Shipbuilding and Onboard Systems

Shipbuilding and Design:

Design Concepts:

- What is the purpose of the vessel?
  - *Oil Tanker?*
  - *Pleasure Craft?*
  - *Tugboat?*
  - *Sail Training?*

- What waters will it sail in?
  - *Mississippi River?*
  - *Offshore?*
  - *Great Lakes?*

- What size will it be?
  - *Will it fit in the Welland?*
  - *Do I want to be able to explore the North Channel?*

- What construction material?
  - *Some materials are not compatible with certain uses*

Design Factors:

- Stability
- Watertight Integrity and Subdivision
- Internal Layout
- Rig design
- Engine Selection

Stability

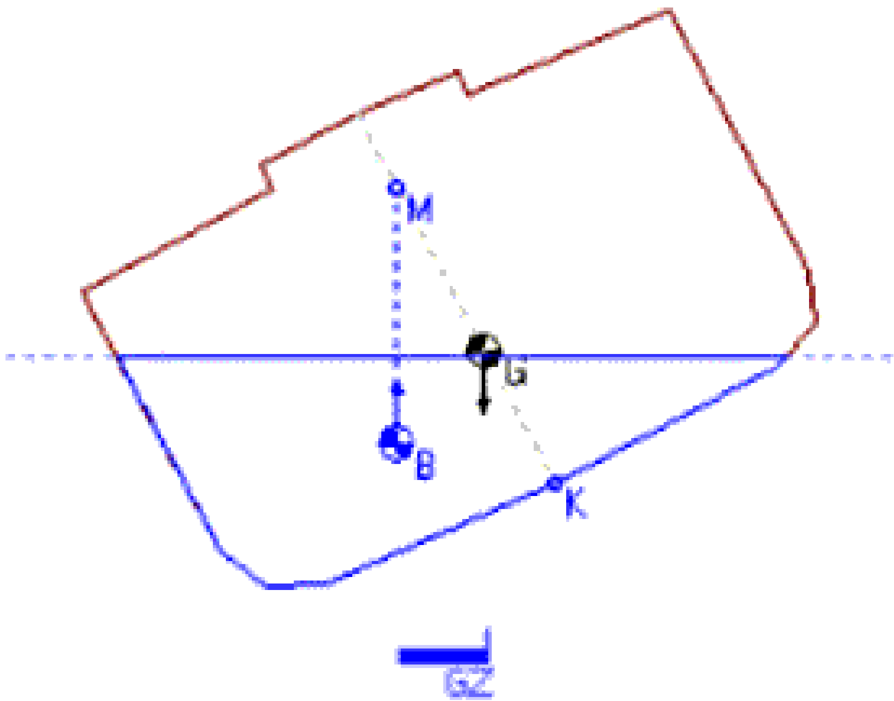
The term Stability refers to a vessel's tendency to stay upright in the water.

- This is a very important factor for any ship, and sailing vessels in particular.
- A ship can be 'tender' or 'stiff', this is a description of its initial stability. The amount a vessel will heel with little force being acted upon her is initial stability. Playfair is a tender ship in comparison with Pathfinder
- Initial stability doesn't actually indicate a vessels ability to stay upright, and 'tender' ships can actually have quite good maximum stability

Terms and Definitions:

- Center of Buoyancy: The point through which the force of buoyancy acts vertically upwards (B)
- Center of Gravity: Center of Gravity (G) is a downward force, it is the centre of all the weight onboard
- (G) rises and falls when weights are moved, added, and/or removed

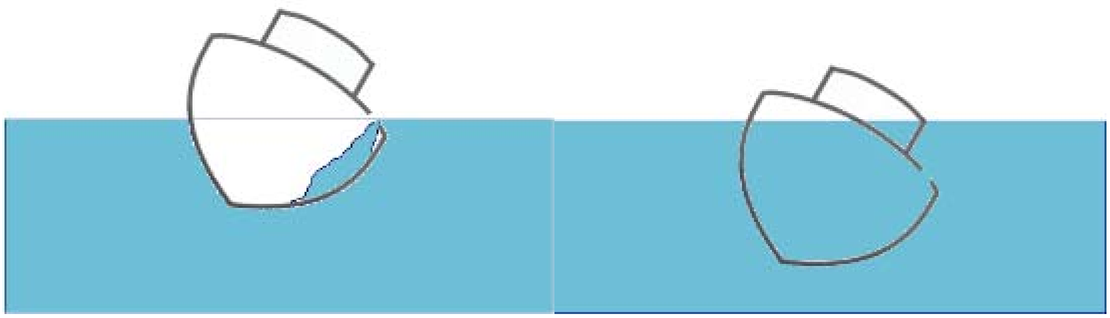
- (G) and (B) counteract each other
- Metacentre: (M) This is the point at which all lines drawn vertically from CB (at different angles of heel) will meet. It is the point at which the hull will pivot around.
- (GZ) is the Metacentric Height. That is, the distance between (G) and the line between (B) and (M). The longer this is, the stiffer the ship will be.



<u>Setting and Dousing of sails expands and contracts our windage, which translates to force, which affects the vessel in the same way as putting weight aloft. Dousing sail will lower our CG, reducing heeling and improving our Stability</u>

Downflooding

- **One of the greatest threats to do with stability is downflooding.**
  - **This can occur well before any danger of capsize. It is when water floods down an opening and fills the ship. This often results in a rapid loss of the vessel**

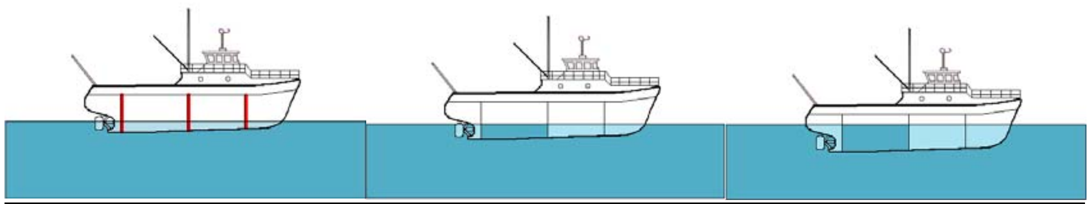


Watertight Integrity

- Refers to a vessels ability to prevent water from getting below.
  - A ship could be very unstable, yet have great W/T integrity, or it could have almost no W/T integrity and yet be very stable
- Placement of hatches, their design, and construction all affect this.
  - Skylights, ventilators and other openings must also be kept in mind.
- Our scuttles are 12” in diameter, when the edge of our weather decks are submerged the scuttle is about 2 feet below the Waterline. At this depth an open scuttle would let in approx. 3000 Gallons Per Minute
  - For reference, the hand bilge pumps onboard can’t exceed 30 GPM, even when being pumped very quickly.

Watertight Subdivision

- **Bulkheads are in place to divide the ship into many separate compartments.**
- This means that if one compartment is flooded, either through downflooding or hull damage, it won't sink the vessel.
  - This requires that Watertight Doors are always kept shut when not in use



Damaged Stability

- Note that a vessel with one or more compartments flooded experiences damaging changes to her stability.
  - This means that even with other safety features in place a chain of events can be started that will still result in the loss of the vessel.
  - **It is best to ensure the chain never begins**

Safety Measures to do with Downflooding:

- Hatches: Should be shut at night and in heavy/squally weather. If unsure, shut it!

- Skylights: Leeward ones should always be shut, windward ones should be shut at night and in heavy/squally weather. If they are on the centreline, then don't worry about leeward/windward. If in doubt, shut it!

- Ventilators: Should be shut in heavy/squally weather, know where they are and how to shut them. If unsure, shut it!

- Watertight Doors: Only open them when going through. Should be shut and dogged whenever not in use. Always shut after use!

At any time the Master may order the hatches, skylights, vents, and W/T doors to be shut and remain that way. If this order is given, then obey it promptly.

Ship Design and Layout

- Thought needs to be given to many different aspects of a ship, each area needs to be large enough to be useful, but shouldn't take up too much space by itself.
  - Living Spaces

- Machinery Spaces
- Galley
- Storage
- Tankage
- Other Potential Compartments:
  - Nav. Station
  - Classrooms
  - Work and maintenance areas
  - Cargo Space

Rig Design

- A big factor in rig design is what kind of sailing vessel you want. The differences can be huge
  - 12 Meter (America's Cup)
    - *Tall, engineered for maximum power/weight ratio*
    - *Very fragile*
  - Volvo Ocean Racer
    - *Very high power/weight ratio*
    - *More substantial than a 12 Meter's rig, but still somewhat fragile*
  - 400' Barque
    - *Hugely over-rigged, low power/weight ratio*
    - *Lots of redundancy and safety*
    - *Pinnacle of simplicity and ruggedness*
  - 40' Cruising Yacht
    - *Somewhere in between*
    - *Modern rig design, with modern materials*
    - *Over-rigged and simple nonetheless*

- A lot of what is discussed these days is upwind performance and speed.
  - Other factors, such as safety, redundancy and simplicity are often forgotten

- It is important to know exactly what you want out of your vessel before you start designing it

- A well designed rig is one that is an integral part of the ship. It is in the designer's mind from Day One

- If the rig is just added onto an already designed hull then many problems can occur

- Important points of consideration:
  - Lead of lines
  - Placement of spars
  - Swing room for booms, gaffs and yards
  - Chain Plate and Lug placement

- Strength/Weight of materials used
- Strength of attachment points

- Something else that seems obvious, but has been overlooked, is "where do the masts go below decks?"
  - What compartment are they in?
  - Do they get in the way?
  - Are they accessible for inspection and maintenance?

Engine Selection

- The two main fuel choices are Diesel or Gas. Both are petroleum products, but gas is more refined than Diesel.
  - This means that gas ignites at a lower temperature. This basic, but major, difference is what is responsible for the differences between Gas and Diesel engines.

- Diesel
  - Heavier Engine
  - More efficient as they get bigger
  - Simpler to maintain
  - Diesel fuel has a high flashpoint (it will not ignite easily)
- Gas
  - Lighter Engine
  - More efficient in smaller engines
  - Require more attention
  - Gas fumes can ignite easily

In fact, due to the safety considerations alone, Transport Canada asks that all STV's be equipped with diesel as opposed to gas engines.

- The size and horsepower of an engine also affect selection. You want to maximize available power without taking up too much space.A sailboat generally has a smaller engine for a given size than an equivalent powerboat.
- An engine will spin faster and produce more power the higher you throttle it up.
- Transmissions are used to engage and disengage the shaft, giving us Forward, Reverse and Neutral.
  - Transmissions can be non-reducing (1:1 rpm ratio) or they can have **reduction gears**, which reduce the engine RPM as they are transferred to the shaft. Playfair's transmission, made by Velvet Drive, is a 1.91:1 reduction gearing. This means that for every 191 RPM the engine does, the shaft does 100.

  - *The hull design of our vessels means we want the propeller to spin at roughly 1000 RPM at maximum continuous speed. For different designs of boat this can be a very different number. Engines and transmissions are selected based on this. Playfair's Detroit Diesel has a maximum* *continuous rating of 1800 RPM, which gives a shaft speed of 1800/1.91 = 943 RPM.*

Construction

Basic Method of Construction for traditionally built vessels

- Mid to Large-Size vessels, built of wood or metal, are constructed in a similar manner:
  - The Keel is laid first
  - Stem and sternpost are added
- Frames are added along the length of the ship
- Finally, the skin is added. This might be planking, plating or sheathing, depending on material used

This is only a very brief and simple explanation of what is a complicated and laborious process. Building a ship can take from months to even years, depending on the complexity and size of the design.

Lofting

- Lofting is the process of drawing out each piece of the ship in full, and then building the piece from this pattern
- This is so that mistakes are not made when converting plans into real-life objects, calculations or measurements can be very easily messed up, but this ensures a good fit.
- With computer design and cutting, this can be skipped in metal vessels. Any well-built hand constructed ships will have this though.

Construction Materials

- There are 5 basic materials used in modern ship Construction
  - Steel
  - Aluminum
  - Fibreglass/GRP
  - Wood (Traditional and Moulded)
  - Ferro-Cement

Steel

- Very strong, easy to work with provided proper training and equipment are available
- Before welding, which became widespread in the early 1900’s, vessels were riveted. Kajama is an example of a riveted ship
- Welding is a very quick, cheap and easy way to construct a high strength vessel.
- It allows for easy modifiying and repair, with basic tools
- Steel corrodes over time, but modern coatings are very effective

Aluminum

- Very light, very expensive

- Worked in basically the same way to steel, but welding it requires special equipment and training which leads to higher production and maintenance costs
- Lower place on Galvanic Table than steel. Aluminum is a lot more susceptible to electrolysis and corrosion, so more care must be taken.

Wood (Traditional)

- Very laborious, requires high skill level for quality construction and repairs
- Creates beautiful, unique vessels

Moulded Construction:

- A mould is constructed to build the ship on.
- This might be a concave mould, where the material fills in the mould
- Or it could be a convex mould where the material is spread overtop of it

Wood (Moulded)

- Uses strips of wood and lots of glue between layers. Sometimes fibreglass is used between layers as well
- Creates a very strong form, with lots of opportunity for unique design. Difficult to modify and repair
- Often these vessels are a combination, the skeleton is built and then the skin is laid over it

Ferro-Cement

- A steel mesh (the ferrous part) is used to construct a mould
- This mould is then covered in layer upon layer of cement
- This method is relatively cheap, relatively easy and allows some very intricate designs
- It can be strong if properly done, some Ferro-Cement boats are still afloat after almost 100 years!
- It can also be a very unsafe method if done improperly, and good hull inspections are next to impossible.

Fibreglass/FRP/GRP

- Cheap, especially for production of a lot of one design
- Pretty easy and cheap to maintain
- Not at all traditional

Launching

- When building a boat the launching must be kept in mind. This is especially true for larger vessels.
- There are three basic methods:
  - Crane
  - Slide in sternways
  - Slide in sideways

Terms and Definitions:

Length Overall (LOA)
The length of the vessel excluding rigging. It is a common term but can be misused. Length on Deck is a better way to describe a boat's size as it eliminates overhanging rails, clipper bows, and other features that do not add to interior space.

Load Waterline Length (LWL)
The length of the vessel on its floatation lines. If the designer calculated correctly, this is the same as the Design Waterline (DWL) when the boat is new. Most boats, however, sink a bit or change trim over the years as they accumulate gear, provisions, and other things, so the LWL is rarely what was drawn on the plans.

Length on Deck (LOD)
Length of the vessel on its weather deck.

Beam
The greatest width of the vessel, often written as Beam (Max).

Beam WL
The greatest width at the LWL.

Draught
The maximum depth of the vessel

Air Draught
The total height of the vessel, measured from the Waterline. Includes rigging, antennae and anything else

Displacement
The weight of water that the boat displaces. This is equal to the boat's weight. Displacement is usually expressed in pounds in small craft but may also be given in cubic feet. Multiply the cubic feet by 64 to get the displacement in pounds. Large yachts may have the displacement given in tons, but bear in mind that these are long tons of 2240 pounds and each ton contains 35 cubic feet of sea water.

Wetted Surface (WS)
The underwater area of the hull, including rudder and centreboard, usually expressed in square feet. A boat with a high WS has more skin friction and is slower in light air than a boat of equal size and sail area with a low WS. For this reason, most modern sailing yachts sport fin keels and spade rudders, as these offer less WS than the older full keeled designs. The figure has little significance for powerboats.

Centre of Lateral Plane (CLP) a.k.a. Centre of Lateral Resistance (CLR)
The centre of the underwater area of the hull. Important only for sailboats because it is a guide to the location of the sail and rig.

Centre of Effort (CE)
The theoretical centre of the sail area. It moves around as you set and douse sail.

Deadrise Angle
The angle the bottom of the boat makes with the LWL when viewed from the ends. A flat bottom boat has zero deadrise, while a deeply veed hull has great deadrise. Powerboats that have a lot of deadrise forward and less deadrise at the transom are called warped bottom hulls. Those that carry the same deadrise angle from bow to stern are called monhedron hulls.

Topsides
To many people this means the deck and cabin, but they are wrong. The topsides is the part of the hull below the sheer line (deck edge) and above the LWL.

Sail Area/Displacement Ratio
The sail area in square feet divided by the displacement in cubic feet to the ⅔ power. Ratios much below 15 indicate a lightly canvassed boat and are suited to motorsailers. Offshore cruisers have ratios in the 15 to 16 range, coastal cruisers 16 to 17. Ocean racers may fall in the 17 to 20 range, while ratios over 20 are usually given only to daysailers, class racers and high performance boats.

Onboard Systems

- Electrical
- Stove Fuel
- Fresh Water
- Grey Water
- Black Water
- Machinery Systems

Electrical Distribution

- Both our ships have battery banks which store electrical power. The battery bank is not large, and the more power we use the more we need to run the engine to charge the batteries.
- **This is why it is important to not use more power than is necessary and never plug anything in without checking with the XO.**

Electrical Safety

- In general, as PO's you will not be doing anything involving electricity. It is still important to know how to be safe around it.
  - Never use electrical tools when it is wet out, or you are wet (from rain, waves, swimming or whatever)
  - If a breaker is tripping, do not try to force it open, it will allow itself to be reset when it is ready
  - If a cord is in the water, pull it out

- If something, anything, is creating sparks, let an officer know
- **Don't let the shore power cord go in the Water, not just the ends either. A bight of cord in the water is still a problem**

<u>Stove Fuel</u>

- Different types
  - Propane: A gaseous mixture. Heavier than air, very flammable. Requires attention and care to use safely.
  - Diesel: Very difficult to use properly, always on so it makes the Galley very hot.
  - Alcohol: Very low flashpoint, so it is a big cause of fires. Not very high hot when it burns, meaning you need to carry a lot.
  - Electric: Pulls a huge amount of power. Requires a generator to be running. Not very practical for boats which don't want to run a Genset all the time.

<u>**Propane Safety**</u>

- Propane is an explosive gas, and it is heavier than air, meaning it will sink down low and sit around if not properly aired out
- Make sure that burners and the stove light quickly, and do not let them go out
- Always turn the tank off when not in use
- Do not ignore the sniffer alarm. Bring it to the attention of an officer.

<u>Fresh Water Systems</u>

- Fresh (potable) water is the stuff we drink. It sits in large tanks and is drawn out by a pump when necessary.
- <u>It is important not to waste water</u>
  - We don't want our schedule dictated by when we need to fill up freshwater.

<u>Sea Water Systems</u>

- Sea Water comes from all around the ship, it is the water we float in. For our vessels we use it in the heads, the head sinks, to cool the engine and for the firehose.
  - This water comes in through Seacocks, which are large valves piercing the hull. All of our seacocks are in the E/R. Putting all of our 'holes' in one compartment is an important safe design feature.

<u>Waste Water Systems</u>

- Grey Water, also known as 'Sinkwaste' is the waste water from sinks. On other boats this could also include showers, washing machines and any other modern amenities that generate waste water.
  - Grey water collects in a holding tank, but is then pumped Overboard. The reason for the tank is so that there isn't a bunch of different individual discharges piercing the hull, instead there is just one.

- Blackwater comes from the Heads. It collects in a tank which is then pumped out by septic trucks or at marinas. It is illegal to discharge Blackwater in the Great Lakes
  - Do not pump any non-sewage down the heads (<u>Vomit is not sewage</u>!) If we fill up our tanks we need to find a port to pumpout in.

<u>Machinery Systems</u>

- All engines, whether diesel or gasoline have a few basic requirements to ensure that they operate properly:
  - Cooling System (water, as opposed to air-cooled)
  - Fuel Supply Systems
  - Ventilation System, required to continue providing cool air for both combustion and cooling. An exhaust vent is also needed to expel the hot, dirty air which is in the engine room
  - Exhaust System, required to expel the exhaust from the engine itself and carry it outside the ship