Marine Construction & Welding

NA21003

Autumn 2020

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Syllabus

1. Ships: Introduction & Classification

2. The Shipbuilding Industry

3. Loads on Ship & Structural Requirement

4. Ship Structure

- Basic Structural Components
- Structural Subassemblies
- Structural Assemblies
- Midship Sections*
- Structural Alignment & Continuity

Syllabus

5. Ship Construction & Launching

6. Materials for Construction

- Shipbuilding Materials
- Steel Material Preparation
- Plate Cutting
- Plate & Section Forming

Syllabus

7. Welding

- Introduction
- Welding Parameters
- Fusion Welding Methods
- Solid State Welding
- Residual Stress and Distortion
- Distortion Control and Mitigation
- Welding defects

8. Nondestructive Testing

9. Accuracy Control

Resources

Ship Construction:

- **Ship Construction* by D.J Eyres & G.J Bruce
- *Ship Design and Construction* by Taggart/ Lamb (SNAME)
- *Ship Construction and Welding by N.R Mandal

Basic Naval Architecture:

- ***Introduction to Naval Architecture* by E.C Tupper
- *Basic Ship Theory* by *K.J Rawson & E.C Tupper*
- *Principles of Naval Architecture* series (SNAME)

Introduction

- **Ship Theory**

  The science of building ships by investigating its characteristics before it is constructed

- **Shipbuilding**

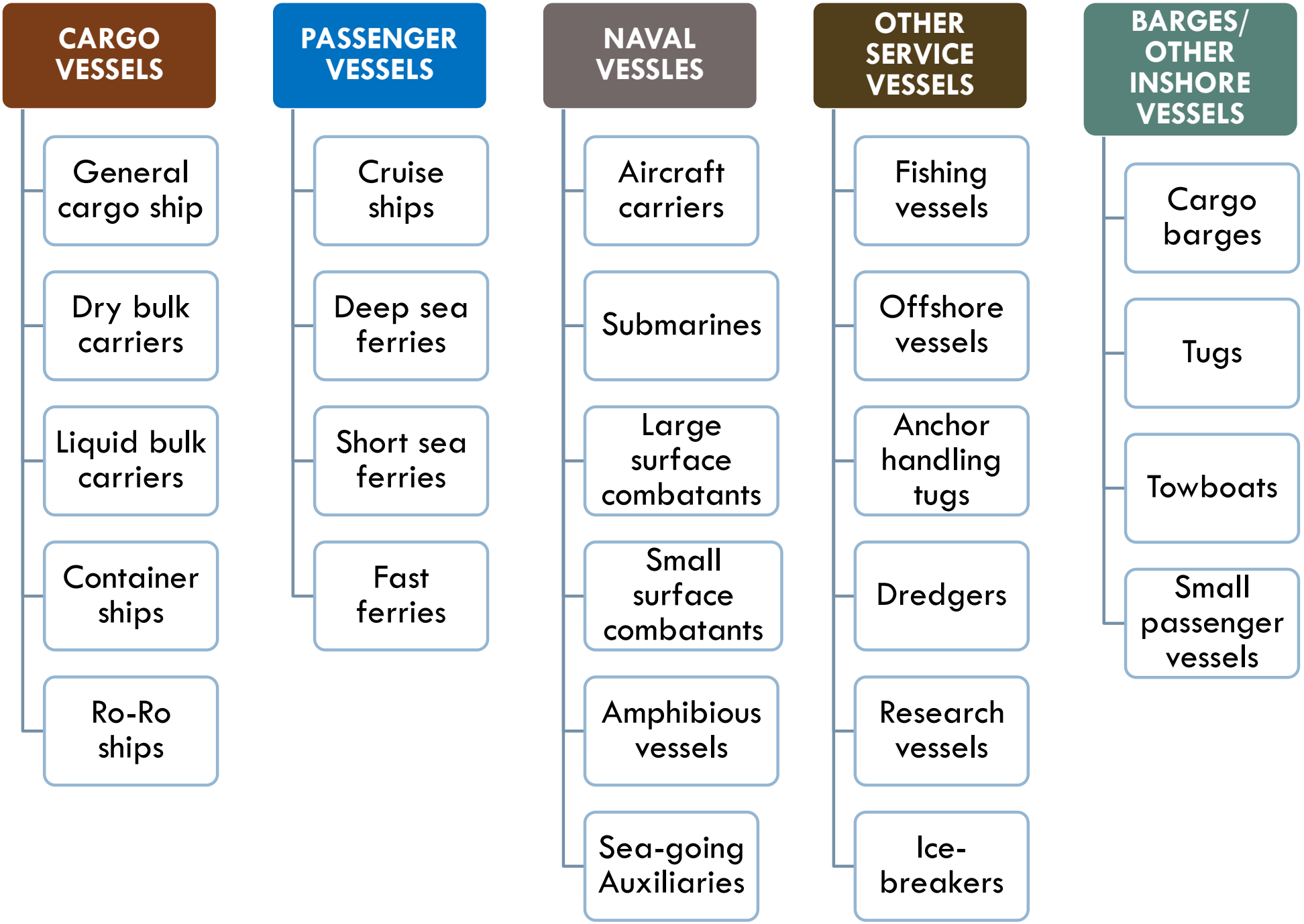
  The construction of ships according to design requirements

Introduction

Shipbuilding existed as early as around 5000 years ago

Through the ages shipbuilding evolved as oared ships, sail ships, and with the industrial revolution into steamships, diesel and gas turbine powered, and nuclear powered ships.

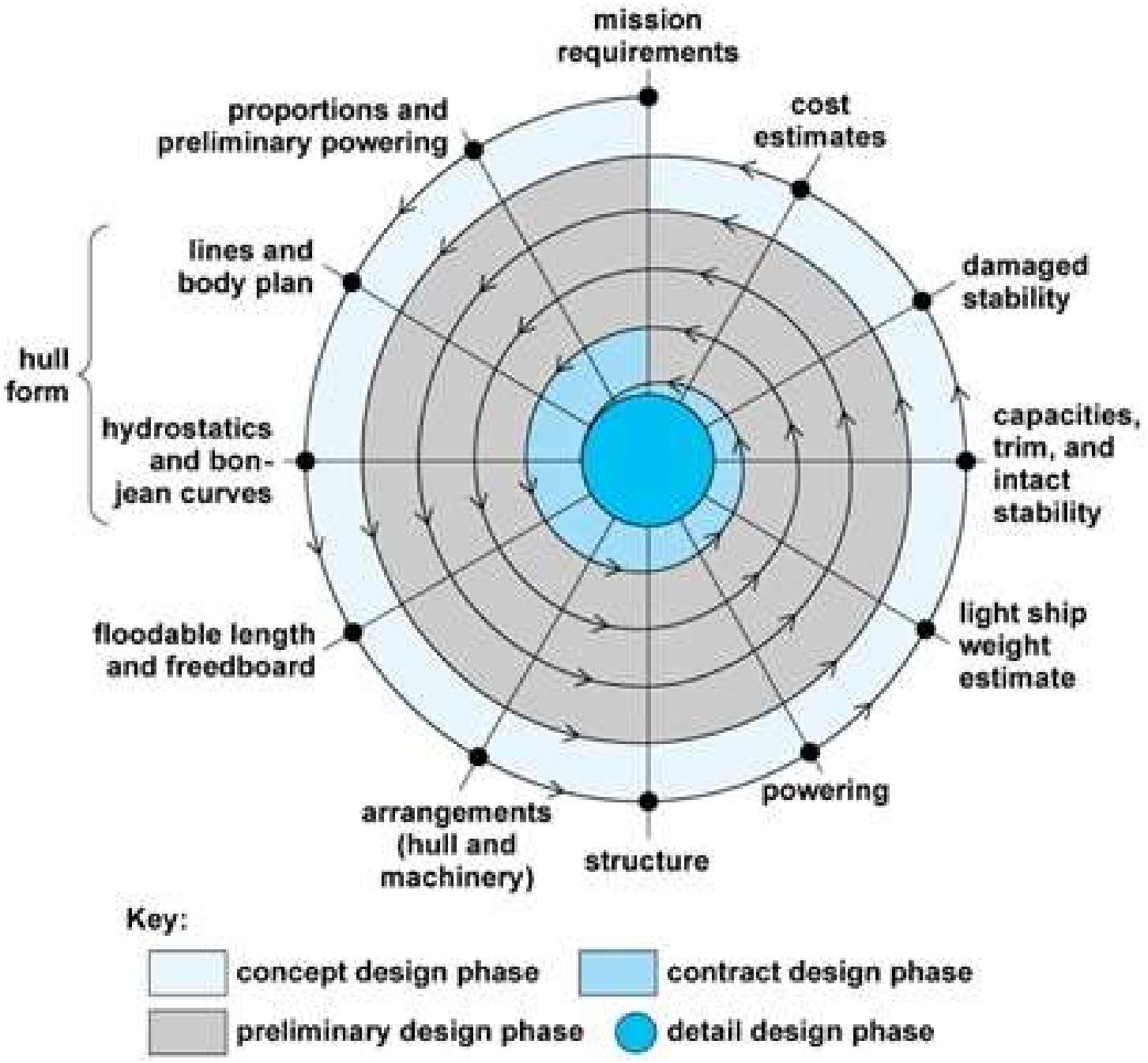
World Fleet


CARGO VESSELS
General cargo ship
Dry bulk carriers
Liquid bulk carriers
Container ships
Ro-Ro ships
PASSENGER VESSELS
Cruise ships
Deep sea ferries
Short sea ferries
Fast ferries
NAVAL VESSLES
Aircraft carriers
Submarines
Large surface combatants
Small surface combatants
Amphibious vessels
Sea-going Auxiliaries
OTHER SERVICE VESSELS
Fishing vessels
Offshore vessels
Anchor handling tugs
Dredgers
Research vessels
Ice-breakers
BARGES/ OTHER INSHORE VESSELS
Cargo barges
Tugs
Towboats
Small passenger vessels

Different aspects of Naval Architecture can be understood from the Ship Design Spiral.

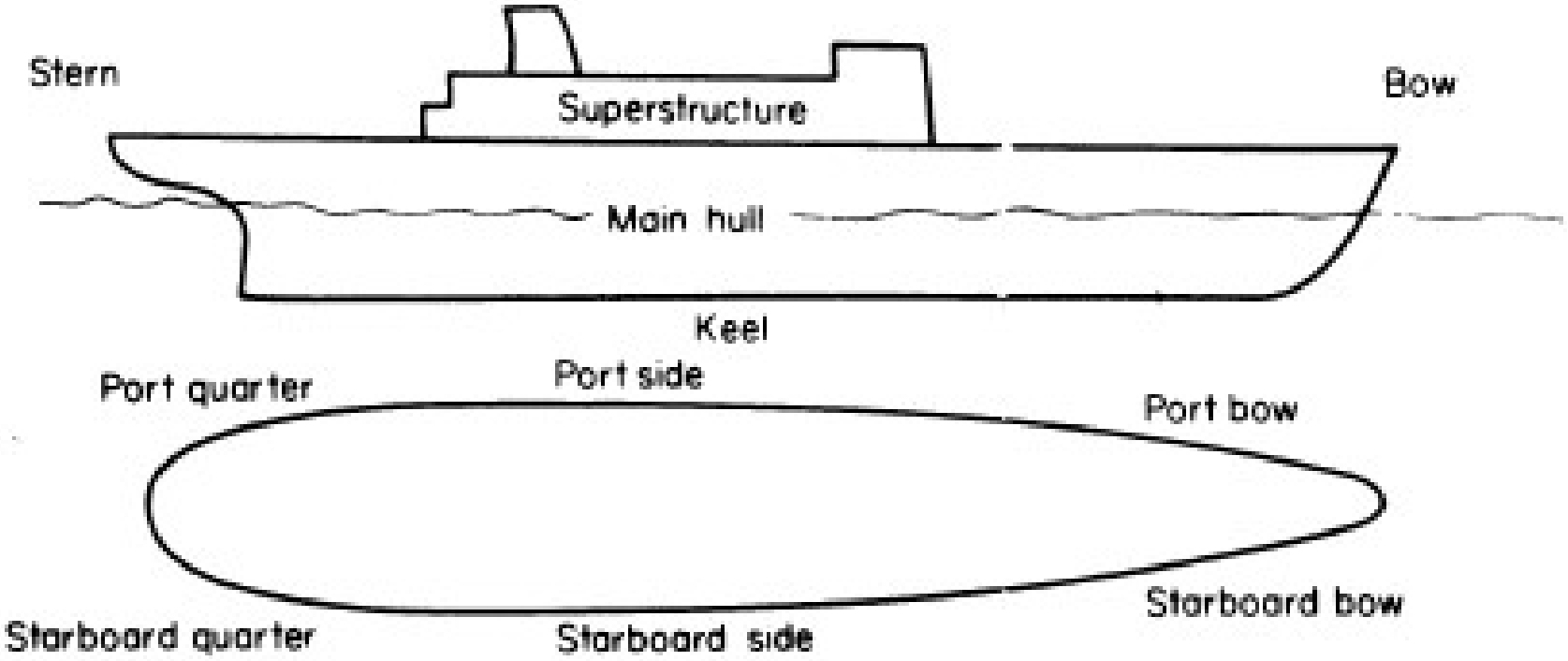
An iterative approach is used to arrive at the final design starting from the basic requirements of the owner.

Ship Design Spiral

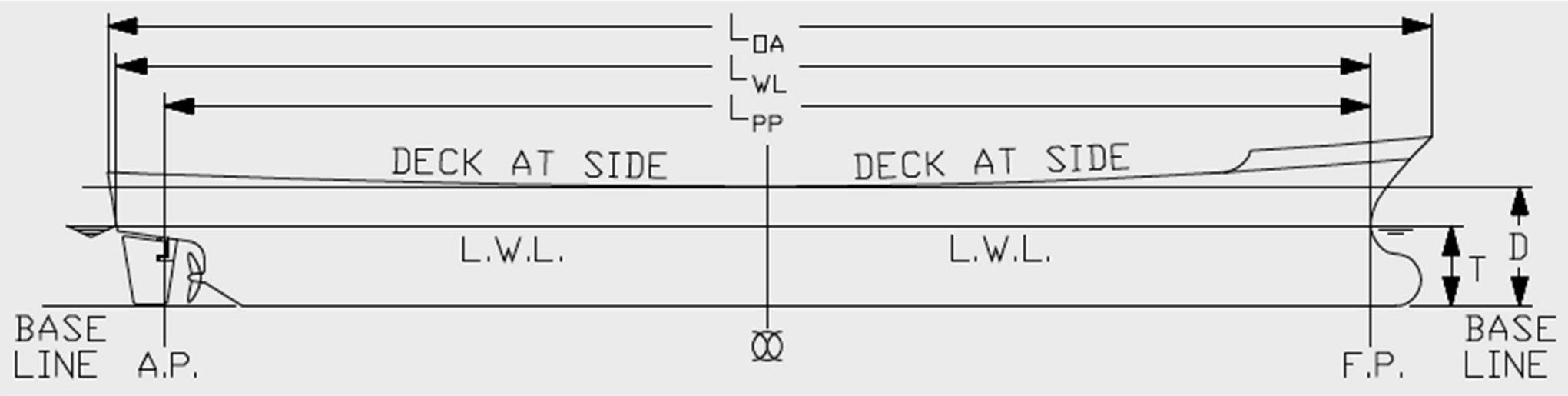


Ship Geometry & Nomenclature

Ship Nomenclature



Ship Nomenclature



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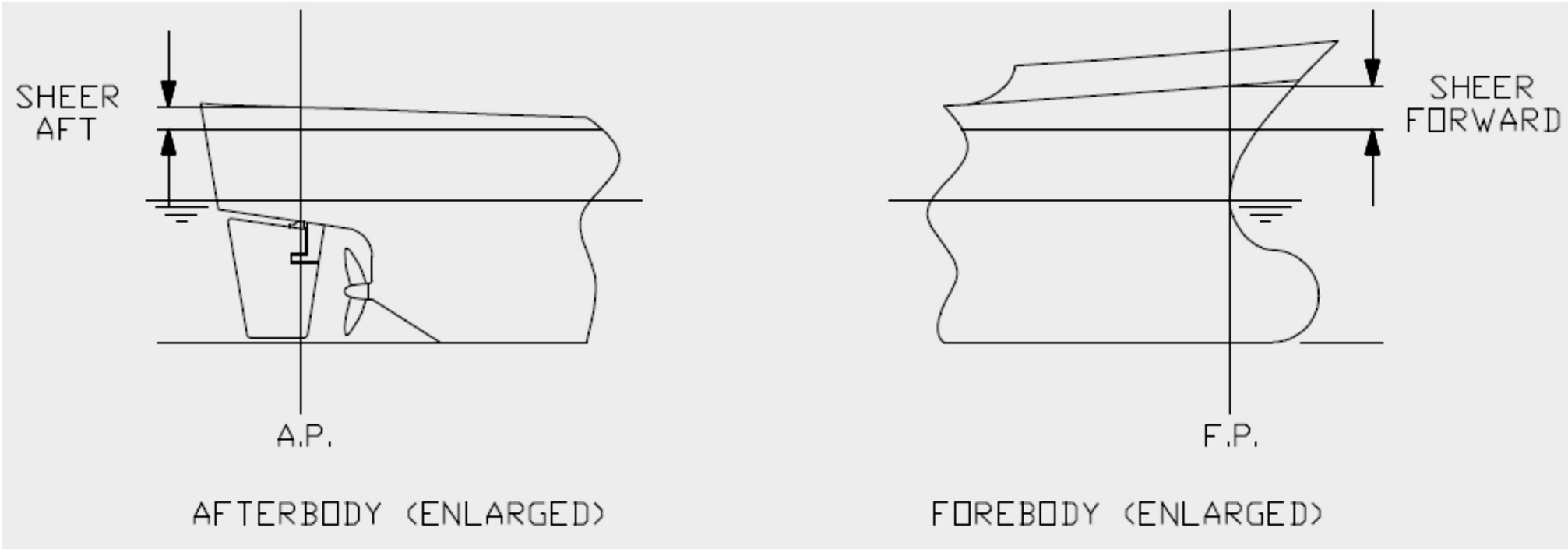

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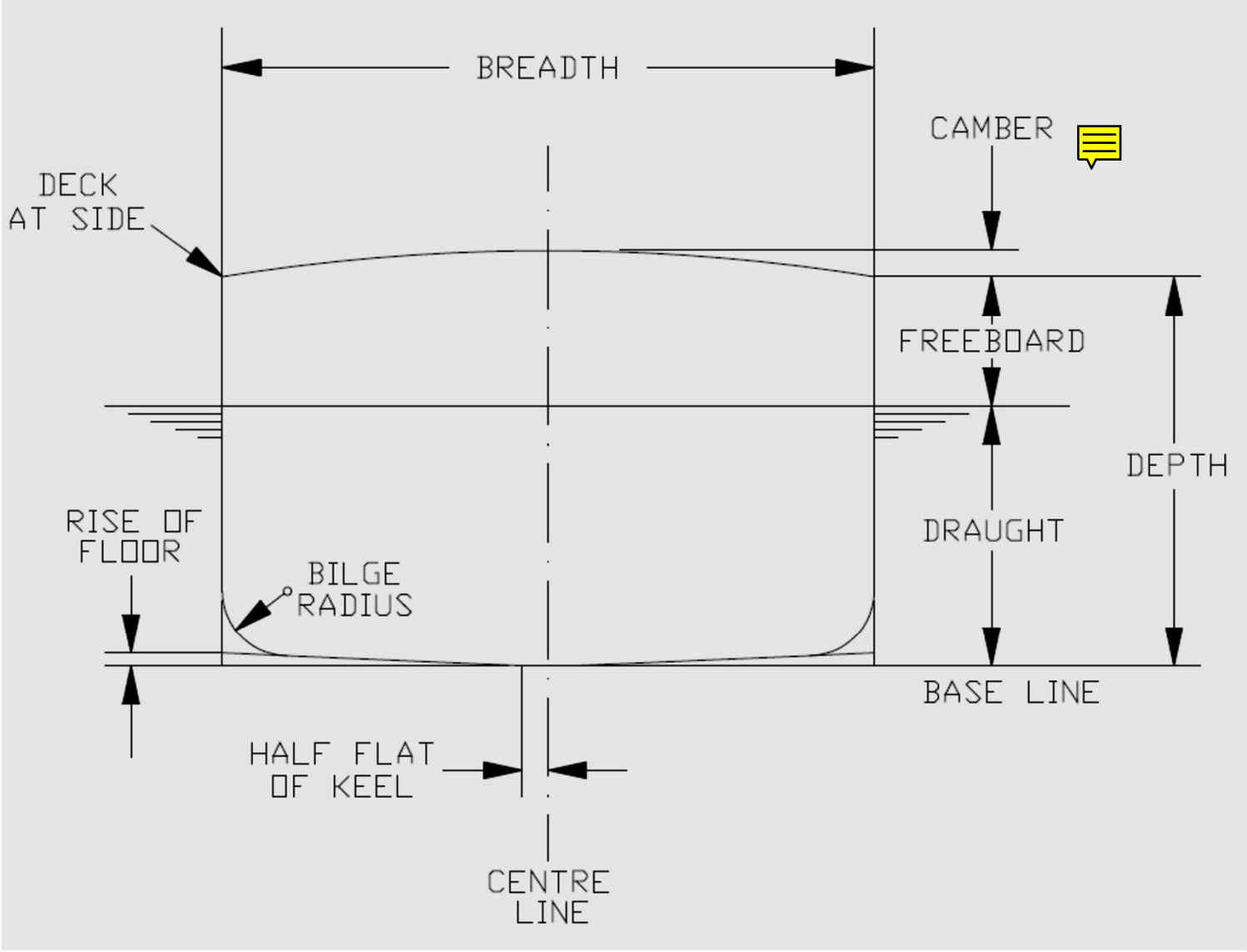

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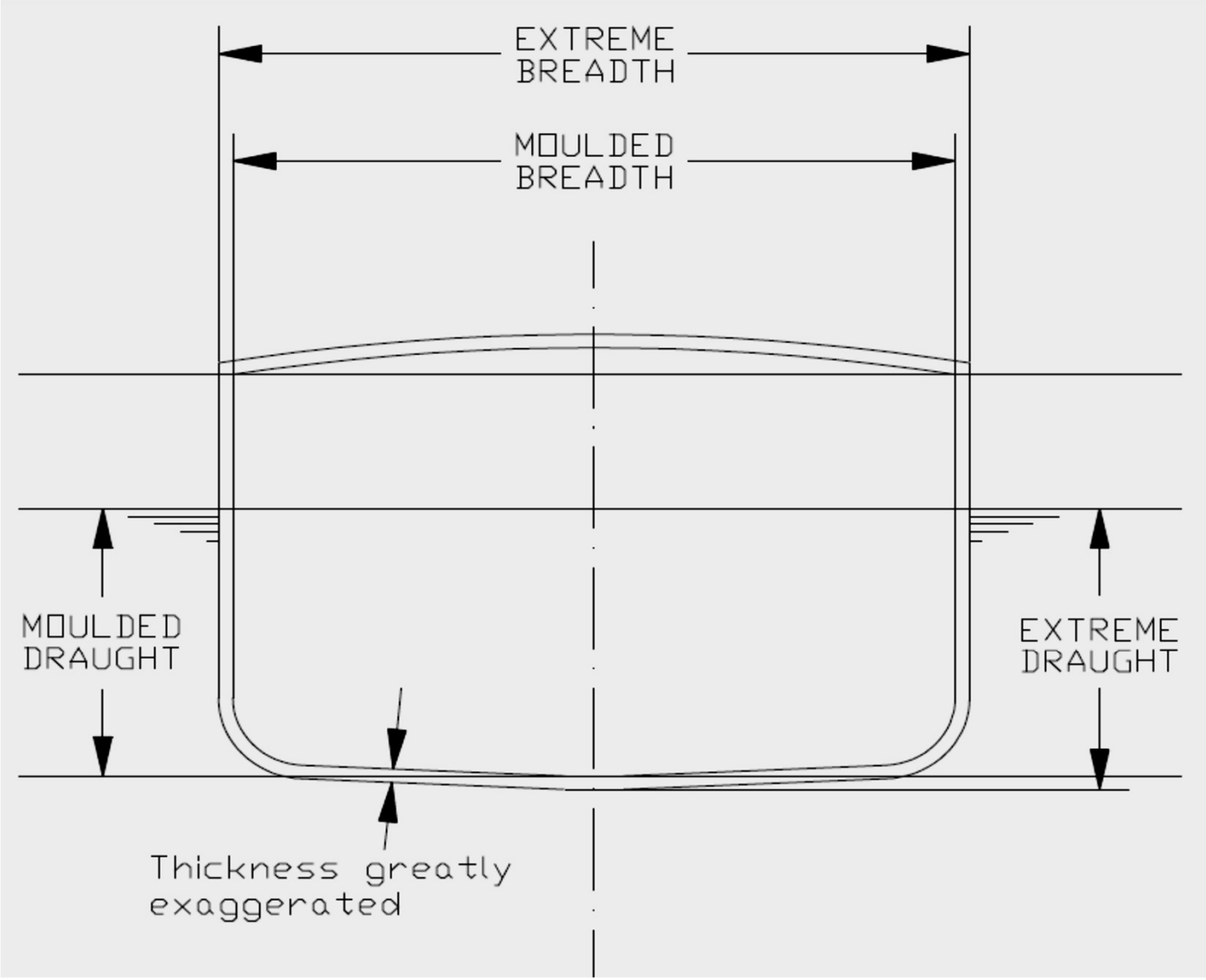
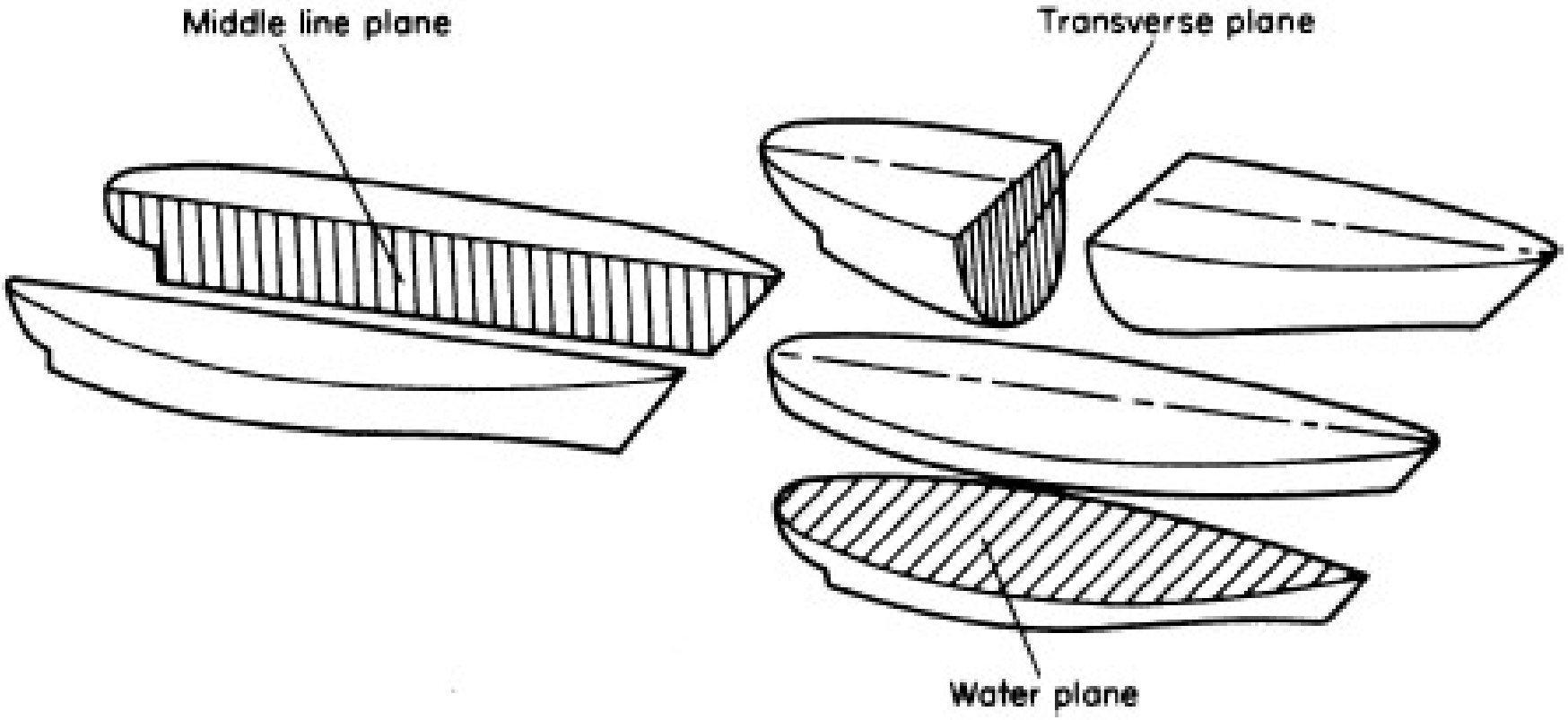


Ship Geometry

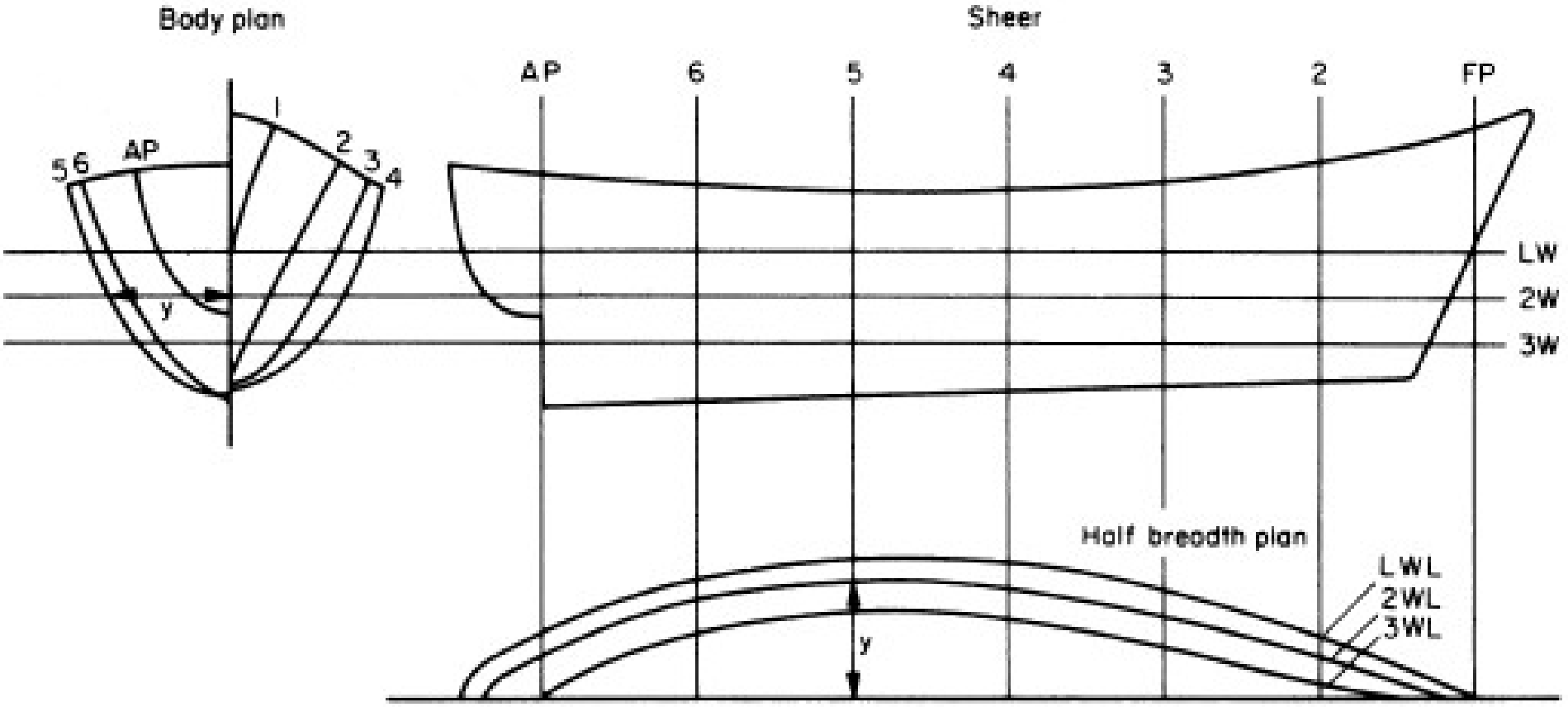
- The three-dimensional hull form can be represented by a well defined set of curves.

- Given hull geometry, these curves can be generated by tracing the intersections of the hull with three sets of mutually orthogonal planes.

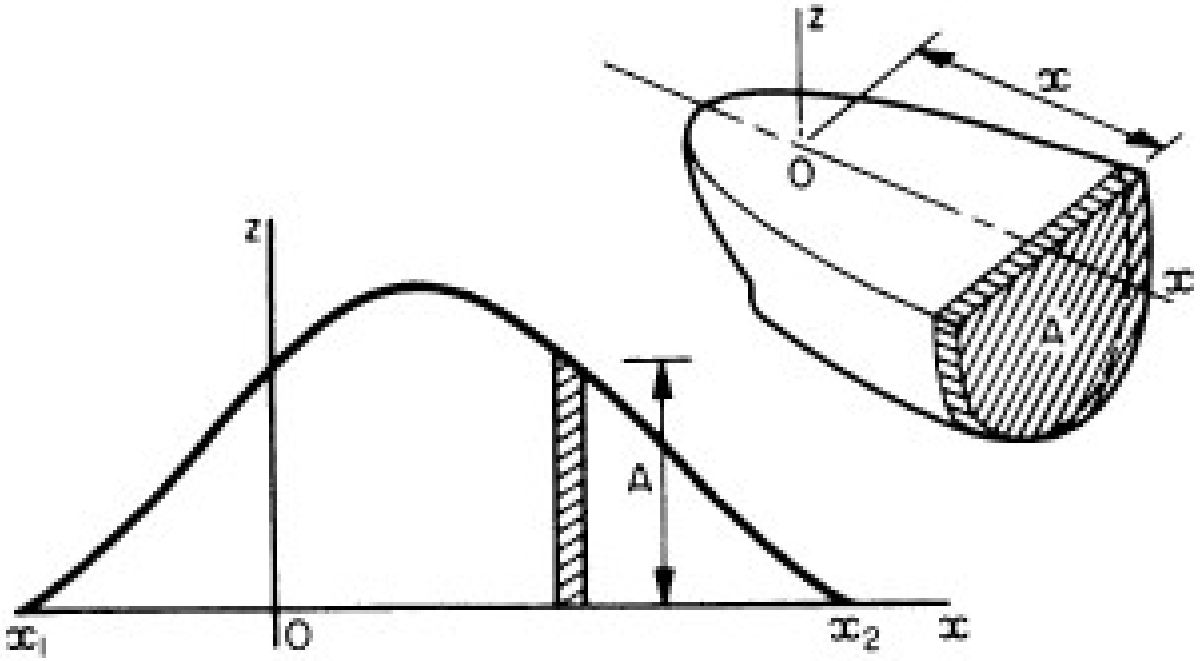
Ship Geometry



Ship Geometry

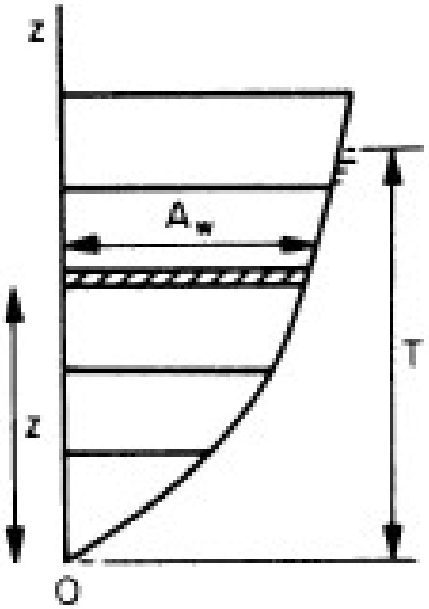


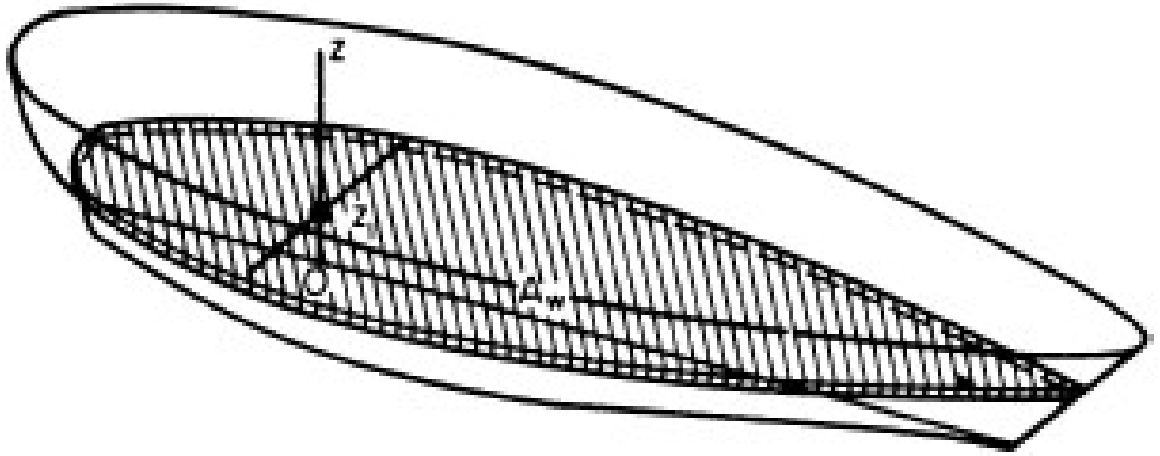
Ship Displacement



$$\nabla = \int_{x_1}^{x_2} A \, dx$$

Ship Displacement





$$\nabla = \int_0^T A_w \, dz$$

The Marine Industry

The ***international marine industry*** can be structurally divided into five groups:

1) SHIP DESIGN:

Naval architectural firms

University schools/ departments

Classification societies

2) SHIP CONSTRUCTION:

Shipbuilding industry: major, medium-sized, and small shipyards

The Marine Industry

3) MARINE MANUFACTURING:

Provide machinery, outfit, equipments, etc. to the shipyards.

Main engine & other machineries
Propulsion system
Cargo-handling system
Steering and Mooring system
Navigation system etc.

4) SHIP OPERATION:

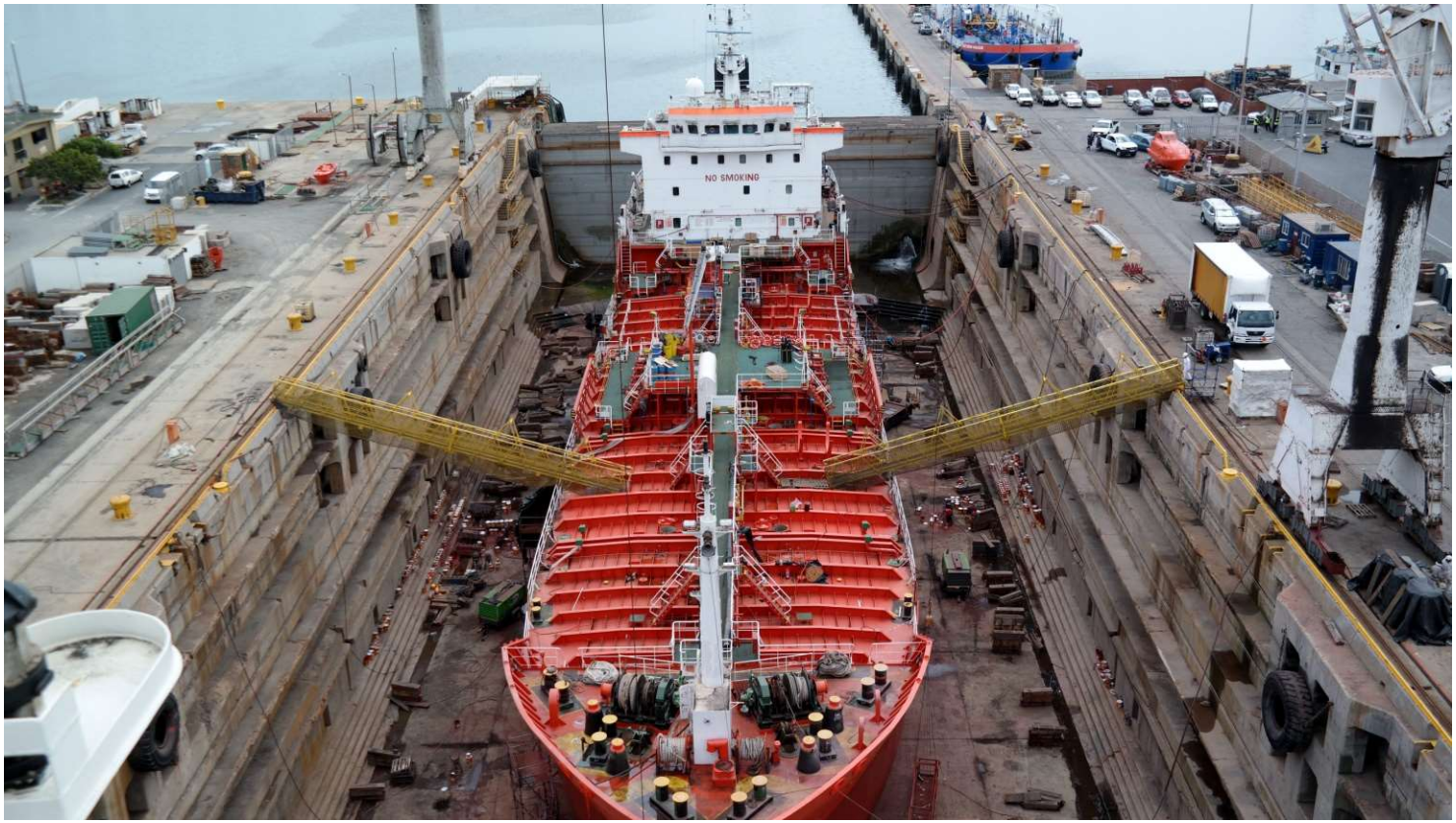
Government agencies, navies, multinational corporations, independent operators etc.

The Marine Industry

5) SHIP REPAIR:

Mainly **dry-docks** used for maintenance and repair activities

Very large, large, small, and very small, depending on capacities



The Marine Industry

The International Maritime Organization:

IMO, a specialized agency of the United Nations, is the global standard-setting authority for the safety, security and environmental performance of international shipping.

Role:
To create a regulatory framework for the shipping industry that is fair and effective, universally adopted, and universally implemented.

Flag of Convenience:

The flag of a suitable country (with good political connections) is adopted for official (taxation) purposes

The Shipbuilding Industry

The industry requires a very wide range of equipment, materials, and skills.

Characteristics

PRODUCT SIZE:

- Size varies from a few metres to a few hundred metres
- Built on land, and need to be put into water (launching)
- Industry involves production, launching, and operation aspects

Characteristics

MANHOUR REQUIREMENT:

- Labour intensive industry with huge manhour requirement
- Production time typically varies from 1-4 years (ship size)
- Evaluation of manhour difficult due to overlapping and complex activities involved

Characteristics

MATERIALS USED:

- Wide variety of materials used for construction
- Engineering requirement followed by boarding and lodging facilities for passengers and crew

Characteristics

MULTIPLE SKILLS:

- Complex construction and mission requires a wide range of skills
- They include- welding, fitting, piping, mechanical, electrical, and navigational equipment installation, air conditioning and ventilation etc.

Characteristics

UNIT PRODUCTION:

- Customer driven unit production market
- Each unit different from others depending on the owner's specific requirements
- No provision for prototyping

Characteristics

SERIES PRODUCTION:

- More than one vessel with identical specifications

- 'Sister ships'-
  for medium to big vessels - 5-10
  for smaller vessels – around 50 or more.

- Timeline of building sister ships different. The next vessel production is started only when the previous one has progressed. Fabrication done separately.

- Some modifications based on feedback of sister ships in service.

Characteristics

DELIVERY SCHEDULE:

- Inputs from the customer: Type of cargo, Volume/Weight of cargo, Operation route, Cruising speed.
- Shipbuilder needs to work out the design, build strategy, delivery schedule, and cost of the ship.
- Contract between builder and ship owner: delivery date, ship cost, speed requirement

Characteristics

SHIP SPEED:

- Cruising speed determines the number of round trips and hence the generated revenue per year
- Higher speed means greater power requirement leading to higher fuel consumption increasing operating cost
- Speed of operation to be decided in the contract between the ship owner and builder

Shipyards in India

PUBLIC

- Mazagon Dock Limited- Mumbai
- Cochin Shipyard Limited
- Hindustan Shipyard Limited- Visakhapatnam
- Garden Reach Shipbuilders and Engineers- Kolkata
- Goa Shipyard Limited
- Naval Dockyards (Mumbai & Visakhapatnam)

PRIVATE

- ABG Shipyard Limited
- Bharati Shipyard Limited
- L&T Shipbuilding Limited
- Pipavav Shipyard (now Reliance Defence and Engineering Limited)

Classification Societies

Develop rules and maintain design, construction, and operation standards for marine vessels through surveys

ROLE:

- Technical plan review
- Surveys during construction
- Sea-trials
- Surveys after construction (periodic surveys)
- Classification standards (develop rules from basic principles, experience and analysis)

Classification Societies

- American Bureau of Shipping (ABS)
- Bureau Veritas (BV)
- China Classification Society (CCS)
- Det Norske Veritas Germanischer Lloyd (DNV GL)
- Indian Register of Shipping (IRS)
- Lloyd's Register (LR)
- Korean Register of Shipping (KR)

Common forum: **International Association of Classification Societies (IACS)**

Loads on Ships

Loads on ships

Types of service loads:

- Static
- Slowly varying/ Quasi-static
- Rapidly varying

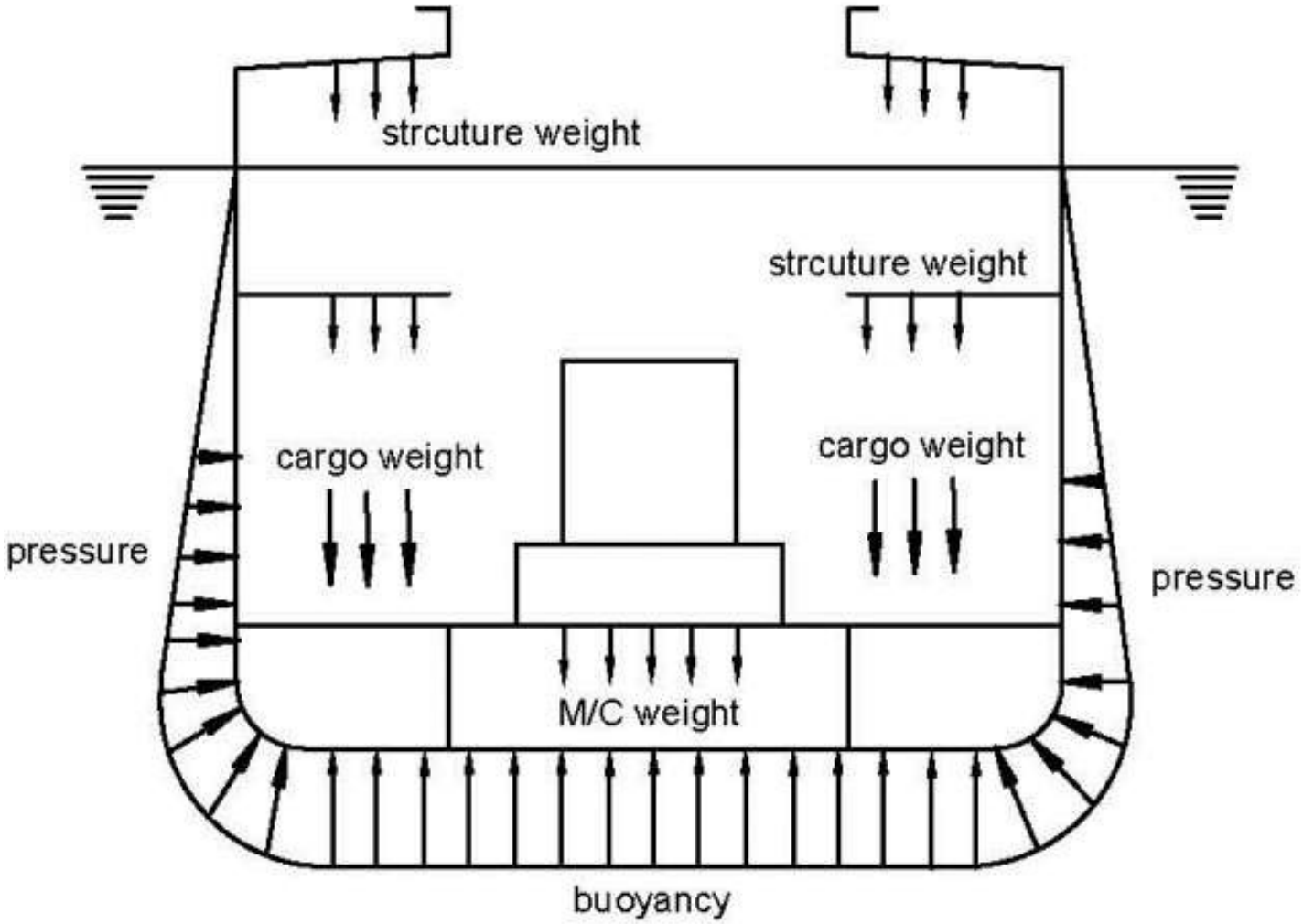
Loads on ships

Static loads:

Do not change over a short period of time

- **Stillwater loads:** External hydrostatic pressure, buoyancy forces,
- **Lightship weight items:** machinery, fittings and fixtures, piping, steering gear, other fixed equipments etc.
- **Dead weight items:** Cargo, fuel, water, provisions, crew, etc.

Loads on ships



Static loads on ship

Loads on ships

Slowly-varying loads.:

Time period slightly greater than the natural flexural periods of the ship's primary structure.

Caused due to wave actions and ship motions and considered quasi-static

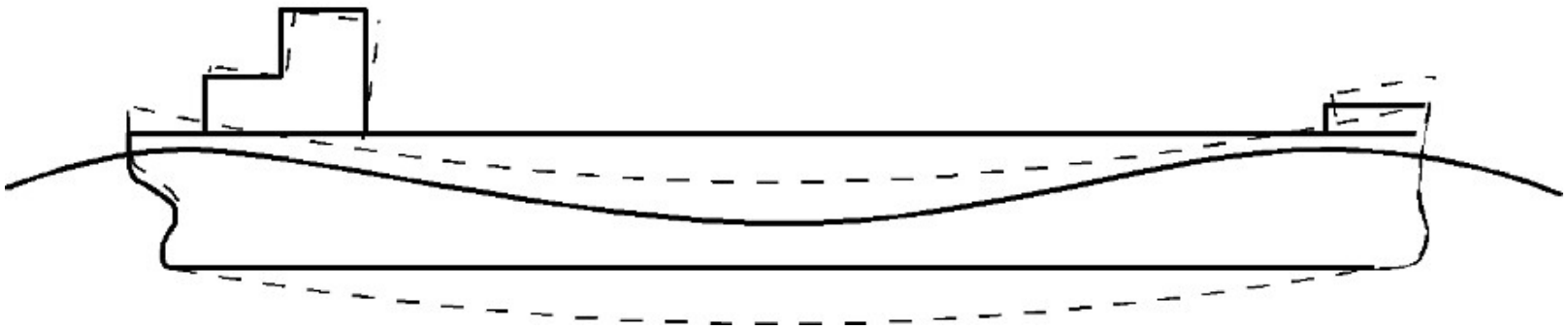
Based on distribution, they may cause

- Longitudinal bending
- Transverse distortion (racking)
- Combinations (bending, racking and torsion/ twisting)

Loads on ships

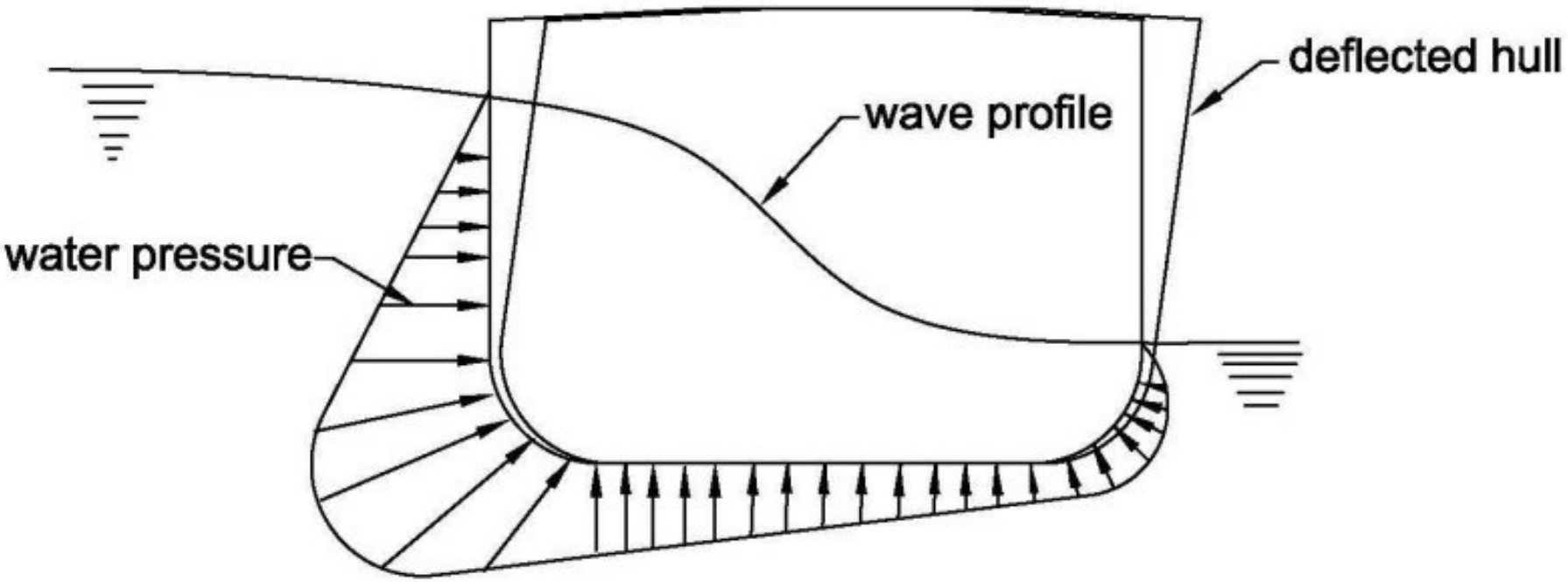
Hogging

Sagging



Longitudinal Bending

Loads on ships



Racking

Loads on ships

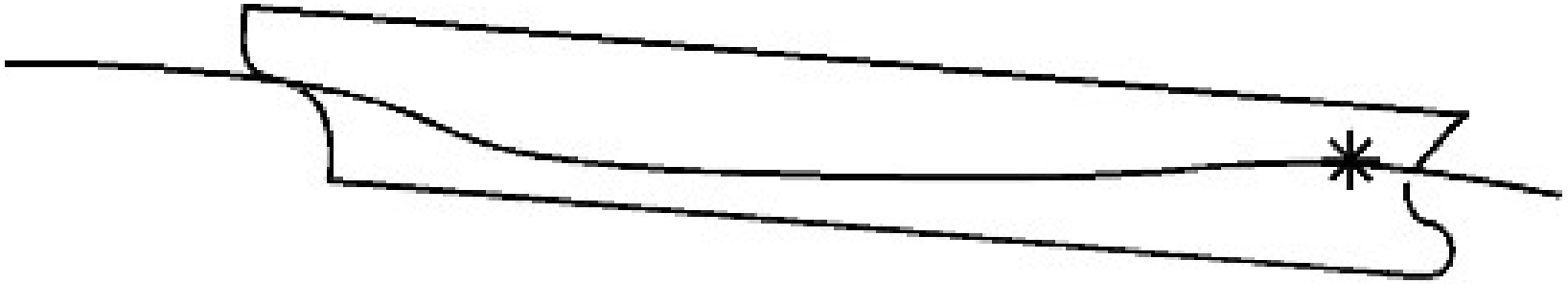
Rapidly-varying loads:

Dynamic loads with time period of the order of the natural periods of vibration or flexure of the ships

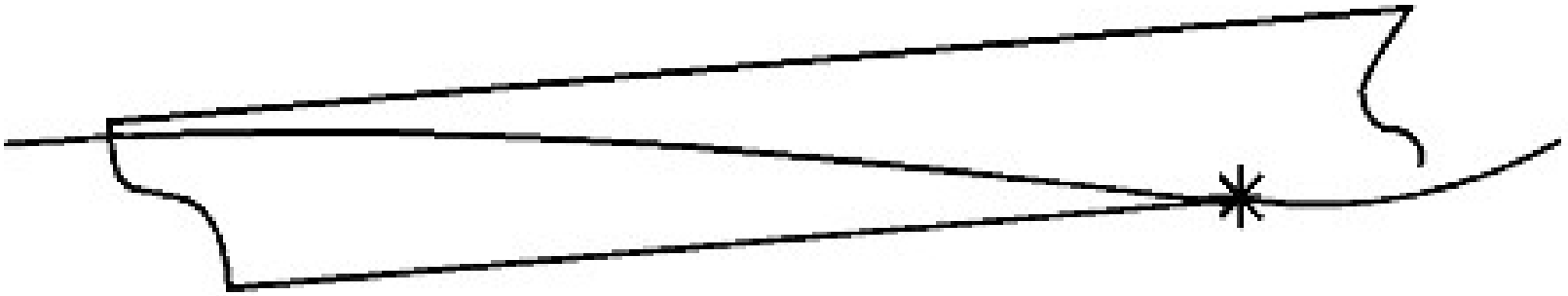
Generally local in nature. Some examples:

- Slamming: Impact of the bow (forward) with the wave surface
- Springing: Hull girder vibrations due to oscillating wave loads
- Mechanical vibrations caused by operating propeller and machinery
- Loads due to combat and weaponry for naval ships

Loads on ships



Bow flare slamming



Bottom slamming

Static Equilibrium

Buoyancy Force on ship = Weight of ship

$$\rho g \int_0^L a(x)\,dx = g \int_0^L m(x)\,dx = g\Delta$$

where:

$a(x)$ = immersed cross-sectional area

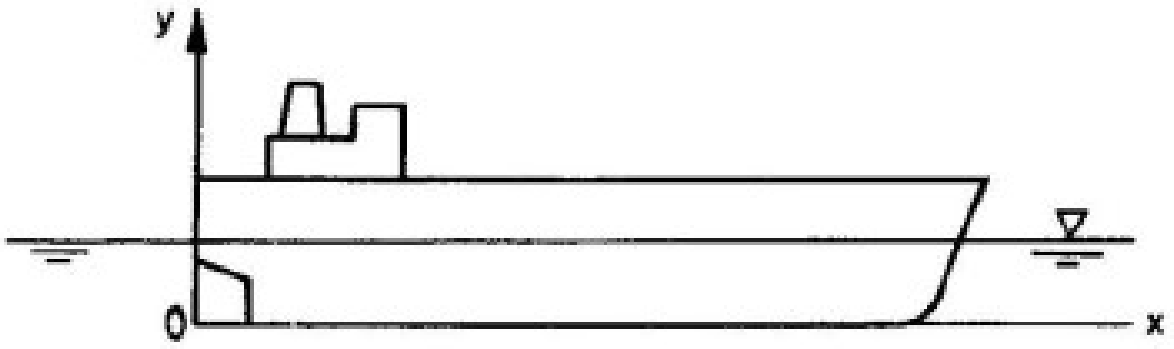
$m(x)$ = mass distribution

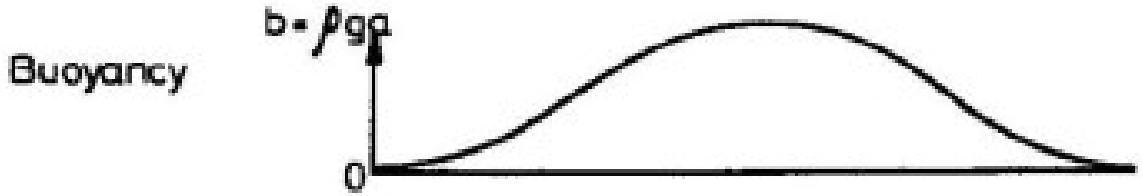
ρ = density of seawater

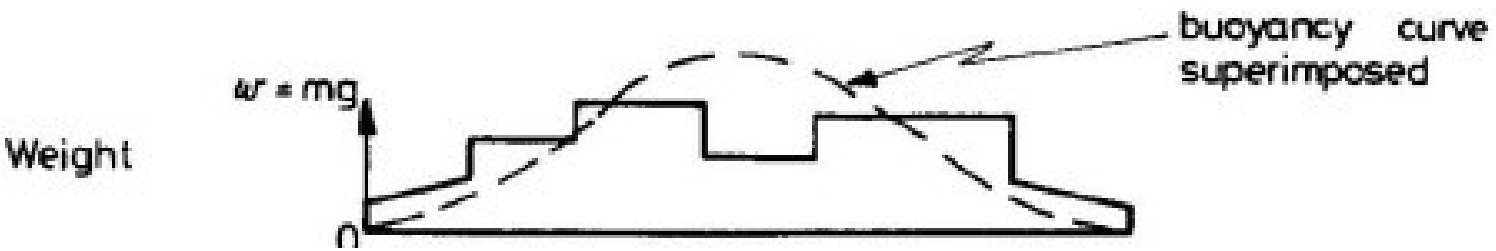
g = gravitational acceleration

Δ = displacement

Static Equilibrium







Shear Force & Bending Moment

- Local segments of the vessel may have more or less weight than the local buoyancy

- Difference between weight and buoyancy curves gives the shear forces along the vessel

$$f(x) = b(x) - w(x)$$

Shear Force:

$$Q(x) = \int_0^x f(x)dx$$

Bending Moment:

$$M(x) = \int_0^x Q(x)\,dx$$

Shear Force & Bending Moment