



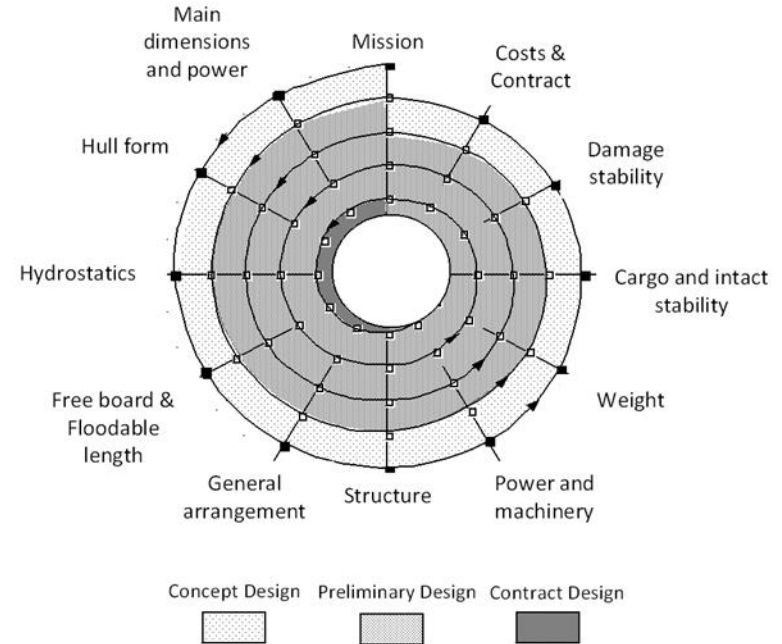
Aalto University
School of Engineering

MEC-E1004 Principles of Naval Architecture

Lecture 2 – Reference ship/data

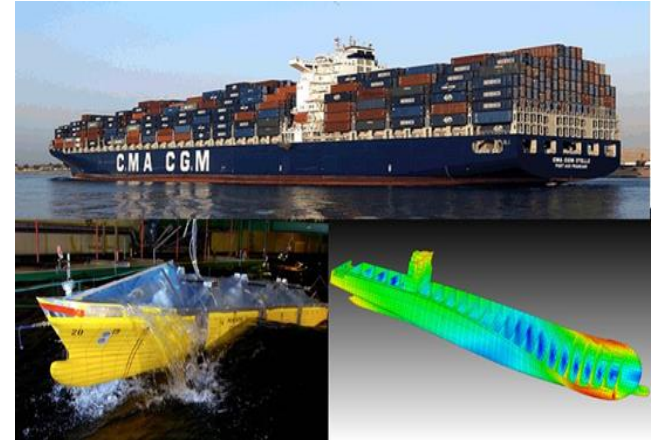
What will you learn ?

- After the lecture, you will be able to
 - *List and explain the different principles of categorizing a ship*
 - *Categorize the ship you design in your group project*
 - *Explain the use of reference data*
 - *Apply the above to identify a suitable reference ship for your group project*



Assignment 2 – Reference ship/data

- Define and discuss your ship's category/type
- Collect and analyze technical information on your ship type
 - *General characteristics, requirements, challenges*
 - *Discuss 2 technical/scientific articles on related topics*
- Present a reference ship (or ships) and related data (e.g. main dimensions, machinery, cargo/passenger capacity)



Terminology – many definitions

Vessel

- A water-born vehicle that has its own or external power production and steering

Ship

- A large water-born vehicle that has its own power production and steering
 - *A ship is an vessel, but a vessel is not necessary a ship*

Yacht

- A medium-size water-born vehicle used for leisure
 - *Larger than a boat, smaller than a ship*

Boat

- A small water-born vehicle propelled by oars, paddle, sails, or motor for travelling, transport, leisure



Image credit
Damen



Image credit
Viking Line

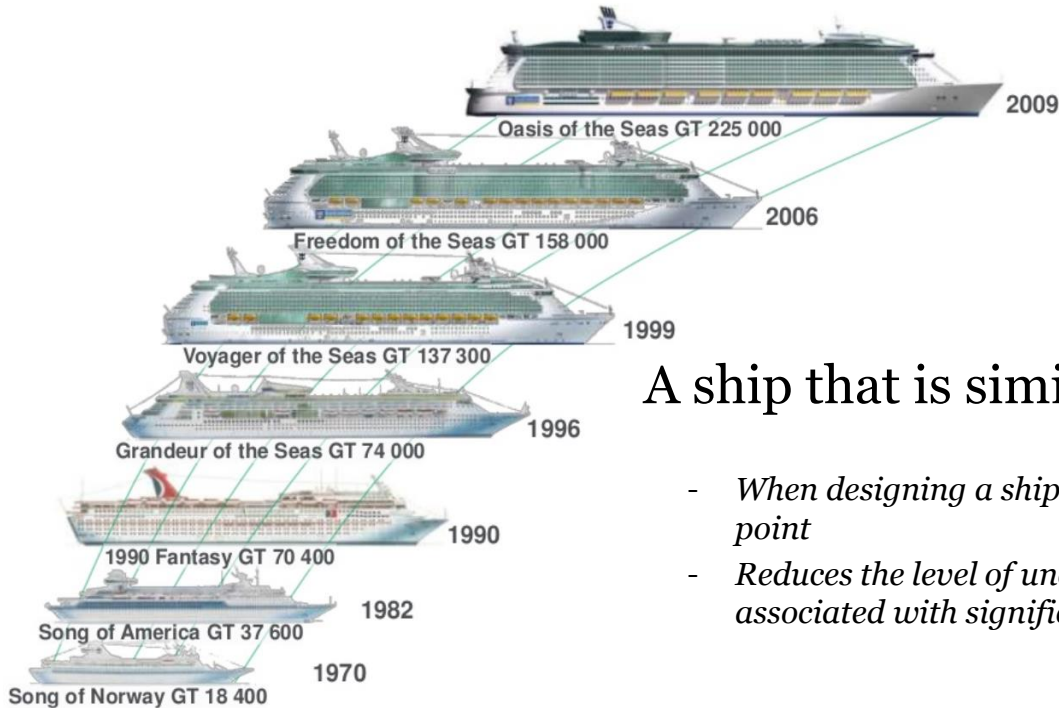
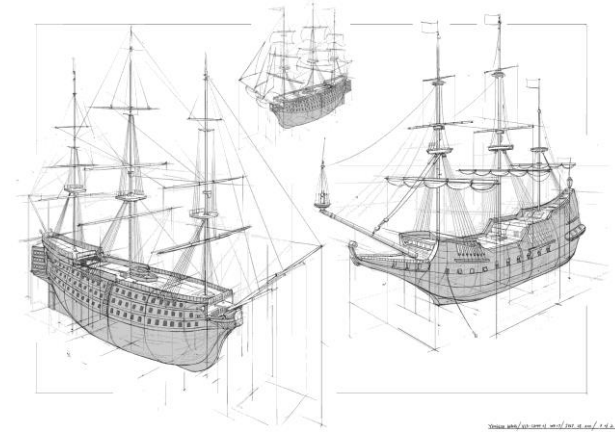


Image credit
Nautor's
Swan



Image credit
Buster

What is a Reference Ship ?



A ship that is similar to the ship designed

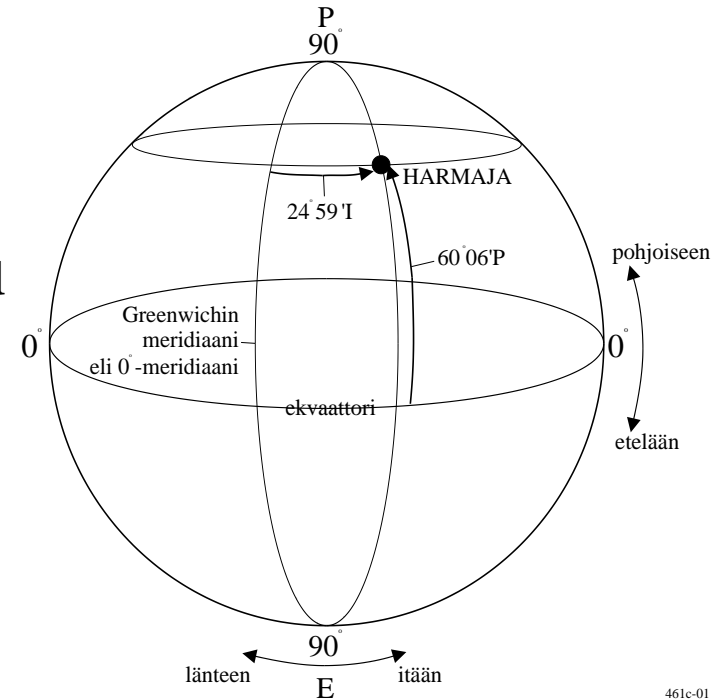
- *When designing a ship, reference ships are commonly used as starting point*
- *Reduces the level of uncertainty - Important !! as a ship generally is associated with significant technical and economic risks*

Image credit STX Europe / Meyer Werft

Design space coordinates

- Position coordinates are given in degrees and minutes
 - *One degree = 60min*
- Longitudes and latitudes are equal, but one should notice that in reality longitudes get shorter towards the poles
- 1 Nautical mile = 1 852 m
- Background
 - *Circumference of earth around equator ~40000 km*
 - *1 Nautical mile = one minute (1/60) of one degree of latitude (1/360)*

$$\frac{40000\text{km}}{360 \cdot 60} = 1.852 \times 10^3 \text{ m}$$



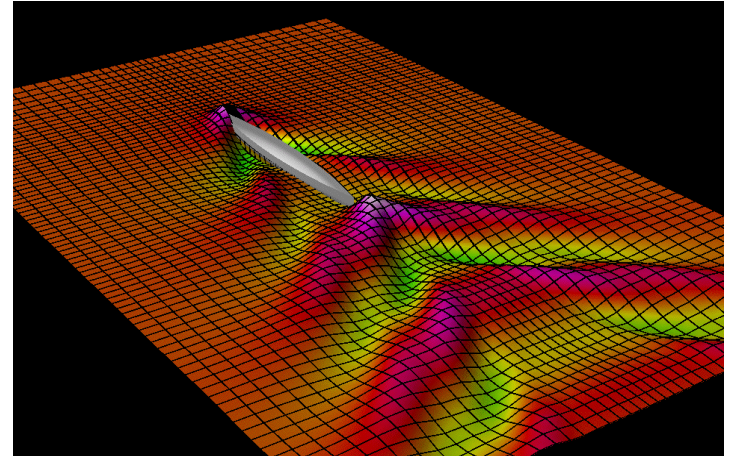
*Harmaja lighthouse coordinates:
60° 06' N (North), 24° 58' E (East)*

Ship Speed - Definition

A ship's speed is measured in knots

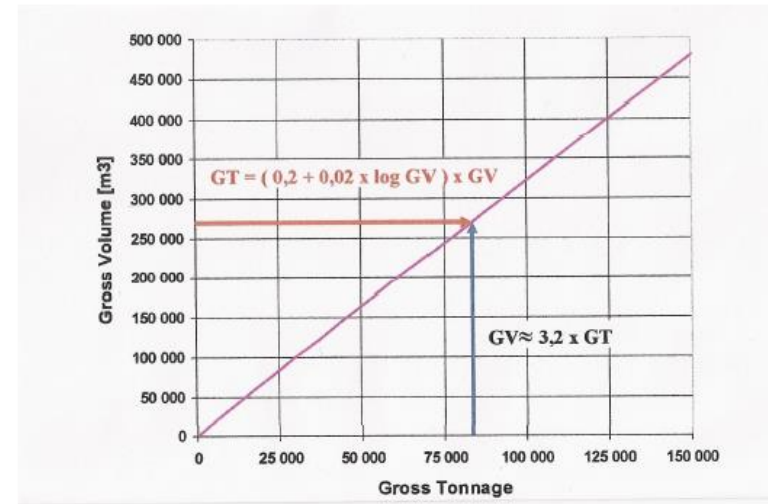
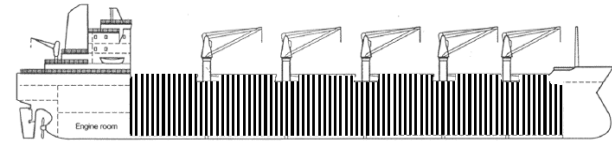
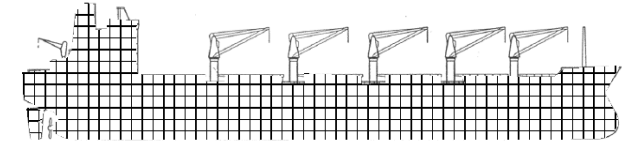
- *1 knot = 1 nautical mile / per hour*
 - *1 nautical mile = 1 852 m*
 - *1 knot = 1,852 km/hr \approx 0.514 m/s*
- Hydrodynamic speed
 - *Froude Number (dimensionless)*

$$F_N = \frac{v}{\sqrt{gL}}$$



Tonnage

- Gross tonnage (GT)
 - *The volume of a ship's closed spaces*
- Net tonnage
 - *The volume of a ship's usable spaces*
- Tonnage information is public
 - *No-physical measures*
 - *Many types of costs/tariffs (e.g. port costs, channel tariffs) are determined per GT*



Weights

Lightship weight (\approx a ships own weight)

- The weight of a ship in metric tons without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, passengers and crew and their belongings
 - *Includes standard outfitting, inventory according to the List of Inventory, spare parts according to the Class Society requirements and with liquids in engine room systems*

Deadweight (\approx the weight of what a ship is carrying)

- Defined as the difference between an actual displacement and the lightship weight
 - *SOLAS: “Deadweight is the difference in tones between the displacement of a ship in water of a specific gravity of 1.025 at the load waterline corresponding to the assigned summer freeboard and the lightweight of the ship”*
 - *Expressed in either long tons or metric tons*
- It is a measure of ship’s ability to carry various items: cargo, stores, ballast water, provisions and crew, etc.

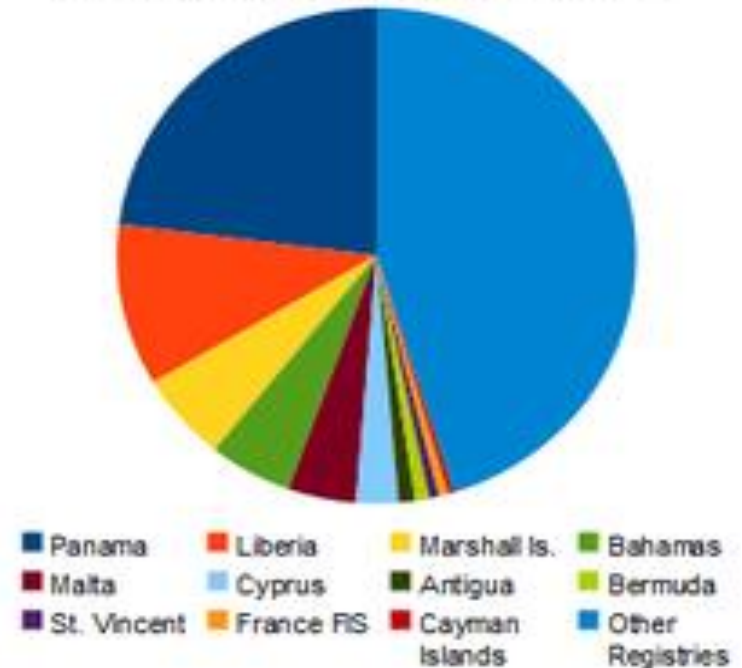
Displacement (= Lightship weight + Deadweight = Total ship weight)

- The weight of water displaced by this vessel at any waterline
 - *The product of the volume of its underwater portion and the density of the water in which it floats*
 - Expressed in long/imperial tons (1 long ton \approx 1.01605 metric tons)
-

Flags of Convenience

- A flag of a country (flag state) under which a ship is registered in order to avoid financial charges, or restrictive regulations in the owner's country
 - *Flag state allows foreign owners and maintenance of its fleet*
 - *Registering is quick and easy*
 - *Taxation is non-existing*
 - *Control may be inadequate*

Top 11 FOCs
As Percentage of World Fleet in DWT



Ship categories

Question: Can you mention any ship category/type? For what design purpose(s) is it useful to divide ship into categories?

Ship type categories - general

- Ship mission
- Applied technologies
- Operational area
- Design limiting factors
- ...

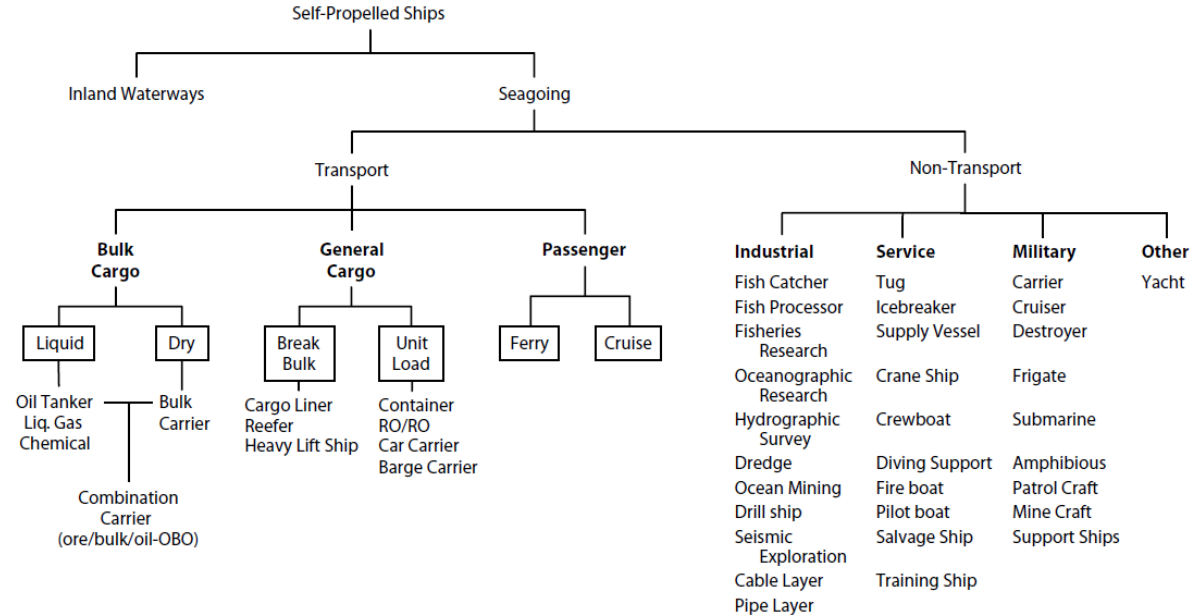
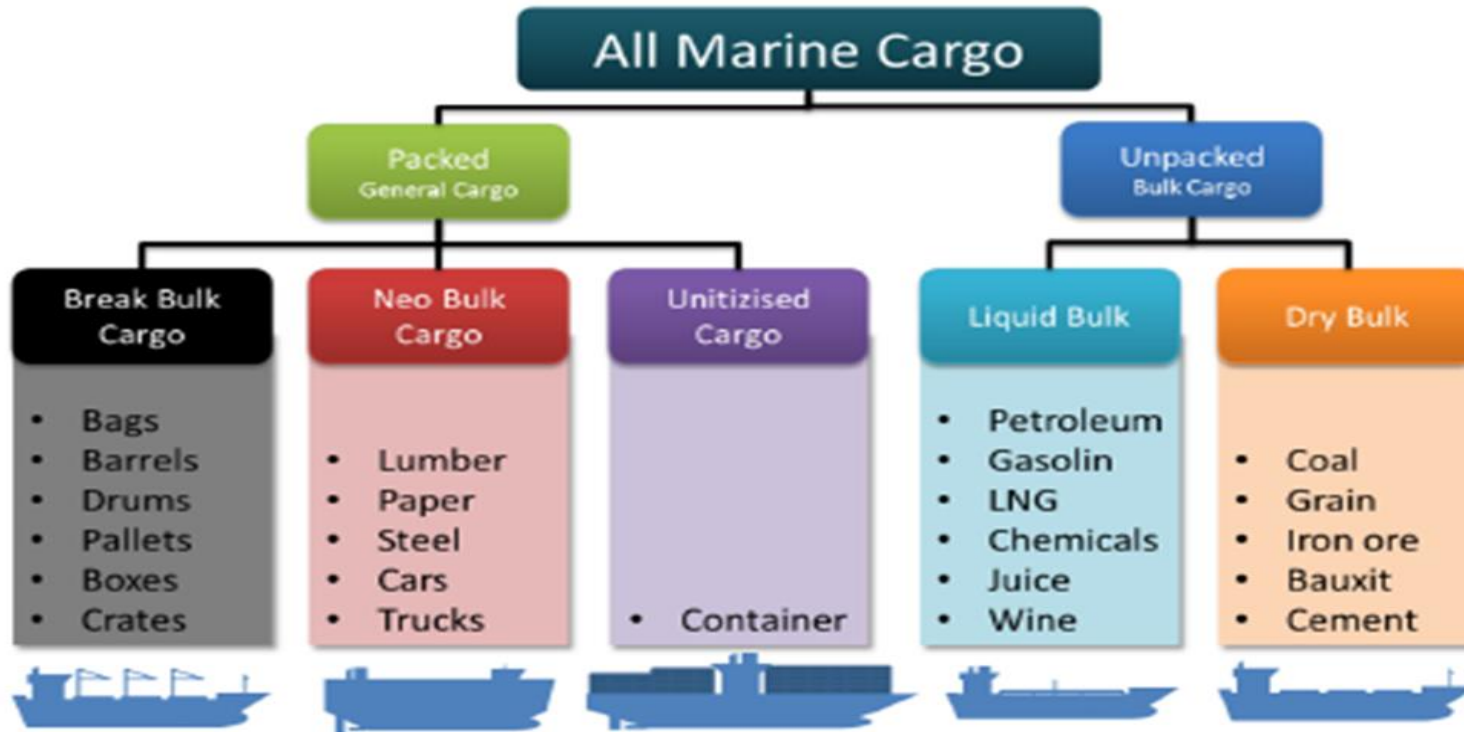


Figure 5.5 Ship Type Categories

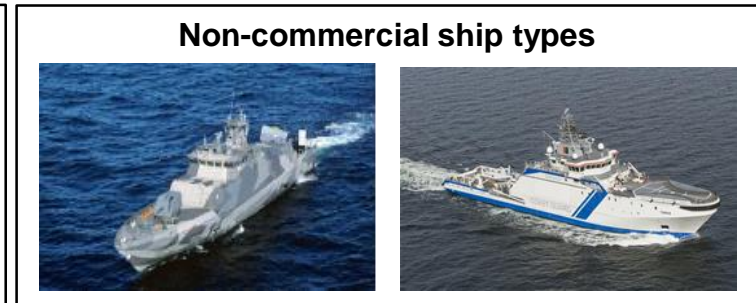
Image credit Lamb, T. Ship design and Construction, SNAME 2003

Ship type categories – cargo based



Ship type categories – mission based

- Commercial / merchant ships
 - ✓ Bulk carriers, tankers, cruise ships, feeders,...
 - ✓ Industrial ships
- Non-commercial ships
 - *Navy ships, research ships, coastguard ships,...*
- Special-purpose / service ships
 - *Icebreakers, multi-purpose icebreakers...*
- Industrial ships
- Leisure ships/ yachts/ boats
- ...



Ship type categories – tech based

- Type of lift (how the lift is achieved)
 - *Hydrostatics, hydrodynamics, lift equipment (e.g. hydrocopter)*
- Applied structures and materials
 - *Welded steel, bolted steel, composites, light metal alloys, wood, concrete,...*
- Type of cargo handing
 - *On-board crane, ...*
- Type of propulsion device
 - *Single/twin screw (most common), water jet, sail/kite, air propeller,...*
- Type of energy source
 - *Diesel engine(s) (M/S , Motor Ship)*
 - *Steam turbine(s) (STS, Steam Turbine Ship)*
 - *Gas Turbine(s) (GTS, Gas Turbine Ship)*



Image credit Yachting World / C. Launay



Image credit Wärtsilä

Ship type categories – operations based

- *The operational area determines the assumed worse environmental conditions (e.g. wave height, ice conditions) and sets constraints in terms of ship draft and size...*
- *The design conditions are determined considering ship building costs (overly conservative vs. weak), flexibility with regards to ship usage, etc.*
- *Examples of operational-area based ship types*
 - Ocean going vessels with unlimited range of operation conditions
 - Basis for design: Winter conditions in the North Atlantic (most severe environment)
 - Ships designed for specific areas (Baltic Sea, North Sea,...)
 - Ships designed for protected seaways (max. distance to shore)
 - Inland waterway vessels (rivers and lakes)
 - Limited draught (channels) and maximum height (bridges)
 - No large waves



SHIPS IN STORM COMPILATION- MONSTER WAVES

<https://www.youtube.com/watch?v=aBM7NgMhg90>

Ship type categories – limiting factors based

- Weight limited ships
 - $DW \sim 80\%$ of displacement
 - Heavy cargo carriers
- Space limited ships
 - $DW \sim 20\%$ of displacement
 - Light cargo ships (e.g. cruise ships), RORO ships, ROPAX ships
- Size limited ships
 - Limited by main dimensions
 - Panamax, New Panamax, Aframax, Chinamax, Suezmax, ...

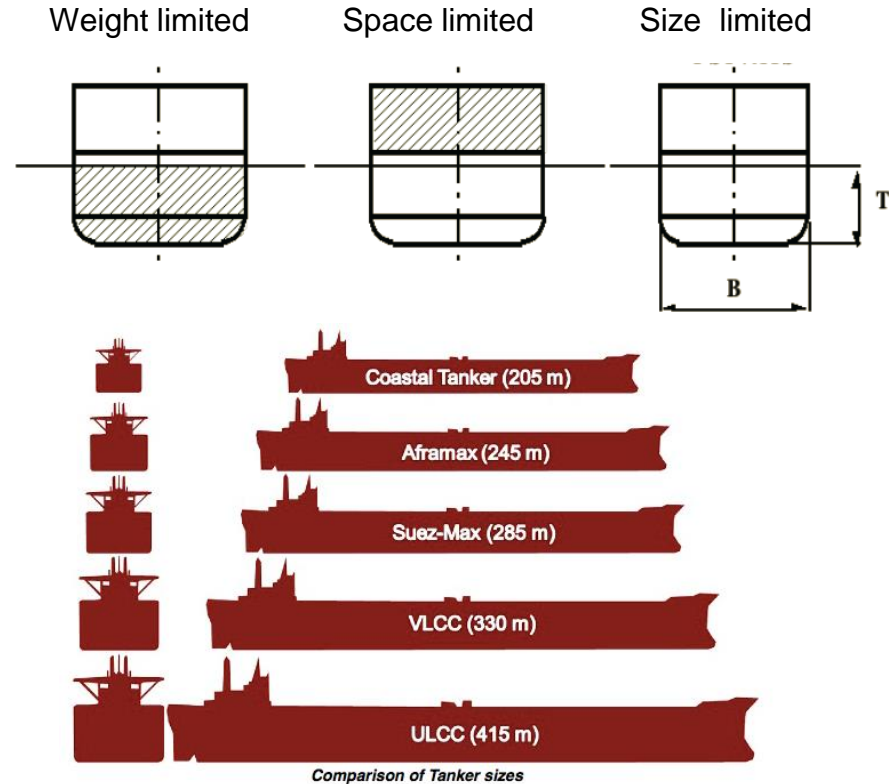


Image credit maritime-connector.com/

Ship type categories – cargo handling based

- *Vertical lifting*
 - Lift on-Lift off = Lo-Lo
- *Horizontal transport*
 - Roll on- Roll off = Ro-Ro
- *Pumping*



Image credit Viking Line



Image credit offshore-fleet.com



Image credit
Turkey SeaNews

Ship type categories – hull no. based

- Mono/single hull
- Catamaran (two hulls)
- Trimaran (three hulls)

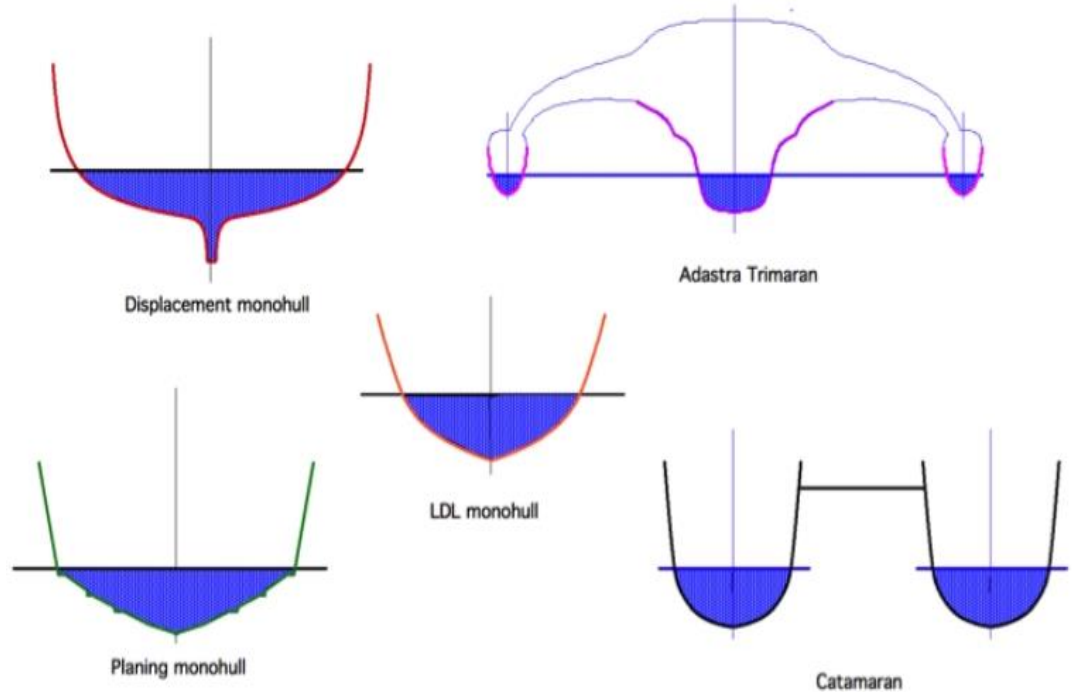
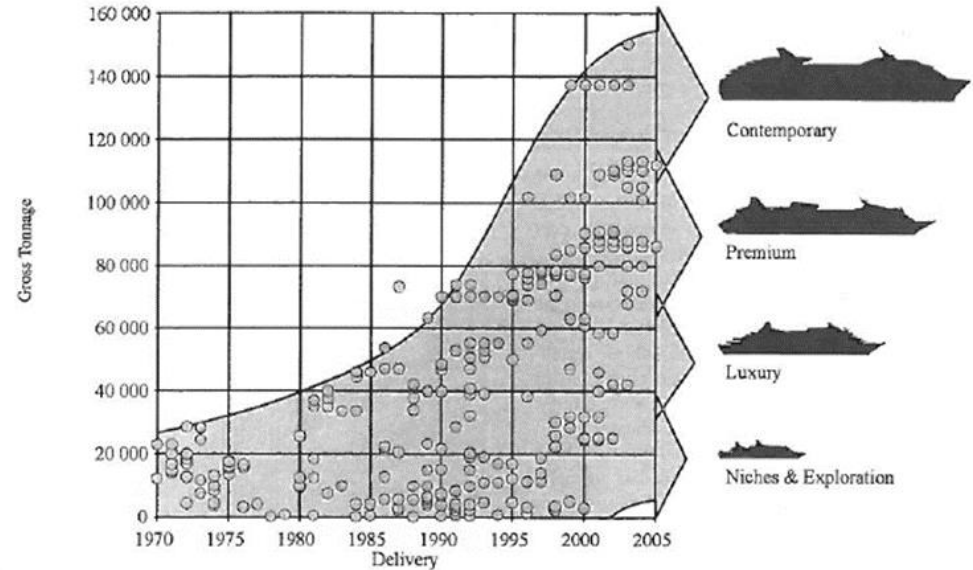


Image credit shuttleworthdesign.com

Ship type categories – market based

- Makes it possible to determine and analyze various category/segment-specific
 - *Technical solutions*
 - *KPIs (e.g. crew size/number of passengers, space/passenger)*
 - *Trends*
- Example of cruise segments
 - *First class (mass market lines)*
 - *Premium*
 - *Luxury*
 - *Niches & exploration...*



Reference ships / data

Question: Can you mention any drawbacks of using reference data/ships?

Out-of-box” thinking still allowed



Source: <https://www.ntd.tv/2017/03/07/strangeness-seas-worlds-weirdest-ships/>

Summary

Ships can be divided into categories/types in various ways

- *Ship mission*
 - Commercial, non-commercial ships, special-purpose ships,...
- *Applied technology*
 - Type of lift / structural solution / cargo handling / propulsion / energy source /...
- *Operational area*
 - Ocean going vessels, inland waterway vessels,...
- *Design limiting factors*
 - Weight/ space / size limited ships
- *Cargo handling system*
- *Number of hulls*
- ...

A ship's main features are largely determined by its category / type

- Categorization is useful e.g. for the selection of reference ships