Information Pack

Rolls-Royce Brunel 200 Inter-School Competition

Next year marks the 200th anniversary of the birth of Isambard Kingdom Brunel, one of the most innovative engineers of the 19th Century. To commemorate the occasion, Brunel 200 is running a number of activities in the City of Bristol and the South West, between April and September 2006.

Rolls-Royce is a key partner in Brunel 200, and for our contribution to the celebrations, we are hosting two competitions for schools in Bristol and South Gloucestershire. The first project is poster based, open to students in Years 1-4 and the second is a Design & Make, Ship Build project, open to Years 5-9. The details of both projects are enclosed.

The National Curriculum

The projects have been designed with the flexibility to be included in the school curriculum, although this is not a requirement to participate in the competition. It is up to individual schools to decide the time they would like to invest, it could be anything from a few hours to 40 hours. From our experience, projects conducted within normal school hours as part of the curriculum are the most rewarding, in terms of success and participation. To underline our commitment to the National Curriculum, we have summarised how each project could be tied to a number of subjects in the *Teacher Guidance Notes*, in response to feedback from our questionnaire in March 2005.

Grand Final & Prizes

Later in the academic year, schools will be able to submit their entries, which if selected, will be invited to a Grand Final, where a panel of judges will award prizes. For both projects, an award will be made to the Top 3 in each year group (Bronze, Silver and Gold) as well as the overall winner for each project. There will of course be a number of other prizes awarded for various categories on the day itself.

The winning posters will be displayed at Rolls-Royce, with the overall winning poster, professionally framed and then returned to its school. The winning team of the Ship Build project will receive a commemorative statue of Brunel. The grand prize for both projects is a tour of Concorde, the world's only successful supersonic passenger airliner, and an activity day at the Rolls-Royce facility for the winner's entire class.

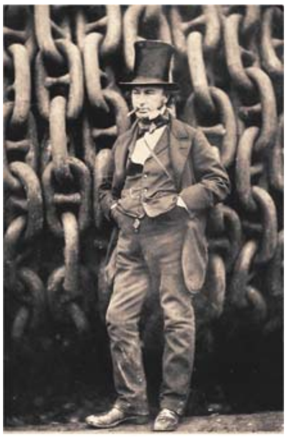
Timescales

It is recommended that all participating schools complete their projects by *03 April 2006*. We will contact you in March with details on how to submit your projects. In response to the feedback from our questionnaire, we will be hosting a grand final in July 2006; the exact details of which are currently being worked on.

Next Steps

The two projects are defined in the pack and we have provided *Teacher Guidance Notes* to get you started. The pack also contains information on *Brunel*, the *SS Great Britain* and *Marine Propulsion*, but it is one of our aims to get students to conduct research on their own, therefore the information provided should used as a starting point. You are free to copy the pages and distribute them to your students, but please abide by the copyright notice on the rear cover. We may be able to provide an electronic copy, in Adobe PDF format if you wish to print out copies, in which case please contact us.

Brunel 200 & Rolls-Royce



"2006 marks the 200th anniversary of the birth of Isambard Kingdom Brunel, one of the most versatile, audacious and inspirational engineers of the nineteenth century.
His achievements changed the world and shaped the way we live today." – brunel200.com

To mark the anniversary of Brunel's 200th birthday, the City of Bristol are holding various events, exhibitions and competitions to celebrate his achievements as an engineer, with particular regard to some of his greatest creations which are situated in Bristol.

For further information contact:

Brunel 200
BCDP, Leigh Court,
Abbot's Leigh,
Bristol
BS8 3RA

tel: 01275 370816
email: *Andrew@brunel200.com*
www: *www.brunel200.com*.

"The invention was nothing.
The achievement was making the thing work" – Sir Frank Whittle

Rolls-Royce plc is a global power systems company providing power for land, sea and air, with leading positions in civil aerospace, defence, marine and energy markets. Our core technology is the gas turbine, which Sir Frank Whittle developed leading up to, during and after the Second World War.

The *Rolls-Royce Brunel 200 Inter-School Competition* is one of many Community Projects in the Bristol and South-Gloucestershire area which Rolls-Royce participates in. Teams of young engineers have helped children build gliders (*Flying Start Challenge*), taken them on a tour of engineering & technology (*High Flyers*) as well as support projects like the *SS Great Britain*.

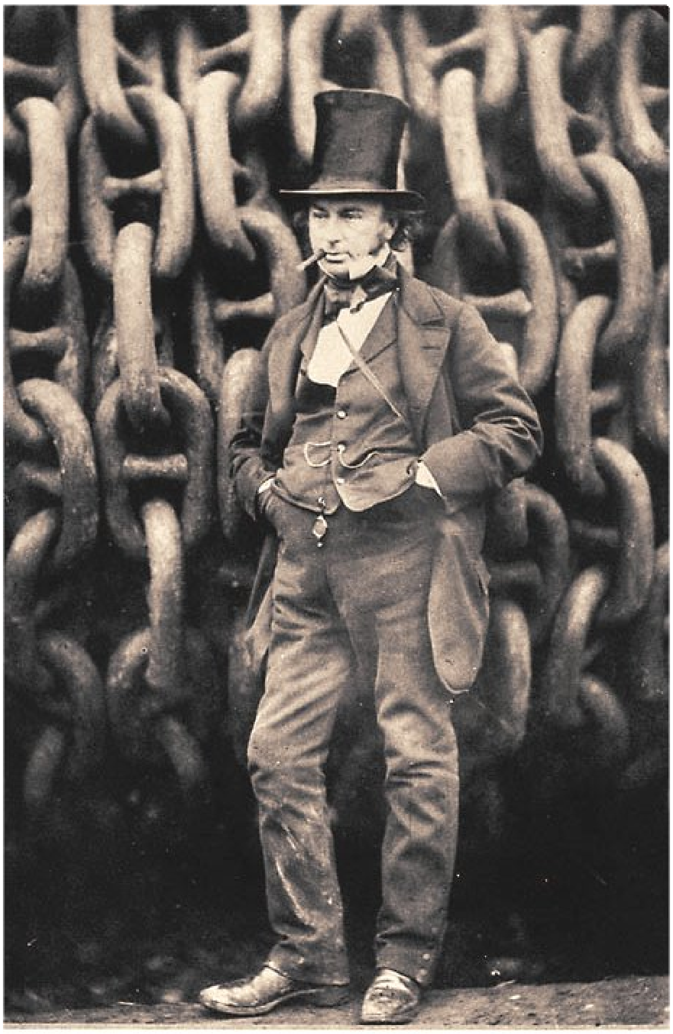
To contact the *Rolls-Royce Brunel 200 Team* refer to the *Contacts* page.
To inquire about or request further information on Community Projects please contact Roger James (roger.james@rolls-royce .com).
For information about Rolls-Royce, visit our website, *www.rolls-royce.com*.

Isambard Kingdom Brunel: **1806 – 1859**

Isambard Kingdom Brunel's career spanned civil, mechanical and marine engineering, as well as architecture, the arts and design.

His career begun in 1820, when he travelled to France to gain a more formal education in his chosen field of engineering (there was no formal training in Great Britain until the 1850s). Upon completion of his Apprenticeship in France, he returned to work in his father's drawing office, and soon became a very ambitious man and adopted the phrase "En Avant", meaning "Get Going".

Brunel is perhaps most widely associated with Bristol due to some of his finest creations being located here, such as the *SS Great Britain* - fully refurbished after 35 years extensive renovation - and the Clifton Suspension Bridge, which had its foundation stone laid in 1831 but is completed in 1864, 5 years after his death.



Throughout his career Brunel reached for the impossible, sometimes getting there and other times failing spectacularly. He however, is widely recognised as an engineering genius and his appeal remains today, coming second to only Sir Winston Churchill in the BBC's *Great Britons* (2002).

Isambard Kingdom Brunel: **Timeline**

1806 Birth of Isambard Kingdom Brunel, in Portsea, Portsmouth.

1820 Travels to France, to gain a more academic understanding of engineering.

1822 Joins his father's drawing office on return from France.

1825 Construction of the Thames Tunnel begins, with Brunel formally becoming resident engineer a few years later in 1827.

1831 While recovering from an injury when working on the Thames Tunnel, Brunel learns of a competition to design a bridge over the Avon at Clifton. In 1831 he is awarded first prize, and on the 21st June the foundation stone is laid.

1832 Brunel is appointed chief engineer of the Great Western Railway (with no previous railway experience!), and starts to survey the route from Bristol to London.

1836 Brunel begins work on his first ship, the *SS Great Western* (a paddle-steamer) for the Great Western Steamship Company. He also marries Mary Horsley, after first meeting the Horsley's through a mutual friend in 1832. They go on to have three children.

1841 The Bristol-to-London section of the Great Western railway is opened.

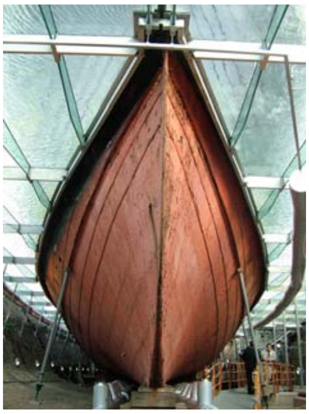
1843 *SS Great Britain* Launched as a luxury transatlantic passenger liner.

1859 Brunel dies after a stroke, while working on the *SS Great Eastern*.

1864 The Clifton Suspension Bridge opens.

1800 **1870**

The SS Great Britain



"Technological innovation, inspirational design and some truly revolutionary features lay behind the development of the *SS Great Britain*, the world's first iron-hulled, steam-powered ocean going ship" – ssgreatbritain.org

(A painting by John Walter showing the launch of the SS Great Britain in 1843)

Technologically Advanced

The *SS Great Britain* was built in 1843 under the supervision of Isambard Kingdom Brunel for the Great Western Steamship Company. Originally it was envisaged as a paddle-steamer, but was quickly changed by Brunel to take advantage of the latest in marine propulsion technology – the screw propeller.

The *Great Britain* was intended for the expanding transatlantic passenger trade, an example of the growing importance of world communications at the time. *On 26 July 1845, she completed her maiden voyage to New York in an astounding 14 days! (A whole day quicker than his previous ship, the SS Great Western).*

Arguably Brunel's finest work, the *SS Great Britain* was the forefront in technological advancement and marked the beginning of a rich nautical history.

BRUNEL'S
ss GREAT BRITAIN

The *SS Great Britain Trust*, kindly provided the photos on this page.
For further information visit their website, *www.ssgreatbritain.org*.

Alternatively,

Brunel's ss Great Britain
Great Western Dockyard
Gas Ferry Road
Bristol BS1 6TY

The SS Great Britain: **Timeline**

1806 Birth of Isambard Kingdom Brunel.

1843 *SS Great Britain* Launched as a luxury transatlantic passenger liner, built in Bristol Docks.

1854 The *Great Britain* was used as a troop ship, carrying troops to and from the Crimean War.

1903 December 17th, the Wright brothers make their historic flight and begin the era of powered flight.

1930 Sir Frank Whittle submits patents for the jet engine.

1800 **1900** **2000**

~1830 The end of the Industrial Revolution.

1914-1918
The First World War.

1970 Salvage and Restoration of the *SS Great Britain* takes place in Bristol is completed in 2005.

1886 The ship was used as a coal hulk, and supplied the battle cruisers *HMS Inflexible* and *HMS Invincible*.

1882 Engines removed from the ship and it is turned into a fast three-masted sailing ship, due to high maintenance costs.

1939-1945
The Second World War
(above is one the key fighters of the War, the *Supermarine Spitfire*, powered by a Rolls-Royce *Merlin*).

1852 The Ship was re-built as a fast and luxurious emigrant clipper, which circumnavigated the globe.

Brief Guide to Marine Propulsion

Introduction

Today people travel by planes, jets, helicopters and cars, which are all fast machines. People in general have travelled by water for thousands of years. Moving over water was quicker and easier than overland by using the natural element of wind. Boats could also transport large cargoes over great distances. The first large galley ship was believed to have been used in the Mediterranean in 3000BC. An example is shown below.

The picture is of a "galley" which moves by rowing (man power) and *sails*, which use the wind to make the boat move forward.

What is Propulsion?

"Propellare" is the Latin word for propel which is defined as "to drive forward". *Propulsion is the action of propelling or pushing forward*.

A propulsion system is a machine that creates a force called thrust to push the object forward. If we look back in time the main ways used in moving boats are with *oars* (or *paddles*), *sails*, *paddle wheels, propellers* and more recently *water jets*. We will look at each of these to find out how they make boats move.

Oars and Paddles

Paddling was probably one of the first methods used to propel boats. Paddles and oars are tools made for pushing against the water. As it is pushed through the water, the boat tends to travel forwards as a reaction to this backwards force. This follows one of *Newton's Laws*.

Sir Isaac Newton's 3rd Law of Motion

"For every action there is an equal and opposite reaction."

Rowing was discovered when people realised that by facing the back of the boat, and pulling a long oar through the water, they were using their body strength more effectively.

Using Oars was effective for small vessels, but proved very costly (in ship weight, number of people etc) for carrying cargo from one place to another. One solution was to the wind (which was free!) to try and propel ships. Early designs of sails were simply a large surface made of fabric to give the wind something to push against.

The main limitation of this design was that couldn't travel against the direction of wind. To overcome this, sailors used the wind and sails to generate a force in the direction they wanted to travel. To achieve this, they needed much more control (see *Steering*).

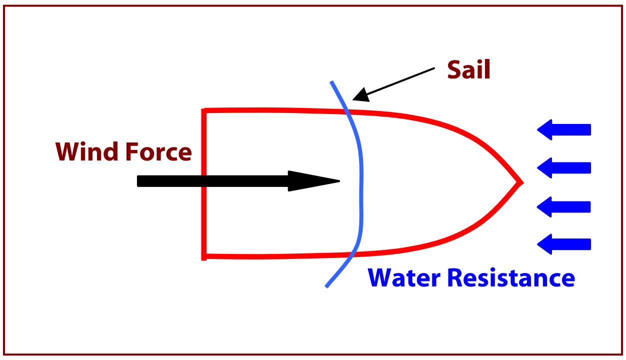
How does a sail work?

A sail is a surface, which is used to generate a force by being placed in the wind. It is similar to an aeroplane wing but operates in a vertical position.

The first sails were large and simply captured the wind, to propel the ship. The diagram shows the two main forces involved, the wind and the resistance of the water. The water resistance exists because the ship pushes the water away as it travels through it. Try clapping and then do exactly the same in large bucket of water. You need more effort to clap in water than

Brief Guide to Marine Propulsion

air. The force you feel resisting your hands is the water resistance.



What happens with yachts?

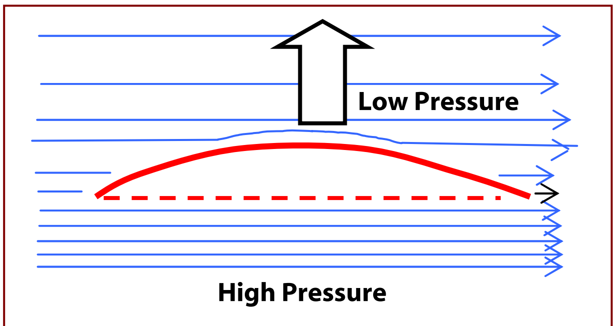
A good example of a type of ship that can travel against the wind is a yacht.

When the wind hits the surface of the sail, one side of the sail will have a higher pressure than the other. The higher pressure air tries to reach the low pressure air generating a force called lift. The sail is then pulled towards the side of lower pressure, which causes the movement of the boat. We then use a *rudder* to steer the yacht.

It was *Daniel Bernoulli*, a Dutch-Swiss scientist and mathematician who discovered this phenomenon with the following:

Bernoulli's Principle

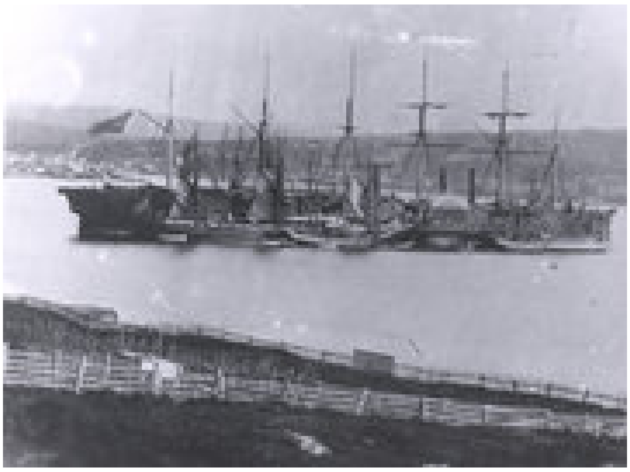
"In fluid flow, an increase in velocity happens at the same time as a decrease in pressure."



Paddle Wheels and Propellers

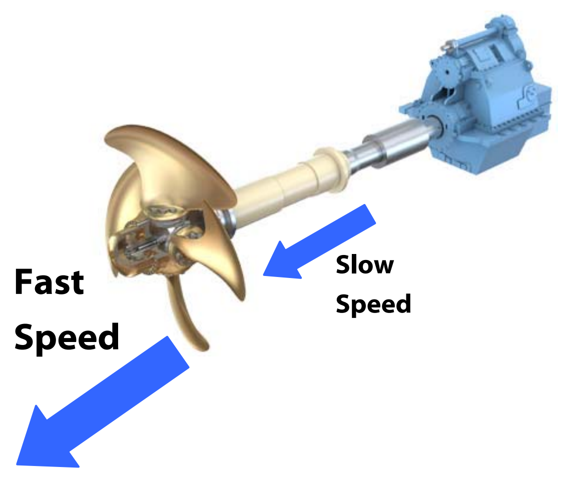
At the beginning of the 1800s, steam engines were adapted so that they could power ships. The first steam engines rotated a *paddle wheel* at the back of a ship or two paddle wheels at each side.

Below is a picture of the *SS Great Eastern* designed by Brunel it was propelled with *paddle wheels*, *propellers* and *sails*!



Water is what we call an incompressible fluid meaning it is not possible to "squash" or "squeeze" it like a gas such as air.

When something is pushed into water and the water has no-where to go the water will push back. While the water may have some direction to go around the blade, generally, the water pushes back against the paddle wheel blade and allows the boat to move in the opposite direction.



The water travels at a slow speed into the blade; the screw-like design then squeezes the water quickly out the back.

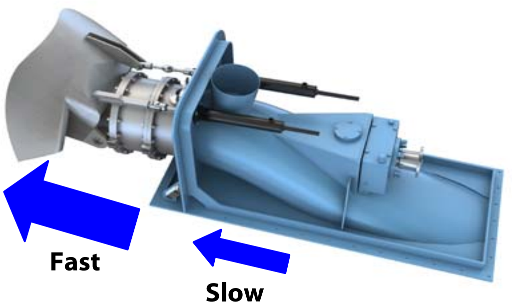
Brief Guide to Marine Propulsion

In the 1840s screw propellers were invented. Much like a sail, a propeller works in the same way to produce thrust as there is a difference in pressure from the front and the rear surfaces of the blades.

Today, we still use propellers but in various shapes and sizes.

Water jets

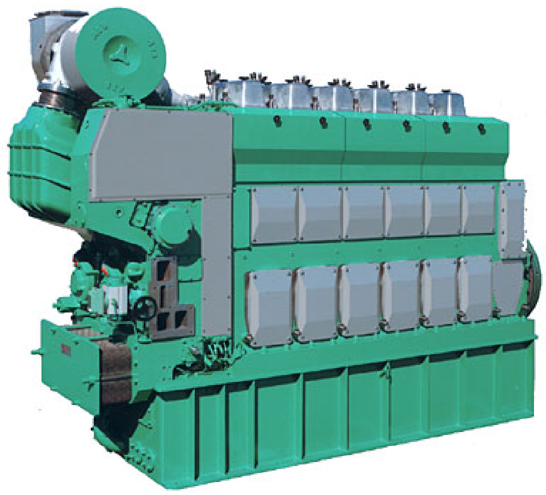
Modern fast powerboats are powered by water jet, sometimes called a pump-jet. These work in the same way as a rocket or a jet engine.



It works through Isaac Newton's 3rd Law of motion this time slow moving water is sucked in and blown out the back at a faster speed, producing a force. The boat then reacts by moving in the opposite direction.

More Power…and the Future

The invention of the steam engine to power paddle wheels and propellers has drastically changed the way ships and boats are driven. *With today's technology it is how we power a ship that has become equally important.*

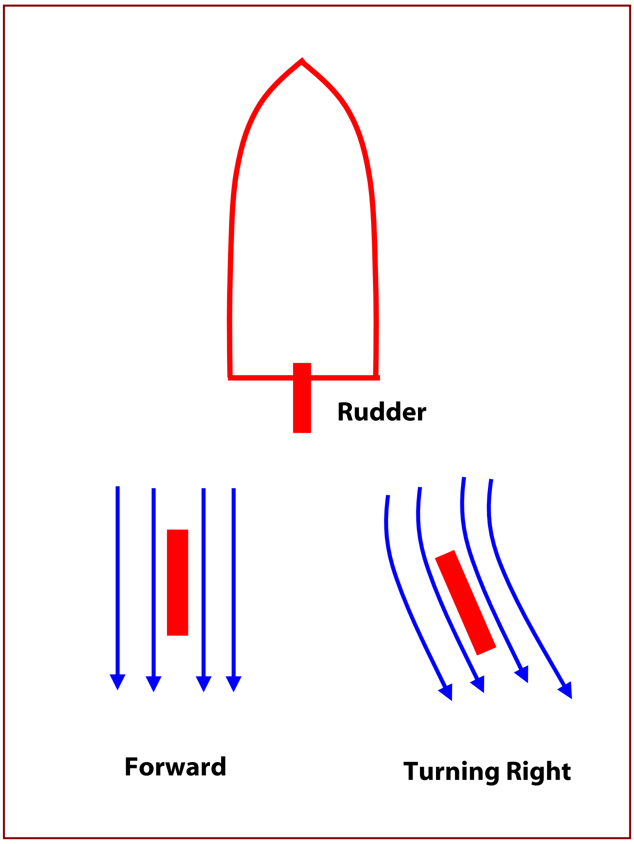


Nowadays there are diesel engines that work like the ones in your car as well as Gas Turbines like those on jet planes.

Brief Guide to Marine Propulsion

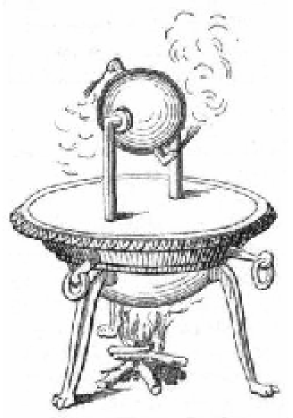
Steering - Rudders

The rudder was invented by the Chinese over *5000 years ago* and is still used today. It is a flat piece of wood or metal, which is fixed to the back of the boat or vessel and stands upright in the water.

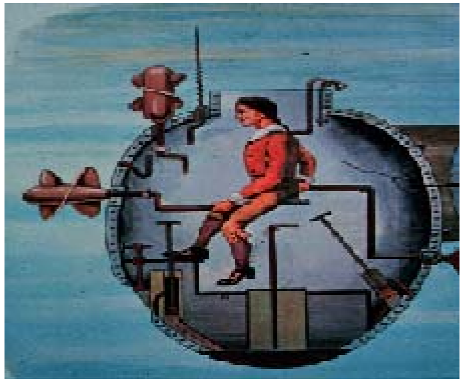


As we move the rudder to the right we steer the boat to the right. The rudder applies a force against the flow of water that passes along the hull, which causes the boat to change direction. A greater force is created by a rudder than steering oars as they are placed deeper in the water and have a larger surface area than steering oars which means they are strong enough to steer larger ships too.

History of Marine Propulsion

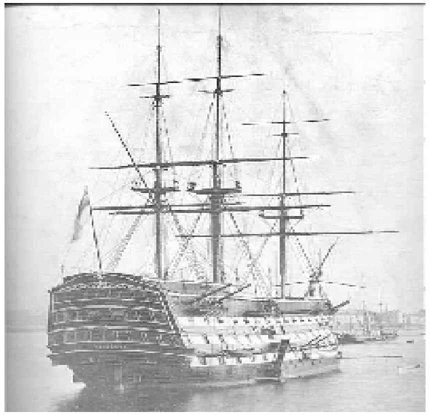


Hero of Alandria was a Greek engineer and geometer. *His most famous invention was the first documented steam engine*, the *aeolipile*. His invention dates back to about 150BC



Named because of its shape, the **Turtle** was *the first recorded submarine and was first used on 7th September 1776* when it attacked the HMS Eagle.

The **Santa María** was the largest of the three ships used by Christopher Columbus in his first voyage across the Atlantic Ocean in 1492. *It took him 71 days to cross the Atlantic Ocean.*



The **HMS Victory** launched 1765 costing around £63,000 to build. She is the *oldest ship still in commission in the world* and sits in dry dock in Portsmouth as a museum ship.

The paddle steamer **Waverley** is the last survivor of the fleets of Clyde steamers, and t*he last sea-going paddle steamer in the world*.

The **SS Great Britain** was designed by Isambard Kingdom Brunel and built in a specially adapted dry dock at Bristol. *In 1845 it took the SS Great Britain just 14 days to cross the Atlantic.*

Rolls-Royce

brunel 200

History of Marine Propulsion

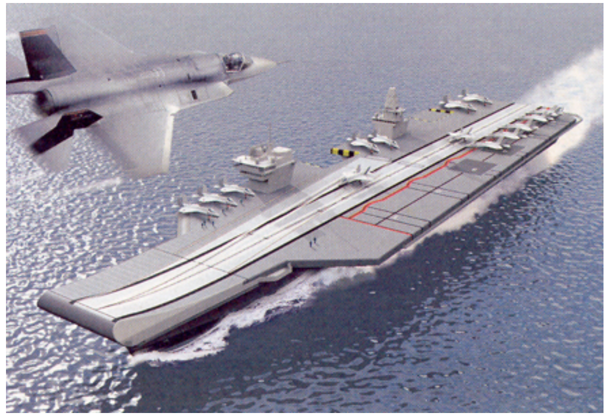
The sixth **HMS Dreadnought** of the British Royal Navy was the *first battleship to be powered by steam turbines*, making her the fastest warship of her size.

A German World War II **U-boat.** Germany had the largest submarine fleet in World War II. Winston Churchill was quoted as saying, "*The only thing that really frightened me during the war was the U-Boat peril.*"

A **catamaran** is a type of boat consisting of two hulls joined by a frame. *Catamarans were used as early as 5th Century*. (Picture shows the Rolls-Royce powered high speed ferry.)

Cargo ship or **freighter** is any sort of ship that carries goods and materials from one port to another. *Thousands of cargo carriers ply the world's seas and oceans each year*.

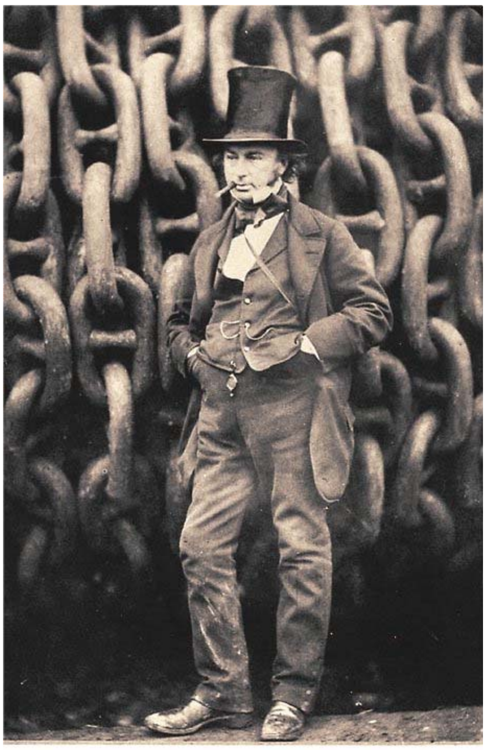
Titan X-Craft - Rolls Royce engines have been selected for X-Craft, an experimental high-speed aluminium catamaran.

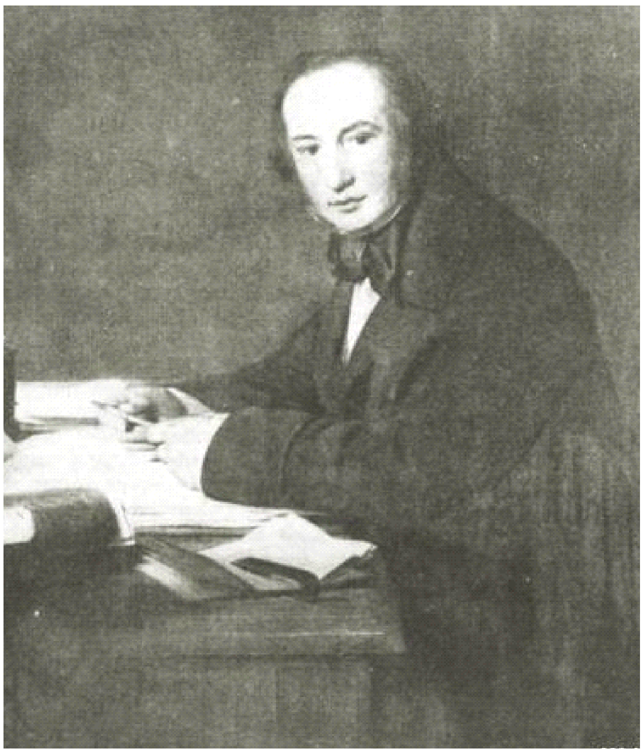


Future Carrier - For the UK Future Carrier, Rolls-Royce is the principal contractor for the propulsion system. The MT30 engines will power the Future Carrier and produce enough *power for 1 million pieces of toast!*

Poster Project

Isambard Kingdom Brunel's ship the *SS Great Britain* revolutionised passenger travel at sea. If Brunel was alive today, what sort ground breaking new invention do you think he would design to revolutionise passenger transport across the Atlantic Ocean?





Poster Project

Would he design another ship?

This ship is a new design from FastShip Inc., based in Philadelphia in the United States. It is a cargo ship that is capable of travelling at 40 knots. *That is fast enough to water ski behind!*

The FastShip is powered by 5 Rolls-Royce Jet Engines!

Or would he design a new type of plane?

This plane is an Airbus A380 and is currently the largest passenger airliner in the world. When it enters service it will be capable of carrying *555 passengers* at a time.

The A380 uses 4 Rolls-Royce jet engines!

What about a bridge?

The Clifton Suspension bridge was designed by Brunel who won the contract to construct the bridge in 1830. Unfortunately he died before the bridge was completed but the bridge was finished as his memorial and finally opened in 1864.

The bridge is 414m long and stands 76m above the water. It was originally designed for horse and carts, but is capable of handling between 11-12,000 motor vehicles passing over it each day.

Poster Project

Or a tunnel?

The Eurotunnel links the rail and motorway networks of the United Kingdom and France. The system comprises three tunnels, each of approximately *50km in length* and running under the English Channel between terminals in Folkestone, Kent and Coquelles, France.

The first tunnel breakthrough was on 1st Dec 1990 and the Eurotunnel was officially opened on 6th May 1994.

What about something totally new?

Why not combine the best bits of all these ideas, or think up something completely new!

It doesn't matter how crazy your imagination is, and whether you think the best method orfcrossing the Atlantic is via a brief trip to space or in a hot air balloon powered by sheep!

We want to see *your* ideas!

Why don't you research Brunel's greatest creations and use these ideas to understand how he would think in today's modern world!

Let your imagination run wild and remember, at the time when Brunel was thinking up these new designs people said they were impossible, but they worked!

Once you have some ideas, draw or paint a picture of your idea on a sheet of A3 paper and you could win a prize.

Who knows, maybe you could be the next Brunel!

Poster Project

Judging Guidelines

The posters will be judged in the following categories: -

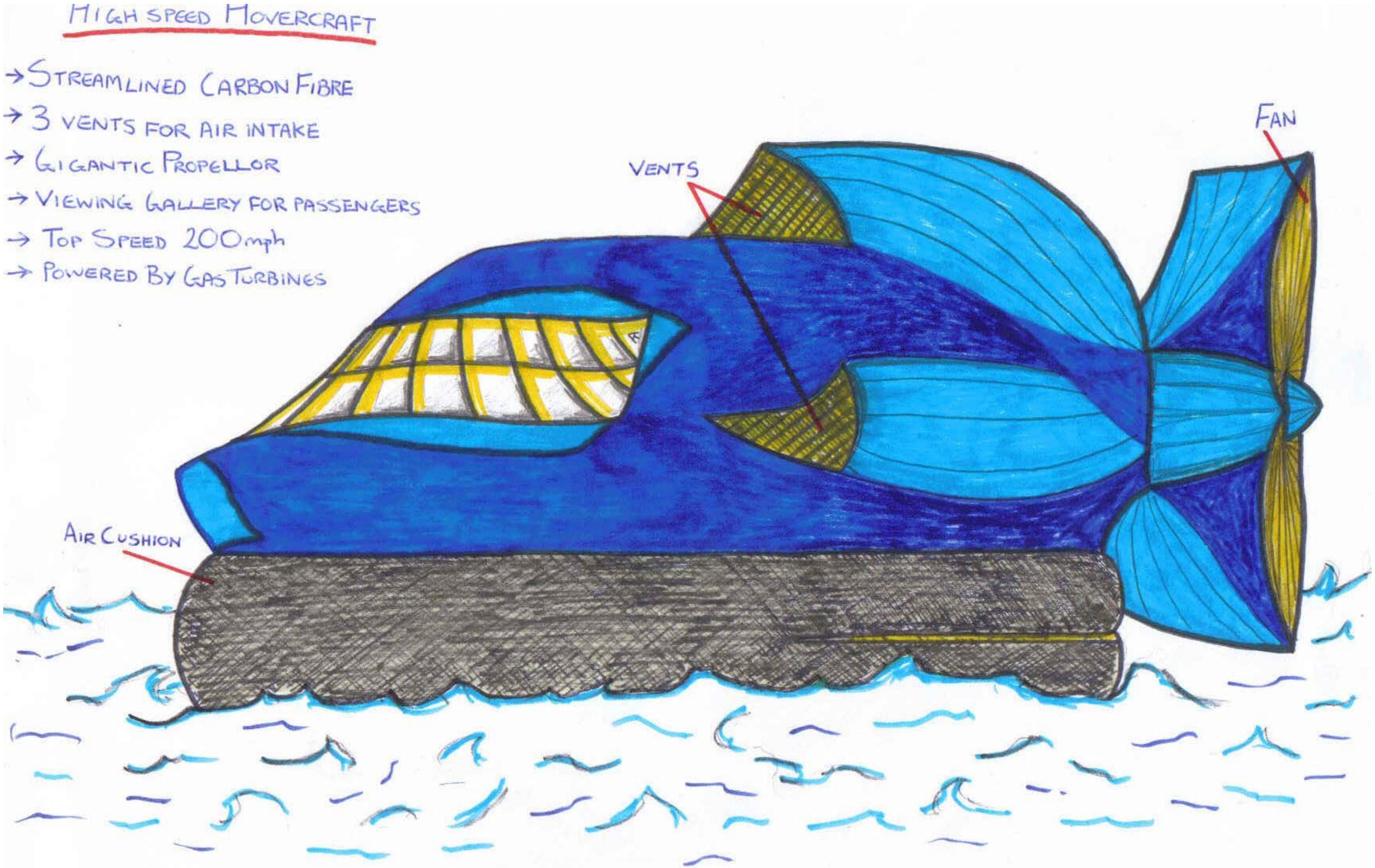
Year 1:	Gold, Silver, Bronze
Year 2:	Gold, Silver, Bronze
Year 3:	Gold, Silver, Bronze
Year 4:	Gold, Silver, Bronze
All Years:	Overall Winner

The posters will be judged according to the following criteria: -

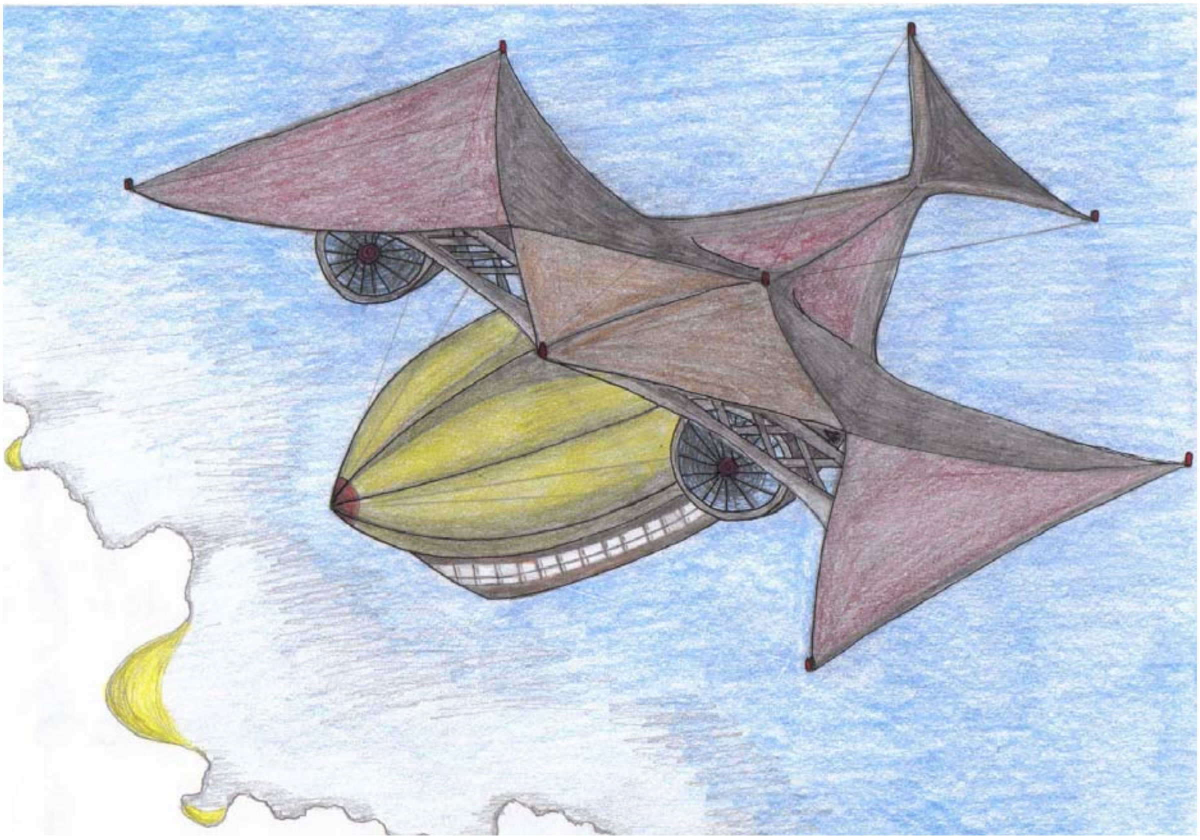
1. *Innovation*
   Brunel was a famous innovator and was not afraid to try something radical and different.
2. *Demonstration of Learning*
   Designs should show ideas inspired by research into Brunel.
3. *Environmental Impact*
   The impact to the environment from the new transport method should be considered.
4. *Originality*
   Evidence of pupil's own ideas.

The posters must be of A3 size but may be constructed in any manner from pencil to paint or pen to crayon.

Poster Project: **Examples**



Poster Project: **Examples**



Poster Project: **Teacher Guidance Notes**

Introduction

The Poster Competition has been designed to be suitable for many different applications across Key Stages 1 & 2. The task has been set in such a way that it may be applied to various subjects and areas, some of which will be highlighted below. The references to the National Curriculum are made from the official website: www.nc.uk.net

Design & Technology

1. *Developing, planning and communicating ideas*

The poster competition is the ideal format for pupils to communicate their ideas by drawing. It is hoped that they will be able to generate ideas for the poster by drawing on their own experiences and from those that they can research, in particular the ideas of Brunel.

2. *Investigating and evaluating a range of familiar products*

You may choose to incorporate the question from this poster competition into a study of different mediums of transport, in order to allow the pupils to discuss and evaluate the suitability of each medium for crossing the Atlantic.

ICT

1. *Gather information from a variety of sources*

The pupils could use a variety of sources including, books, Internet, videos, people and TV to collect information about Brunel and the things that he designed and built. This information can then form the inspiration behind their ideas for the poster competition.

2. *Exchanging and sharing information*

The competition could be a way for pupils to learn how to present their work effectively using a variety of forms including images and maybe text. They should design their posters in the knowledge that they may be put on public display.

History

1. *Finding out about the past from a variety of sources of information*

This could be applied to the pupils finding information about Brunel from sources including, stories, eye-witness accounts, pictures, photographs, artefacts, historic buildings and visits to museums, galleries and sites. Studying Brunel is particularly relevant as he was a world famous engineer and pioneer.

2. *Local History Study*

Brunel lived in Bristol, so he would be highly suitable for a study of how the work of an individual has had an impact on the local area.

Art and Design

1. *Exploring and Developing Ideas*

This project would encourage pupils to explore ideas and to use their experiences and imagination to develop these ideas into artwork. A project could involve the pupils collecting visual and other information to help them develop their ideas in a sketchbook before completing their poster.

2. *Investigating and making art, craft and design*

The poster competition is after all an art based one, so if nothing else, it could be run as a simple art exercise.

Ship Build Project

Introduction

The Steam Ship *Great Britain* (*SS Great Britain*) was the first ship to have an Iron hull and employ screw propellers. When it was launched in 1843, it was the largest ship afloat and marked the beginning of a new era in ship design and propulsion. Isambard Kingdom Brunel, Thomas Guppy, Christopher Claxton and William Patterson designed the ship, which was built in a dry dock in Bristol.

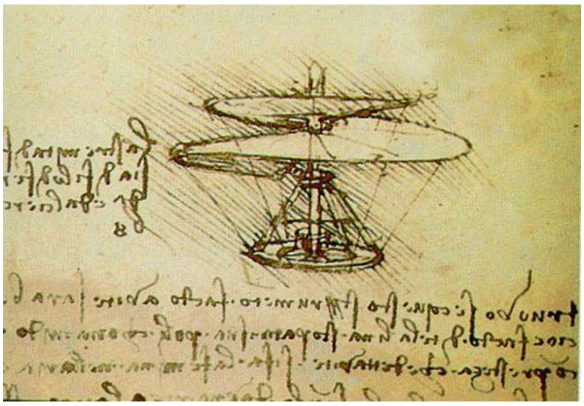
The introduction of the iron hull and the screw propeller was at the time, the leading edge in marine technology. 162 years on, Rolls-Royce continues the tradition of innovation and technological achievements with its Marine business.

Brief History

To illustrate the impact of the *SS Great Britain*, a short history of the propeller is presented below:

945 BCE The Egyptians use a screw like device for water irrigation.

287-212 BCE The renowned Archimedes designs screw to pump water out of ships.



1452-1519 Leonardo Da Vinci draws a screw for water pumping. His design for a helicopter resembles a marine propeller. (Image from NASA, used in accordance with its guidelines).

1661 The screw propeller was not utilised until the advent of steam power, when Toogood and Hays adopted the Archimedean screw as a ship propeller.

1802 Screw development picked up pace in the 19th Century. Colonel John Stevens built and experimented with a single screw and twin screw steam powered ship, but it was not accepted in his native America.

1836 Smith & Ericsson obtain patents for screw propellers marking the modern development of propellers for ship propulsion.

The Accident Francis Petit Smith had a collision in his boat on the Paddington Canal, in which his two turn wooden Archimedean propeller lost half its blade. The boat started to speed-up immediately and Smith realised the benefits if a shorter screw.

1839 Isambard Kingdom Brunel was so impressed by Smith's screw; he redesigned the SS Great Britain to be driven by steam powered screw propellers instead of the original paddle wheels.

1848 The British Admiralty conduct a tug-of-war contest between two similar ships, the propeller driven *Rattler* and the paddle wheels driven *Alecto*. The *Rattler* wins (and drags the *Alecto* backwards) with a speed of 2.8 knots (nautical miles per hour).

1860s The screw propeller had not fully matured but outperformed paddle wheels, which were gradually phased out.

Today Although the propeller was first used as means of marine propulsion hundreds of years ago, it is still used today. New methods to power the propellers have been developed to replace steam engines, such as gas turbines (see in jet engines) and diesels but the basic propeller is still used in modern shipping.

Ship Build Project

Project Brief

The aim of the project is to: "design & build a ship and its propulsion system using recycled or sustainable material, to cover the greatest distance, in the shortest time with as much cargo as possible".

Each entry will be judged for the reasoning behind its design and for the performance of its ship. The design of the ship should be summarised in an A3 poster (of several sheets if needed) showing the justification for each feature, e.g. choice of materials, shape of the hull etc.

The ship itself will be subject to a number of tests including maximum cargo (weight) before sinking, time to travel two metres and the furthest distance travelled. Additional tests will be performed on the finals day.

The specification below outlines the design envelope.

Specification

The table below defines the maximum and minimum criteria for the project.

Maximum Ship Length	400mm
Maximum Ship Width	300mm
Maximum Ship Depth (below water line with 1kg cargo)	100mm
Minimum Cargo Requirement	1kg
Minimum distance travelled (in a straight line)	2 metres
Minimum cargo storage dimensions	Cube of 150mm

The cargo storage area will be used as the platform to put the weights on for loading. Consideration should be given to the stability of the vessel as its being loaded. The attached diagram illustrates the specification.

Judging Criteria

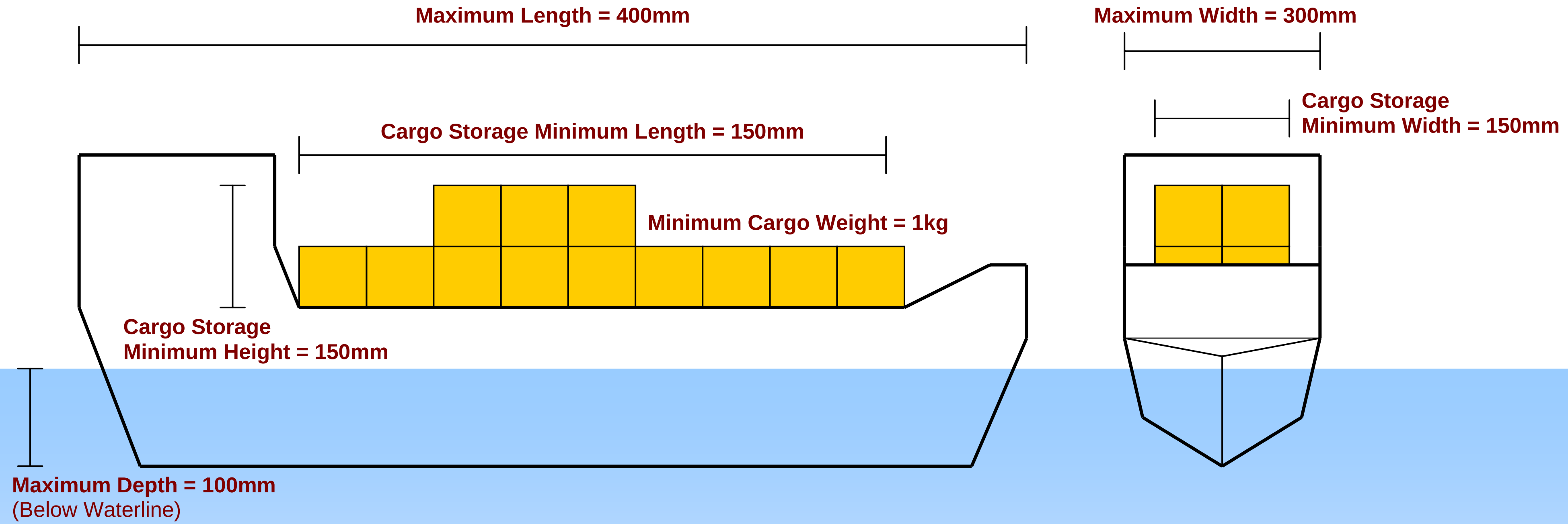
Prizes will be awarded for the overall winner as well as the top 3 projects in each year group (Bronze, Silver and Gold). The following criteria will be used to judge each entry with prizes awarded to the best in each category:

1. Load (weight) Capacity
   How much load the ship can carry before it starts to sink.
2. Range
   How far the ship can travel in a straight line.
3. Speed
   The quickest time to travel a distance of two metres in a straight line.
4. Best Looking
   Nobody likes to travel in an ugly vessel, so design to be easy to the eye.
5. Level of Environmentally Friendly material
   Use of recycled or sustainable material.
6. Most innovative / creative / novel design
   Think "outside the box". Create a fun design.
7. Best design poster
   Good depth and detail, with justifications for design.

It would be very difficult to meet all of the criteria above, and as in engineering, a compromise will have to be made.

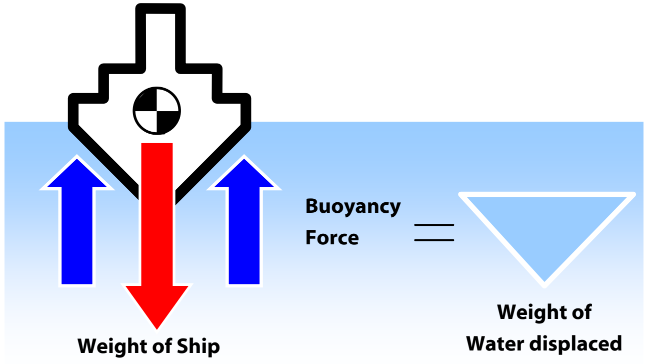
The remaining pages in this section outline the basics of ship, hull and propulsion design.

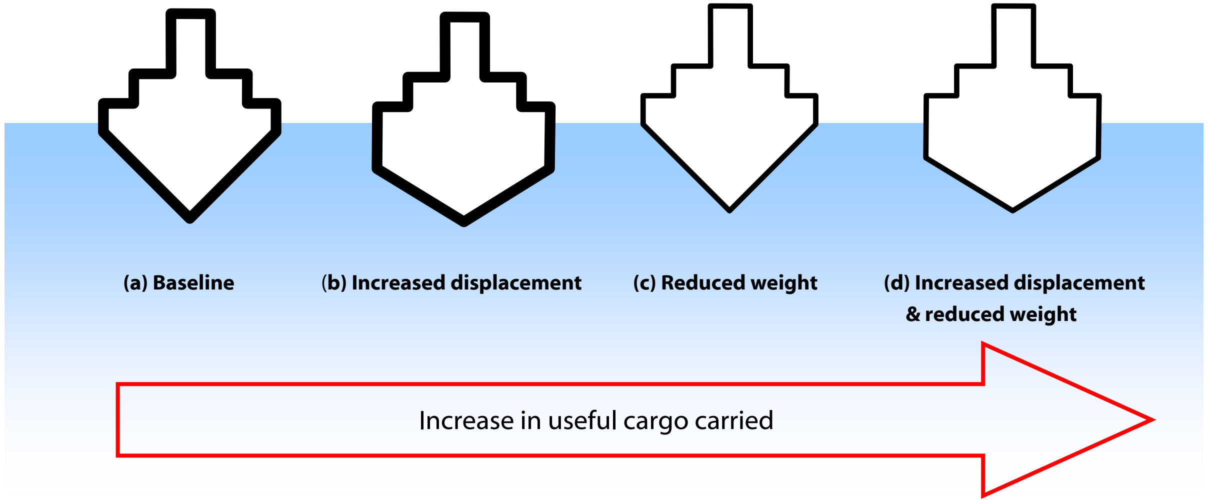
Ship Build Project: **Specification**



Ship Build Project: **Ship Basics**

The fundamental law relating to ship design is the Principle of Buoyancy or sometimes referred to as Archimedes' principle. It states, "The buoyant force is equal to the weight of the displaced fluid".





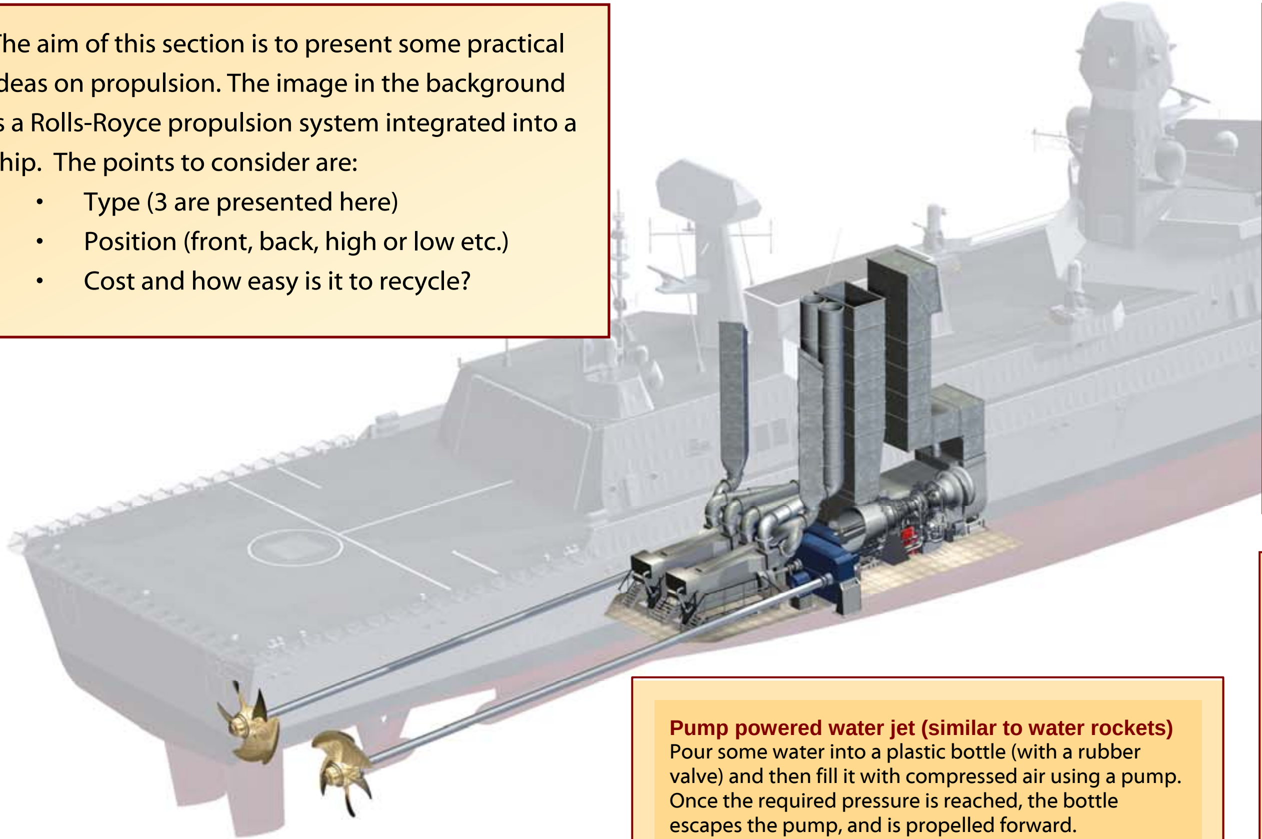
Ships are not solid objects, and are designed to displace fluid of a greater weight than the weight of the ship. Thereby it can carry useful cargo without sinking. To increase the cargo carried, ships have to displace more water (b), reduce weight (c) or both (d).

Gravity pulls the ship down, which displaces the water. The buoyancy force (equal to the weight of the water displaced) reacts against the ship, pushing it up.

If the water displaced is insufficient for the weight of the ship, it will sink. Therefore, the average density of the ship must be less than the density of water (1000 kg/m^3) for it to float.

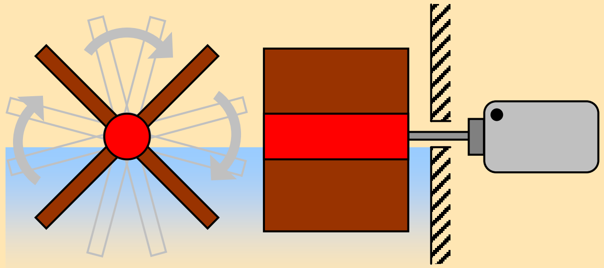
Ships are classified by their displacement i.e. the mass of the water they displace. For example a large LNG (liquefied natural gas) tanker can have a displacement of over 300,000,000 kg, which is more than 20,000 double-decker buses!

Ship Build Project: **Propulsion**



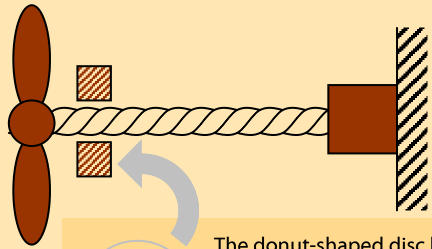
The aim of this section is to present some practical ideas on propulsion. The image in the background is a Rolls-Royce propulsion system integrated into a ship. The points to consider are:

- Type (3 are presented here)
- Position (front, back, high or low etc.)
- Cost and how easy is it to recycle?



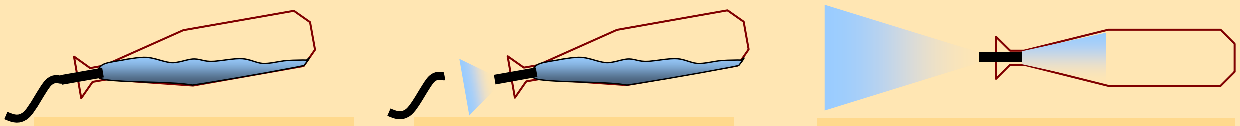
Electric motor powered paddle wheels
The electric motor rotates the paddle wheels to move the ship forward. Brunel's *SS Great Eastern* had both paddles and propellers. However, they need batteries to operate, which are difficult to recycle.
Does the size, number or position of the paddles matter?

Elastic band powered propeller
Care should be taken with the shape of the propeller, which is difficult to get right (although propeller kits for model aircraft can be purchased). The elastic band is twisted and then released. As the band unwinds it rotates the propeller, which drives the ship forward.



The donut-shaped disc holds the propeller in position and provides the necessary tension. *What can you do to help the propeller rotate faster?*

Pump powered water jet (similar to water rockets)
Pour some water into a plastic bottle (with a rubber valve) and then fill it with compressed air using a pump. Once the required pressure is reached, the bottle escapes the pump, and is propelled forward.
How much water should you put in?



(a) Water-filled bottle is pumped full of compressed air.

(b) When the valve pressure is reached, it releases the air pipe.

(c) The compressed air with water escapes the bottle, creating a jet, which propels the bottle forward.

Rolls-Royce

brunel 200

Ship Build Project

Introduction

The Ship Build Project at first glance can be daunting; therefore these notes have been produced to express our intention behind the project and a brief guide on one method to approach the problem. Both projects have also been designed such that they could form part of the National Curriculum for Keystage 1, 2 & 3, particularly in the subject areas of Design & Technology and Science. It should be noted that the comments made for Keystage 2 are equally valid for Keystage 3. From our experience the topics taught in Keystage 3 Design & Technology are the same ones taught both at University and Industry, but in more depth.

Getting Started

Our aim is to give students an overview of engineering projects, in particular the key steps involved. There are four stages to follow: planning, designing, making and testing. The latter two are cyclic, depending on the test results. This is only a guide containing ideas and advice.

Before the Project

It is highly recommended that the Ship Build Project be tackled in teams, with between 4-6 students per team. The project has been set-up to encourage recycling and therefore it is important early on, to ask students to identify suitable ship building material from everyday rubbish in their homes.

Planning

After the teams have been formed, a few hours should be spent planning the project, in identifying what tasks need doing, the health & safety considerations and also conducting research. The latter can take a considerable amount of time, researching different types of ships, their roles and why the differences exist. One idea is to ask each team to research different areas of ship design and then present to the class, so that everybody benefits.

In planning, the students should also consider the tools and processes available to them, to recognise the limiting factors early in the project. At the end of this phase the students should understand the main factors relating to the problem (e.g. buoyancy); what the next steps are including the tests they intend to conduct, and be in possession of research material.

Designing

The first step is to identify what features make a good cargo ship, by using spider diagrams or similar techniques to try and identify the features of a winning design from the research conducted. Having established the desired qualities, the students should then start idea generation using common everyday rubbish as the basis. Students are encouraged to come up with as many designs as possible, these can be just sketches at this stage with some notes to explain the main features. In their teams they should then narrow down their choices to a top 3.

The next stage is to expand these designs further before conducting a trade-off study. This is a method of comparing each feature of the designs and then scoring them, e.g. easy to make 10/10 – difficult to make 1/10. By "adding" the scores a winning design can be identified. The final stage is to develop the design further by identifying the rubbish to use (e.g. plastic bottle, can etc.) and the tools needed to make the ship.

It should be noted that buoyancy calculations should be done before making, which is a good opportunity to make estimates in the volume of various items. Please bear in mind the judging criteria in this phase!

Ship Build Project

Making

Health & Safety should be a top priority and all rules relating to workshop environments should be followed. The make and test element are interrelated. The most significant period of time will be spent in the last two stages, and designs tend to “evolve” at this stage. It should be encouraged that the students bear in mind the end goal and the judging criteria.

Testing

The type of tests needed and how to test should have been established at the planning stage. We recognise that some schools will not have the facility to test their ships. What should be possible, are small tests to prove features of the design, e.g. to check the ship is watertight, pour water into the ship and see if any drips out. If there’s a way out, then there must be a way in. The ultimate test will therefore be at the final!

National Curriculum: Keystage 2 & 3

The notes presented below are for both Keystages in the area of Design & Technology. Where there exists a significant deviation between Keystage 2 & 3, it has been expanded as have appropriate links to Science. The references to the National Curriculum are made from the official website: www.nc.uk.net

Design & Technology

The Nation Curriculum is a good reflection of the steps undertaken in industry to tackle projects such as the one presented. Appropriate links to Science have also been made.

1. *Developing, planning and communicating ideas*
   The design element of the project encourages students to research ship and marine propulsion using a number of resources available to them, including the Library and the Internet. Documenting design decisions generated in a team environment using techniques such as brainstorms or spider-diagrams, practices fundamental communication skills. Students are strongly encouraged to think through and plan necessary actions to fulfil objectives.

2. *Working with tools, equipment, materials and components to make quality products*
   Given that rubbish (drinks bottles, cardboard boxes, crisp packets etc) is likely to be main source of material; it requires students to consider their properties before use. The emphasis on the quality of build is of great importance for ships, as they need to be watertight; consequently poor workmanship can have a big impact.

3. *Evaluating processes and products*
   → Sc1 Investigative Skills
   → Sc1 Obtaining and presenting evidence
   → Sc1 Considering evidence and evaluating
   For this project, it is encouraged that students identify appropriate "pass-off" tests to ensure that the ship performs as expected. Simple tests such as ensuring the hull is watertight, the propulsion system works and is repeatable. An extension of that is identifying tests to determine how to improve the design e.g. does painting the outside of the hull increase its speed or is it better to cover it with foil?
   → Keystage 3: Sc1 Investigative Skills
   Creating multiple ships to test theories puts a lot of strain on resources, therefore it is encouraged to conduct preliminary tests to identify best features for a winning design.
   → Keystage 3: Sc4 Forces & Motion
   Establishes the quantitative relationship between distance, time and speed.

4. *Knowledge and understanding of materials and components*
   → Sc3 Grouping and classifying materials
   → Sc4 Electricity
   The project encourages students to consider the properties of their chosen materials, in particular weight, strength and flexibility. The density of the chosen materials is a key factor in buoyancy calculations. Likewise if they choose electric motors as their method of propulsion, it requires students to understand electrical circuits and the Health & Safety implications.

   → Keystage 3: Knowledge and understanding of systems and control
   In industry projects are often too big for a single team to work on, therefore the solution to a problem is treated as a system, with many sub-systems with one or more team assigned to it. It is encouraged that work is shared in a manner that reflects the sub-systems of the ship e.g. hull design, aesthetics, propulsion etc.

→ Keystage 3: Knowledge and understanding of structures

A successful design is one that can displace the required level of water yet be very light for maximum speed and maximum load capacity. Therefore a strong, rigid and light structure is desirable. These needs encourage students to think of and design efficient structures, e.g. wire frame hull (and stiffeners) with waterproof fabric.

5. *Breadth of Study*

→ Sc1 Scientific Enquiry

→ Sc4 Forces and motion

It is our aim that students undertaking this project will be able to identify features of everyday ships (sea ferries, speed boats etc.) and how that relates to its performance e.g. thin narrow boat is fast but less stable than round bottom hull sea ferry. Ultimately the project is about forces and motion, which manifests itself in a number ways, including propulsion (electrical, mechanical etc.) frictional forces, and the effect of Newton's 3 laws.

→ Keystage 3

According to the National Curriculum "design and make assignments in different contexts". There also exists the potential in this project to compare different materials and control systems (electrical or mechanical).

Resources

Please find a list of sources for further research for the topics covered in the information pack.

Rolls-Royce

www.rolls-royce.com

www.wikipedia.org – Online Encyclopaedia

The Magic of A Name, The Rolls-Royce Story – Peter Pugh (2004)

Brunel 200

www.brunel200.com

Isambard Kingdom Brunel

www.brunel200.com

www.wikipedia.org – Online Encyclopaedia

The SS Great Britain

www.ssgreatbritain.org

Marine Propulsion

www.wikipedia.org – Online Encyclopaedia

Ship Design

www.wikipedia.org – Online Encyclopaedia

Contact Us

Recommendation

We would recommend that you email the team directly as we're all moving around in the company. However, please do not hesitate to contact us. If emailing, then please put "Brunel 200 School" as a subject to help us process your queries quicker.

Telephone (Mon – Thu: 8am – 4.30pm, Fri: 8am – 3.30pm)

Please call for Jessica Hawker, on 0117 97 xxxxx and state "Brunel 200 Competition". She will direct you to team member.

Email

Alternatively, contact the team directly:

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