from the pipe did not affect Njord's maneuverability.

3.9 Testing and Troubleshooting

To assure ourselves that we had designed and created the best ROV possible our company continually tested and adjusted the vehicle. Our testing was carried out in the Peterhead Community Centre Diving Pool, which is connected to Peterhead Academy. From mid-February our company tested out the initial buoyancy of ROV Njord alongside testing the placement of bilge pumps. Our testing was relatively continual (around once a week) leading up to the Regional Finals allowing us to make any adjustments – both minor and major. This gave the poolside team firsthand experience of the product demonstration routine in preparation for the Regionals.

As a company we thoroughly analysed and assessed each area of performance and adapted the vehicle as required. Since our progression from the regionals we have continued to test and improve the control system, cameras and payload tools weekly in the test pool. We were given the mission props from the Regional Competition and have been, and aim to, thoroughly practice the missions in order to provide the best product demonstration as possible in Canada.

The Regional Competition gave our company a strong overview of the success within the company and the areas that required improvements within the project. We therefore came up with an action plan for the time between the finals in order to have sufficient time to carry out testing and troubleshooting.

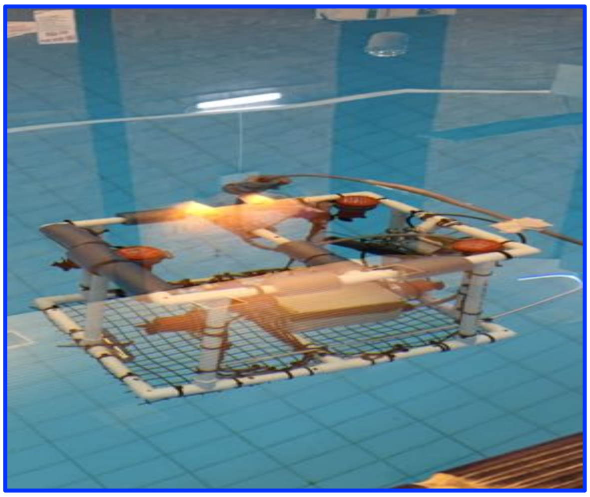
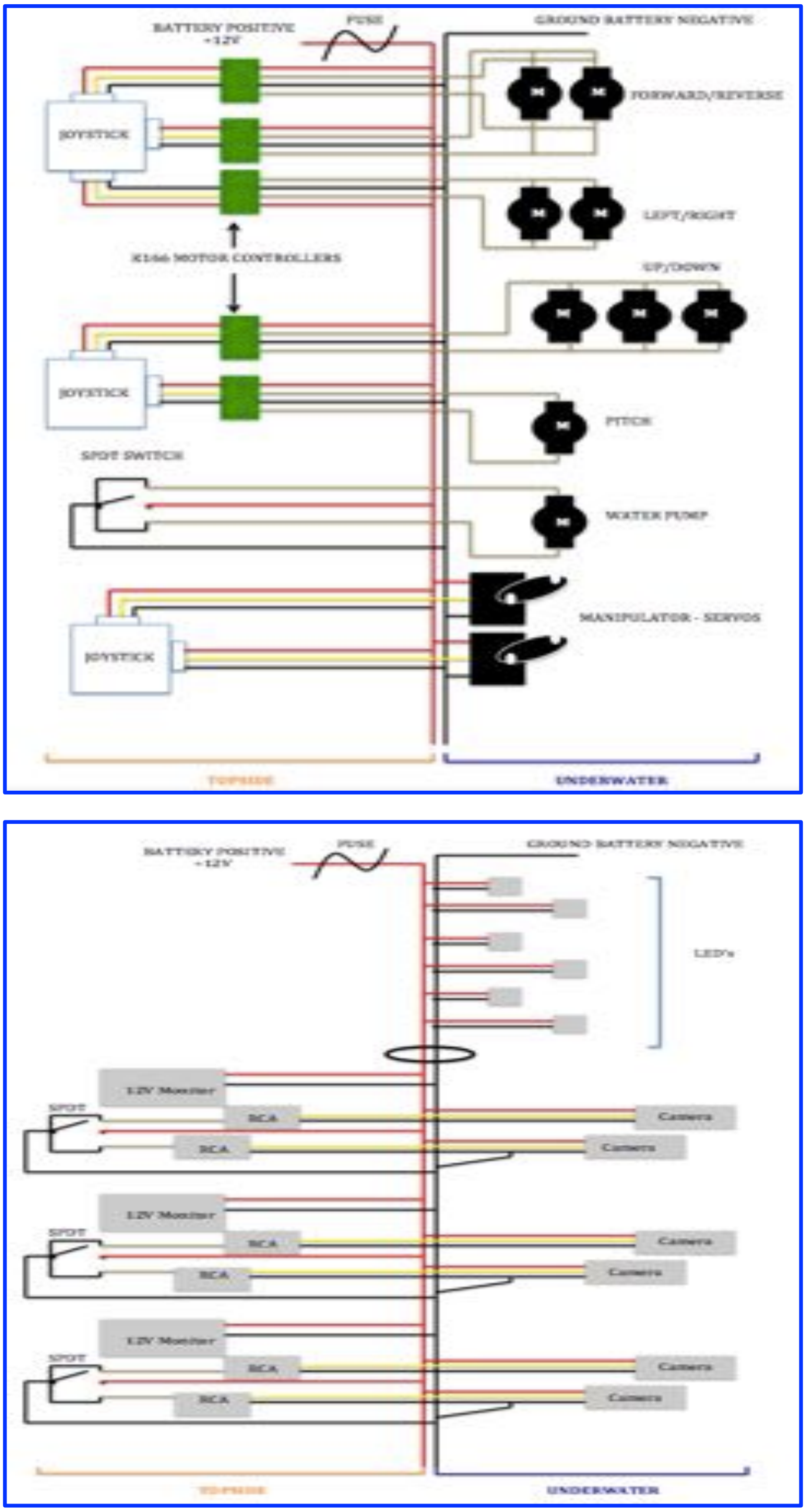


Figure 19 – ROV Njord in the test pool after the Regional Competition, allowing the team to identify areas of strength and weakness (J.Fenty 2015)

4.0 System Integration Diagram

4.1 Blue Toon ROVers System Integration Diagram



Figures 20(Top) & 21(Bottom) – Company SID's, Motors (Top) and Cameras and Lighting (Bottom). (I.Buchan 2015)

5.0 Project Budget

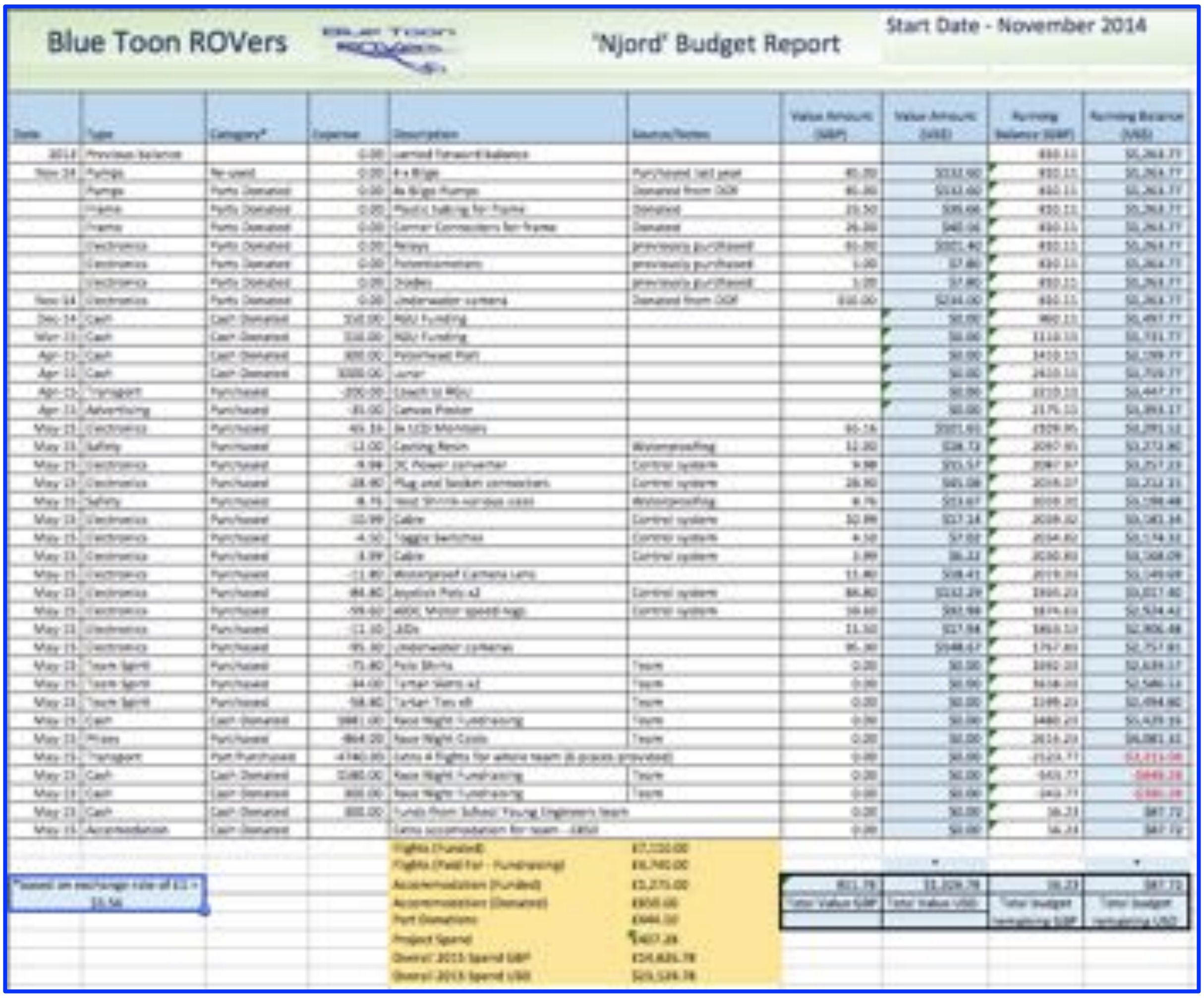
5.1 Blue Toon ROVers Project Njord Budget

Before we started any construction on this year's project we assessed our budget carried forward from the 2014 project, which totaled £810.11 ($1263.77). We decided that these funds were sufficient in order to complete Project Njord in the most cost-effective manner possible.

For the Regional Competition we used the same control system as the 2014 project but completely reconstructed our frame. We kept the same control system as we felt it worked relatively well at the 2014 Regionals however, after winning this year's Regionals, we decided that our control system needed advancing to make our ROV the best on the market. We therefore needed to purchase a lot of new components e.g. joysticks, cameras and monitors. With our budget always a top priority, we sourced new components at the best price available for the correct and reliable items.

Our budget sheet, below, highlights our total spend including flights, accommodation, donations and new parts. It also shows that with a total spend (on the ROV itself) of £407.28 ($635.36) we stayed within our project budget by £402.83 ($623.01) however with other expenses, such as regional competition transport, we spent £753.88 ($1176.05) we stayed in budget by £56.23 ($87.72) overall.

- Figure 22 – Project Njord Budget Sheet (S.Whyte 2014/15)



Blue Toon ROVers

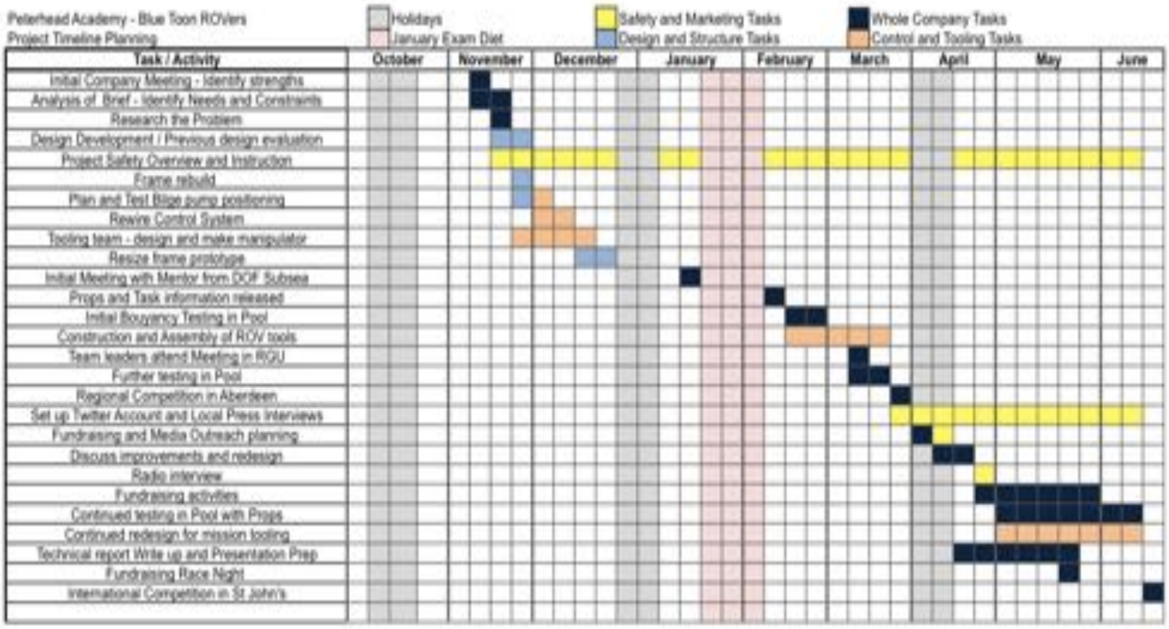
'Njord' Budget Report

Start Date - November 2014

6.0 Company Development

6.1 Project Development Schedule

As a company we compiled a Project Development Schedule, which allowed us to ensure the project remained on track in order for Project Njord to be completed on time and efficiently. The delegation of time and tasks led to smooth operations within the company allowing us to operate to the best of our ability in order meet our client's needs.



Peterhead Academy - Blue Toon ROVers
Project Timeline Planning

- Holidays
- January Exam Diet
- Safety and Marketing Tasks
- Design and Structure Tasks
- Whole Company Tasks
- Control and Tooling Tasks

Task / Activity
- Initial Company Meeting - Identify strengths
- Analysis of Brief - Identify Needs and Constraints
- Research the Problem
- Design Development / Previous design evaluation
- Project Safety Overview and Instruction
- Frame rebuild
- Plan and Test Bilge pump positioning
- Rewire Control System
- Tooling team - design and make manipulator
- Resize frame prototype
- Initial Meeting with Mentor from DOF Subsea
- Props and Task information released
- Initial Bouyancy Testing in Pool
- Construction and Assembly of ROV tools
- Team leaders attend Meeting in RGU
- Further testing in Pool
- Regional Competition in Aberdeen
- Set up Twitter Account and Local Press Interviews
- Fundraising and Media Outreach planning
- Discuss improvements and redesign
- Radio interview
- Fundraising activities
- Continued testing in Pool with Props
- Continued redesign for mission tooling
- Technical report Write up and Presentation Prep
- Fundraising Race Night
- International Competition in St John's

Figure 23 – Project Development Schedule (J.Fenty 2014)

6.2 Challenges Faced

With regards to technical challenges we faced as a team, we felt that the complexity involved with developing a working and intricate control system was the biggest task involved. It required a lot of planning, developing, re-planning and re-developing before we felt that it was the best-suited control system for ROV Njord. To overcome this challenge we used our strengths within the team to contribute thoroughly to creating the best control system. Whereas, our personal challenges had some effect on the project, as after winning the Regional Competition in early April 2015 – we had to work long and hard in order to redevelop the control system and fine-tune ROV Njord's features whilst continually studied and taking part in our final exams during the month of May. This required dedication from the team and some serious time management by having to prioritise revision but yet, give our project the attention it required.

6.3 Lessons Learned

From our experience during this year's project we faced learned many things including how ROV's work and their role in the Science and Oil industries. However, it would be safe to say that our team members have learned a lot with regards to electronics and how they work. We worked together with those who had a strong knowledge of electronics and learned how the control system was designed, constructed and how it all works. This led to some team members doing wiring for the first time, even soldering for the first time – therefore it was definitely a company-wide learning curve. On the non-technical side of the company we learned that teamwork and planning are hugely important factors in the smooth operation and success of our company. We strive to work together and communicate so that everyone is involved and aware of what is going on with the team.

6.4 Future Improvements

With regards to our 2015 project the Blue Toon ROVers have been continually noting improvements that could be made for future projects. Such improvements include having a more solid design and planning process involving all areas of the company. Testing will be carried out more regularly and intensely on our future vehicles in order to identify flaws early and allow us to make our vehicle the best it can be. Our safety procedures and methods will be reviewed in order to ensure that we remain as safe as possible whilst working on the vehicle and also ensuring that our vehicle is as safe as possible. Our control system may be given some redevelopment to produce an even better system for our ROV

6.5 Project Njord Reflections

As a company, we view our 2015 project as highly successful. Winning the regional competition will be an unforgettable experience for all of our team members providing them with important experience for future careers. Our successes have come in the form of technical success - designing and creating an ROV capable of competing at a very high standard of competition - and also personal success where each and every company member has played a huge part in Project Njord and everyone has learned a lot from the experience. We also feel that dividing our company into sub-divisions has proved highly beneficial in coping with the workload in the various area across the ROV project.

The attention that has been received from the team has been incredible, the media relations, fundraising and school feedback has led to a massive sense of achievement throughout the company, making us feel proud of ourselves and Project Njord.

7.0 Media Outreach
7.1 Blue Toon ROVers Media Outreach

As Media Outreach is regarded as a bonus stage of the International Finals our company decided to publicise locally after our regional final victory. Our company's success was published in 3 different local newspapers, with 5 different articles reviewing our successes and future plans. After contacting some local reporters they decided to use and follow our story on our journey to Canada. One article highlighted our company's need to fundraise in order for our full company of 10 members plus our mentor to travel to the International Finals. Our regional victory provided 6 team member places and a place for our mentor at the finals, but with team morale in mind we decided to try and fundraise an extra £4000 ($6262) to have the whole team present. This would allow us to have full selection of expertise whilst at the finals and will give everyone the opportunity to represent the Blue Toon ROVers in St John's, Newfoundland. Our fundraising efforts included local business donations, and a Horse Race Night to meet our target.

4 of our team members also took part in a local radio interview with the intent to raise awareness of our company's work. This interview was aired during a local news section hosted by the radio. We are currently in discussion with the local news station, STV Aberdeen, trying to have them air a story of our journey on their programme, as they already provided TV coverage of the Regional Finals in April.

Our school frequently mentioned our progress on their own twitter page along with us having created our own twitter page to keep our followers up to date with our project. @BlueToonROVers

Below are photographs of our newspaper cuttings (A.Reid 2015):

Engineering starlets triumph in offshore robot design contest

SKILLS

"Competition gives them a good insight into the industry"

Peterhead Academy triumphs in ROV contest

School teams put their robots through a series of underwater missions

"It is all about gaining experience and putting the things that you learn in the classroom into practice"

Academy triumphs in ROV competition

Peterhead pupils take top spot in annual event

Cash plea by pupils set for ROV finals in Canada

By Kirstie Ross

A GROUP of budding engineers will represent Scotland at an international competition in Canada.

They have showed determination

EXPERIENCE: Jamie Fenty

Young engineers deserve trip

NEWS: Cash plea by pupils set for Canada – Page 19

IT'S fantastic to see the next generation of entrepreneurs get off to a winning start. The budding engineers at Peterhead Academy who won a Scottish ROV competition deserve praise. They also all deserve to be able to travel to Canada to fly the flag for Scotland. Hopefully, their fundraising drive succeeds and all 10 of them can see this great job through – and possibly return as winners again.

8.0 References
8.1 Acknowledgements

The Blue Toon ROVers would like to thank several people and companies for their continual support throughout our 2015 project. Firstly, we would like to thank Fiona Loudon for being our company mentor and giving us useful advice and supervising our construction and development. We would also like to thank Steve Summers, our mentor from DOF Subsea who again helped us develop our project. DOF Subsea has been one of our main supporters through donating 20 core tether, bilge pumps and a camera. Special thanks go to Graeme Dunbar MATE Scotland Co-ordinator and Margaret Craig of Robert Gordon's University for their support throughout the Regional Finals and our journey to the International Finals.

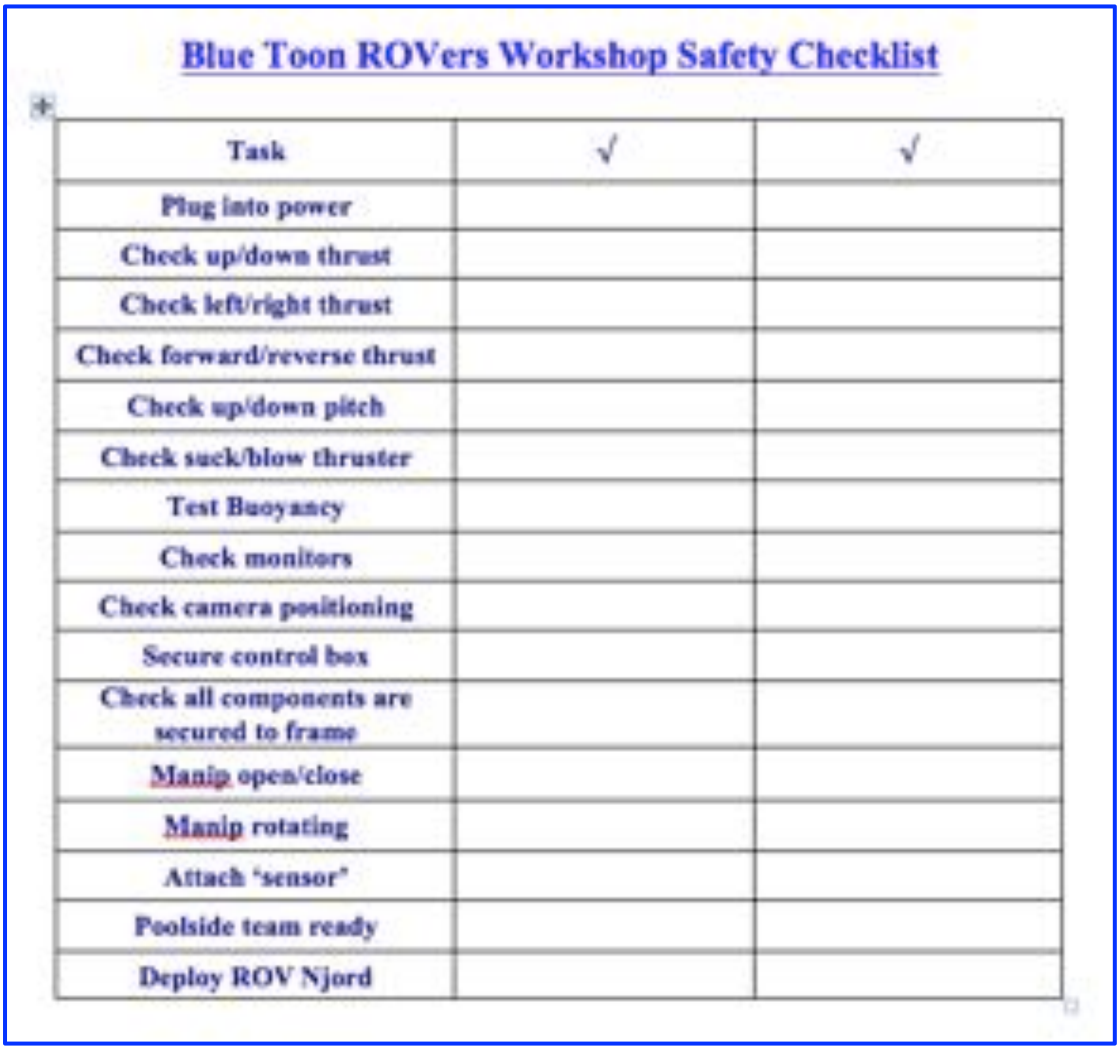
We would like to thank the following companies for their donations listed:
- DOF Subsea (Tether, pumps & camera)
- BP (Competition Sponsor)
- Subsea UK (Regional Competition Sponsor)
- Fugro (Regional Competition Sponsor)
- Peterhead Port Authority (Donation)
- Score Europe (Accommodation in Canada & Canadian Mentor)
- Robert Gordon's University (Flight cases and mission props)
- Oceaneering (Bear Claw Joystick (Back-up))
- MB Plant (Donation)

8.2 Bibliography

- Teach Engineering. (2012). *Engineering Design Process.* Available: https://www.teachengineering.org/engrdesignprocess.php. Last accessed 18th May 2015.
- Stephen Thone. (2003). *Homebuilt ROV's.* Available: http://www.homebuiltrovs.com. Last accessed 20th April 2015.

9.0 Appendices

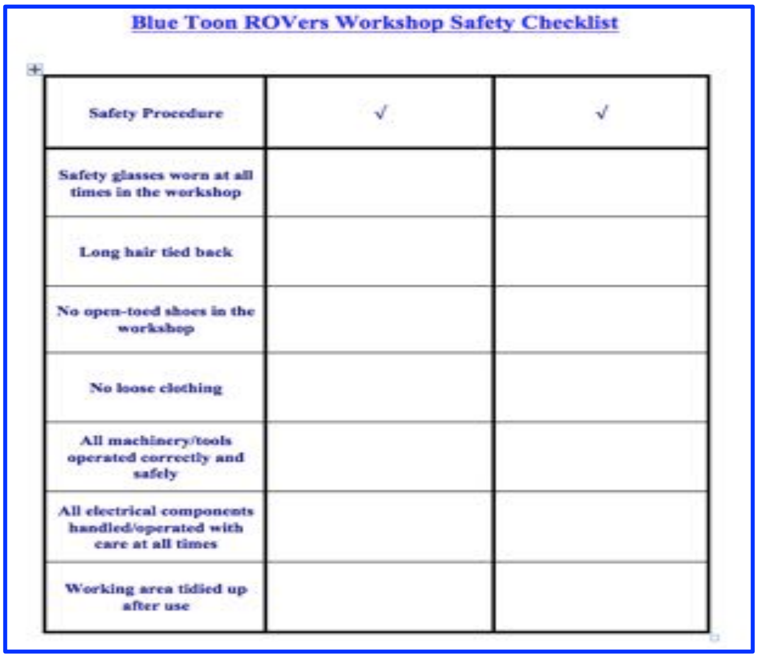
9.1 Appendix 1 – Safety Checklist (Product Demonstration)



Blue Toon ROVers Workshop Safety Checklist

Task	√	√
Plug into power		
Check up/down thrust		
Check left/right thrust		
Check forward/reverse thrust		
Check up/down pitch		
Check suck/blow thruster		
Test Buoyancy		
Check monitors		
Check camera positioning		
Secure control box		
Check all components are secured to frame		
Manip open/close		
Manip rotating		
Attach 'sensor'		
Poolside team ready		
Deploy ROV Njord		

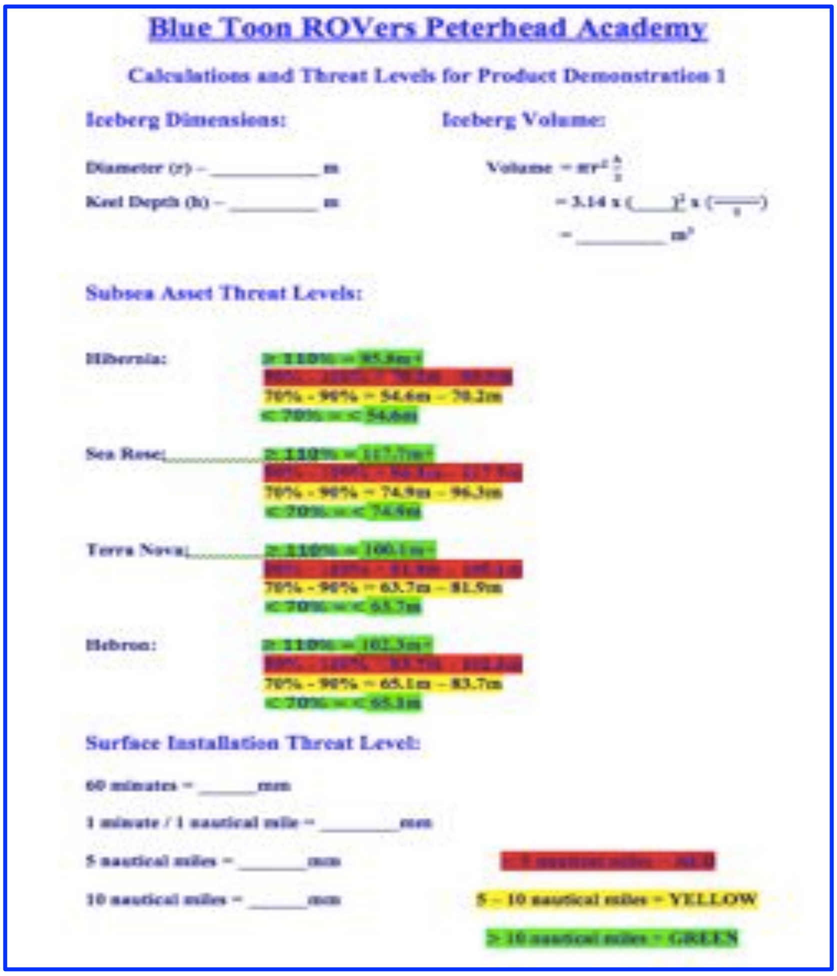
9.2 Appendix 2 – Safety Checklist (Workshop)



Blue Toon ROVers Workshop Safety Checklist

Safety Procedure	√	√
Safety glasses worn at all times in the workshop		
Long hair tied back		
No open-toed shoes in the workshop		
No loose clothing		
All machinery/tools operated correctly and safely		
All electrical components handled/operated with care at all times		
Working area tidied up after use		

9.3 Appendix 3 – Calculation Sheet for Product Demonstration 1



Blue Toon ROVers Peterhead Academy

Calculations and Threat Levels for Product Demonstration 1

Iceberg Dimensions:

Diameter (r) – __________ m

Keel Depth (h) – _________ m

Iceberg Volume:

$$\text{Volume} = \pi r^2 \frac{h}{3}$$

$$= 3.14 \times (\_\_\_)^2 \times \left(\frac{\_\_\_}{3}\right)$$

$$= \_\_\_\_\_\_\_\_\ \text{m}^3$$

Subsea Asset Threat Levels:

Hibernia:
≥ 110% = 85.8m+
90% - 110% = 70.2m - 85.8m
70% - 90% = 54.6m – 70.2m
< 70% = < 54.6m

Sea Rose:
≥ 110% = 117.7m+
90% - 110% = 96.3m – 117.7m
70% - 90% = 74.9m – 96.3m
< 70% = < 74.9m

Terra Nova:
≥ 110% = 100.1m+
90% - 110% = 81.9m - 100.1m
70% - 90% = 63.7m – 81.9m
< 70% = < 63.7m

Hebron:
≥ 110% = 102.3m+
90% - 110% = 83.7m - 102.3m
70% - 90% = 65.1m – 83.7m
< 70% = < 65.1m

Surface Installation Threat Level:

60 minutes = ______mm

1 minute / 1 nautical mile = ________mm

5 nautical miles = ________mm

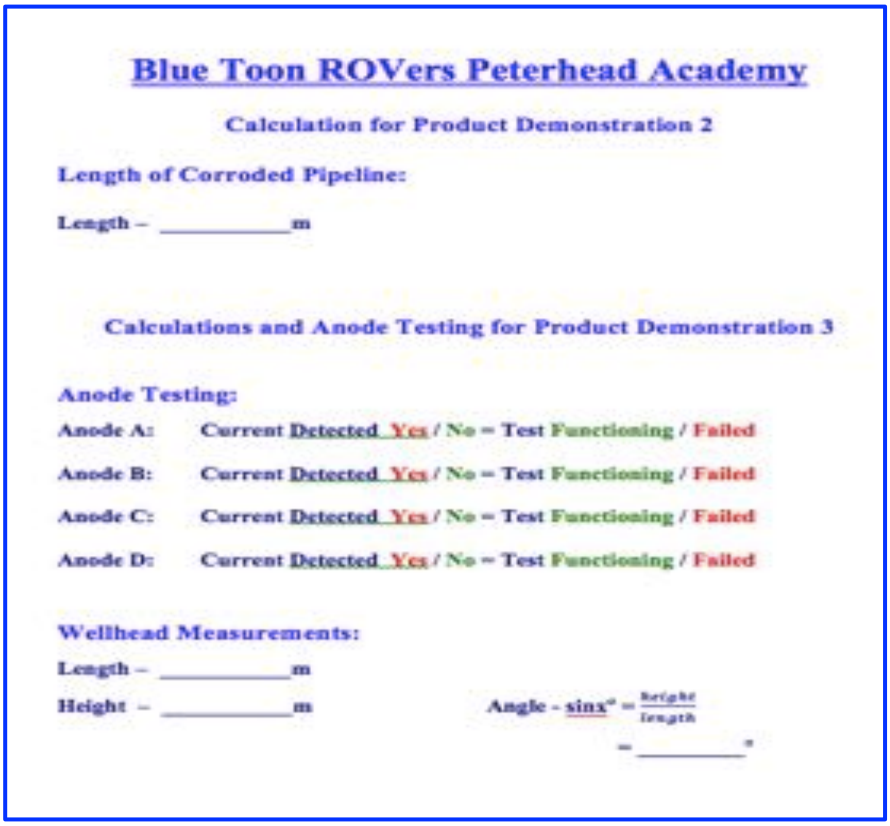
10 nautical miles = _______mm

< 5 nautical miles = RED

5 – 10 nautical miles = YELLOW

> 10 nautical miles = GREEN

9.4 Appendix 4 – Calculation Sheet for Production Demonstration 2 & 3



Blue Toon ROVers Peterhead Academy

Calculation for Product Demonstration 2

Length of Corroded Pipeline:

Length – ____________m

Calculations and Anode Testing for Product Demonstration 3

Anode Testing:

Anode A: Current Detected Yes / No – Test Functioning / Failed

Anode B: Current Detected Yes / No – Test Functioning / Failed

Anode C: Current Detected Yes / No – Test Functioning / Failed

Anode D: Current Detected Yes / No – Test Functioning / Failed

Wellhead Measurements:

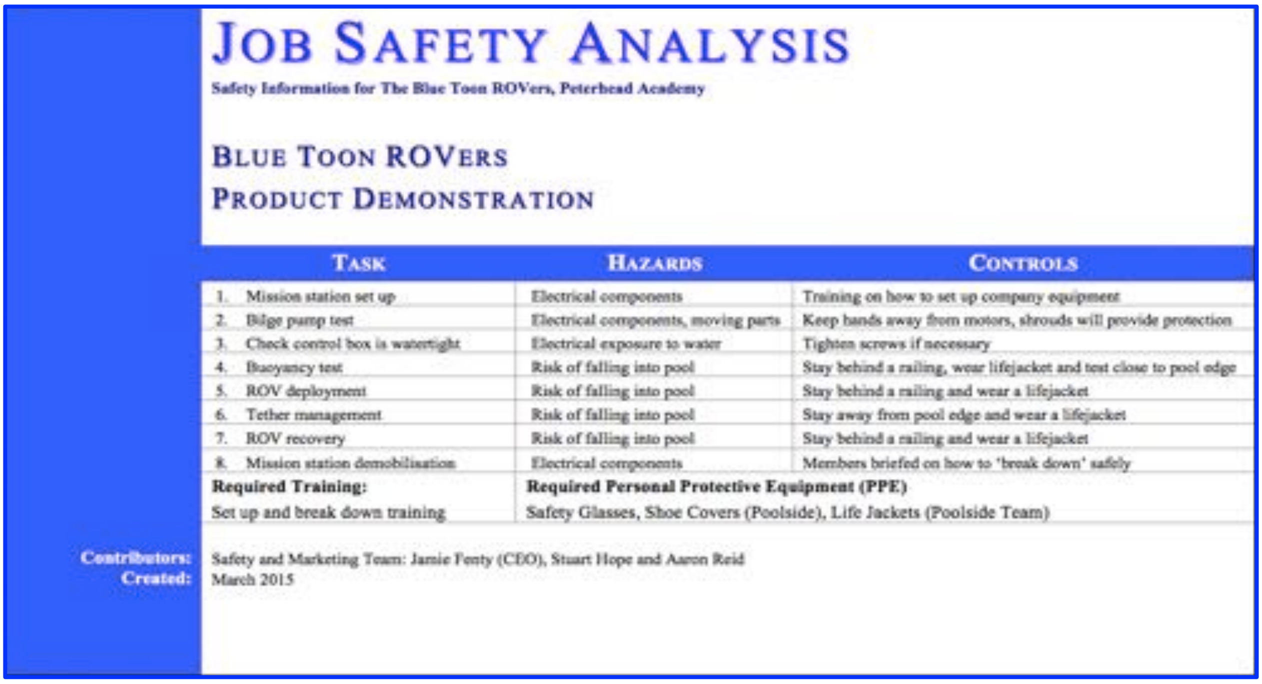
Length – ____________m

Height – ____________m

Angle - $\sin x° = \frac{height}{length}$

= ____________°

9.5 Appendix 5 – Job Safety Analysis (JSA)



JOB SAFETY ANALYSIS

Safety Information for The Blue Toon ROVers, Peterhead Academy

BLUE TOON ROVERS
PRODUCT DEMONSTRATION

TASK	HAZARDS	CONTROLS
1. Mission station set up	Electrical components	Training on how to set up company equipment
2. Bilge pump test	Electrical components, moving parts	Keep hands away from motors, shrouds will provide protection
3. Check control box is watertight	Electrical exposure to water	Tighten screws if necessary
4. Buoyancy test	Risk of falling into pool	Stay behind a railing, wear lifejacket and test close to pool edge
5. ROV deployment	Risk of falling into pool	Stay behind a railing and wear a lifejacket
6. Tether management	Risk of falling into pool	Stay away from pool edge and wear a lifejacket
7. ROV recovery	Risk of falling into pool	Stay behind a railing and wear a lifejacket
8. Mission station demobilisation	Electrical components	Members briefed on how to 'break down' safely
Required Training:	**Required Personal Protective Equipment (PPE)**	
Set up and break down training	Safety Glasses, Shoe Covers (Poolside), Life Jackets (Poolside Team)	

Contributors: Safety and Marketing Team: Jamie Fenty (CEO), Stuart Hope and Aaron Reid
Created: March 2015

9.6 Appendix 6 – CAD Drawings for Manipulator