Blott Matthews Challenge

Pole to Pole Challenge

Barton Peveril College

The Team

Franio van Wyk

My name is Franio and I am the Team Manager for the project, as well as being in charge of any software aspects of the project. This would entail incorporating sonar and navigation systems into the vessel. I am currently studying Maths, Further Maths, Computer Science and Economics, and my main objective during this project would be to ensure that the systems are technologically robust and reliable enough to endure a journey that will take up to 12 months.

Ella Newman

Hi, I'm Ella and I'm currently studying Maths, Physics, and Psychology A level at Barton Peveril College. I am the Co-Team Manager and am working on the electrical supply of how we will propel our vessel across the globe and our general aim of the mission. This entails deciding on what power supply we will use to optimize our journey length for the amount of fuel we are carrying. I am thinking about pursuing a career in engineering in the near future.

Alex Hale

My name is Alex I will be researching into the use and application of renewable energy resources. This is a very important role because it will allow the vessel to travel indefinitely without having to stop for refuelling. The subjects I am taking are Maths, Further Maths, and Physics, which will help me in this area. They will help me with the necessary calculations needed for the journey.

Andrew Rothwell

Hello, my name is Andrew and I am currently studying Maths, Physics, and Psychology A level. My main roles and contributions within this project are to work out the route we will take from the North to the South pole, taking into account the challenges we may face such as weather, tides etc. I have also contributed to the engine and propeller systems of the vessel.

Michael Wise

Hi, my name is Michael and I will undertake the electrical challenges for this project. I am going to design the electrical and mechanical parts of the machine. This is a very important role as it is how we are going to get to the south pole in an efficient manner. At college, I am studying Electrical Engineering and Politics.

The Aim

Basic tasks

The fundamental aim of our project is to carry a 1-tonne load of dimensions 2x2x1.5m from the geographic north pole to the geographic south pole. This journey must take no longer than 12 consecutive months and the vessel must be self-sustainable throughout this time period. Fundamental rules state that no flying is permitted and no use of commercial ports which would take advantage of the equipment there should be used. Existing roads may be used during the journey but no supply drops are permitted.

Possible complications

Weather

Weather threats such as typhoons, tropical storms, and squalls have the potential to provide a threat to the vessel, which could capsize the vessel or disable vital onboard systems, crippling the entire mission. Further to this, a rescue mission to retrieve the vessel would be environmentally costly as fossil fuels may be burnt and polluting materials released into the water. It is therefore imperative to ensure that the vessel is able to withstand natural threats so that environmental damage can be greatly minimized.

For example, hurricane speeds have been known to exceed 156 mph[1], which would have the strength to tear the vessel apart, which whilst in the short term would provide an impact, electrical or chemical hazard to nearby marine life, also has the long term potential to destroy micro-habitats should the materials drift to an area of high population.

[1] Accuweather

Ensuring therefore that the vessel is able to complete its journey safely will be the top priority through all planning.

To avoid environmental hazards from impacts and fierce weather, the hull of the vessel would be made from a fibreglass composite, whose unreactive properties would fare well in the sodium-rich water, and is lightweight, which is optimal for speed, but also strong enough to resist most natural occurrences.

Geographical Hazards

Geographical hazards, much like those of adverse weather have the potential to end the mission if our precautions were not enough to foresee and prevent a catastrophe. Some geographical hazards of note in the water would be icebergs, sandbars, and underwater volcanoes. The presence of coral reefs would also be an environmental hazard of which careful note should be taken to avoid the destruction of microhabitats.

Hazards such as icebergs and sandbars have the potential to ground or puncture the vessel, which would end the mission and possibly destroy thousands of pounds of technology, which would be destroyed by the seawater. Further to the aforementioned high sodium content of the water, in the long term, it would be expected for oxidation of the internal electronics to occur, which would poison the nearby water, possibly terminating the lives of many marine animals.

To avoid these potentially catastrophic incidents from occurring, the route would be carefully planned, taking note of any prevalent hazards such as the Bering Strait, which contains a high density of large icebergs which must be carefully navigated. Further to this, GPS systems along with SONAR would provide the automated systems with constant feedback on what surrounds it, so that it can perform the appropriate actions to avoid a collision.

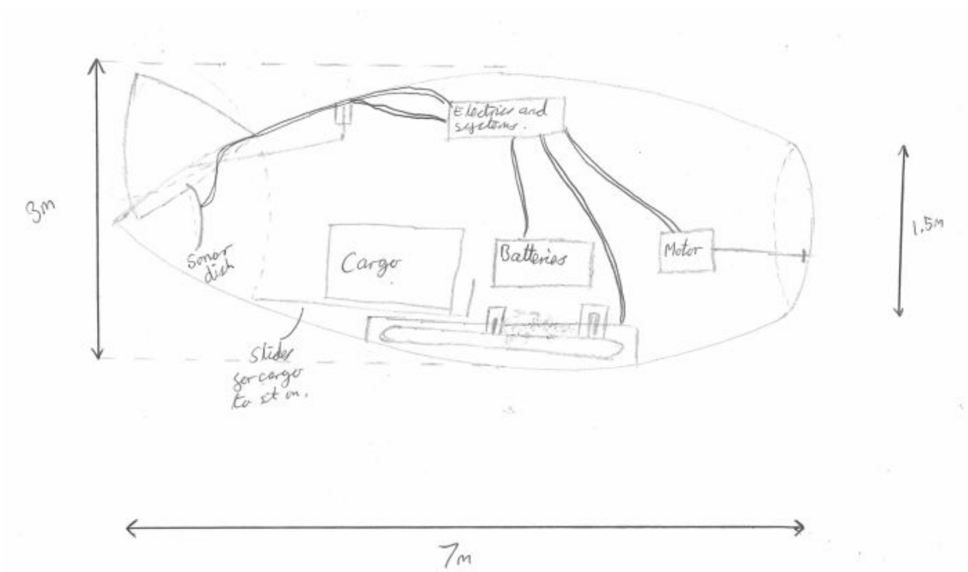
Technological Hazards

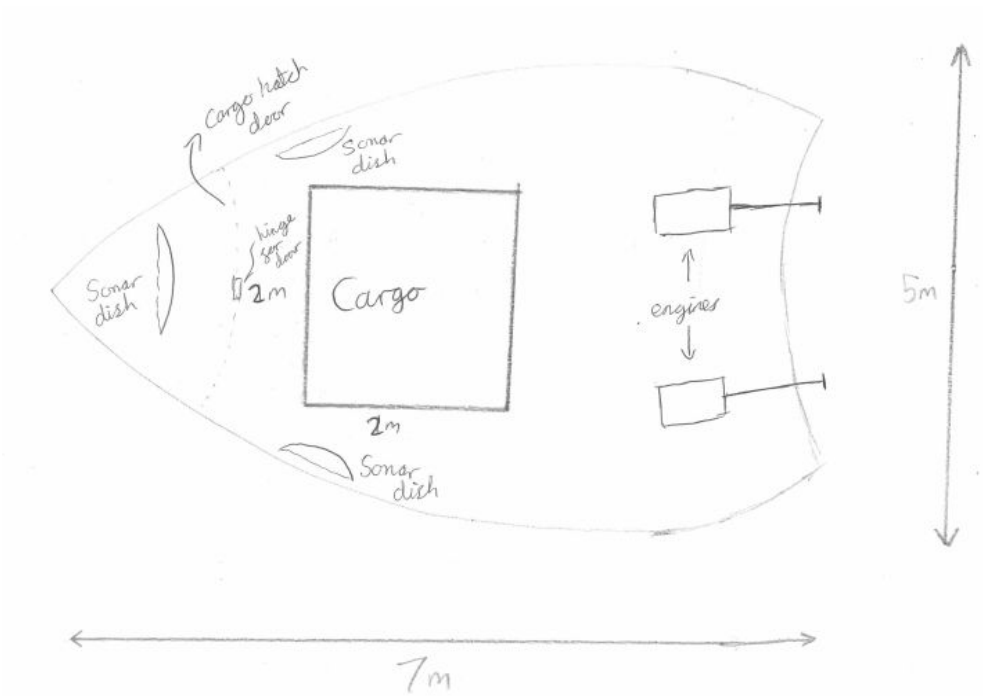
Hazards would occur in the event of failure of propulsion, energy and navigational equipment, which could occur due to poor quality or by not carefully fixing these components to the vessel in such a way as to not get damaged. It would also be imperative, given the high amount of electrical component going into the vessel, for these compartments to be airtight, which would limit the amount of sodium-rich air from getting in, and well cooled, to avoid overheating of the electrical components.

To protect against unplanned equipment failure, there would be rudimentary backup software in place, such as a fishfinder to replace SONAR, which would still be able to find obstacles near to the boat with limited accuracy, which would, of course, be better than nothing at all, given no crew onboard to monitor conditions.

An example of a major technological hazard would be an electrical fire, which has the potential to not only cripple the mission but also cause moderate environmental damage, by locally polluting the water, and allowing large masses of uncontrolled debris to damage stationary wildlife. To deal with this issue, the airtight chamber would be filled with pure Carbon Dioxide, which is completely inert and thus does not pose a fire risk. Initially, we would have wanted to use Argon, though further research showed the per-cubic-metre price to be £2000, and so we settled on CO_2 as a viable alternative to ensure that the fire risk is kept to a minimum.

Diagrams of Vessel





End goal

By the end of the voyage, we would hope to have the payload safely, economically and efficiently transported the roughly 12,500 miles to the south pole. We also aim to have created a vessel which can be reused multiple times after its maiden voyage, whose carbon footprint would be significantly lowered than that of a one-time use vessel.

We also aim to create a transport method which causes as little disruption to existing passages such as shipping lanes or roads as possible. As a result, we would be travelling through the Pacific Ocean rather than the Atlantic Ocean not least because traffic is significantly less, but also because currents are more favourable here and thus less fuel would be used. Our landing site on the south pole will also be in a more remote area nearer to Australia, thus minimising congestion impact as a result of the vessel's presence.

Throughout our project, we will constantly be looking into how the technology we use can be improved upon and made more efficient in order to perform the task more effectively. It is then that we would be able to say that we have done all we can with the present world's resources and technology to create a reliable vessel that can perform tasks well, independent of external support, and continue to run for many years after its initial fabrication.

Vessel Construction

The vessel would be made from fibreglass due to its robust and lightweight nature. It is also a very cheap and readily available material which does not corrode and doesn't require any structural joins, making it more resistant to mechanical shock. This further also aids us in making the vessel as streamlined as possible, decreasing drag in the water. This will reduce the amount of energy we use throughout the journey and, therefore, will need fewer batteries and we can save weight, further reducing the energy usage. It is always good to save as much energy as we can throughout the voyage as we want to minimise the amount of pollution created.

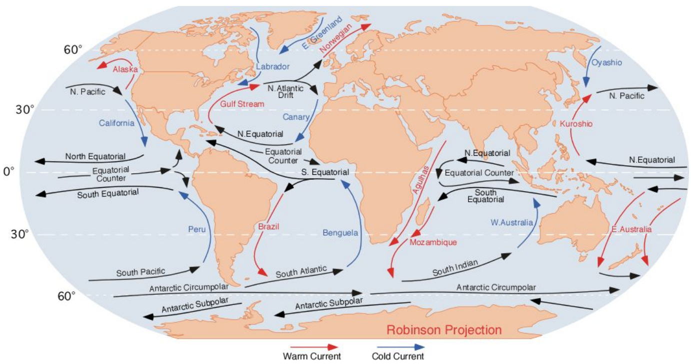
The propeller is made of an alloy of aluminium and stainless steel, which has high torsional strength and rigidity. Further to this, it would be light and corrosion resistant, which would be ideal in the salty waters and salt-rich air at the poles. After conducting research on blades on propellers[2], we have come to the decision that a three bladed propellor would be optimal. A three bladed propellor is lighter and cheaper and is also the best performer at high speeds which we would, of course, intend the craft to travel at.

Arguments for four blades state that we would achieve better acceleration and cruising stability, although considering that we aren't going to be stopping and starting routinely we believe that it would be better to sacrifice the cruising stability for reduced weight and better high-speed performance.

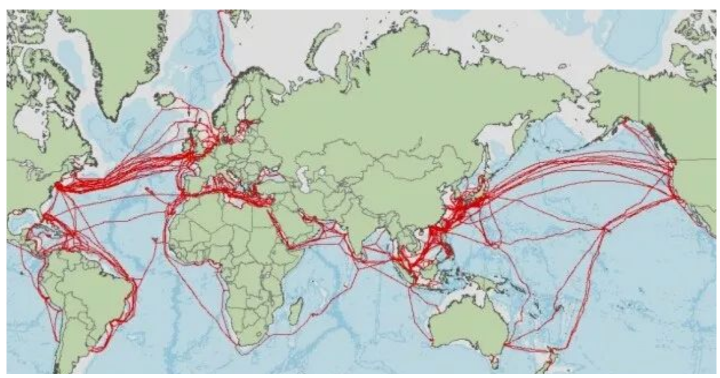
[2] Blade Count

Route

When travelling from the north pole to the south pole, via sea, there are a variety of routes possible, each with their own advantages and disadvantages that we had to consider whilst planning.



For example, the Atlantic Ocean has favourable sea currents[3] that go down west of Europe then across and east of South America. However, the Atlantic is a much busier cargo shipping lane as products are being transported between Europe and North America via vast shipping containers which could cause a problem to our much smaller vessel. Also, the landing spot we aim to reach on the South Pole is much further east, towards Australia, which would create a much longer and unnecessary journey from the Atlantic to our landing spot using more energy and releasing more greenhouse gases into the atmosphere.



For this reason, we have decided to travel via the Pacific Ocean. This is because it still has useful currents which will save energy during the long journey as we are fighting against fewer forces. However, this will take us through the Bering Strait which almost completely freezes over during the winter months, dictating our schedule throughout the voyage. Although, the Pacific has comparatively much less major shipping lanes than the Atlantic. This trade-off is much more favourable towards the Pacific Ocean as it is much easier to change our schedule than thousands of other cargo ships'.

3 Ocean Currents

Anti-collision and navigation

Our anti-collision system involves three sonar dishes, one at the front in the hatch and the other two at either side to our sides. This will give us a 180-degree view of the water and what is in it around us. We will use the sonar and use the programme

Converting from sea to land travel

To convert from sea to land, we have caterpillar tracks ready to deploy from inside of the vessel. As soon as we are within 100m of land, and are floating in the water, the tracks will deploy as the vessel moves closer to ensure that getting on the ground is a seamless procedure.

Converting from land to sea travel

To convert from land to sea travel, we propose for the vessel to fall off the edge into the water. Whilst this sounds like a ludicrous idea, it has been implemented and is in current use by lifeboats to ensure rapid sea entry.[4] Our ship, as a result, has been externally designed and internally protected through the use of shock absorbers to ensure minimal impact from the fall. This method of entry would mean that we can travel in a direct line to the Bering Strait without needing to divert, make the journey time longer, and potentially damage more on-land habitats. The water into which the boat will fall will also be moving, thus limiting the concrete-like impact that would occur. The vessel is also designed with a low centre of gravity, so that the slightest waves could re-right it, continuing the journey to the south pole.

[4] Lifeboat falling into sea

Technological systems

Power supply, storage, and regeneration

Our power supply will be made of multiple cells, which contribute to a 1MWh power storage supply. The optimal temperature for batteries is found to be approximately 20 degrees[5], which would be easy to maintain, so long as the batteries are not kept in direct contact with the hull. Our power sources will come from solar and wind supplies. We will use the highest efficiency solar panels on the market. These are 20% efficient and will generate 200W of power per square metre. We are set aside 15 square metres on top of the vessel. As long as there are 5 hours of good sunlight per day the panels will generate 15kWh of energy per day. We will use two modified commercial wind turbines[6]. We are aware that optimal wind conditions will not constant so both turbines will be retractable to reduce drag and to prevent damage. They are 1000mm in diameter. When the turbines are in use they will generate 1kW of power. There will be roughly 12 hours of good conditions of wind a day so there will be an estimated 24kWh of energy replenished per day. In total that means an estimated 39 kWh of energy replenished from renewable sources.

Land thrust

For travelling on the land we will still be using the same motors used for travel in the sea but prop shaft will be connected to a drive shaft which will, in turn, move the caterpillar tracks which will have deployed. Where will be multiple sensors on the hull of the vessel such as sonar and our pre-planned route which will tell the computers on board when to lower the tracks - which have been stored inside the hull during the journey - when it is time to start travelling on the land.

[5] Optimal Battery Temperature
[6] Wind Turbine Model

Sea thrust

The thrust supply for the sea will come from our two electric motors. We are planning to use two 200kW electric motors giving us 400kW of power which is around 500hp[7]. This will be perfectly adequate with our 1000kWh batteries. Because we won't be using the motors at full power the whole time we will be able to save a lot of power and charge in the batteries. The motor will be connected to their respective prop shafts to propellers to power the vessel. To steer the boat, instead of using a rudder we will use varying engine power to control the boat's yaw. We have chosen this as it uses less moving parts and does not require another motor to power the movement of a rudder.

Loading/unloading cargo

For the loading and unloading of the cargo, we have designed rails to be put into the vessel which the load can be slid down. There will be a buffer at the end of the rails to stop the load going down into the vessel any further and damaging it. We have put a jack onto the top roof of the vessel to push open the door. We will attach a winch at the edge of the cargo hatch to pull out the cargo when need be.

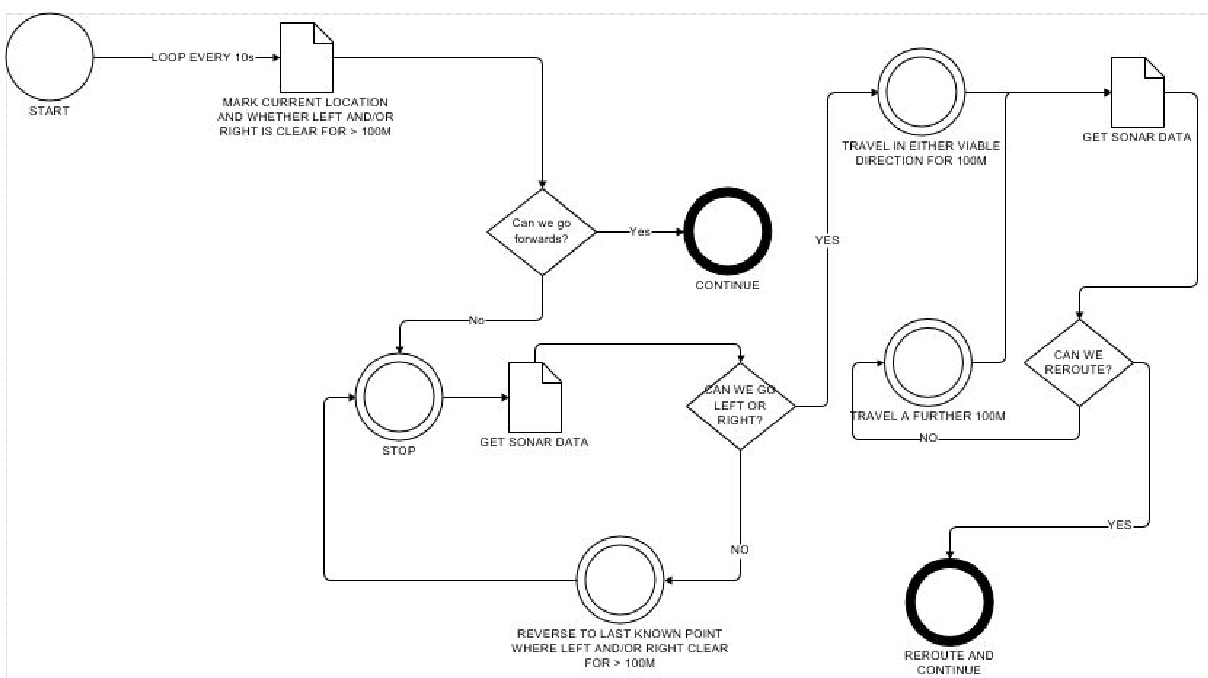
[7] Tesla Model 3

Collision Avoidance on land

As outlined by the diagram, protocols would be put in place to ensure that the vessel isn't hit whilst on land. For example, as shown by the diagram below, if obstacles are found, the automated systems would have a method of avoiding them and being able to continue the journey without the need for human intervention. It is, of course, imperative that the vessel doesn't damage wildlife in the areas that it travels too, so the SONAR would be used as input, which is able to give a wide range of input points, allowing the system to make an informed decision as to what it should be doing all the time.

Anti-collision and navigation

Our anti-collision system involves three sonar dishes, one at the front in the hatch and the other two at either side to our sides. This will give us a 180degree view of the water and what is in it around us. We will use the sonar and use the programme below to control our movements in a way that is safe and efficient.



The main body of our vessel is made up of fibreglass, which itself is not the easiest to recycle and can end up taking a long time to decompose in landfill sites.[8] However, this material is not a pollutant and, therefore only creates litter, which is in no way good but better than harming the atmosphere. This means that it is still better to try and reuse the materials in our vessel. Luckily, there are ways to grind down the fibreglass and reuse as a 'filler' in certain materials, for example, concrete is an excellent application of previously used fibreglass as it creates necessary strength and durability in the end material.

There are also more promising forms of recycling the material in development that will hopefully come through soon. This involves a chemical or mechanical breakdown of the material, breaking the bonds between the glass, resin and other materials such as polyester matting, these components can then be recycled separately.

Lifespan of parts & equipment

It is important all of our parts and especially equipment is able to last the entire journey so our vessel can complete the crossing. For this reason, we have made sure that during the design process of our vessel, we use specific materials that won't corrode due to the constant exposure to seawater and to create watertight compartments to house our electrical and technological systems in a way that they will not be vulnerable to the harsh elements during the journey.

For example, the main body of our vessel will be made out of fibreglass. We chose this because it is cheap, light but most importantly resistant to corrosion and will not wear away during our voyage. This will, therefore, be the main component in contact with the water.

[8] The future of recycling fibreglass

Backup Systems

Remote Override

In case of emergencies, there would be a 24hr emergency override station in which at any one time 2 people would be monitoring the progress of the vessel. They would be each paid £5 an hour, based on a shift scheme. To ensure that they could have a 360-degree view of what is going on - multiple cameras would be on the ship so that any direction of motion can be observed when necessary. Cameras would be located; facing forward, left, right, backward in both air and underwater, with infrared capabilities for 24hr all-weather observation

Human vs AI

There are many advantages and disadvantages that should be considered when thinking about whether we want to have people on board or if we want to have the ship controlled by artificial intelligence. For example, if we do decide to go with human intervention there are more costs and logistical challenges including, food, sleep and any living quarters. This means that the boat must be bigger to accommodate the people on board, however, this also allows us to forget about any computer controlled navigation that must be there to manoeuvre around obstacles and keep on track.

Budget

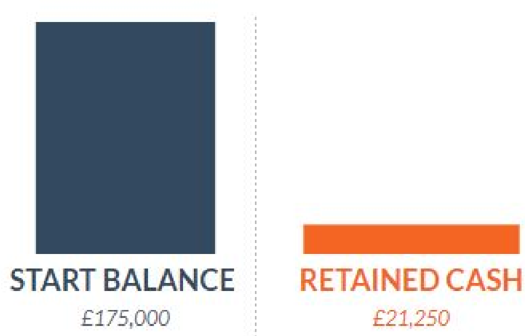
For this project we gave ourselves a budget of £175,000, and whilst our estimations are the best we can currently create, we are aware that expenses might logistically be higher, such as those for the construction phase. Some aspects of the craft were easy to estimate, such as the prices of such as cameras, whereas raw materials, fibreglass hull, and a chassis, were a lot more challenging to get an accurate quote. Please see below an image outlying our rough budget, along with a graphical illustration of budget vs spending.

Expenses

	Planned	
Totals	*£153,750*	
Hull (fibreglass)	£15,000	
Propellors	£2,000	Based off market prices
Engines	£10,000	Tesla motor estimation
Solar panels	£5,000	20% efficiency 200 watt per m^2
SONAR	£9,000	Echopilot FLS
Comms Systems	£15,000	Satellite internet data plan
Satelite Navigation	£250	
Batteries	£10,000	Tesla's £100 per kWh for 2019
Chassis	£10,000	
Land Transport	£20,000	Estimation of tracks and chassis
Wind Turbine	£5,000	Retail price of AirForceTM 1
Shock Absorbers	£6,000	
Wages	£43,800	Based on a salary of £5/hr for 2 people 24hrs a day for 6
Cameras	£2,700	

Budget

	Planned
Totals	*£175,000*
Initial Budget	£175,000



Conclusion

To conclude, the pole to pole challenge has presented us with an array of exciting and difficult challenges which we have taken on board with utmost enthusiasm. We are confident that our vessel design would be capable of overcoming any challenges that would arise during the course of a journey and safely carry the 1 tonne of material to its final destination.

Acknowledgements

Our team would firstly like to thank Mr Blott and Mr Matthews for the outstanding opportunity that they have presented us to enter into the world of engineering, and for their long work within their respective fields. It is thanks to these two gentlemen that we have been given the opportunity to express our admiration for engineering and has allowed us to learn more about specific aspects - such as maritime engineering - as well as developing our skills in group work.

Further to this, we would also like to thank our Engineering teacher, Ms Jane Chapman, for taking the time to set up regular sessions during which we could continue with this project. She has also consistently been able to help us in such a way not as to perform the tasks for us, but strengthen our ability to think beyond what the basic tasks are asking of us. It is thanks to this that we can say we are proud to be able to show what we have achieved.

References

1- https://bit.ly/2TOuBRS

Tropical Storm Image - https://wapo.st/2Sr03Jc

2 - https://bit.ly/2E753tC

3 - https://bit.ly/2RH9NKH

4 - https://bit.ly/2GBJkMi

5 - https://bit.ly/2E5AftK

6 - https://bit.ly/2TNiRPx

7- https://bit.ly/2GparL0

8- https://bit.ly/2UUMsGY