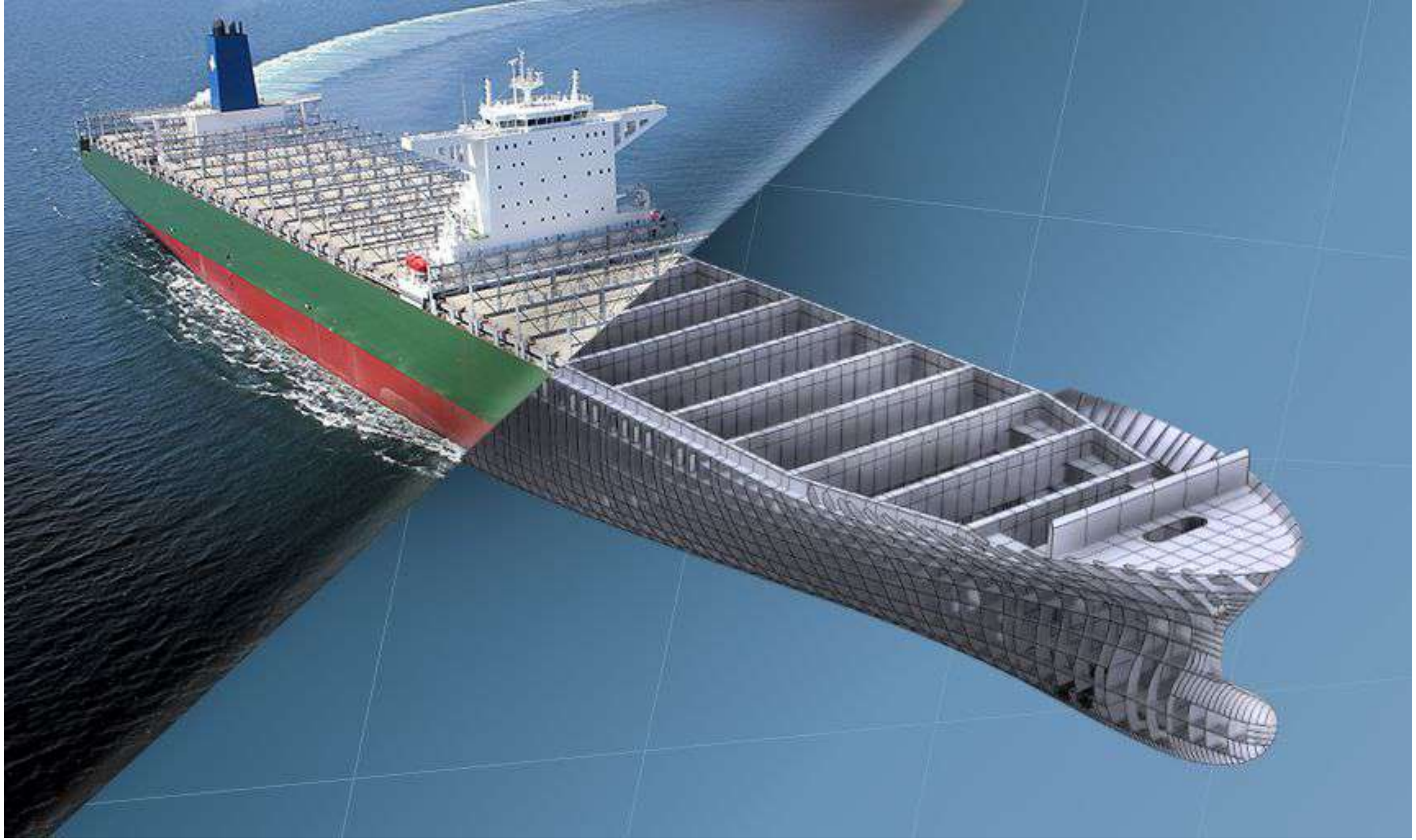

Introduction to Naval Architecture

II SEM –Module 2

Syllabus

2. **Module II**

   Introduction to ship geometry

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Naval Architecture Terms

British and American Spellings

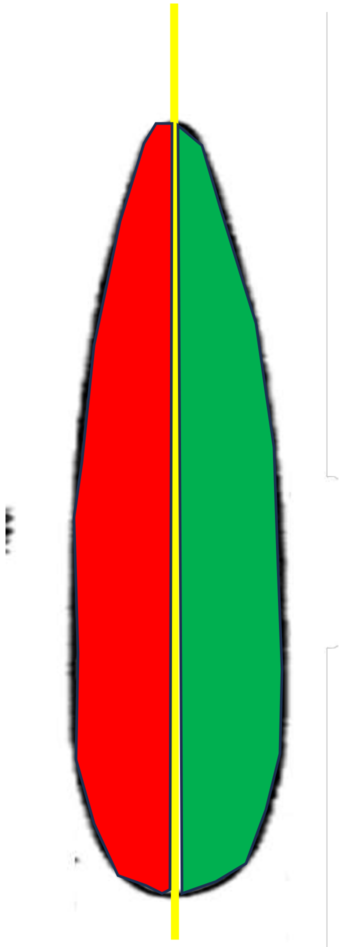
BRITISH	AMERICAN
Colour	Color
Honour	Honor
Centre	Center
Tyre	Tire
Moulded	Molded

Naval Architecture Terms

- Region
  - Port
  - Starboard
  - Forward (Fwd)
  - Midships
  - Aft
  - Bow
  - Stern
  - Quarter
  - Beam
  - Hull
  - Superstructure
- Direction
  - Inboard
  - Outboard
  - Overboard
- Orientation
  - Athwartships
- Motion
  - Astern
  - Ahead


Port
Starboard
ACEBOATER.COM

•Port

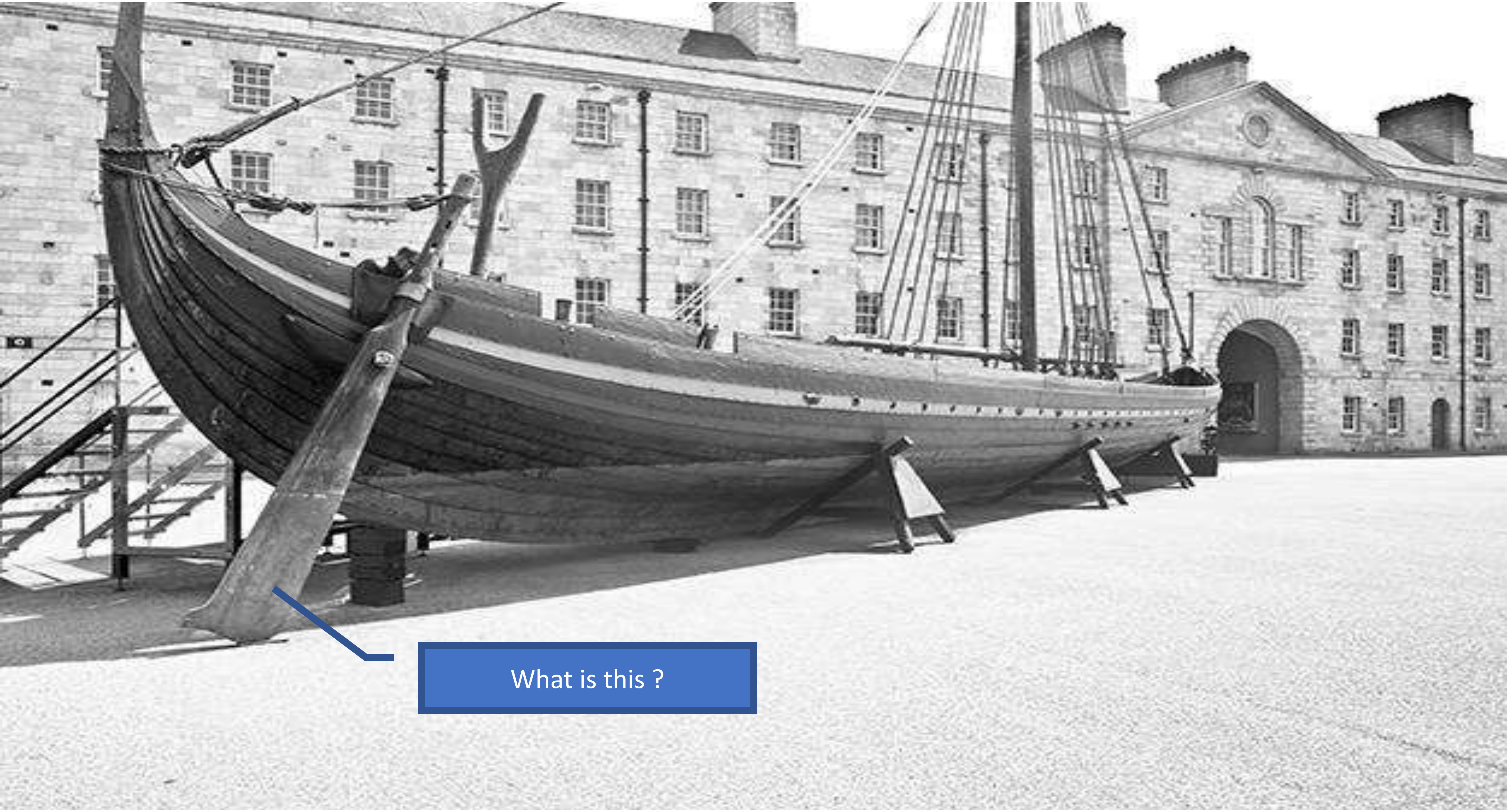


•Stbd

Centre Line
or
Middle Line

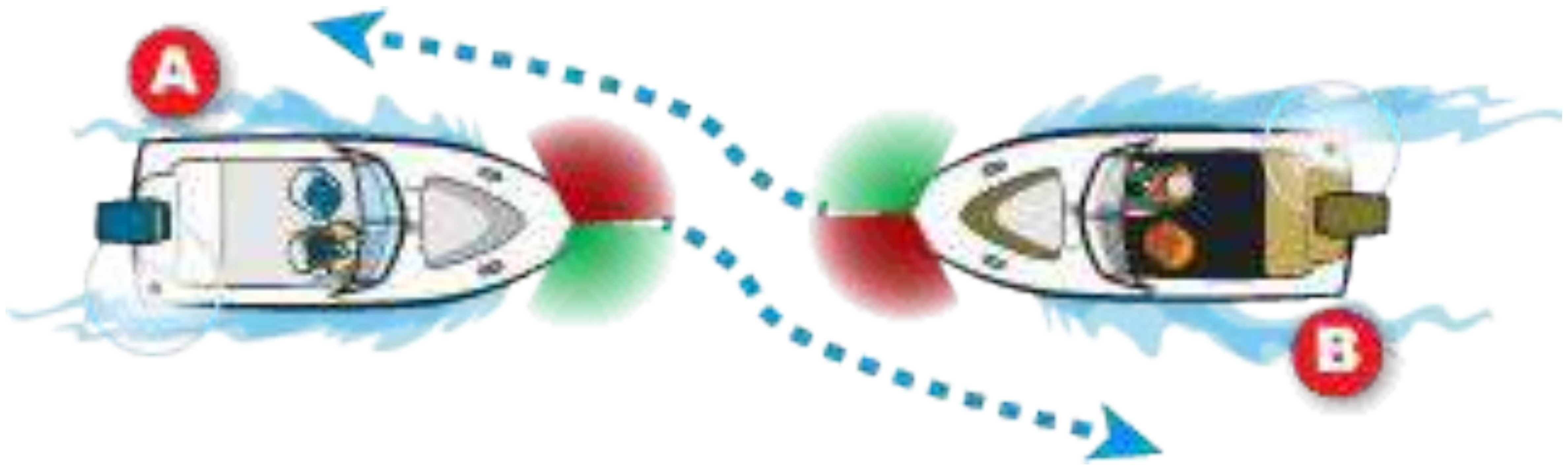

STARBOARD
PORT
savvy

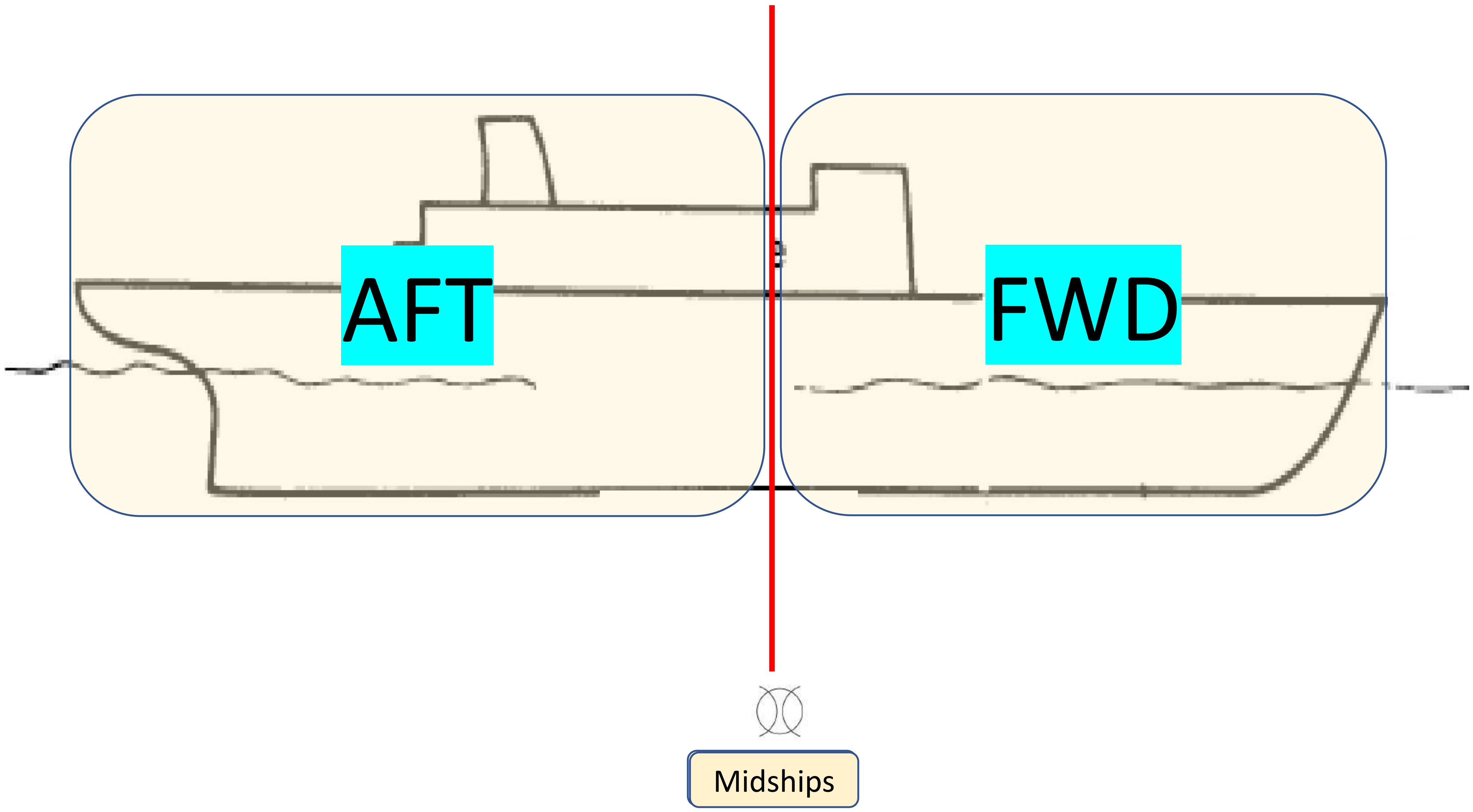
- Why do ships use
- "port" and "starboard"
- instead of
- "left" and "right?"

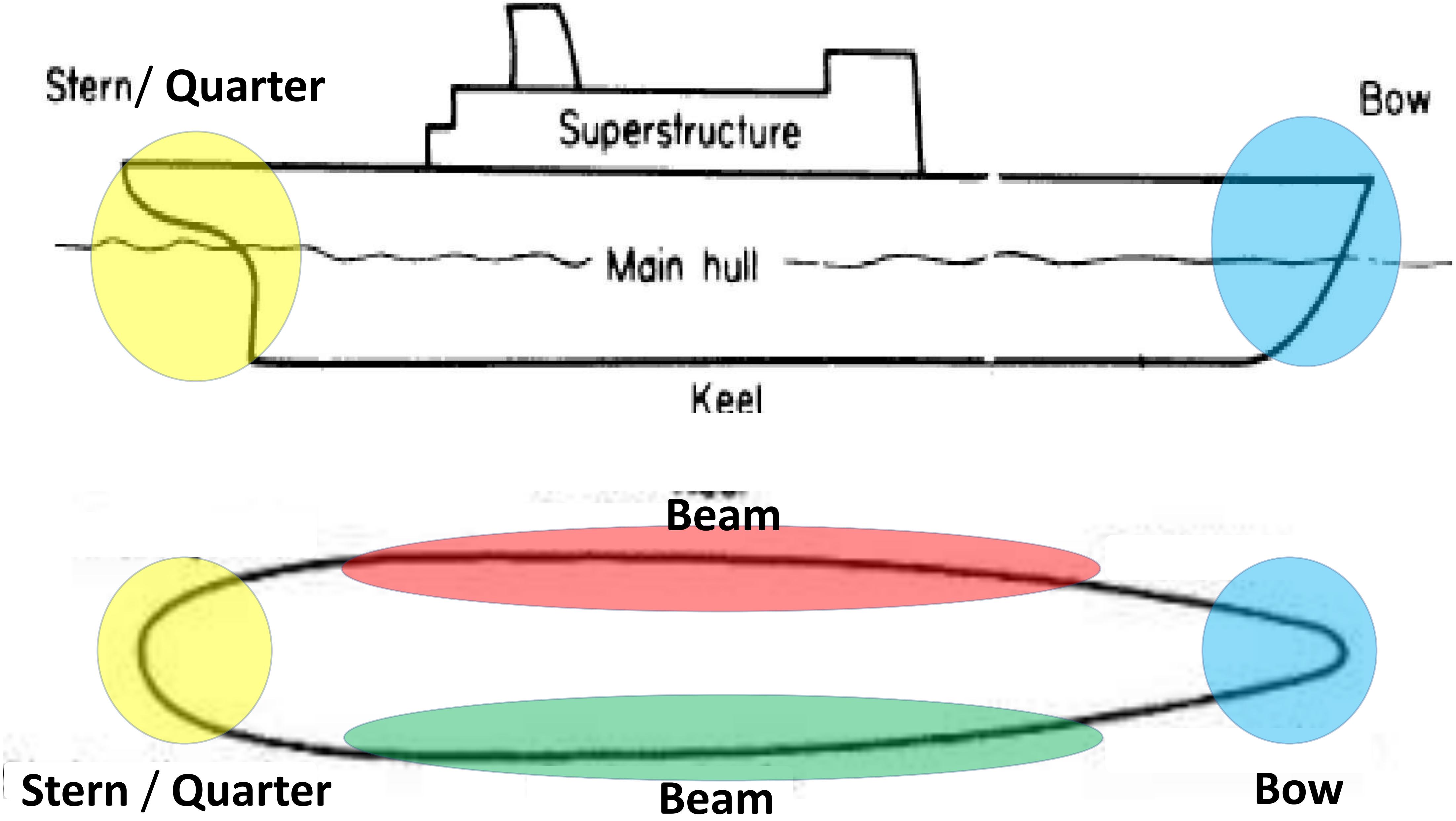

What is this ?

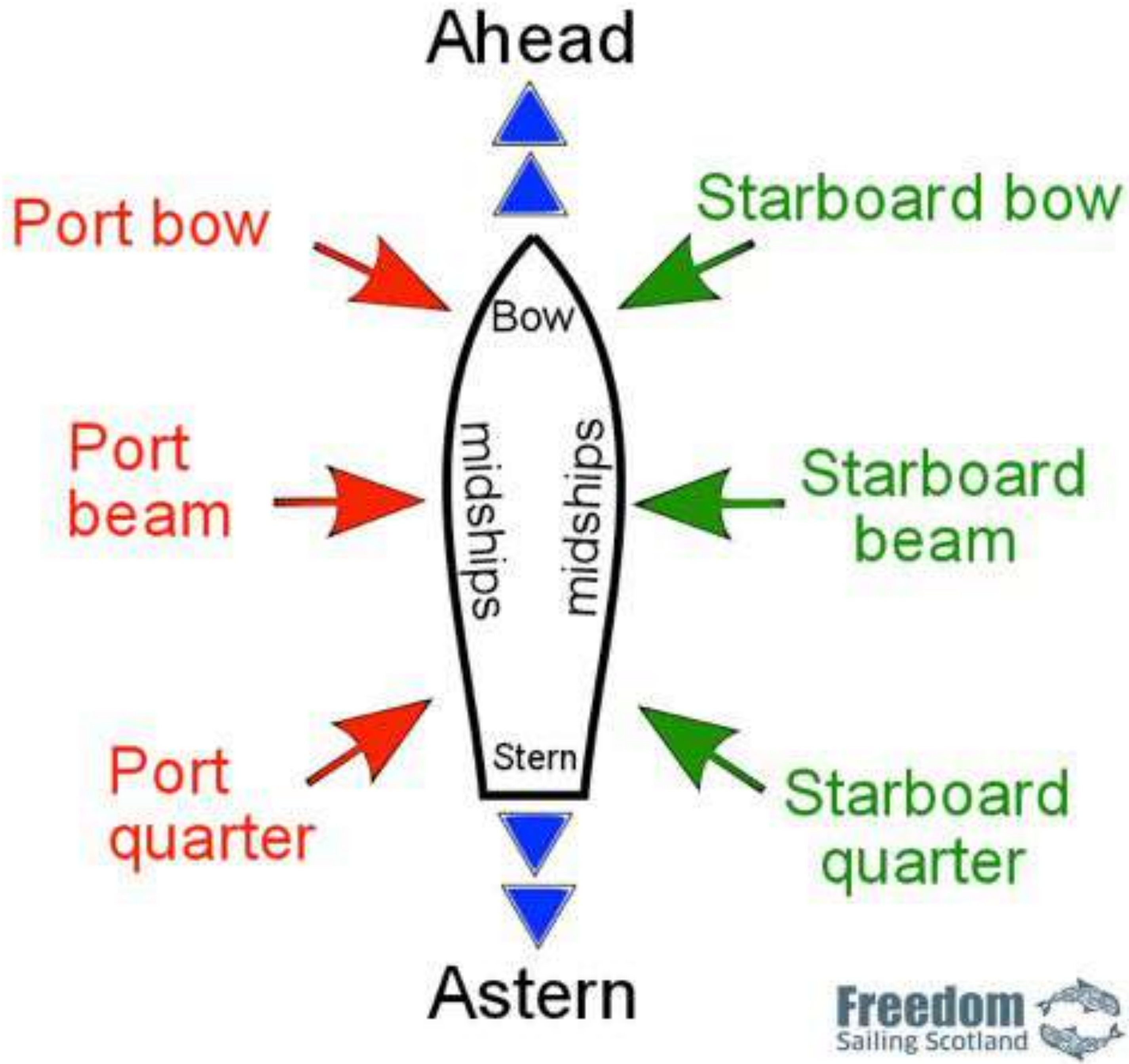
- Ship alongside a jetty

- Rudder was called “Steer board”….Located on right side.
- So to prevent damage to rudder , the left side would touch the “Port” or jetty
- So left side was called “Port” side
- Right side was called “Steerboard” side which later became “Starboard”

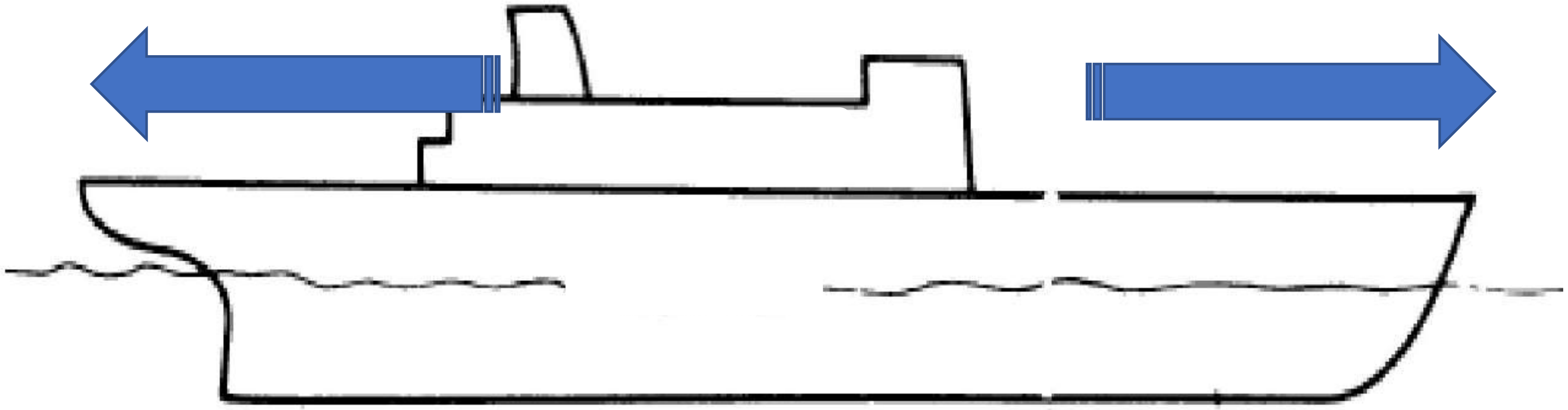

A
B

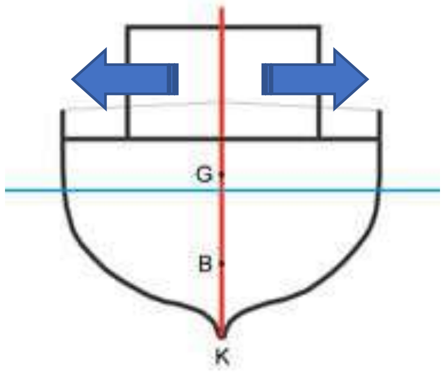

AFT
FWD
Midships

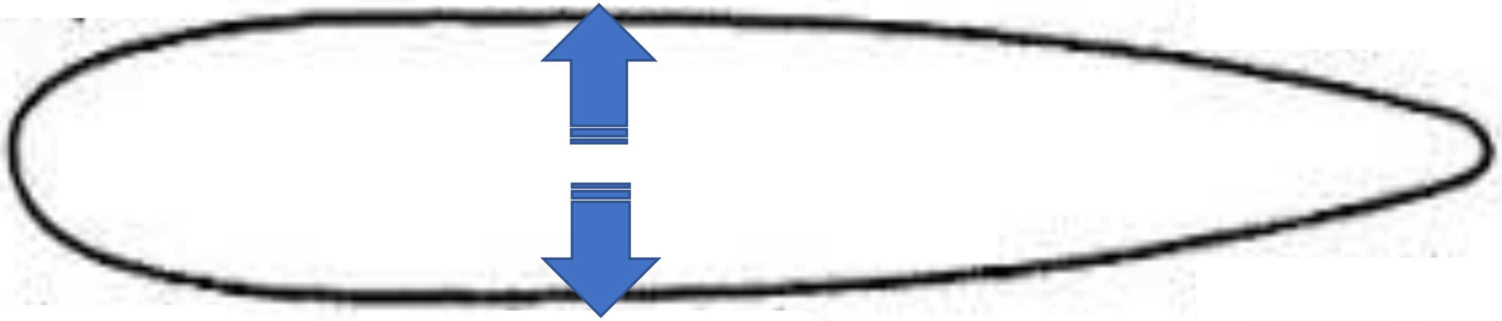

Stern/ Quarter
Superstructure
Bow
Main hull
Keel
Beam
Stern / Quarter
Beam
Bow


Ahead
Port bow
Starboard bow
Bow
Port beam
midships
midships
Starboard beam
Stern
Port quarter
Starboard quarter
Astern
Freedom
Sailing Scotland

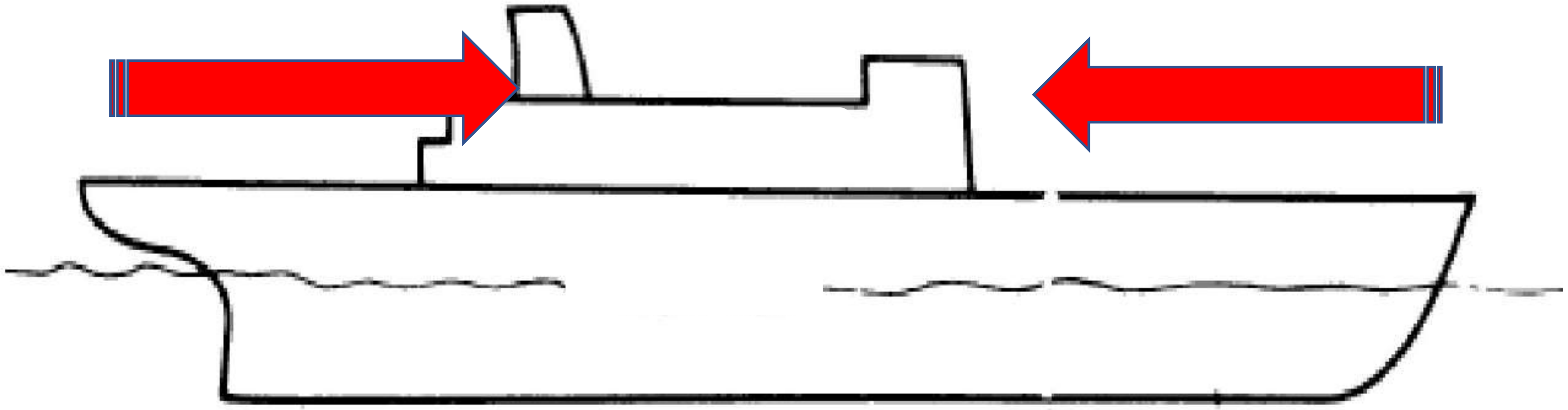
OUTBOARD – outwards direction

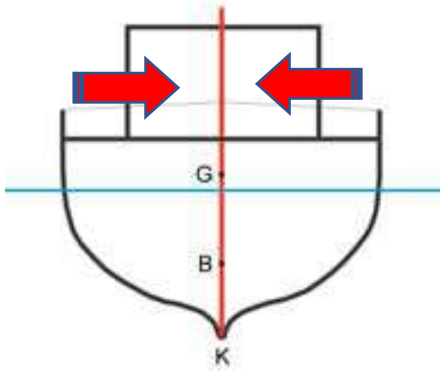


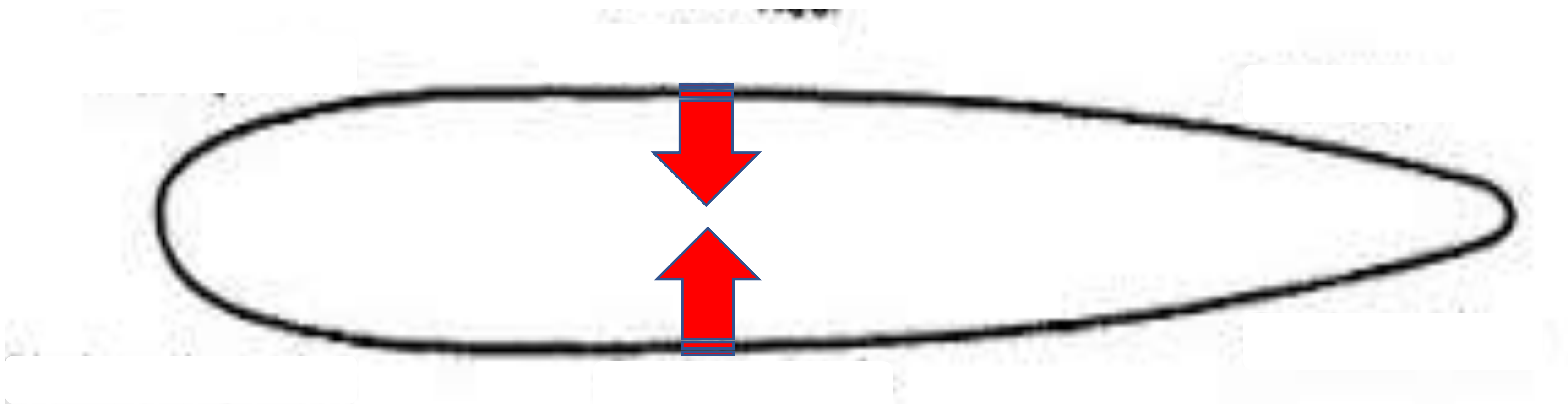




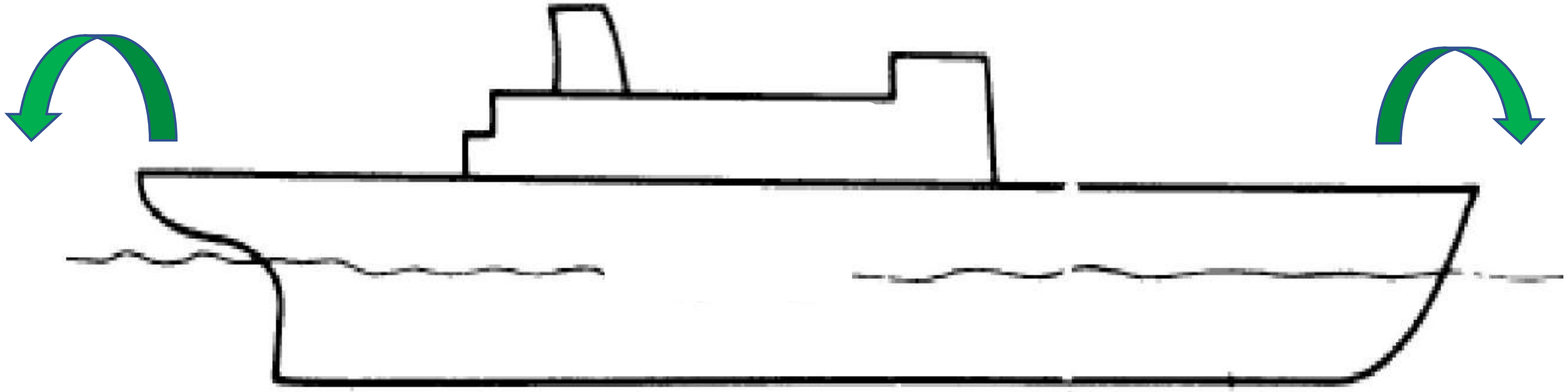
INBOARD- Inwards direction

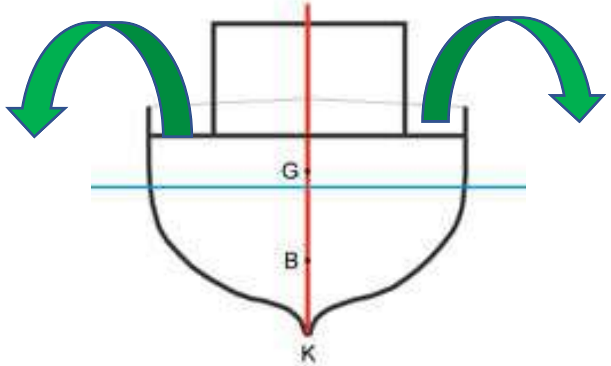




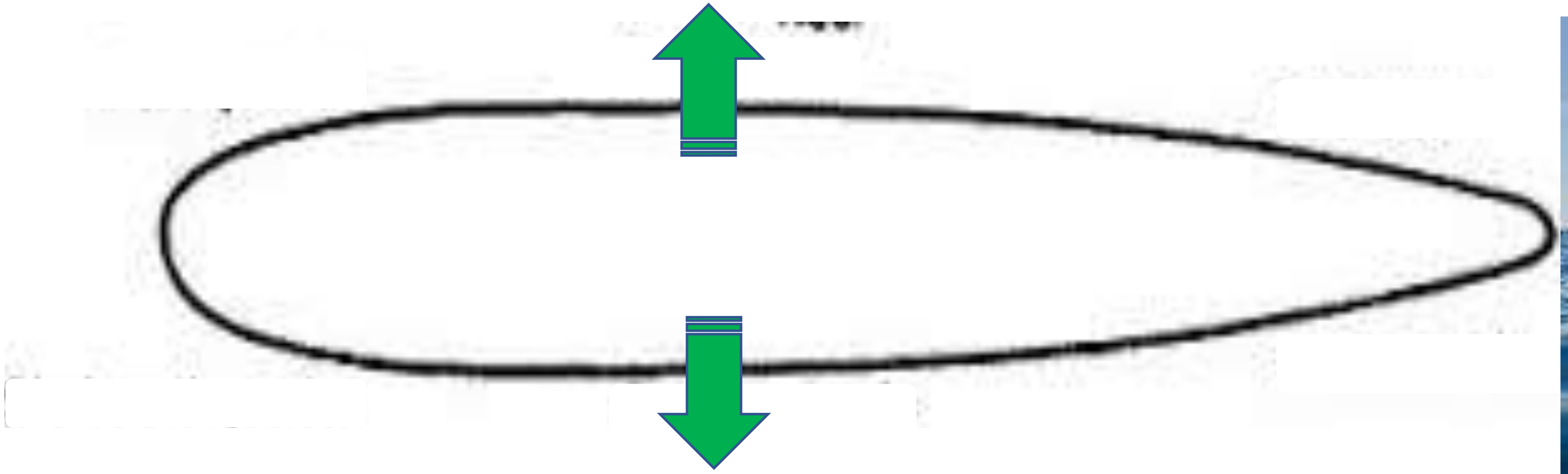


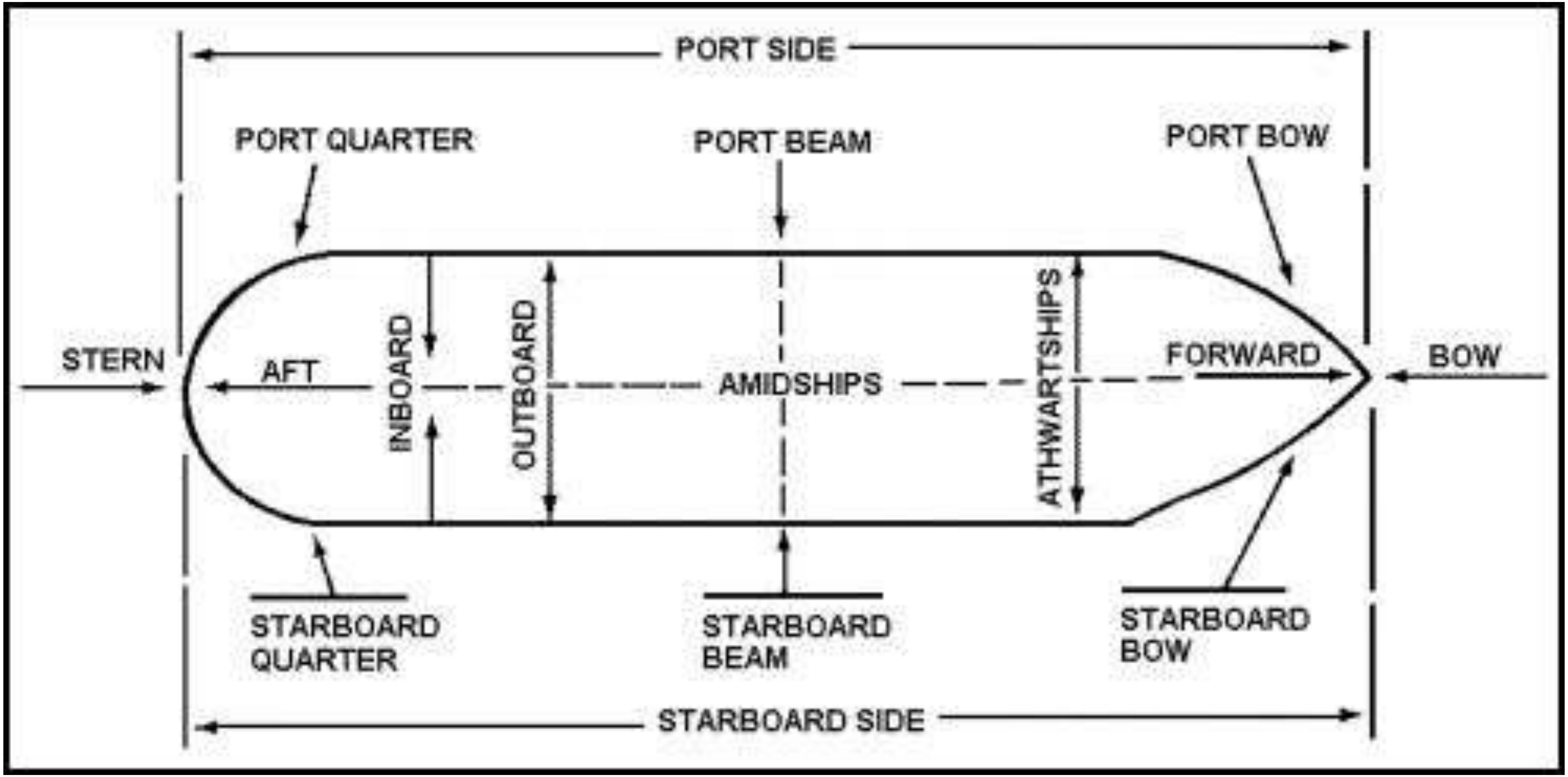
OVERBOARD – outside the ship, in water





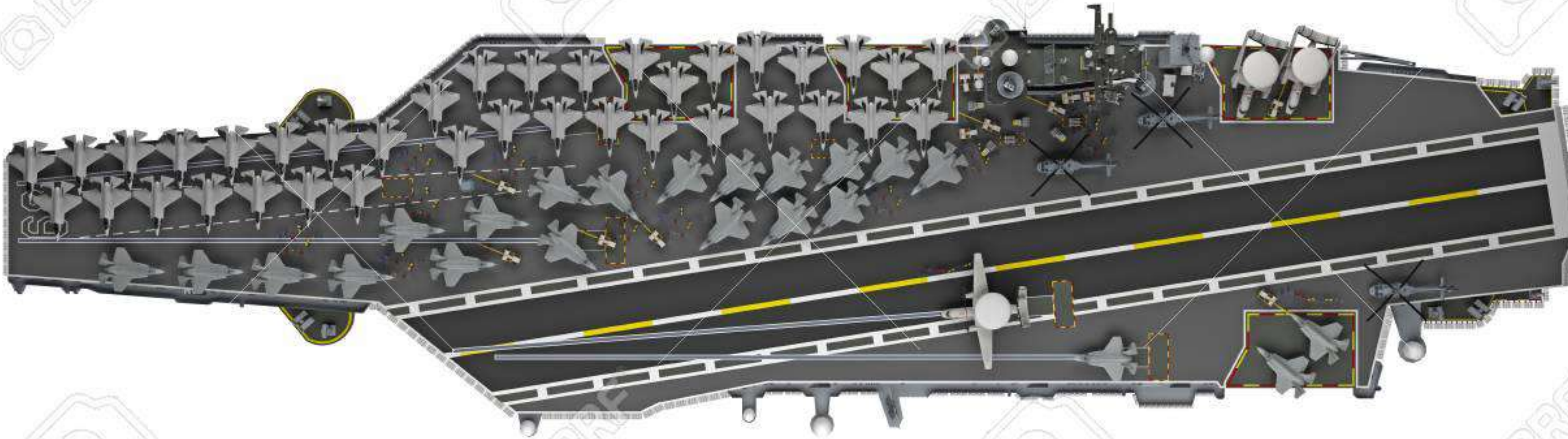
- Person over board – person fallen in water from ship




PORT SIDE
PORT QUARTER
PORT BEAM
PORT BOW
STERN
AFT
INBOARD
OUTBOARD
AMIDSHIPS
ATHWARTSHIPS
FORWARD
BOW
STARBOARD QUARTER
STARBOARD BEAM
STARBOARD BOW
STARBOARD SIDE

Identify the different ship regions in the following pictures


Royal Caribbean




SABRINA I


KYSTVAKT
W303


shipsbusiness.com


COTUNAV


CARNIVAL LEGEND

END

- In case of any doubts you may contact me at

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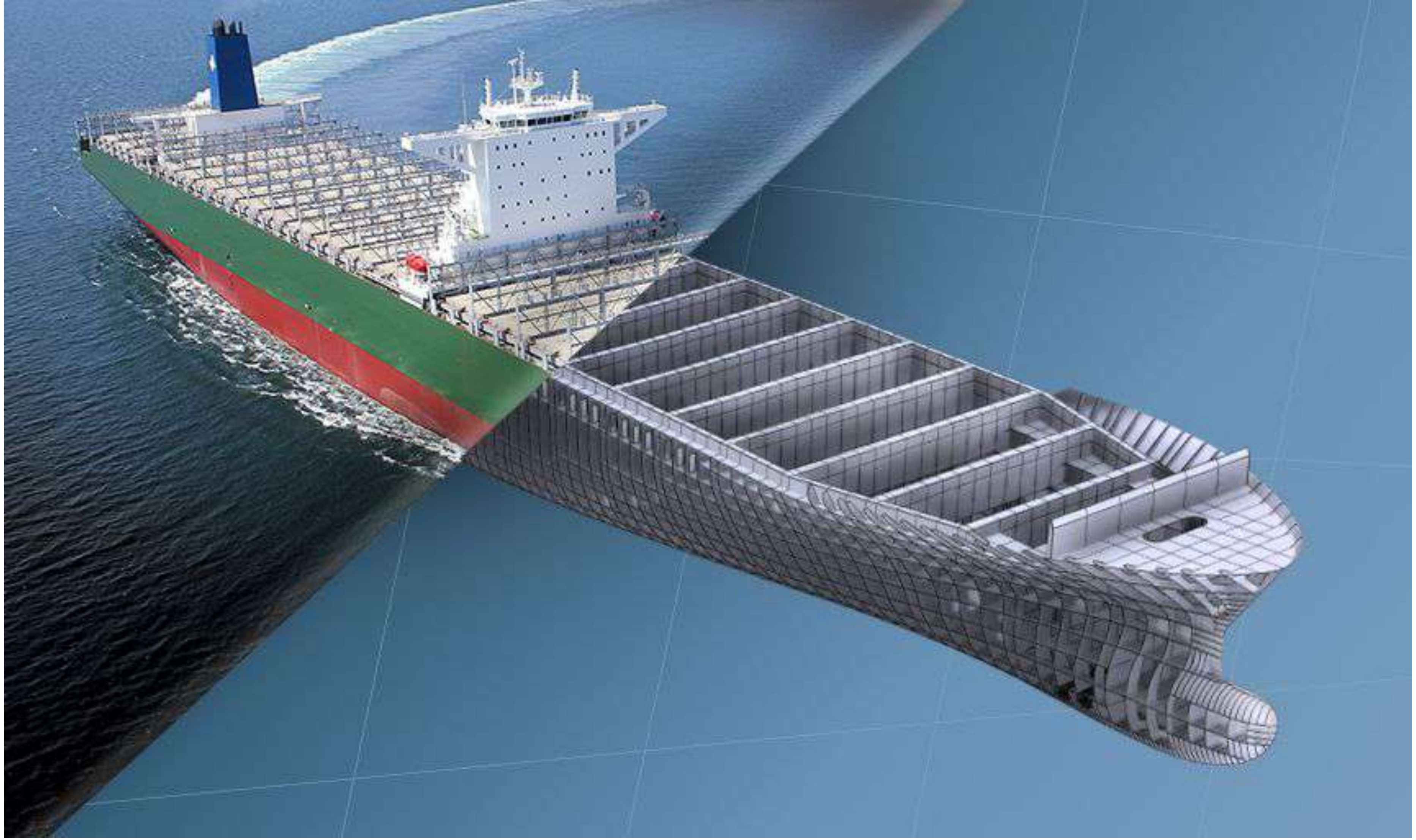
- Email : deepaksebastian.dost@gmail.com



Introduction to Naval Architecture

II SEM –Module 2

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Ship References

Ship References

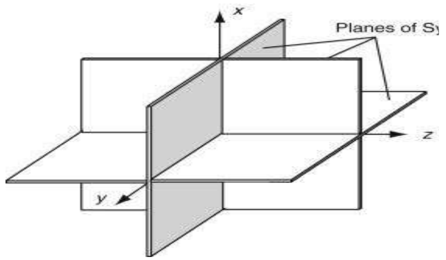
- Reference Directions
- Reference Planes
- Reference Views / Sections
- Reference Lines

Reference Directions

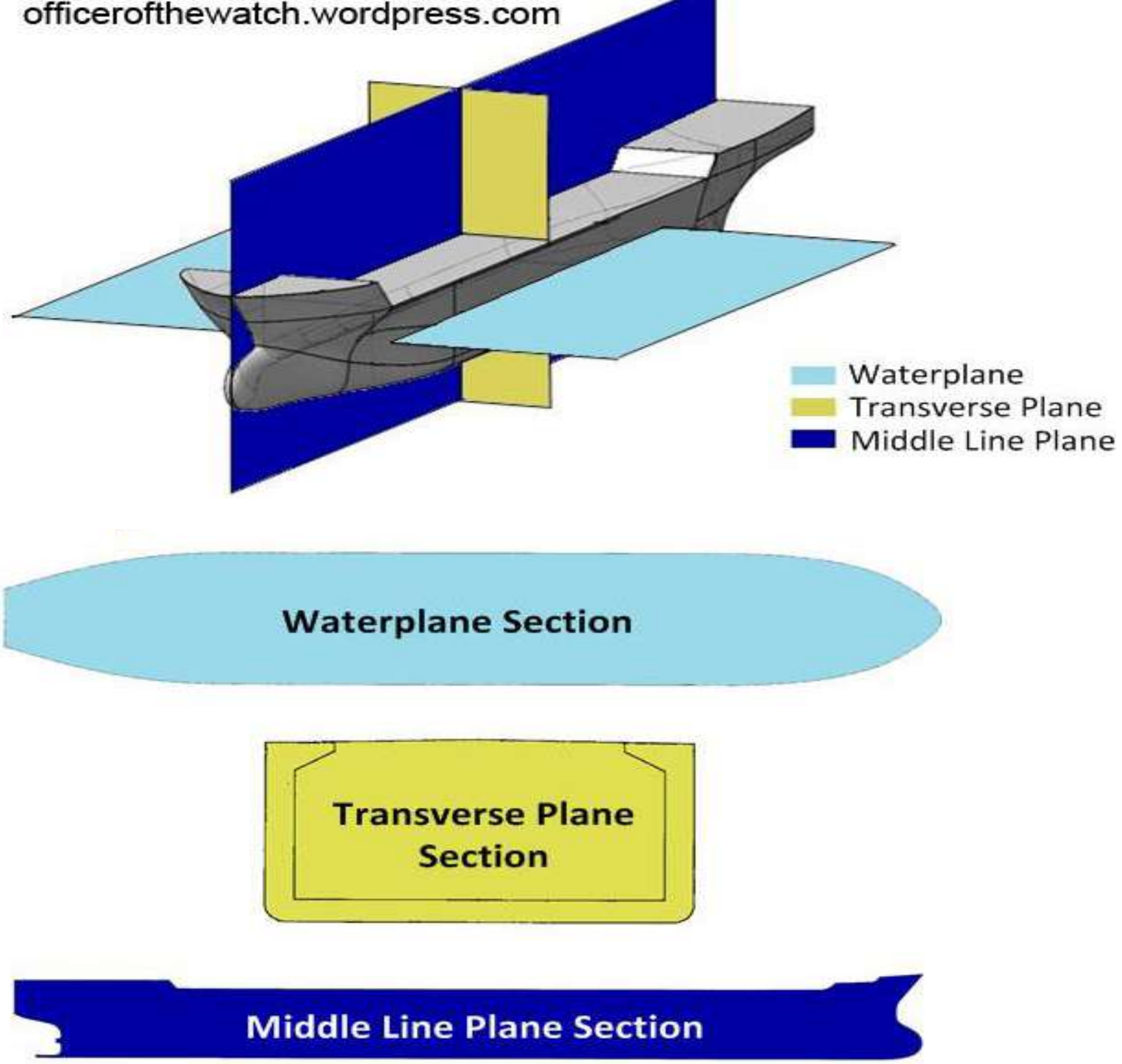
- Longitudinal
  - Fore and Aft(or vice versa) Direction

- Transverse
  - Port to Starboard (or vice versa) Direction
  - Athwartships

Reference Planes



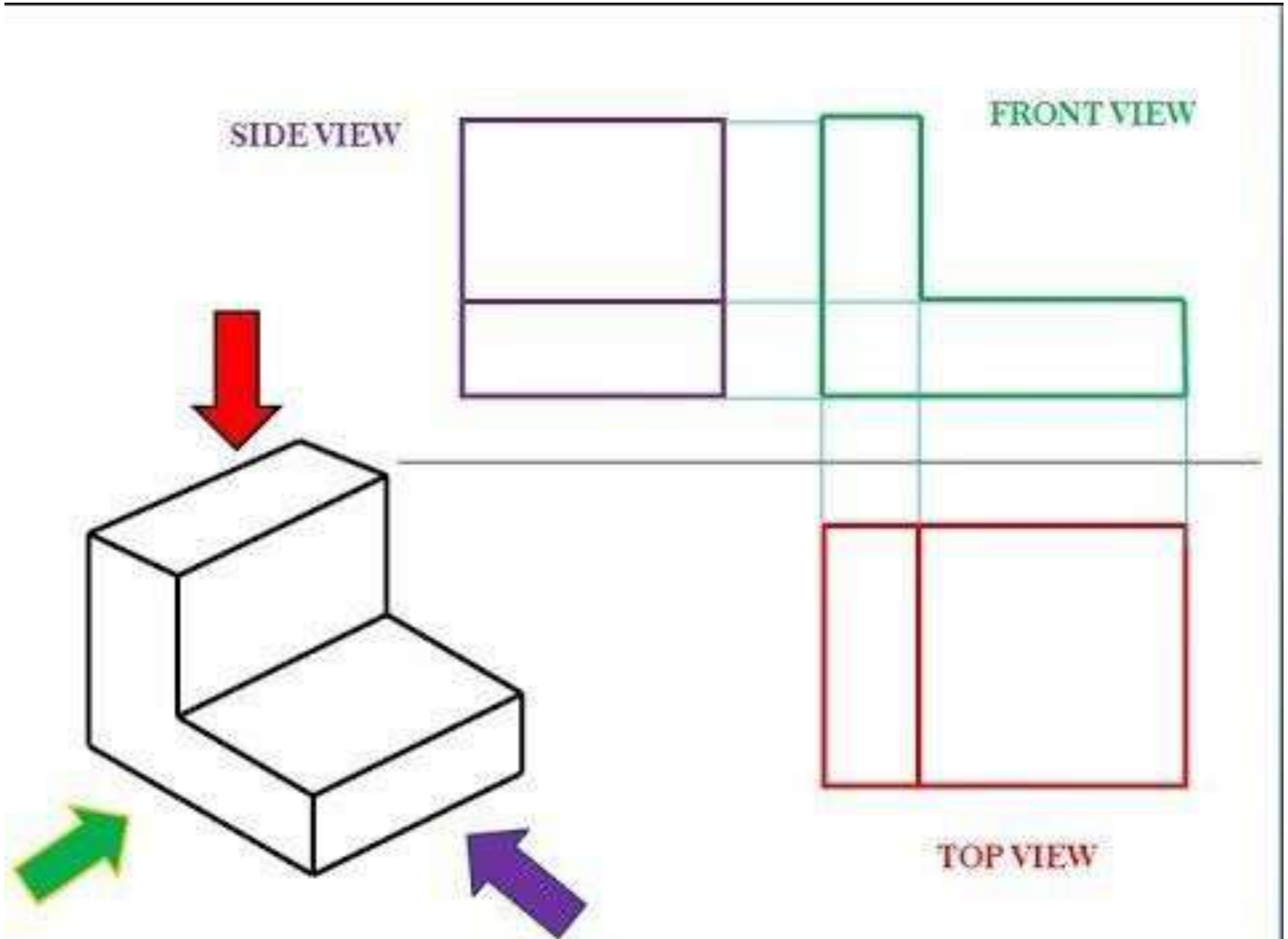
Ship Hull cut by 3 mutually perpendicular planes



Reference Planes

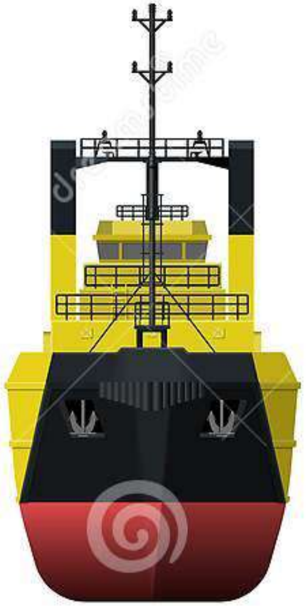
- Buttock Plane
  - At CentreLine it is called the Centreline Plane or MiddleLine Plane
- Water Plane or Waterline Plane
  - At 0 Waterline it is called Baseline Plane
  - At Load Waterline it is called Load Waterplane
- Transverse Plane or Transverse Section Plane
  - At Midships it is called Midship Section Plane

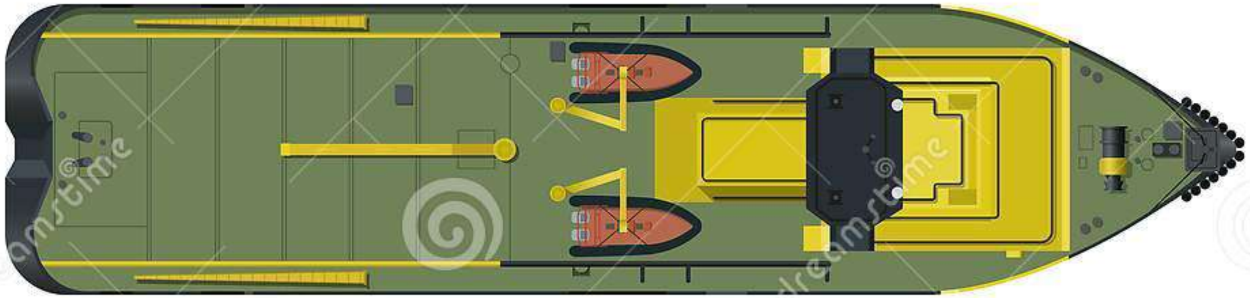
Reference Views - Object



Reference Views-Ship

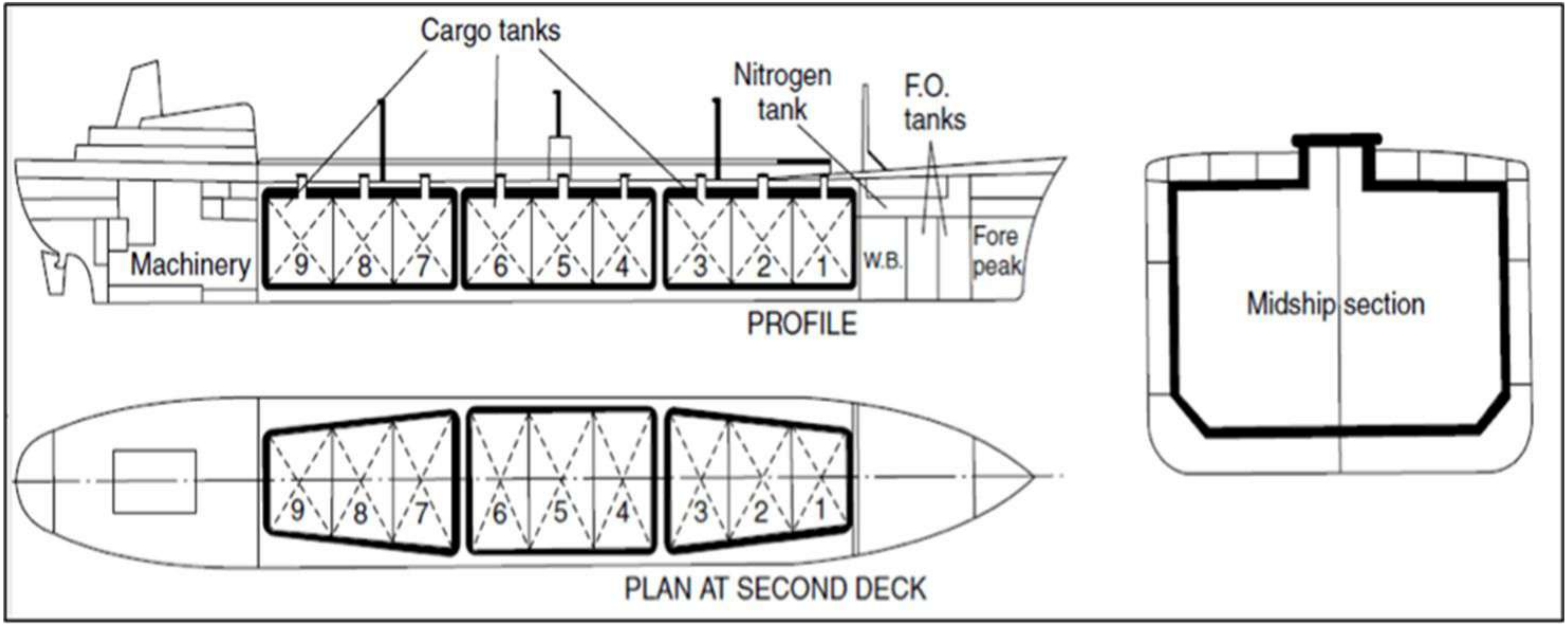
Side View /
Side Elevation/
Profile View /
Longitudinal Section



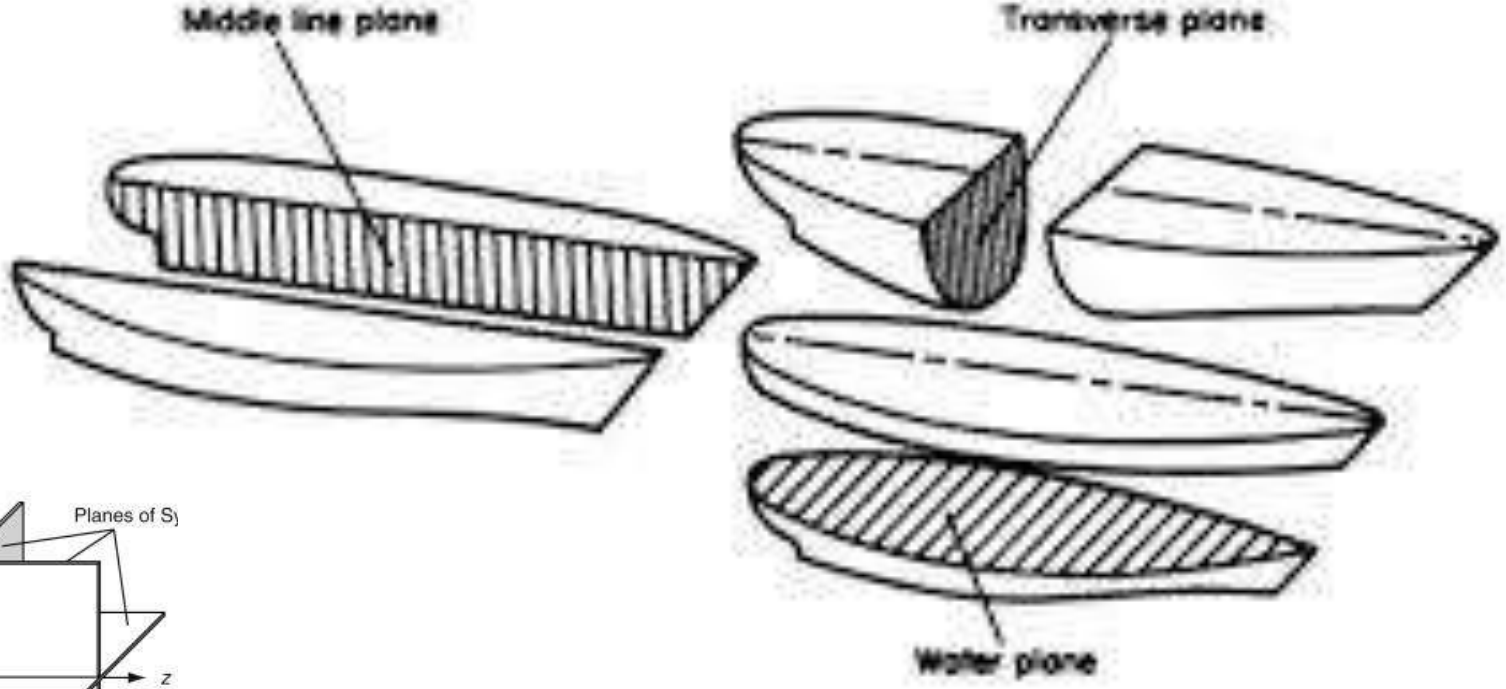


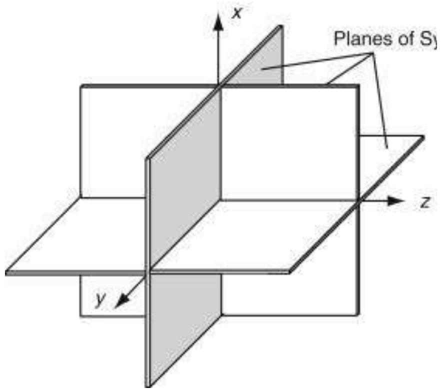
Front View /
Front Elevation /
Transverse Section /
Midship Section

Plan View / Top View

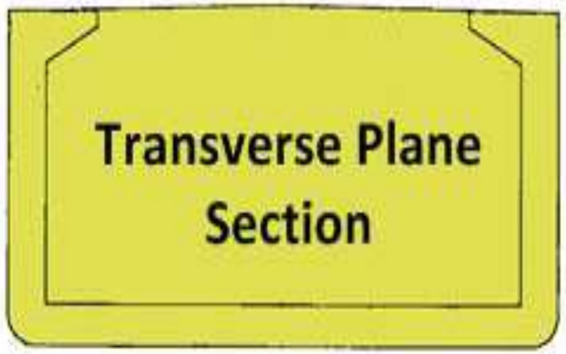

Cargo tanks
Nitrogen tank
F.O. tanks
Machinery
9
8
7
6
5
4
3
2
1
W.B.
Fore peak
PROFILE
Midship section
9
8
7
6
5
4
3
2
1
PLAN AT SECOND DECK

Reference Section Views



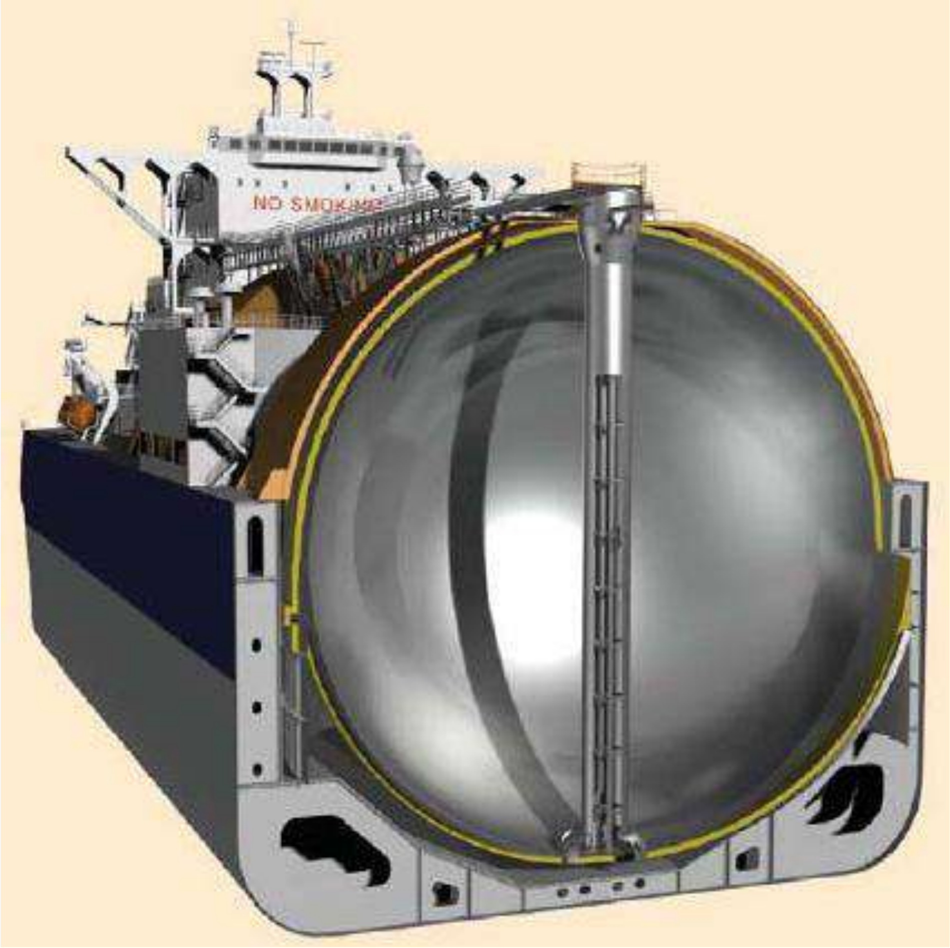



Waterplane Section


Transverse Plane
Section


Middle Line Plane Section

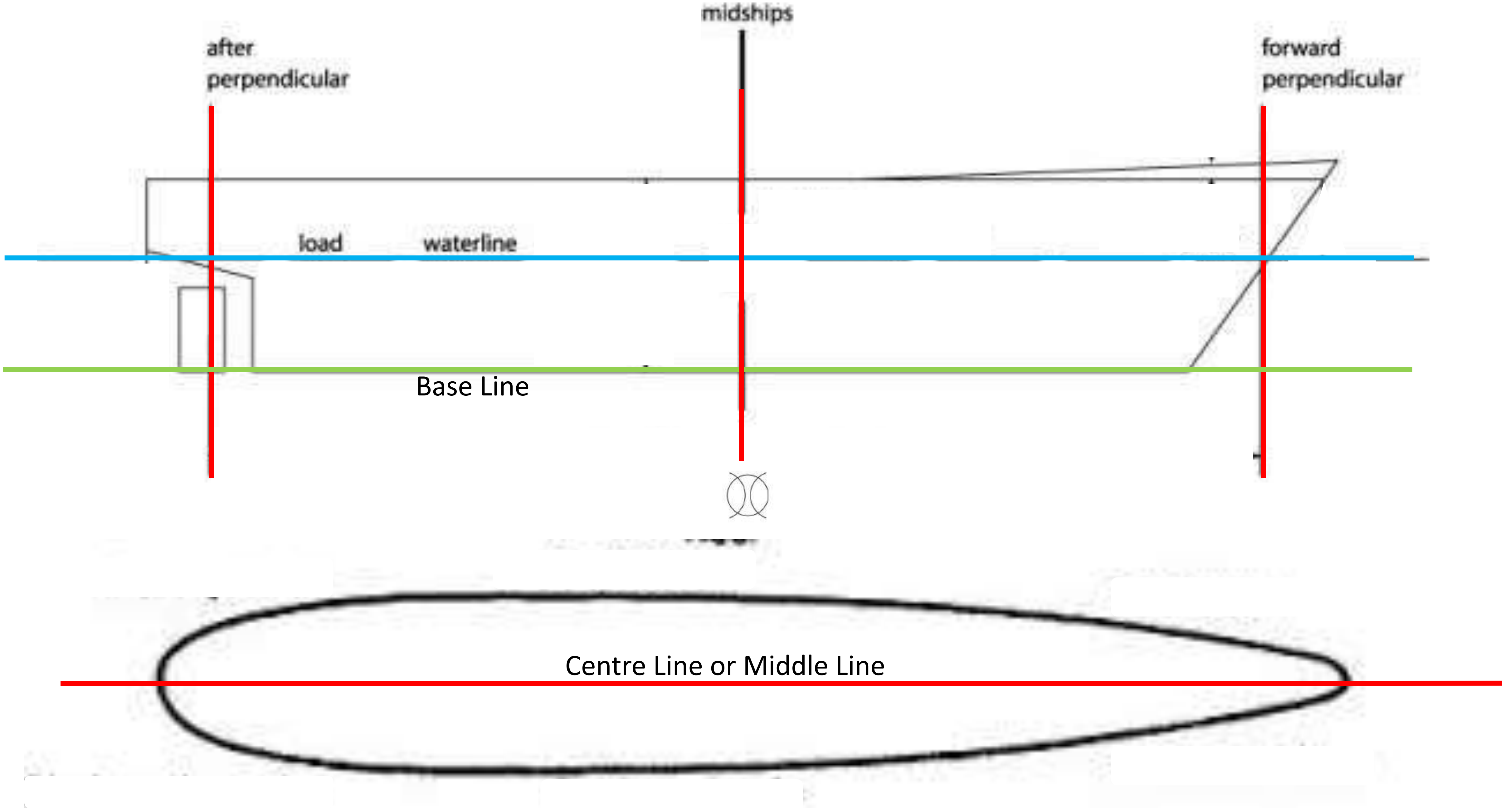
- Tranverse section



- Transverse section


Reference Lines

- Plan View(Top View)
  - CentreLine (**C_L**)
- Profile(Side Elevation)
  - Base Line (BL)
  - Waterline (WL) (At Designed Waterline it's called LWL (Load Water Line))
  - Forward Perpendicular(FP)
  - Aft Perpendicular(AP)
  - Midships


midships
after
perpendicular
forward
perpendicular
load
waterline
Base Line
Centre Line or Middle Line


22
20
19
18
17
16
15

END

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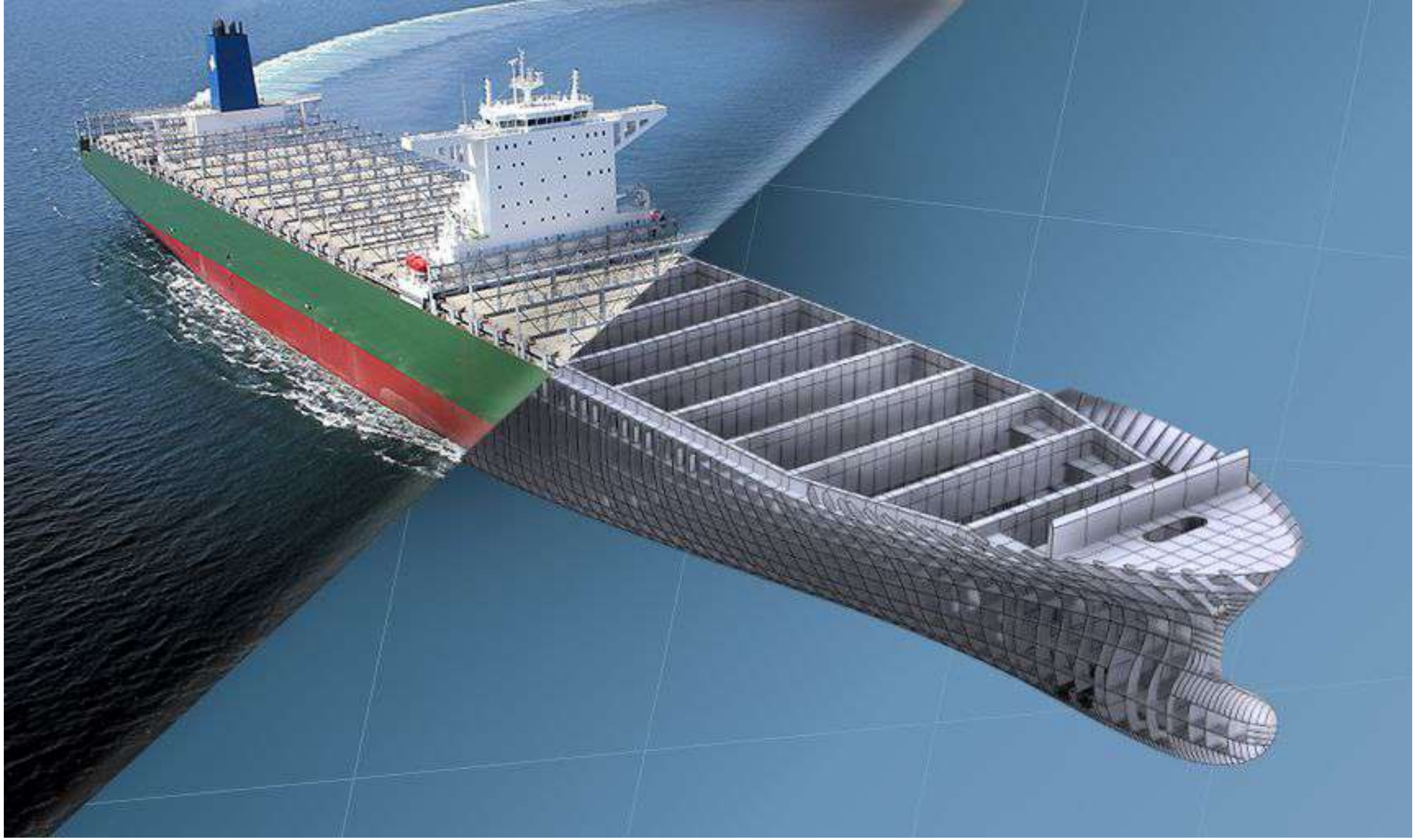

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Ship Dimensions

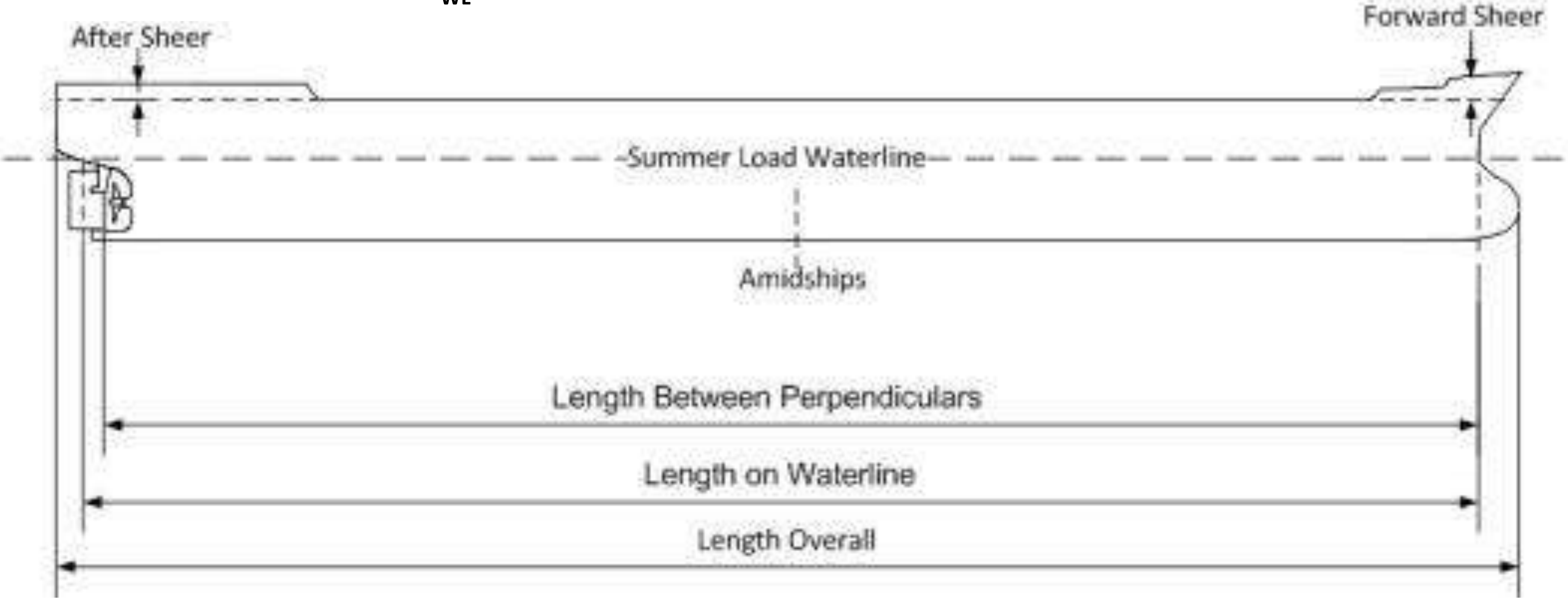
- Dimensions
- Definitions

Dimensions

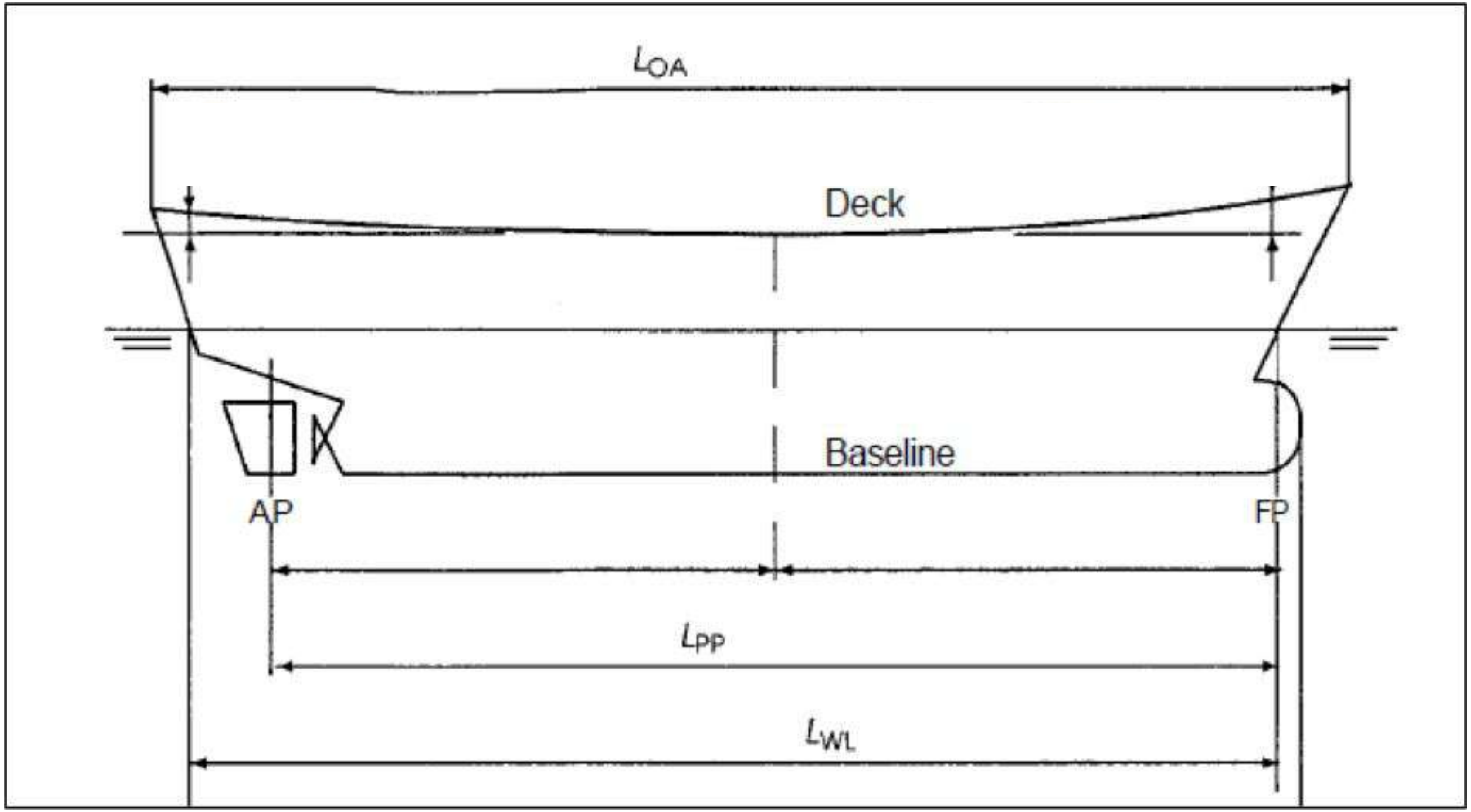
- **Length**
  - **Length Between Perpendiculars (LBP or L_{PP})**
  - **Length OverAll (LOA or L_{OA})**
  - **Length on WaterLine (L_{WL})**
- **Breadth or Beam (B) – Moulded or Extreme**
- **Depth (D) – Moulded or Extreme**
- **Draught or Draft (T) – Moulded or Extreme**
- **Freeboard**
- **Camber**
- **Sheer**
- **Flare**
- **Tumblehome**
- **Rise of Floor (Dead Rise or Rise of Bottom)**

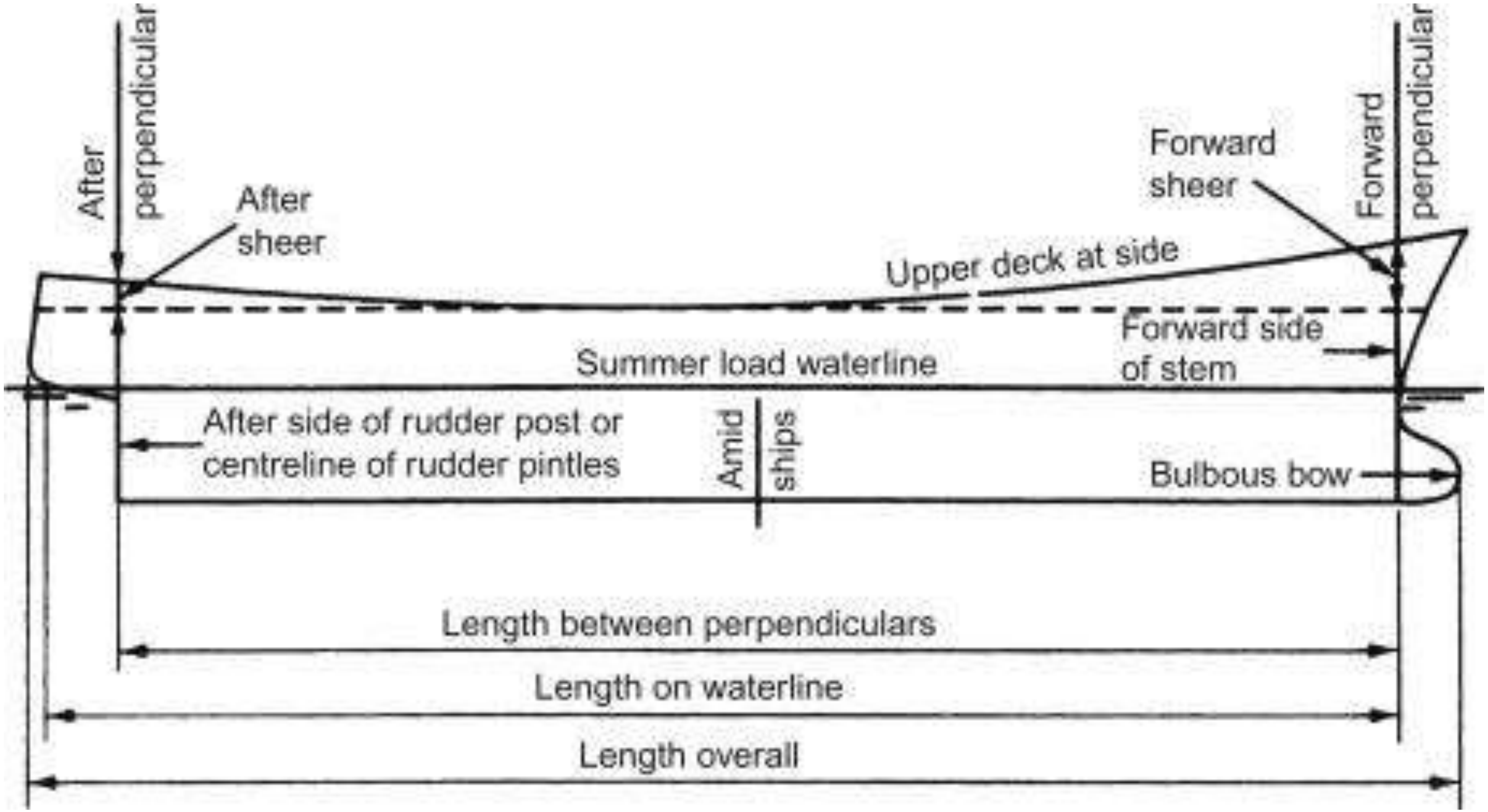
Lengths

Length Between Perpendiculars (LBP or L_{PP})
Length Over All (LOA or L_{OA})
Length on WaterLine (L_{WL})



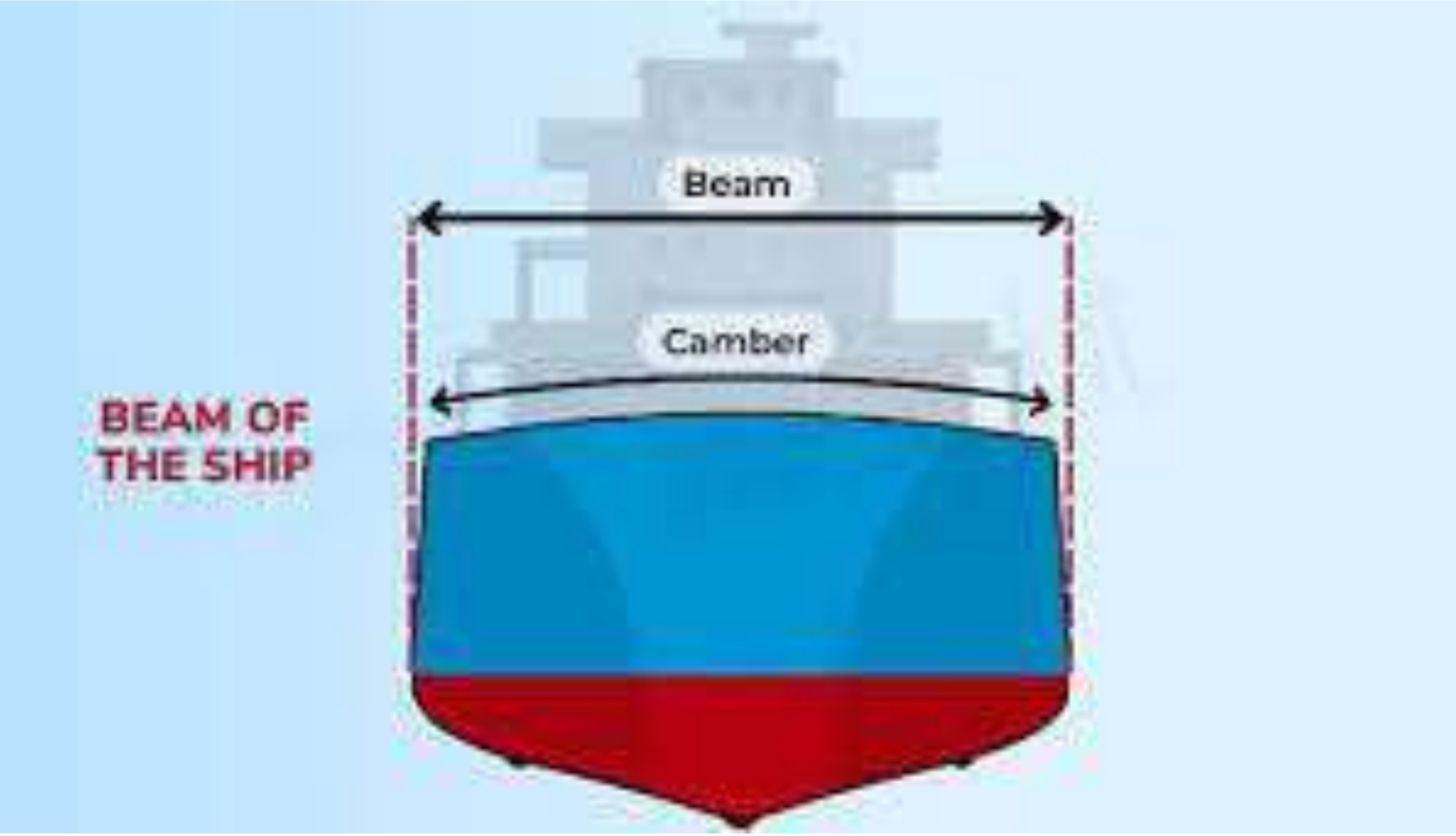
Lengths



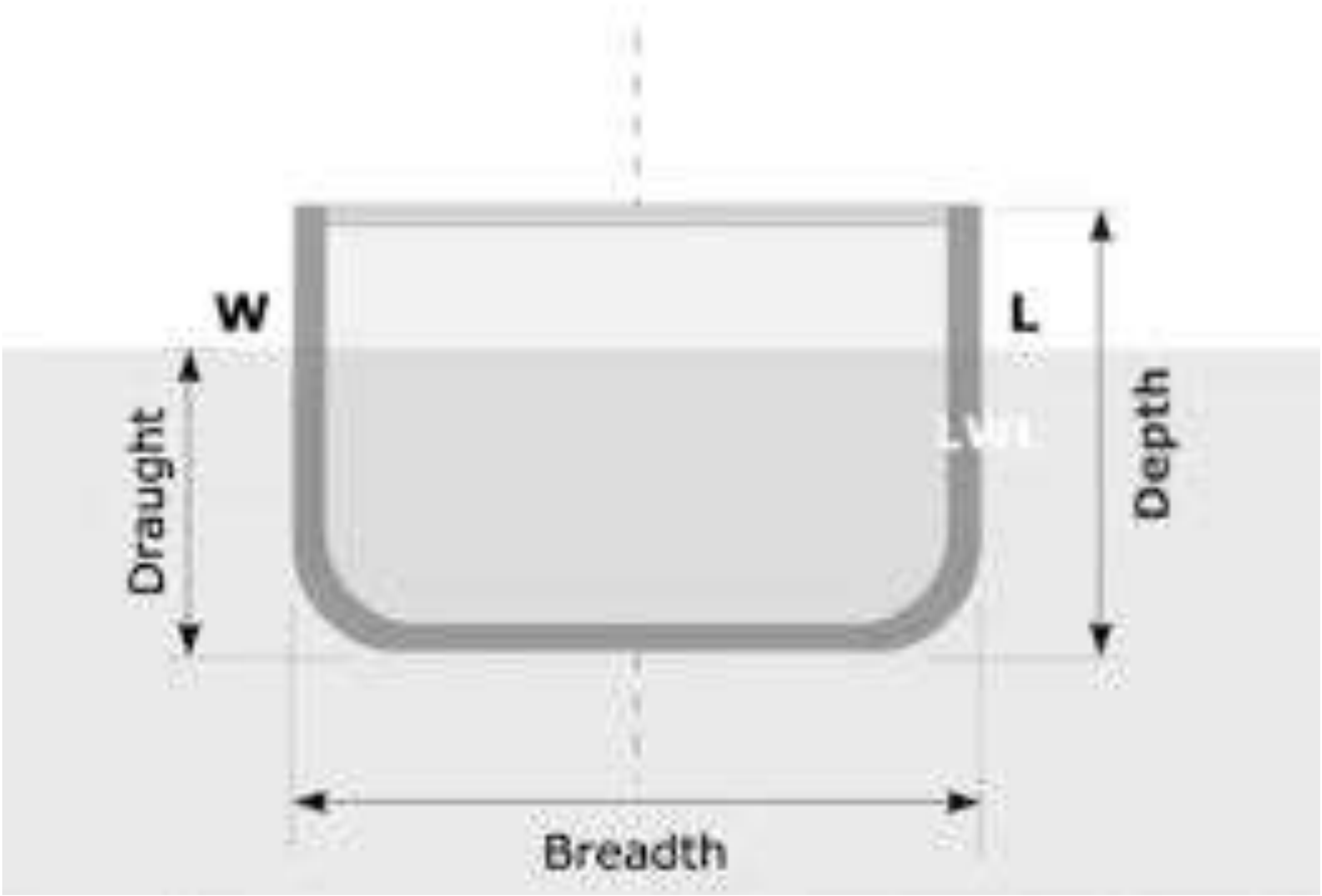


After
perpendicular
After
sheer
Forward
sheer
Forward
perpendicular
Upper deck at side
Forward side
of stem
Summer load waterline
After side of rudder post or
centreline of rudder pintles
Amid
ships
Bulbous bow
Length between perpendiculars
Length on waterline
Length overall

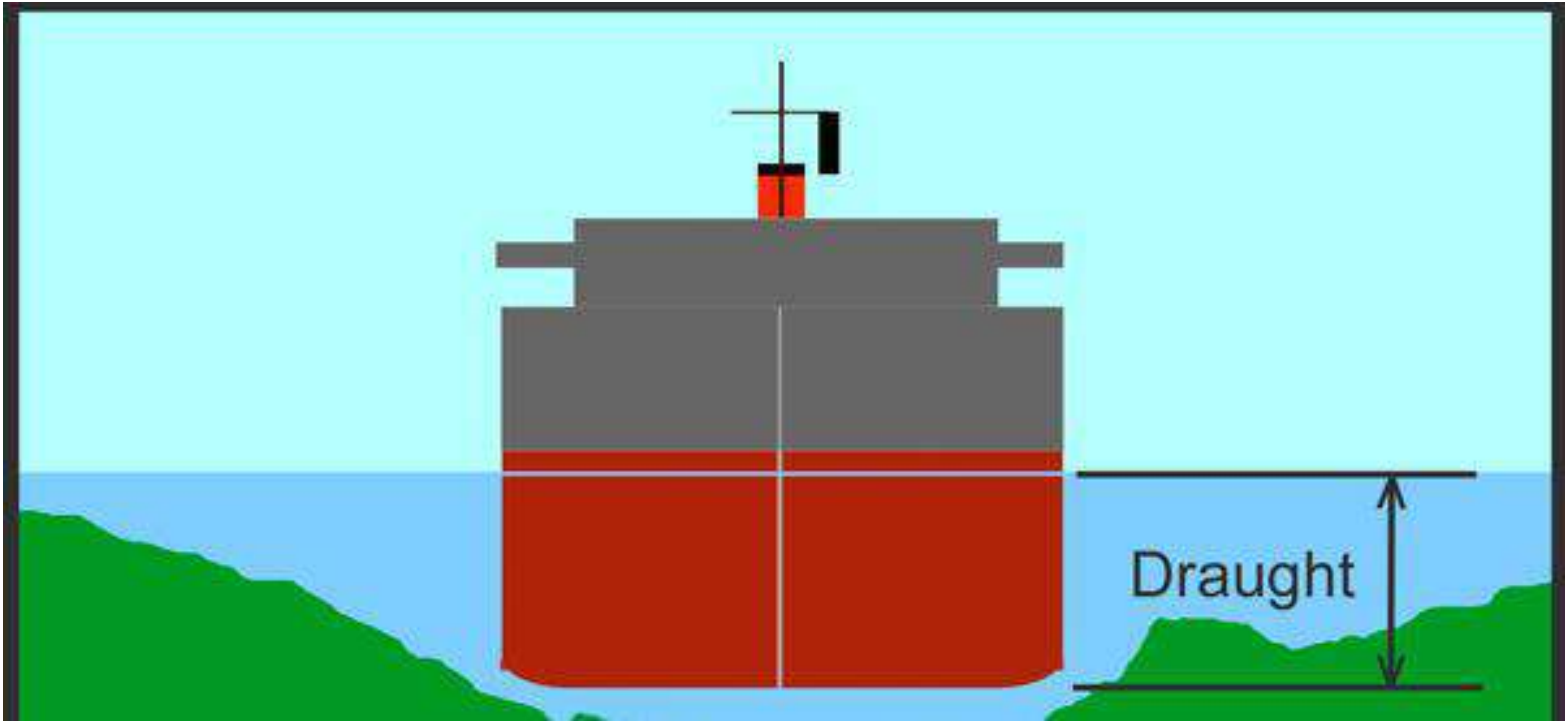
Breadth or Beam (B)



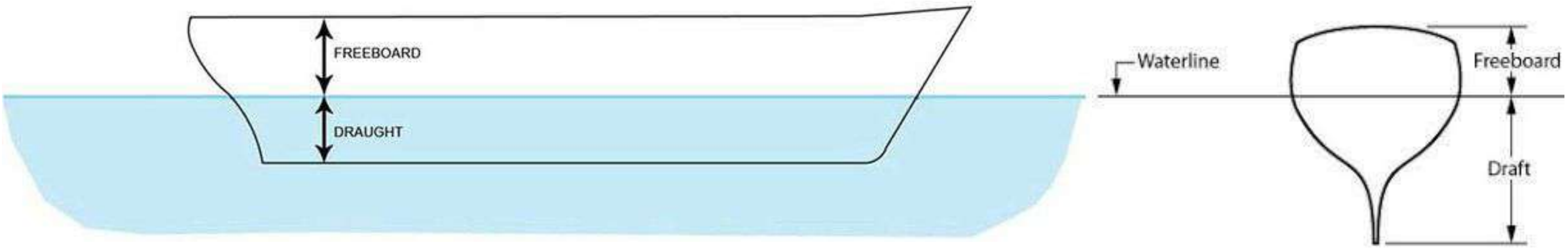
Depth(D)



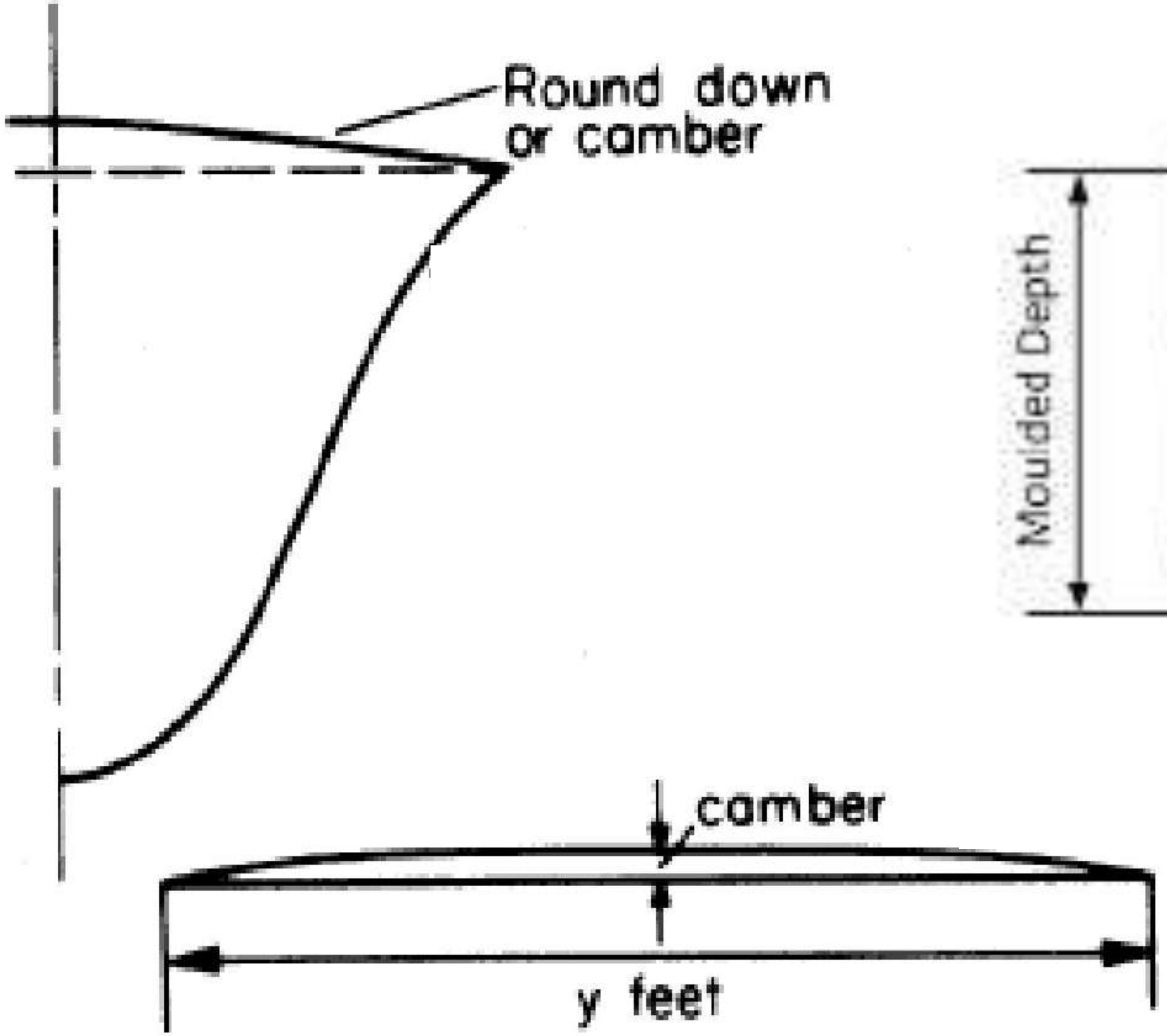
Draught or Draft (T)

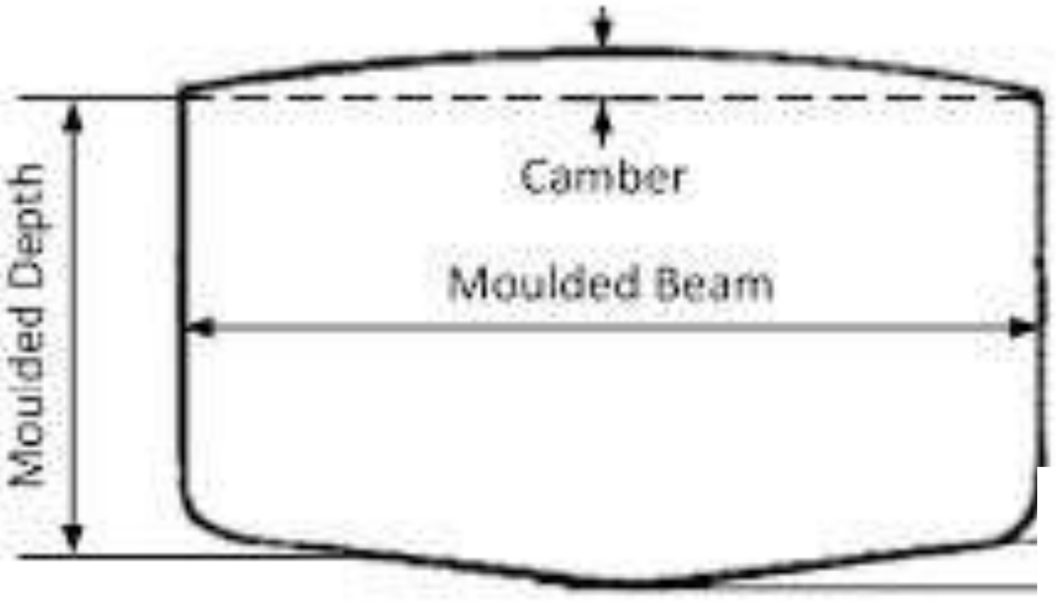


Freeboard(f)

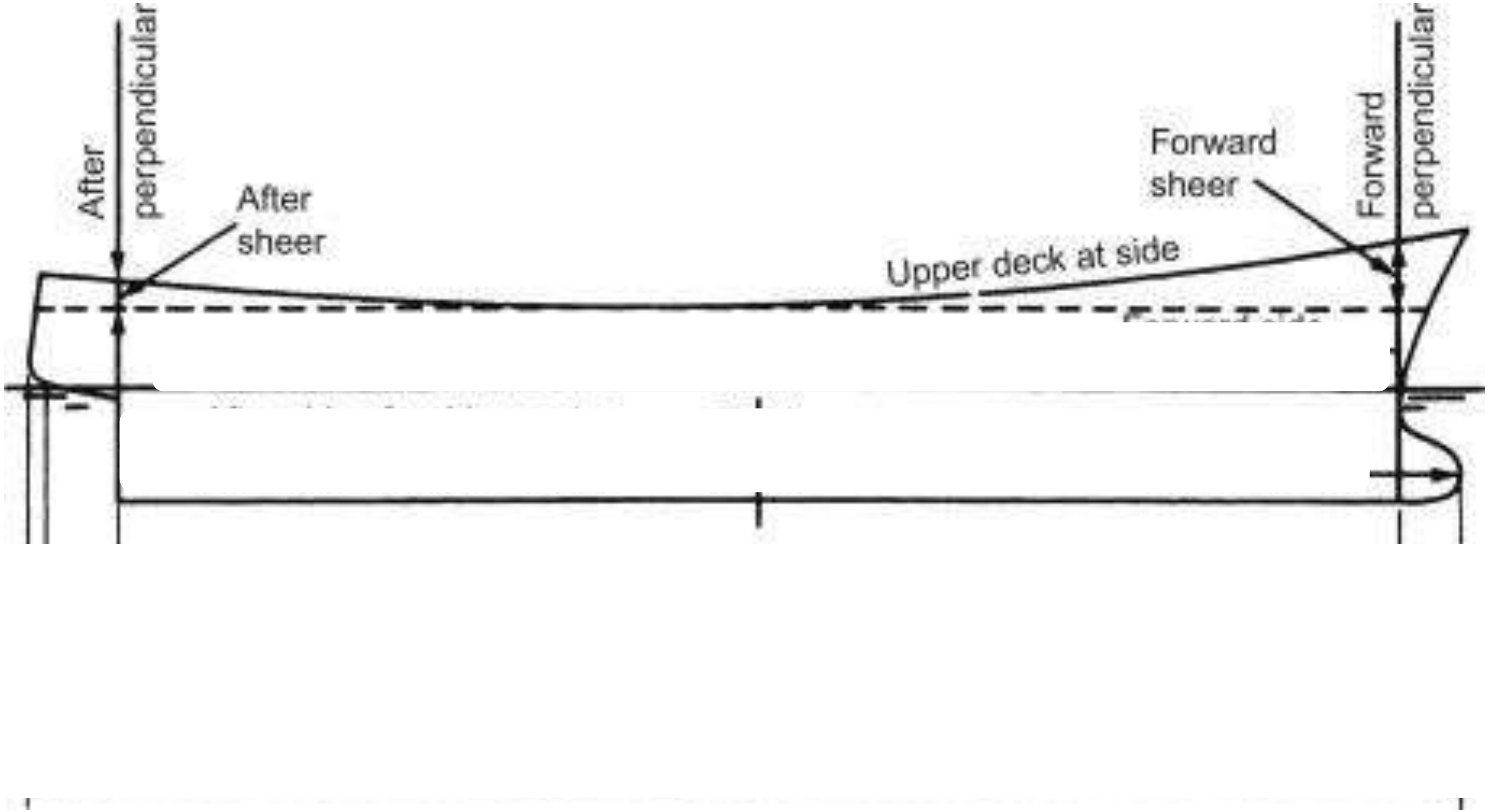


Camber


Round down
or camber
camber
y feet

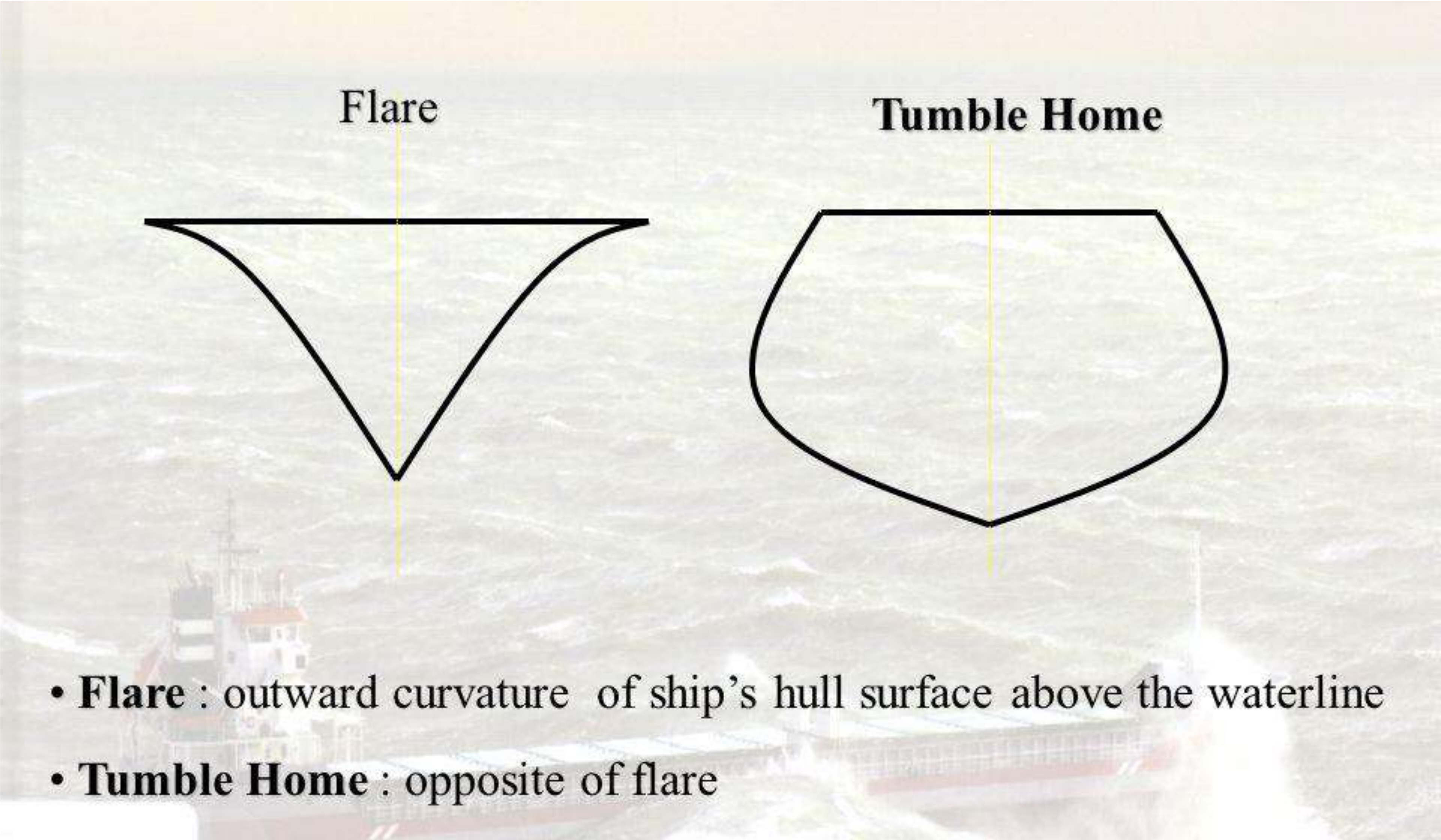

Camber
Moulded Beam
Moulded Depth

Sheer

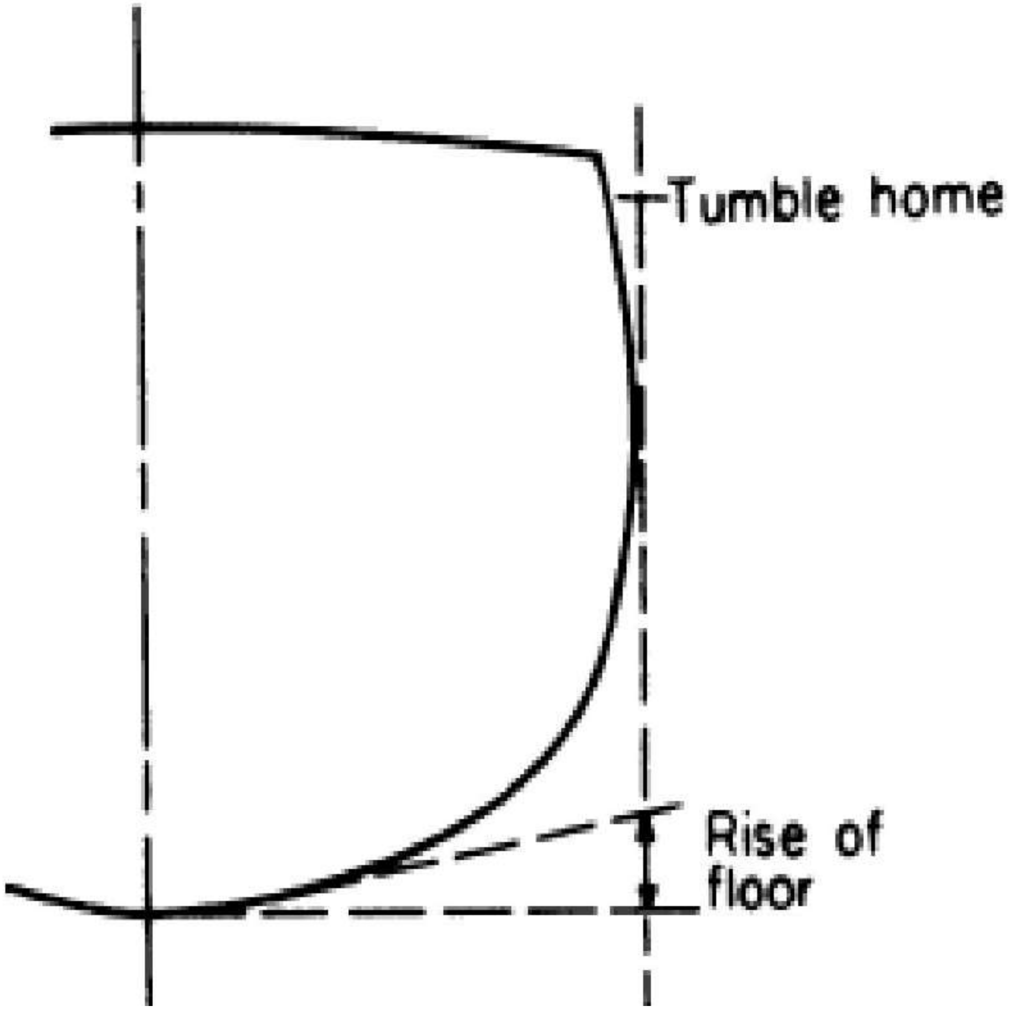


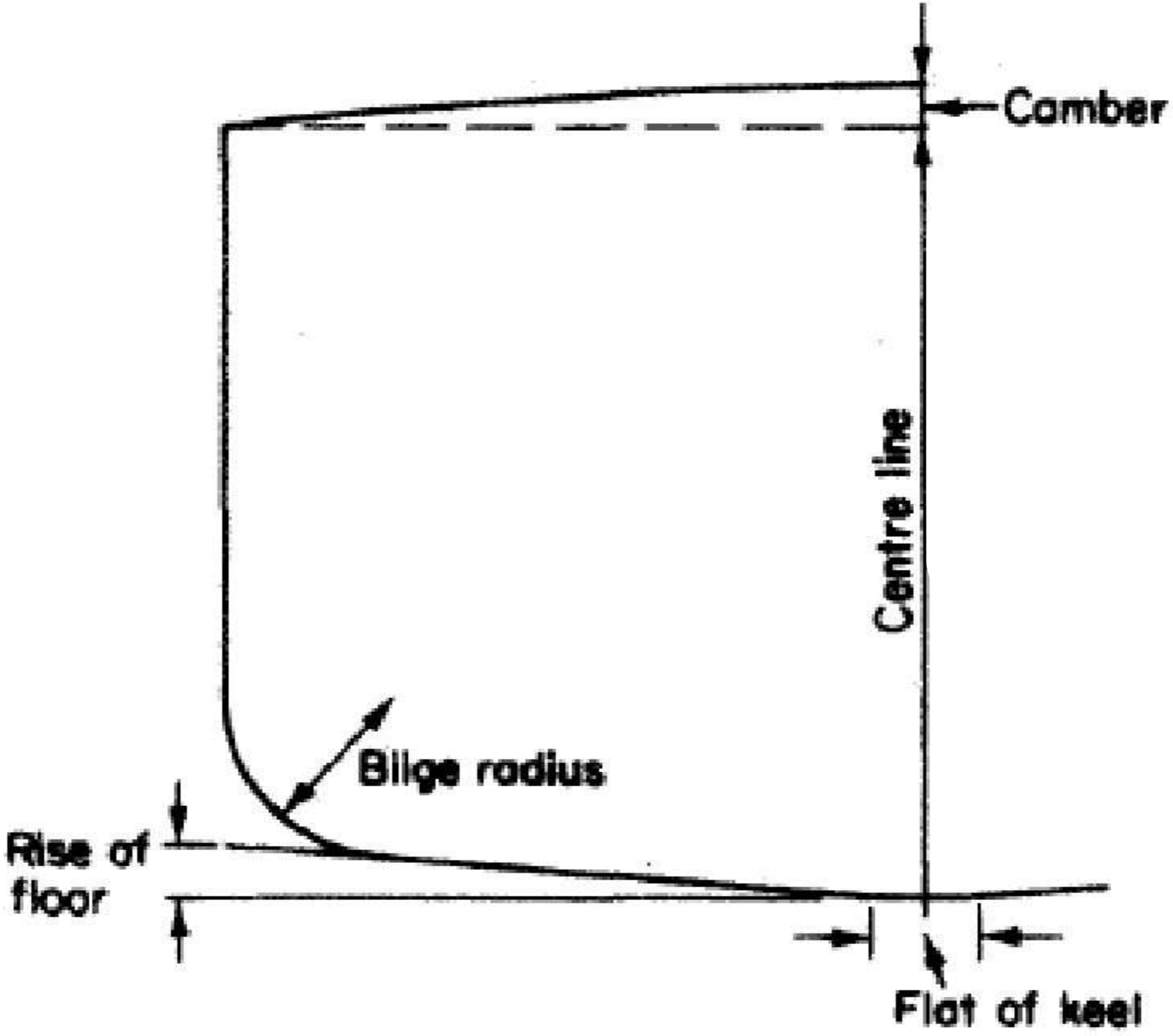
After perpendicular
After sheer
Forward sheer
Forward perpendicular
Upper deck at side

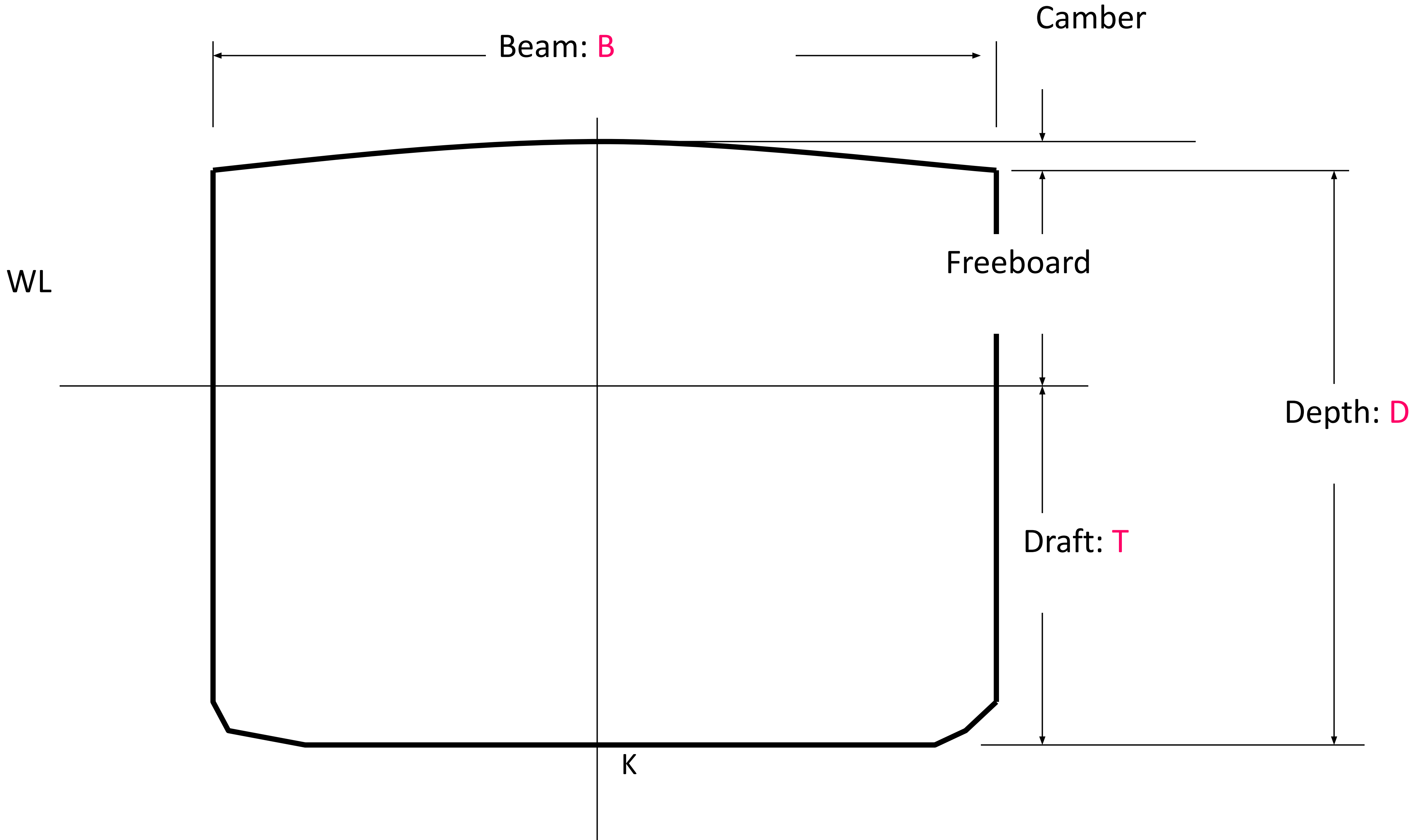
Flare and Tumble home



Rise of Floor or Dead Rise

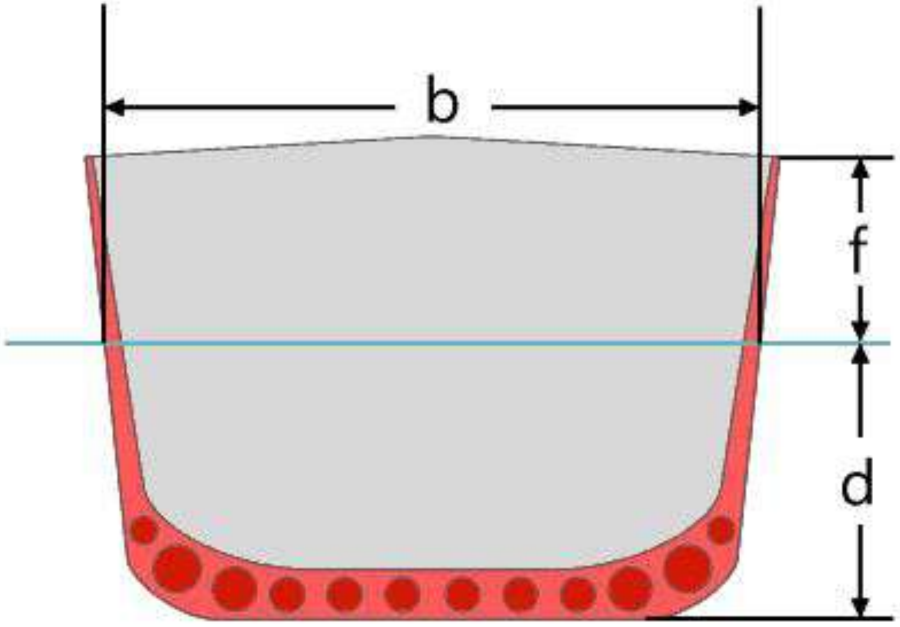




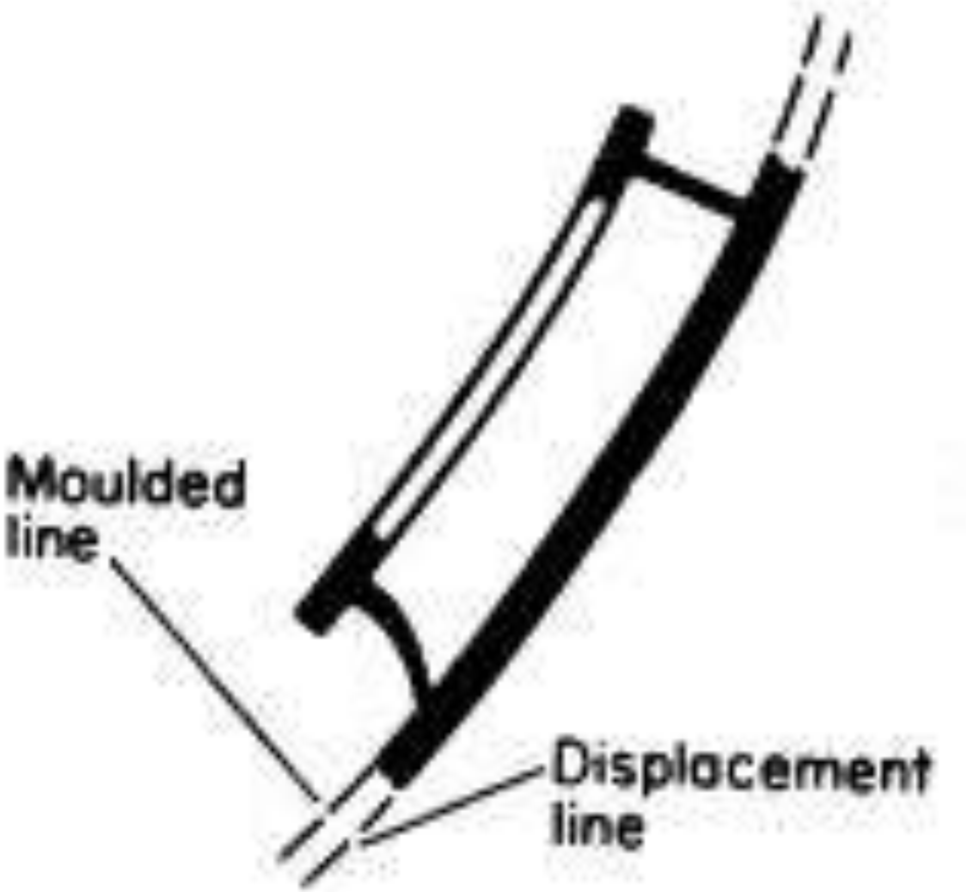

Camber
Beam: B
Freeboard
WL
Depth: D
Draft: T
K

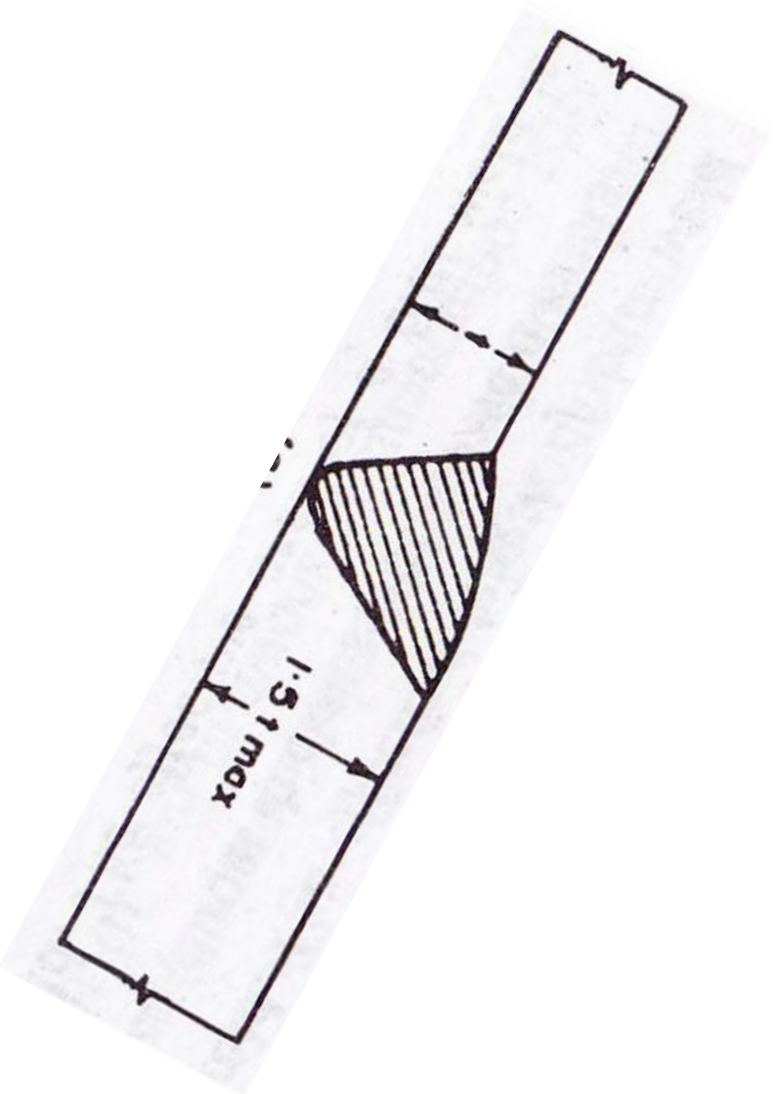
- Moulded Dimensions
  - Dimensions exclusive of the hull plating thickness

- Extreme Dimensions
  - Dimensions inclusive of the hull plating thickness



Moulded and Displacement Lines/Surface



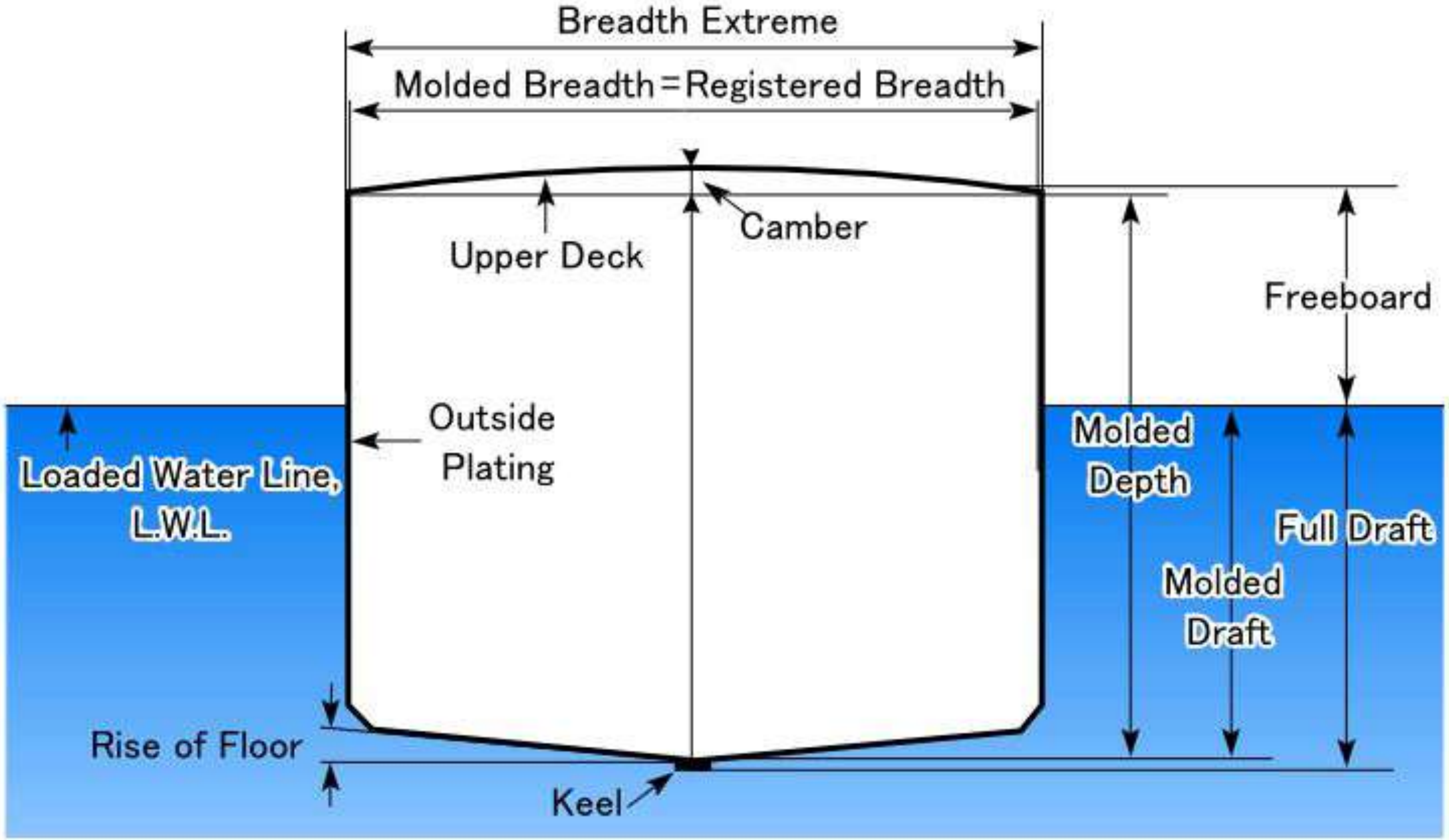


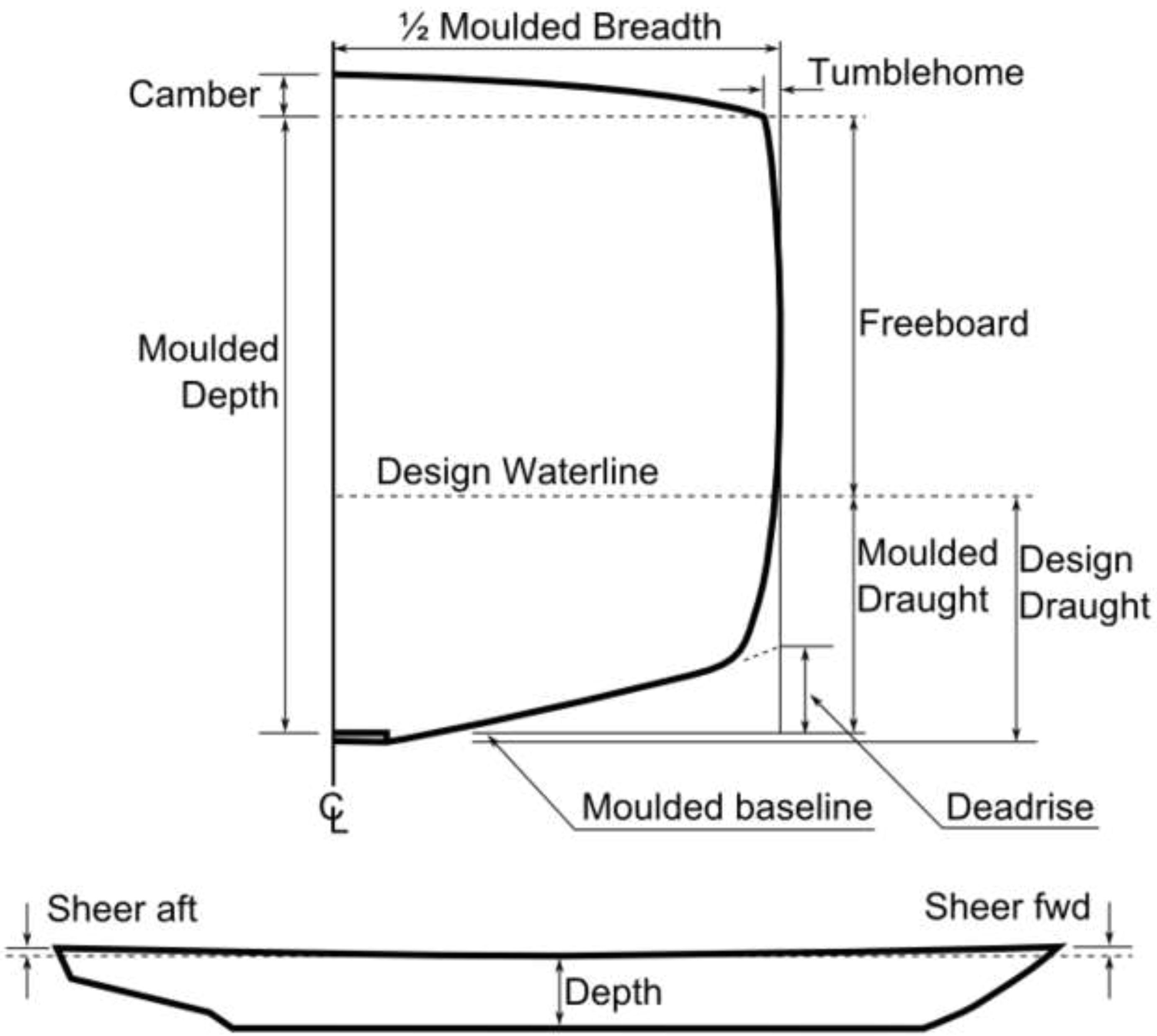
Moulded and Extreme/Displacement Surface

- Origin – Use of wooden moulds set up to establish a surface in space
- Steel, Aluminium vessels
  - Shell is formed of plates of varying thickness
  - The external surface is not smooth and not suitable for definition of a hull form.
  - Convenient to define the hull surface of a ship on the inner surface of shell plating
  - This is the moulded surface which is smooth and continuous.
  - All dimensions measured to this surface are categorized as moulded.
  - Moulded dimensions are used in initial stages of ship design.
  - The shell is the outer covering of the moulded surface.

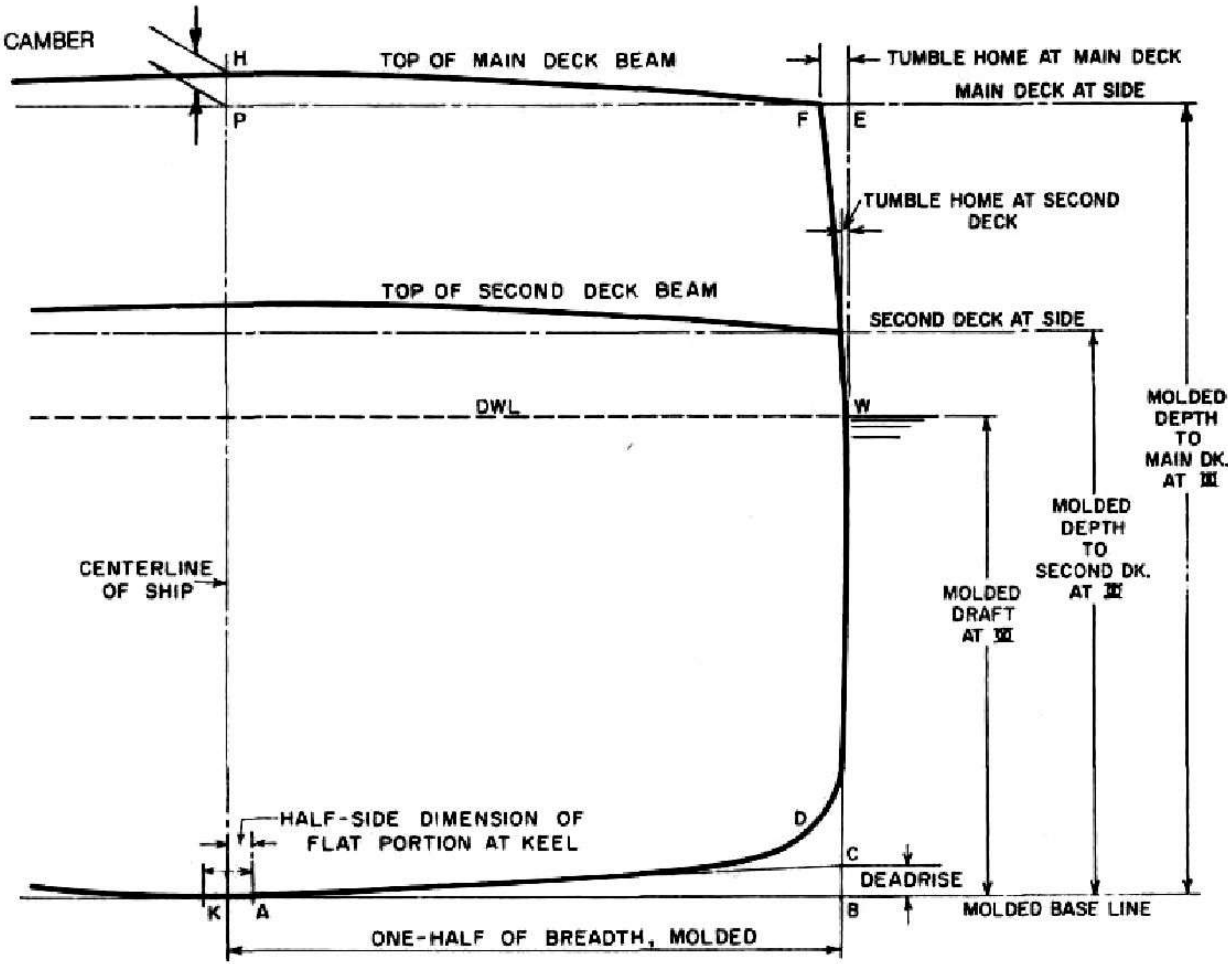
- GRP vessels
  - Moulded Surface is the outer surface of the skin

Ship size (front view)



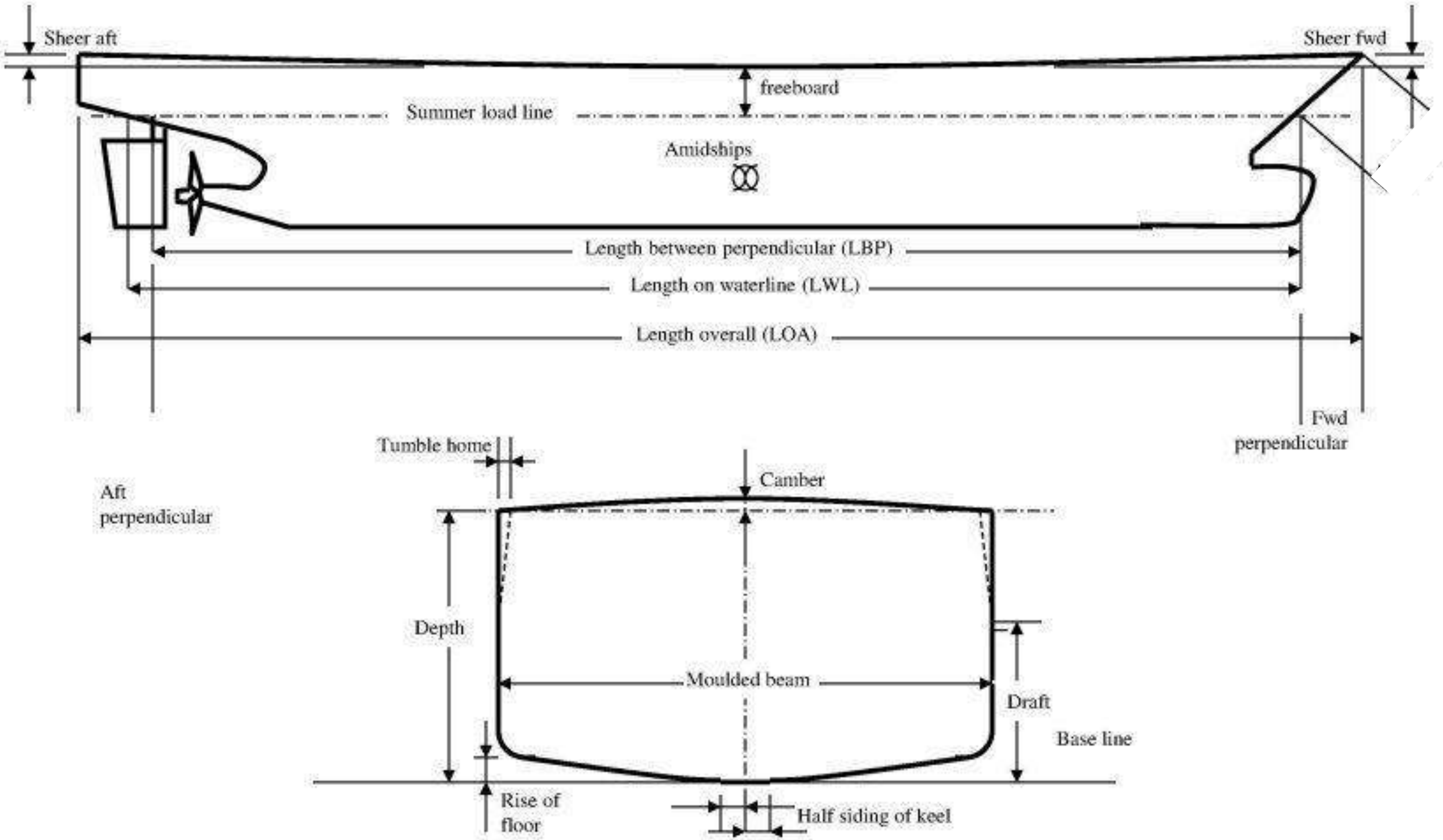


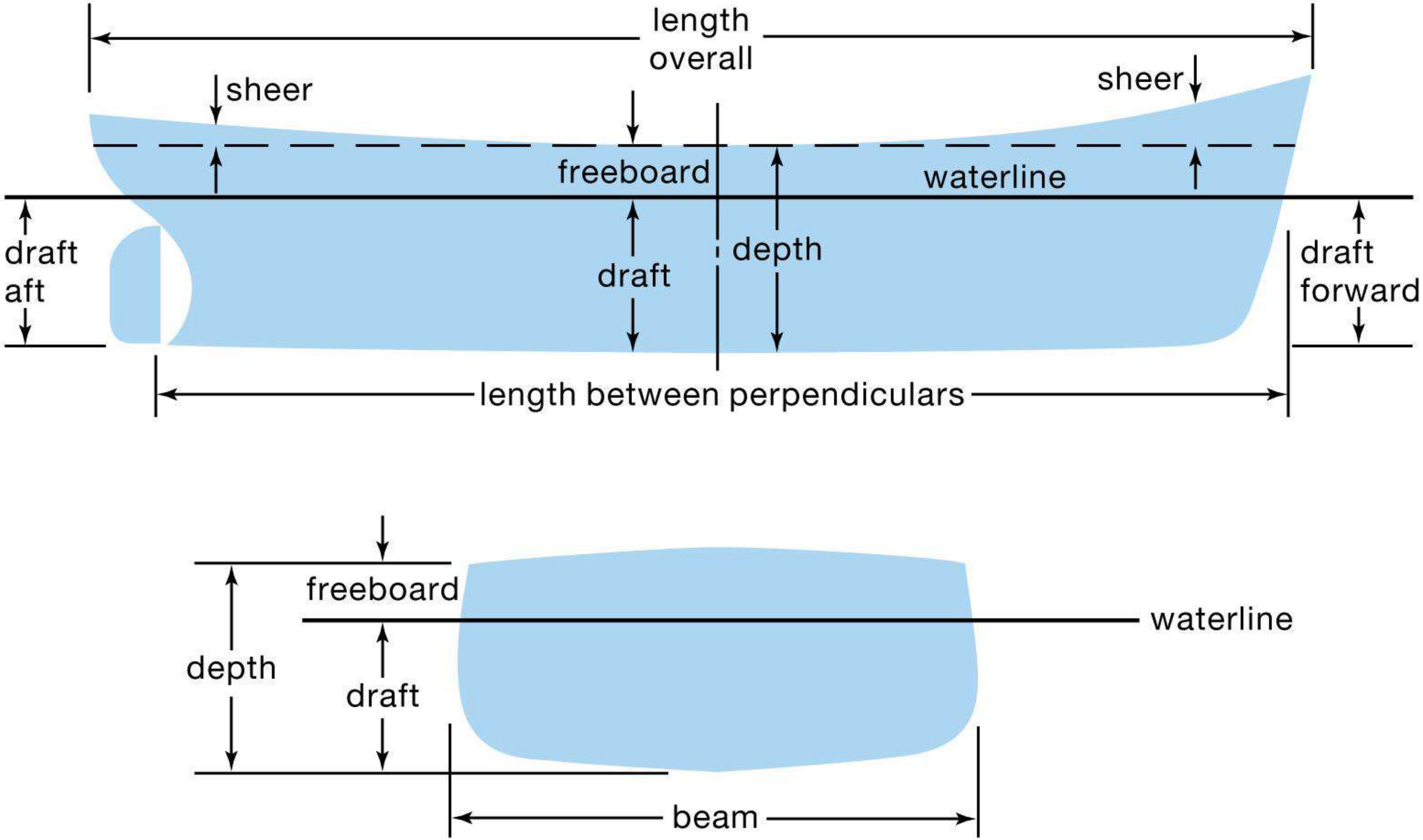
½ Moulded Breadth
Camber
Tumblehome
Moulded Depth
Freeboard
Design Waterline
Moulded Draught
Design Draught
CL
Moulded baseline
Deadrise
Sheer aft
Sheer fwd
Depth



CAMBER
H
TOP OF MAIN DECK BEAM
TUMBLE HOME AT MAIN DECK
MAIN DECK AT SIDE
P
F
E
TUMBLE HOME AT SECOND DECK
TOP OF SECOND DECK BEAM
SECOND DECK AT SIDE
DWL
W
MOLDED DEPTH TO MAIN DK. AT ⊠
MOLDED DEPTH TO SECOND DK. AT ⊠
MOLDED DRAFT AT ⊠
CENTERLINE OF SHIP
HALF-SIDE DIMENSION OF FLAT PORTION AT KEEL
D
C
DEADRISE
K
A
B
MOLDED BASE LINE
ONE-HALF OF BREADTH, MOLDED

SHIP DIMENSIONS




length
overall
sheer
sheer
freeboard
waterline
draft
aft
draft
depth
draft
forward
length between perpendiculars
freeboard
waterline
depth
draft
beam

DEFINITIONS

- Defined in ISO 7462 (1985)
- **Load Water Line (LWL)** – It is generally the Designed Summer Load Line, i.e. the waterline upto which the ship can be loaded, in sea water, during summer, when the waves are lower than in winter. Earlier called the Design(ed) Water Line(DWL).
- **CentreLine**. A line in the Centreline Plane of the ship's hull
- **Base Line** – Line in the longitudinal direction passing through the lowermost part of the hull surface i.e. the keel line.

Definitions

- **Forward Perpendicular(FP) –** A vertical line drawn on the centerline plane, perpendicular to the Base Line through the point where the fore-side of the stem meets the summer load line.
- **After Perpendicular(AP)**- Vertical line drawn on the centerline plane, perpendicular to the Base Line through the point of intersection of LWL with the:
  - Aft side of the rudder post
    - OR
  - Through the axis of the rudder stock.
  - Naval vessels- Intersection of the LWL and the stern of the vessel
- **Midships.** A point or line midway between the After Perpendicular(AP) and Forward Perpendicular(FP).

- **LENGTH**

- **Length Overall(LOA or)** . Distance between extreme ends of the vessel, forward and aft, measured parallel to LWL.

- **Length Between Perpendiculars(L_{PP} or LBP)** – Distance between the AP and FP, measured parallel to LWL.

- **Length on WaterLine (L_{WL}).** Distance between the intersections of the WL with Stem and Stern.

- **Breadth or Beam (B).** Maximum distance between the port and starboard ends, for a given transverse section, measured parallel to LWL. Varies along length. Usually measured at midships.

  - **B_{EXT}** Distance measured to the outerside of the plating including Overhang and Flare.
  - **B_{MLD}** Distance measured to the innerside of the plating

- **Depth(D).**   Vertical Distance between the main deck at side to the keel . Main Deck refers generally to the uppermost continuous deck. Varies along length. Usually measured midships

  - **D_{EXT}** Distance between outer side of keel plating to the outer side of main deck plating at side

  - **D_{MLD}** Distance between inner side of keel plating to the inner side of main deck plating at side.

- **Draught(T)**.   Vertical distance from the keel to the waterline
    - **T_{EXT}** Distance between outer side of keel plating to the WL
    - **T_{MLD}** Distance between inner side of keel plating to WL

- **Freeboard**. The vertical distance between the waterline and the upper side of main deck measured at the ship’s side.
- OR Difference between the Depth(D) and the Draught(T).
- **Camber.** Curvature of deck in the transverse direction. Measured as the vertical distance of upper side of deck at the centreline from the deck at side.

- **Sheer.** A rise in the height of the deck in the longitudinal direction. Measured at any point along the length , it is the height of deck at side, above the deck at side, at midships.

- **Flare.** The outward curvature of the side shell above the waterline.

- **Tumble Home.** The inward curvature of the side shell above the water line.

- **Rise of Floor.** The rise of the bottom shell plating line above the base line measured at the line of max breadth.

END

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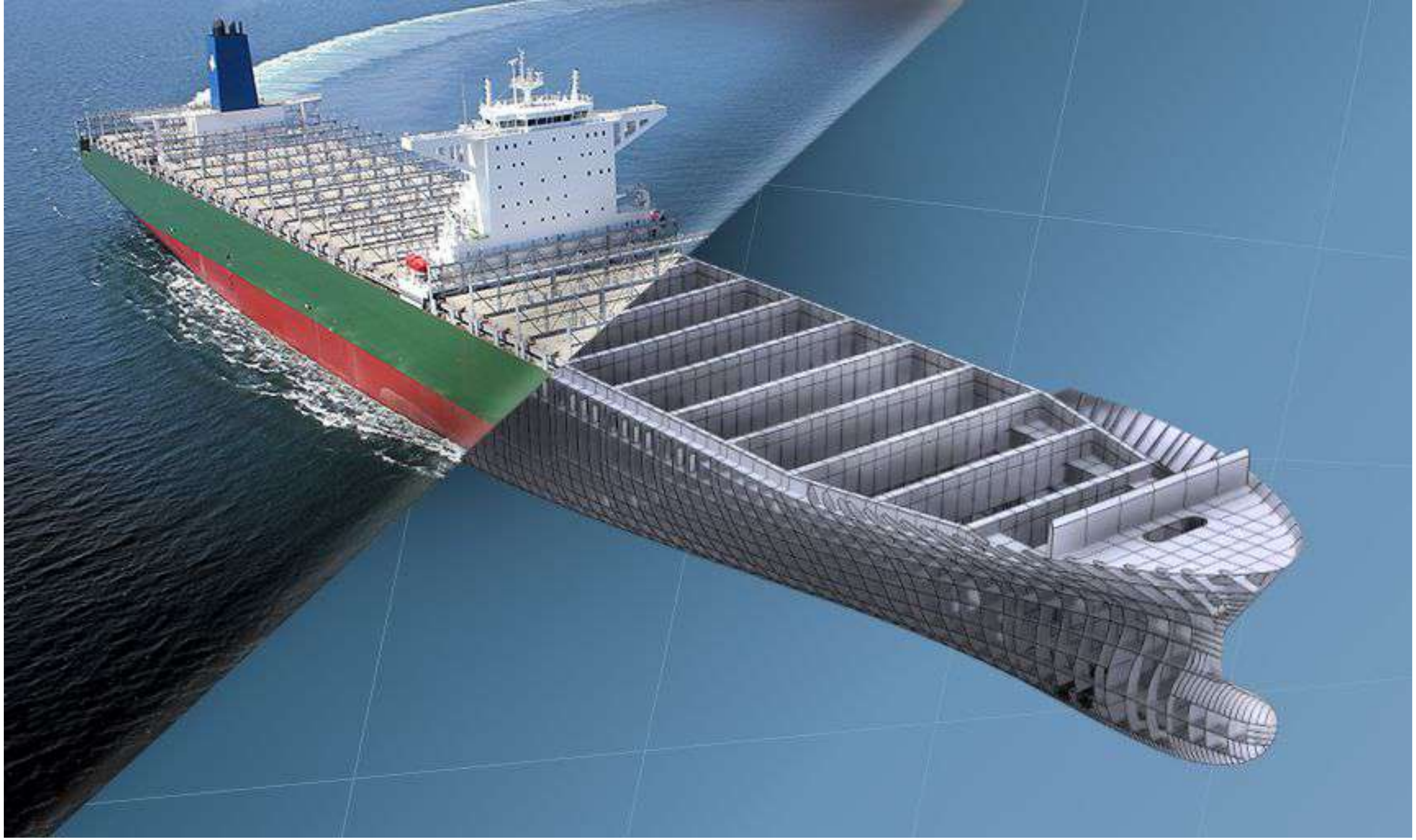


Introduction to Naval Architecture

II SEM –Module 2

Syllabus

2. **Module II**

   Introduction to ship geometry

   Some physical fundamentals - Archimedes principle, laws of floatation stability and trim. The ship's form-main dimensions, lines plan, coefficients and their meaning, Fairing process and table of offsets; Hydrostatic particulars &Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF)

Ship Parameters

- Archimedes Principle, Law of Flotation
- Volume
- Displacement
- Reserve of Buoyancy
- Lightship Weight
- Deadweight
- Tonnage

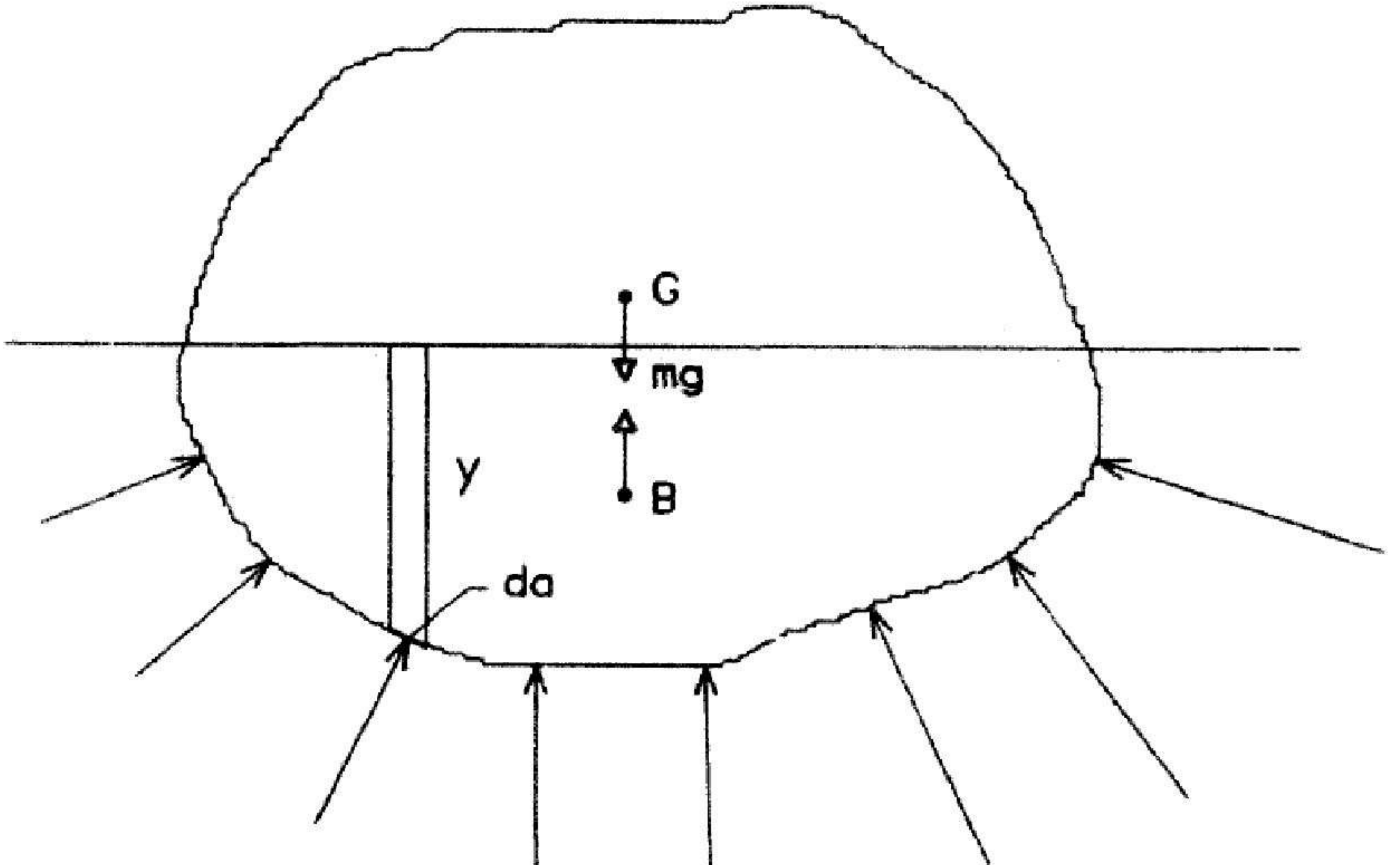
Archimedes Principle

- *Any body*
- *completely or partially submerged in a fluid (gas or liquid) at rest*
- *is acted upon by an upward, or buoyant, force*
- *the magnitude of which is equal to the weight of the* ***displaced*** fluid

Archimedes Principle

- Try pushing a stick into water…..Easy
- Try pushing an empty bucket(from the closed side) or a football into water… feel some resisting force?
- This is the buoyancy force which is equal to the weight of the displaced fluid
- Weight of the displaced fluid = submerged volume x density of the fluid in which the object is floating

But how is the buoyancy force generated?



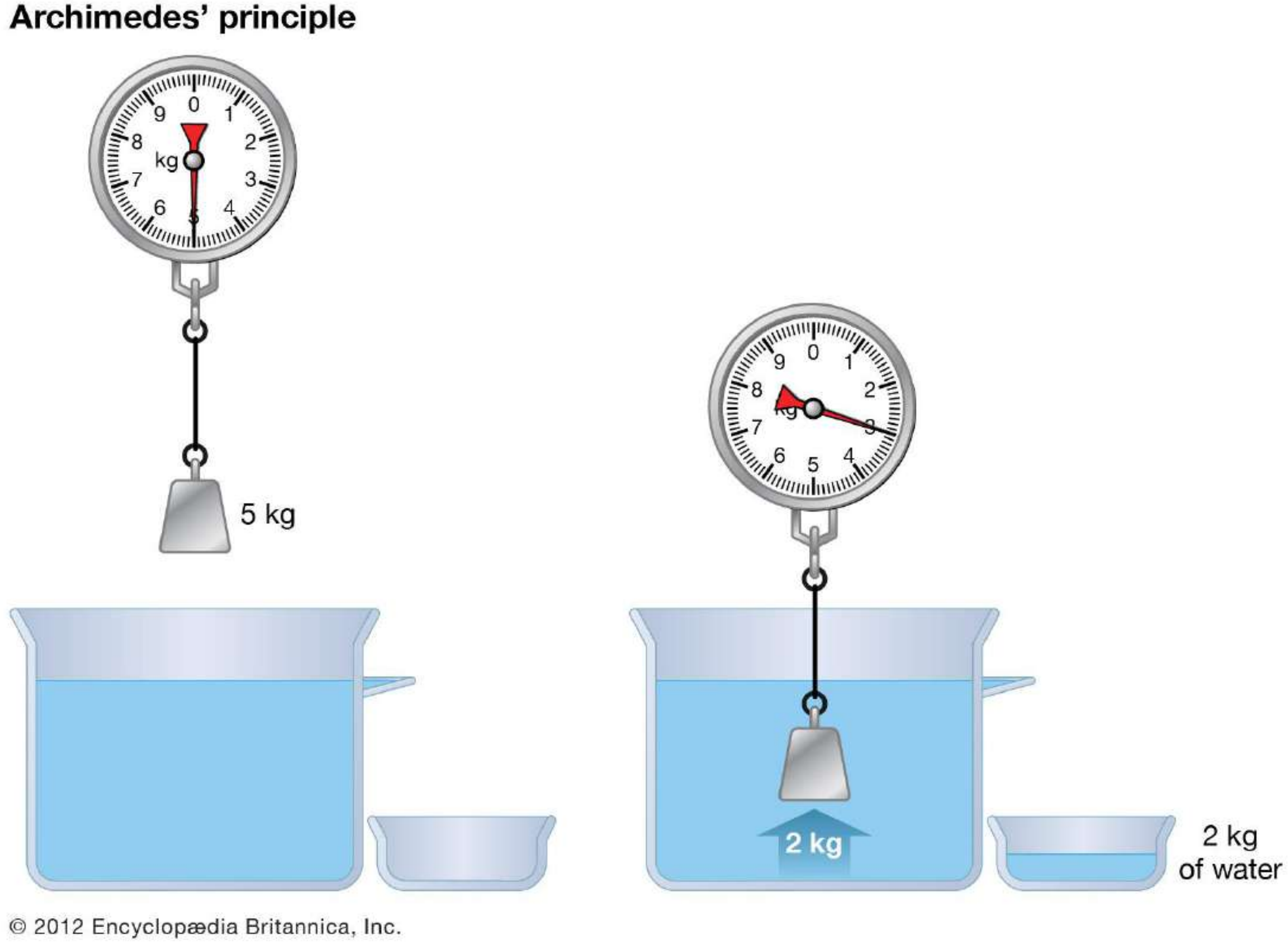
- Hydrostatic pressure which act on the body
- Normal to the surface
- Can be resolved into horizontal and vertical components
- The horizontal components will cancel out..Otherwise..?
- The sum of the vertical components should be equal to the weight
- Assumed to act through the centre of the immersed volume .. Called Centre of Buoyancy (B)

Archimedes Principle

- Consider a body in air (outside a fluid). What force does it experience?
- It experiences a downward force i.e. its weight, due to gravity
  - Weight = mg (assumed to be acting through ..?)
- When this body is gradually submerged in still water, does it continue to experience the gravitational force?
  - Yes
- Does it experience a buoyancy force?
  - Yes, from the moment, any volume of the body is submerged.
- Will it sink?
  - Depends. It will continue to sink till mass of displaced fluid is equal to the mass of the body

Archimedes Principle

- Mass in air =5kg
- When fully submerged
- Mass of displaced water = 2kg
- Buoyancy force = 2kg
- Net force acting on body
  - = 5-2 = 3kg acting downwards
  - 3kg indicated on weighing scale



Law of Floatation

- Will a body floating freely in still water experience a downward force i.e. its weight, due to gravity
    - Yes
- But it does not sink
- Is the body in equilibrium?
    - Yes
- It means that there is an opposing equal and opposite (upward) force.. We call it Upthrust or Buoyant Force
- Archimedes says ,
    - Buoyancy force = Weight of the displaced fluid
    - = (Volume x Density)of the displaced fluid x g
    - =($\blacktriangledown$ x ρ) x g
    - = $\blacktriangle$ x g

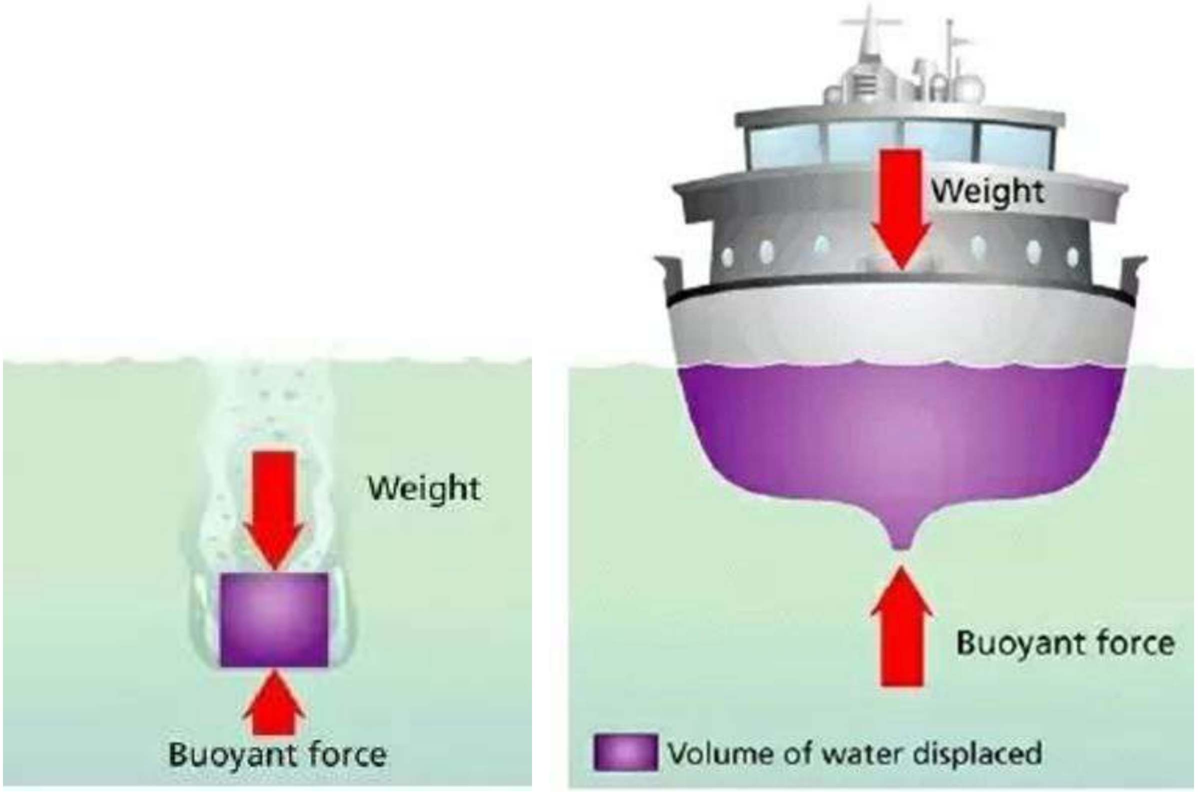
Law of Flotation (Corollary of Archimedes Principle

- When a body is floating freely in a liquid

- Weight of the body = the Buoyancy = Weight of Fluid displaced

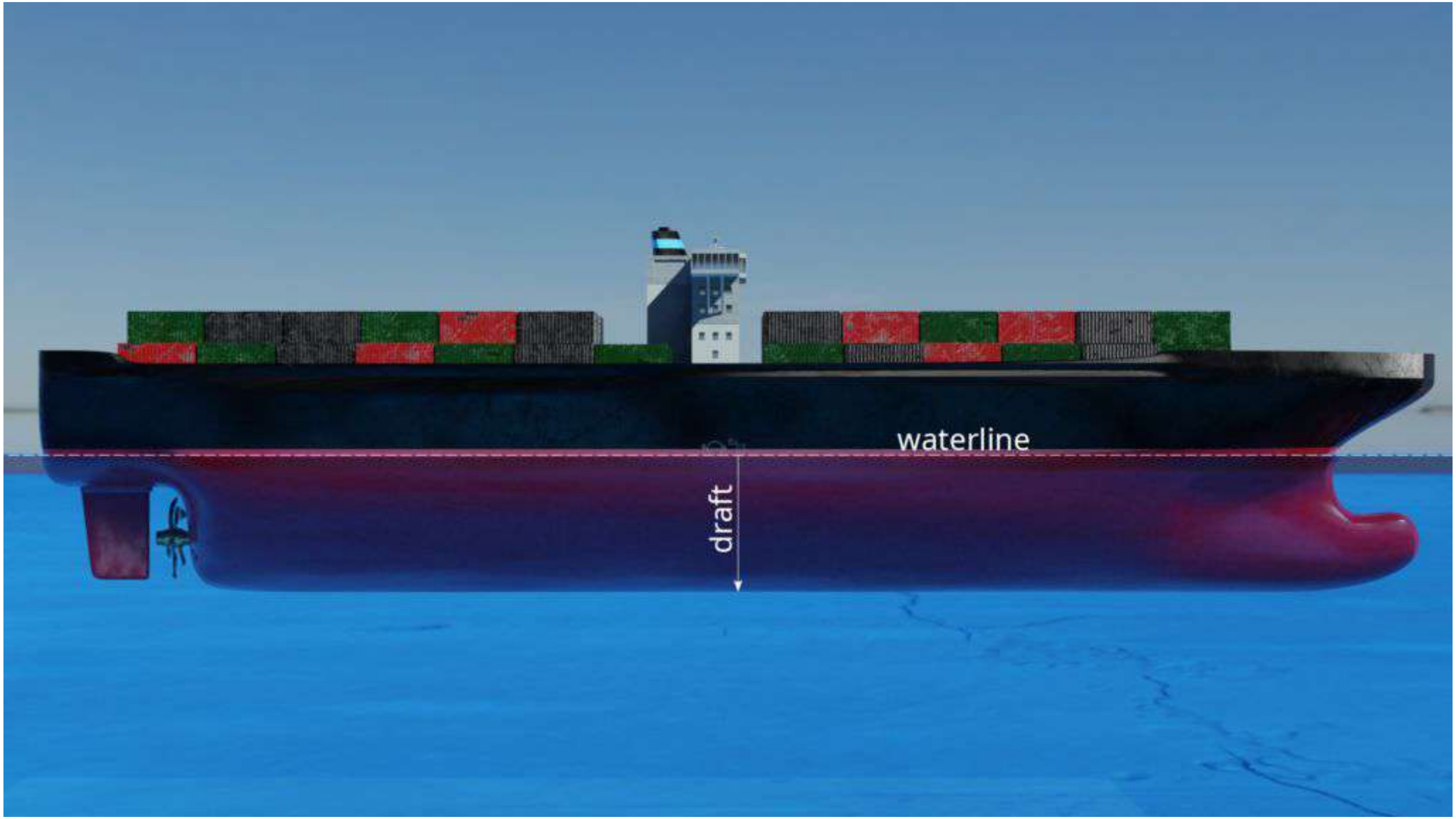
Watertight(Intact) Volume

- A solid Block of steel weighing W tonnes sinks in water because W is more than the Buoyancy force
- The Block does not displace enough volume to generate sufficient buoyancy force to equally oppose its weight
- A Vessel made of the same steel weighing the same W tonnes does not sink because Buoyancy force = W
- The vessel displaces enough volume to generate sufficient buoyancy force to equally oppose the weight.
- It is also important that the immersed volume inside the ship is Intact, or Watertight i.e. water cannot enter inside this volume
- If water enters this volume, then it is said that the Watertight Integrity of the immersed volume has been breached.Then the volume is NOT intact or watertight anymore and will not contribute to the buoyant force



Relevance of submerged volume

- The submerged volume of any floating body is a geometric shape
- Various properties or parameters can be calculated for this shape
- The nature of this shape determines the behaviour of the object


waterline
draft


total ship mass of 50,000 t
water level
displaced water mass of 50,000 t

Volume and Displacement

- **Volume of Displacement or Volume**(∇, Nabla)
  - Volume of the immersed or underwater portion of a ship
- **Displacement** (Δ, Delta)
  - Total Mass of the ship
  - Mass of the fluid displaced by the immersed volume of the ship
  - = ∇ x density of the fluid (ρ)
    - Mass Displacement
    - Weight Displacement = Mass Displacement x g

Lightship Weight

- Weight of the ship when construction is over
- Includes
  - Structure (Steel / Aluminium / Plastic..)
  - Outfitting
    - Equipment/ Machinery /Fittings
    - Pipelines, cabling/wiring, trunking,
    - Insulation, Paint coating
- Measured in tonnes

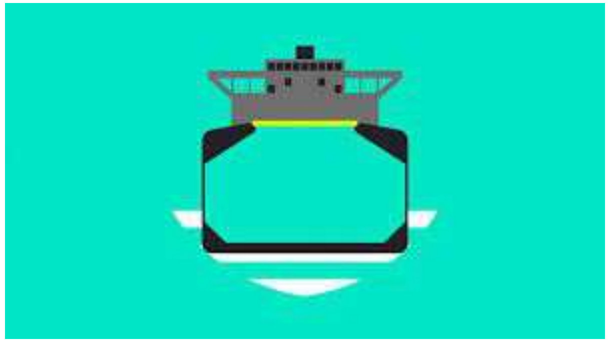
Deadweight

- Weight of items other than lightship weight
- Includes
  - Cargo
  - Fuel
  - Lub Oil
  - Freshwater
  - Ballast water
  - Crew and effects
  - Food Stores
  - Machinery / Equipment stores and spares
- Measured in tonnes

Displacement, Lightship Wt and Deadweight

- Displacement = Lightship Weight + Deadweight
  - Deadweight = Displacement – Lightship Weight
  - Lightship Weight = Displacement – Deadweight

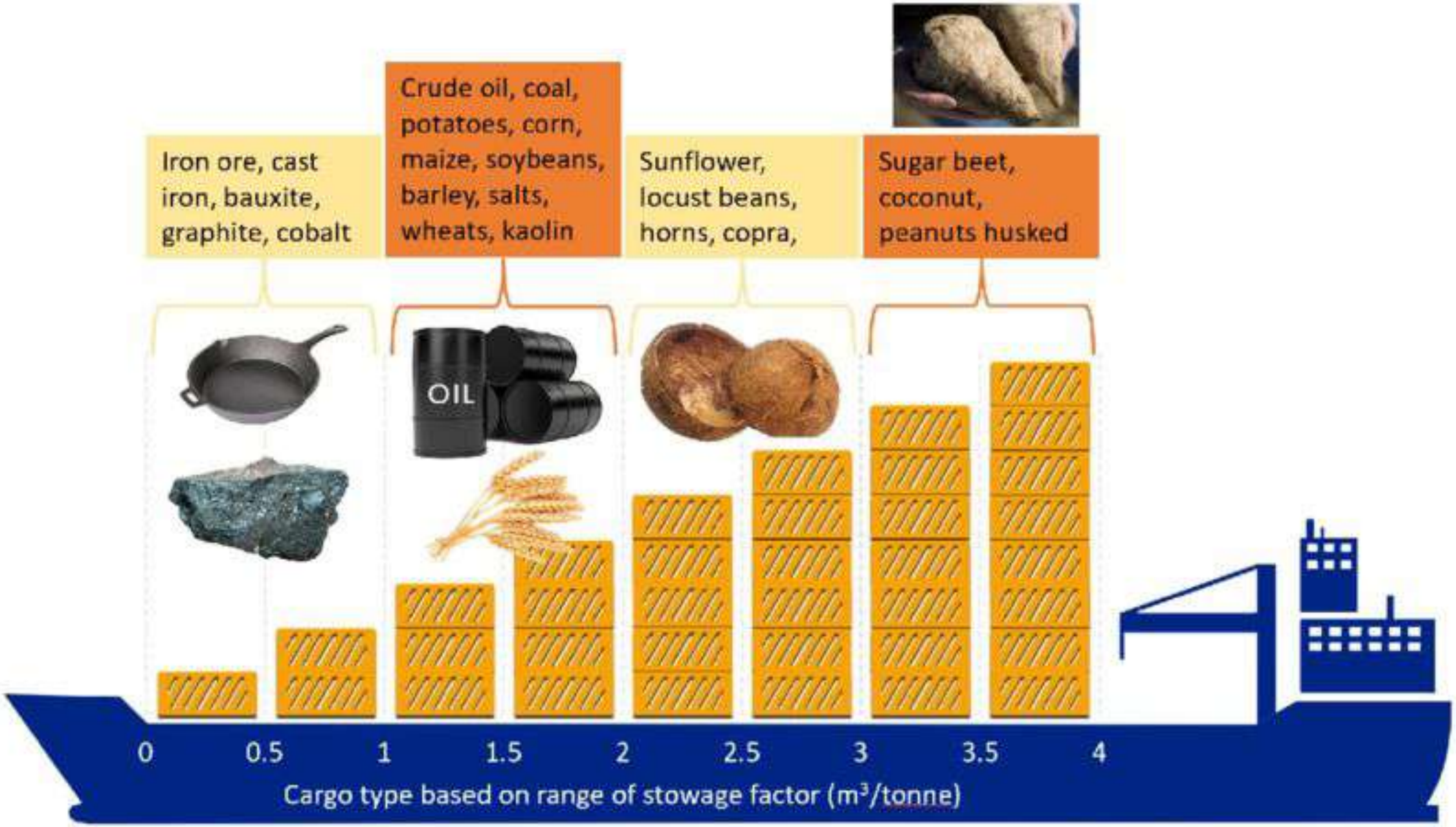
Stowage Factor



Stowage Factor (SF)

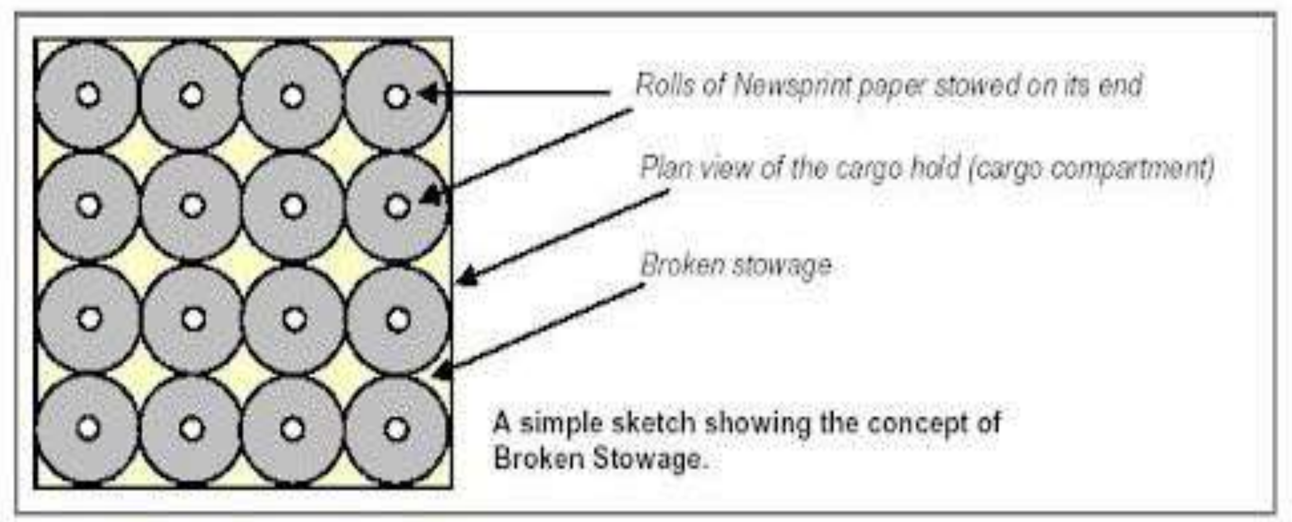
- This is amount of volume that a unit mass of a type of cargo will occupy.
- Stowage factor varies with :
  - Shape & size of the cargo
  - Shape of hold
  - Sizes of packings, slack or tightly filled bags
- Stowage factor is expressed in Vol / Mass:
  - Cubic Metres per Tonnes (m^3/ton)
  - Cubic Feet per Ton (ft^3/ton)
- Is SF inverse of density ?

Stowage Factor



Broken Stowage

- This is the volume “lost” in a compartment due to
  - Shapes and Sizes of cargo
  - Contour/shape of the hold
- Expressed in term of percentage (%)

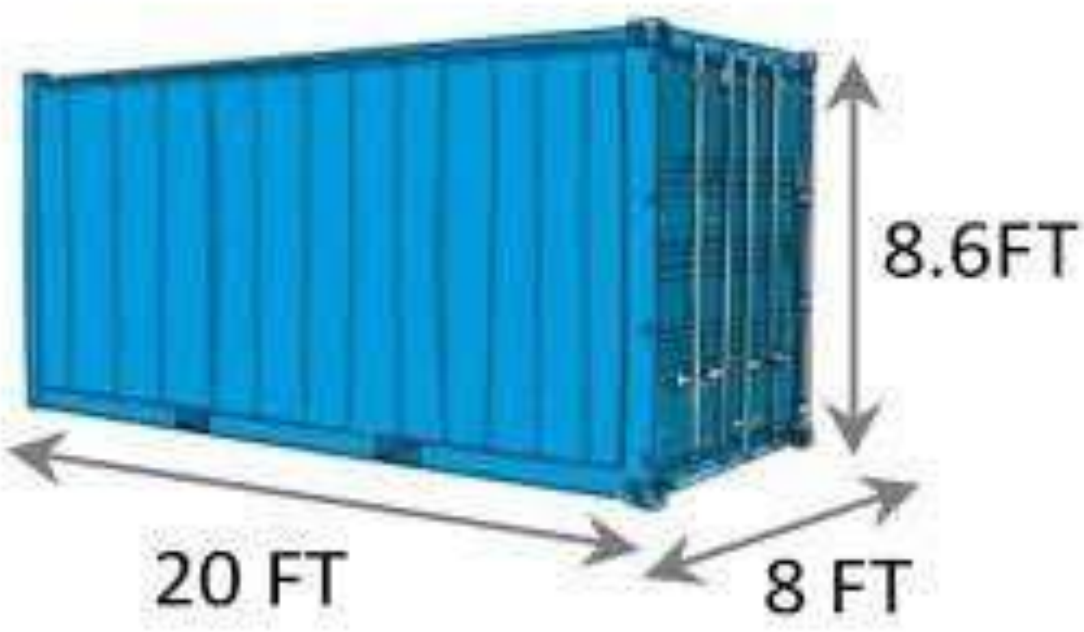


TEU (Twentyfeet Equivalent Unit)

- General Unit or Cargo Capacity used for Container Ships

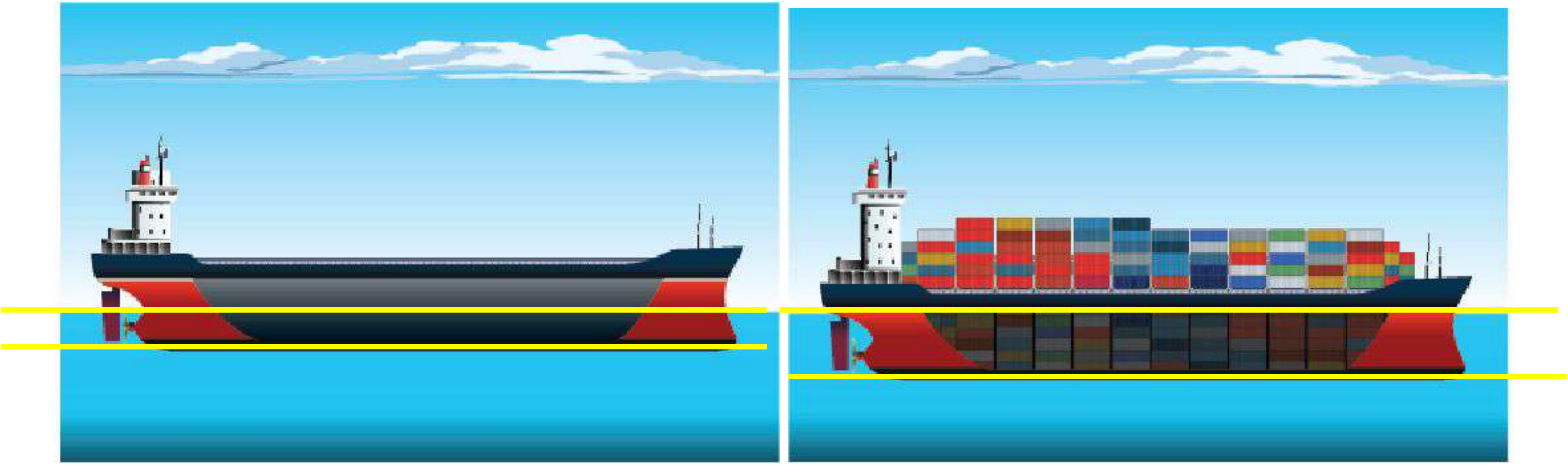
- Dimensions of trucks/trailers anc container ship dimensions are

- Standardisation , Efficient Cargo Handling



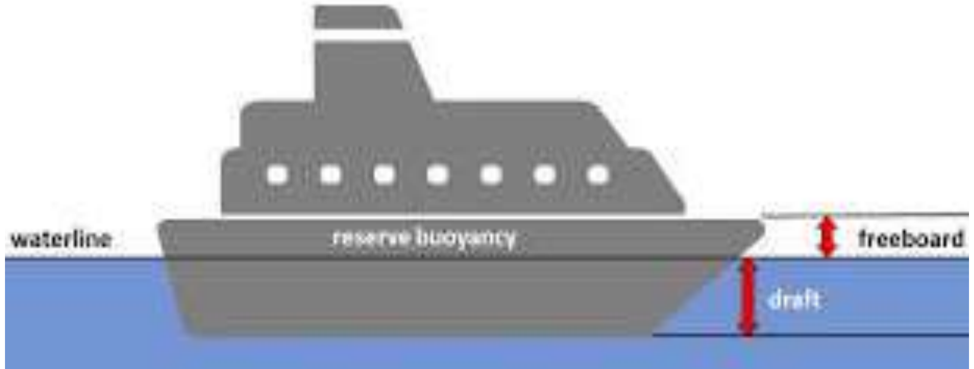
Reserve of Buoyancy

- Consider a container ship (without containers) with displacement Δ, floating at a draft T. So Displacement = Buoyancy
- When fully loaded with containers, the displacement Δ increases , and T increases . Displacement = Buoyancy, still



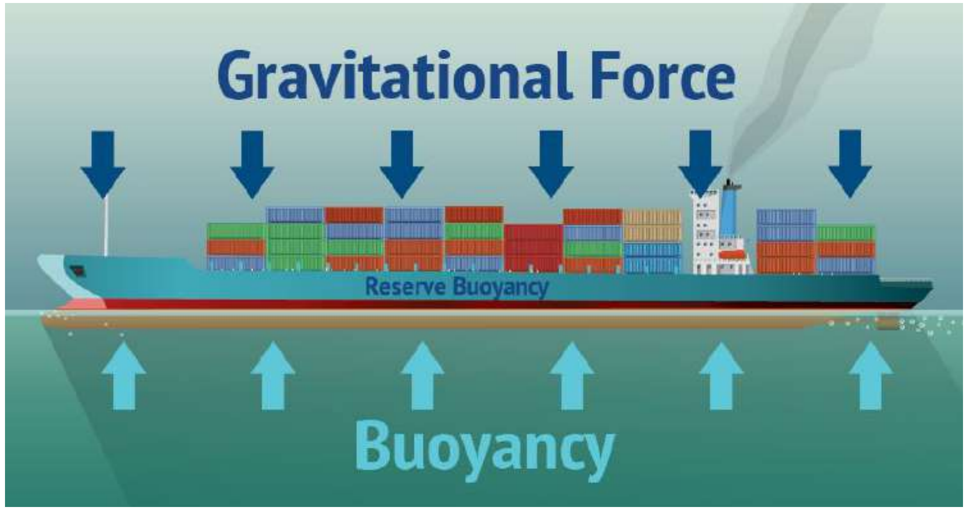
Reserve of Buoyancy

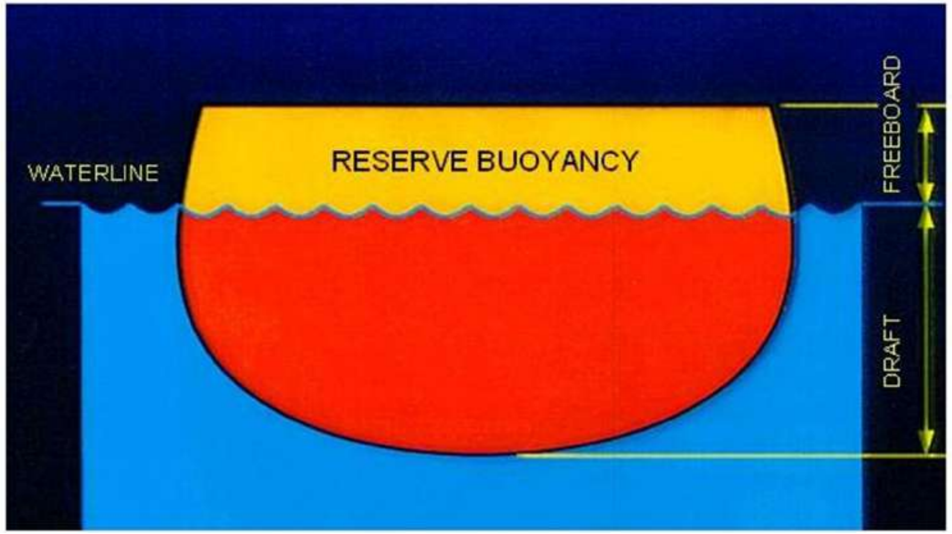
- The ship continues to stay afloat because, Displacement is still equal to Buoyancy
- Buoyancy force increased corresponding to increase in Displacement. How?
- Buoyancy force increased because submerged volume increased. Where did the additional volume come from?
- Volume increased because of increase in draft. Draft could increase because there was freeboard available
- So, if there is a watertight (or intact) volume of the ship above the waterline (in the freeboard region), the ship can increase its displacement without sinking
- This reserve of intact volume is called Reserve Buoyancy or Reserve of Buoyancy

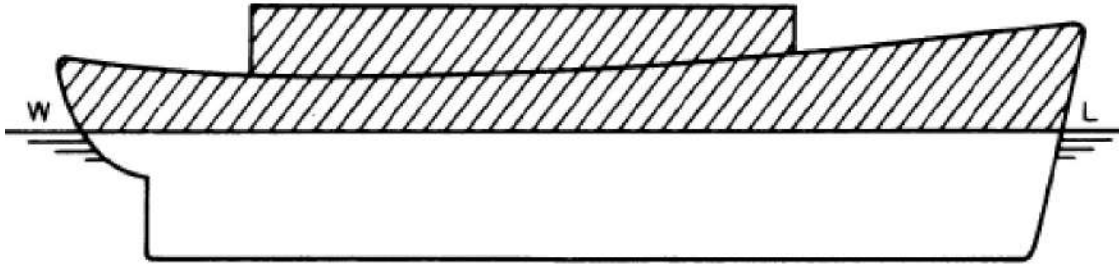


Reserve of Buoyancy(RoB)

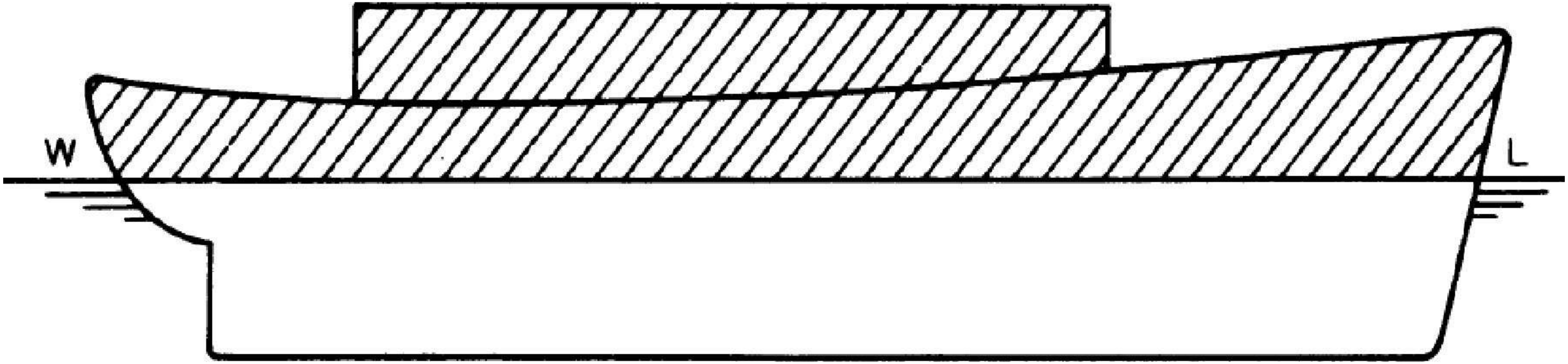
- WATERTIGHT volume of a vessel above the waterline at which it is floating is called Reserve of Buoyancy
- It is an allowance for increase in the draft of the ship without sinking
- Measure of its ability to stay afloat in the event of
  - Damage
  - Increase in weight
- Normally RoB extends only till the free board
- If the superstructure is watertight, it can also form part of RoB







Reserve of Buoyancy



Reserve of Buoyancy -Summary

- Reserve of Buoyancy
  - Watertight volume of a ship above the waterline
  - Measure of the ship's ability to withstand the effects of flooding
  - Expressed as a percentage of the displacement

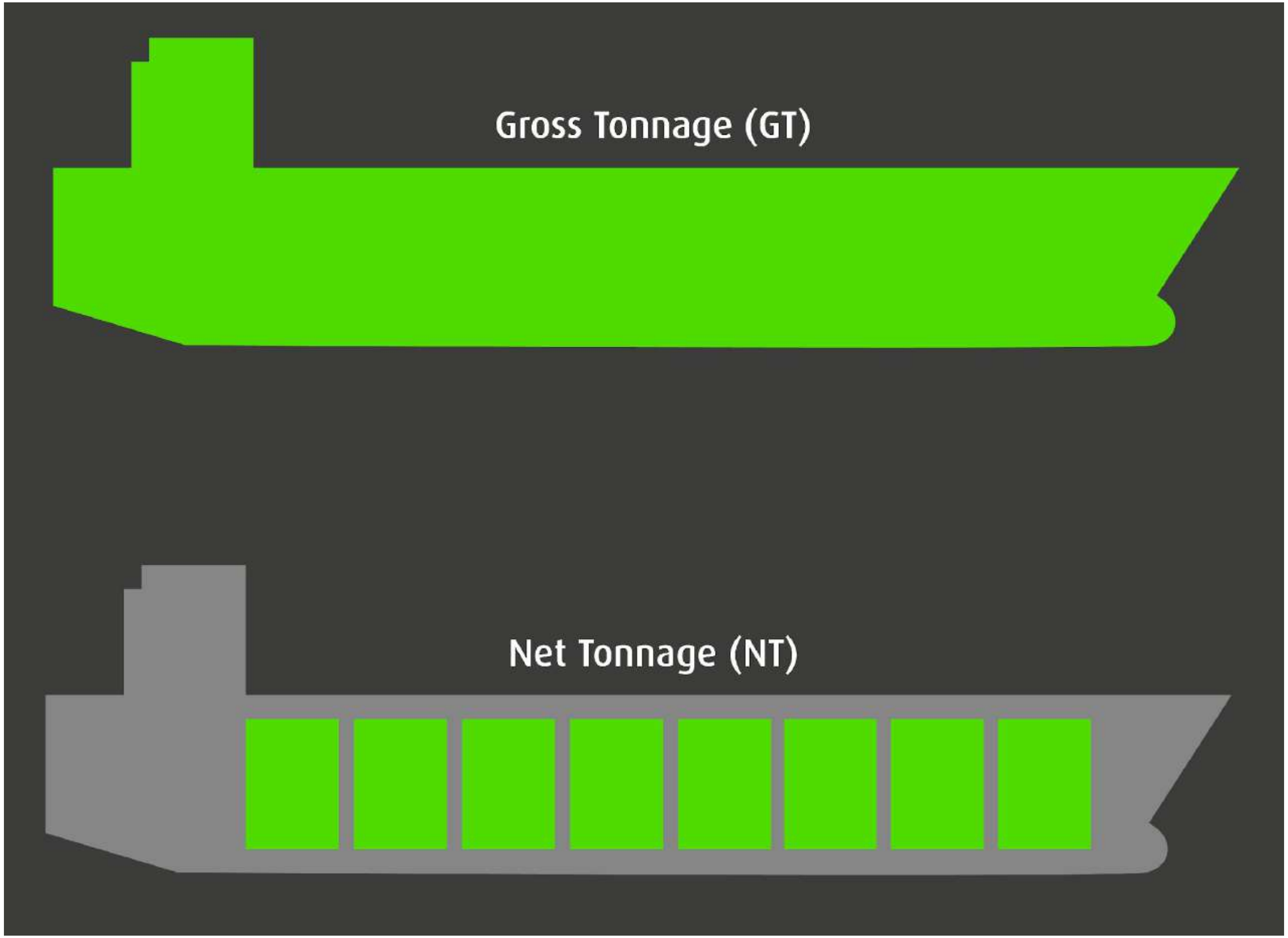
Gross Tonnage (GT)

- A value indicative of Total Volume of *all enclosed spaces* on a vessel. This includes the Engine Room and other non-cargo spaces.
- Obtained by multiplying the Volume with a factor
- Application of rules and regulations related to operations, manning safety etc.
- Earlier called Gross Register Tonnage (GRT)

Net Tonnage (NT)

- Value indicative of Volume of <u>only the cargo-carrying spaces</u> on the vessel.
- Obtained by multiplying the cargo carrying Volume with a factor
- Determines the earning capability of the vessel. Most port/anchorage dues, charges and taxes apply to vessels based on this.
- Earlier called Net Register Tonnage (NRT)

GT vs NT



END

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Gross Tonnage :

The gross tonnage (GT) of s ship shall be determined by the following formula :

$GT = K_1V$ where V= Total volume of all enclosed spaced of the ship in cubic metres.

$K_1 = 0.2 + 0.02 \log_{10}V$ (**or as tabulated in Appendix II).**

Net Tonnage :

(1) The net tonnage (NT) of a ship shall be determined by the following formula :

$NT = K_2V_c \frac{4D^2}{3D} + K_3 (N_1 + \frac{N_2}{10})$, which formula :-

(a) the factor $\frac{4D^2}{3D}$ shall not be taken as greater than unity;

(b) the $K_2V_c \frac{4D^2}{3D}$ shall not be taken as less than 0.25 GT ; and

(c) NT shall not be taken as less than 0.30 GT, and in which : V_c = total volume of cargo spaces in cubic metres.

$K_2 =$ $0.2 + 0.02 \log_{10}V^c$ **(or as tabulated in Appendix II.)**

D= moulded depth amidships in metres as defined in rule 2(15).

d= moulded draught amidships in metres as defined in sub-rule (2) of this rule.

$K_3 =$ $1.25 \frac{GT + 10.000}{10,000}$

$N_1 =$ Number of passengers in cabins with not more than 8 berths,

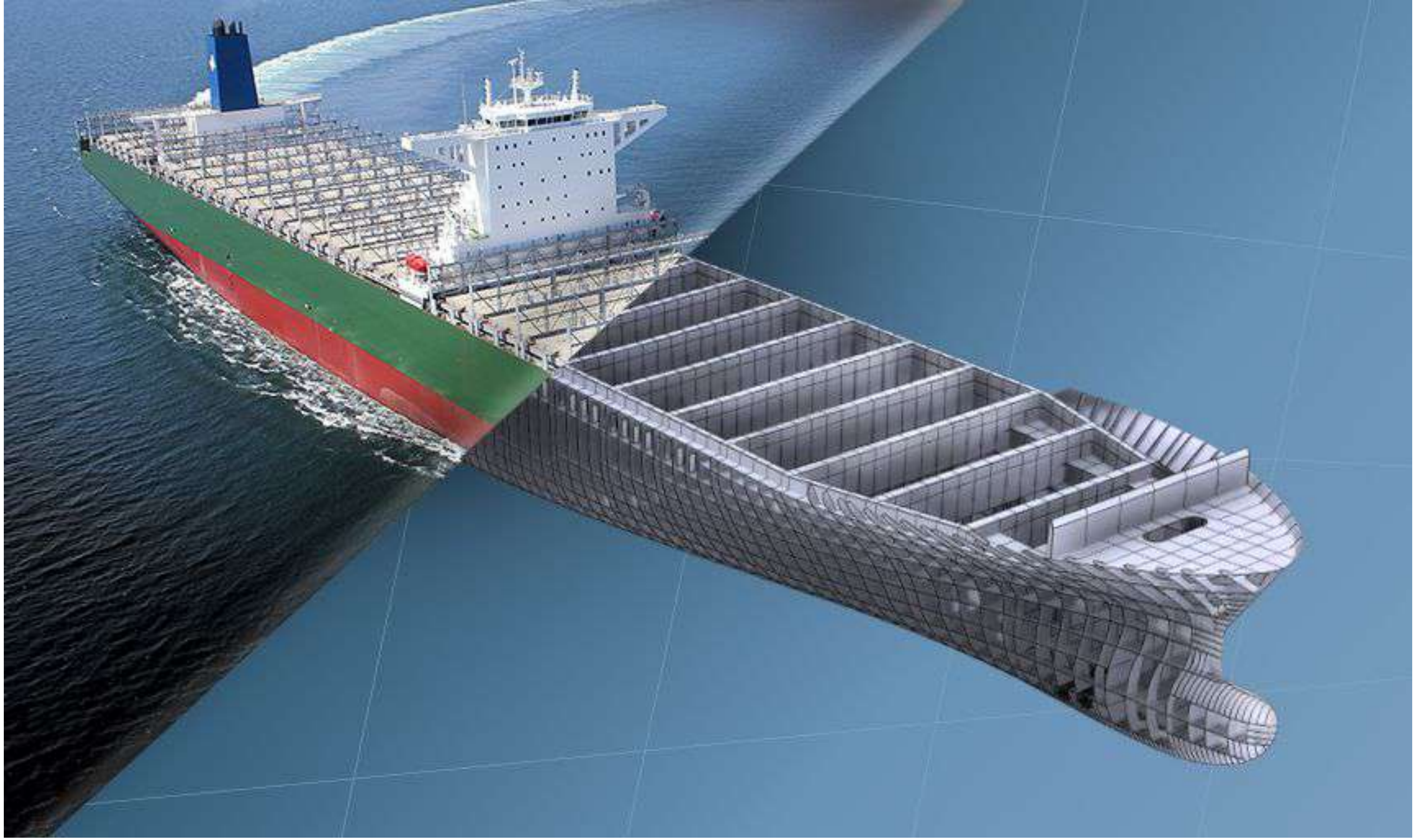
$N_2 =$ Number of other passengers,

$N_1 + N_2 =$ total number of passengers the ship is permitted to carry as indicated in the ship's

Deck cargo and cargo in other spaces :

(1) If any ship other than a ship exclusively engaged in trading between any port or place in India carries any deck cargo or cargo in spaces not included in the computation of net tonnage, the tonnage of space so utilized for carrying cargo shall be measured in the manner specified in Schedule I and added to the relevant tonnage of the ship and the levy of dues based on ship's register tonnage.

(2) The tonnage of spaces referred to in sub-rule (1) shall be ascertained by a surveyor or by an officer of the customs referred to in section 3 of the Customs Act, 1962, in the manner directed in Schedule I and when so ascertained shall be entered by him in ship's official log book and also in a memorandum which he shall deliver to the Master and the Master shall, when any dues are demanded on ship's tonnage produce that Memorandum in the like manner as if it were ship's Certificate of Registry or in the case of a ship other than an Indian ship, a document equivalent to a Certificate of Registry.



Introduction to Naval Architecture

II SEM –Module 2

Syllabus

2. **Module II**

   Introduction to ship geometry

   Some physical fundamentals - Archimedes principle, laws of floatation stability and trim. The ship's form-main dimensions, lines plan, coefficients and their meaning, Fairing process and table of offsets; Hydrostatic particulars &Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF)

Ship Parameters

- Archimedes Principle
- Law of Flotation
- Volume
- Displacement
- Reserve of Buoyancy
- Form Co-efficients

Co-efficients of Form
or
Co-efficients of Fineness

- Define the Form or Fineness of the underwater Hull Form

- Full(Fat) or Slender (Slim)

- Hull form towards aft , forward and midships

Co-efficients of Form
or
Co-efficients of Fineness

- Area Co-efficients
  - C_{WP} – Waterplane Area Co-efficient
  - C_M – Midships Section Area Co-efficient

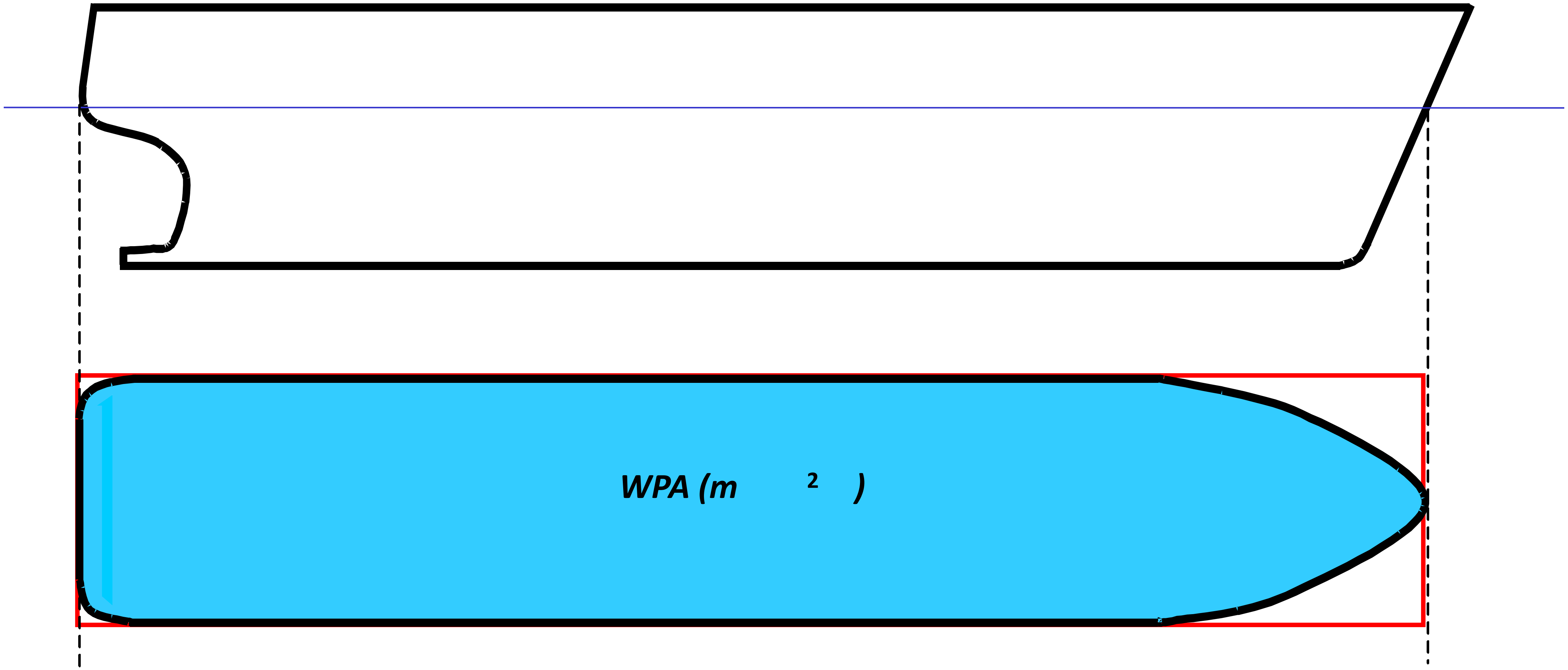
- Volume Co-efficients
  - C_B – Block Co-efficient
  - Prismatic Co-efficient
    - C_P – Longitudinal Prismatic Co-efficient
    - C_{VP} – Vertical Prismatic Co-efficient

C_W : Co-efficient of Fineness of Waterplane

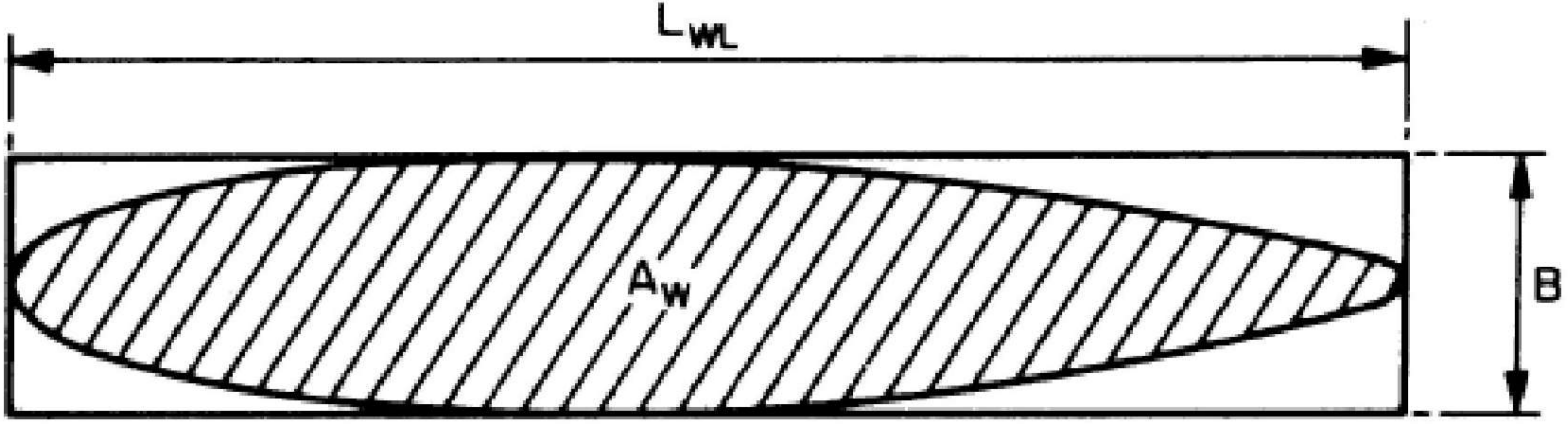
Co-efficient of Waterplane

Waterplane Co-efficient

Waterplane Area Co-efficient



C_W : Co-efficient of Fineness of Waterplane
Co-efficient of Waterplane
Waterplane Co-efficient
Waterplane Area Co-efficient



Coefficient of fineness of waterplane, $C_{WP} = \dfrac{A_W}{L_{WL}\,B}$

C_W : Co-efficient of Fineness of Waterplane
Co-efficient of Waterplane
Waterplane Co-efficient
Waterplane Area Co-efficient

- At any given draft , it is the Ratio between Area of Waterplane (A_W) and the Area of the Circumscribing Rectangle (L_{WL} x B_{MLD}) i.e. product of Length on Waterline and Moulded Breadth

- Varies with Draft

- Is plotted as a function of the Draft

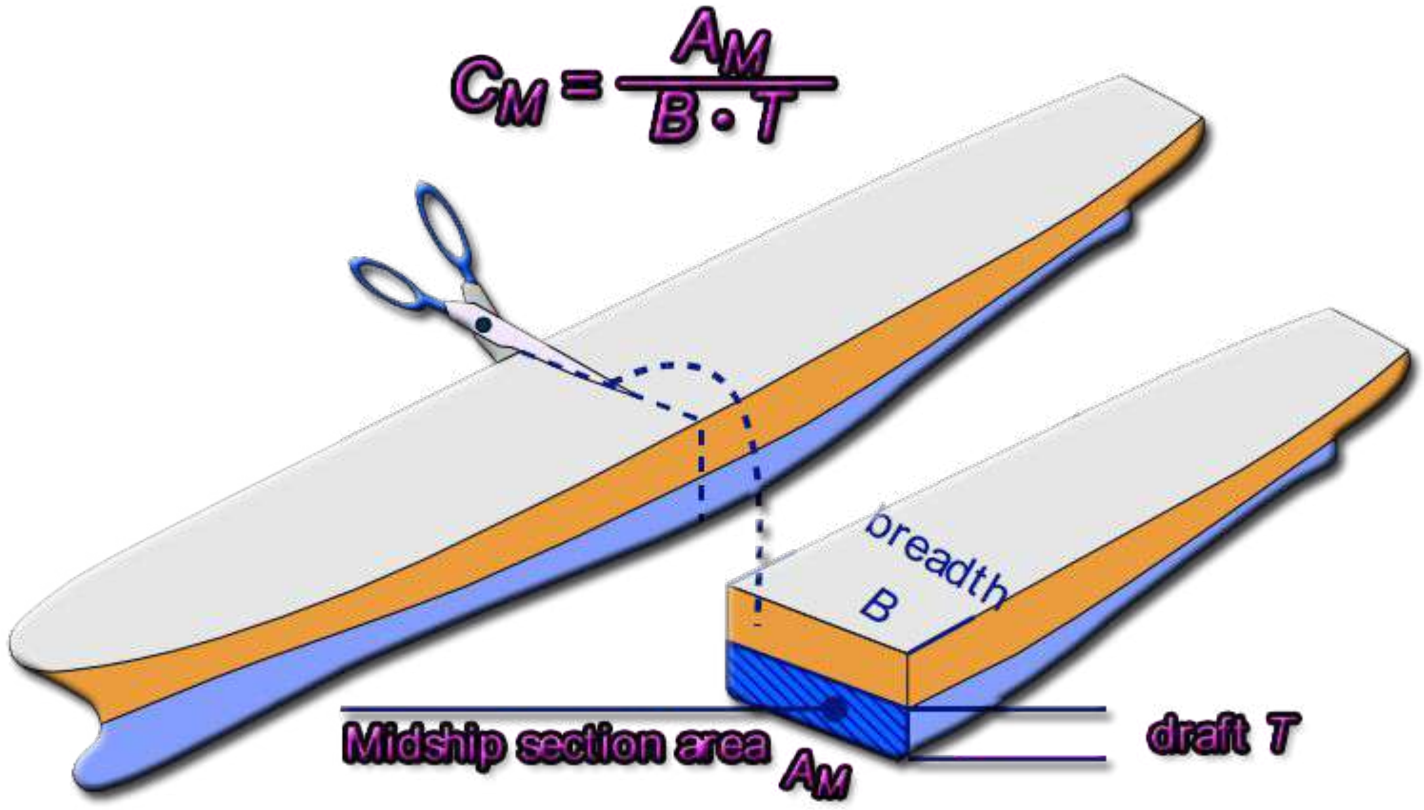
Problem

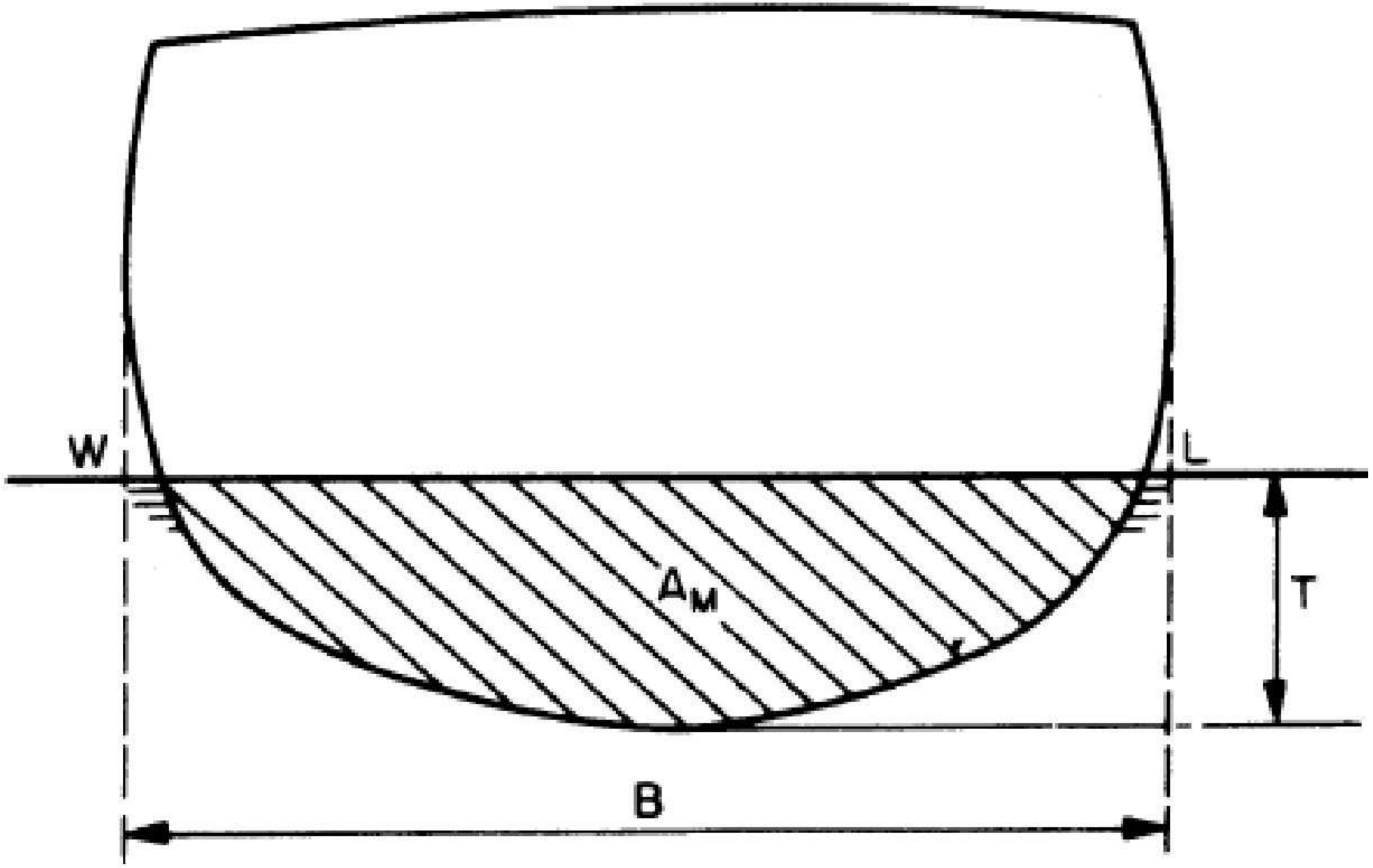
Find the area of the water-plane of a ship 36 metres long, 6 metres beam, which has a coefficient of fineness of 0.8.

$$\text{Area of water-plane} = L \times B \times C_w$$
$$= 36 \times 6 \times 0.8$$

$$\underline{\text{Area of water-plane} = 172.8\ \text{sq m}}$$

C_M - Midship Co-efficient
Midship Section Co-efficient
Midship Area Co-efficient





Midship section coefficient, $C_M = \dfrac{A_M}{BT}$

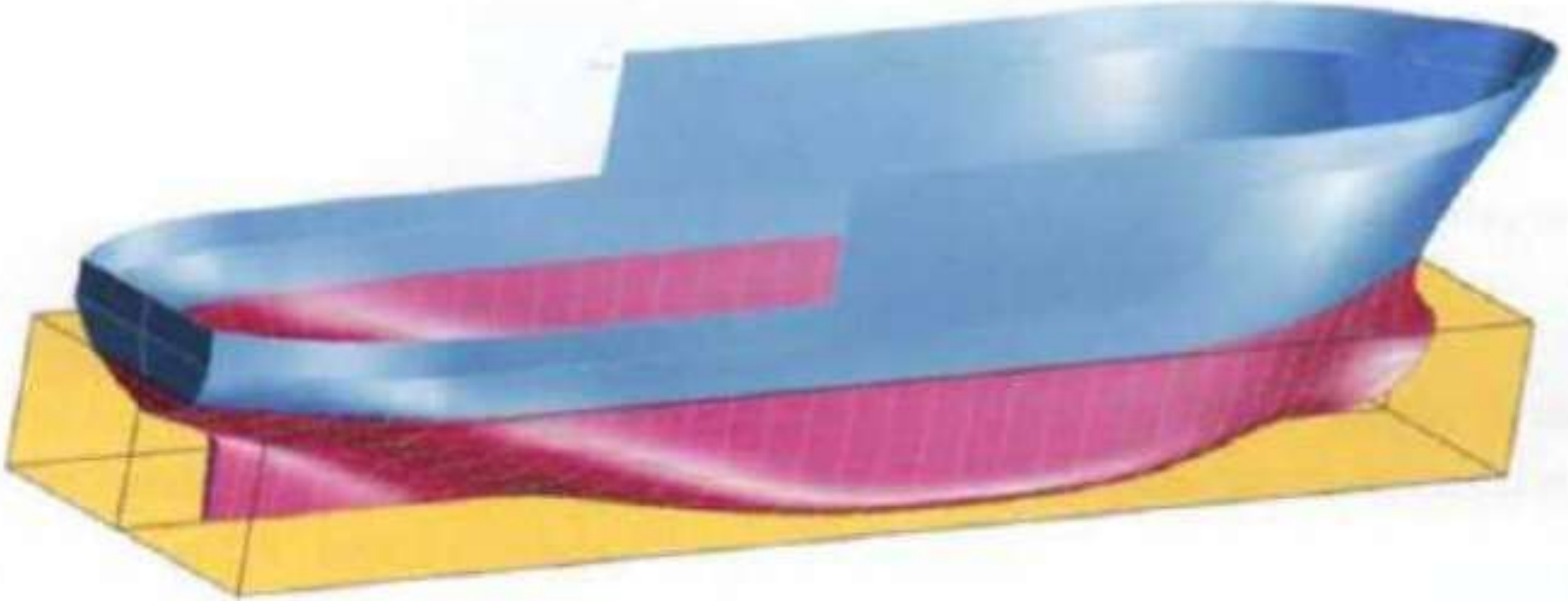
C_M : Midship Co-efficient
Midship Section Co-efficient
Midship Area Co-efficient

- At any given draft , it is the Ratio between Immersed Area of the Midship Section (A_M) and the Area of the Circumscribing Rectangle (B_{MLD} x T_{MLD}), i.e. product of Moulded Breadth and Moulded Draft at Midships

- Varies with Draft

- Is plotted as a function of the Draft

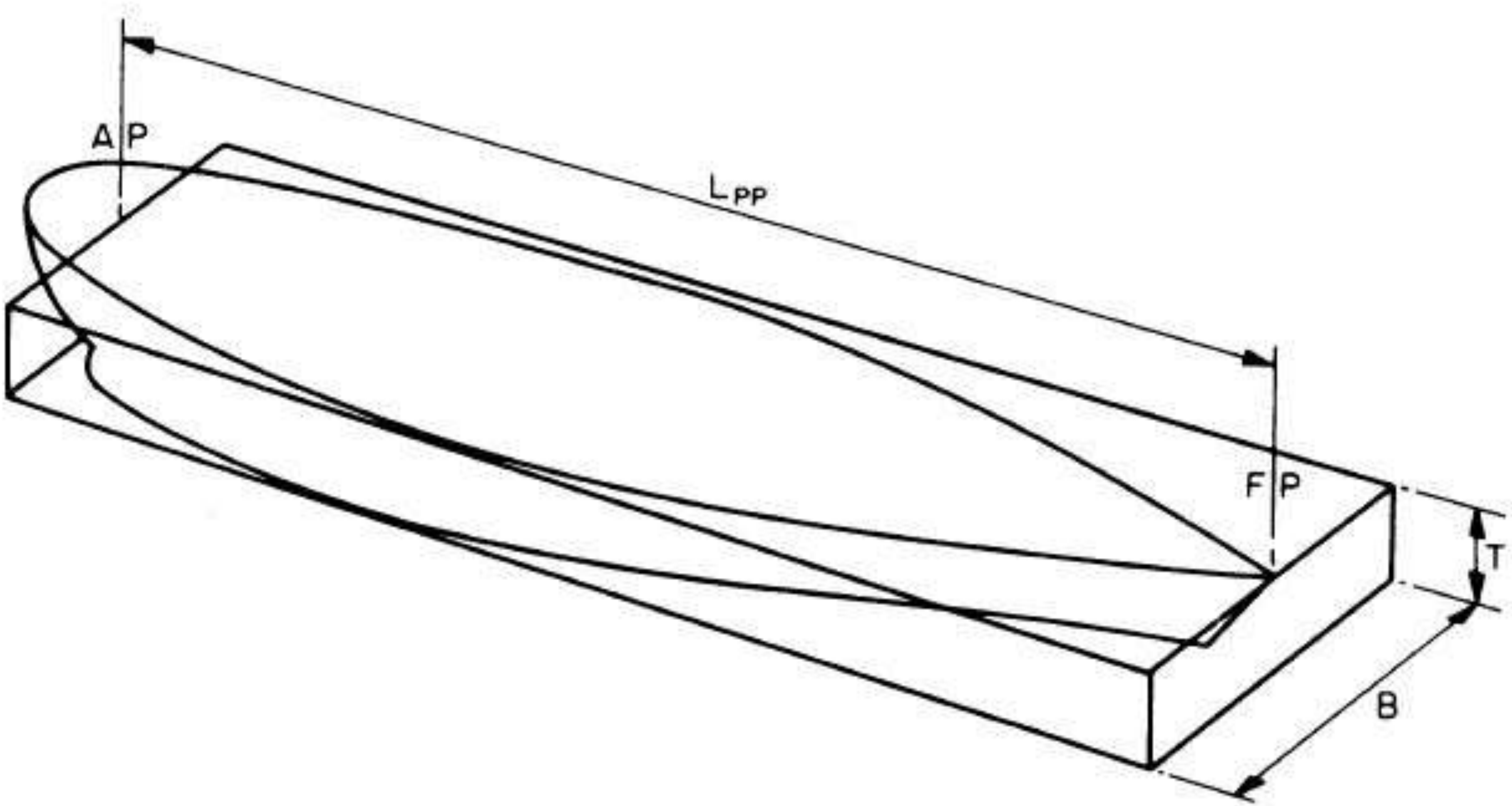
C_B : Block Co-efficient



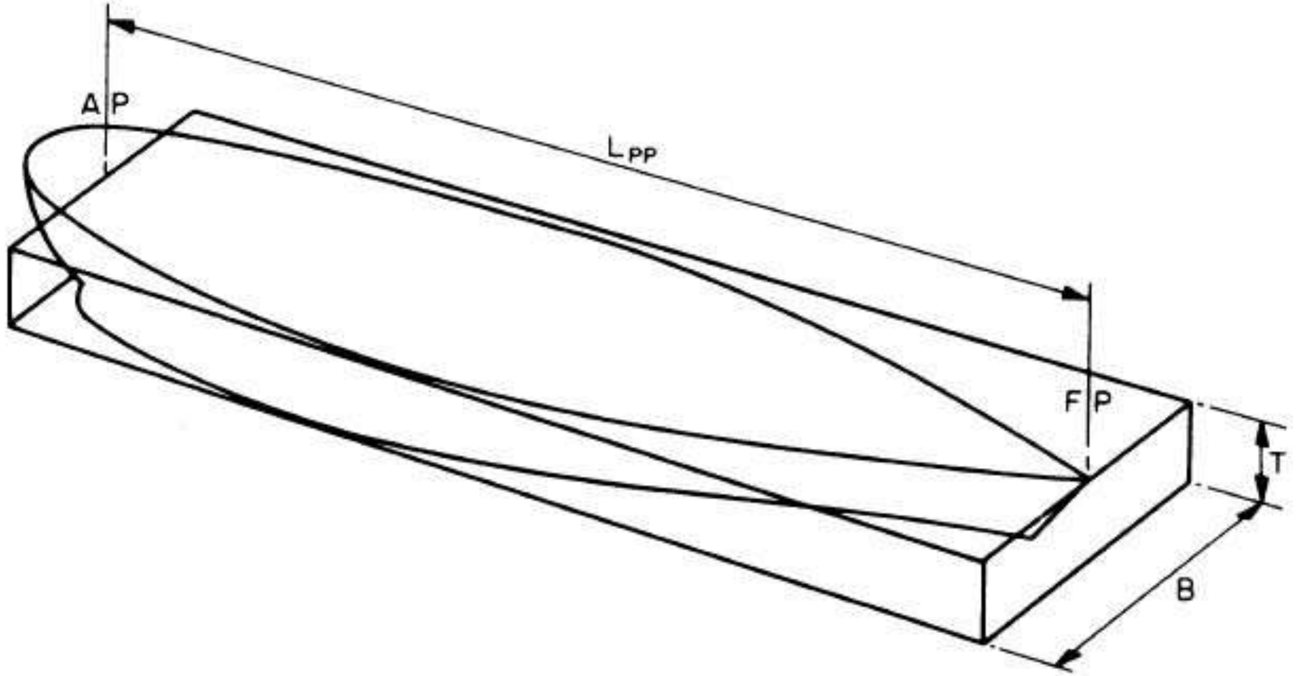
C_B : Block Co-efficient

- At any given draft , it is the Ratio between Volume of Displacement of the Moulded Form and the Volume of the rectangular prism (L_{PP} x B_{MLD} x T_{MLD}), i.e. product of Length Between Perpendiculars or , Maximum Moulded Breadth at LWL and Moulded Draft
- Varies with Draft
- Is plotted as a function of the Draft

C_B : Block Co-efficient



C_B : Block Co-efficient



$$\text{Block coefficient } C_B = \frac{\nabla}{L_{pp} BT}$$

where L_{pp} is length between perpendiculars
B is the extreme breadth underwater
T is the mean draught.

Ship type	*Typical C_b fully loaded*	*Ship type*	*Typical C_b fully loaded*
ULCC	0.850	General cargo ship	0.700
Supertanker	0.825	Passenger liner	0.625
Oil tanker	0.800	Container ship	0.575
Bulk carrier	0.750	Coastal tug	0.500

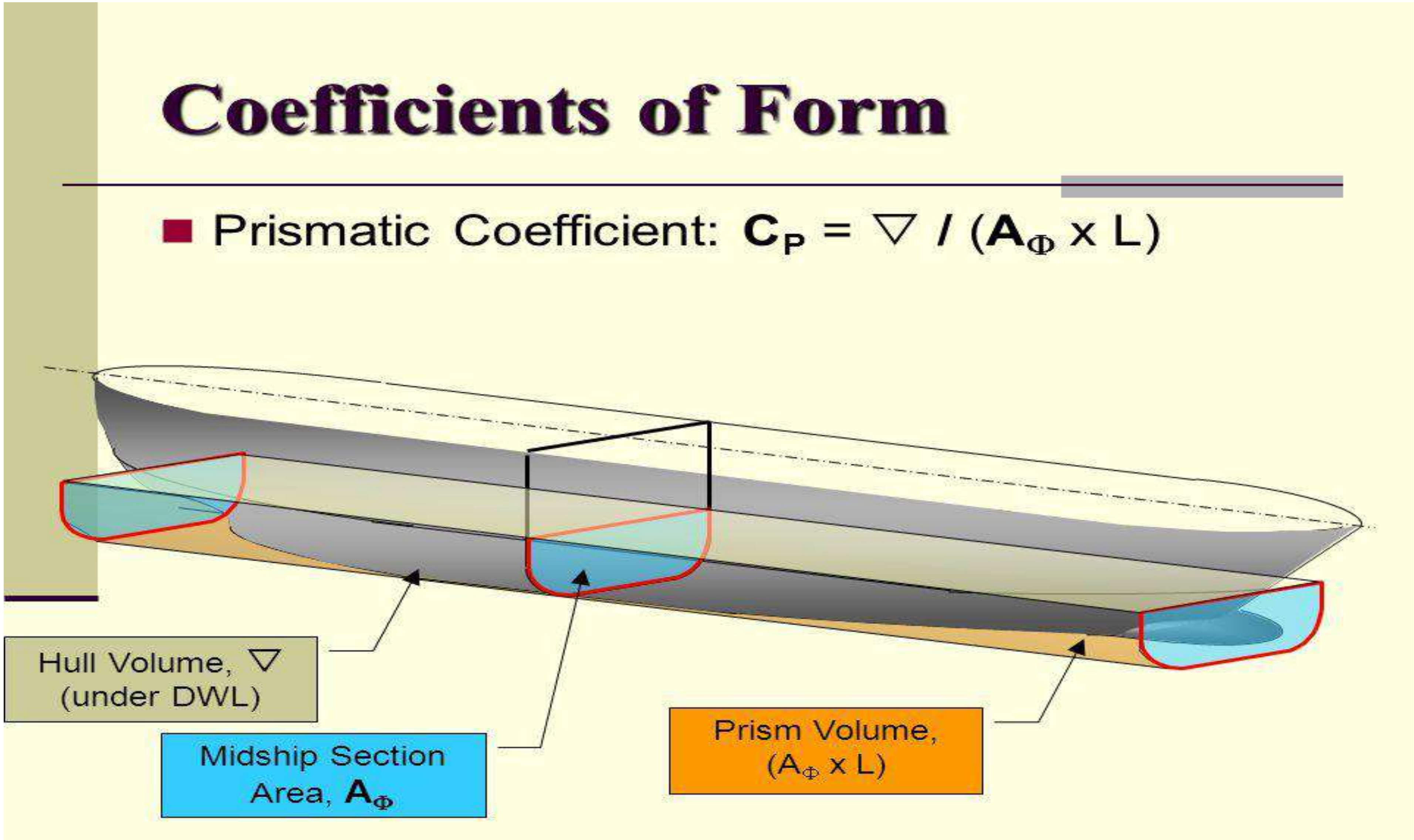
medium form ships (C_b approx. 0.700), full-form ships ($C_b > 0.700$), fine-form ships ($C_b < 0.700$).


NO SMOKING
SAFETY FIRST
EAGLE TURIN

C_P : Prismatic Co-efficient

- Comparison of underwater Volume of the ship with a prism
  - Longitudinal Prismatic Co-efficient , C_P
    - Prism has same cross section throughout the Length
    - Cross section of prism along length is the area of midships
  - Vertical Prismatic Co-efficient, C_{VP}
    - Prism has same cross section throughout the Depth
    - Cross section of prism along depth is the area of load waterplane

Longitudinal Prismatic Co-efficient , C_P



C_P : Longitudinal Prismatic Co-efficient

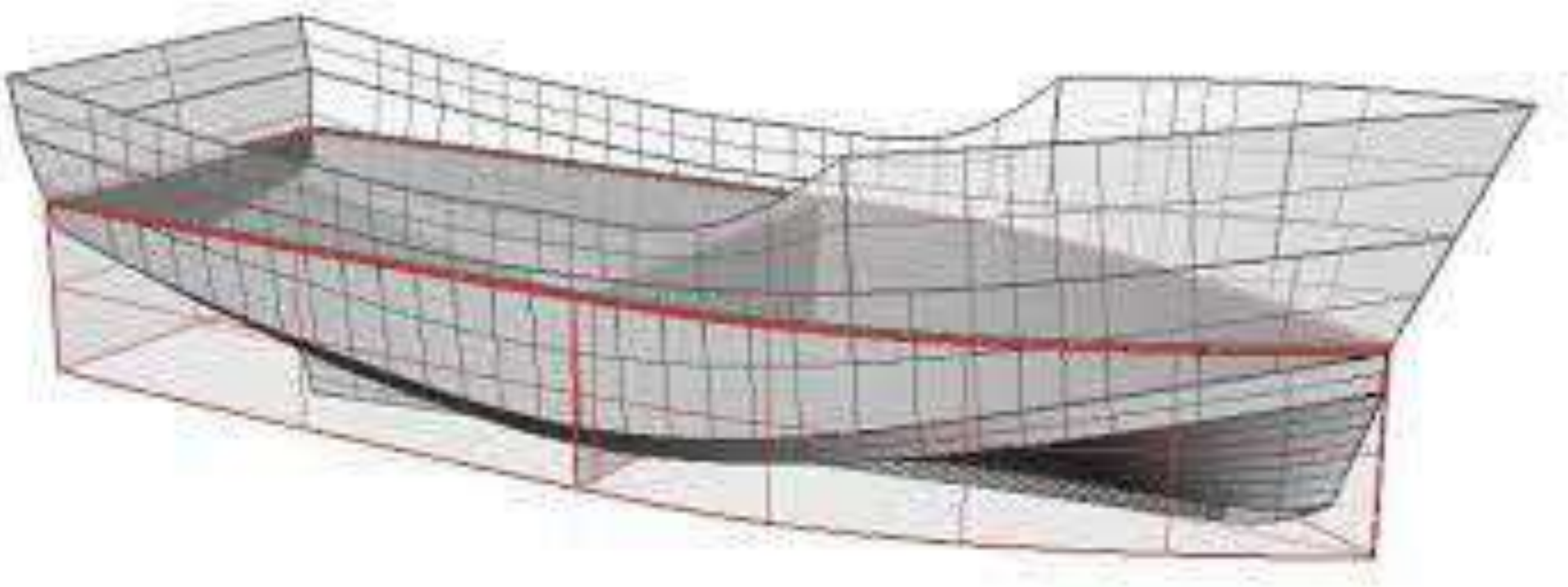
- At any given draft , it is the Ratio between Volume of Displacement of the Moulded Form and the Volume of the prism (A_M x L_{PP}), i.e. product of Area of Midships and Length Between Perpendiculars

$$\text{Longitudinal prismatic coefficient, } C_P = \frac{\nabla}{A_M L_{PP}}$$

- Varies with Draft

- Is plotted as a function of the Draft

Vertical Prismatic Co-efficient, C_{VP}



C_{VP} : Vertical Prismatic Co-efficient

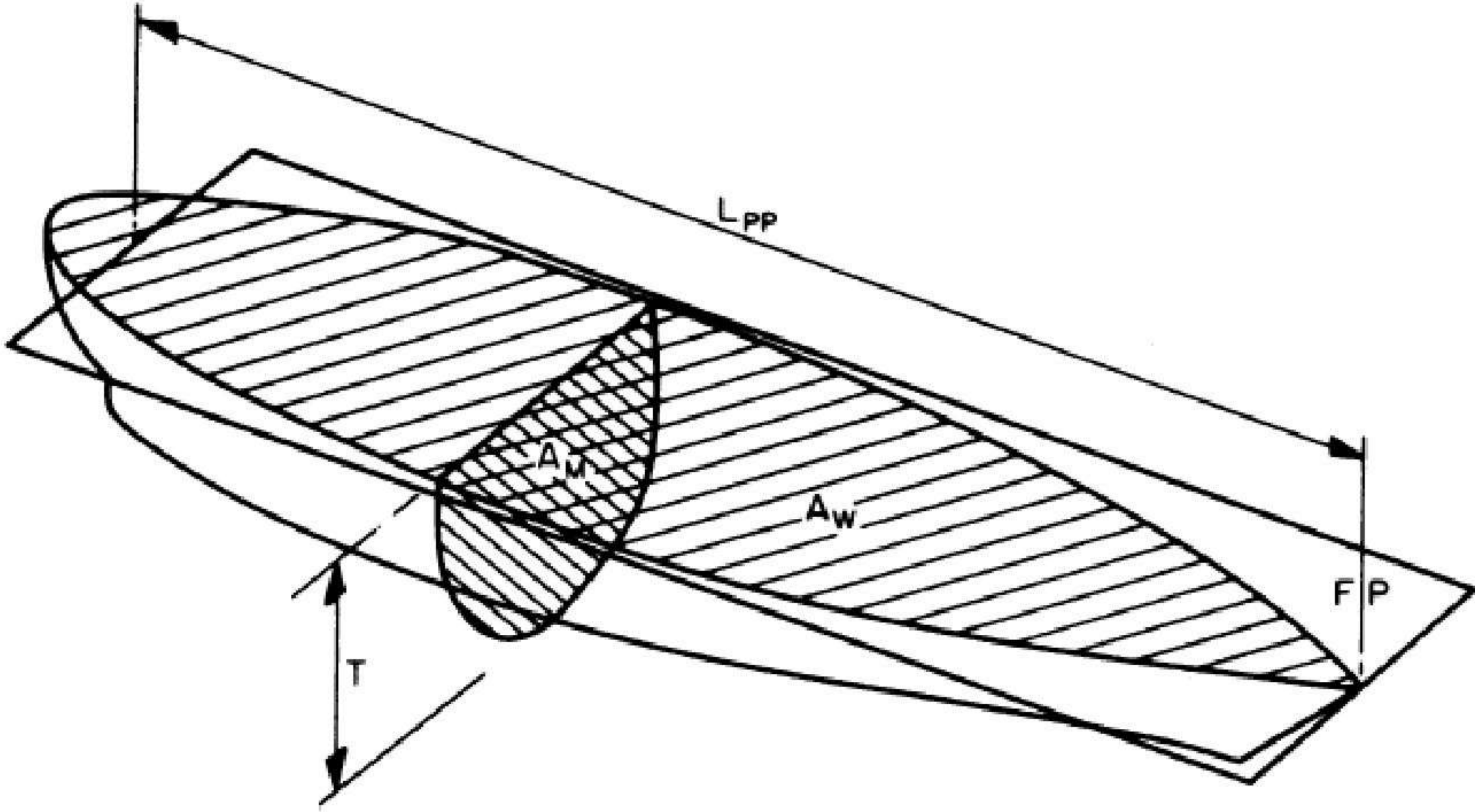
- At any given draft , it is the Ratio between Volume of Displacement of the Moulded Form and the Volume of the prism (A_M x L_{PP}), i.e. product of Design(Load) Waterplane Area and Draft

$$\text{Vertical prismatic coefficient, } C_{VP} = \frac{\nabla}{A_W T}$$

- Varies with Draft

- Is plotted as a function of the Draft

C_P : Prismatic Co-efficient



Find the Form Coefficients for this ship

- $L = 14.251$ m
- $B=4.52$ m
- $T = 1.908$m
- $\nabla = 58.536$ m^3
- $A_M = 6.855$ m^2
- $A_W = 47.595$ m^2

- $C_B = 0.476$
- $C_W = 0.739$
- $C_M = 0.795$
- $C_P = 0.599$

A ship of L_{BP} 200 m has a beam of 22 m and a draught of 7 m. If C_P is 0.75, water plane area is 3500 m^2 and mass displacement in salt water is 23000 t, calculate C_B, C_W, and C_M.

Dead Weight Co-efficient (C_D or C_{DW})

- Ratio of Deadweight to Displacement

$$C_{DW} = \frac{DW}{\Delta}$$

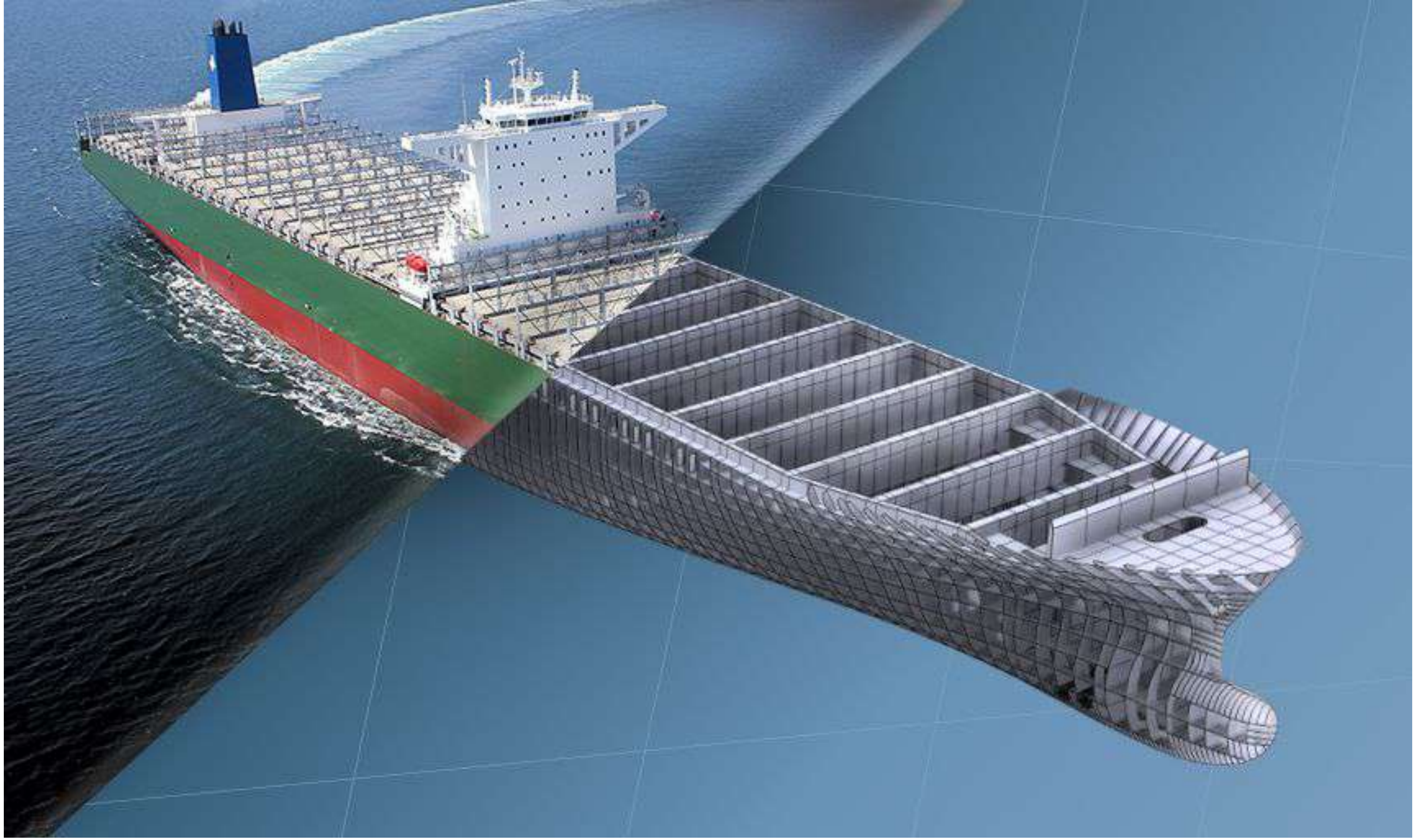
- Used in Preliminary stages of design

Ship Type	C_{DW}	Ship Type	C_{DW}
Oil Tanker	0.800 - 0.860	Container Carrier	0.600
Ore Carrier	0.820	Passenger Liner	0.35 - 0.40
General Cargo	0.700	Ro/Ro Vessel	0.300
LNG/LPG	0.620	Cross-Chanel Ferries	0.200

END

- In case of any doubts you may contact me at

- Mobile : 9969293383
- Email : deepaksebastian.dost@gmail.com



Introduction to Naval Architecture

II SEM –Module 2

Syllabus

2. **Module II**

   Introduction to ship geometry

   Some physical fundamentals - Archimedes principle, laws of floatation stability and trim. The ship's form-main dimensions, lines plan, coefficients and their meaning, Fairing process and table of offsets; Hydrostatic particulars &Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF)

What is CoG

- Centre of Gravity (CoG)
- CoG of a body is the imaginary point through which all the mass of the body is assumed to be concentrated
- It is the imaginary point through which the force of gravity on a body mass is considered to act vertically downwards
- It is the point about which the body would balance its weight distribution

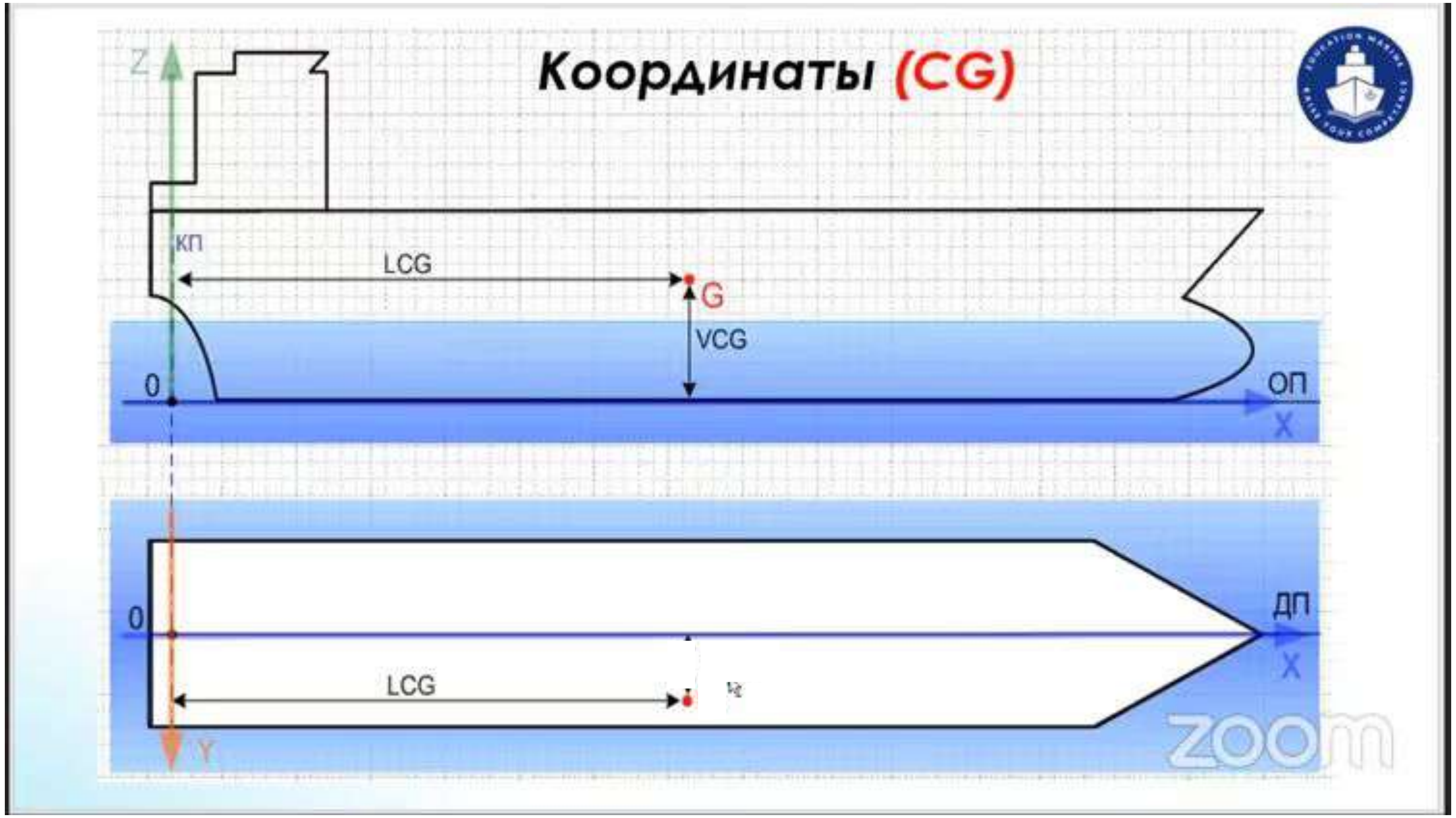
Centre of Gravity

- Centre of Gravity(G) is the centroid of the mass distribution of the ship
- Its position can be defined by specifying its distance relative to a reference point, axis or plane.
- Considering the three mutually perpendicular planes of reference for a ship, it can be defined in space by three co-ordinates (x, y, z)
    - X axis : Along the Length – from a reference Transverse Plane (at Midships)
    - Y axis : Along the Breadth – from a reference Buttock Plane (Centreline Plane)
    - Z axis : Along the Depth – from a reference Water plane (Baseline Plane)

LCG – Longitudinal Centre of Gravity

- LCG is the distance of the Centre of Gravity (G) from any transverse reference axis (at AP, Midships, FP etc. but Midships by convention

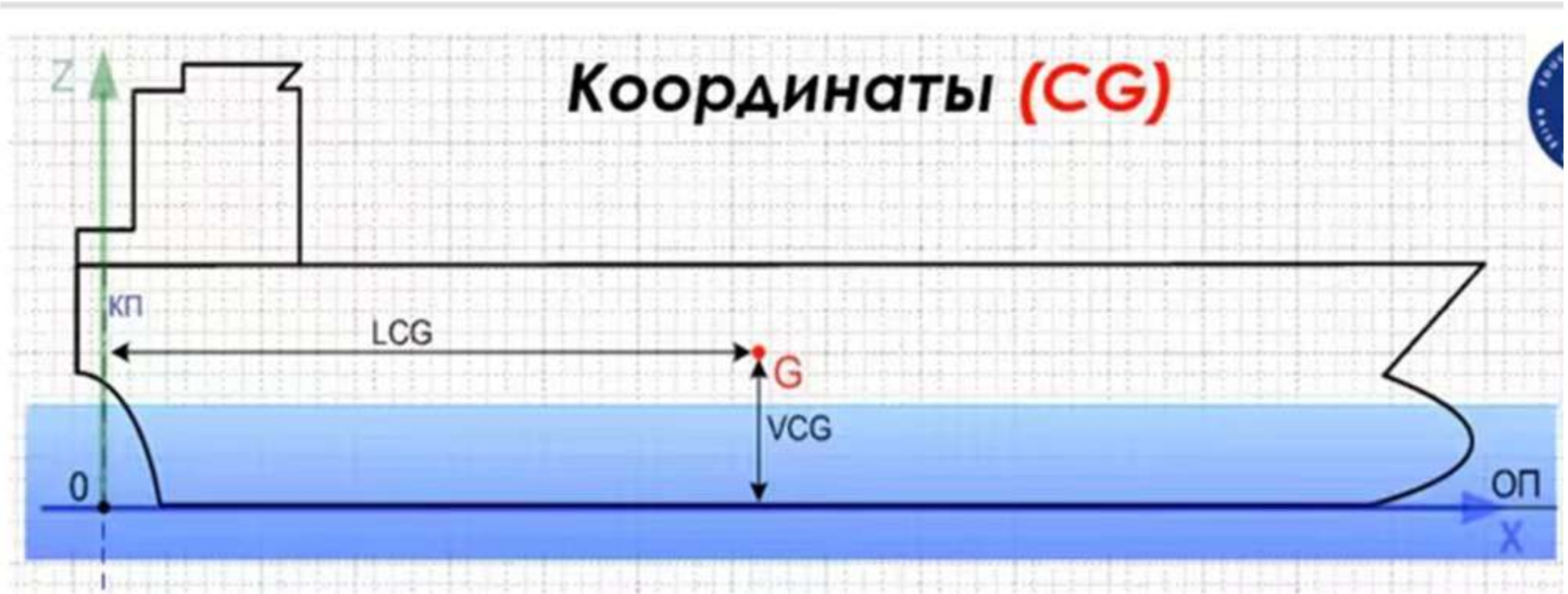
Unit – Metres



VCG (or KG) – Vertical Centre of Gravity

- VCG or KG is the distance of the Centre of Gravity (G) from the Baseline or the Keel(K)

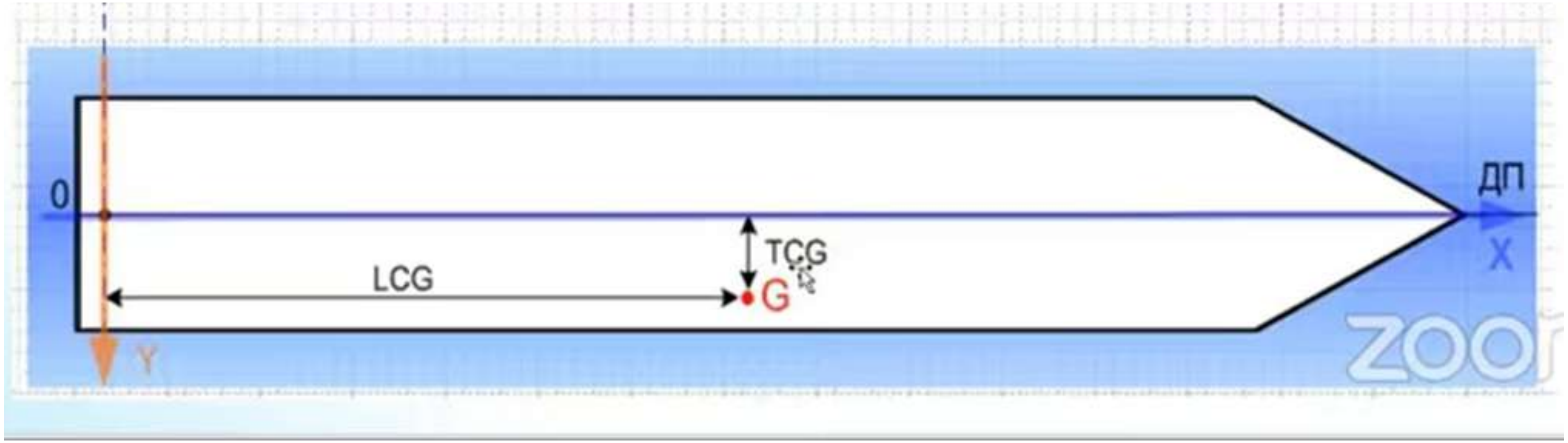
Unit – Metres



TCG – Transverse Centre of Gravity

- TCG is the distance of Centre of Gravity (G) from the Centreline towards Port or Starboard
- Low values of TCG, i.e. tending to 0 is desirable to prevent inclination to port/ starboard due to inequilibrium

Unit – Metres



Centre of Buoyancy (B)

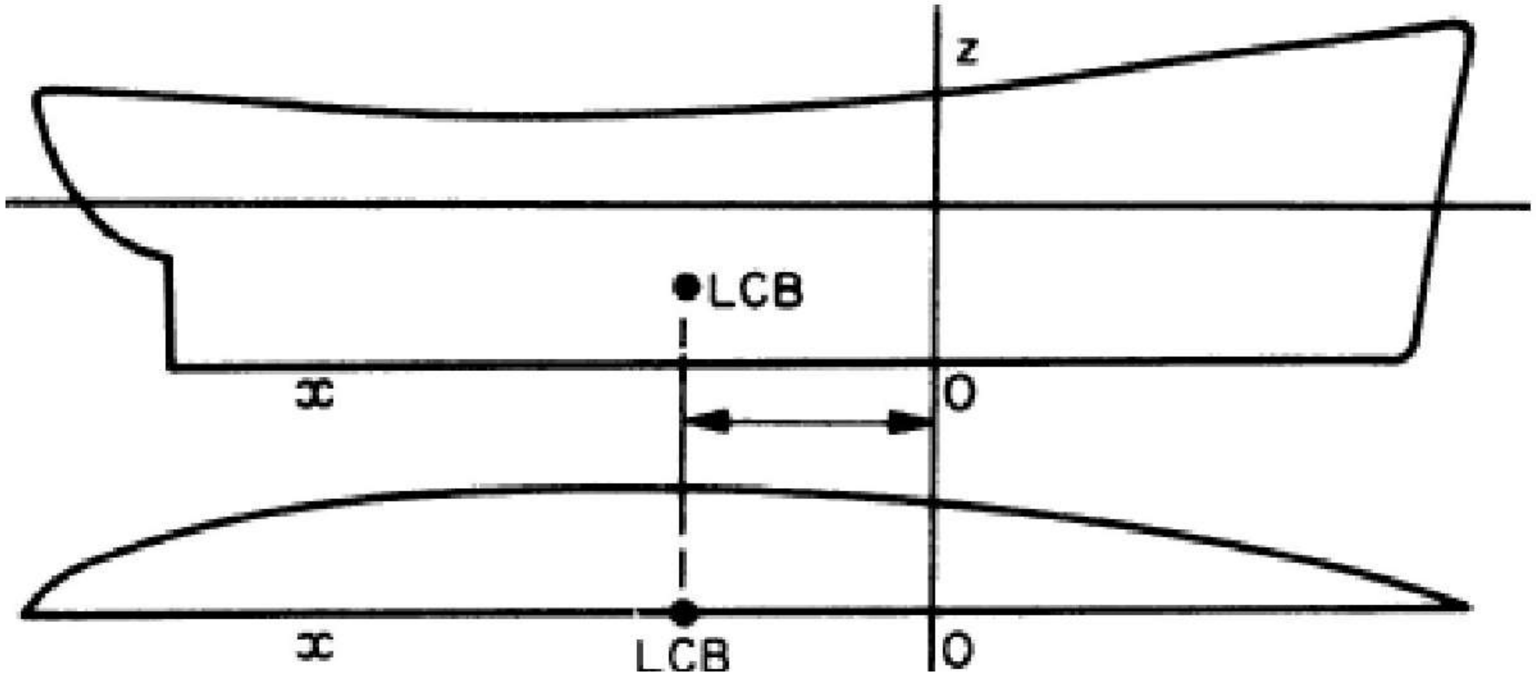
- Centre of Buoyancy(B) is the point through which the buoyancy force is assumed to act .
- It is the centroid of the submerged volume
- Its position can be defined by specifying its distance relative to a reference point, axis or plane.
- Considering the three mutually perpendicular planes of reference for a ship, it can be defined in space by three co-ordinates (x, y, z)

  - X axis : Along the Length – from a reference Transverse Plane (at Midships)
  - Y axis : Along the Breadth – from a reference Buttock Plane (Centreline Plane)
  - Z axis : Along the Depth – from a reference Water plane (Baseline Plane)

LCB – Longitudinal Centre of Buoyancy

- LCB is the distance of the Centre of Buoyancy (B) from any transverse reference axis (at AP, Midships, FP etc. but Midships by convention

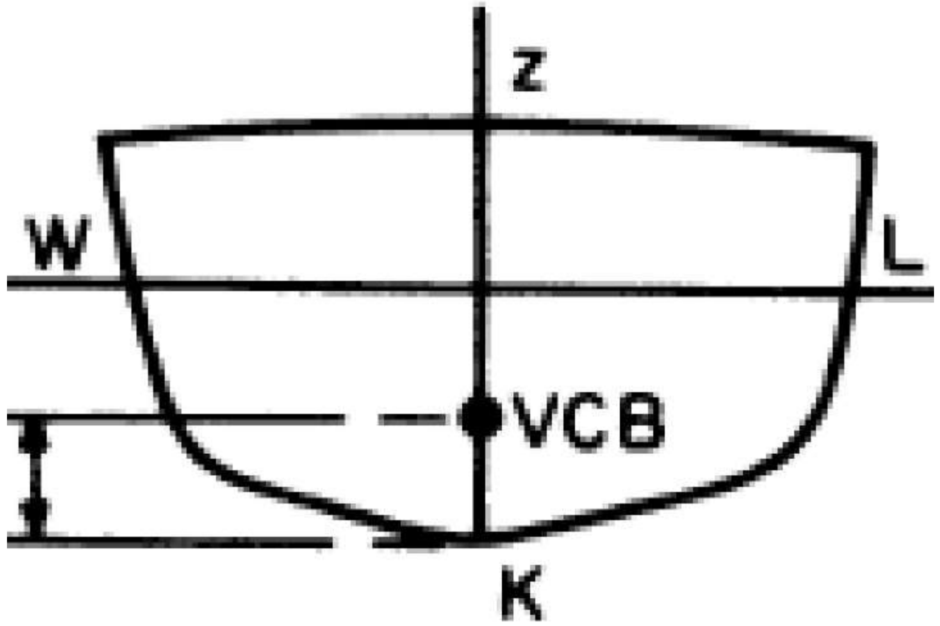
Unit – Metres



VCB (or KB) – Vertical Centre of Buoyancy

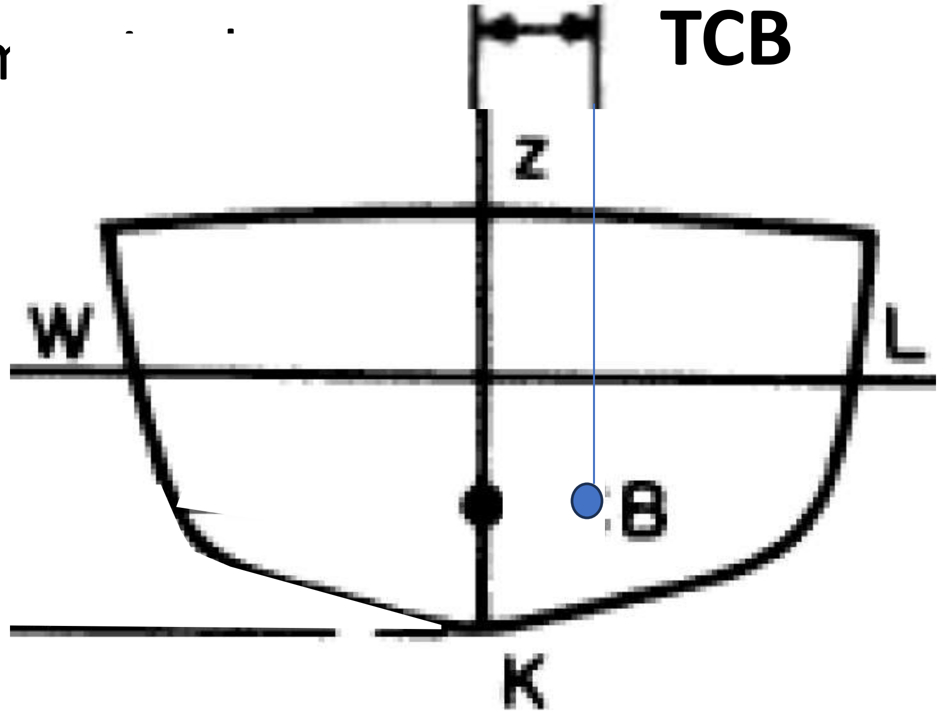
- VCB or KB is the distance of the Centre of Buoyancy (B) from the Baseline or the Keel(K)

Unit – Metres



TCB – Transverse Centre of Buoyancy

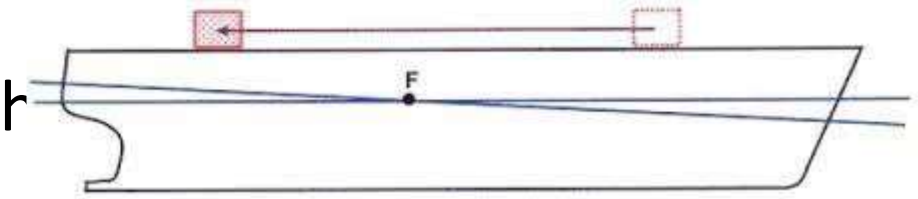
- TCB is the distance of Centre of Buoyancy (B) from the Centreline towards Port or Starboard
- Generally TCB = 0 because ship is symm

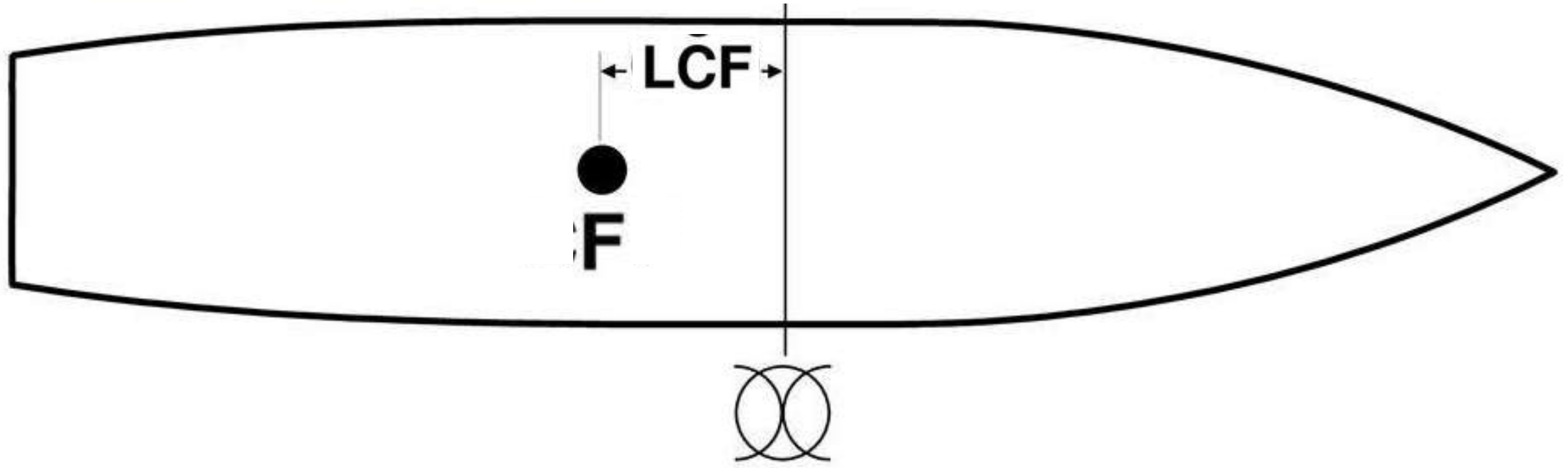


Unit – Metres

Centre of Flotation(F)

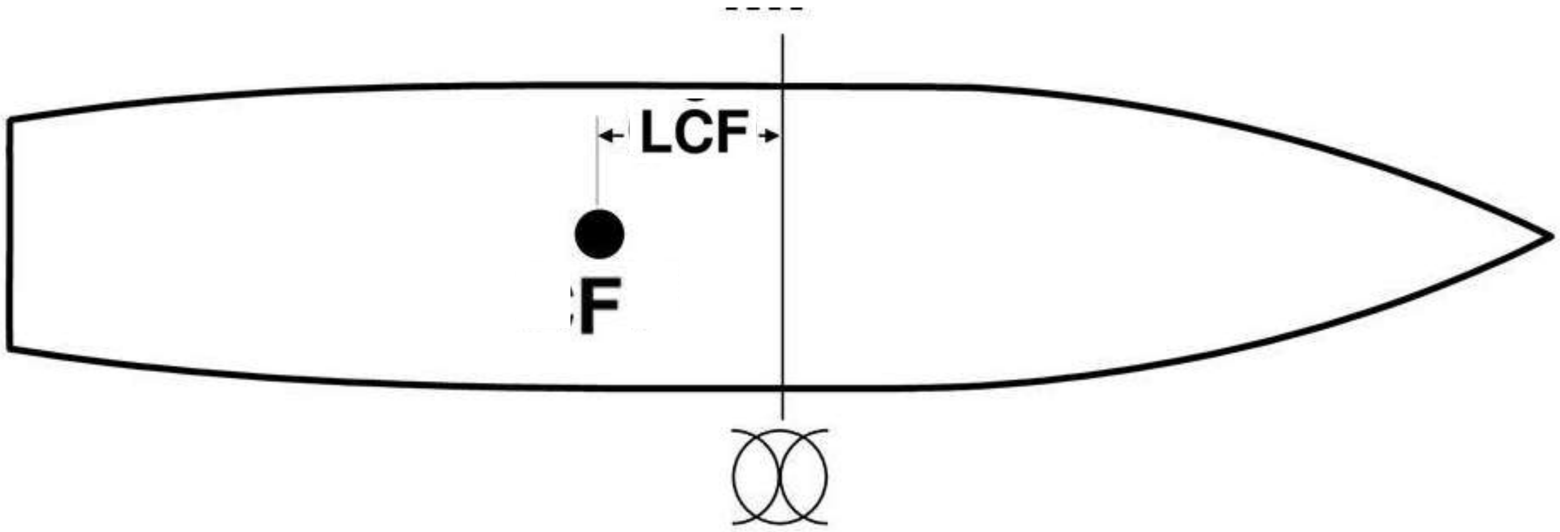
- F is the Centroid of the Water Plane Area at the draft at which the ship is floating
- LCF is the distance of F from a transverse reference axis (usually midships)
- It is the point about wh
- Unit – Metres





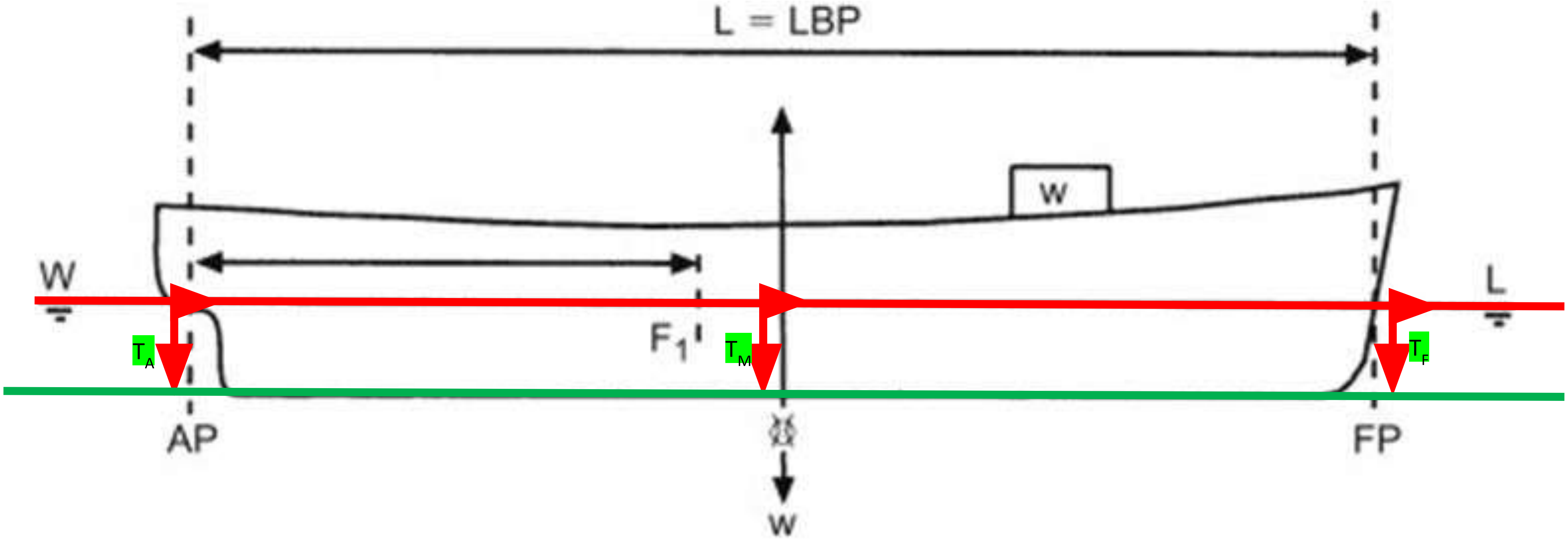
LCF – Longitudinal Centre of Flotation

- F is the Centroid of the Water Plane Area at the draft at which the ship is floating
- LCF is the distance of F from a transverse reference axis (usually midships)
- It is the point about which the ship trims
- Unit – Metres



Drafts

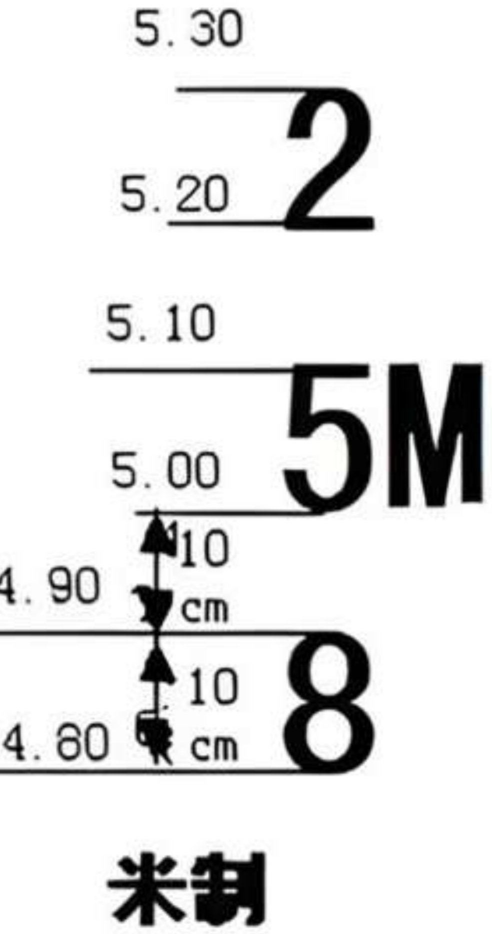
- Draft are generally measured at FP, AP and Midships
- Practically draft marks may not be welded exactly on FP or AP
- When Waterline is parallel to Baseline , $T_A = T_M = T_F$ (Even Keel)

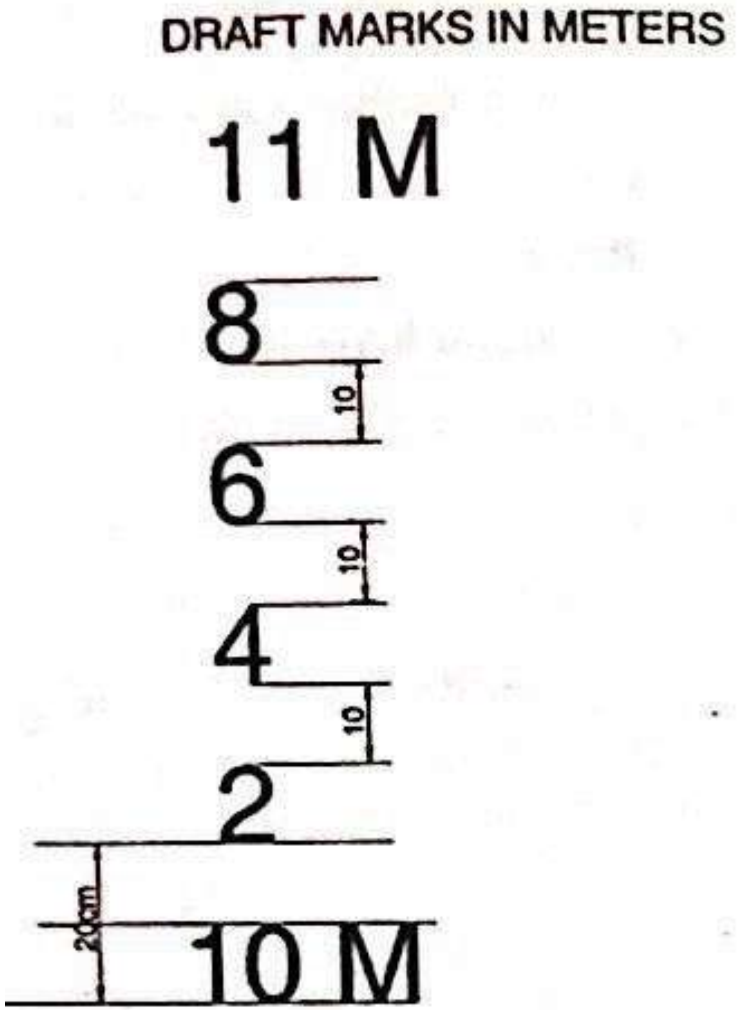


Draft Marks

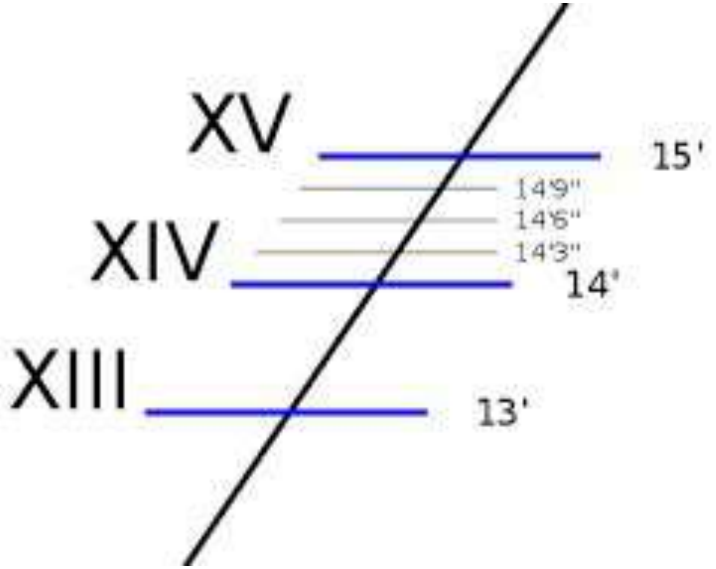
- Practically draft marks may not be welded exactly on FP or AP

How to read draft marks – in Metres

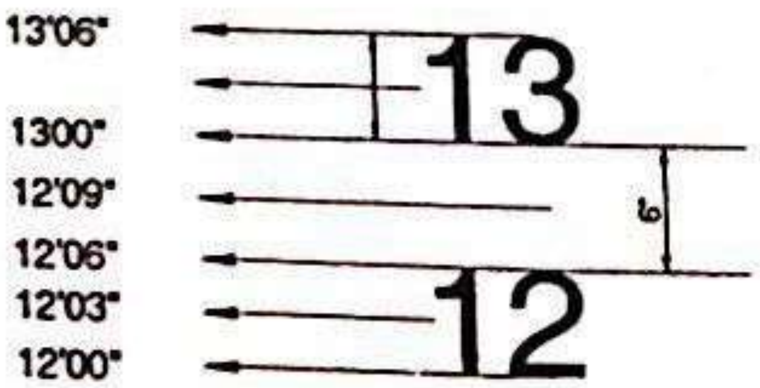




How to read draft marks – in Feet



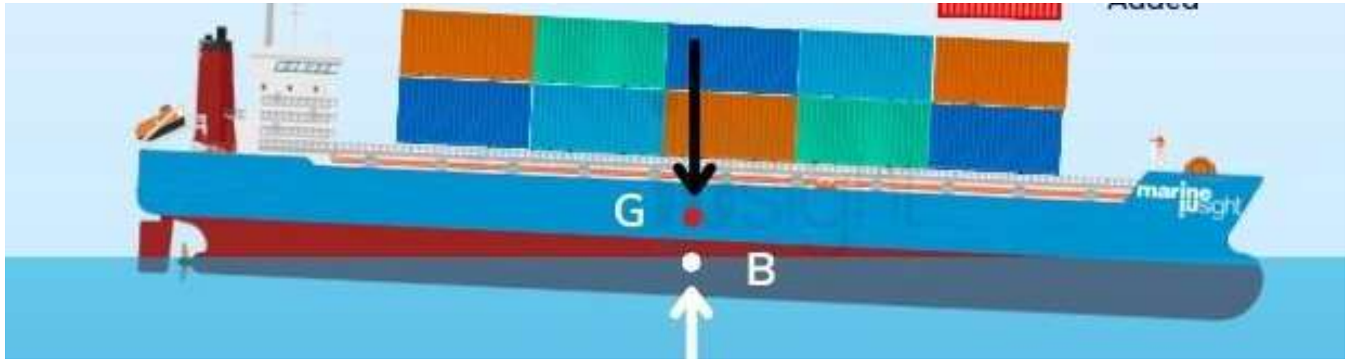
DRAFT MARKS IN FEET



Draft marks.

Inclination of Ship

- Types
  - Longitudinal
    - Trim



- Transverse
  - Heel
  - List

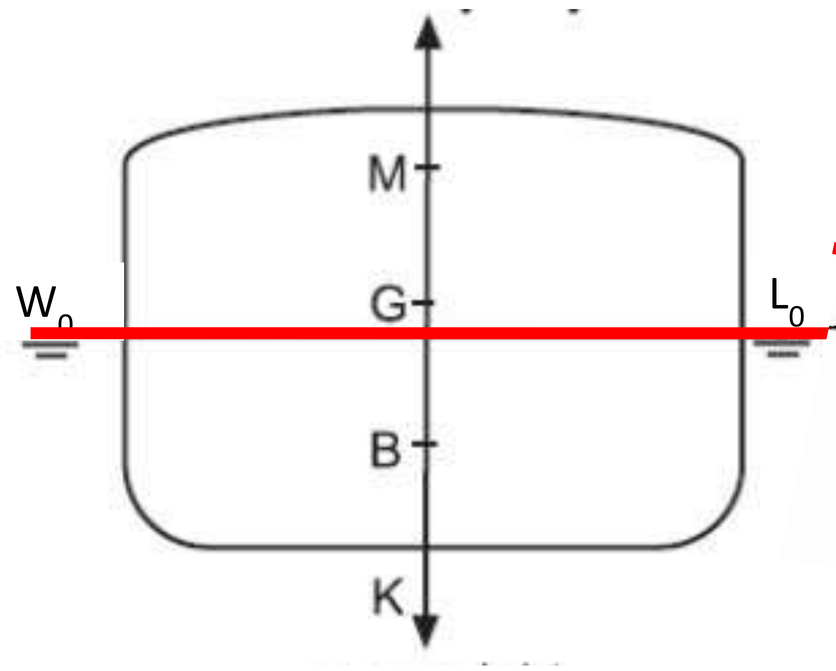
Ways to represent inclined waterline- Transverse view

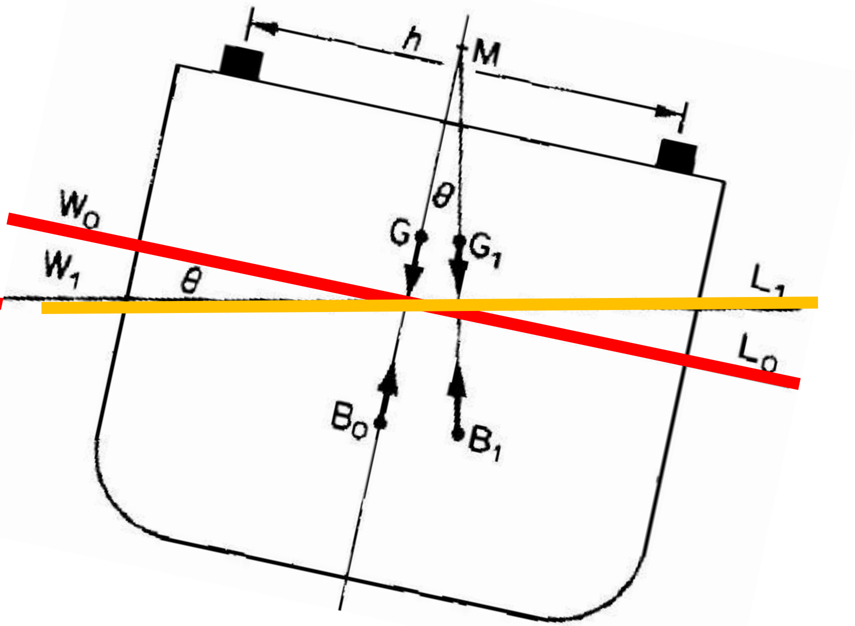
- There are 2 ways

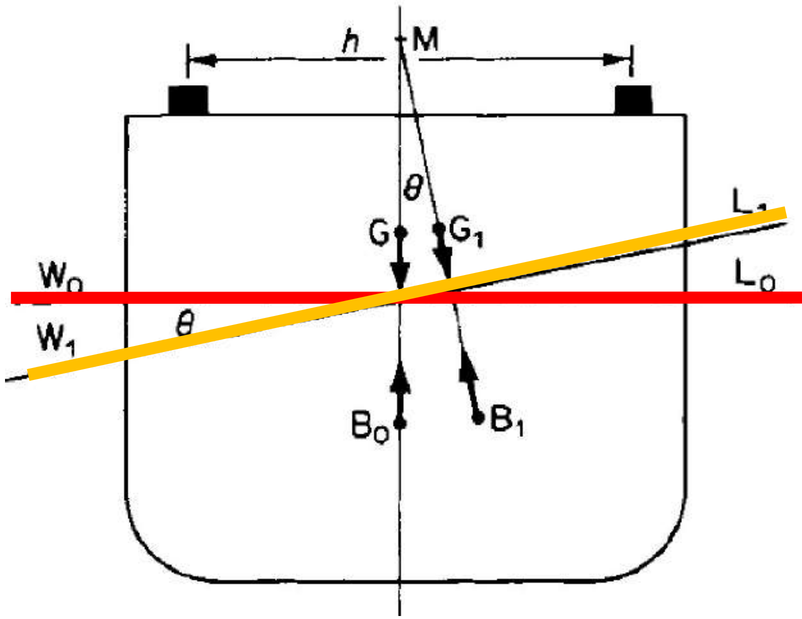
Ship Upright.
Original WL is horizontal

Ship and original WL is inclined.
New Waterline is horizontal

Ship and original WL is upright .
New WaterLine is inclined

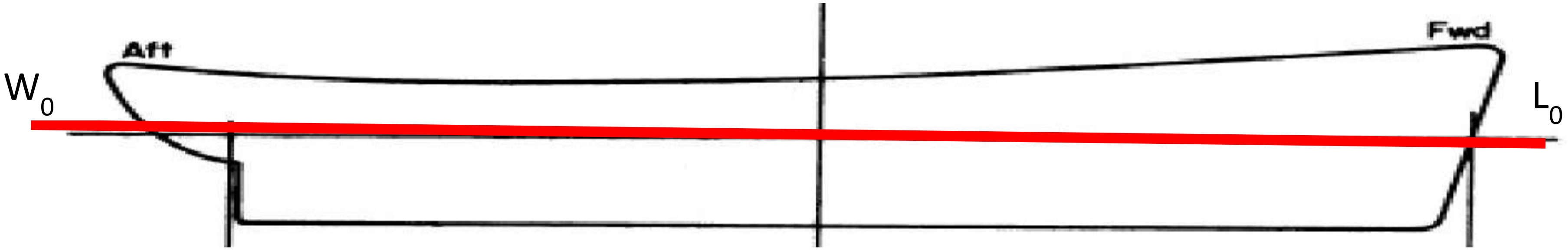




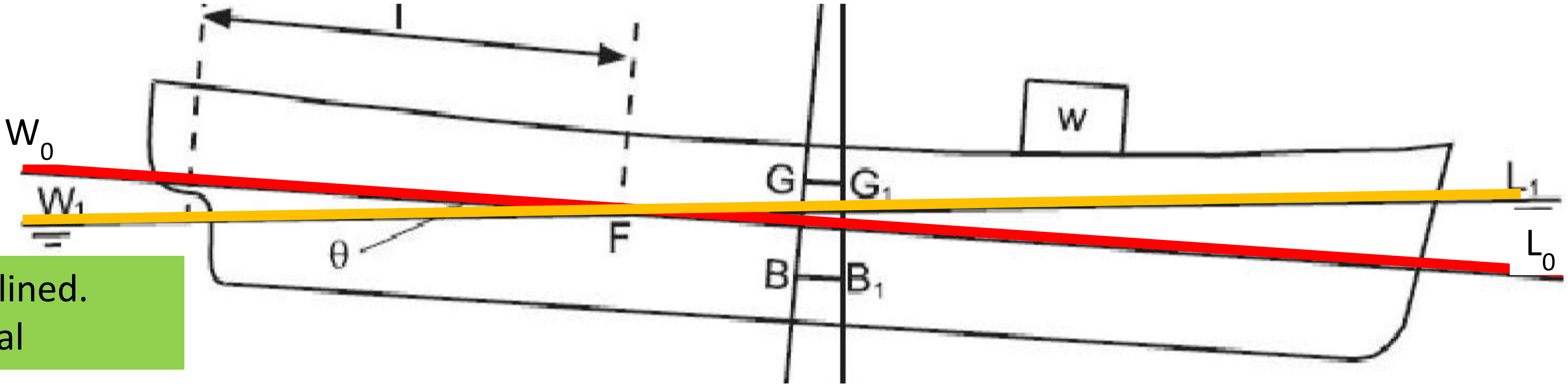


Ways to represent inclined waterline – Longitudinal View (Profile)

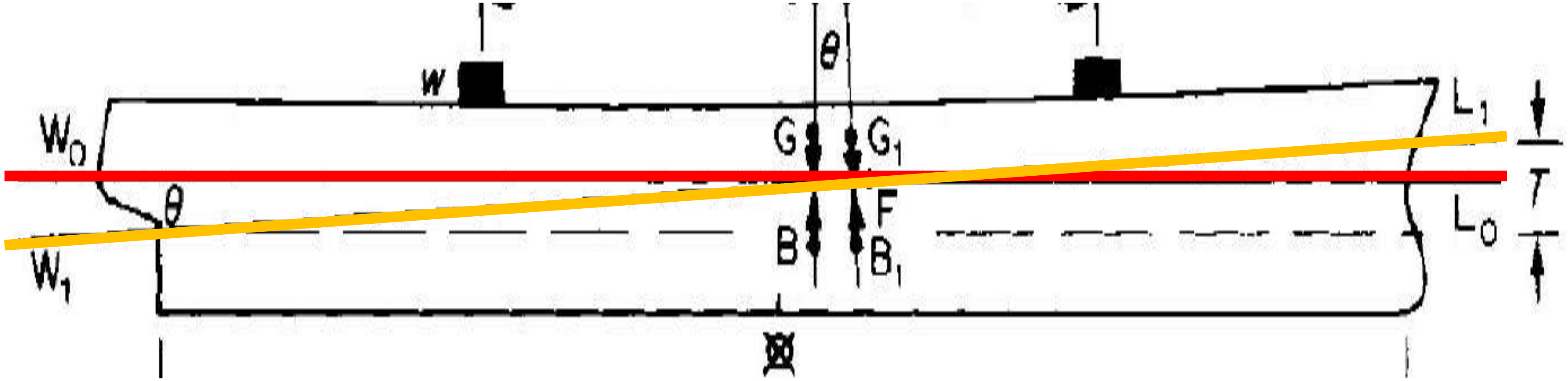
- There are 2 ways



Ship Upright.
Original WL is horizontal

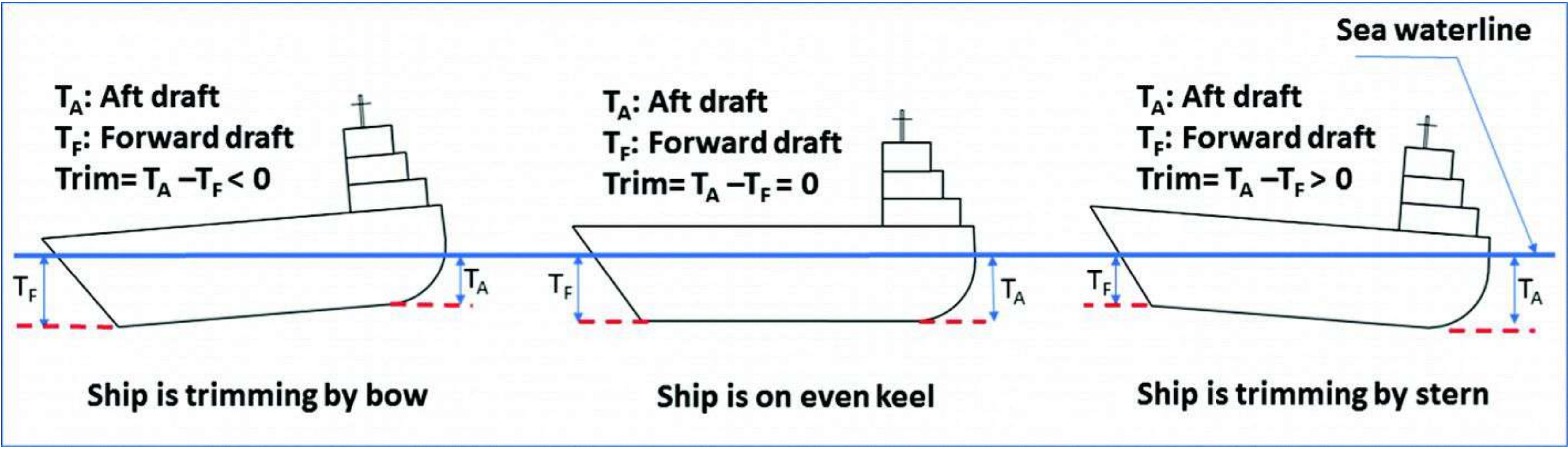


Ship and original WL is inclined.
New Waterline is horizontal



Ship and original WL is upright
New WaterLine is inclined

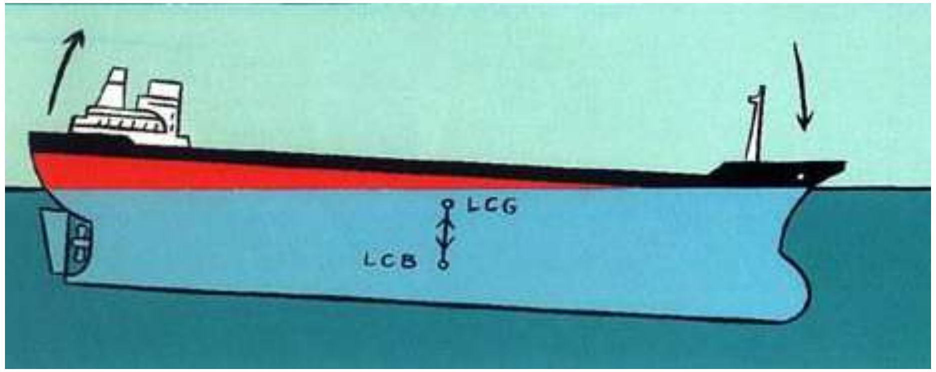
Trim

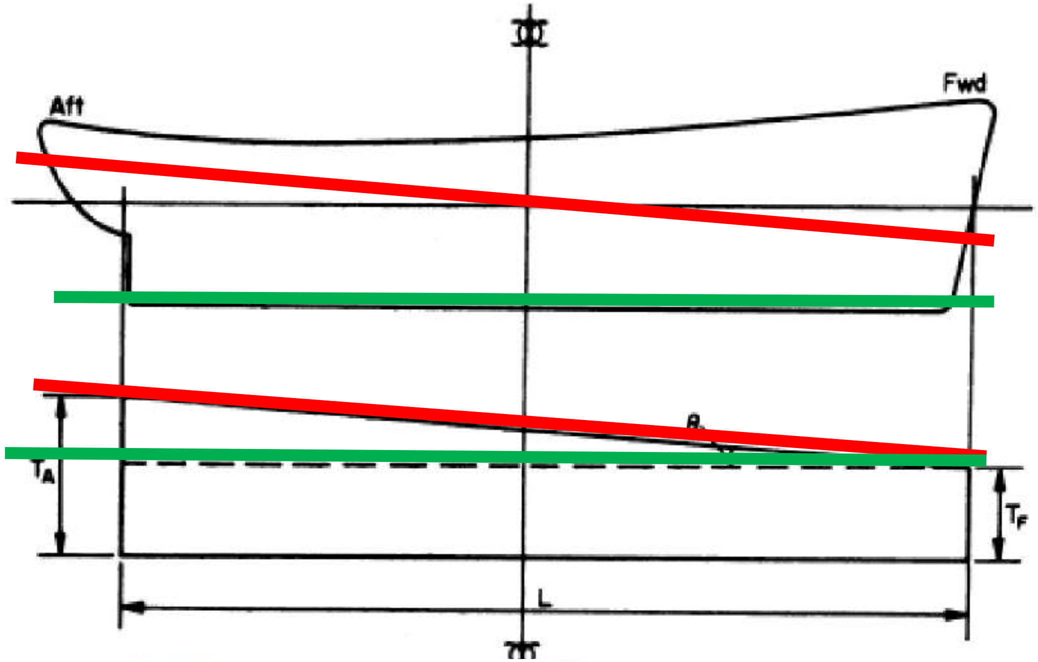


Sea waterline
T_A: Aft draft
T_F: Forward draft
Trim= $T_A - T_F < 0$
T_F
T_A
Ship is trimming by bow
T_A: Aft draft
T_F: Forward draft
Trim= $T_A - T_F = 0$
T_F
T_A
Ship is on even keel
T_A: Aft draft
T_F: Forward draft
Trim= $T_A - T_F > 0$
T_F
T_A
Ship is trimming by stern

Trim (Longitudinal Inclination)

- It is the
  - Longitudinal Inclination of the ship
  - Angle between the Base Line and the Waterline
  - Expressed as difference between Forward and Aft Drafts or as an angle





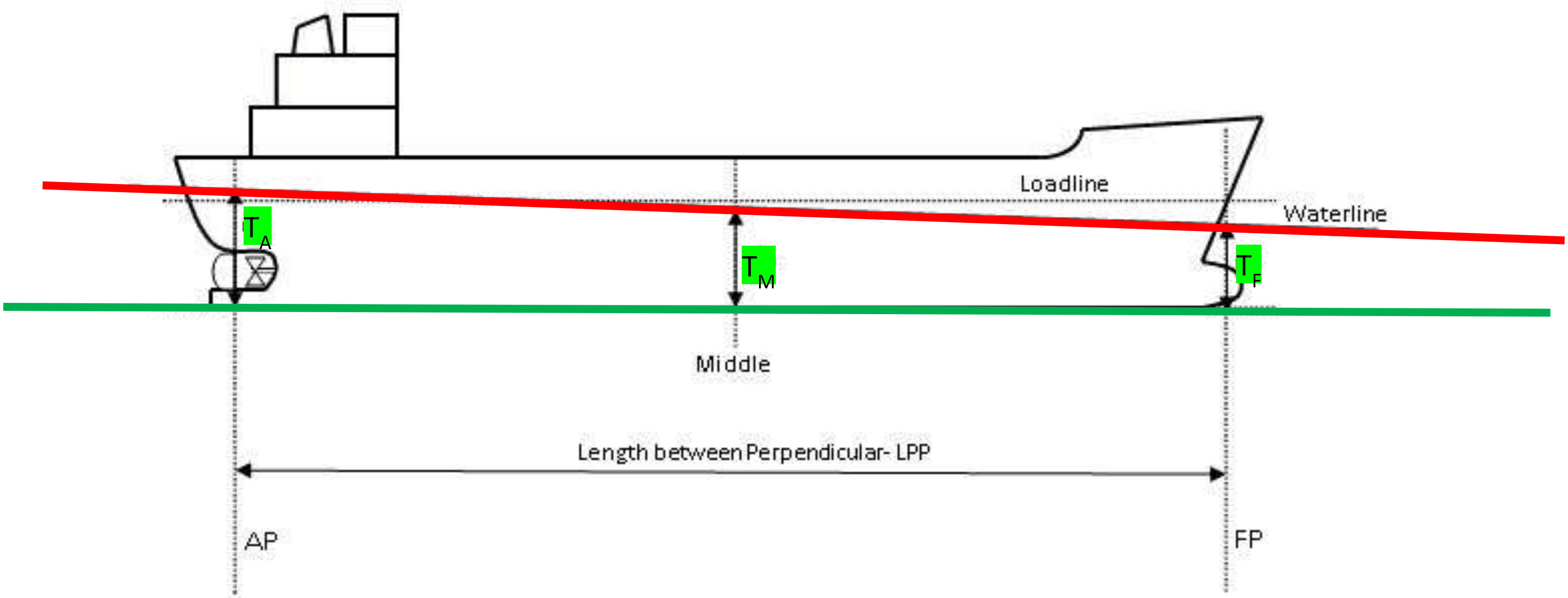
$$\text{trim} = T_A - T_F$$

$$\text{angle of trim } \theta = \frac{T_A - T_F}{L}$$

: L is the horizontal distance between the points at which T_A and T_F are measured.

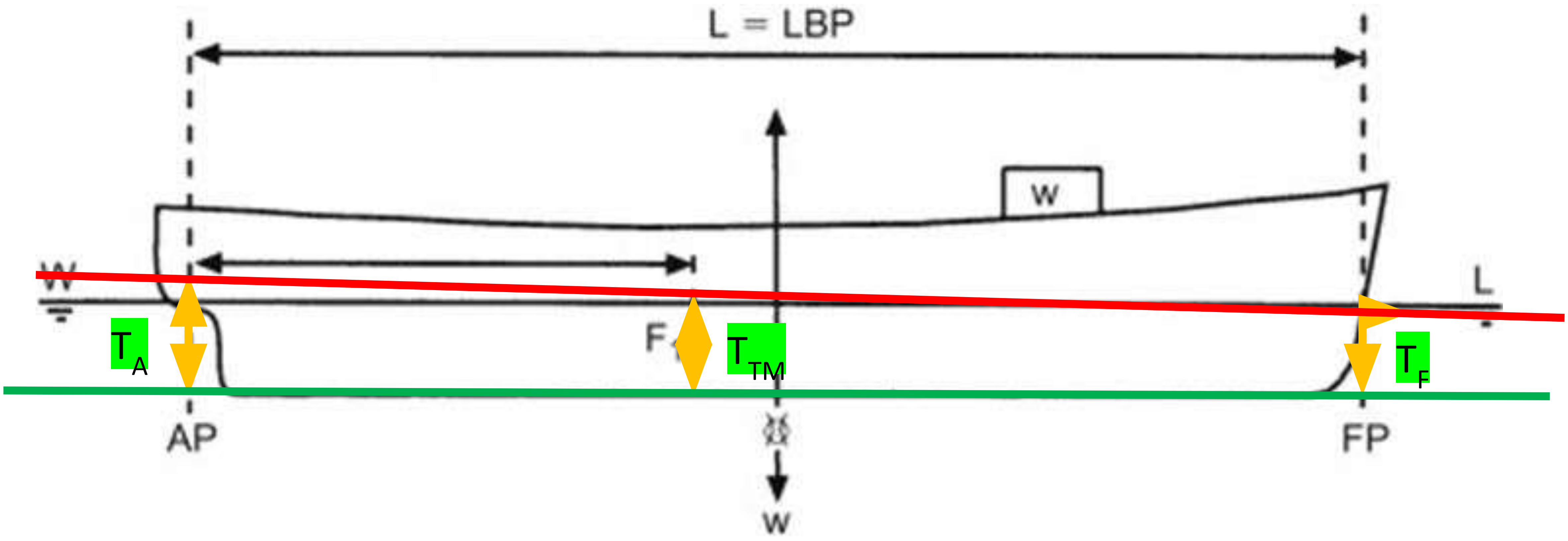
Mean Draft

- When WaterLine is not parallel to baseline the ship is said to have a Trim
- T_A not = T_F
- $T_{Midships}$ = Mean Draft =(T_A + T_F) /2



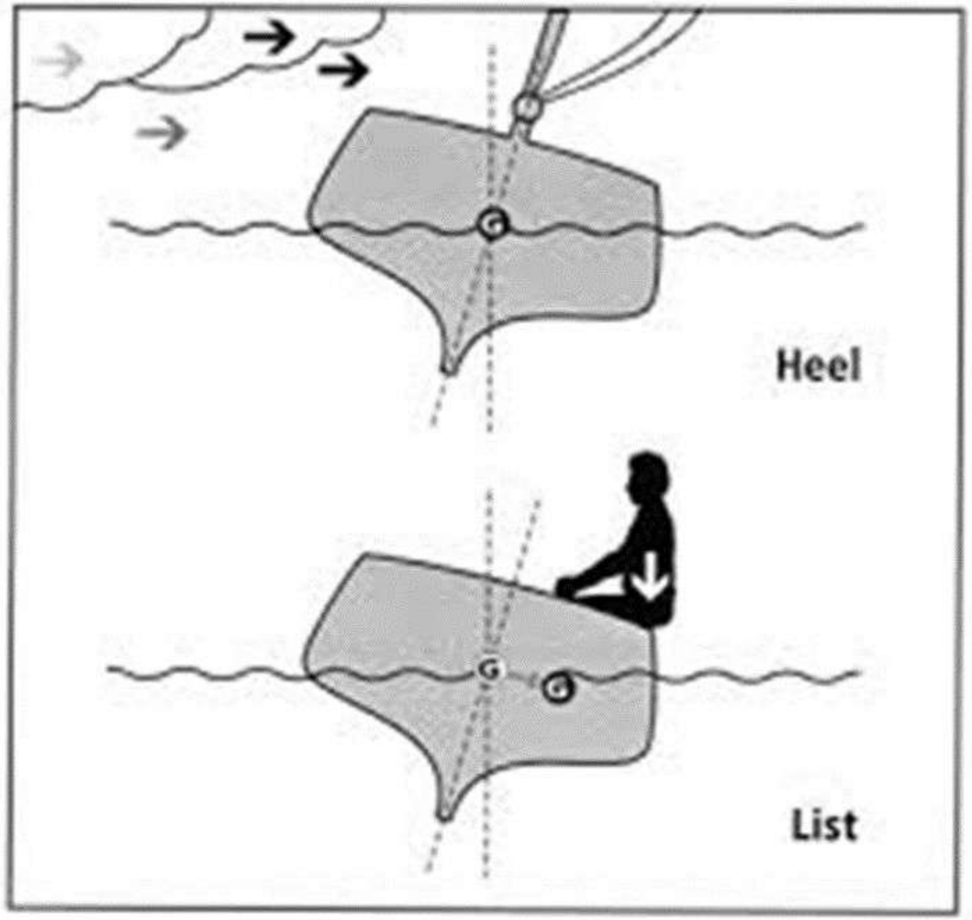
True Mean Draft

- Mean Draft (T_M)= (T_A + T_F)/2
- True Mean Draft (T_{TM}) = Draft at Centre of Floatation (F)



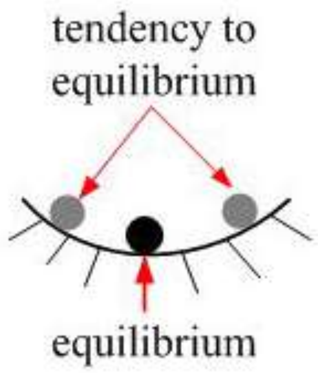
Heel and List (Transverse Inclination)

- Heel – Transverse Inclination of ship caused due to external forces such as Wind, Waves, Interaction with fixed on moving structures, addition or removal of weight, etc.
- List - Transverse Inclination of ship caused due to internal forces such as shifting of weight, fluids etc, within the ship.
- Both defined in degrees and direction (Port and Stbd) .
  - 10 degrees heel to port
  - 5 degrees list to stbd

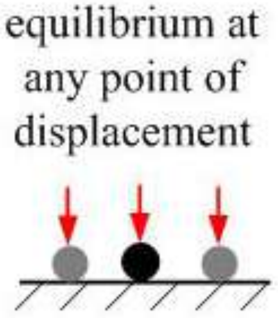


States of Equilibrium - Object

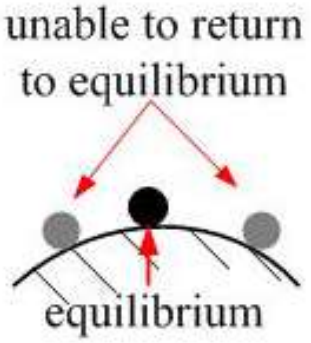
- For any object when disturbed by an external force there could be 3 equilibrium conditions
- Stable Equilibrium
  - When the object tends to return to its original position



- Neutral Equilibrium
  - When the object stays in the new position

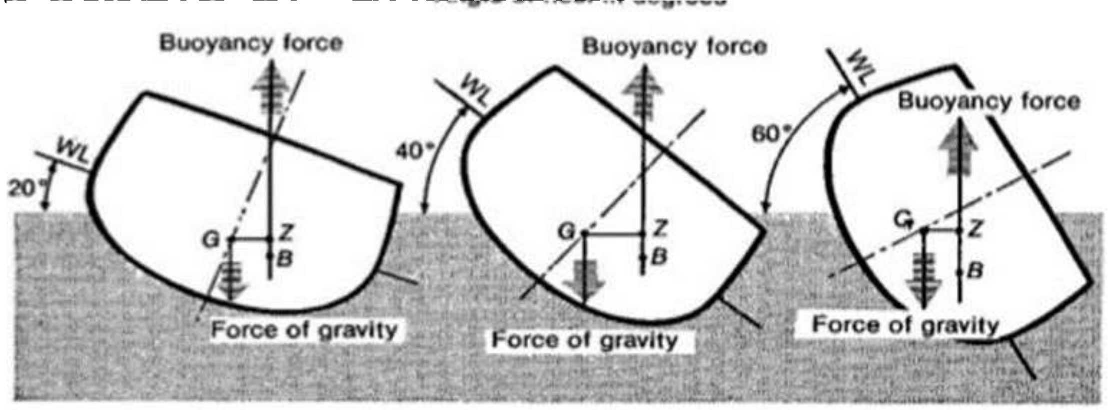


- Unstable Equilibrium
  - When the object tends to move away from original position



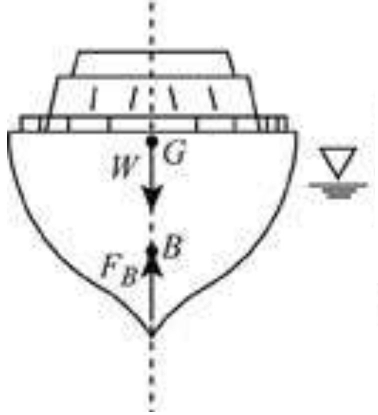
Stability of Ship

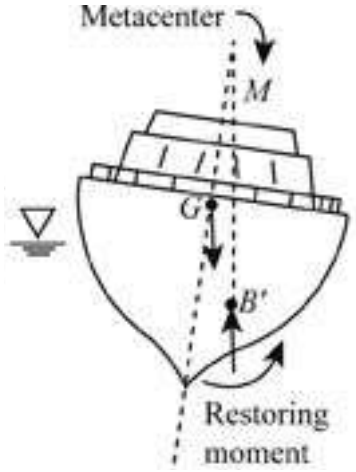
- What is your biggest worry when you board a boat ?
- Will it capsize and sink?
- So, for a ship floating upright, its stability is paramount
- When a ship inclines, either due to external force or due to internal weight shift, one issue of concern is its stability
- What do we mean by ship being stable?
- How do we estimate whether the ship is stable or unstable?



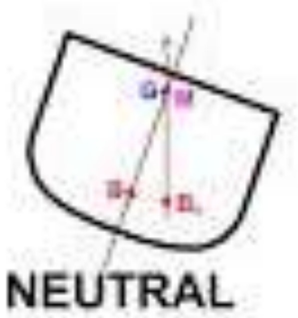
States of Equilibrium - Ship

- For a ship in upright position, when disturbed by an external force, it inclines to an angle

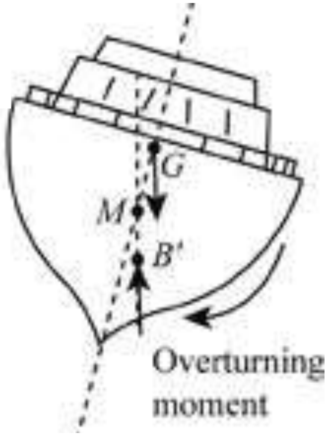




  - Stable equilibrium- If it tends to return to upright position



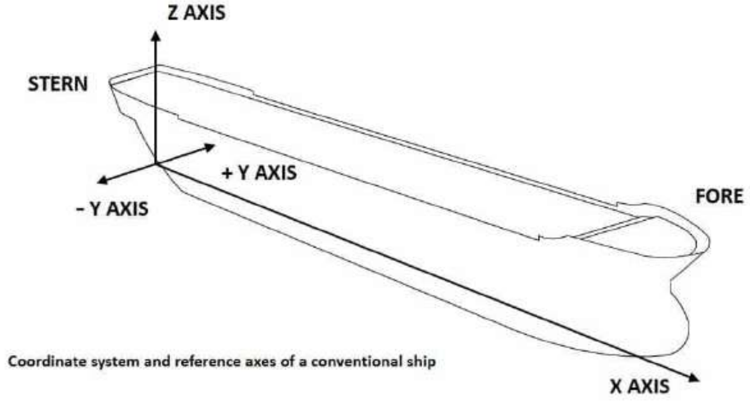
  - Neutral equilibrium - If it remains in the inclined position



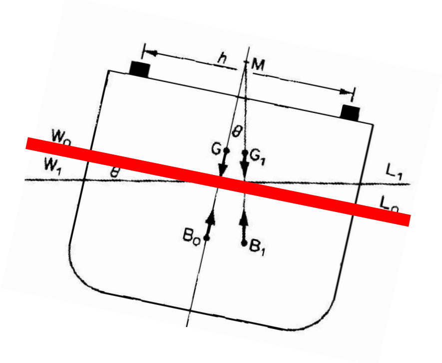
  - Unstable equilibrium -If it tends to incline further away from upright position

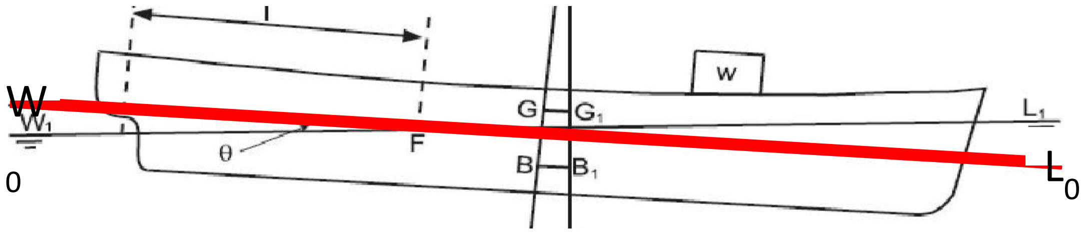
Stability - Perspectives

- Types of Stability considered
  - Transverse Stability
    - Stability about the X axis (Longitudinal Axis)
    - Port –Starboard (Athwartship) Direction
  - Longitudinal Stability
    - Stability about the Y axis (Longitudinal Axis)
    - Fore – Aft Direction



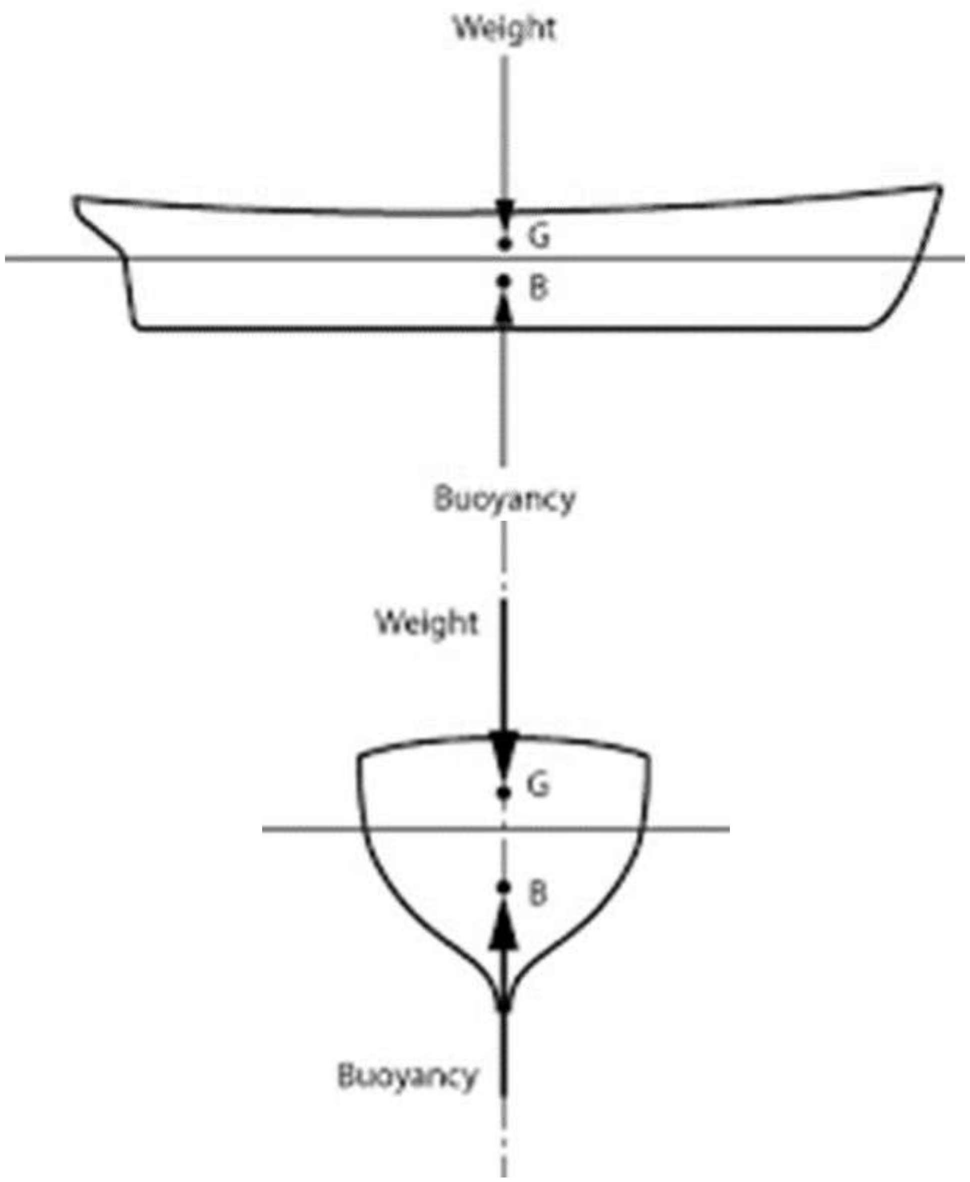
Coordinate system and reference axes of a conventional ship





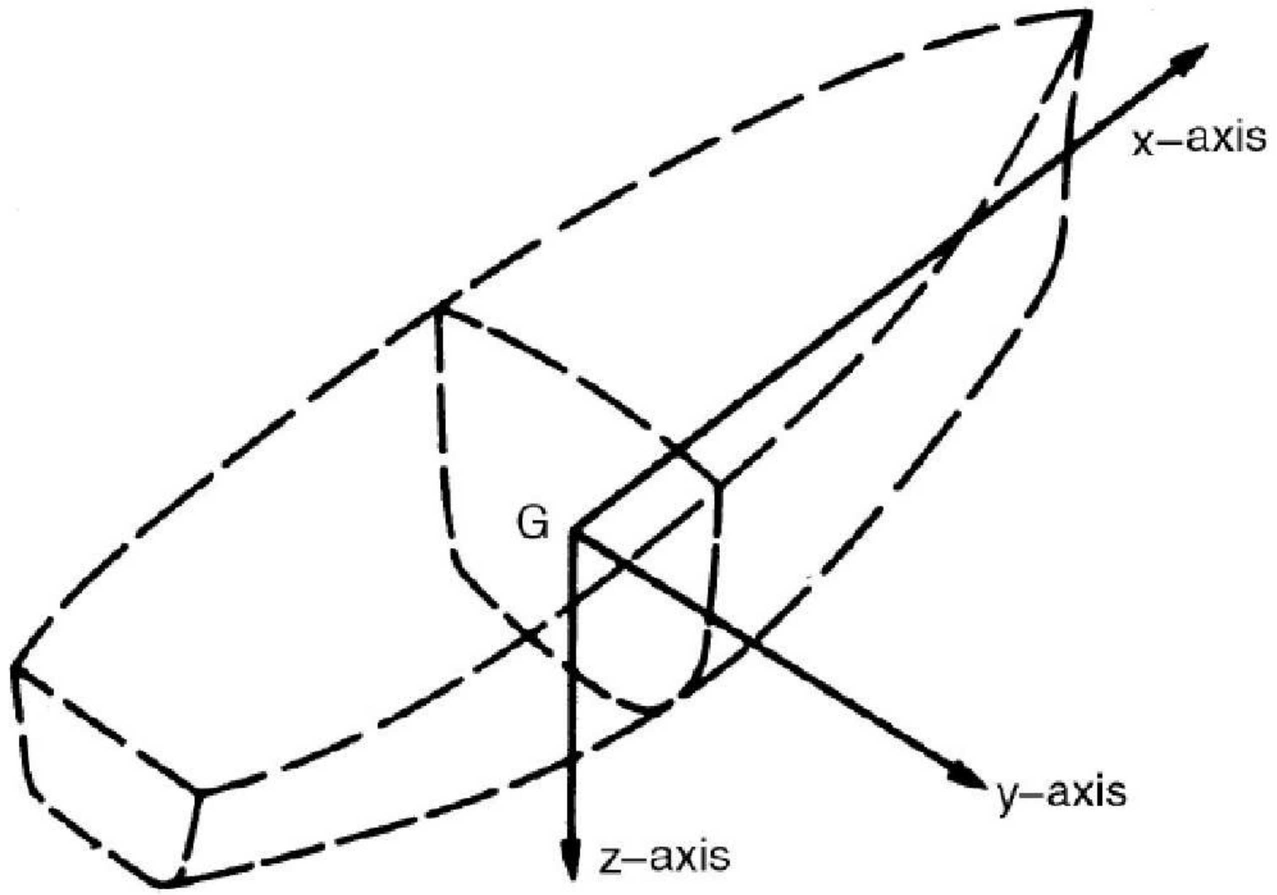
Initial state of Equilibrium of ship

- What are the 2 main forces acting on a ship
  - Weight of the ship(W) is assumed to be acting through the Centre of Gravity (G)
  - Buoyancy Force (b) assumed to be acting through the Centre of Buoyancy(B)
- For a ship to be floating in equilibrium..
  - Weight of the ship(w) has to be equal to the Buoyancy Force (b)
  - B and G have to be in the same vertical line
- Which is more likely to happen? Ship losing stability in the
  - Transverse Direction
  - Longitudinal Direction

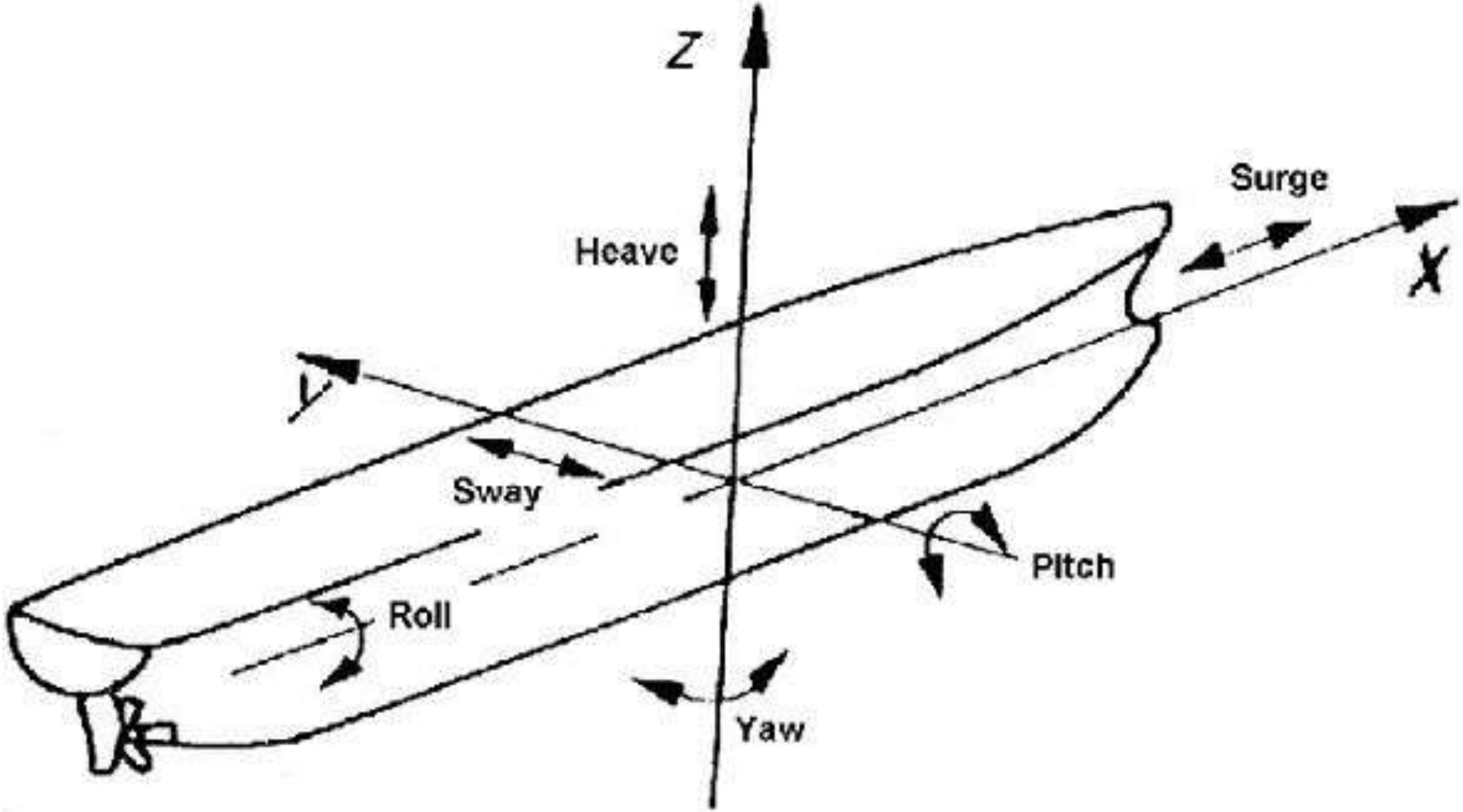


Ship Motions

Coordinate Axes



Degrees of Freedom of Motion

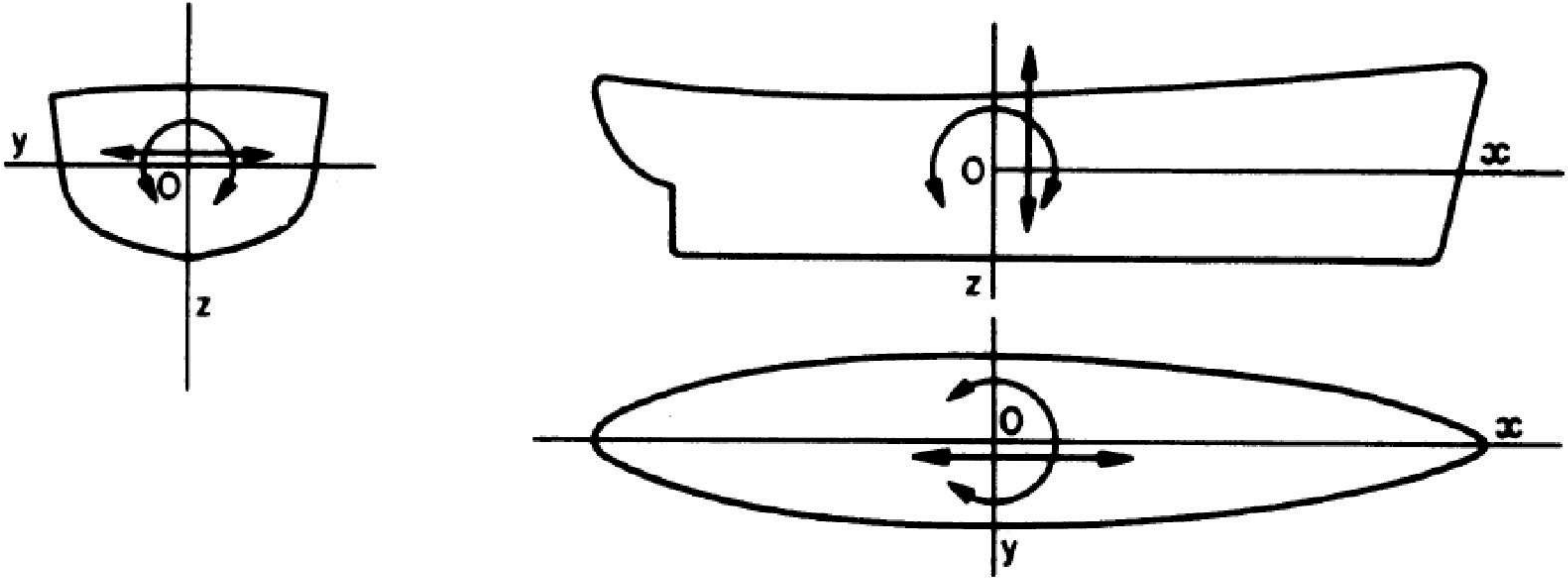


Ship Motions

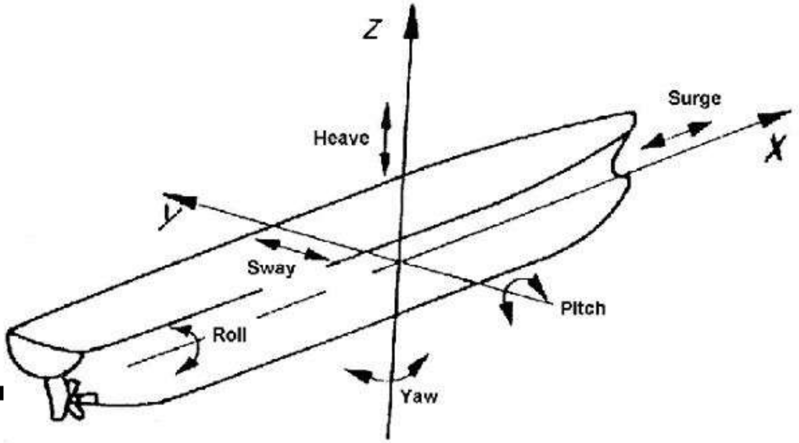
Axis	Translational	Rotational
X	Surge	Roll
Y	Sway	Pitch
Z	Heave	Yaw

- Heel / List
- Trim

Can you indicate the motions



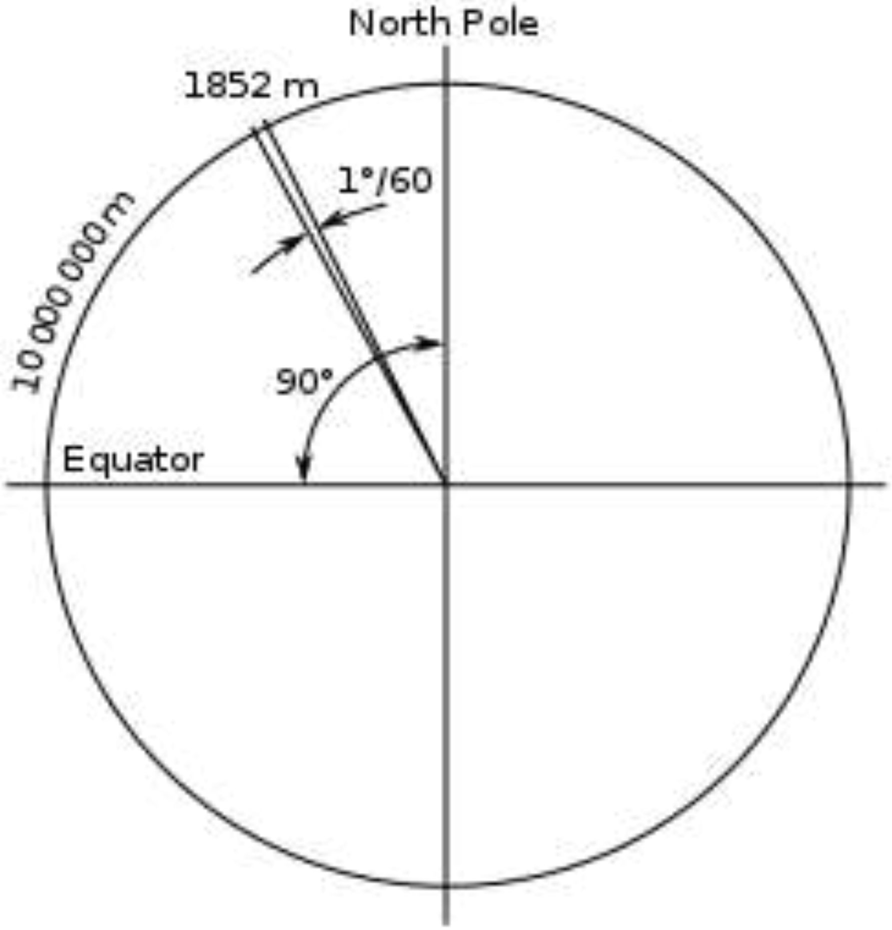
Summary of equilibrium conditions



Axis	Equilibrium condition for	
	Translation along:	Rotation about:
x	Neutral	Stable, neutral or unstable
y	Neutral	Stable, neutral or unstable
z	Stable	Neutral

Nautical Mile(NM)

- Unit of Length
- Used in air, space and marine navigation
- the meridian arc length corresponding to one minute (1/60 of a degree) of latitude.
- Represented by NM
- 1 NM = 1,852 metres (6,076 ft; 1.151 mi).



Knot (kn or kt)

- Unit of speed
- Used in air, space and marine navigation
- Speed equal to 1 nautical mile / hr (1NM/ hr)
- Represented as “kn” or “kt”
- 1kn = 1NM/ hr = 1.852 km/hr = 0.5144 m/s

END

- In case of any doubts you may contact me at

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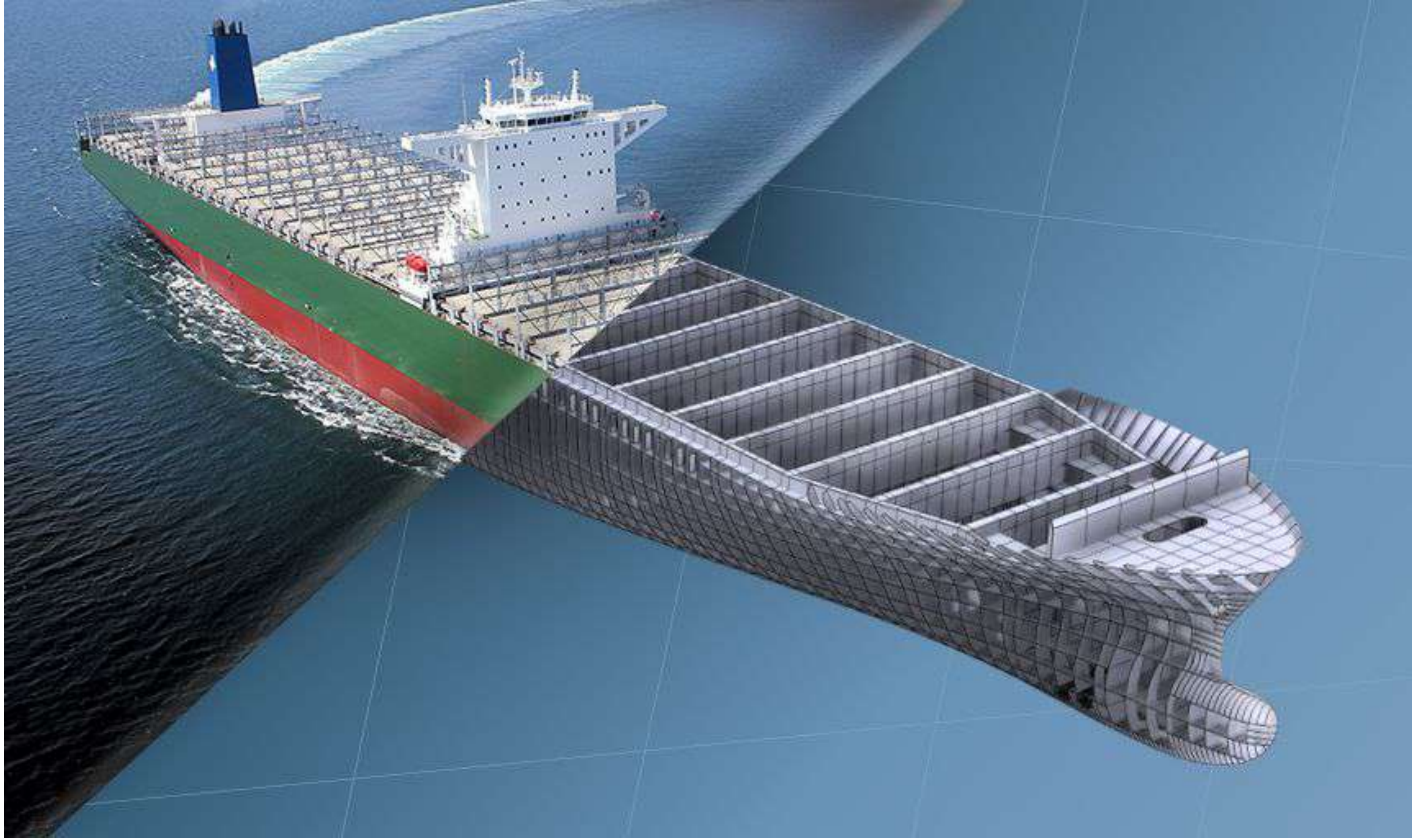


Introduction to Naval Architecture

II SEM –Module 2

When does draft change?

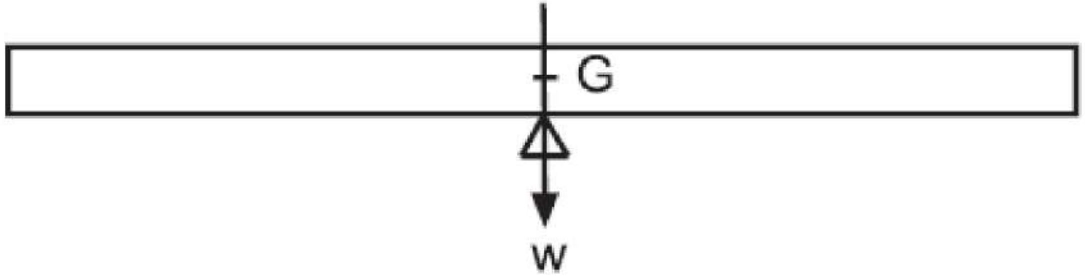
- When equilibrium between Weight and Buoyancy of ship is disturbed
- Shift of CoG. It can be caused by change in position of the Centre of Gravity or G of the ship. G will move if
  - Weight within the ship is SHIFTED
  - Weight is ADDED to the ship
  - Weight is REMOVED from the ship
- Shift of CoB It can be caused by change in position of Centre of Buoyancy. B will move if there is a change in submerged volume. It can happen when
  - There is change in density of the fluid in which the ship is floating
  - When submerged volume is breached
  - External force acting on the ship causing the ship to change immersed volume
- At times we need to examine hydrostatic properties in various loading conditions so as to make decisions.
- So based on change of loading, we need to predict the new draft to find the new hydrostatic properties

What is CoG

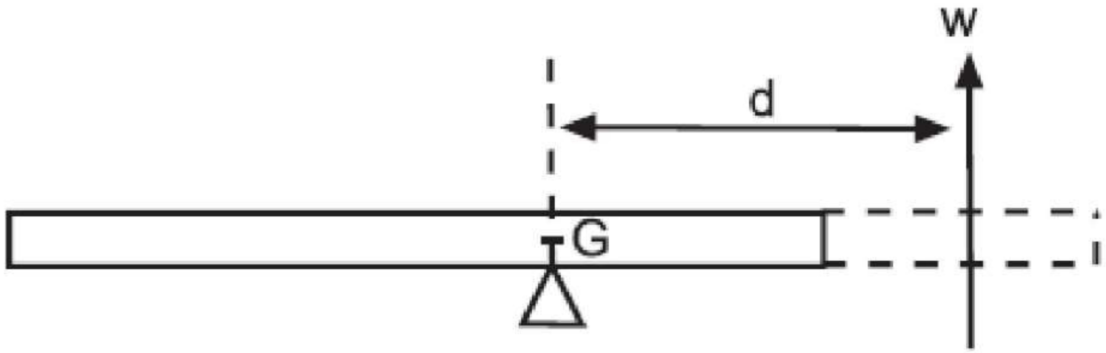
- Centre of Gravity (CoG)
- CoG of a body is the imaginary point through which all the mass of the body is assumed to be concentrated
- It is the imaginary point through which the force of gravity on a body mass is considered to act vertically downwards
- It is the point about which the body would balance its weight distribution

Shift of CoG – due to removal of weight

- CoG of a homogeneous body is its geometrical centroid
- Consider a homogeneous plank of Weight “W” acting through its CoG at G

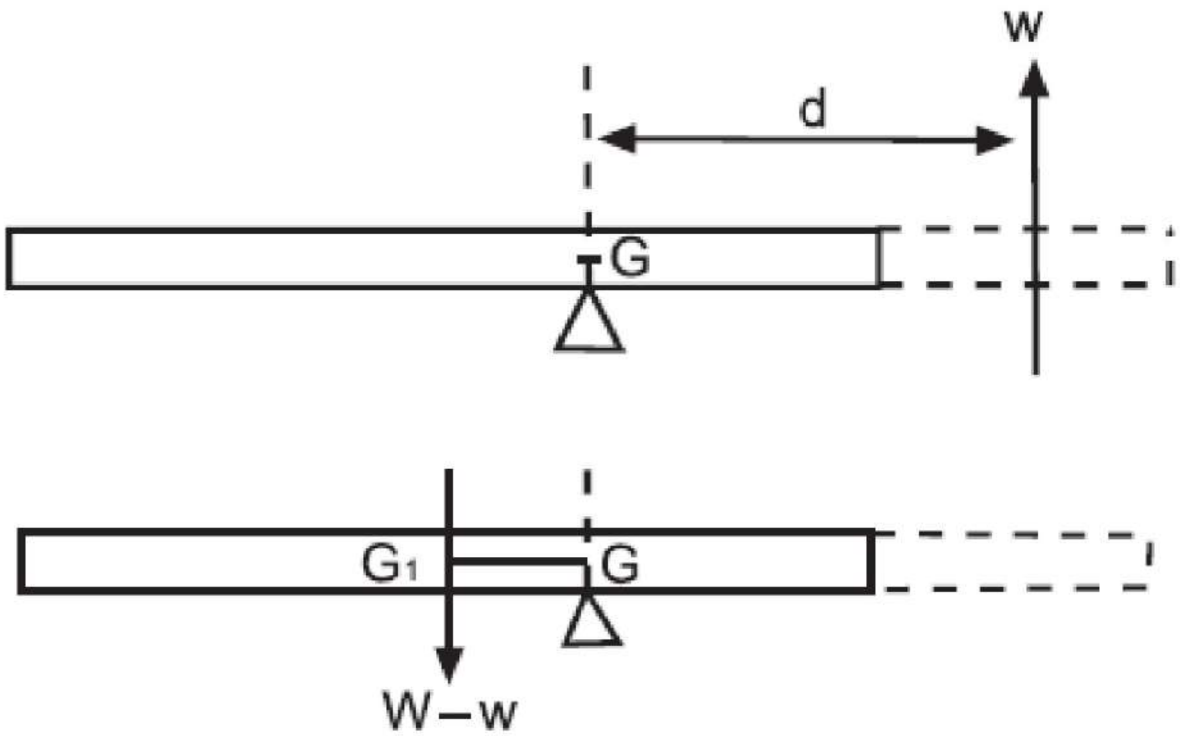


- If a short length of the plank of weight “w” with its CoG at a distance “d” from G, is cut out



Shift of CoG – due to removal of weight

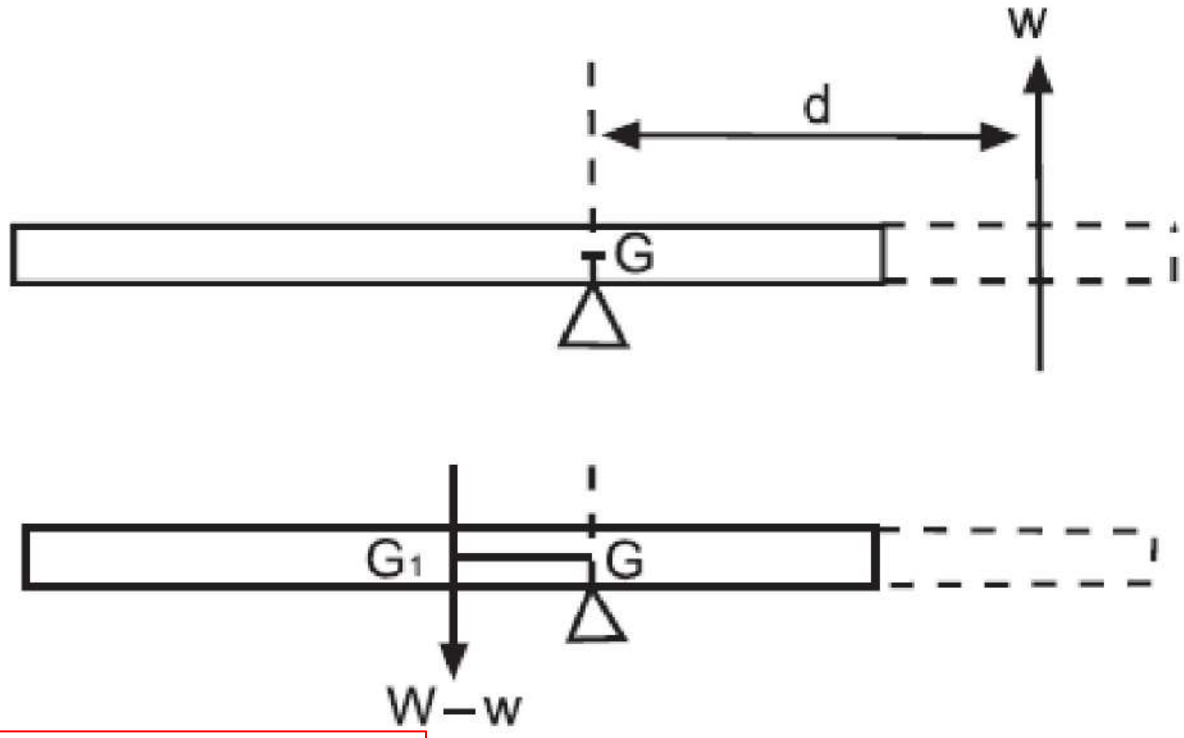
- Then G would shift to G_1 which is the geometrical centroid of the new shortened piece



- The weight of the shortened piece will be "(W-w)"

Shift of CoG – due to removal of weight

- To find the shift of CoG, i.e. GG_1 , let us take moments about G
- Moment caused by the removed piece is "(w x d)"
- Moment caused by the remaining piece is " (W-w) x GG_1 "
- But both moments are the same



$$(W - w) \times GG_1 = w \times d$$

$$GG_1 = \frac{w \times d}{W - w}$$

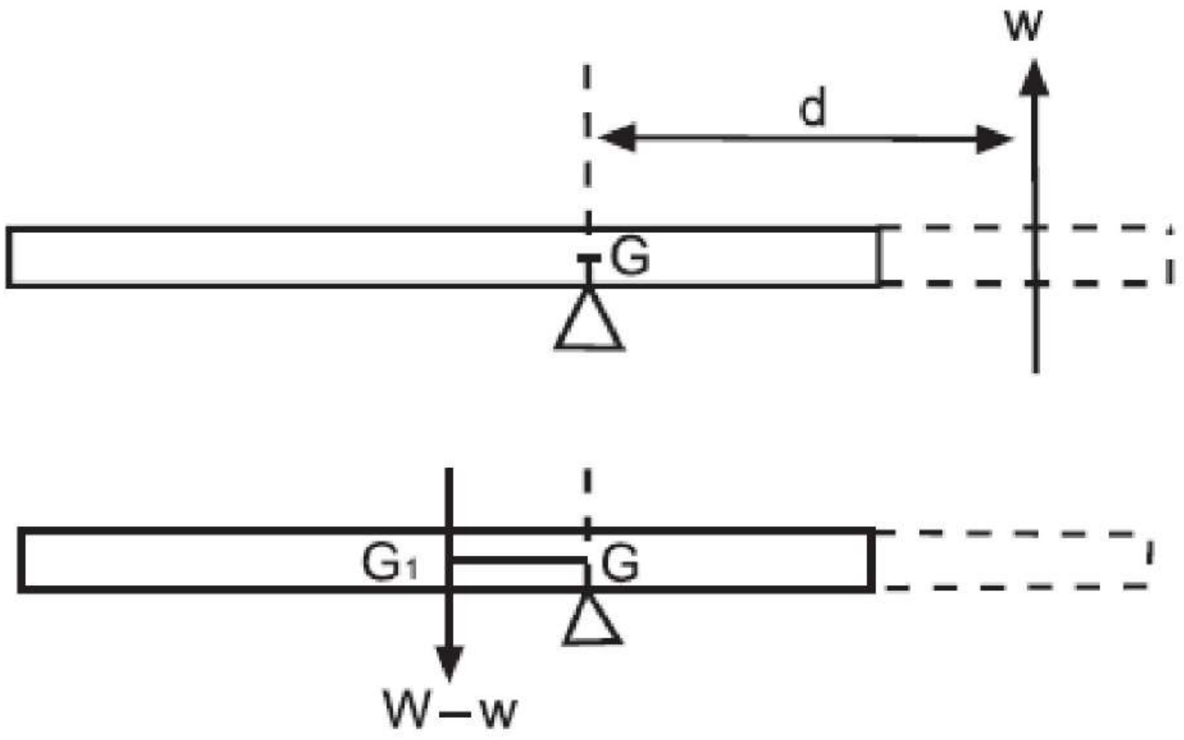
$$\boxed{GG_1 = \frac{w \times d}{\text{Final mass}}}$$

Shift of CoG – due to removal of weight

$$(W - w) \times GG_1 = w \times d$$

$$GG_1 = \frac{w \times d}{W - w}$$

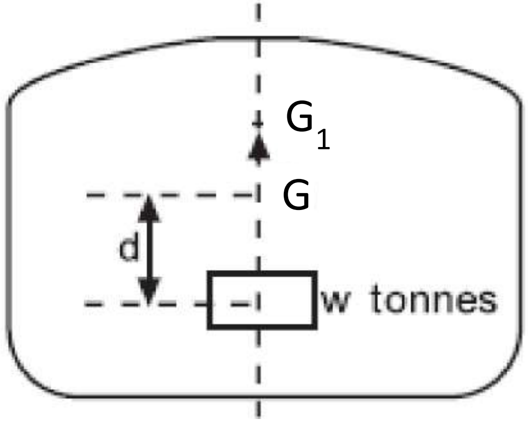
$$\boxed{GG_1 = \frac{w \times d}{\text{Final mass}}}$$



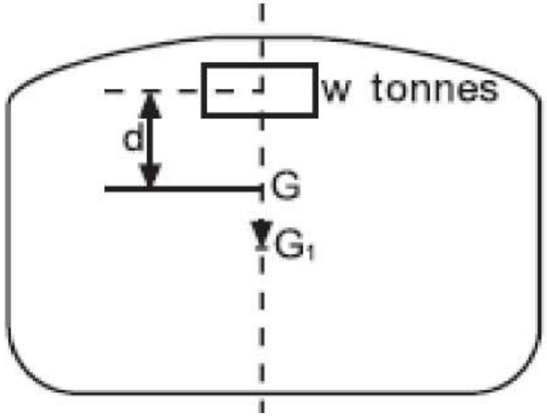
- When a weight is removed from a body
  - CoG of the body will move directly away from the CoG of the removed weight
  - Distance moved by CoG is found by dividing the moment (w x d) by the Final Weight of the body

Shift of CoG – due to removal of weight

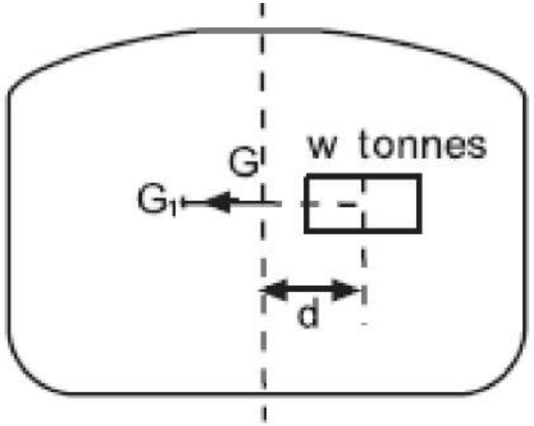
- In the case of a ship
  - When weight is removed from below G
    - G moves up



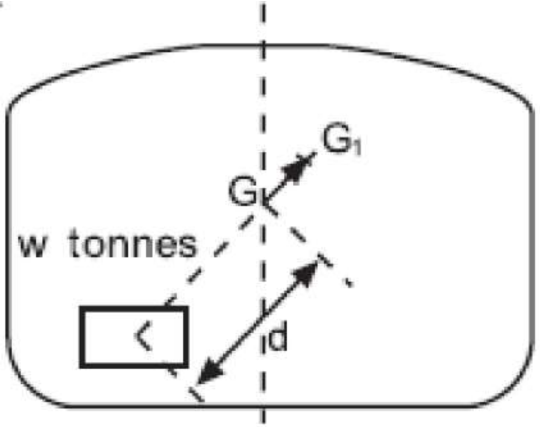
  - When weight is removed from above G
    - G moves down



  - When weight is removed from from side of G
    - G moves to opposite direction



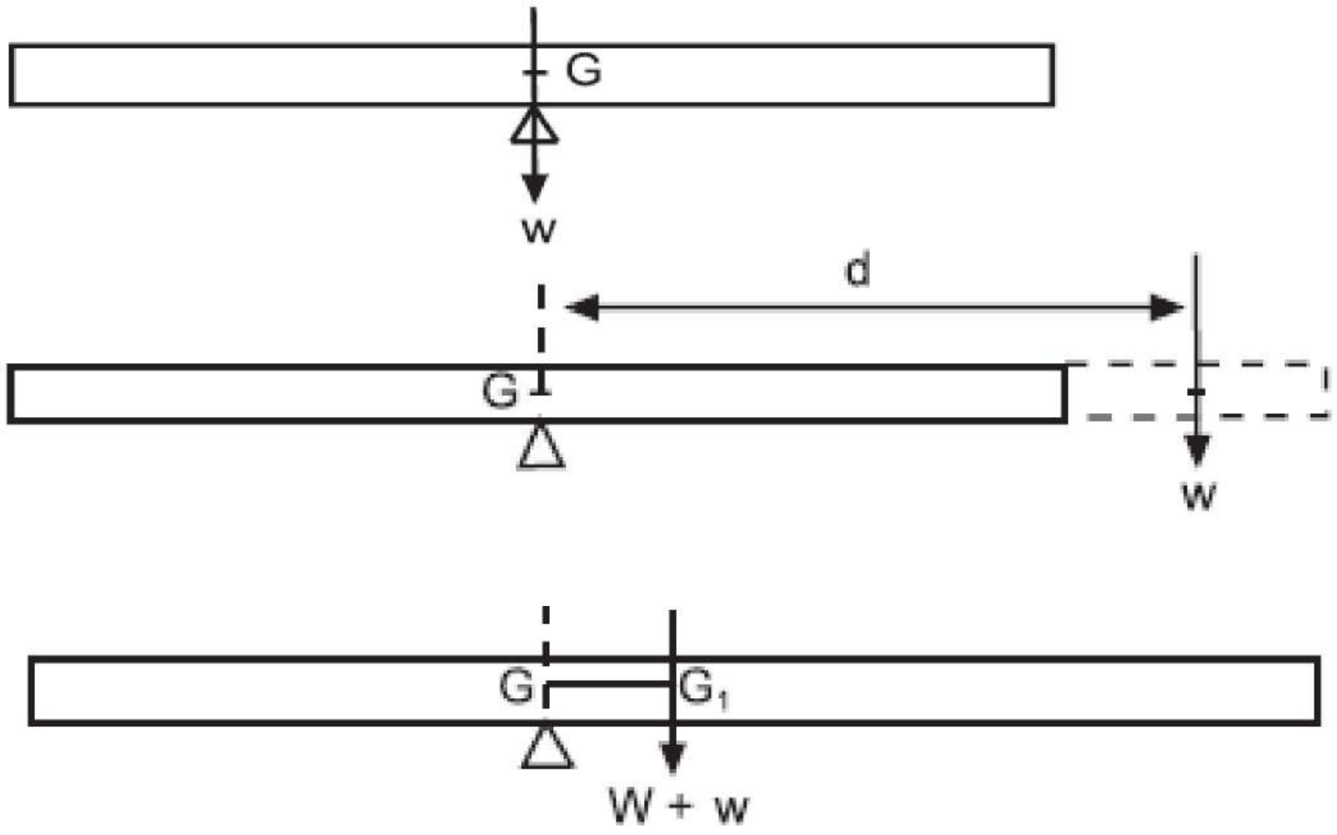
  - When weight is removed from a position diagonal to G



$$GG_1 = \frac{w \times d}{\text{Final displacement}}$$

Shift of CoG – due to addition of weight

- When a piece of plank is added, G would shift to G_1 which is the geometrical centroid of the new extended piece



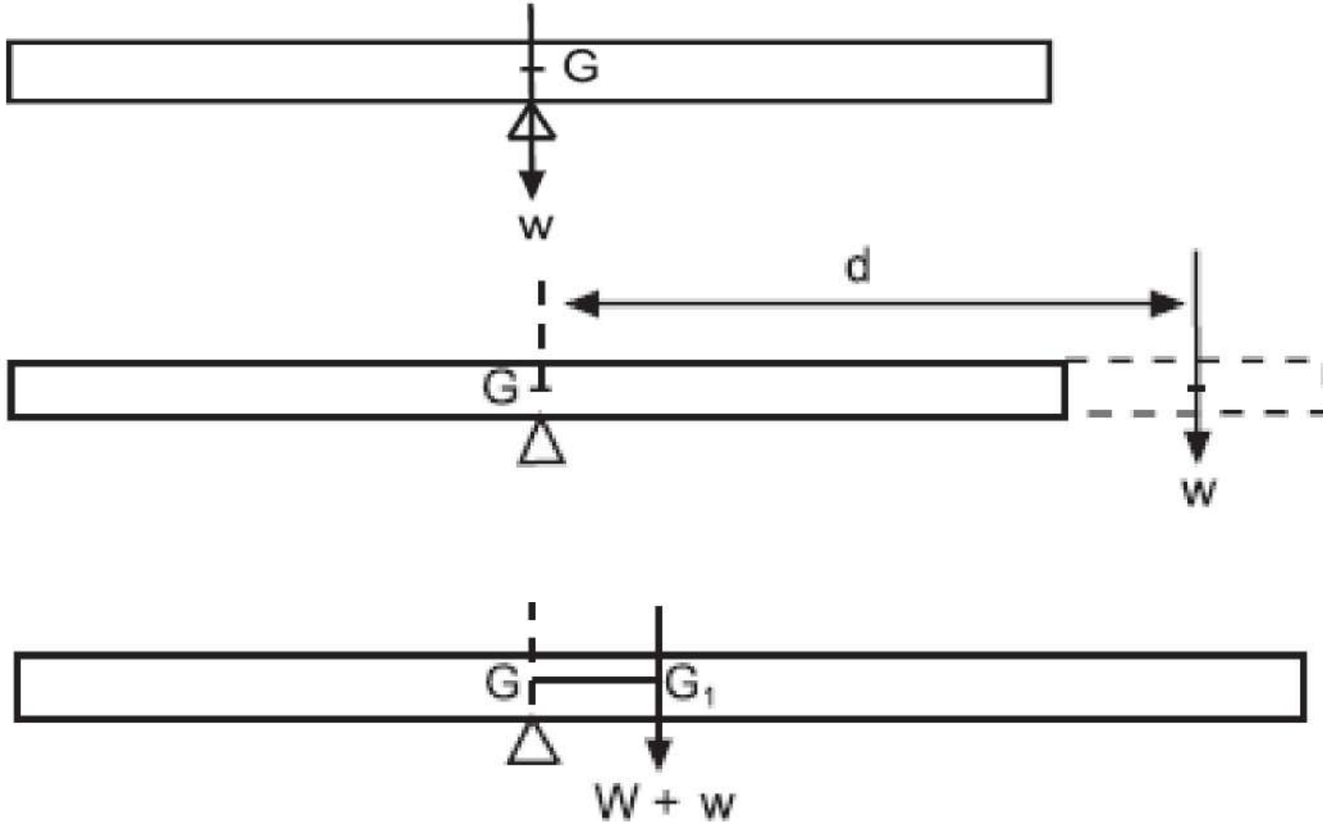
Shift of CoG – due to addition of weight

- The weight of the extended piece will be "(W+w)"
- Taking Moments about G , we get

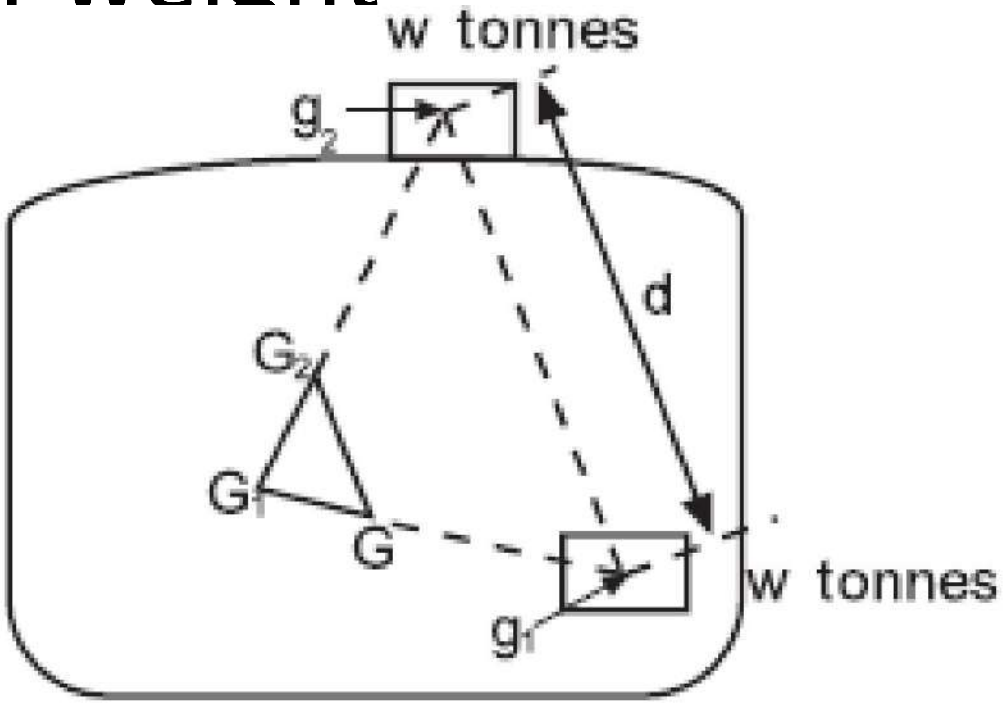
$$(W + w) \times GG_1 = w \times d$$

$$GG_1 = \frac{w \times d}{W + w}$$

$$GG_1 = \frac{w \times d}{\text{Final mass}}$$



Shift of CoG – due to Shifting of weight

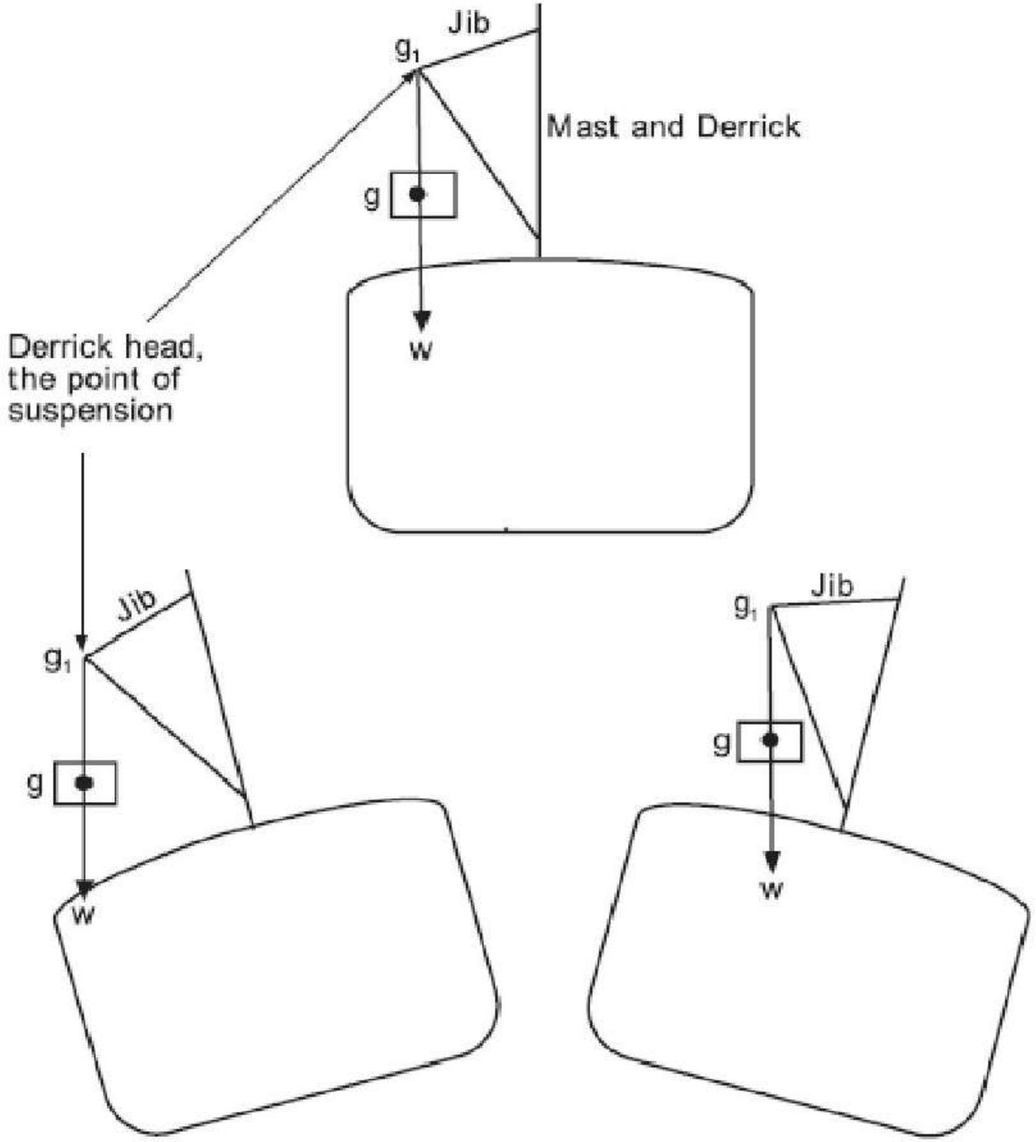


- CoG of Ship is at G
- A weight "w" is inside the ship with its CoG at g_1
- If the weight is taken out of the ship, G will move to G_1
- If the weight is again placed on the ship on the deck with its CoG at g_2 then the CoG of the ship will move from G_1 to G_2
- So if the weight is shifted from g_1 to g_2 , then CoG of the ship will shift from G to G_2
- GG_2 will be parallel to g_1 g_2
- Where W is the displacement of the ship

$$GG_2 = \frac{w \times d}{W}$$

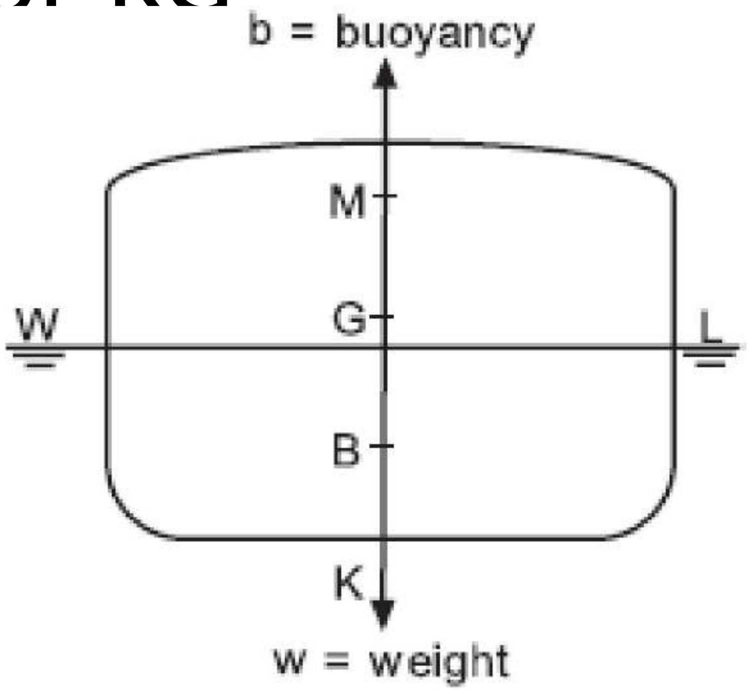
Shift of CoG – effect of suspended weight

- When a weight is suspended from any point in a ship
- Gravity force acting on the weight is considered to be acting vertically downwards through the point of suspension
- Centre of gravity of a suspended weight is considered to be at the point of suspension



Vertical Centre of Gravity (VCG) or KG

- VCG or KG is important to determine stability
- Consider that many weights are added, removed or shifted on a ship,
- To find KG.. It is easier to take moments about K



$$\text{Final KG} = \frac{\text{Final moment}}{\text{Final displacement}}$$

A ship of 6000 tonnes displacement has KG = 6 m. The following cargo is loaded:

1000 tonnes, KG 2.5 m

500 tonnes, KG 3.5 m

750 tonnes, KG 9.0 m

The following is then discharged:

450 tonnes of cargo KG 0.6 m

and 800 tonnes of cargo KG 3.0 m

Find the final KG.

A ship of 6000 tonnes displacement has KG = 6 m and KM = 7.33 m. The following cargo is loaded:

1000 tonnes, KG 2.5 m

500 tonnes, KG 3.5 m

750 tonnes, KG 9.0 m

The following is then discharged:

450 tonnes of cargo KG 0.6 m

and 800 tonnes of cargo KG 3.0 m

Find the final KG.

Weight	*KG*	*Moment about the keel*
+6000	6.0	+36 000
+1000	2.5	+2500
+500	3.5	+1750
+750	9.0	+6750
+8250		+47 000
−450	0.6	−270
−800	3.0	−2400
+7000		+44 330

$$\text{Final KG} = \frac{\text{Final moment}}{\text{Final displacement}}$$

$$= \frac{44\ 330}{7000} = 6.33\ \text{m}$$

Final KG = $\underline{6.33}$ m, as calculated

END

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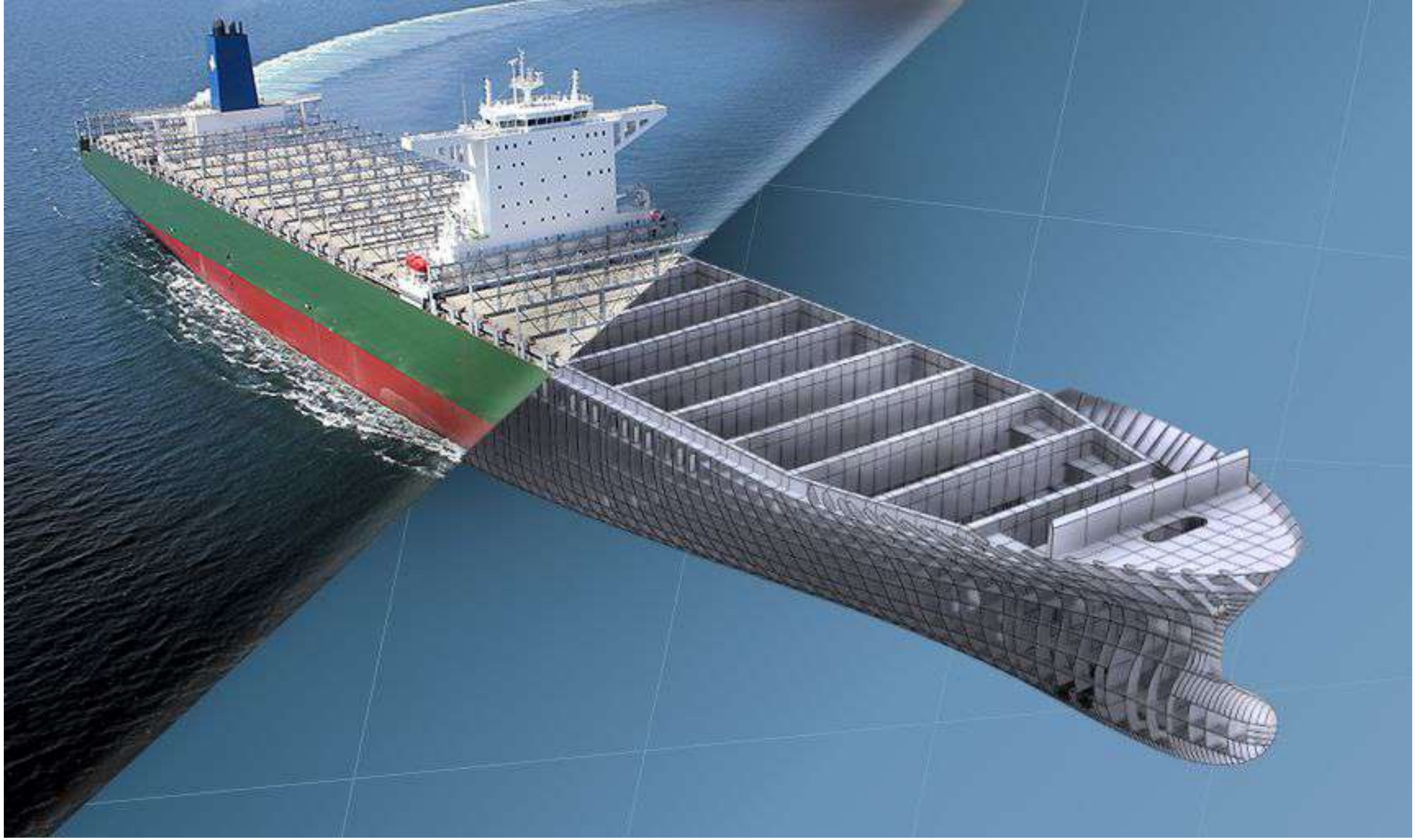


Introduction to Naval Architecture

II SEM –Module 2

Syllabus

2. **Module II**

   Introduction to ship geometry

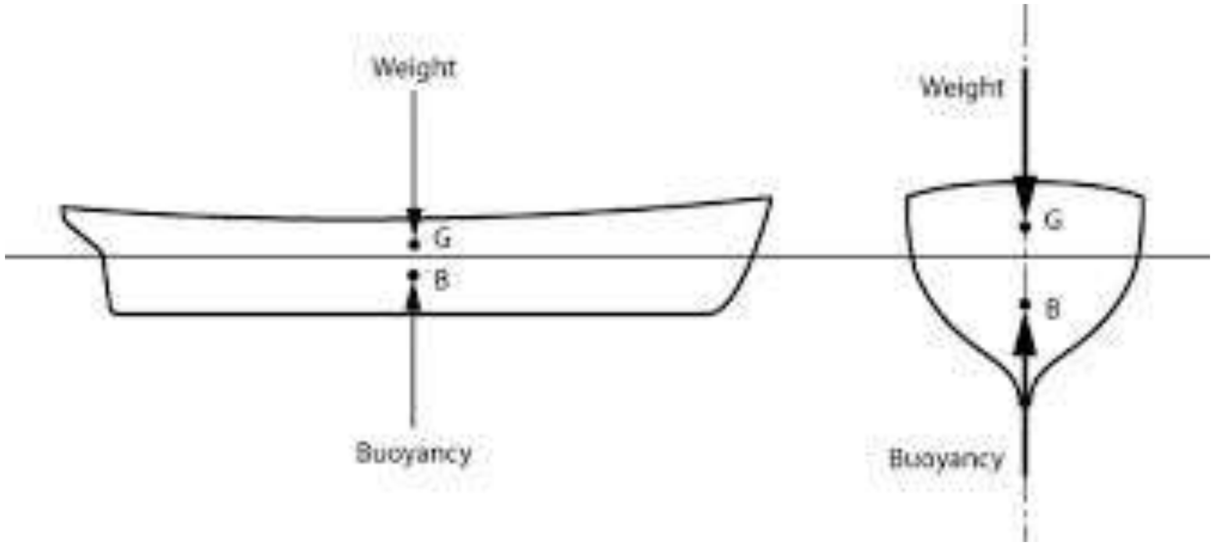
   Some physical fundamentals - Archimedes principle, laws of floatation stability and trim. The ship's form-main dimensions, lines plan, coefficients and their meaning, Fairing process and table of offsets; Hydrostatic particulars &Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF)

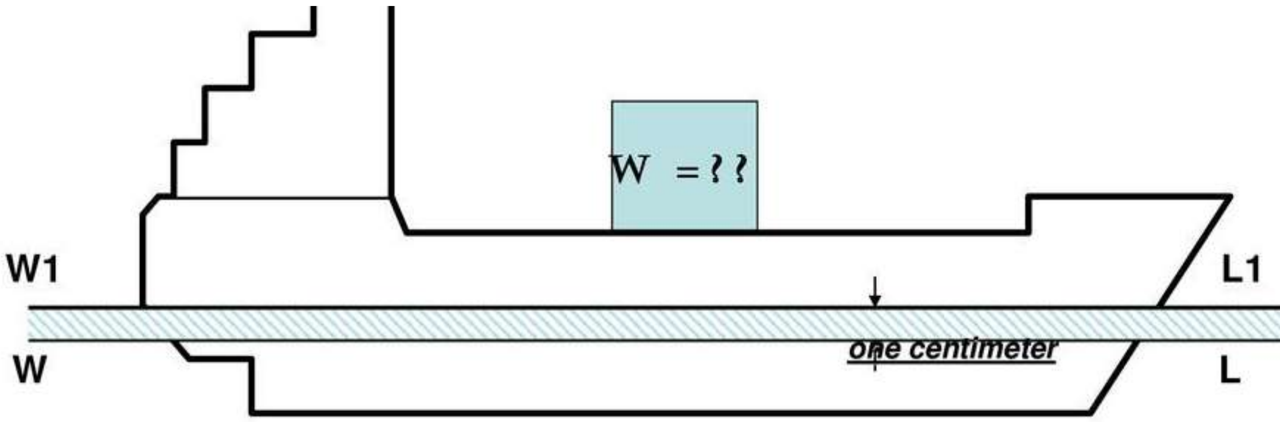
When does draft change?

- When equilibrium between Weight and Buoyancy of ship is disturbed
- Shift of CoG. It can be caused by change in position of the Centre of Gravity or G of the ship. G will move if
  - Weight within the ship is SHIFTED
  - Weight is ADDED to the ship
  - Weight is REMOVED from the ship
- Shift of CoB It can be caused by change in position of Centre of Buoyancy. B will move if there is a change in submerged volume. It can happen when
  - There is change in density of the fluid in which the ship is floating
  - When submerged volume is breached
  - External force acting on the ship causing the ship to change immersed volume
- At times we need to examine hydrostatic properties in various loading conditions so as to make decisions.
- So based on change of loading, we need to predict the new draft to find the new hydrostatic properties

TPC – Tonnes per Centimetre

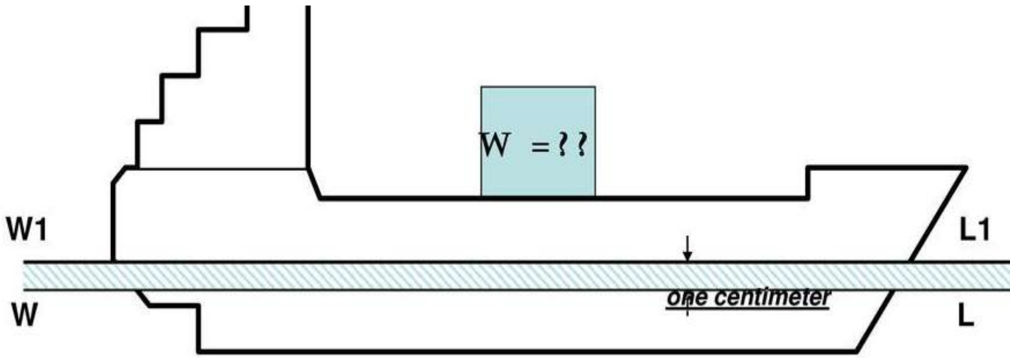
- For a ship to be floating at a given draft, Weight(W) = Buoyancy(B)
- When a weight is added to the ship, say at the Centre of Flotation for that draft…
- ..The ship will need to displace more volume, so it will sink deeper
- Knowing the amount of mass or weight required to increase or decrease the draft by a base value (say 1 cm) , is useful for loading unloading estimations





TPC – Tonnes Per Centimeter

- Consider a volume bounded by 2 waterplanes(W_1L_1 & WL), 1 cm apart and assuming both waterplanes to have same area since they are so close
- Volume = Area of waterplane (A_{WP}) x 1cm
- Mass = Volume x Density (of fluid in which the ship is floating)
- = Area of waterplane (A_{WP}) x 1cm x density
- TPC at any draft is the mass that must be loaded or discharged to change the ship's mean draft in salt water by 1 cm
- $TPC_{SW}(t) = A_{WP}(m^2) \times (1(m)/100) \times 1.025\ (t/m^3)$
- $TPC_{FW} = A_{WP} \times (1(m)/100) \times 1.0(t/m^3)$
- Unit of TPC – Tonnes
- Tonne force(tonnef) is also used, in which case it is multiplied by "g"



Change in Draft – due to change in Density

- Relative Density (RD) or Specific Gravity(SG)
- Mass Density is Mass per unit Volume
  - Mass density of Fresh Water (FW) = 1000 kg/m^3 = 1 ton/m^3
  - Mass density of Sea Water (SW) = 1025 kg/m^3 = 1.025 ton/m^3
- RD or SG

$$\text{SG or relative density of a substance} = \frac{\text{Density of the substance}}{\text{Density of fresh water}}$$

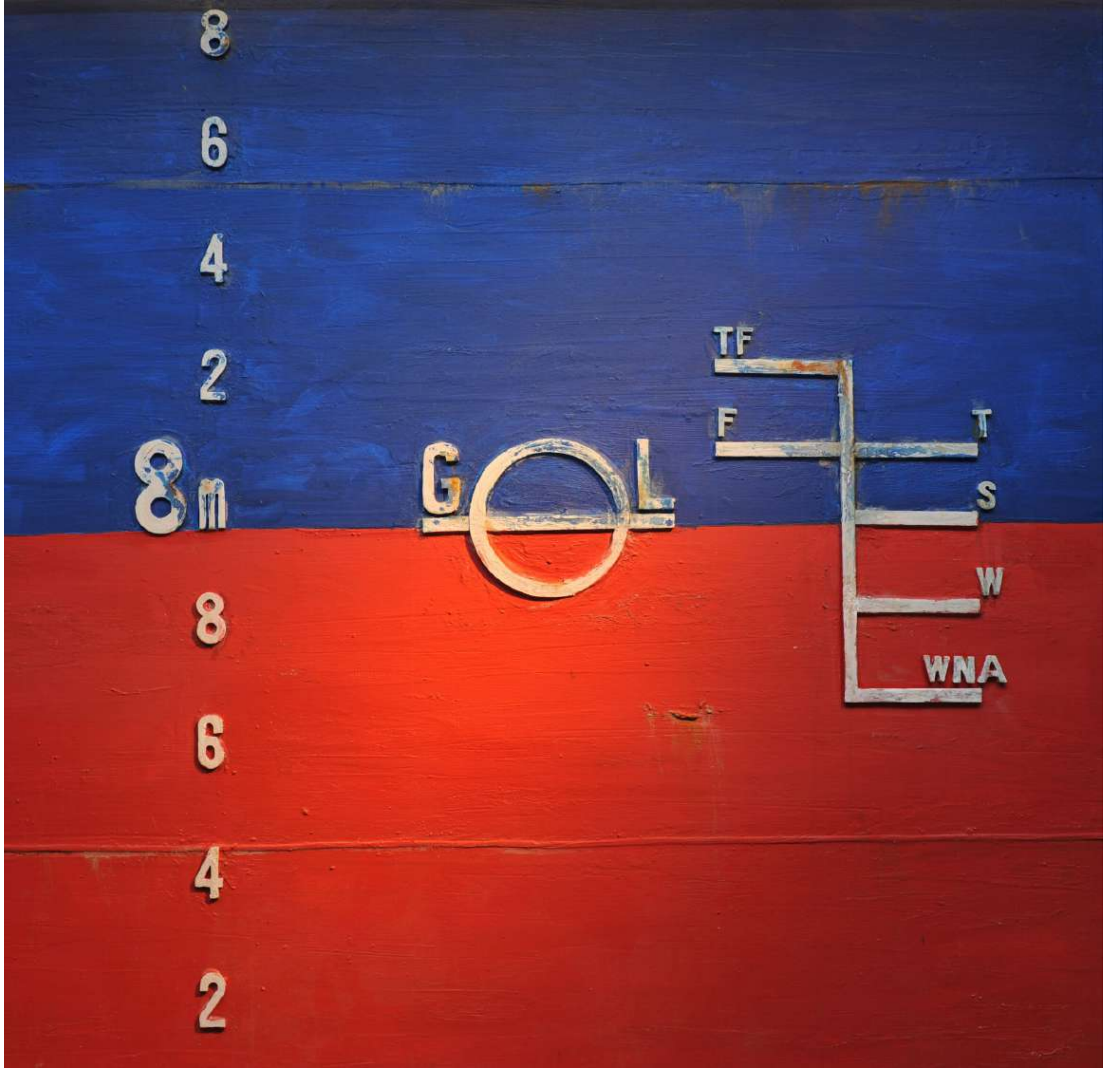
Find the density of a fuel oil whose relative density is 0.92

$$\begin{aligned} \text{Density in kg per cu. m} &= 1000 \times \text{SG} \\ &= 1000 \times 0.92 \\ \therefore \text{Density} &= 920\,\text{kg per cu. m} \end{aligned}$$

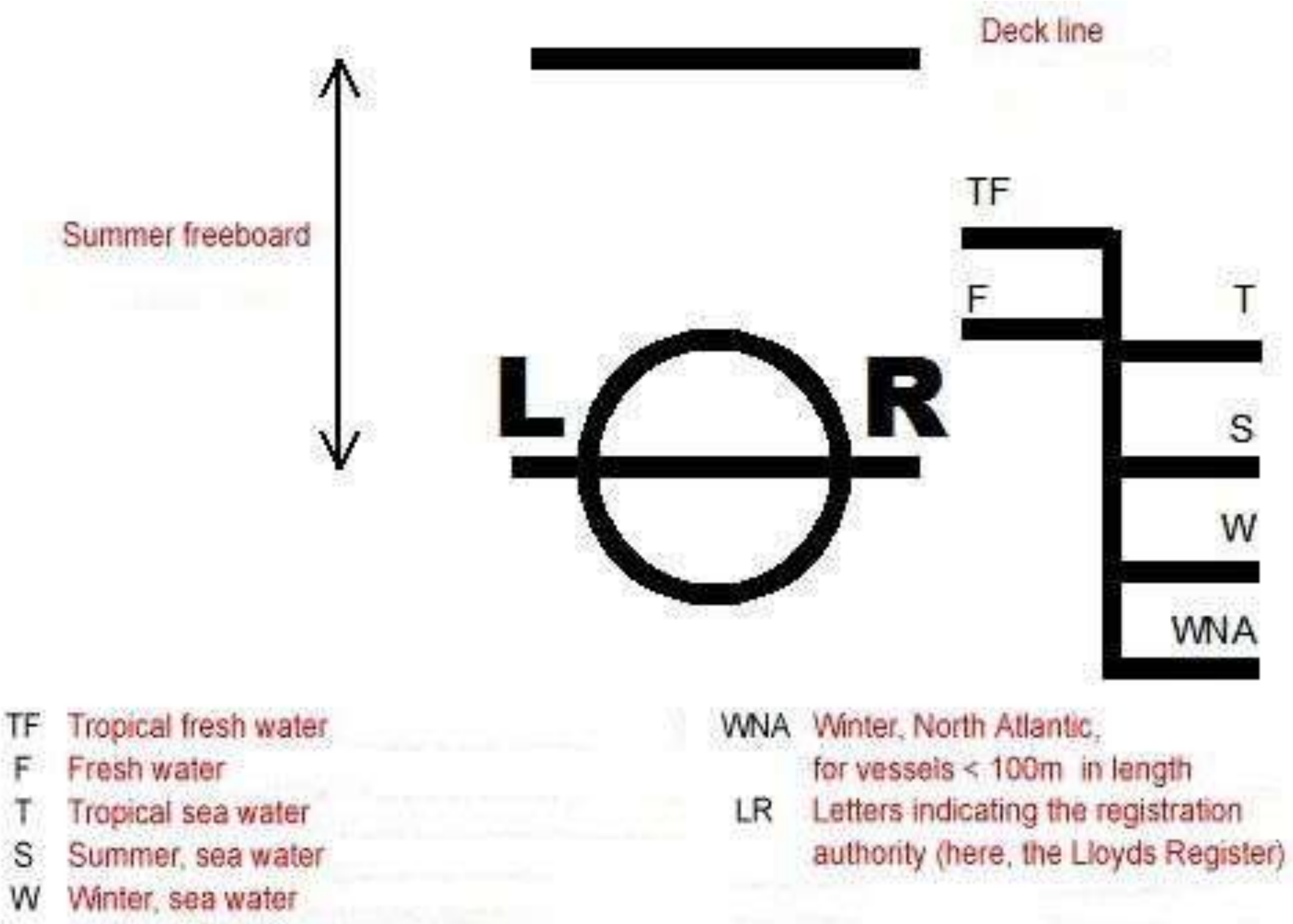
Change in Draft – due to change in Density

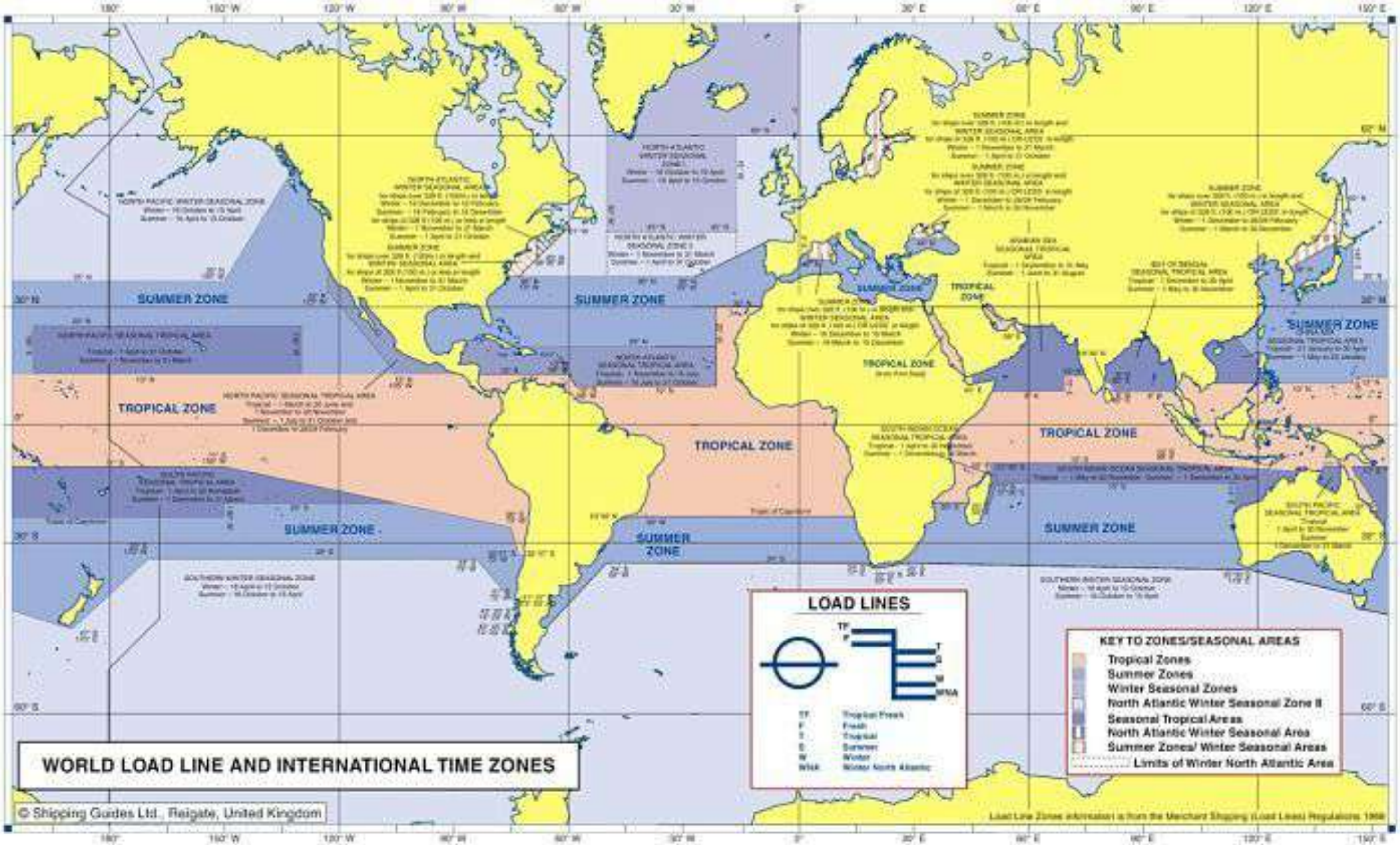
- When a ship moves between fluids of different densities, without any change in its mass..
- ..The Volume of displaced water will change because it has to displace the same mass
- The Mass of displaced water will NOT change (assuming no weight is added or removed from the ship
- When the submerged volume changes, the draft will also change
- When there is increase in density, i.e. When ship moves from FW (1 t/m^3) to SW (1.025 t/m^3), E,g River to Sea, lesser submerged volume is required to displace the same mass as that of the ship. Hence the draft reduces.
- When there is decrease in density, i.e. When ship moves from SW (1.025 t/m^3) to FW (1 t/m^3) , eg. Sea to river, more submerged volume is required to displace the same mass as that of the ship. Hence the draft increases

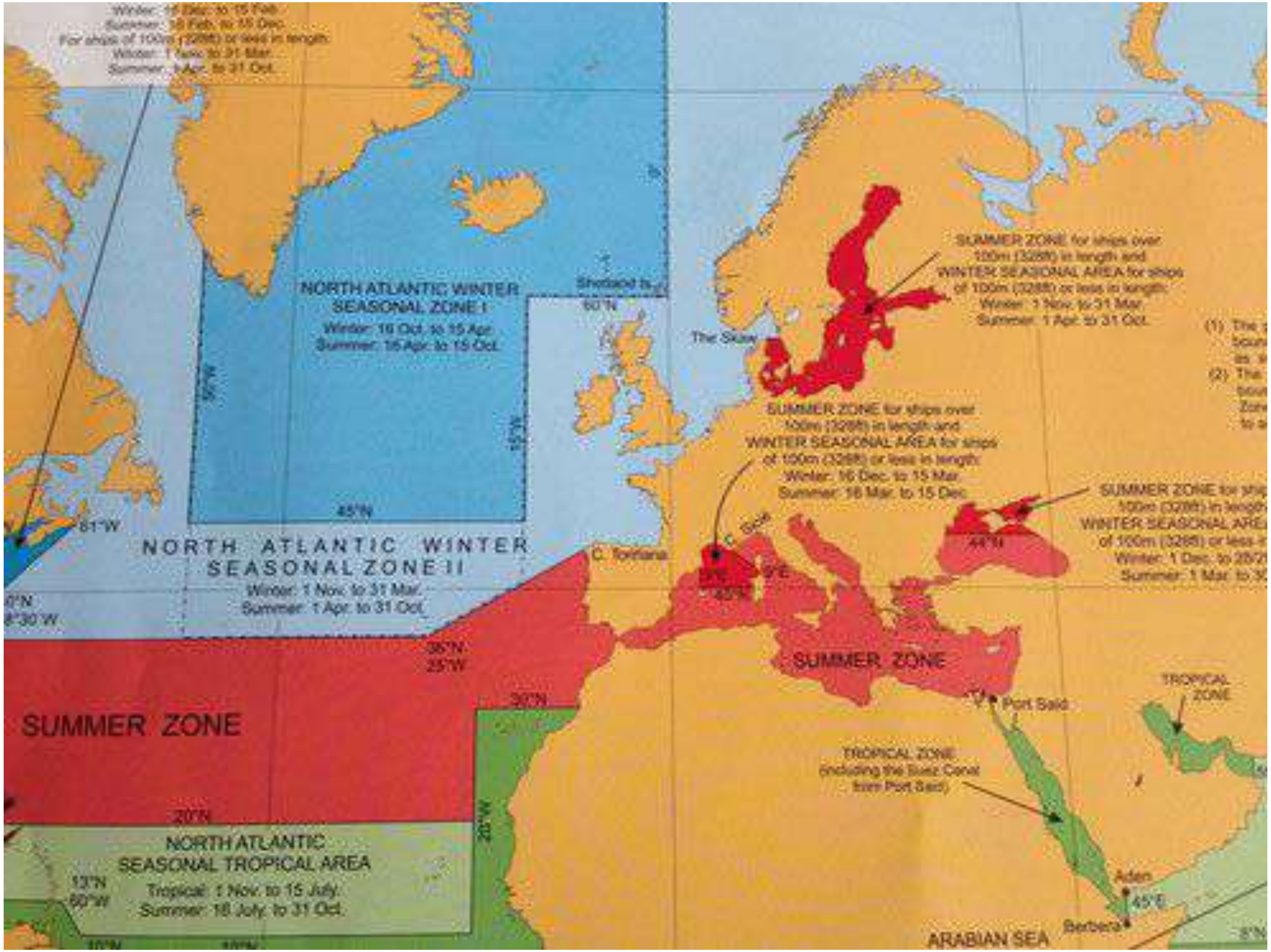
Load line Marking-Plimsoll Line /Marks



Plimsoll Mark



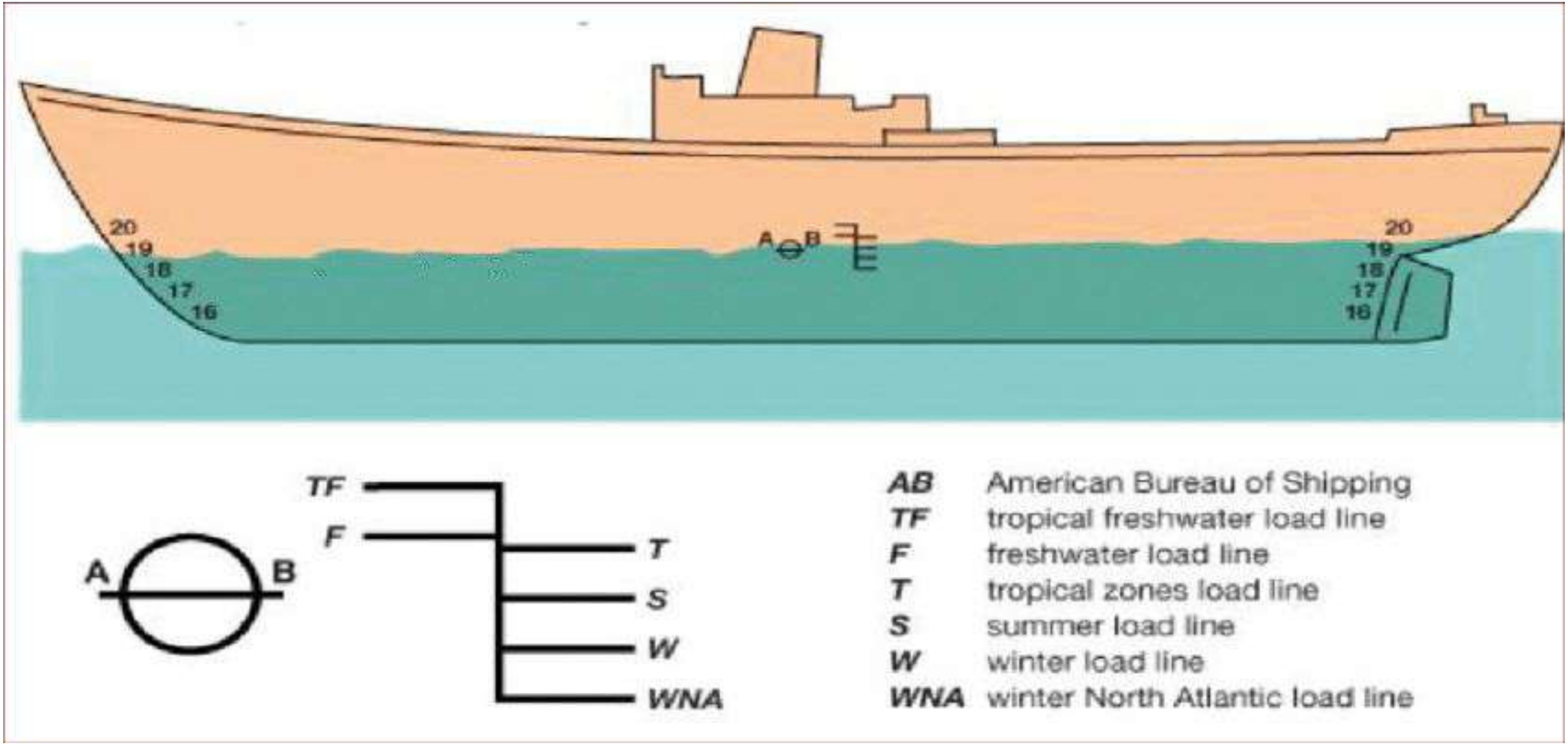

WORLD LOAD LINE AND INTERNATIONAL TIME ZONES
© Shipping Guides Ltd., Reigate, United Kingdom
SUMMER ZONE
SUMMER ZONE
SUMMER ZONE
TROPICAL ZONE
TROPICAL ZONE
TROPICAL ZONE
SUMMER ZONE
SUMMER ZONE
SUMMER ZONE
LOAD LINES
TF
F
T
S
W
WNA
KEY TO ZONES/SEASONAL AREAS
Tropical Zones
Summer Zones
Winter Seasonal Zones
North Atlantic Winter Seasonal Zone II
Seasonal Tropical Areas
North Atlantic Winter Seasonal Area
Summer Zones/ Winter Seasonal Areas
Limits of Winter North Atlantic Area



Winter: 16 Dec. to 15 Feb.
Summer: 16 Feb. to 15 Dec.
For ships of 100m (328ft) or less in length:
Winter: 1 Nov. to 31 Mar.
Summer: 1 Apr. to 31 Oct.
NORTH ATLANTIC WINTER SEASONAL ZONE I
Winter: 16 Oct. to 15 Apr.
Summer: 16 Apr. to 15 Oct.
Shetland Is.
60°N
50°N
15°W
45°N
61°W
NORTH ATLANTIC WINTER SEASONAL ZONE II
Winter: 1 Nov. to 31 Mar.
Summer: 1 Apr. to 31 Oct.
The Skaw
SUMMER ZONE for ships over 100m (328ft) in length and WINTER SEASONAL AREA for ships of 100m (328ft) or less in length:
Winter: 1 Nov. to 31 Mar.
Summer: 1 Apr. to 31 Oct.
SUMMER ZONE for ships over 100m (328ft) in length and WINTER SEASONAL AREA for ships of 100m (328ft) or less in length:
Winter: 16 Dec. to 15 Mar.
Summer: 16 Mar. to 15 Dec.
C. Toriñana
C. Sicié
9°E
43°N
44°N
35°N
25°W
30°N
SUMMER ZONE
SUMMER ZONE
20°N
20°W
NORTH ATLANTIC SEASONAL TROPICAL AREA
Tropical: 1 Nov. to 15 July.
Summer: 16 July. to 31 Oct.
13°N
60°W
Port Said
TROPICAL ZONE (including the Suez Canal from Port Said)
TROPICAL ZONE
Aden
45°E
Berbera
ARABIAN SEA

Plimsoll Mark –Zones

- **TF Tropical Fresh Water**: Tropical areas where the water is fresh (e.g. the Amazon River.)
- **F Fresh Water**: Areas where the water is fresh (e.g. parts of the St Lawrence Seaway and the Great Lakes of North America.)
- **T Tropical Sea Water** : Any area inside the tropics (e.g. a ship going from Nigeria to the Caribbean Sea will pass through tropical water.)
- **S Summer Sea Water**: Summer zones are marked on a special map of the world according to the general weather conditions experienced. The entire South African coast is a designated Summer Zone, even during winter!
- **W Winter Sea Water**: Winter zones are marked on a special map of the world. These are zones where stormy conditions can occur at particular times of the year.
- **WNA Winter North Atlantic Sea Water**: The northern part of the North Atlantic Ocean in winter and in some areas of the Southern Ocean. These are areas where severe stormy conditions are experienced regularly.



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WNA
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B
AB American Bureau of Shipping
TF tropical freshwater load line
F freshwater load line
T tropical zones load line
S summer load line
W winter load line
WNA winter North Atlantic load line


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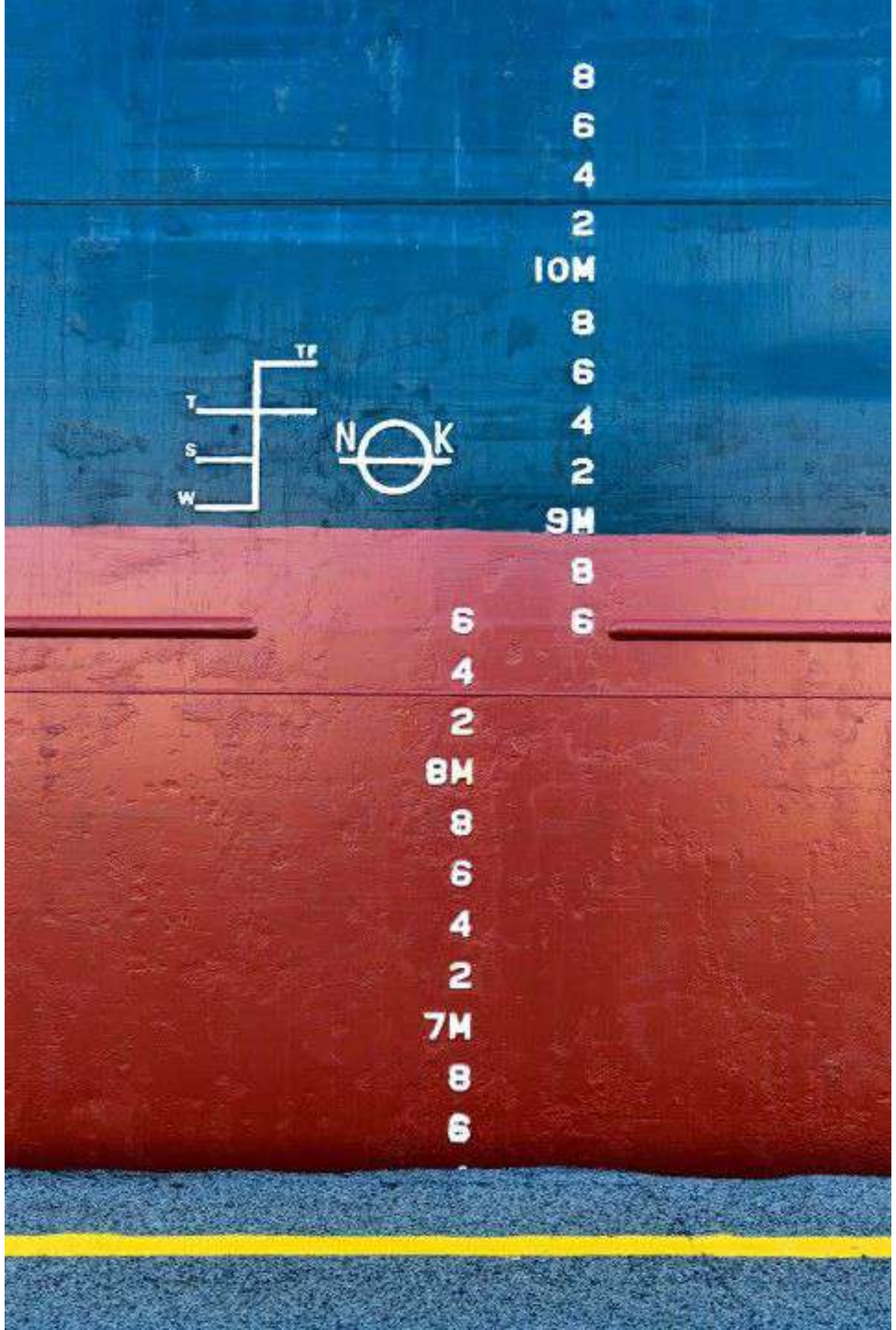
Plimsoll Marks



Change in Draft – due to change in Density

- To find the change in draft
  - For Box Shaped Vessels

$$\text{New mass of water displaced} = \text{Old mass of water displaced}$$

$$\therefore \text{New volume} \times \text{new density} = \text{Old volume} \times \text{Old density}$$

$$\frac{\text{New volume}}{\text{Old volume}} = \frac{\text{Old density}}{\text{New density}}$$

$$\text{But volume} = \text{L} \times \text{B} \times \text{draft}$$

$$\therefore \frac{\text{L} \times \text{B} \times \text{New draft}}{\text{L} \times \text{B} \times \text{Old draft}} = \frac{\text{Old density}}{\text{New density}}$$

$$\frac{\text{New draft}}{\text{Old draft}} = \frac{\text{Old density}}{\text{New density}}$$

Change in Draft – due to change in Density -Fresh Water Allowance (FWA)

- To find the change in draft
  - For Ship Shaped Vessels
    - a term called Fresh Water Allowance(FWA) is introduced
    - FWA is defined in millimetres
    - It is the change in mean draft when the ship passes from SW to FW or vice versa
    - If ship moves from FW to SW, FWA is deducted and vice cversa

$$\text{FWA (in mm)} = \frac{\text{Displacement (in tonnes)}}{4 \times \text{TPC}}$$

How to keep draft same when Density of the medium changes

- Requirement may exist to keep draft same when moving between different fluid densities
- Since draft is to be kept constant, submerged volume will have to be kept the same. Then the mass (or displacement) of the ship will need to be altered (increased or reduced) by loading or discharging cargo or ballast water

$$\text{New volume of water displaced} = \text{Old volume of water displaced}$$

$$\frac{\text{New displacement}}{\text{New density}} = \frac{\text{Old displacement}}{\text{Old density}}$$

$$\frac{\text{New displacement}}{\text{Old displacement}} = \frac{\text{New density}}{\text{Old density}}$$

- Find the new displacement . Its difference with old displacement is the mass that needs to be added or removed , to maintain same draft

A ship of 6400 tonnes displacement is floating in salt water. The ship has to proceed to a berth where the density of the water is 1008 kg per cu. m. Find how much cargo must be discharged if she is to remain at the salt water draft.

$$\frac{\text{New displacement}}{\text{Old displacement}} = \frac{\text{New density}}{\text{Old density}}$$

$$\text{New displacement} = \text{Old displacement} \times \frac{\text{New density}}{\text{Old density}}$$

$$= 6400 \times \frac{1008}{1025}$$

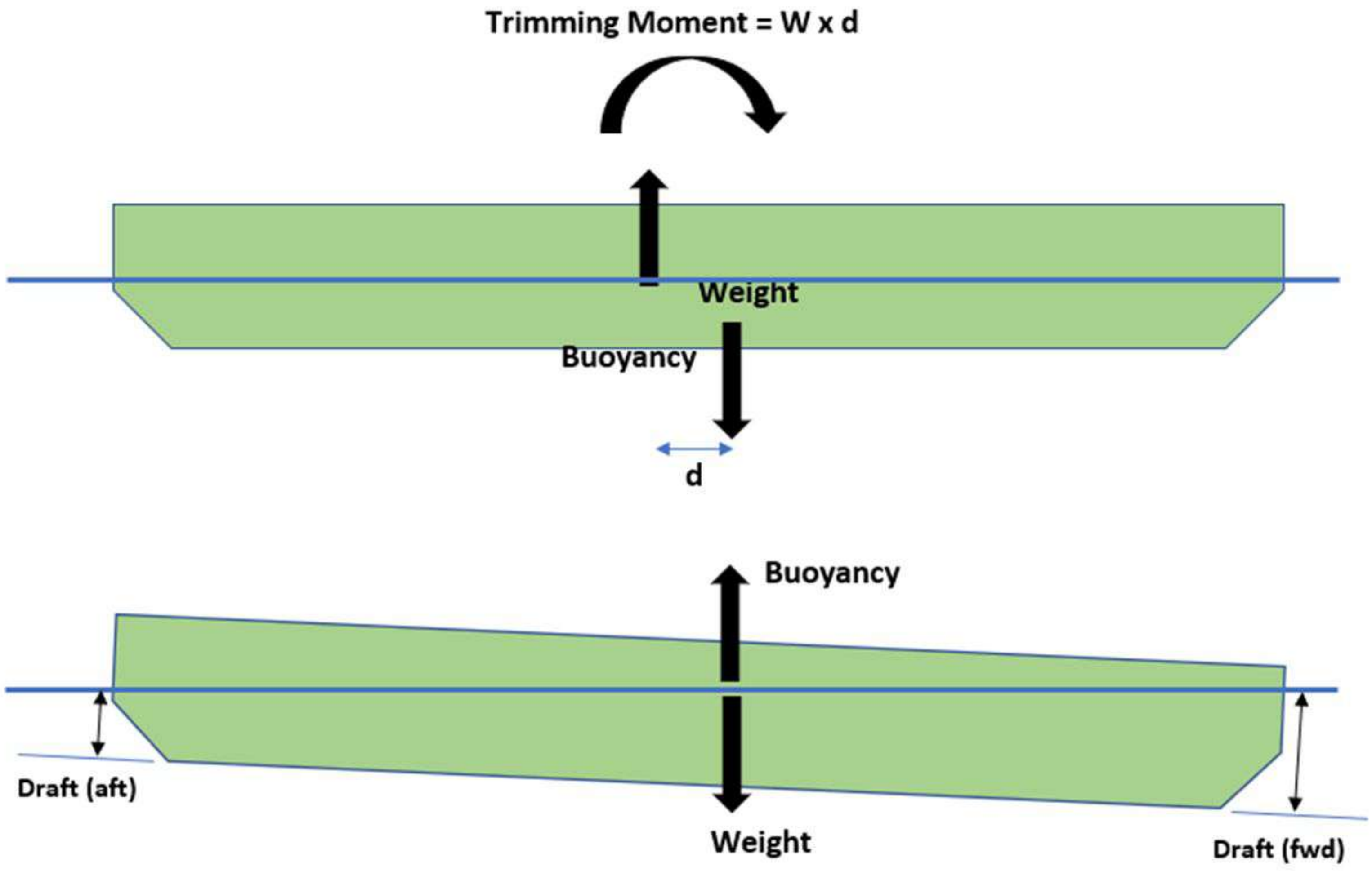
$$\text{New displacement} = 6293.9 \text{ tonnes}$$

$$\text{Old displacement} = 6400.0 \text{ tonnes}$$

$$\underline{\text{Cargo to discharge} = 106.1 \text{ tonnes}}$$

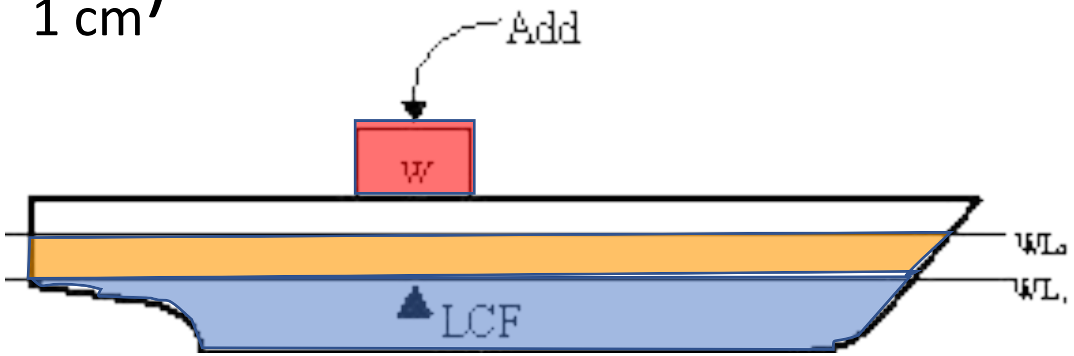
MCT_{1cm} - Moment to Change Trim by 1 cm

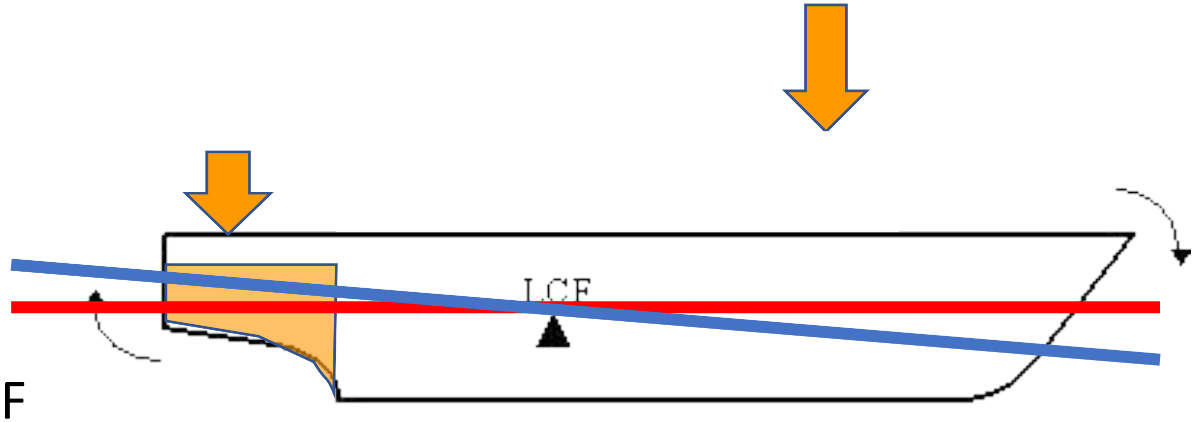
- If G and B are not in the same vertical line (Longitudinally)
- A Trimming moment is created
- How much will be the trim ?
- What will be the drafts, forward and aft?



Moment to Change Trim by 1 cm (MCT $_{1\ cm}$)

- TPC gives us the weight that we need to add or remove from the ship to increase or decrease the draft
- At times, after loading or unloading of a ship, we may find that the ship is having a trim by forward or aft.
- To correct the trim, weight needs to be shifted, added or removed such that it creates a moment that will correct the trim
- If we know how much moment is required to trim by an elemental value, say, 1cm then
- We can calculate the moment required for any amount of trim and accordingly,
- The ship trims about the Centre of Flotation(CoF)
- Identify a tank or space on deck where a weight can be removed, added or shifted. Find distance from CoF and the weight of liquid or solid. Then check whether it will generate the required moment
- Then shift, add or remove the weight to achieve the desired correction to trim





FWD Trimming Moment

END

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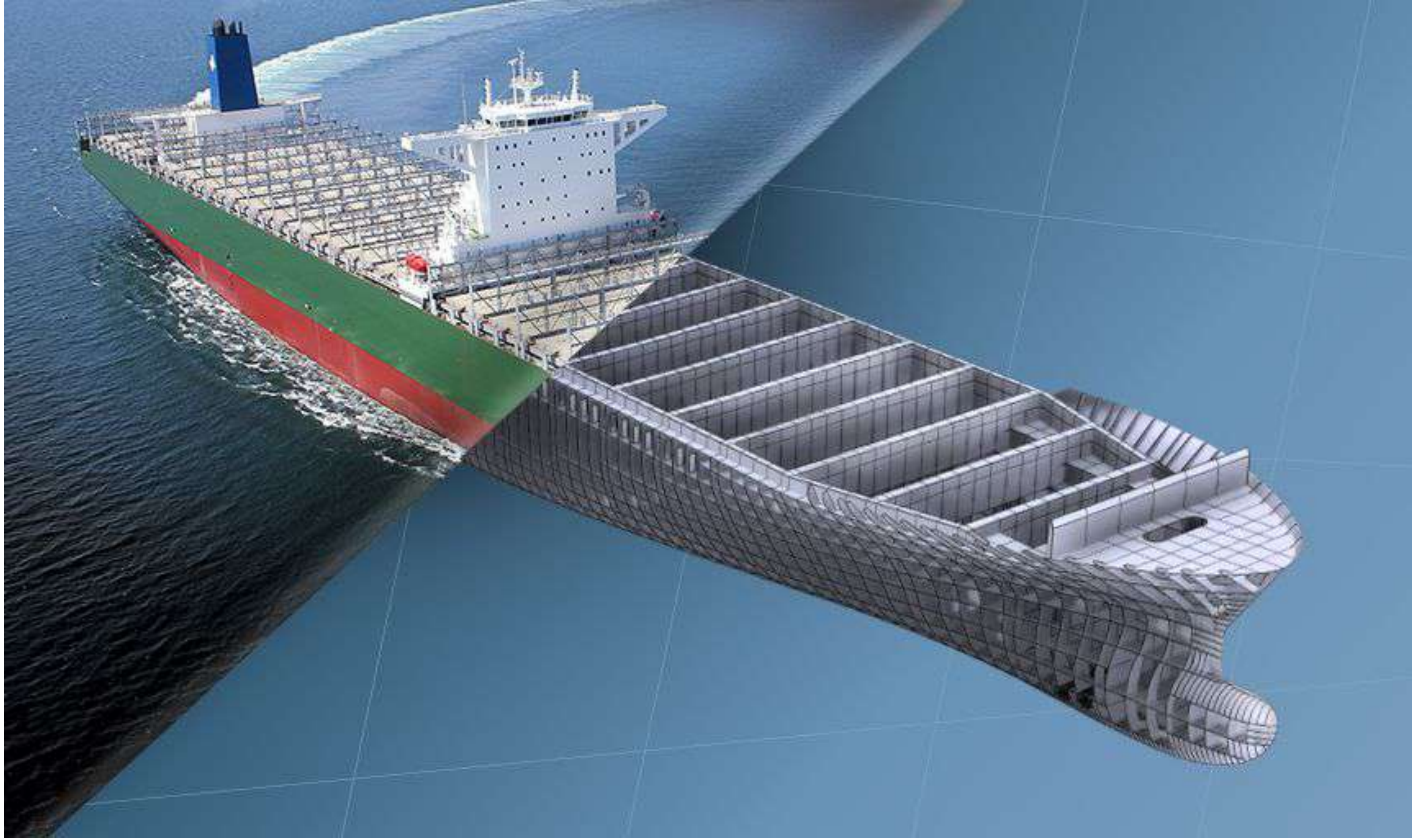
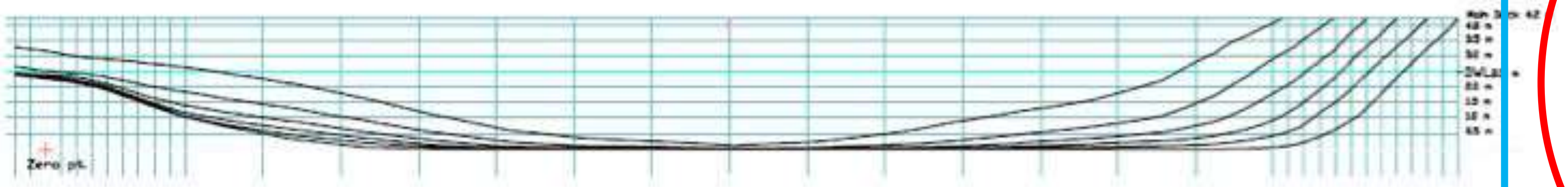
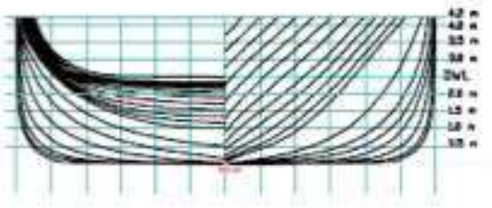


Introduction to Naval Architecture

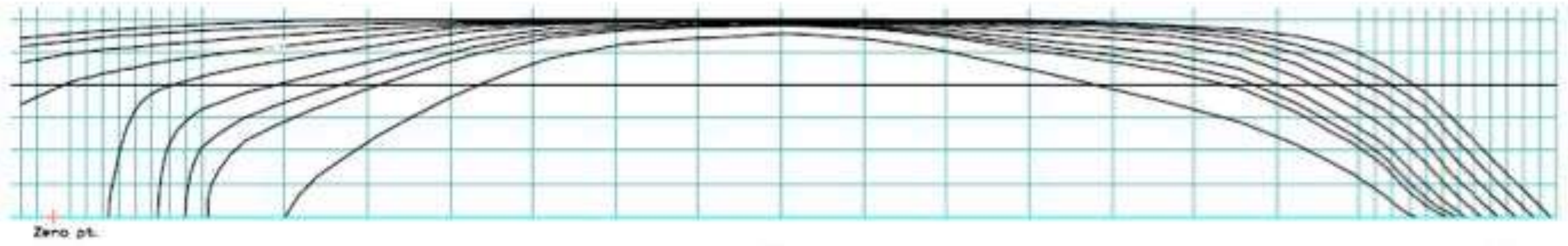
II SEM –Module 3



SHEER PLAN
(PROFILE)

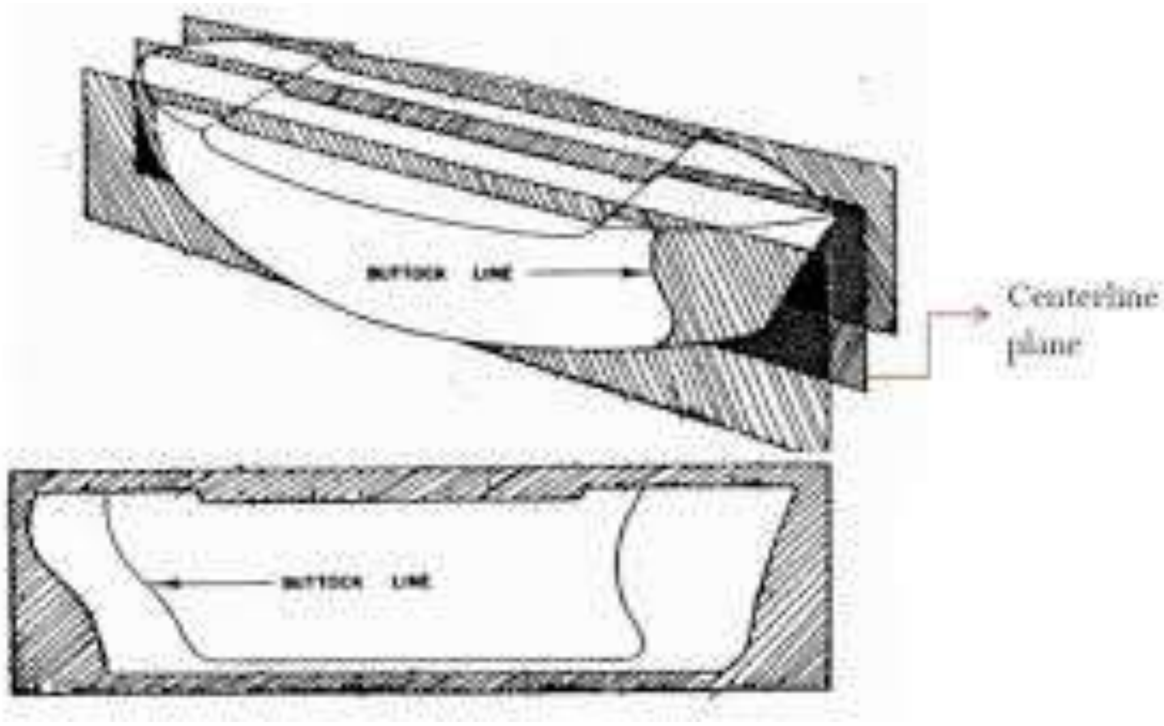


BODY PLAN



HALF BREADTH PLAN

Sheer Plan (Profile)

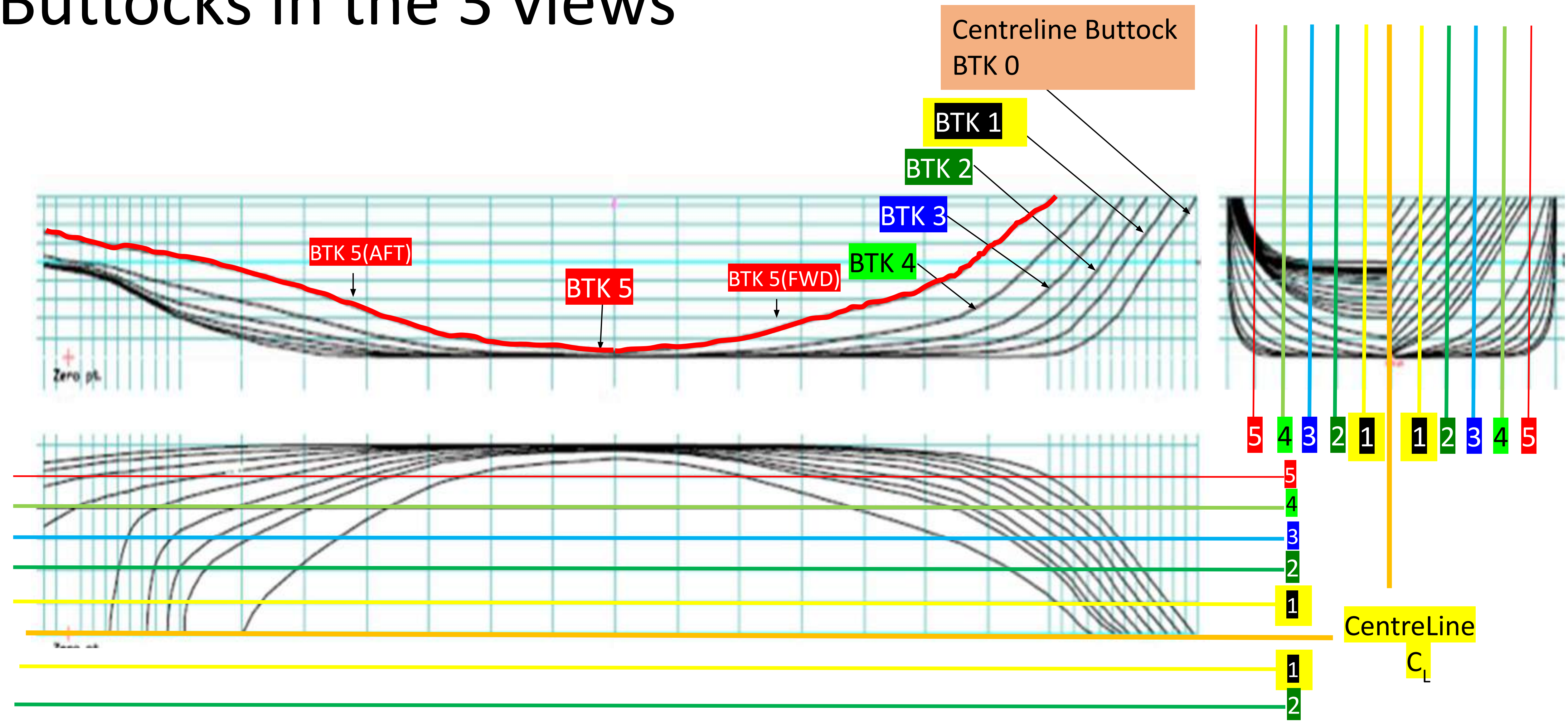


Can we use the offset table to draw?

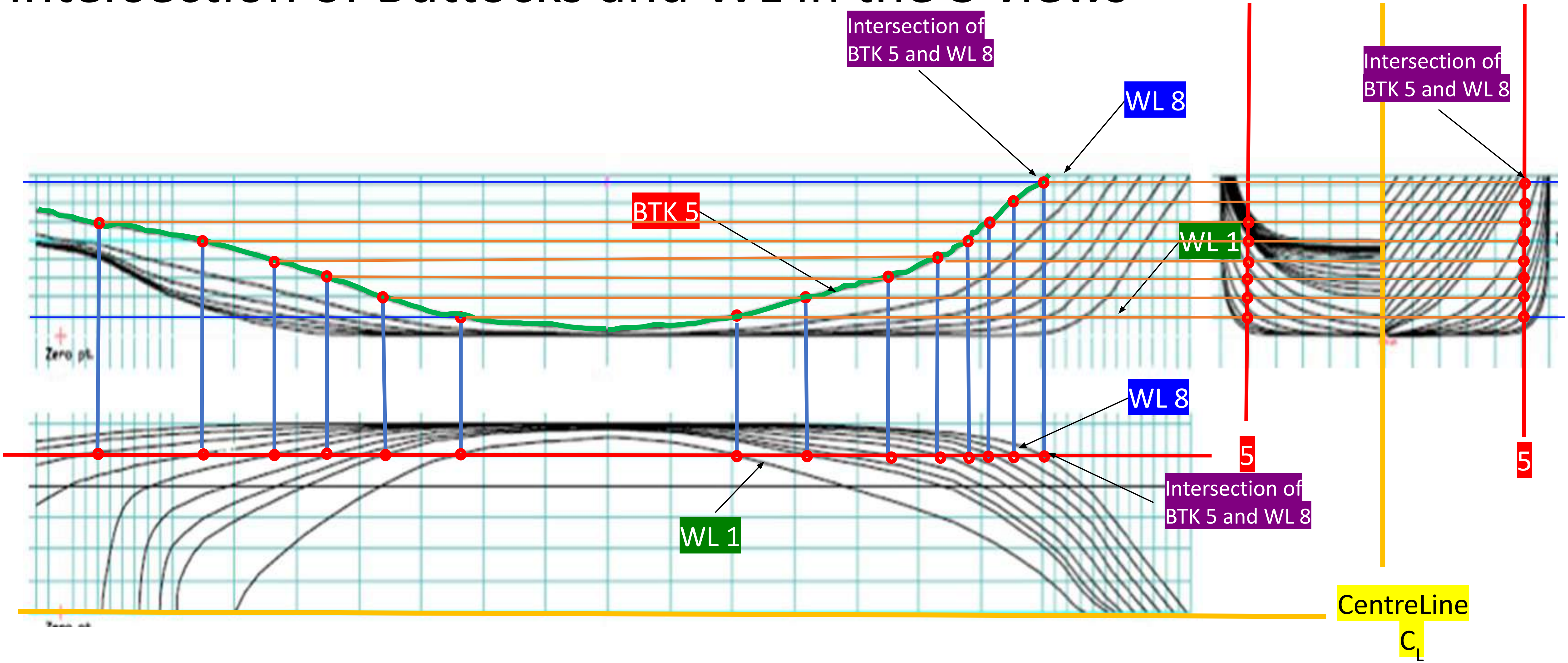
- Sheer Plan cannot be drawn from the offset table
- It has to be drawn by lifting points from the Body Plan and Half Breadth Plan

STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.96	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.98	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.98	10	10	10	10	10	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.56	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65	5.34	5.71	6.03	6.51	6.82	7.01	7.13	7.27	7.4	7.57	7.9	8.24
18.5	1.58	3.4	4.01	4.45	4.72	5.19	5.39	5.55	5.71	5.91	6.05	6.2	6.61	7.05
19	0.6	2.25	2.72	3.1	3.38	3.7	3.79	3.87	4	4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41	1.81	2.11	2.31	2.4	2.15	1.9	1.84	1.98	2.11	2.28	2.7	3.23
20	0	0.84	1.21	1.4	1.48	1.32	1.04	0.7	0.32	0.06	0	0.03	0.3	0.72

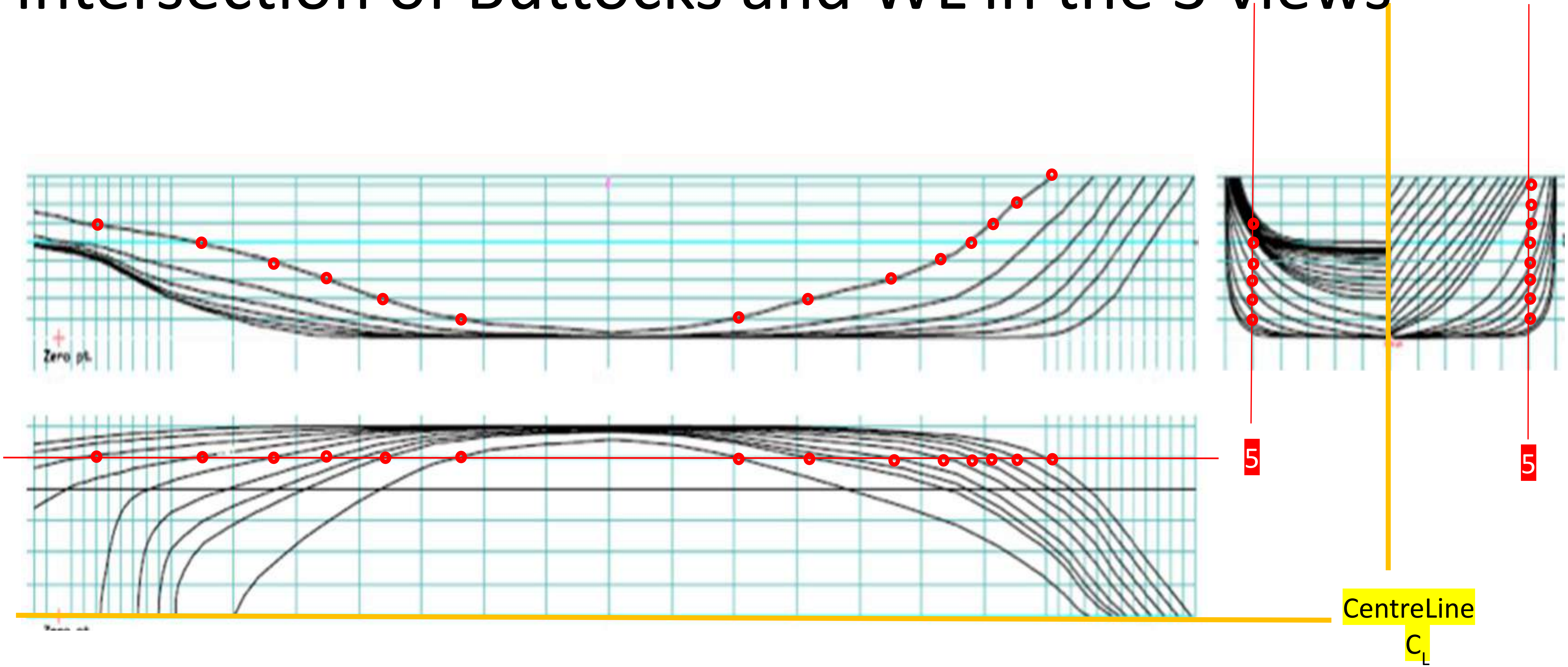
Buttocks in the 3 views



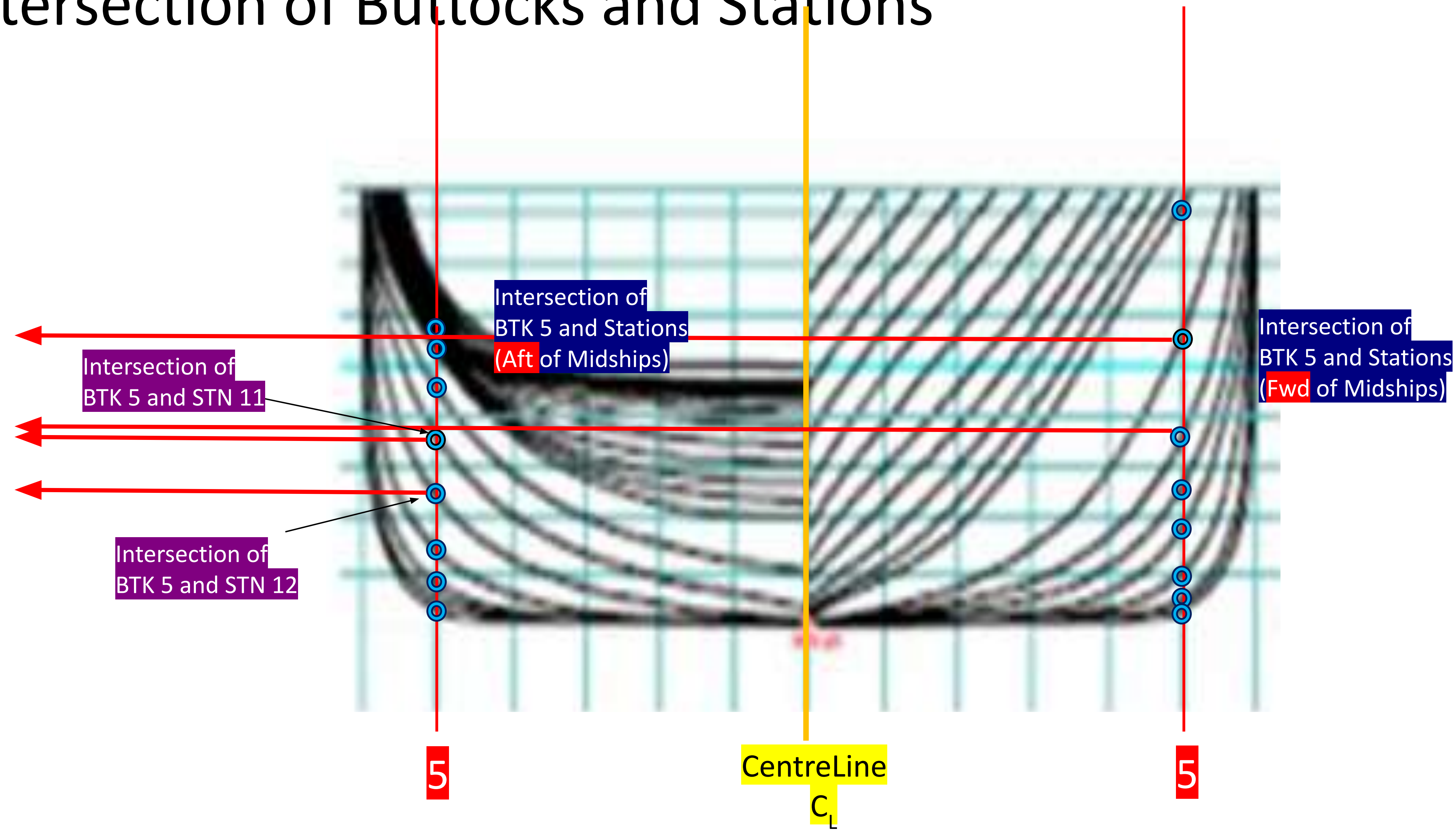
Projecting Buttock points from Half Breadth Plan- Intersection of Buttocks and WL in the 3 views



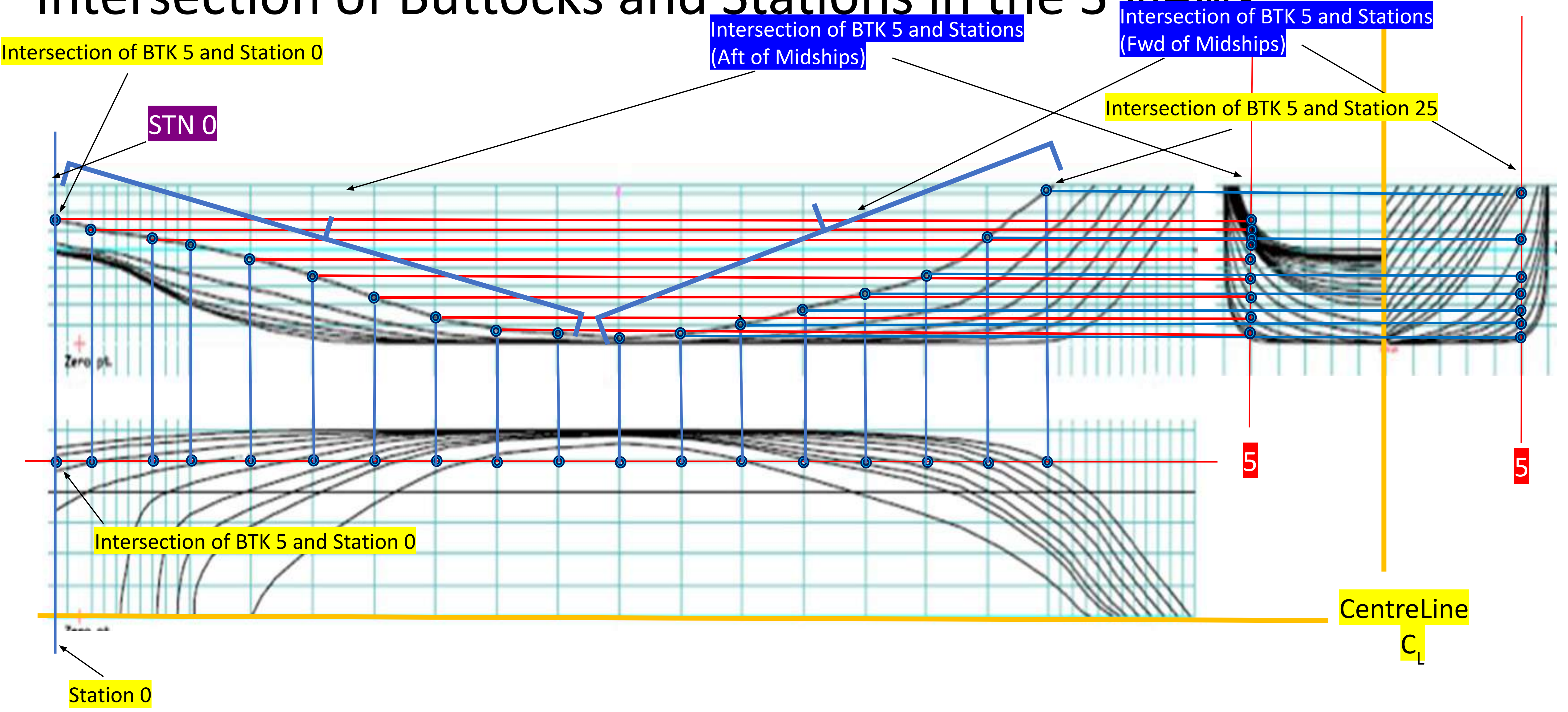
Intersection of Buttocks and WL in the 3 views



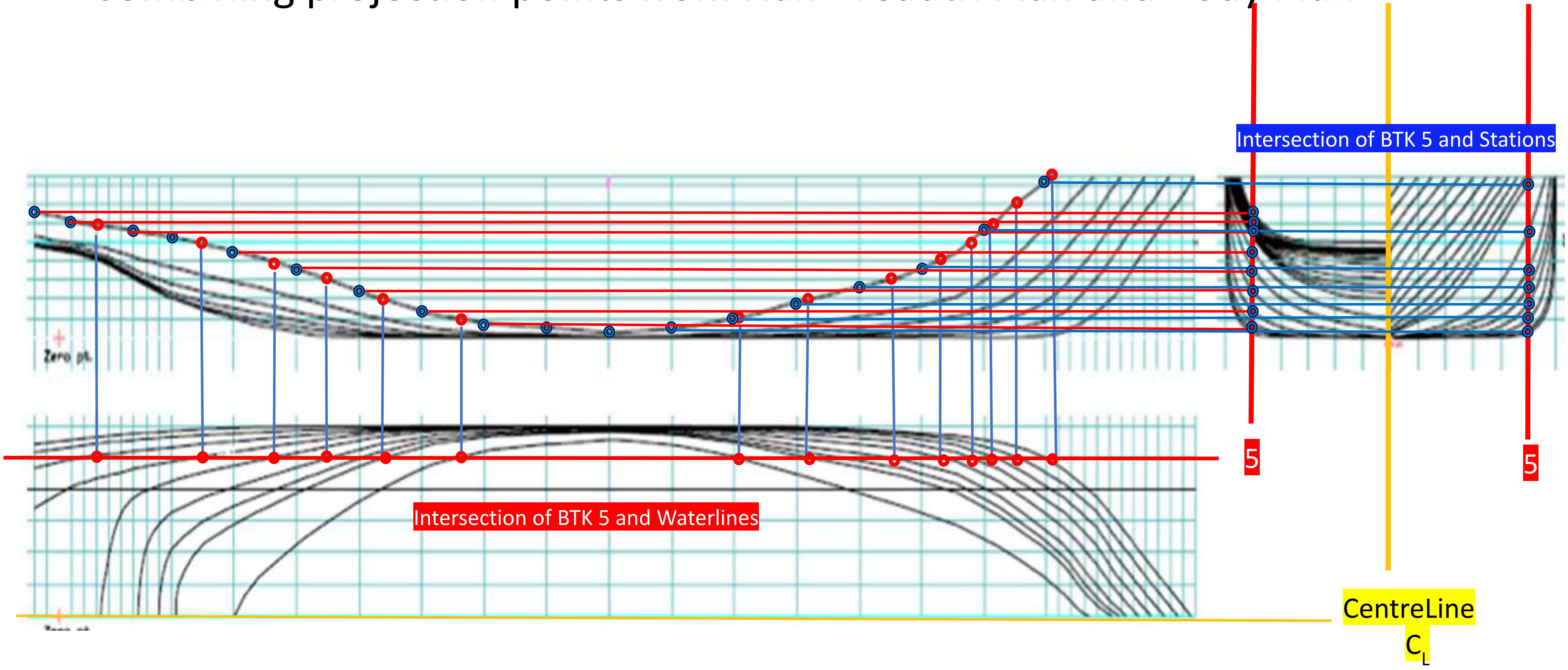
Projecting buttock points from Body Plan- Intersection of Buttocks and Stations



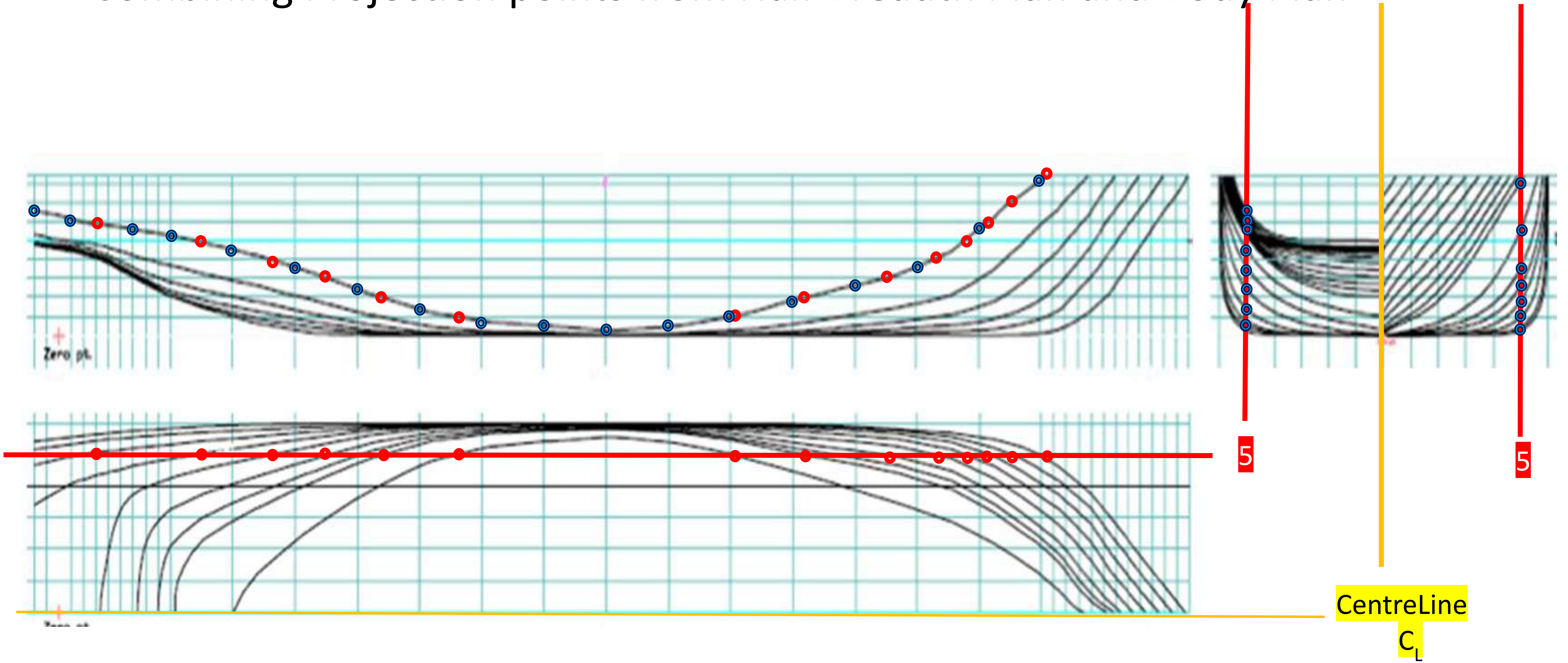
Projecting Buttock points from BodyPlan- Intersection of Buttocks and Stations in the 3 views



Combining projection points from Half Breadth Plan and Body Plan



Combining Projection points from Half Breadth Plan and Body Plan



END

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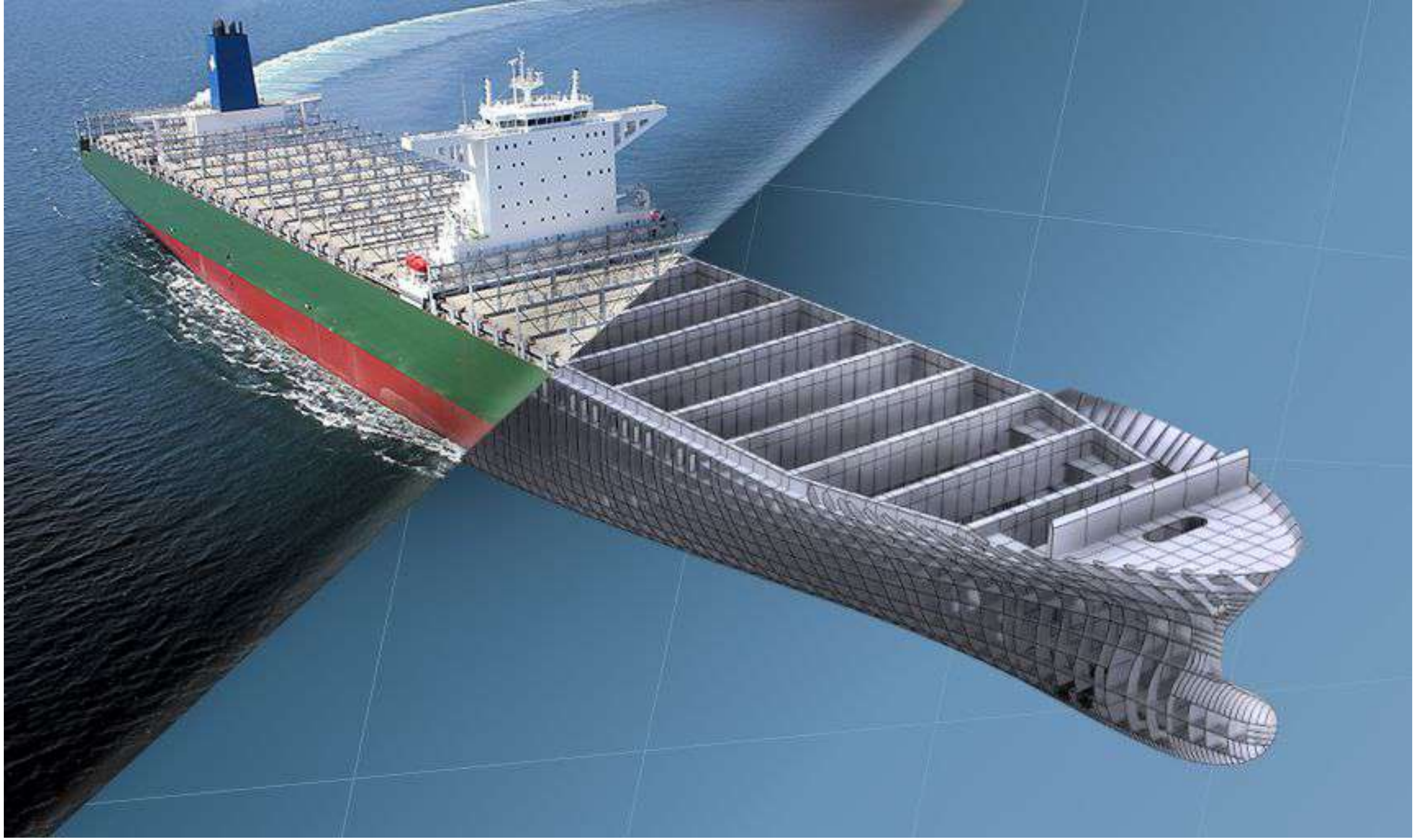
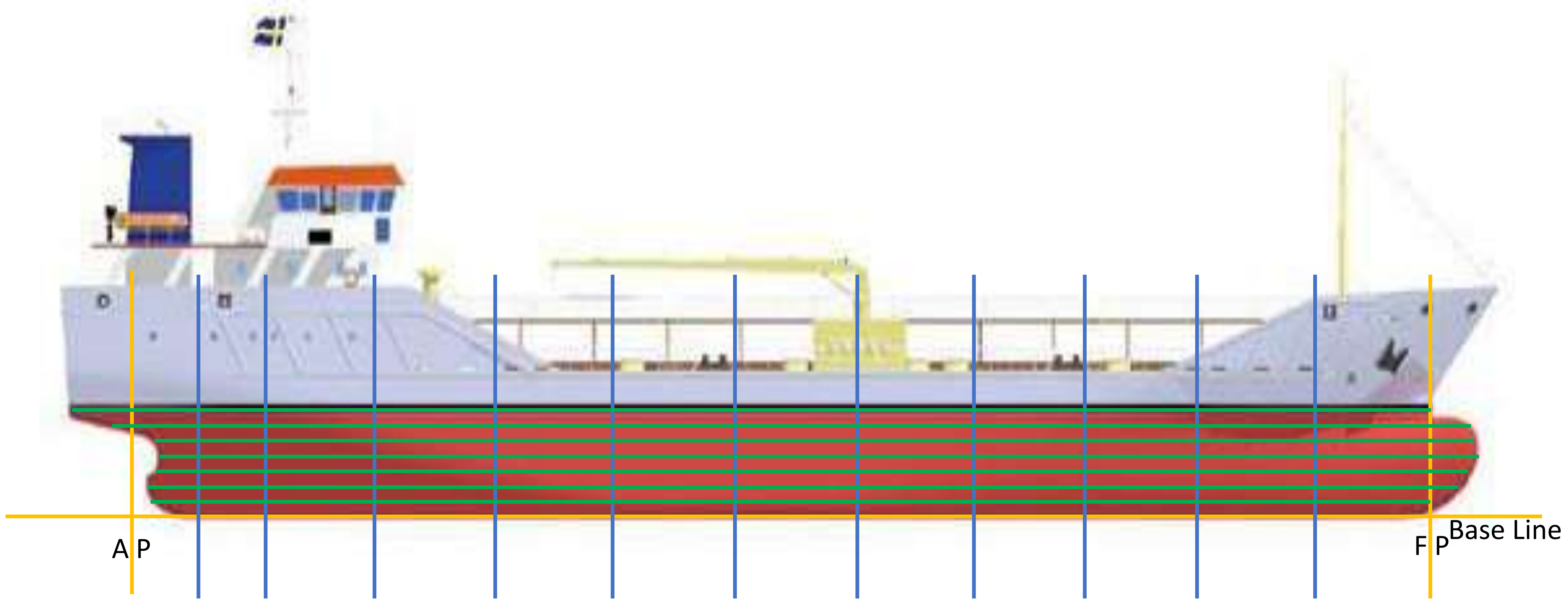


Introduction to Naval Architecture

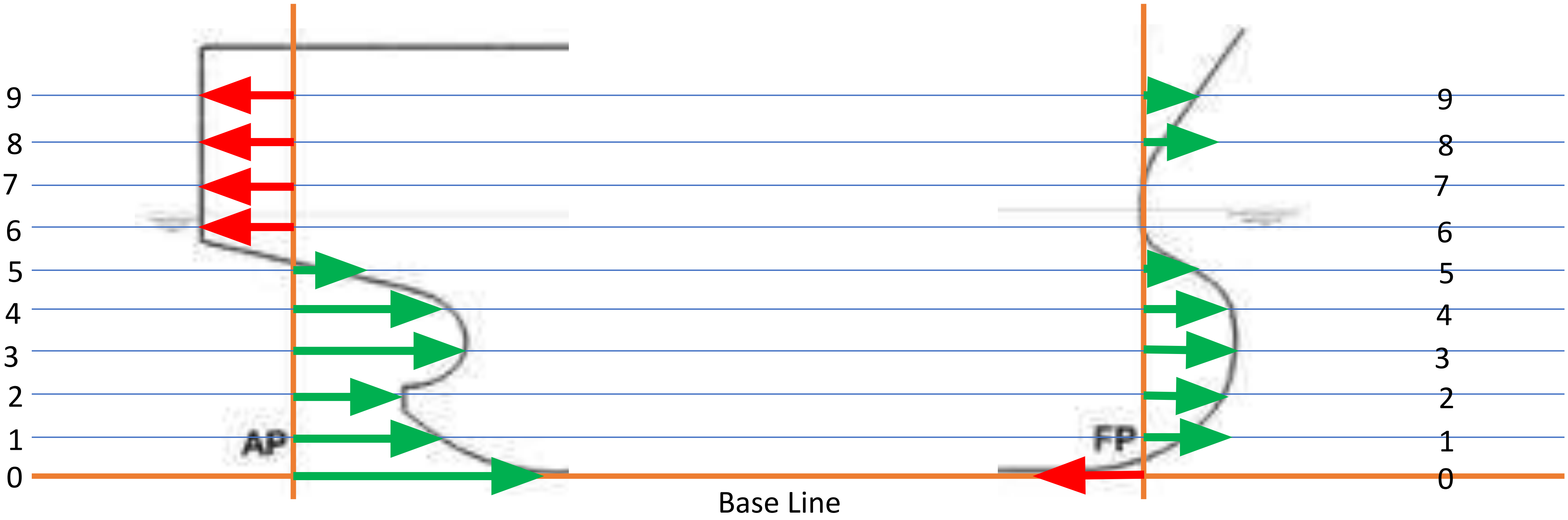
II SEM –Module 3

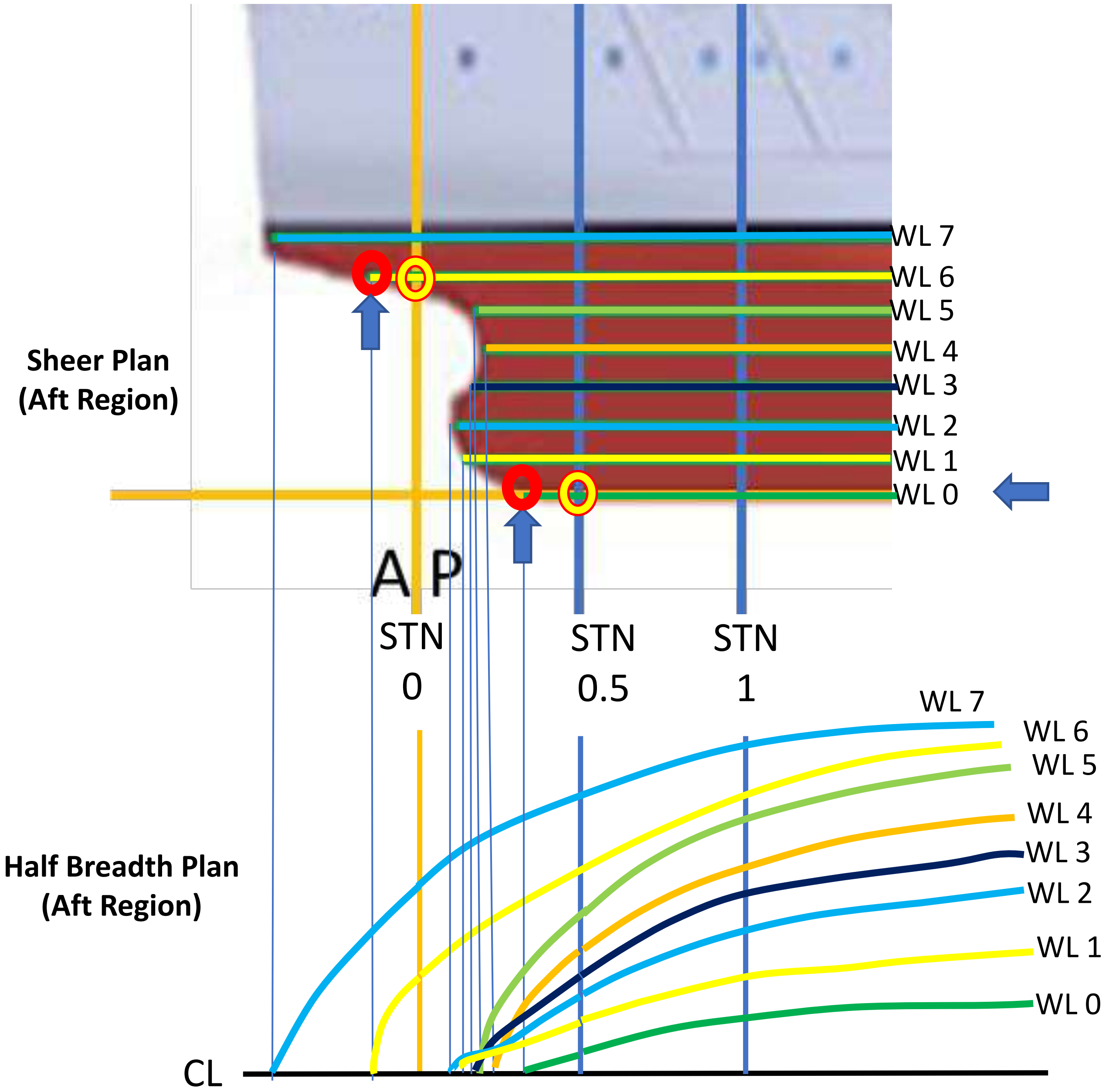
Sheer Plan (Profile)



Stem and Stern Profile – How it is defined

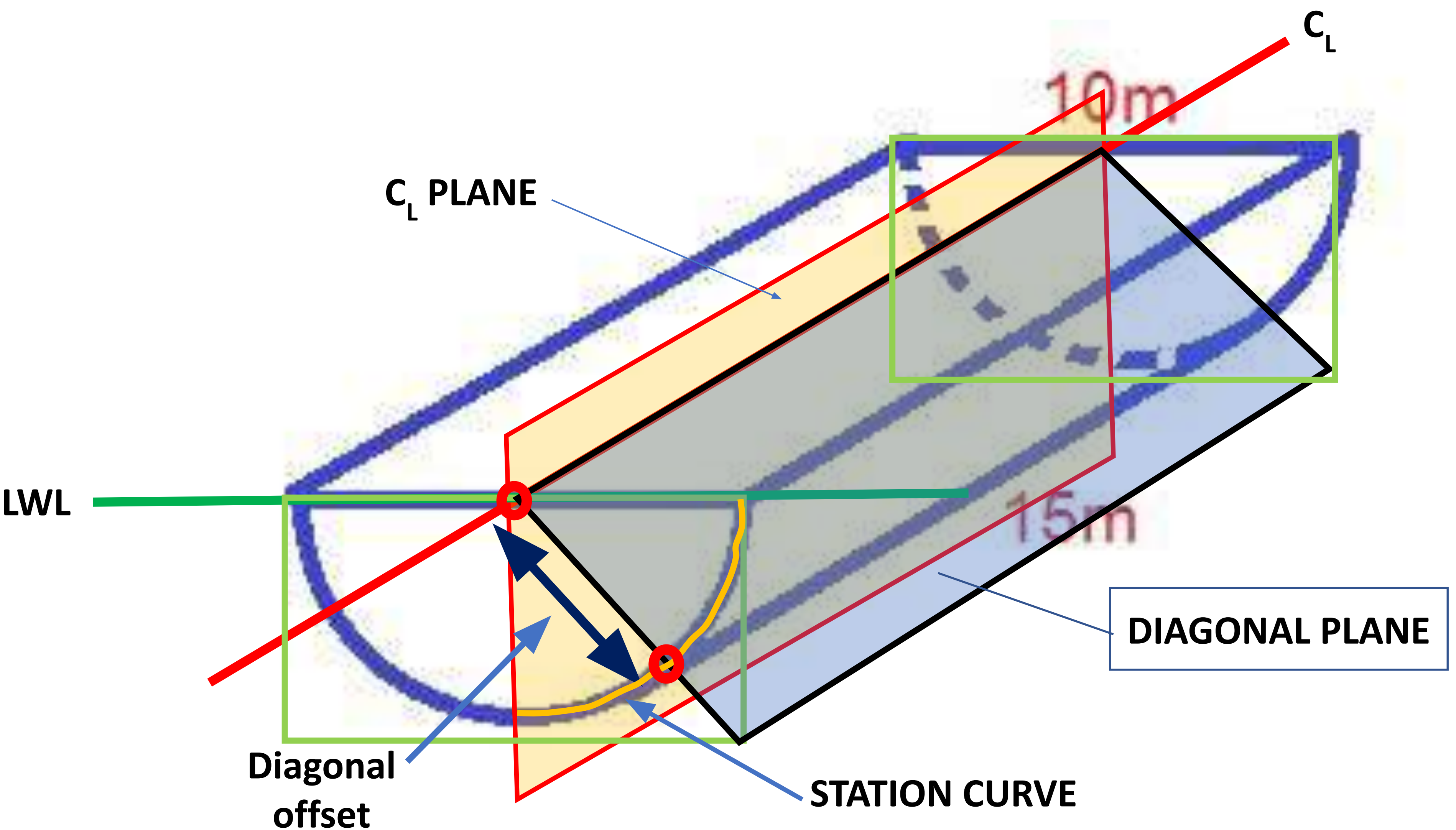
- Stern Profile – AP is the reference
- Stem Profile – FP is the reference

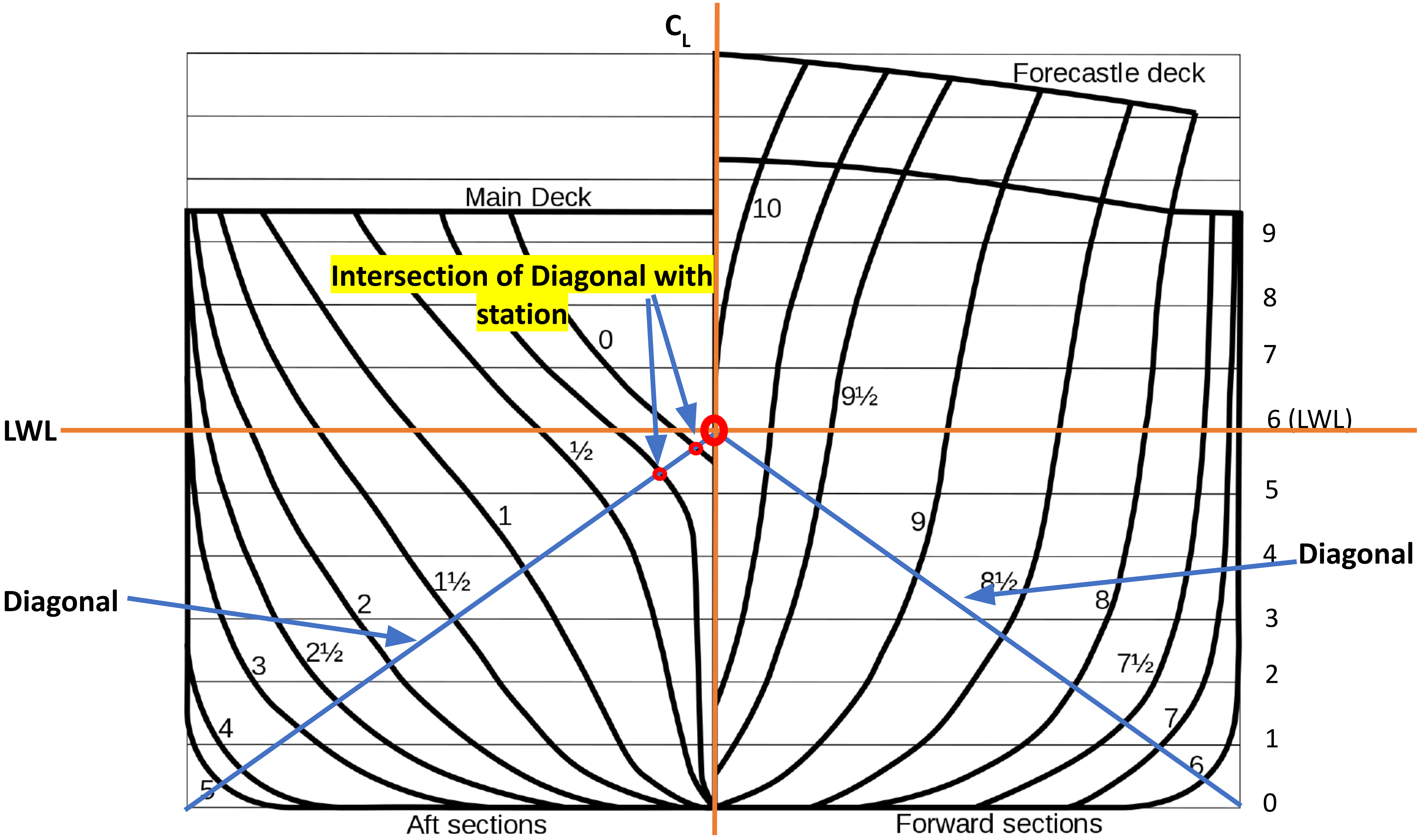




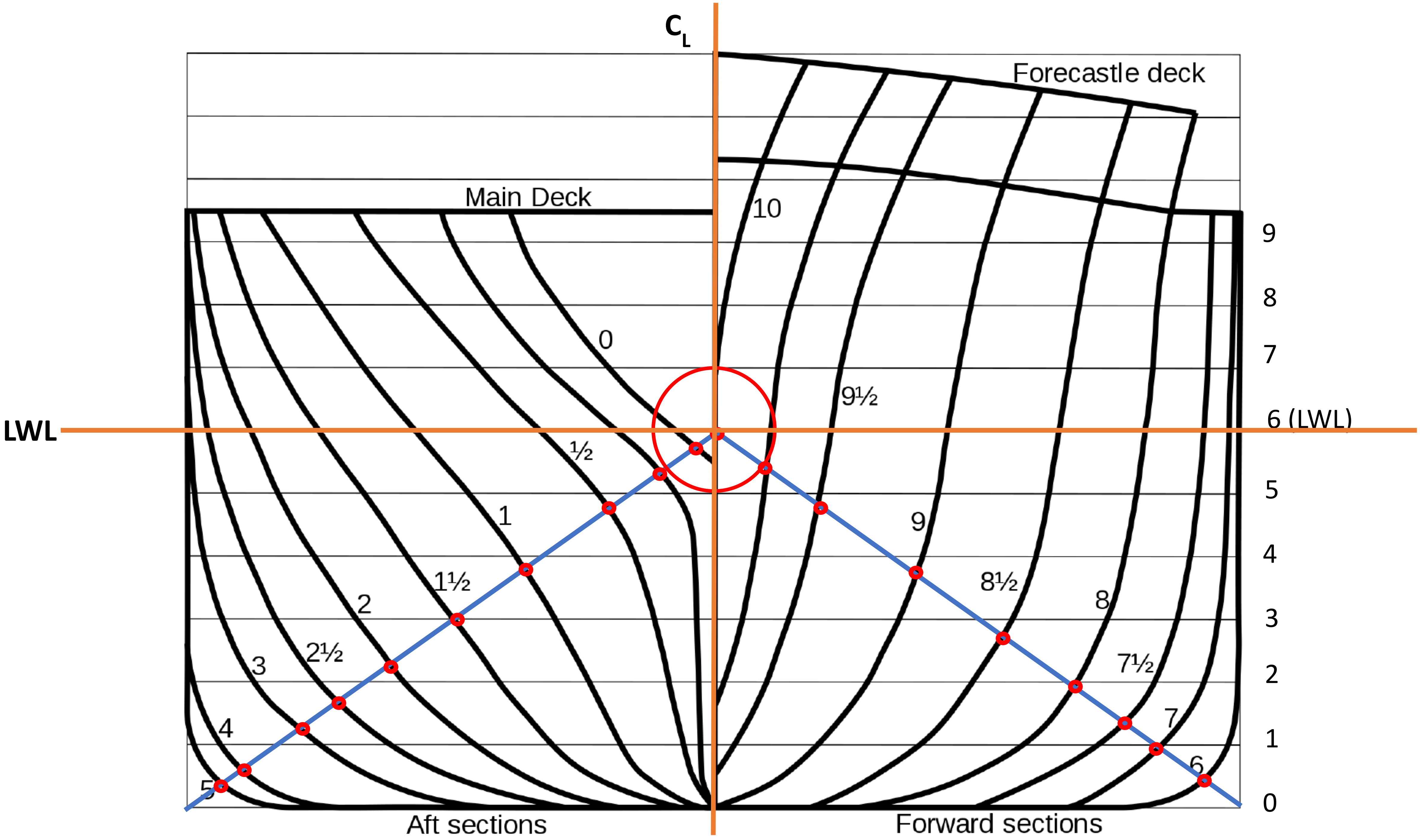
	WL	0	1	2	3	4	5	6	7
STN									
0		-	-	-	-	-	-	2.4	2.7
0.5		0.8	1.3	1.5	1.8	2.1	2.4	2.7	3.2
1		1.2	1.1	1.7	2.4	2.7	3.3	3.8	4.2
1.5									
2									

Drawing of Diagonal

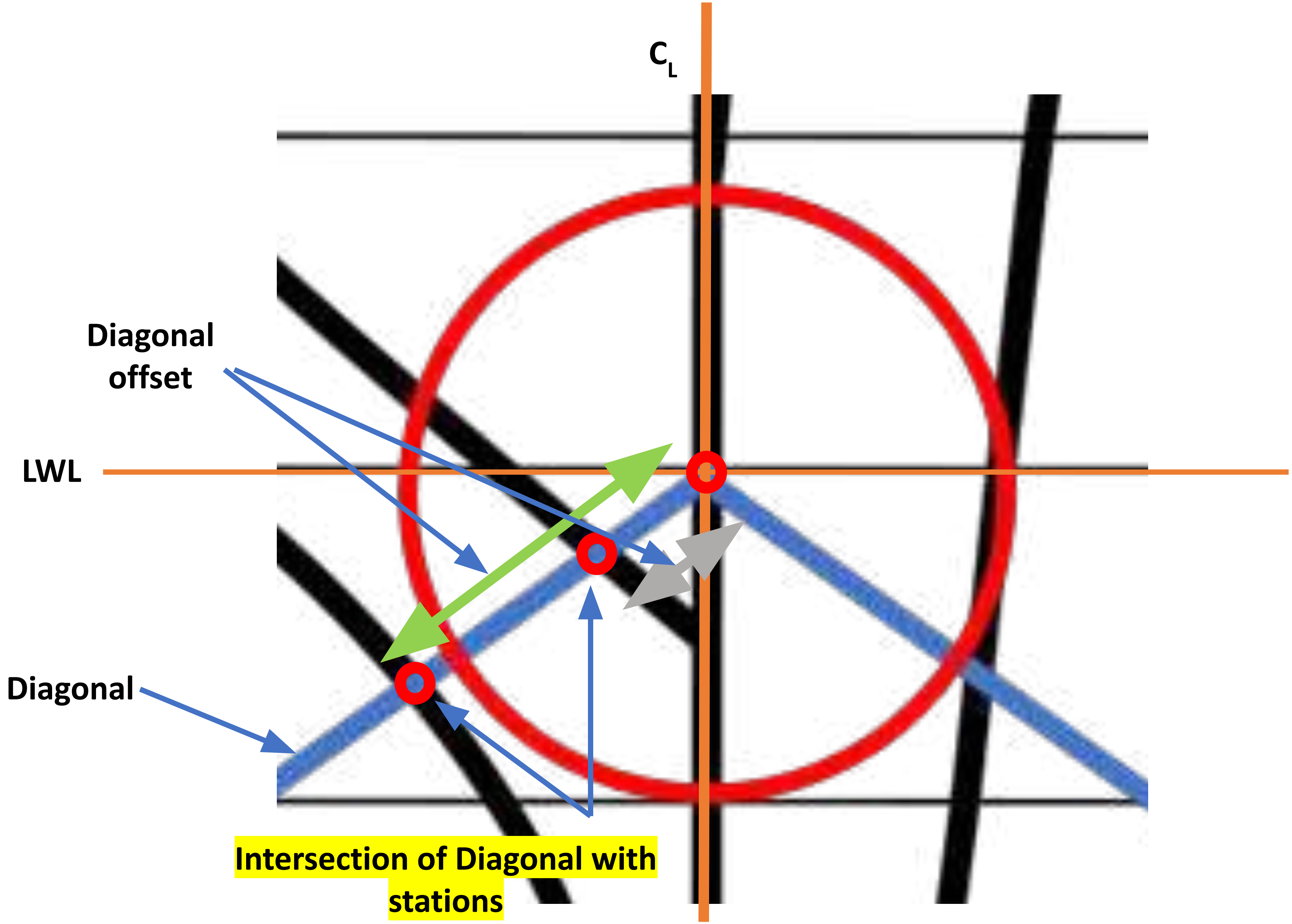


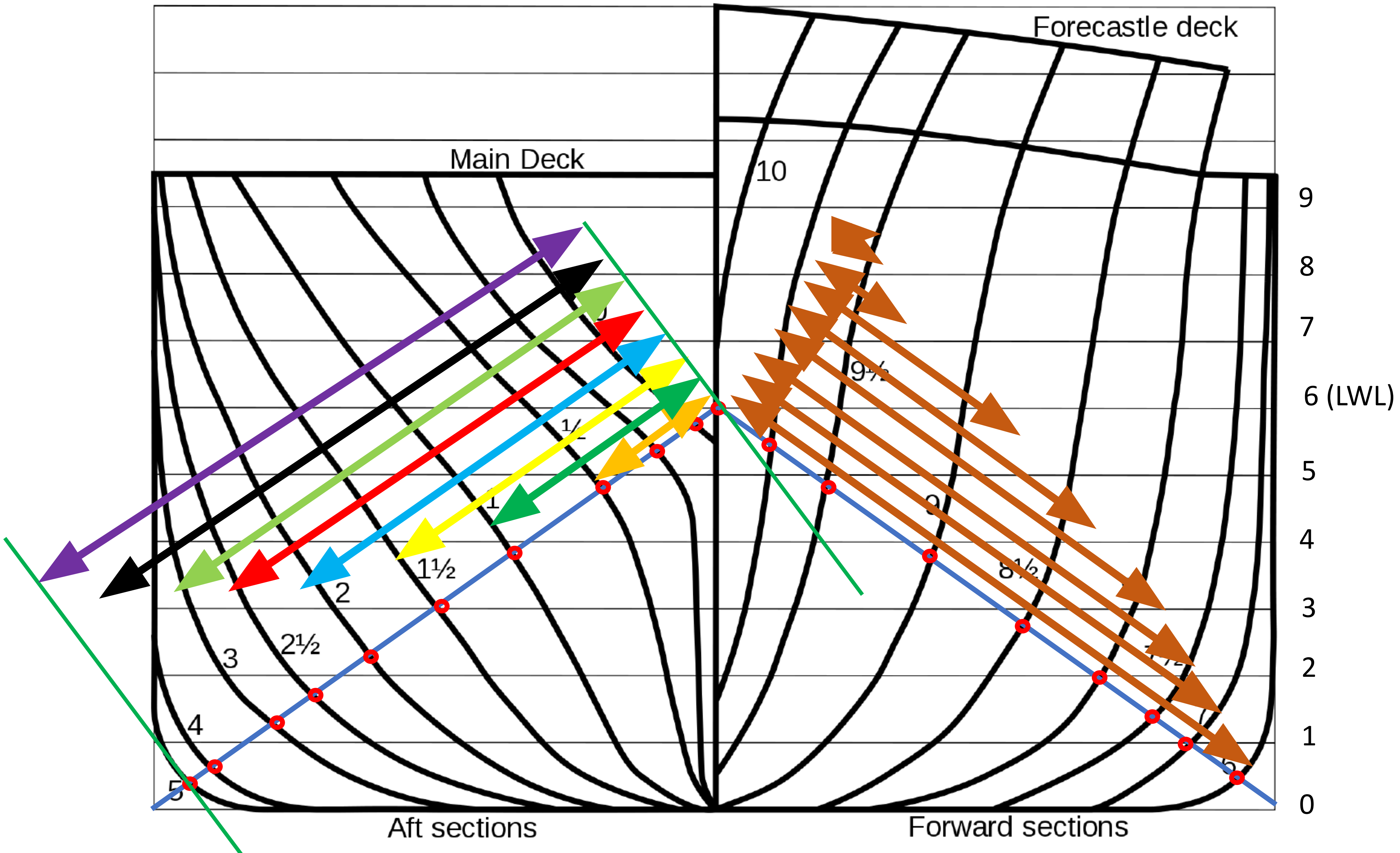


C_L
Forecastle deck
Main Deck
10
Intersection of Diagonal with station
0
9½
LWL
6 (LWL)
½
1
9
Diagonal
1½
8½
2
8
2½
3
7½
4
7
5
6
9
8
7
5
4
3
2
1
0
Aft sections
Forward sections



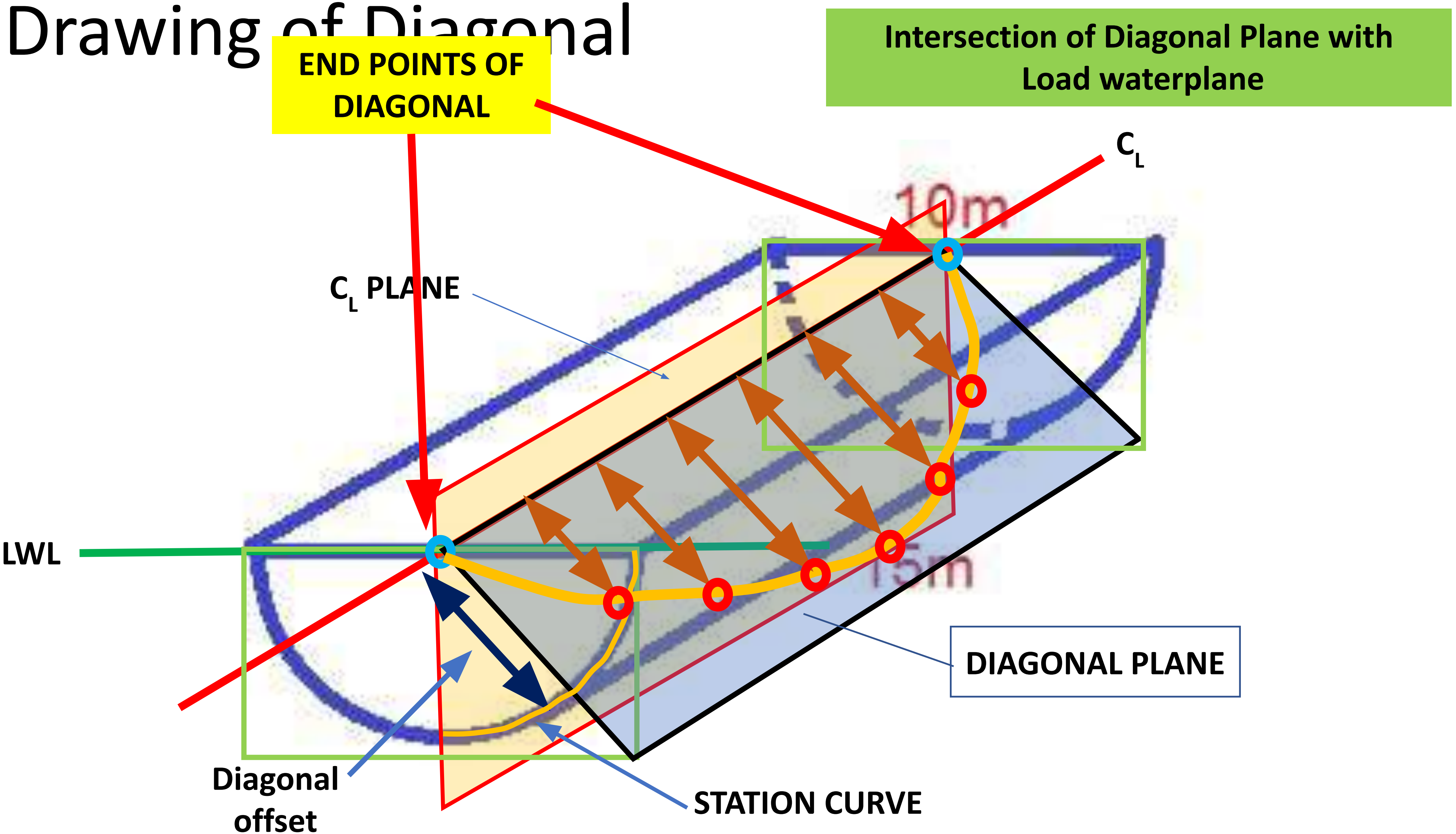
C_L
Forecastle deck
Main Deck
10
0
9½
LWL
6 (LWL)
½
1
9
1½
8½
2
8
2½
3
7½
4
7
5
6
Aft sections
Forward sections
9
8
7
5
4
3
2
1
0

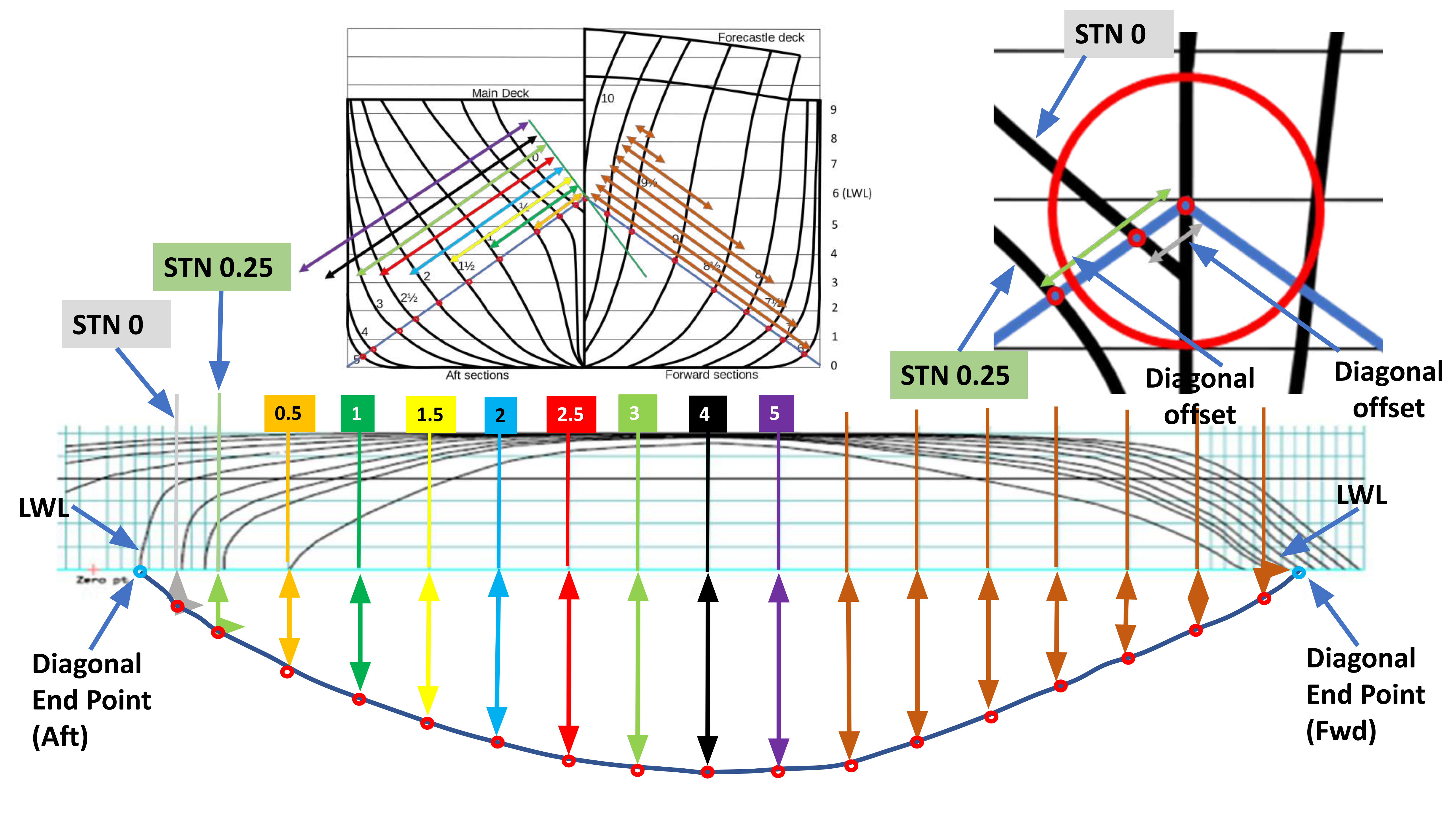

C L
Diagonal offset
LWL
Diagonal
Intersection of Diagonal with stations



Forecastle deck
Main Deck
10
9½
9
8½
3
2½
2
1½
1
4
5
9
8
7
6 (LWL)
5
4
3
2
1
0
Aft sections
Forward sections

Drawing of Diagonal



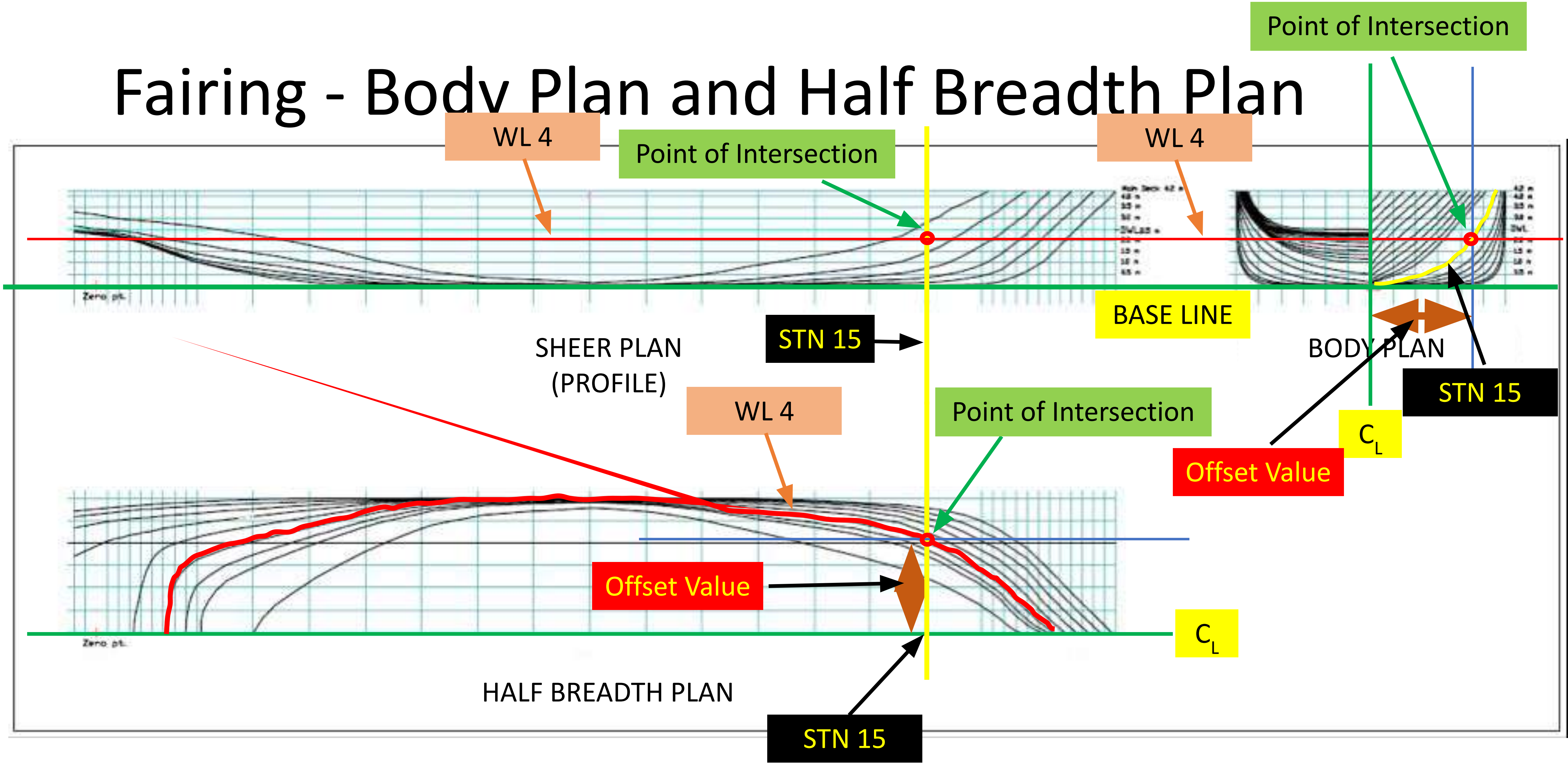


STN 0
STN 0.25
Forecastle deck
Main Deck
Aft sections
Forward sections
6 (LWL)
0.5
1
1.5
2
2.5
3
4
5
LWL
Diagonal End Point (Aft)
Diagonal End Point (Fwd)
Diagonal offset
Diagonal offset
Zero pt

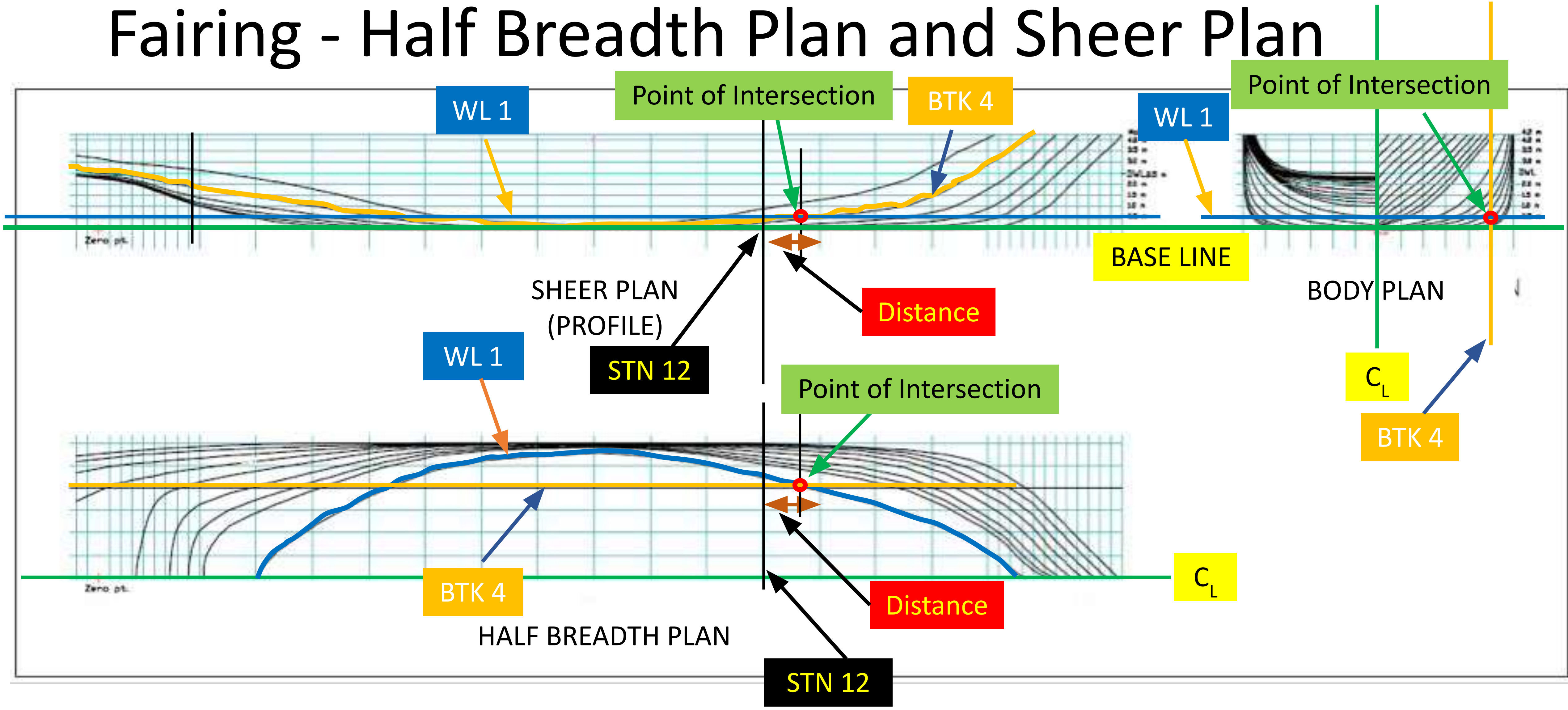
Fairing of Lines Plan

- Smooth Surface
  - Smooth and continuous
  - No localized bumps and sharp bends
  - No discontinuities or points of inflection except at stem, stern and chines where it is intentional
- Consistency
  - Correspondency between all three views
  - A point on hull surface when projected orthographically on three different planes should be consistent in all three views

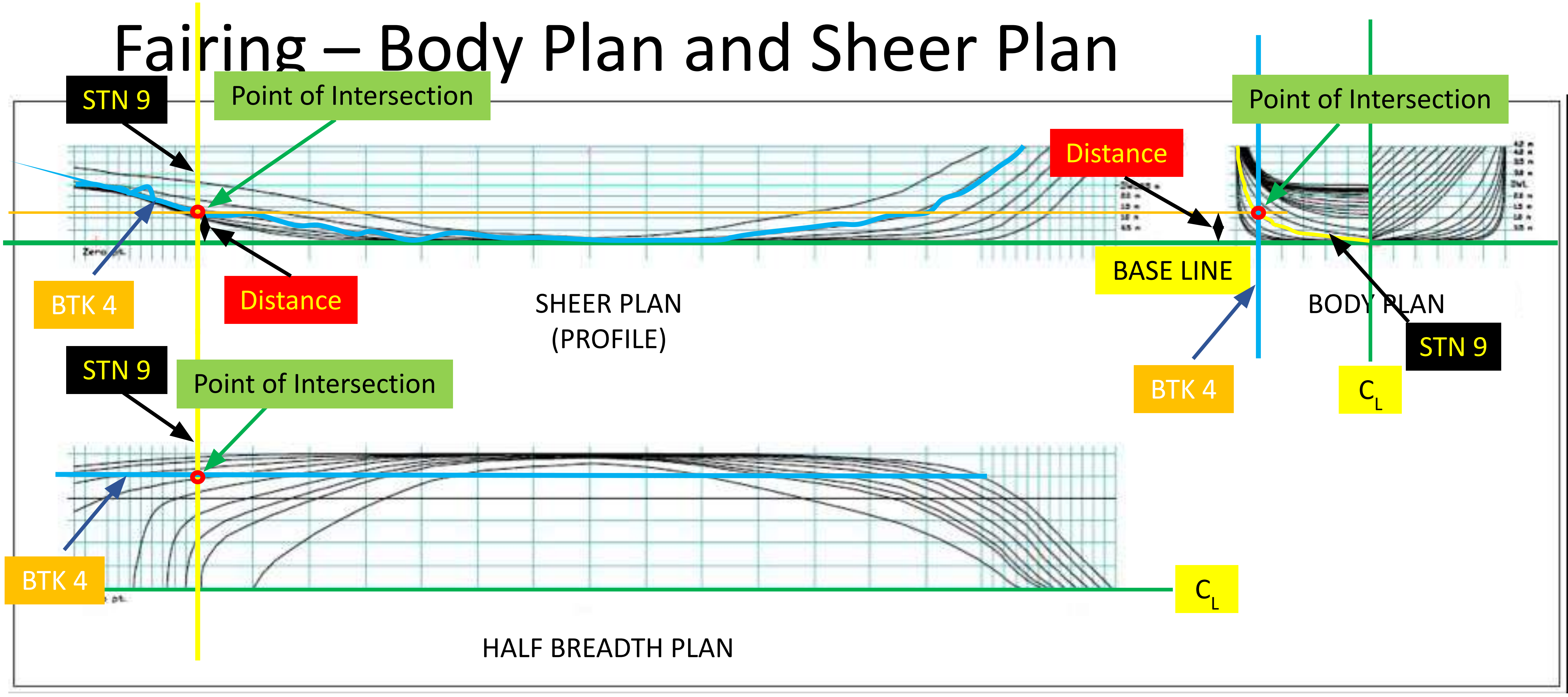
Fairing - Body Plan and Half Breadth Plan



Fairing - Half Breadth Plan and Sheer Plan



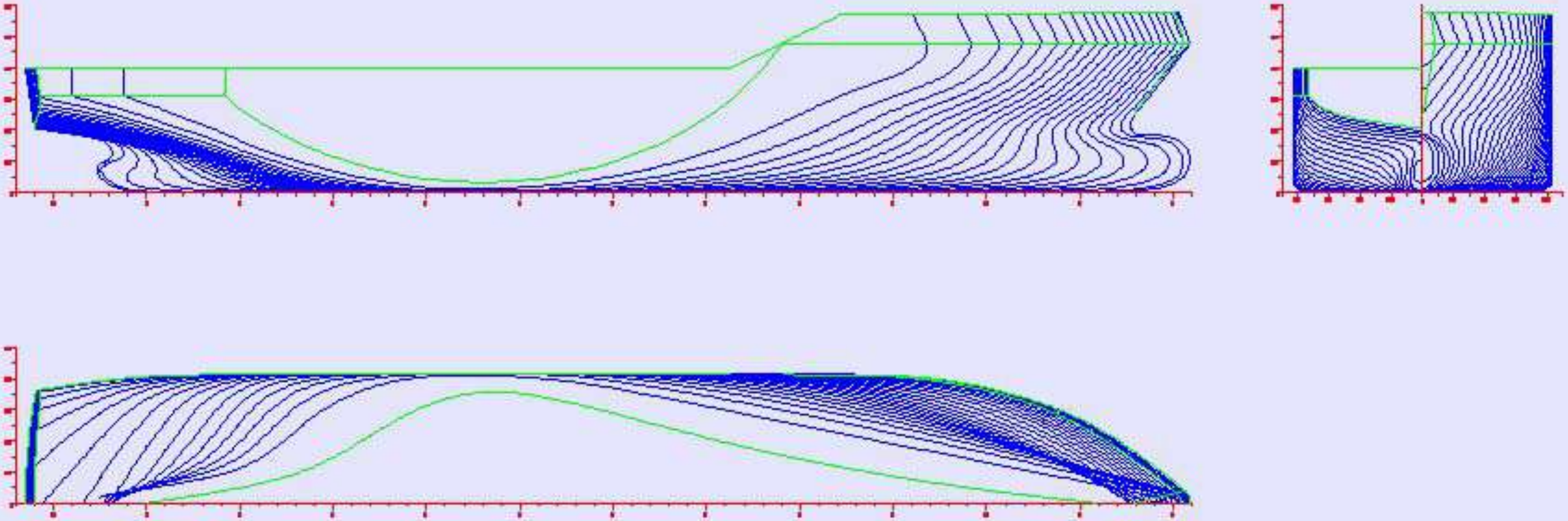
Fairing – Body Plan and Sheer Plan



Fairing of Lines Plan

- Process
  - Iterative
  - Laborious
  - Subjective depending on individual judgement

- Purpose -Smoothness of hull form helps in
  - reducing resistance,
  - increasing fuel efficiency
  - ease of development of plates for construction



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