

Introduction to Naval Architecture

II SEM – Module 5

Course Content

1. Module I

Introduction ships and Naval Architecture discipline

Historical review - Ancient types of vessels (rafts, boats, and ships), the role of ship in the ages of the great discoveries, Role of a Naval Architect in the Maritime Industry.

Types of ships: - terms and definitions, cargo ships (general cargo ships, bulk carriers, container ships, Ro-Ro ships, barge carriers, tankers), fishing vessels, factory ships, supply ships, Cable ships, ice breakers, research vessels, warships, hydrofoils, air cushion vehicles, small pleasure crafts (yachts, ketches, etc).

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)

3. Module III

Introduction to Bonjean and hydrostatic curves

Integration rules: - Trapezoidal rule; Simpson's rules, 6 ordinate rules; Tchebycheff's rule; Areas, volumes and moments Bonjean calculations and curves, sectional area curves. Hydrostatic calculations and curves.

4. Module IV

Introduction to ship structures

The ship and her structural members - shipbuilding materials (properties, compositions), Bottom structure, shell plating and framing, decks, hatches and hatch covers, Superstructures, bulkheads, tanks, holds, fore and aft structure, stern and rudder.

5. Module V

Introduction to ships Machinery

Introduction to ships Machinery: Propulsion machinery - development of ship propulsion, general arrangement of propulsion plants, Main engines (Diesel engines, steam engines & turbines, gas turbines, Diesel-electric drive, nuclear power plants) Auxiliary machineries. Bridge, Navigation Lights Communication Equipment, Lifesaving appliances and fire-fighting equipment, Anchoring, mooring and towing equipment, cargo handling equipment.

Module 5 : Introduction to Ship Outfitting

- Outfitting (Everything other than Structure)
 - Machinery (Engine, Reduction Gear, Turbine, DA, DG etc)
 - Equipment/Appliances (Motors, Pumps, Switchboards,
 - Fittings (Doors, Hatches, Portholes, Valves
 - Piping (Ballast Water, Fresh Water, Fuel, Lub, Cargo, Firemain, Chilled water...)
 - Trunking /Ducting (HVAC – Heating, Ventilation, AC)
 - Cabling (Electrical, Data)
 - Insulation (Thermal –Hot/ Cold, Acoustic)
 - Painting
 - Habitability (Bunks, furniture, panelling, sanitary, lighting

Equipment / Appliances

- Anchoring, Mooring and Towing
- Life saving
- Firefighting
- Navigation
- Communication
- Cargo handling

Anchoring vs Mooring

- Anchoring
 - Fixing a vessel's position using an anchor
 - When berthing in harbour not available
 - When ship needs to stop at sea
- Mooring
 - Fixing a vessel's position by securing to a permanent structure on the shore or on the sea bed
 - Cargo loading unloading
 - Safety



Anchoring



Mooring



Anchor

- Anchor
 - Need
 - Primitive
 - Origin of Modern day anchor
 - Cable
 - Ring
 - Shaft
 - Arms
 - Flukes



Anchor

- Modification
 - Introduction of Stock



Anchor

- Admiralty Pattern / Plan / Fisherman



Anchor

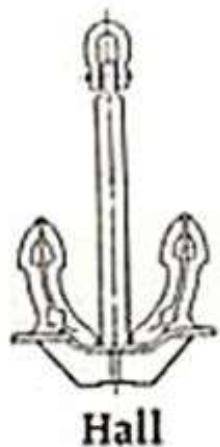
- Drawback of Stock Anchors
 - Only one fluke is used
 - Fouling with cable
 - Consumption of deck space
 - Difficulty in handling
- Modification
 - Stockless Anchor

Anchor

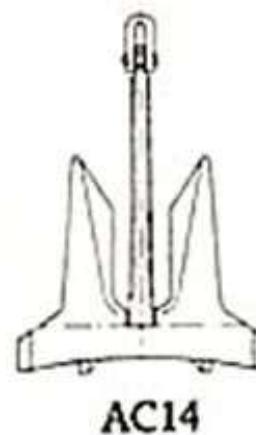
- Stockless Anchor Types (Based on Shape)
 - Fluke Type
 - Plow Type
 - Claw Type

Anchor

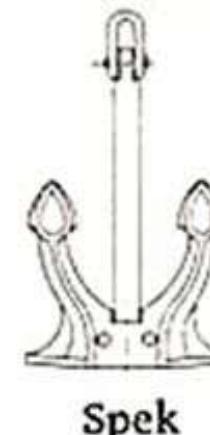
- Fluke Type
- Most common in sea going vessels
- Large anchors



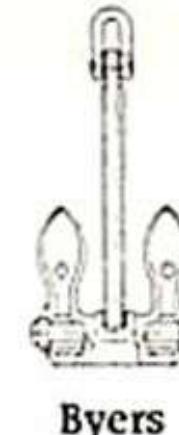
Hall



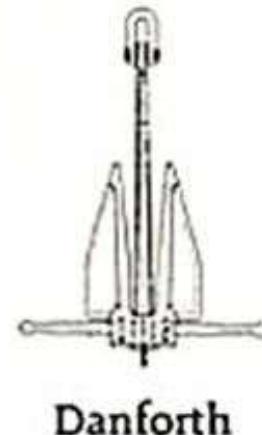
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Spek



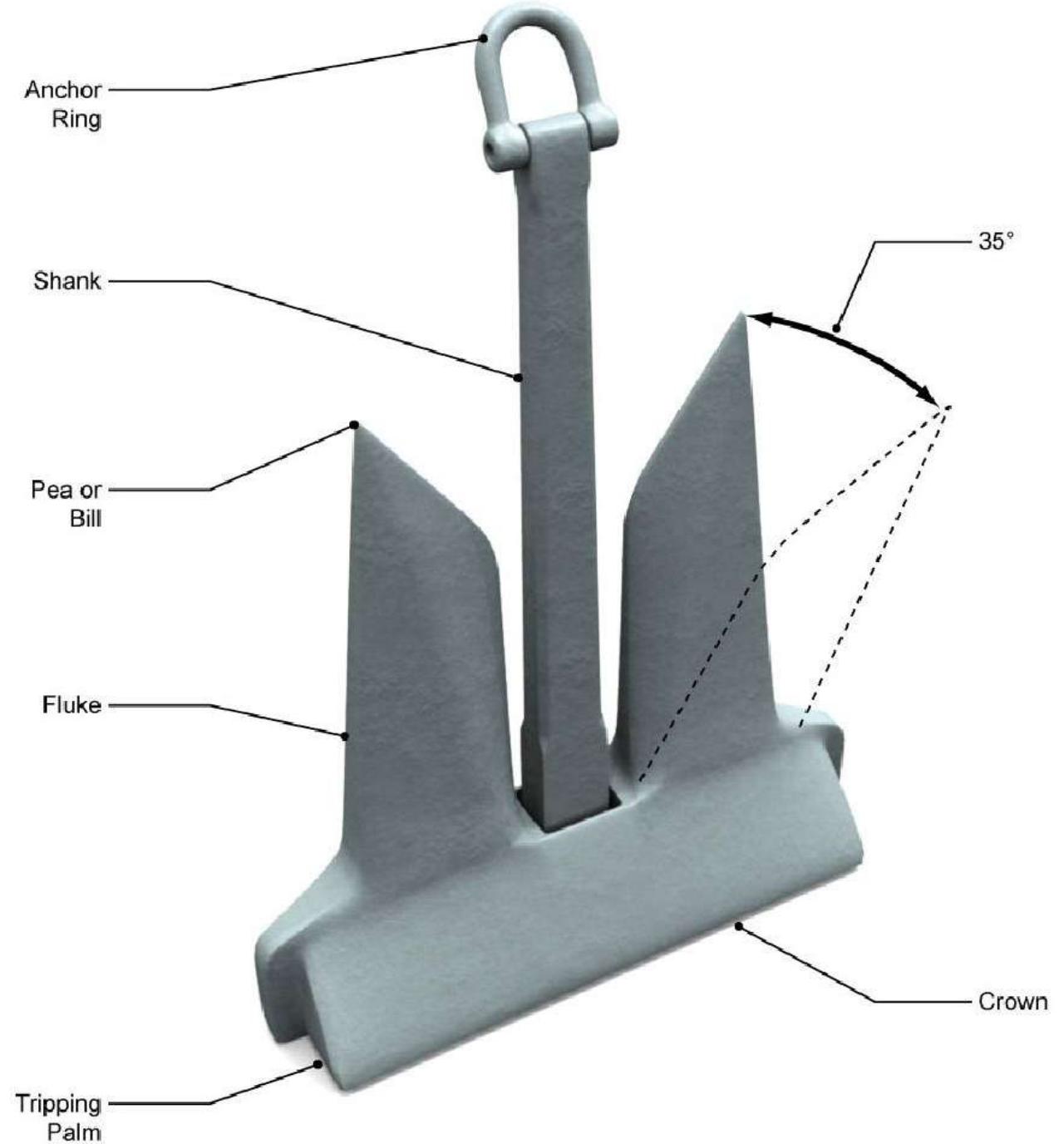
Byers

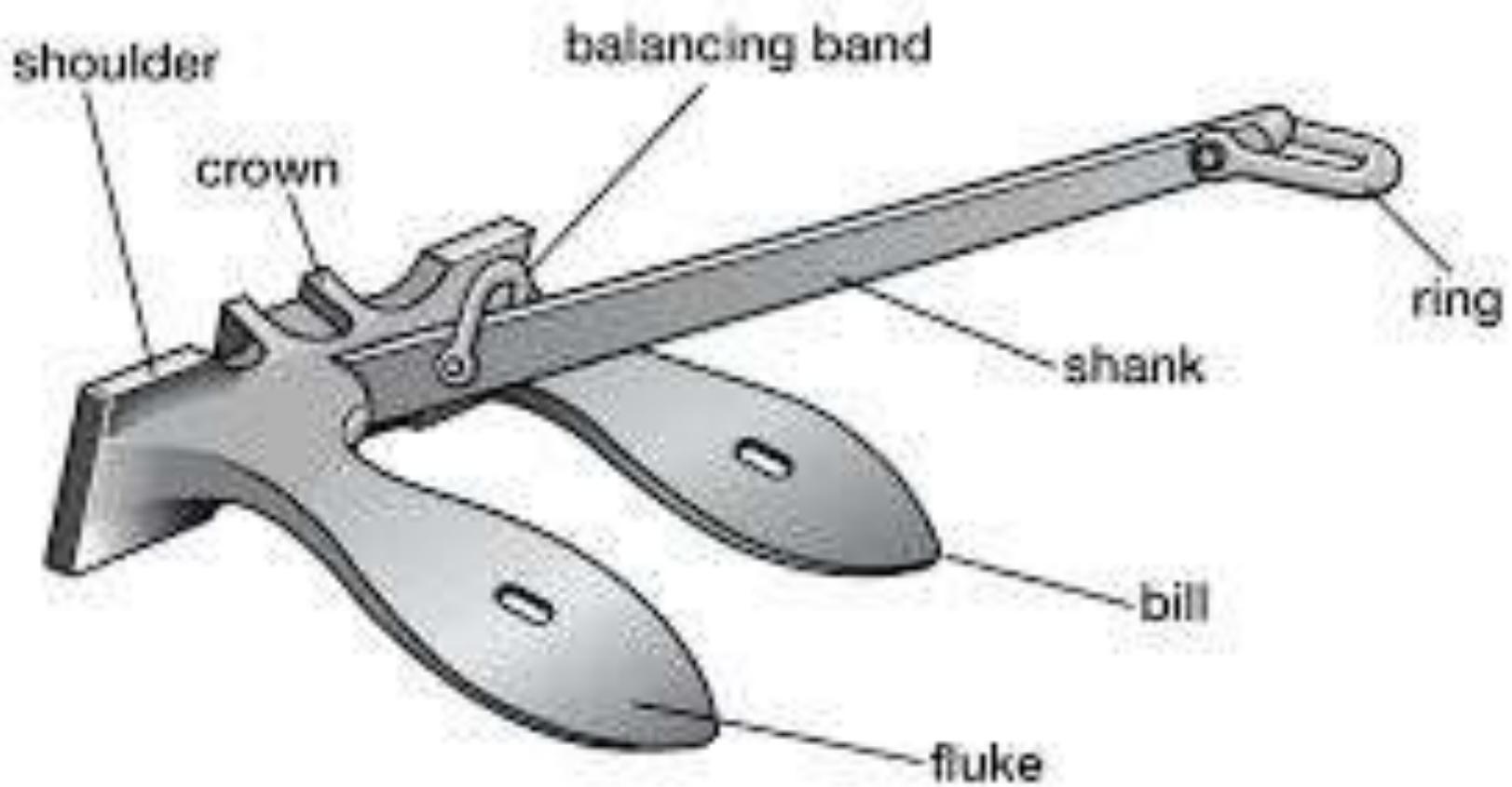


Danforth

Anchor

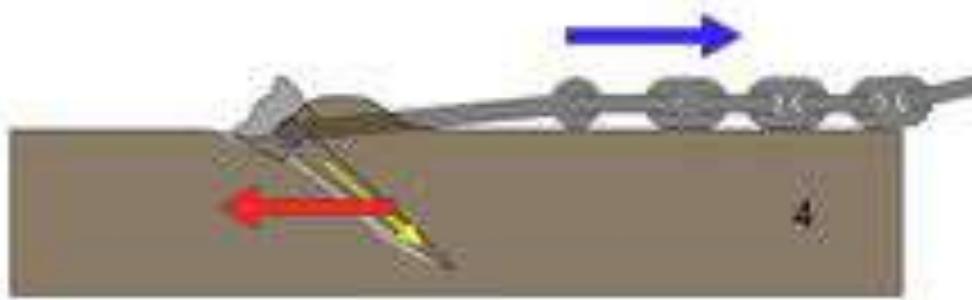
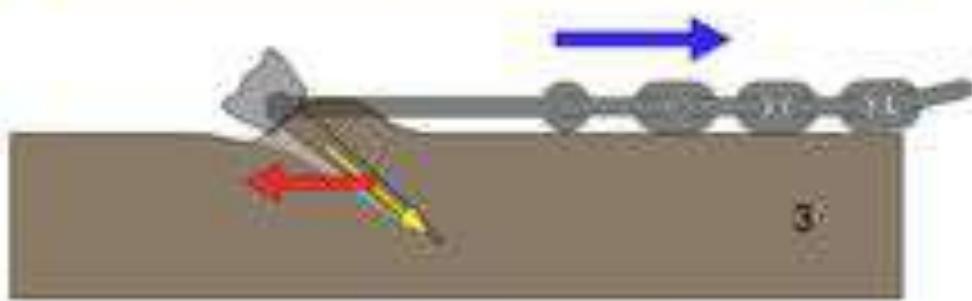
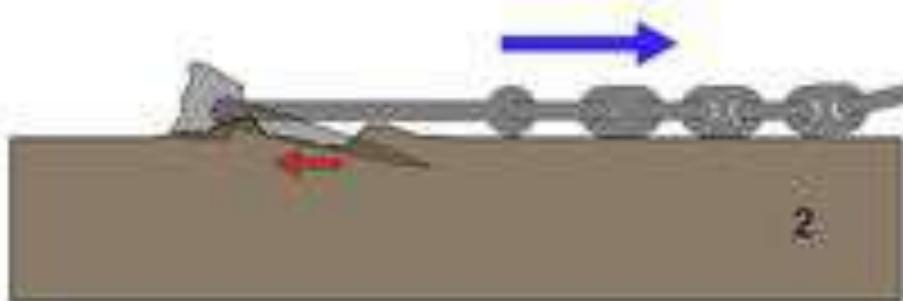
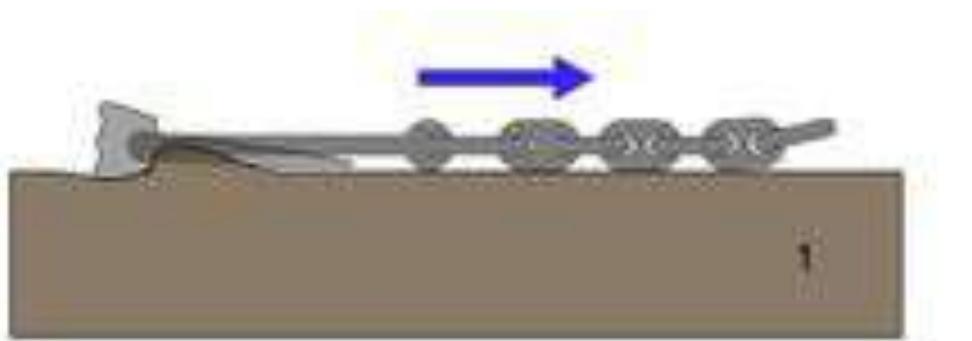
- Fluke Anchor Parts





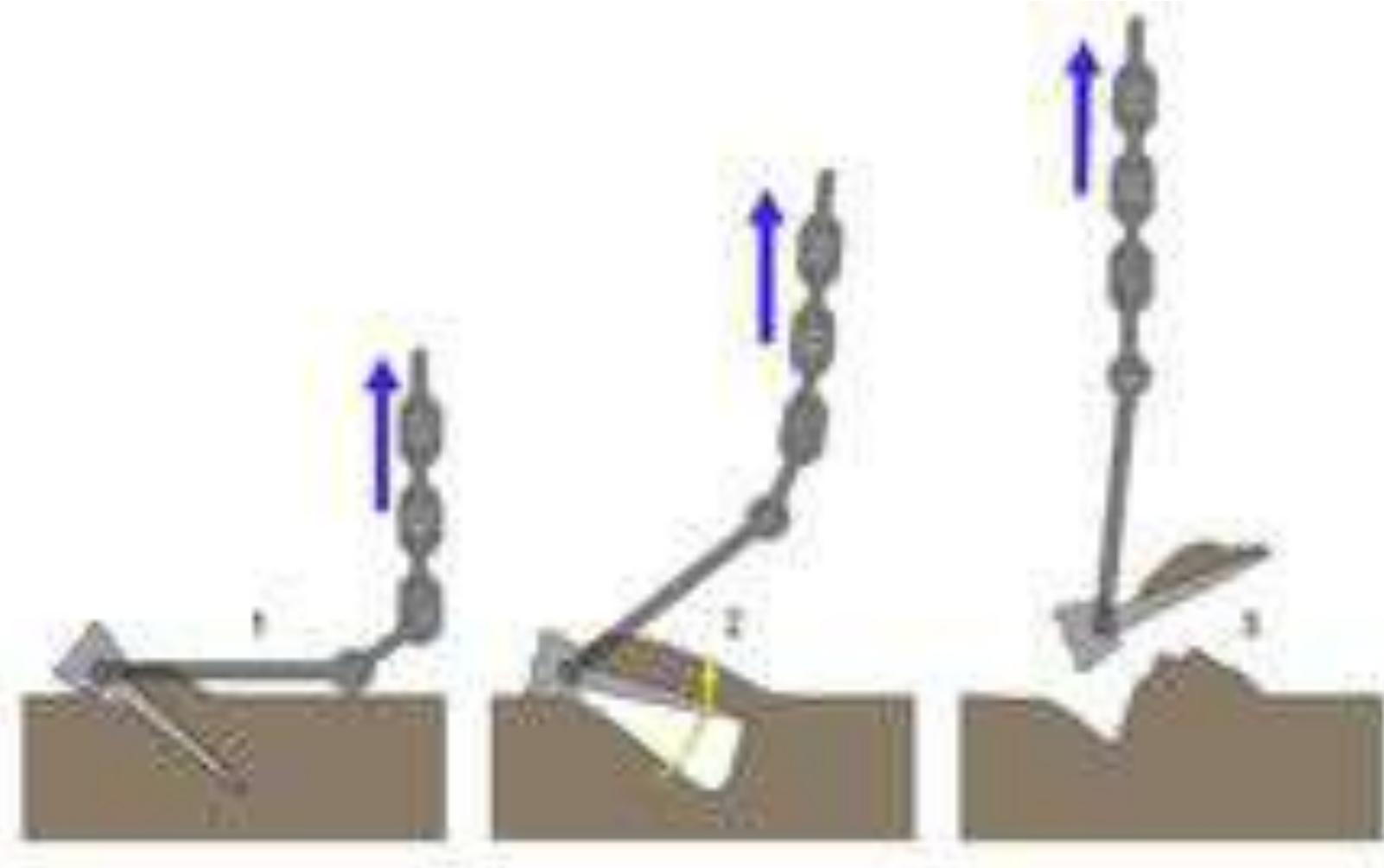
Anchor

- Fluke Anchor action



Anchor

- Fluke Anchor action



Anchor

- Plow Type / Coastal Quick Release (CQR)
 - Pleasure vessels
- Variation –Delta (arched shank)



Anchor

- Claw Type (also called Bruce)

- Design by Peter Bruce
- Shape of open claw



Anchor

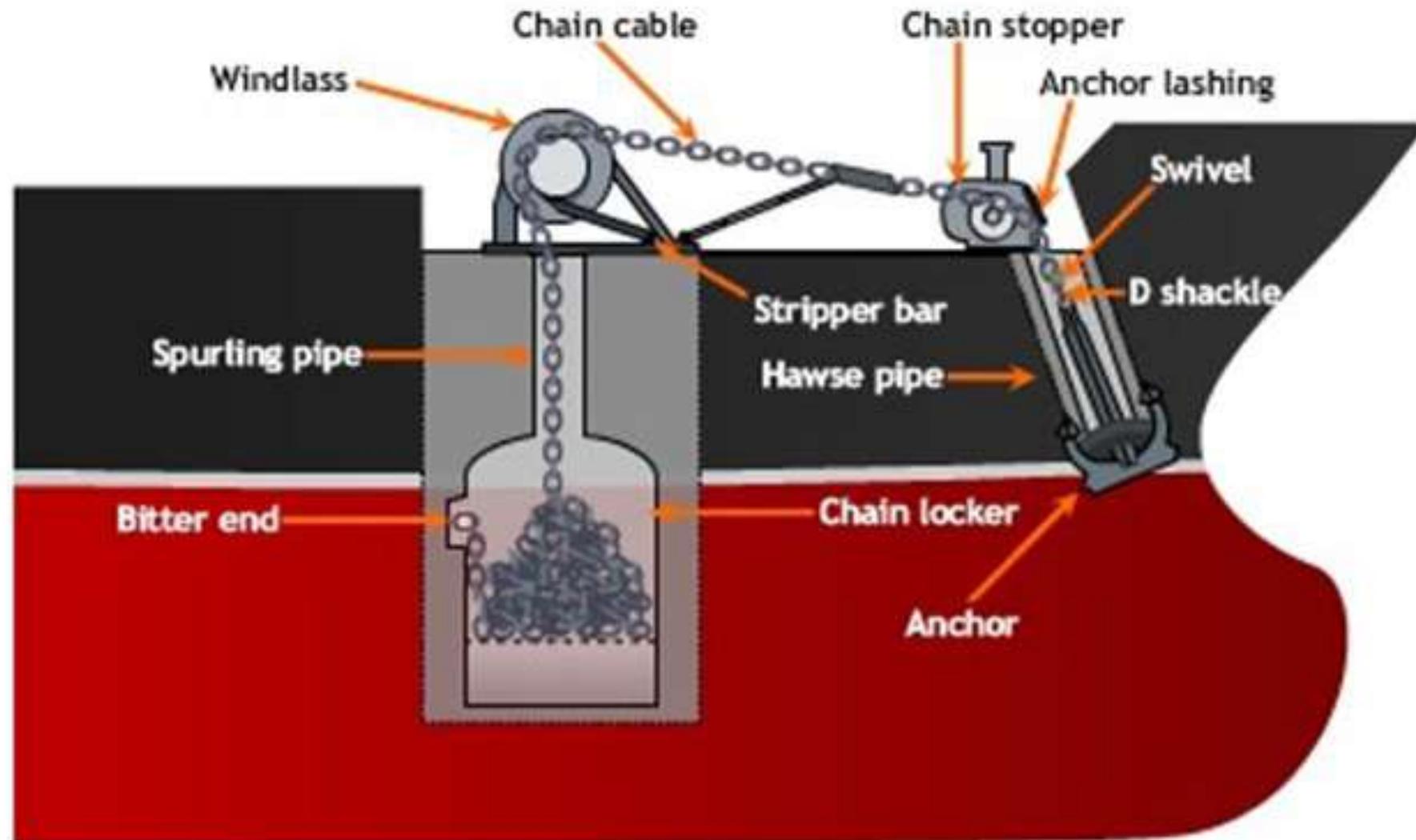
- Stockless Anchor Type (Based on Location)
 - Bower Anchor (at bow –centre, port or stbd)
 - Sheet Anchor –The second bower anchor to be used in emergency
 - Stream Anchor – At the stern, for landing ships



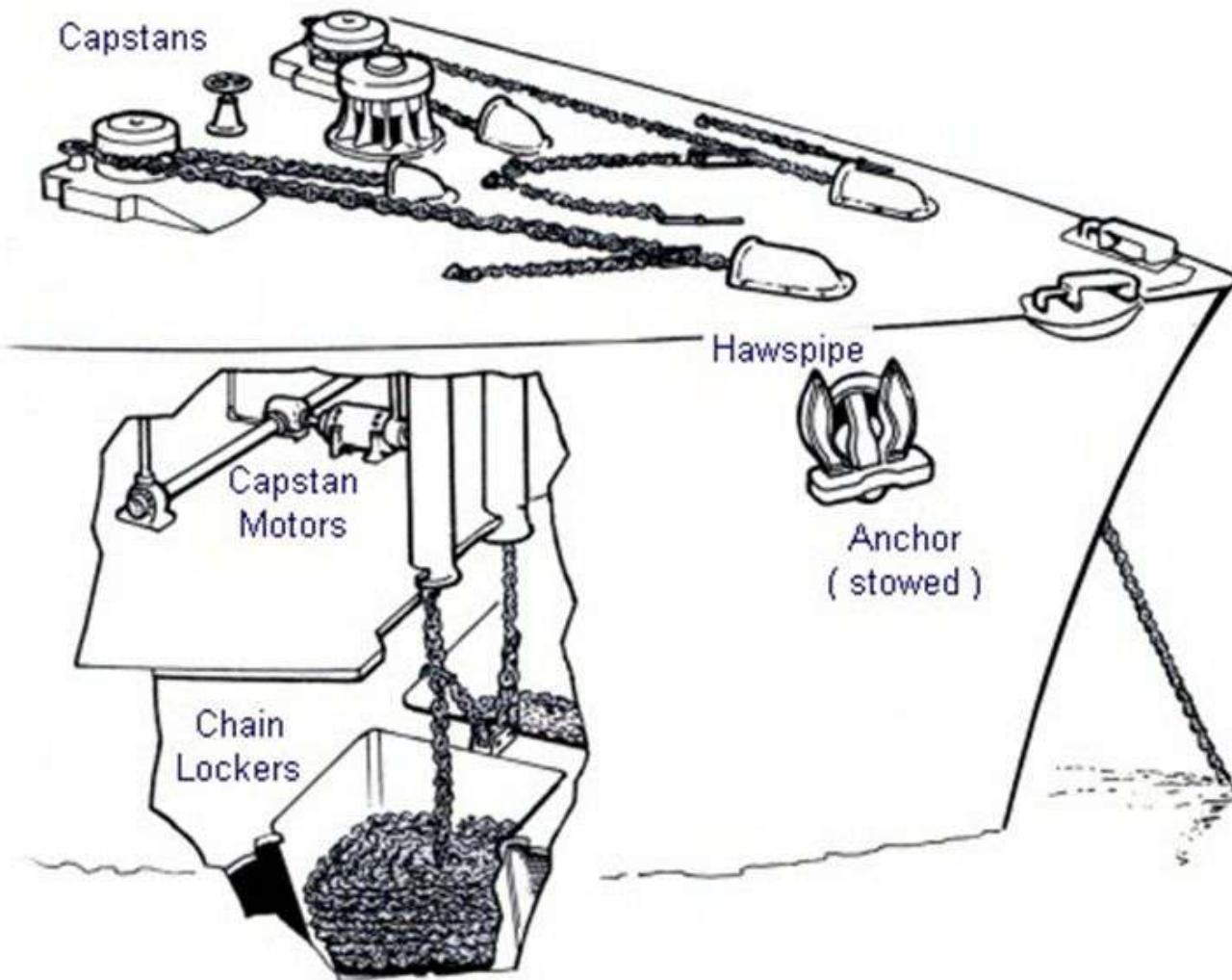
Anchor Handling

- Fittings
 - Chain Cable, Stoppers etc.
- Equipment
 - Windlass, Capstan etc.
- Structure
 - Chain Locker, Hawsepope, Spurling Pipe etc

Anchor Handling Arrangement



Anchor handling Arrangement

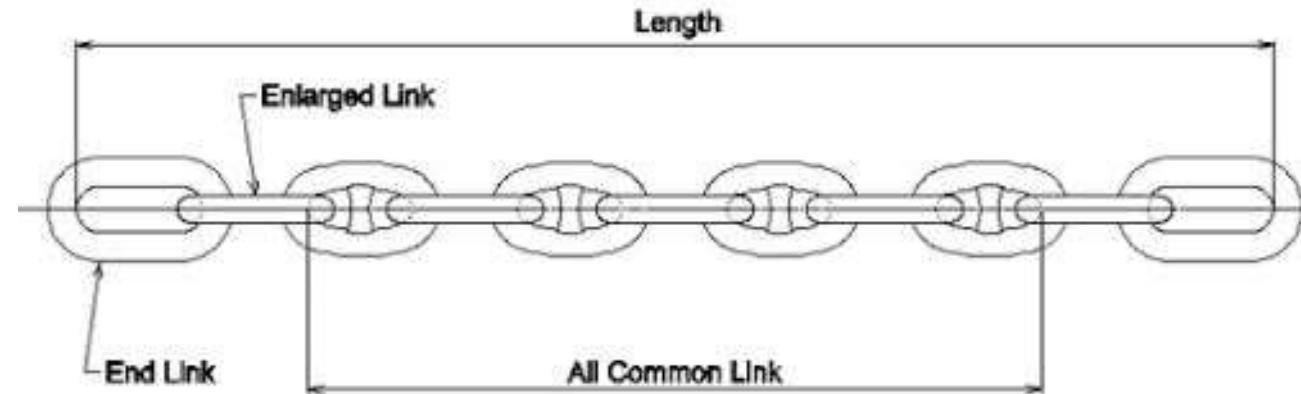
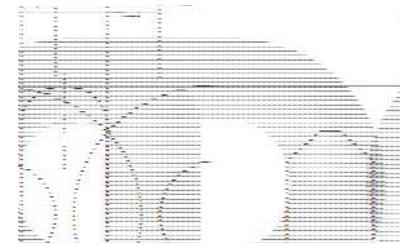
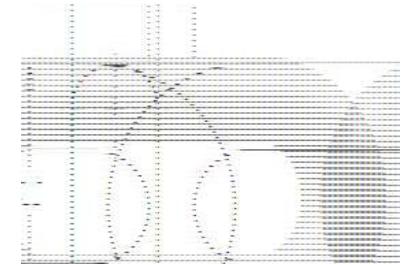


Anchor Handling Fittings - Anchor Chain Cable

- Connects Anchor to ship
- Rope – for small vessels
- Chain – for bigger vessels
 - Strength reqd for heavier anchors
 - Withstand more wear and tear
 - Provide weight to ensure anchor lies horizontal on sea bed

Anchor Chain Cable

- Parts
 - Links
 - Studless Link (or Open Link)
 - Stud Link (Common Link)
 - Shackles (or shots)
 - A set of interconnected links
 - Standard lengths of 13.75m(half shackle) and 27.5 m (full shackle)



Anchor Chain Cable

- Parts(contd)

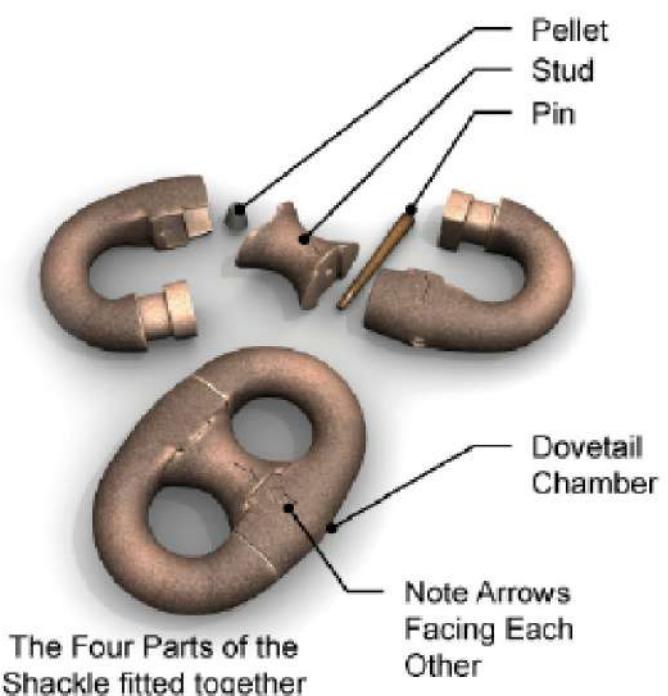
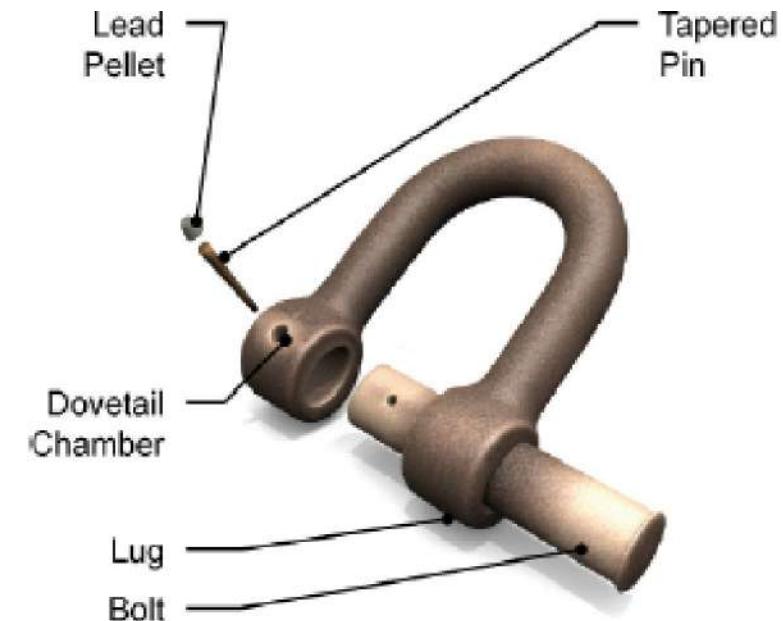
- Shackles (for joining)

- Another meaning – a link which can be opened and closed using a bolt
 - Used to join lengths of cables

- Joining Shackle

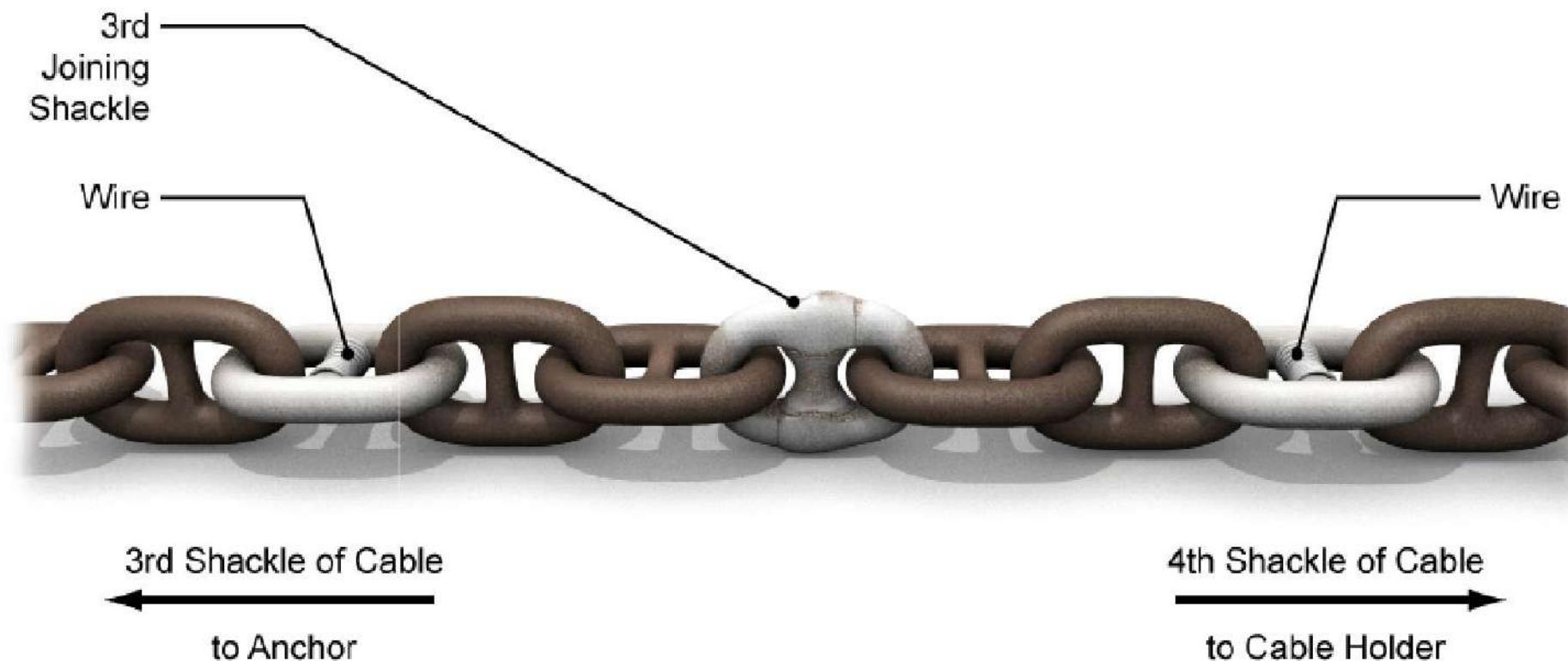
- Lugged joining shackle

- Lugless joining shackle



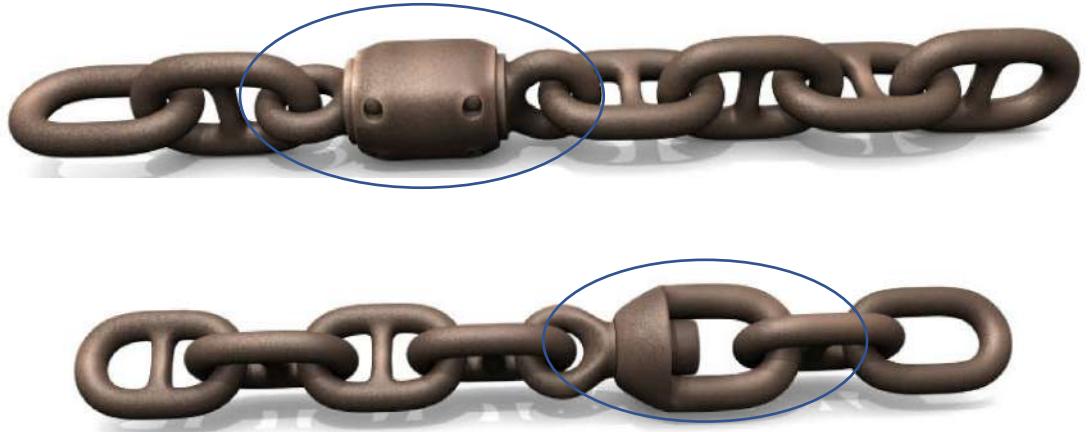
Anchor Chain Cable

- Marking / identification
 - Numbered from Anchor to Ship
 - Specific links on both sides of joining shackles are painted



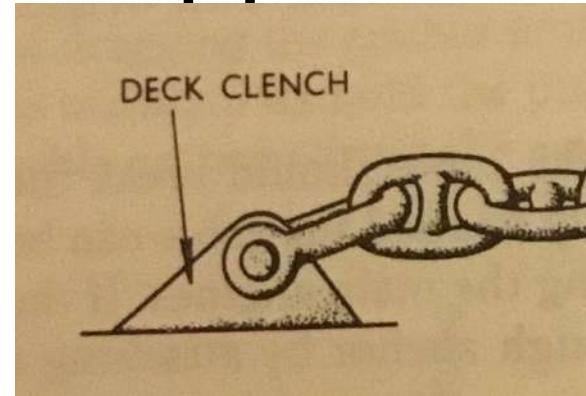
Anchor Chain Cable

- Parts(contd)
 - Swivel Piece
 - Connects anchor and chain cable and inboard end in ship
 - Prevents twisting and jamming
 - Box Type
 - Cup Type

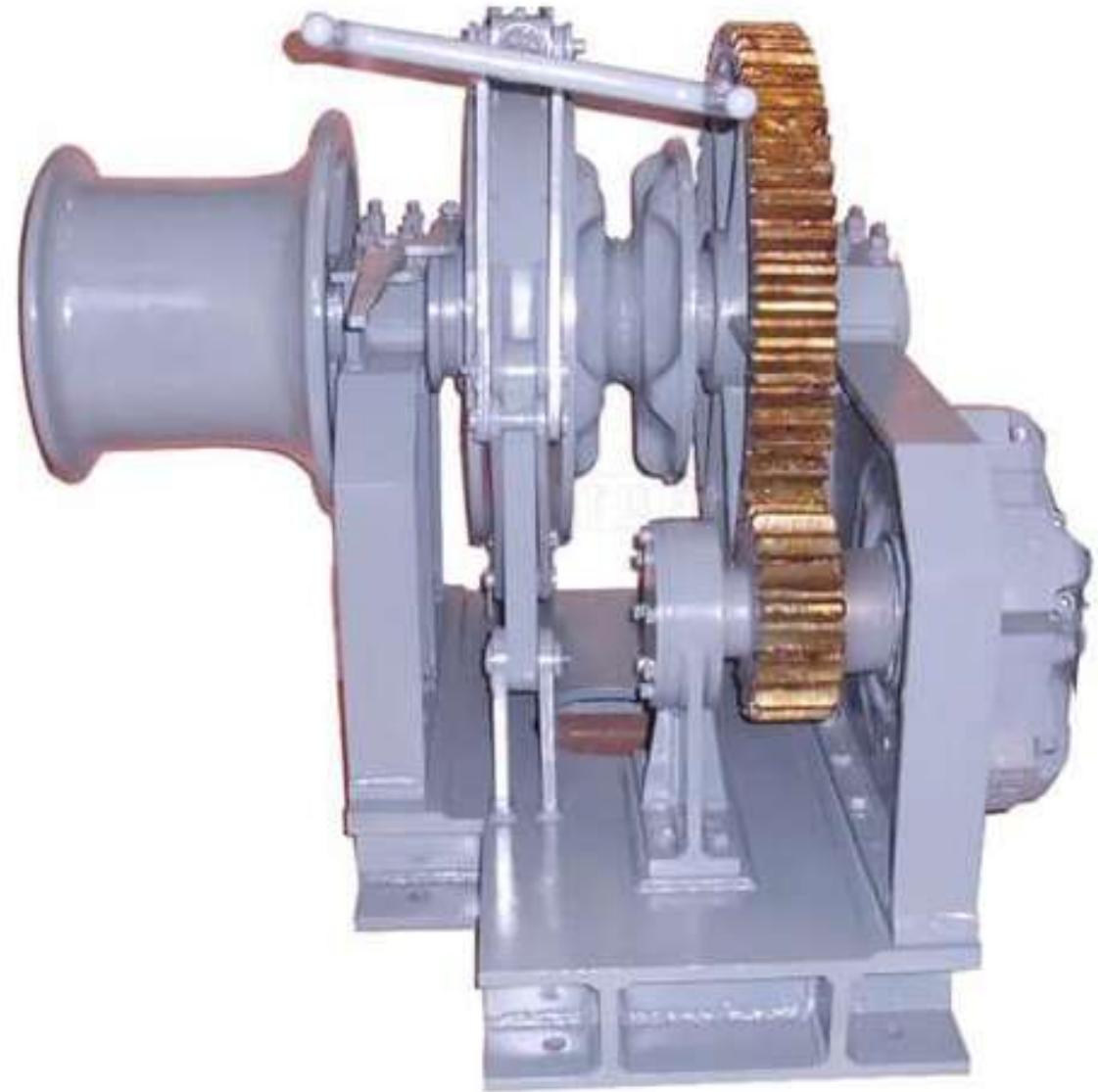
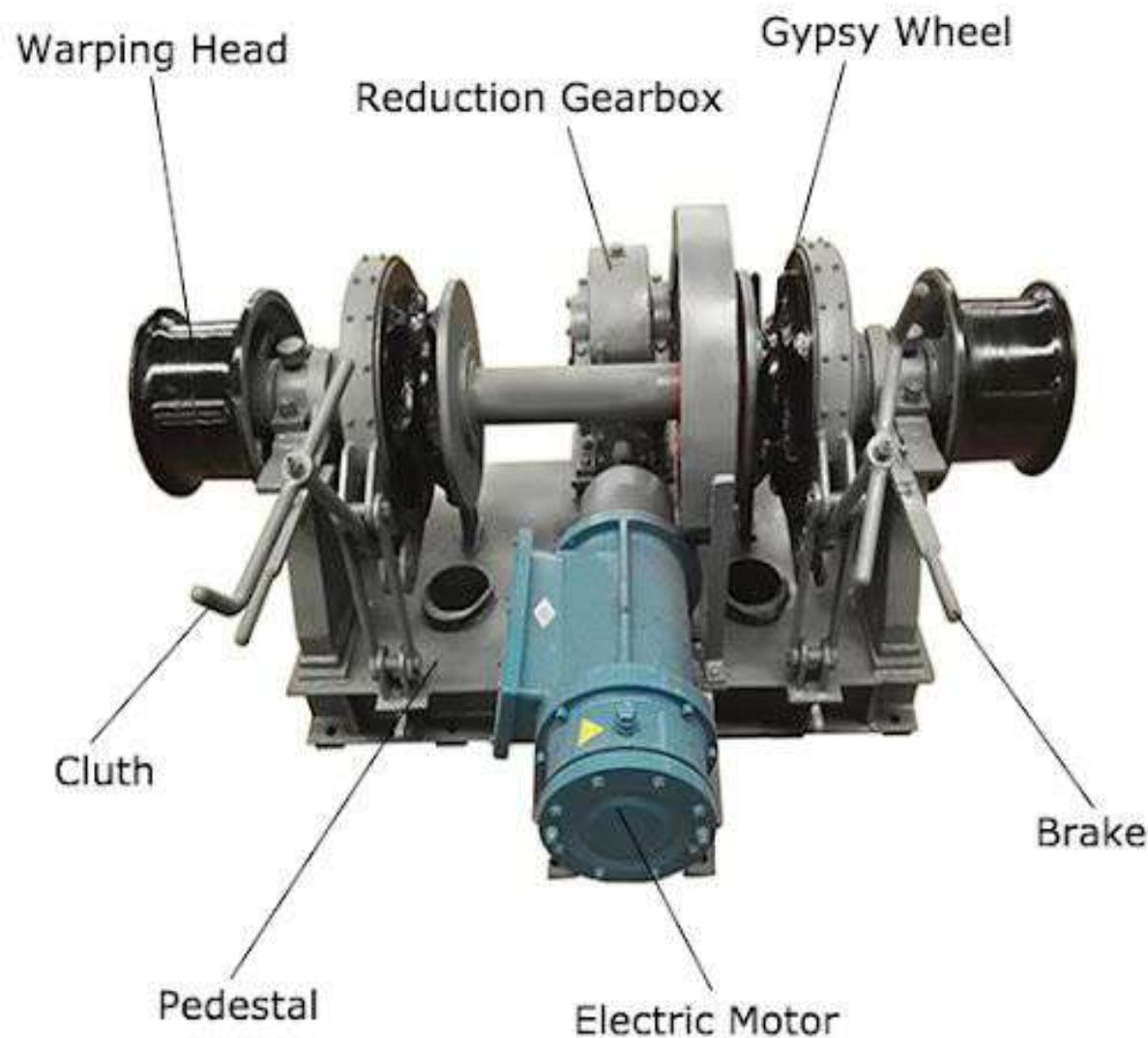


Anchor Handling Fittings - Stoppers

- Stoppers/ Slip
 - Connected to a welded strong point on deck on one end and to the anchor chain on the other end.
 - Ease in handling and Redundancy
 - Blake Slip
 - Bottle Screw Slip



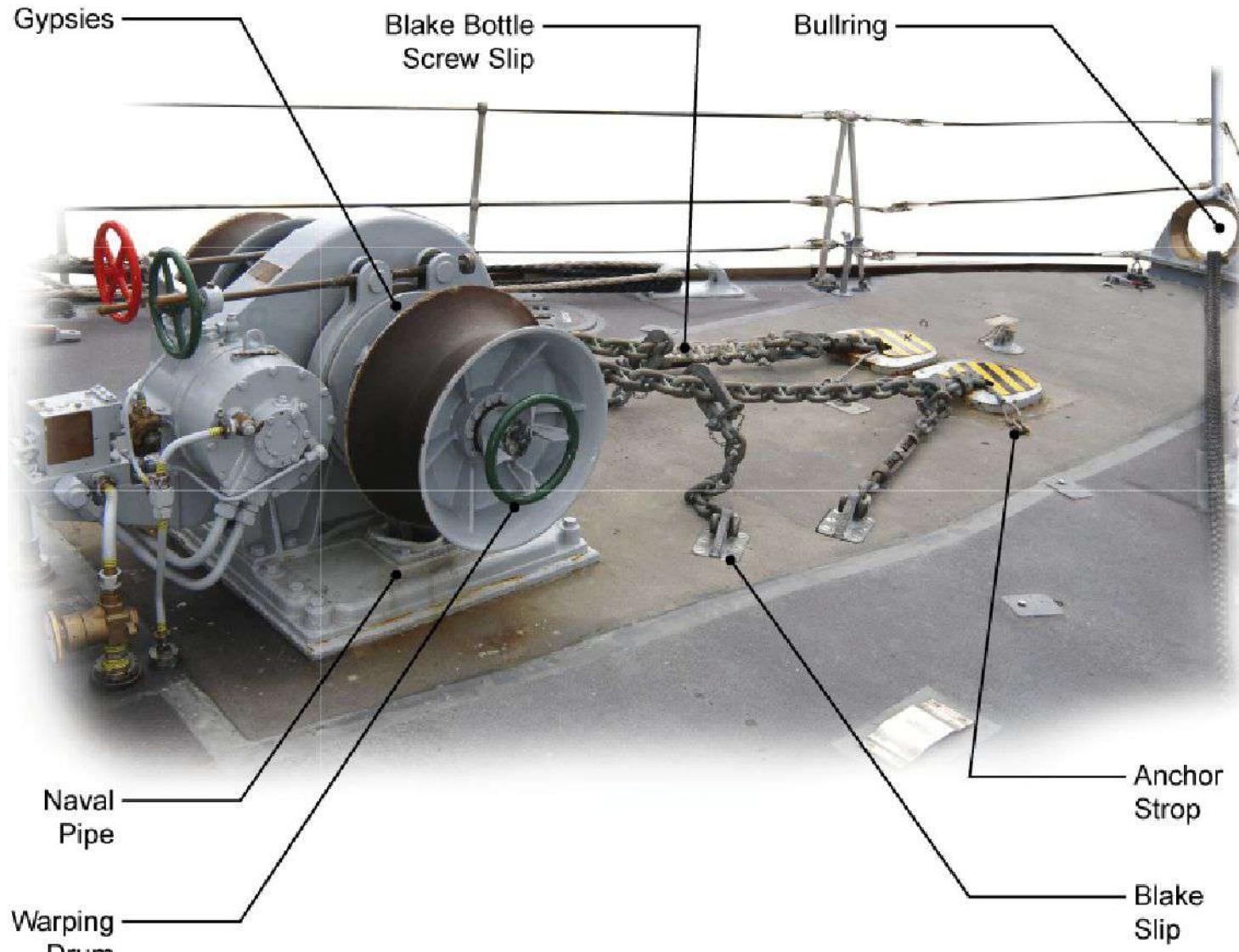
Anchor Handling Eqpt - Windlass





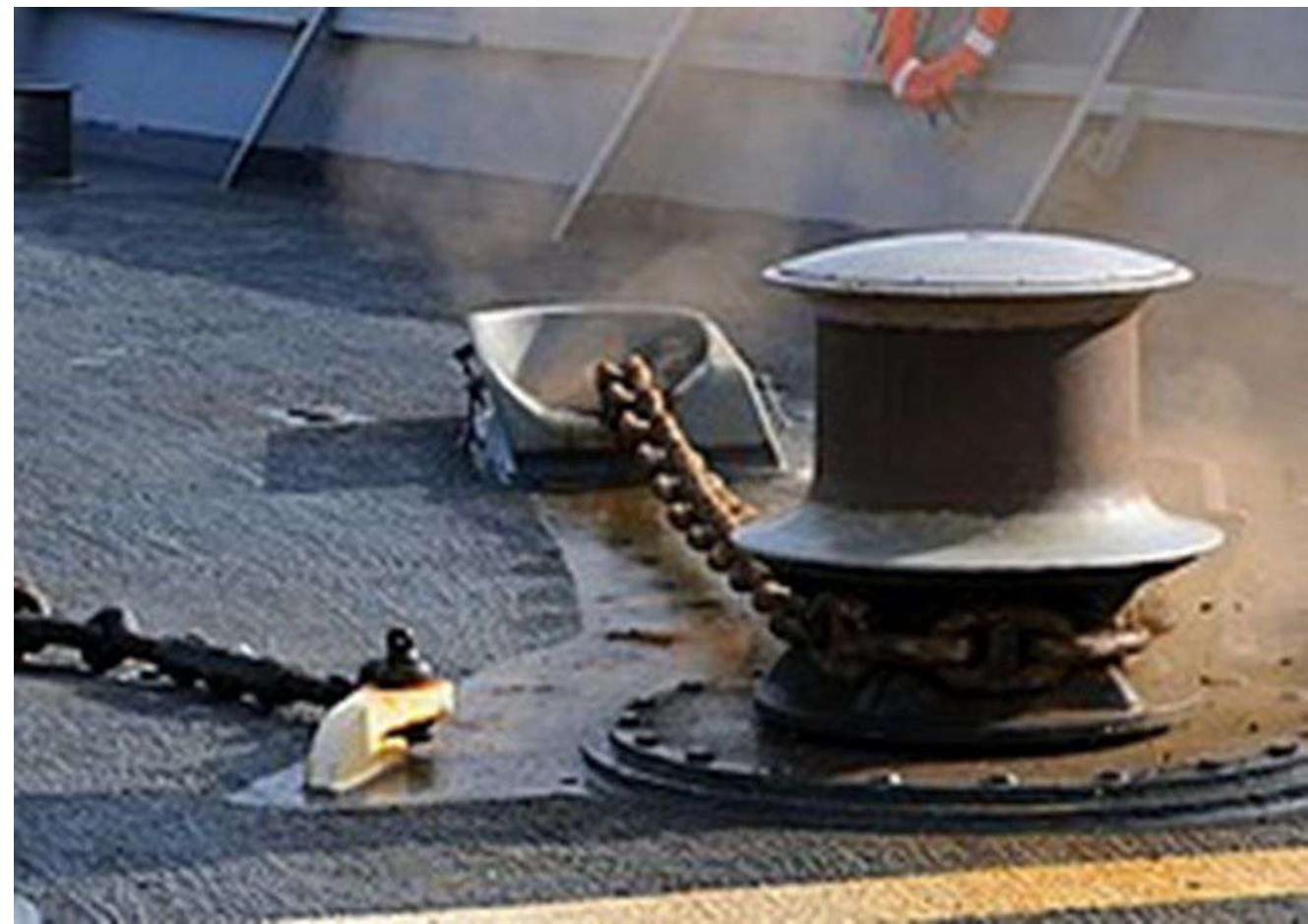
Anchor Handling Equipment

- Windlass
 - Motor
 - Horizontal Shaft



Anchor Handling Eqpt - Capstan

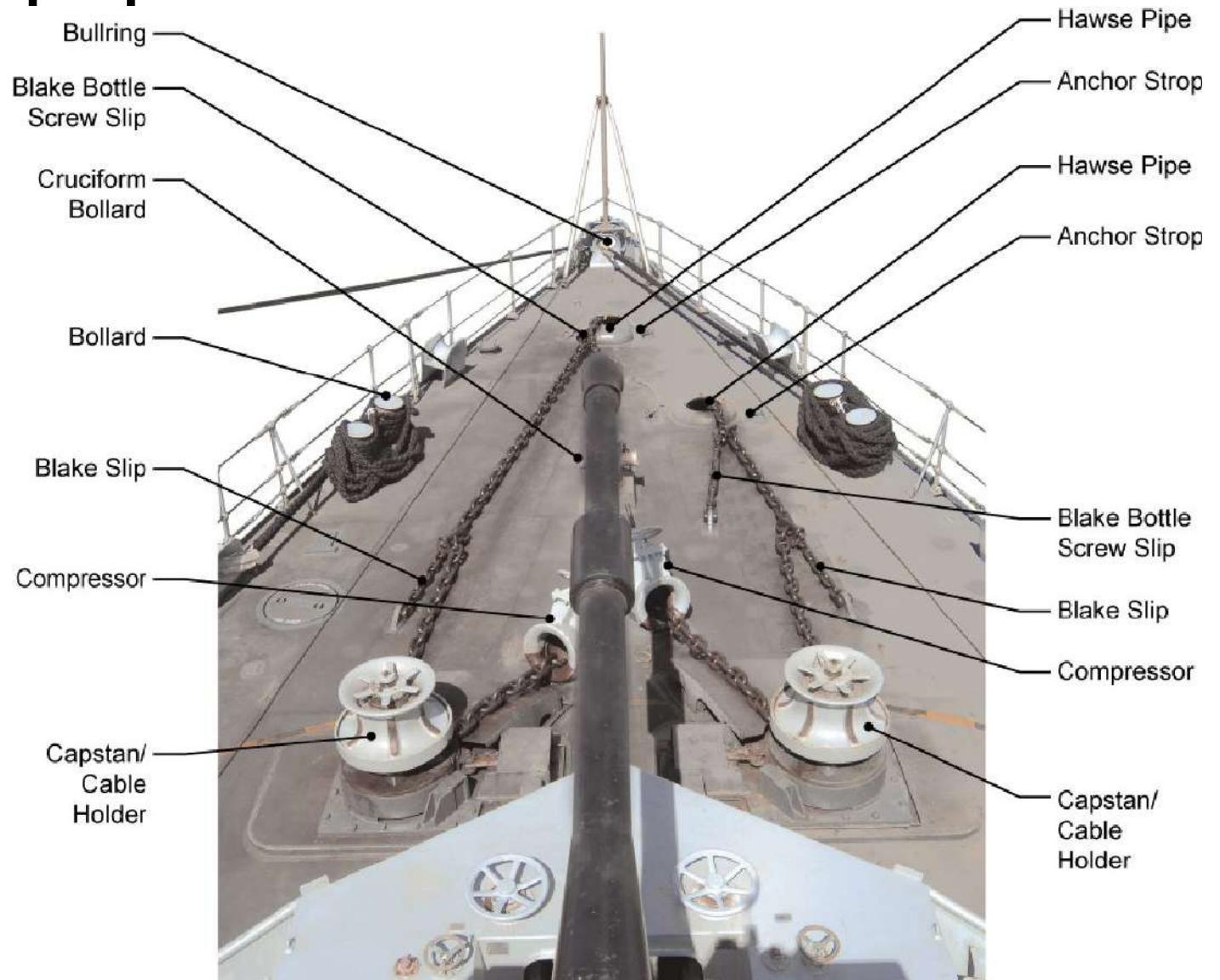






Anchor handling Equipment

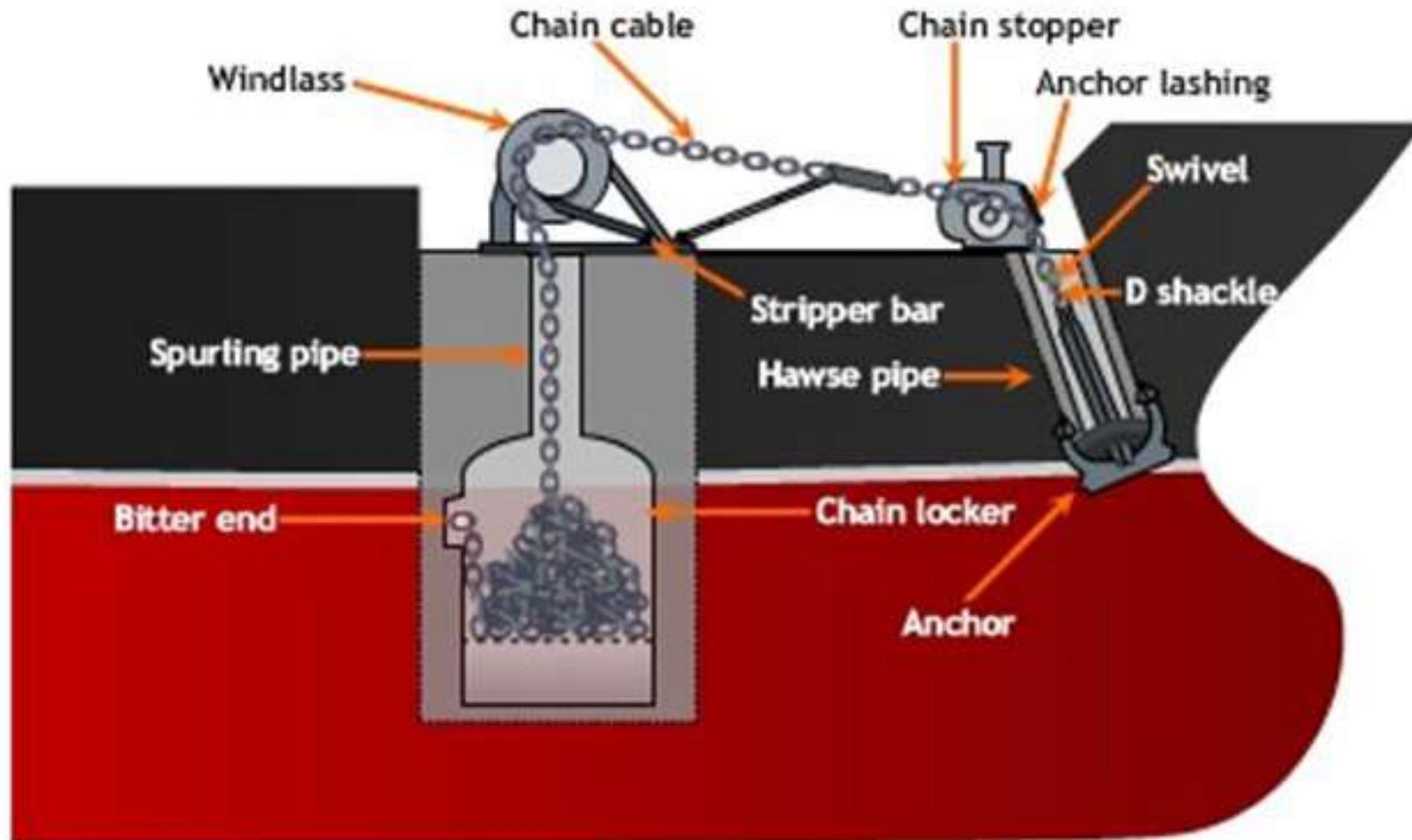
- Capstan
 - Motor
 - Vertical Shaft



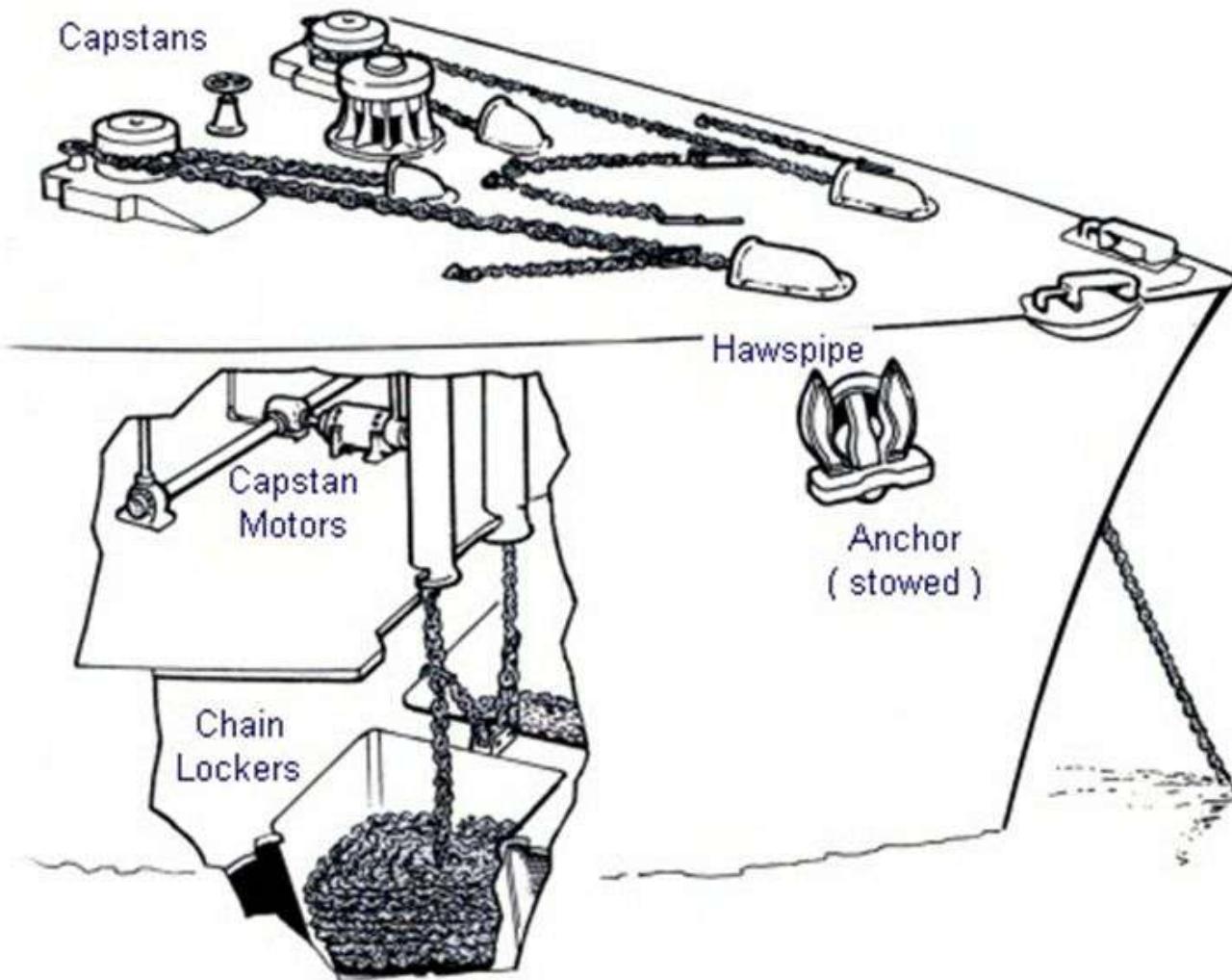
Anchor Handling - Structural Parts

- Hawse Pipe
 - Chain from main deck passes through hawsepipe into the water
- Spurling Pipe (or Naval Pipe)
 - Chain from capstan/windlass passes through naval pipe into the chain locker
- Chain Locker (or Cable Locker)
 - Where chain is stored

Anchor Handling Arrangement



Anchor handling Arrangement



Hawsepipe



Cruise Ship Anchors

cruiselineanchors.com



Hawsepipe



Chain Locker , Spurling Pipe



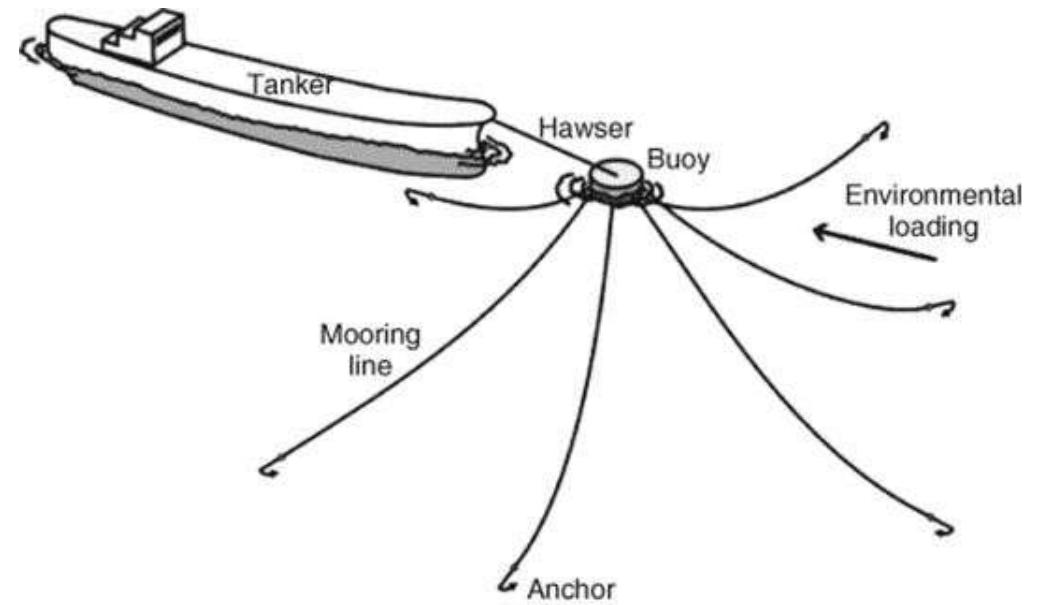
Chain Stowage in a Chain Locker

Chain Locker – Bitter End

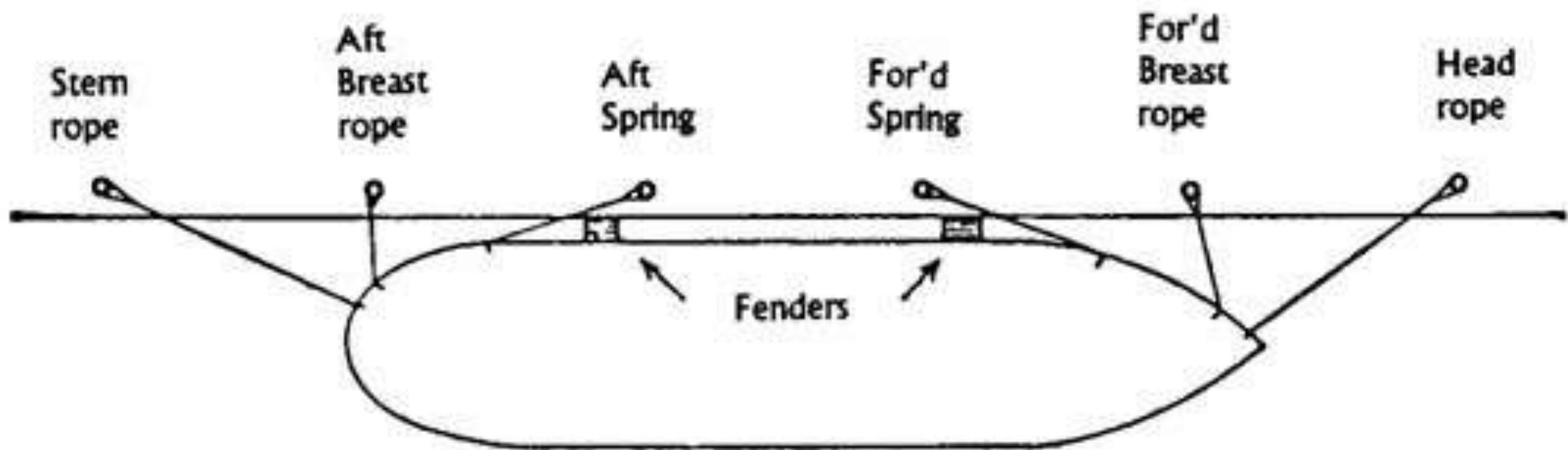


Mooring Arrangement

- Types of Mooring
 - Mooring to a Shore Structure
 - Pier
 - Quay
 - Jetty
 - Dock
- Mooring to a Permanent Anchor
 - 2 /3/4 legged
 - Head and Stern
 - Trot



Mooring Ropes





Mooring



Anchoring / Mooring – Deck Fittings

- Bollard(or Bitt)
- Cleat
- Chock
- Fairlead

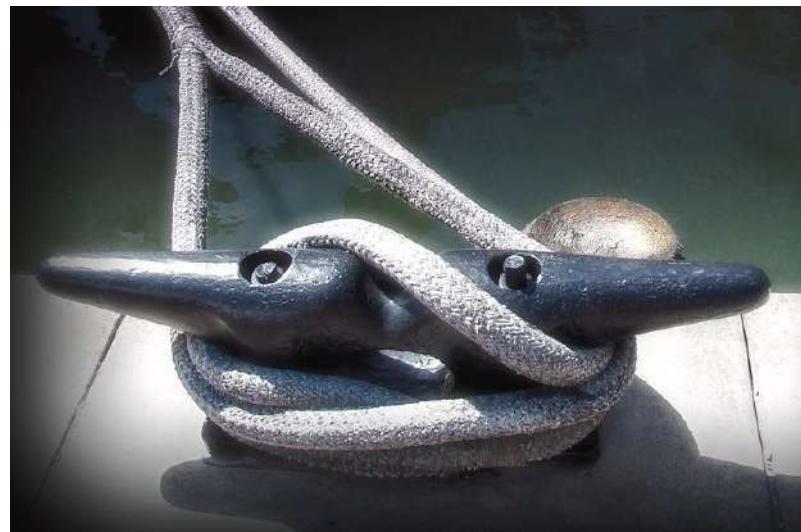
Anchoring / Mooring – Deck Fittings

- Bollard(or Bitt)
 - Single
 - Double
 - Cruciform



Anchoring / Mooring – Deck Fittings

- Cleat



Anchoring / Mooring – Deck Fittings

- Chock
 - Closed
 - Open
 - Roller



Anchoring / Mooring – Deck Fittings

- Chock

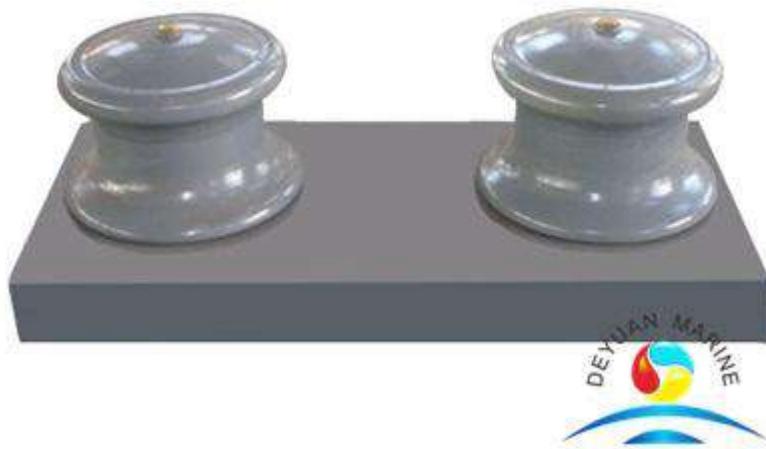


Anchoring / Mooring – Deck Fittings



Anchoring / Mooring – Deck Fittings

- Fairlead
 - Normal
 - Pedestal



Anchoring / Mooring – Deck Fittings

- Roller Fairlead

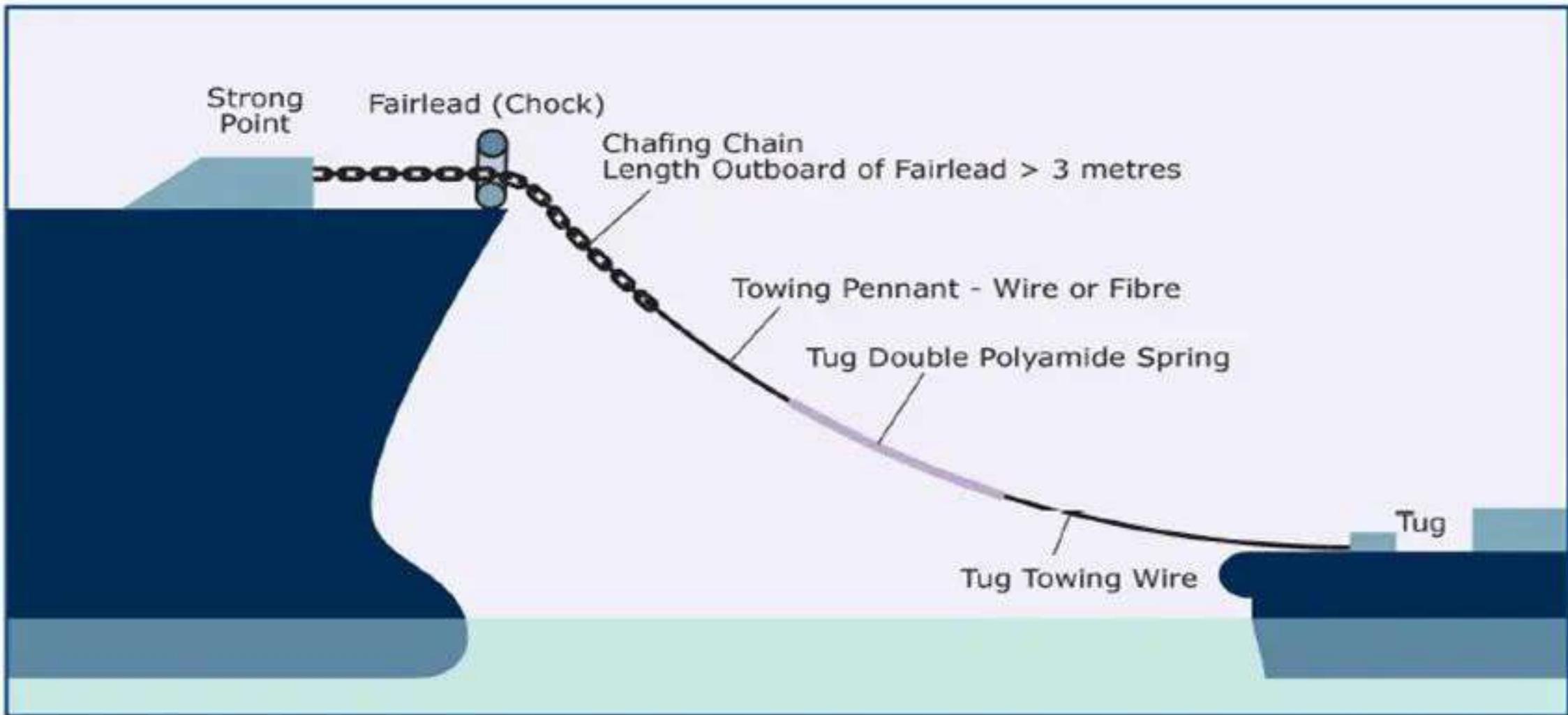


Anchoring / Mooring – Deck Fittings

- Pedestal Fairlead

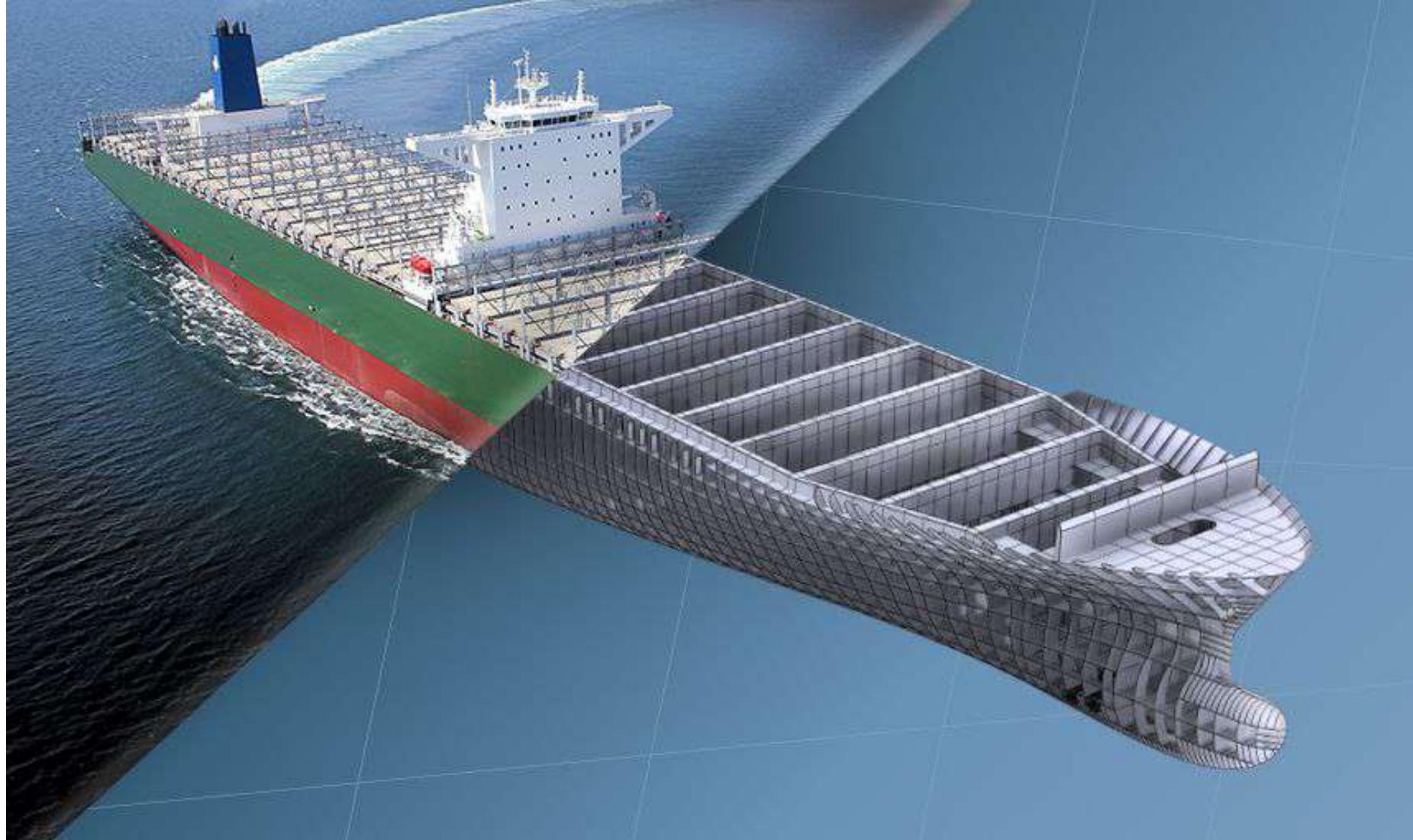


Towing arrangement



END

- In case of any doubts you may contact me at
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Introduction to **Naval Architecture**

II SEM – **Module 5**

Fire Fighting Systems (FFS)

- Mandatory FFS given in SOLAS
- Engg Specifications given in FFS Code
- Applicable for ships built after 01 Jul 2002

Guidelines

- Fire Prevention
- Fire Suppression
- Structural Integrity
- Escape

Firefighting Gear

- Equipment / Systems

- Portable
 - Fixed

- Gear

Fire Fighting Equipment

- Portable Equipment
 - Fire Extinguishers
 - Foam
 - CO₂ (Carbon Dioxide)
 - DCP (Dry Chemical Powder)
 - Portable Foam Applicators



Firefighting Systems

- Fixed System
 - Fire Main
 - Carbon Dioxide System
 - Steam System
 - Systems using gaseous products of fuel combustion
 - Foam System
 - Pressure Water Spray and Water Mist
 - Automatic Sprinkler
 - Inert Gas

Firefighting System







RESCUE
STATION
DO NOT BE CLOSED
DURING OPERATIONS

CARL

RESOLVE

TECHNICAL

ZINGER

KOTI

13

Firefighting System

- Carbon Dioxide System



Firefighting Gear

- Personal Protection
 - Firefighters Outfit
 - Suit
 - Helmet
 - Axe
 - Boots
 - Light
 - Belt
 - Safeline
 - Emergency Escape Breathing Devices

Firefighting Gear

- Firefighters Outfit



Fireman Suit



Fireman Helmet



Rubber Boots



Fireman Axe



Explosion-proof Light



Self-contained Air Breathing Apparatus



Belt



Fire Proof Safeline

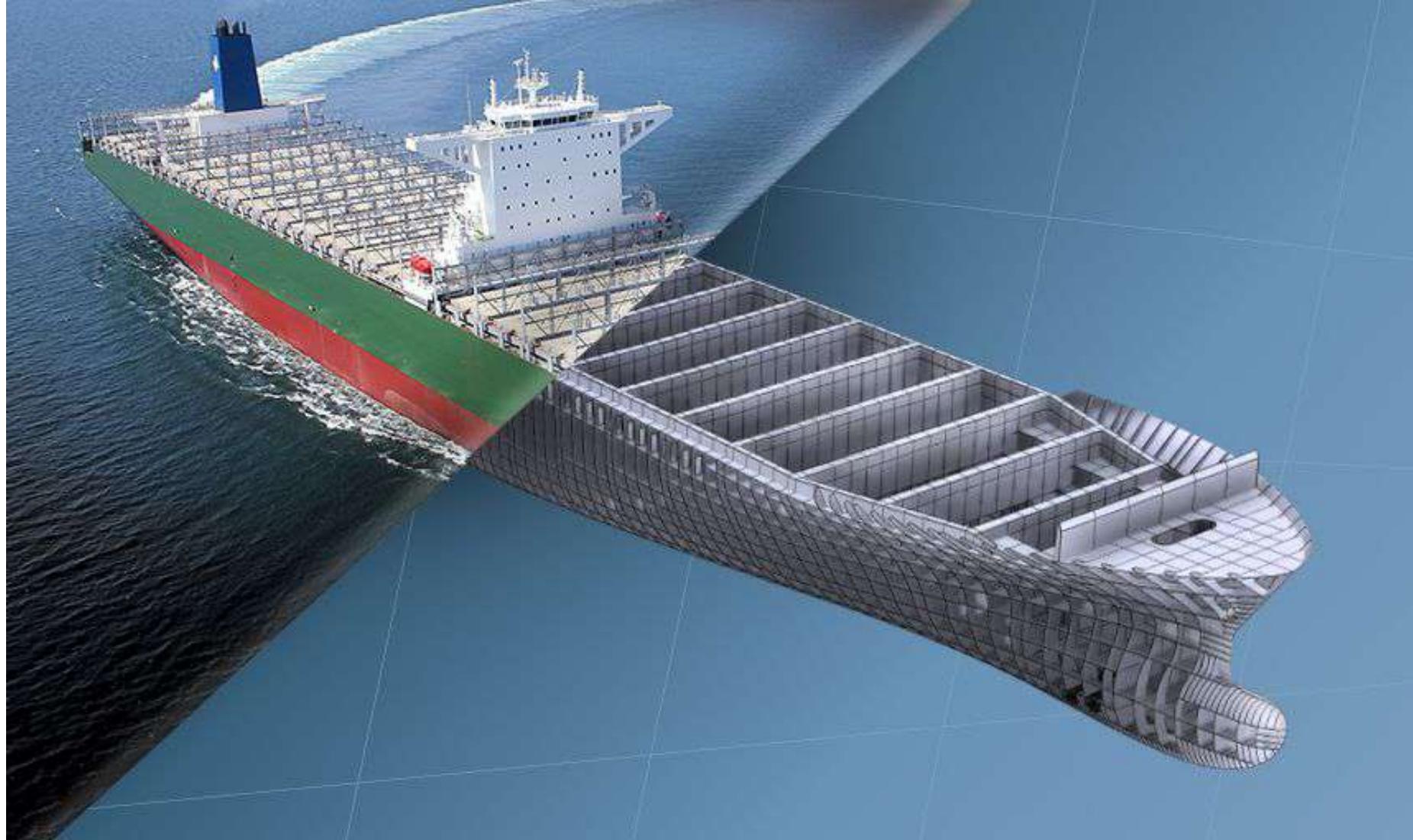
Firefighting Gear

- Emergency Escape Breathing Devices



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Introduction to **Naval Architecture**

II SEM – **Module 5**

Life Saving Appliances (LSA)

- Appliances that are used to save human life at sea
- Documented in SOLAS
- Technical Requirements mentioned in LSA Code
 - Personal Life Saving Appliances
 - Visual Signals
 - Survival Craft
 - Launching and Embarkation Appliances
 - Other Life Saving Appliances

Personal Life Saving Appliances

- Lifebuoy
- Life Jacket
- Immersion Suit
- Anti Exposure Suit (AES)
- Thermal Protection Aid (TPA)

Lifebuoy



Life Jacket



TYPE I



TYPE II



TYPE III



TYPE IV



TYPE V

Immersion Suit, AES, TPA

A E S



Immersion Suit



T P A



Visual Signals

- Rocket Parachute Flares
- Hand Flares
- Buoyant Smoke Signal

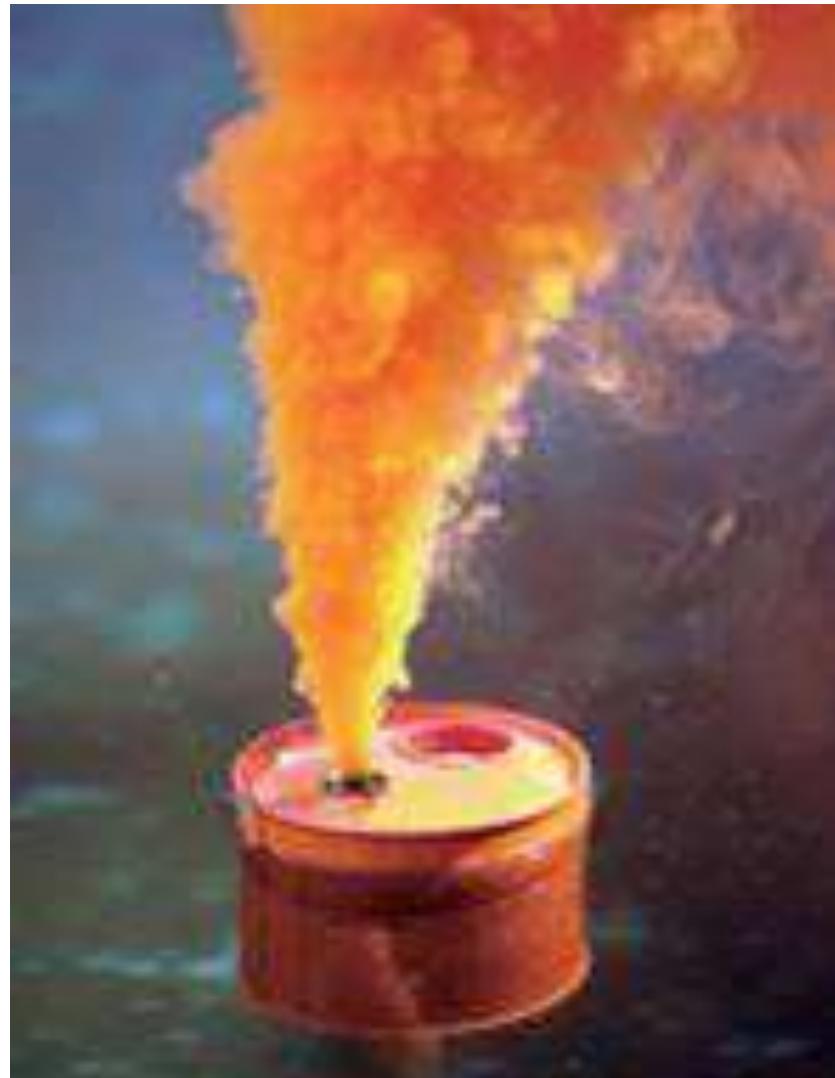
Rocket Parachute Flare



Hand Flare



Buoyant Smoke Signal



Survival Craft

- Life Rafts
- Life Boats
 - Open
 - Partially Enclosed
 - Totally Enclosed
- Rescue Boats

Life Raft

- Collapsible
- Automatically Inflatable
- Min 30 day survival
- Hydrostatic Release Gear
- No propulsion



Life Raft



Life Boat

- Rigid
- Self propelled
- Open



Life Boat

- Partially Enclosed



Life Boat

- Totally Enclosed



Rescue Boat

- To rescue a person in distress
- Life boat can be used as Rescue boat



Launching and Embarkation Appliances

- Launching Appliances for Survival craft
 - Falls and Winch
 - Single Arm Type
 - Twin Arm Type
 - Free Fall
 - Float Free
- Embarkation Appliance
 - Accommodation Ladder
 - Marine Evacuation System (MES)
 - Chute
 - Slide

Launching Appliances for Survival Craft

- Falls and Winch
 - Lowered and hoisted using ropes and motor
 - Davit Arrangement
 - Single Arm Type



Launching Appliances for Survival Craft

- Falls and Winch
 - Lowered and hoisted using ropes and motor
 - Davit Arrangement
 - Twin Arm Type



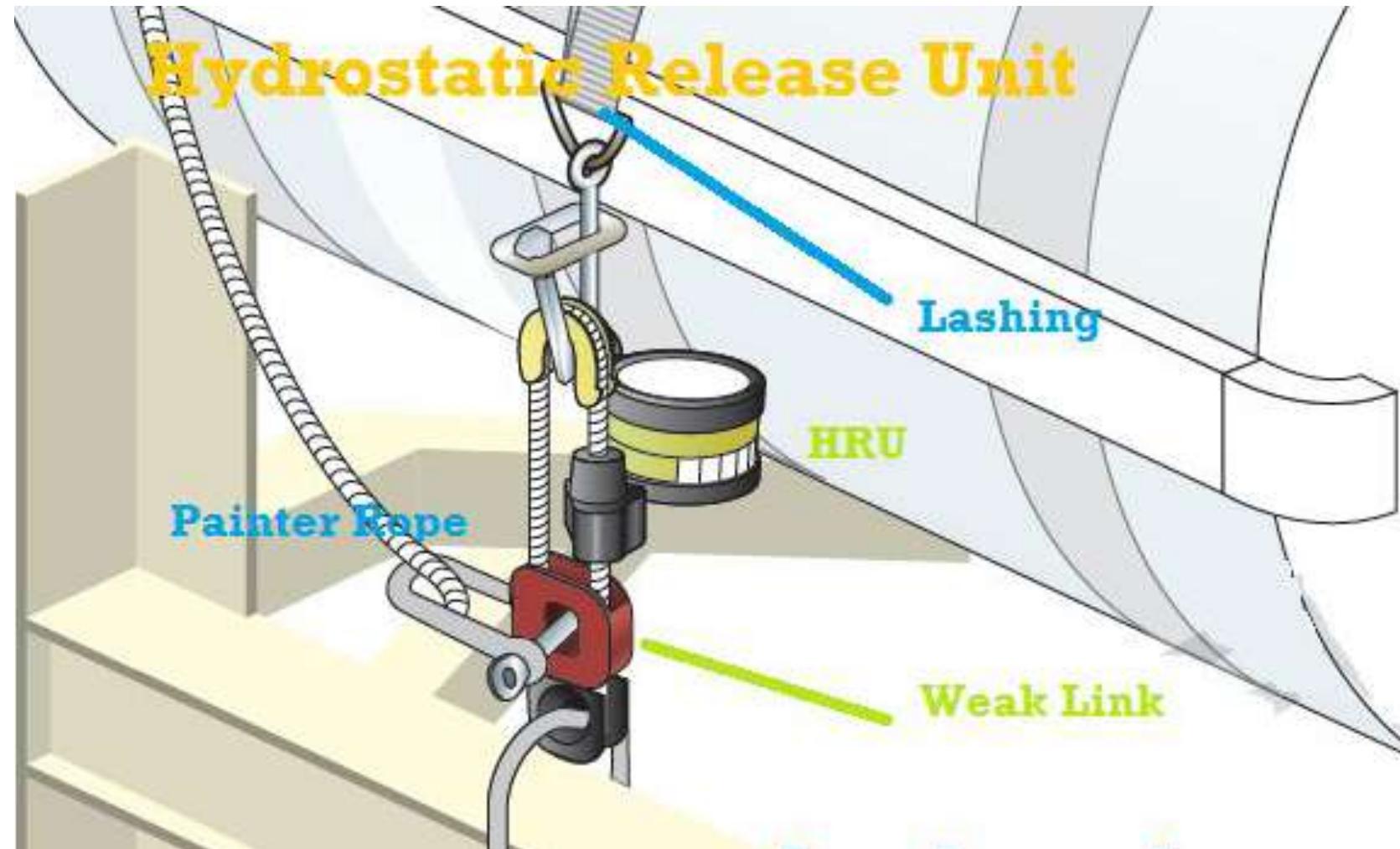
Launching Appliances for Survival Craft

- Free Fall
 - Falls under gravity
 - Only totally enclosed Lifeboats can be lowered using this



Launching Appliances for Survival Craft

- Float free
 - Automatically released and floats when vessel sinks to a certain depth
 - Hydrostatic Release Gear
 - Used for life rafts



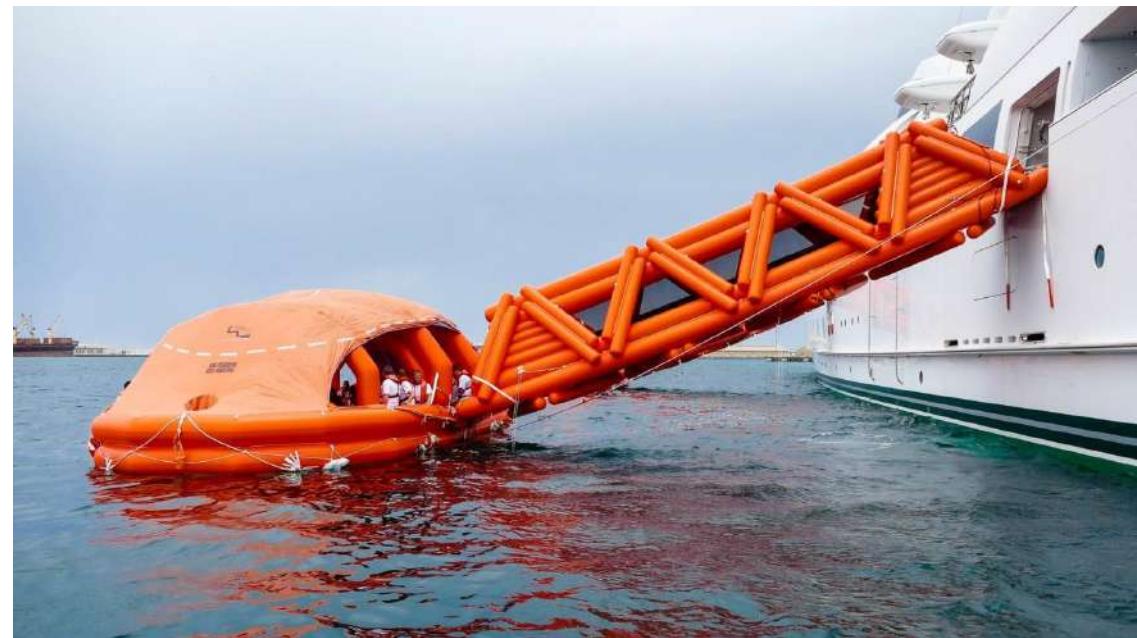
Embarkation Applianc

- Accommodation Ladder
 - Portable / Retractable
 - Used for embarkation of personnel
 - Used at sea



Marine Evacuation System

- Rapid transfer from ship to survival craft
- Eliminates Risk of drowning, hypothermia
- Chute
- Slide



Other Life Saving Appliances

- Line Throwing Appliance
- General Emergency Alarm
- Public Address System

Other Life Saving Appliance

- Line Throwing Appliance



Other Life Saving Appliance

- General Emergency Alarm



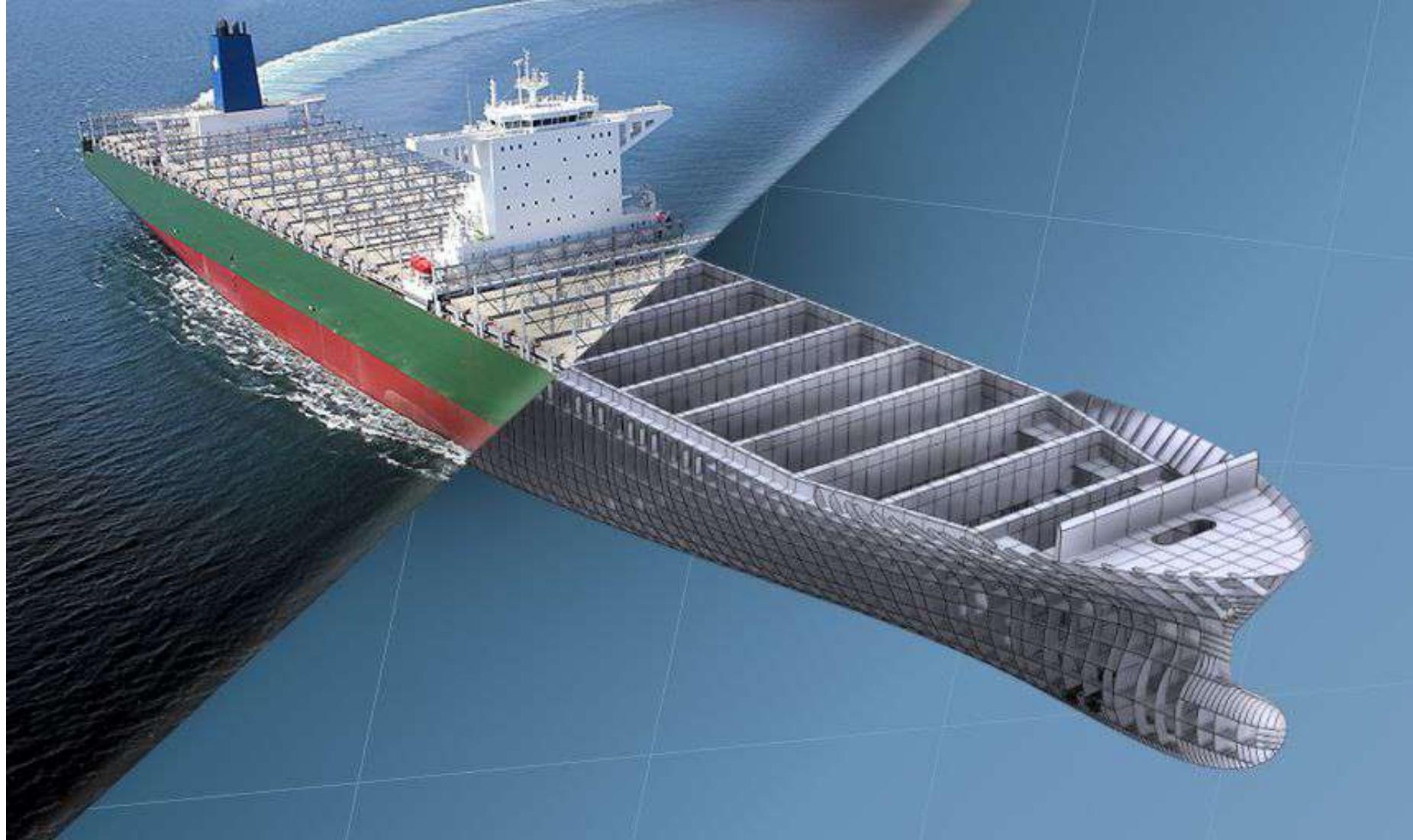
Other Life Saving Appliance

- Public Address System



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Introduction to **Naval Architecture**

II SEM – **Module 5**

Navigation and Communication Equipment / Aids

Navigation

- Bridge / Wheel house



Navigation

- Ship's Bridge



Navigation Equipment

- Some of the main equipment specified in SOLAS are
 - Magnetic Compass
 - Gyro Compass
 - Pelorus
 - ECDIS (Electronic Chart Display and Information System)
 - Radar
 - GPS Receiver
 - Echo Sounder
 - Speed and Distance measuring device
 - Rudder, Propeller Parameters Indicator
 - Auto Pilot

Navigation Equipment

- Standard magnetic compass, independent of any power supply
- To determine the ship's heading and display the reading at the main steering position



Navigation Equipment

- Gyro compass
- to determine and display heading
- by shipborne non-magnetic means



Navigation Equipment

- Pelorus or compass bearing device, independent of any power supply,
- To take bearings over an arc of the horizon of 360°

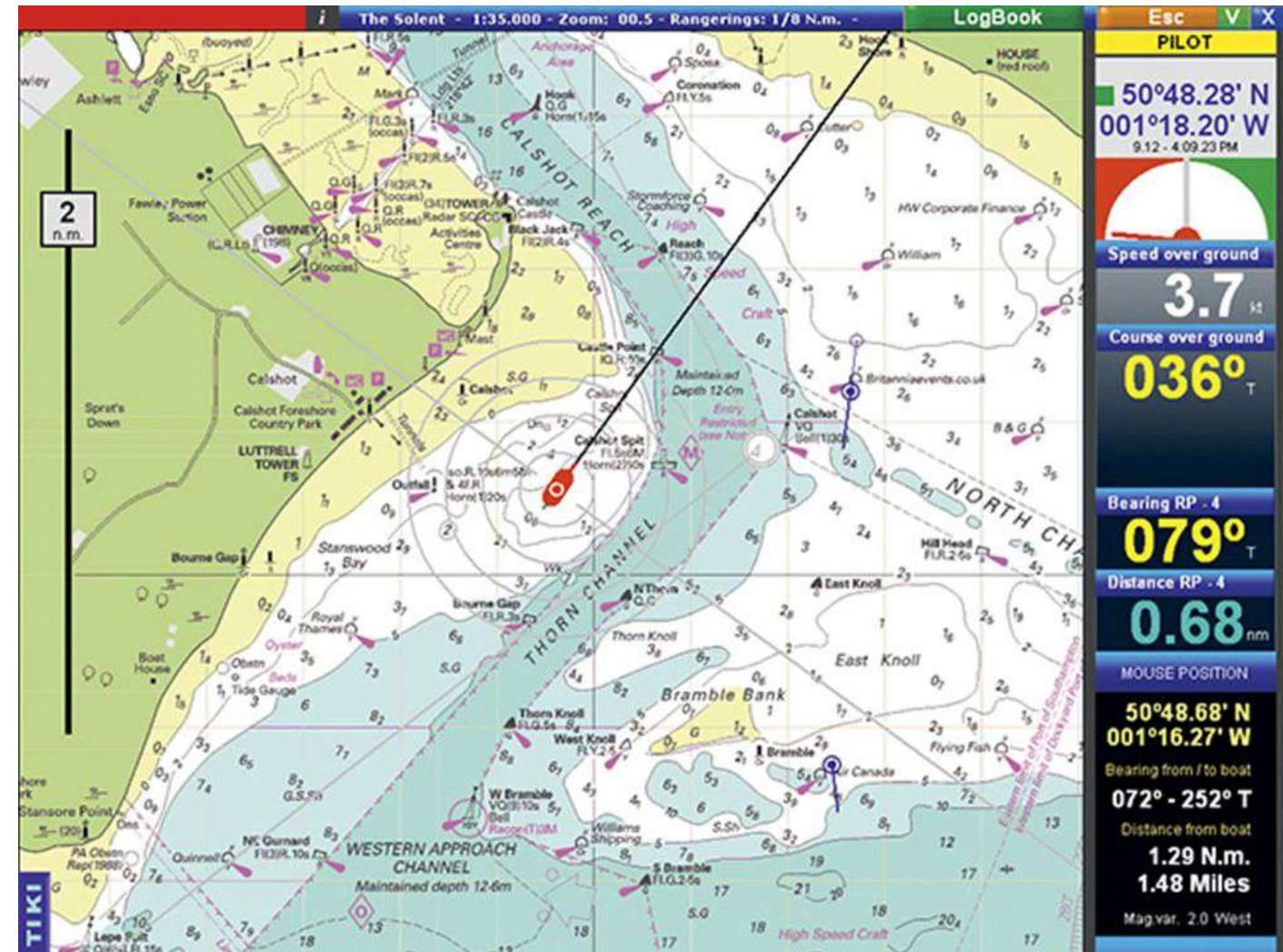


Navigation Equipment

- Physical Charts were used in Olden days
- The ECDIS (Electronic Chart Display and Information System) is a specialized digital navigation computer.
- It stores a set of Electronic Navigation Charts (ENCs) and/or Raster Charts, which can display all the necessary geographic information a crew needs to complete a voyage.

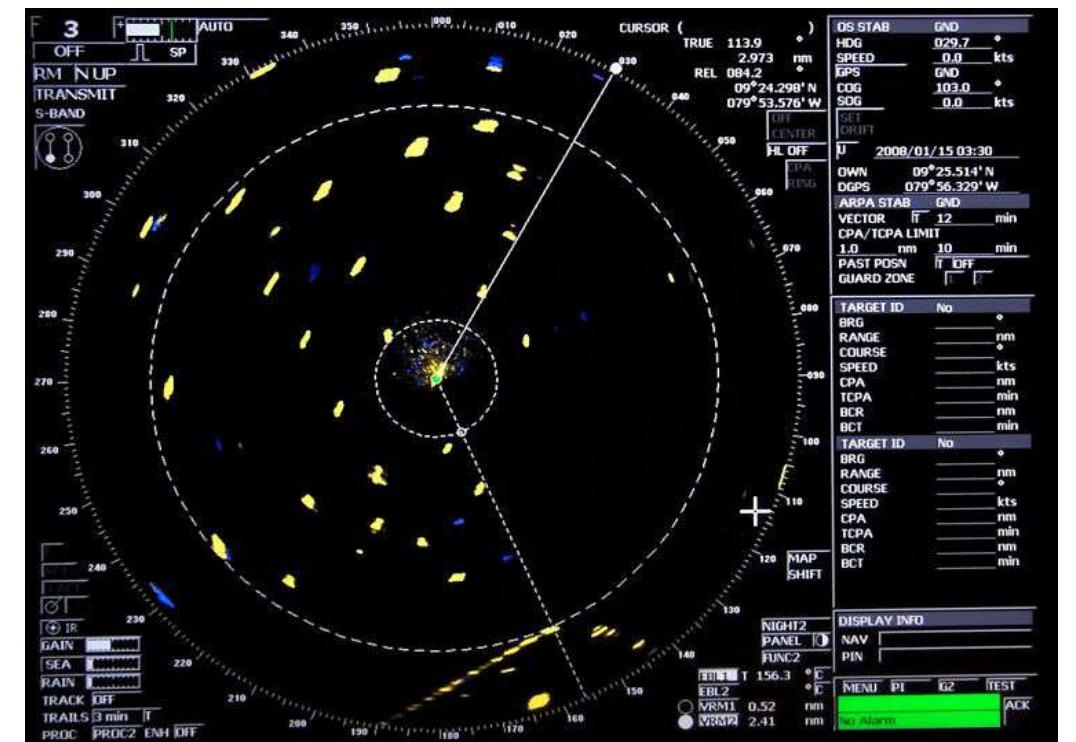


Navigation Equipment



Navigation Equipment

- 9 GHz Radar
- to determine and display the range and bearing of other surface craft, obstructions, buoys, shorelines and navigational marks
- to assist in navigation and in collision avoidance



Navigation Equipment

- a GPS receiver for a global navigation satellite system or a terrestrial radionavigation system,
- To update the ship's position by automatic means



Navigation Equipment

- Echo sounder
- to measure and display the available depth of water



Navigation Equipment

- ARPA –Automatic Radar Plotting Aid
- to plot electronically the range and bearing of targets to determine collision risk



Navigation Equipment

- Speed and distance measuring device
- to indicate speed and distance through the water



Navigation Equipment

- Rudder, Propeller, Thrust, Pitch and operational mode indicators,
- To determine and display rudder angle, propeller revolutions, the force and direction of thrust



Navigation Equipment

- Autopilot
- It assists the human operator in controlling the ship by keeping the steering in autopilot
- which allows them to concentrate on broad aspects of the operation

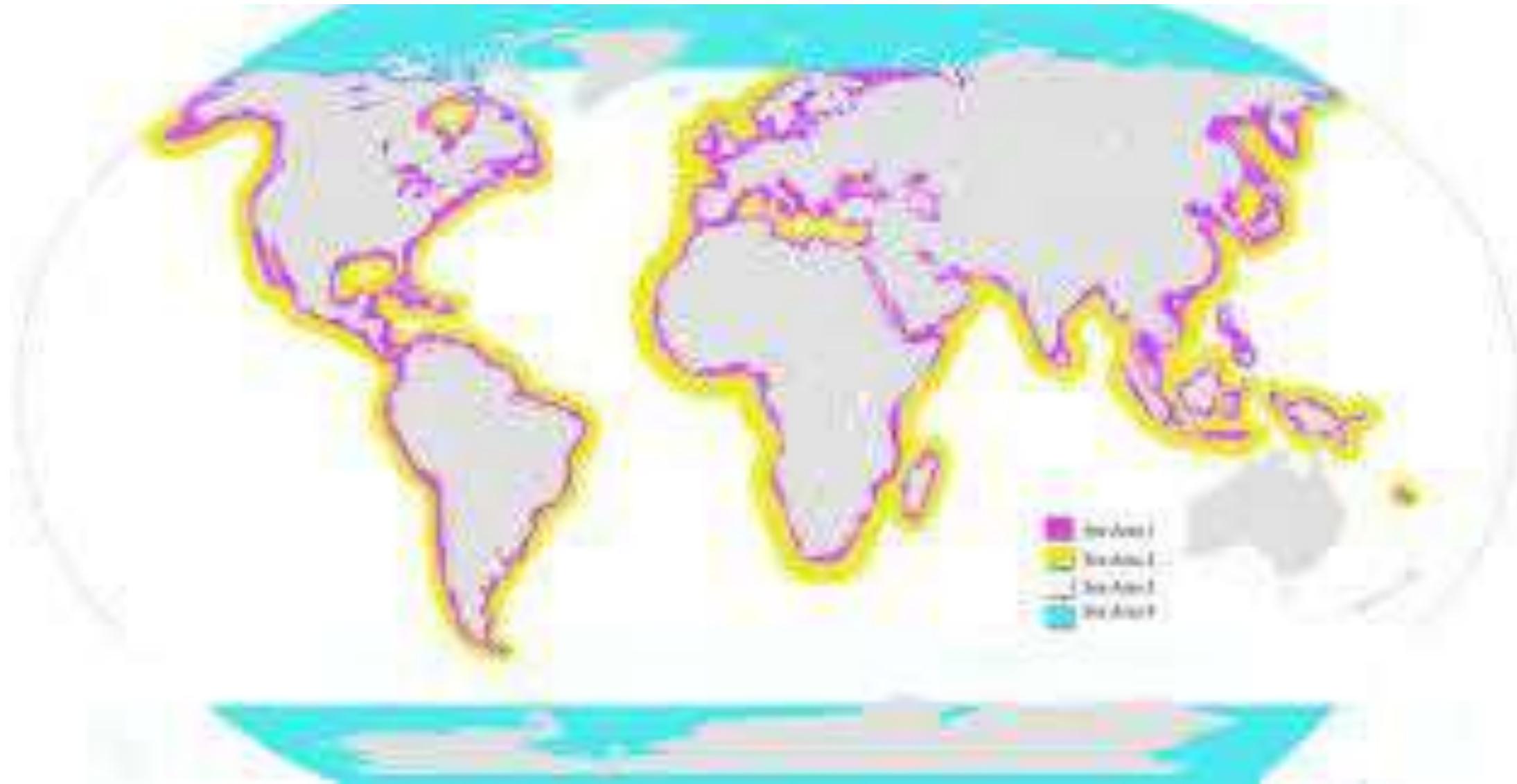


Communication Equipment / Aids

- 1999 – IMO Adopts a Safety Procedure for Communications, under SOLAS
- called Global Maritime Distress Safety System(GMDSS)
- World divided into 4 sea areas
- All ships involved in international voyages have to carry communication equipment as prescribed by GMDSS depending on the zone

Communication Equipment / Aids

- Sea Areas



Communication Equipment / Aids

- All ships above 300 GRT involved in international voyages have to carry some or all the following communication equipment as prescribed by GMDSS
 - Radio with DSC(Digital Selective Calling)
 - VHF(Very High Frequency)
 - HF(High Frequency)
 - MF(Medium Frequency)
 - INMARSAT (INternational MARitime SATellite Organisation)
 - NAVTEX (NAVigational TElex)
 - EPIRB(Emergency Position Indicating Radio Beacon)
 - SART(Search and Rescue Radar Transponder)
 - AIS (Automatic Identification System)

Communication Equipment / Aids



SART



MF/HF RADIO



EPIRB



VHF RADIO



INMARSAT-C



NAVTEX

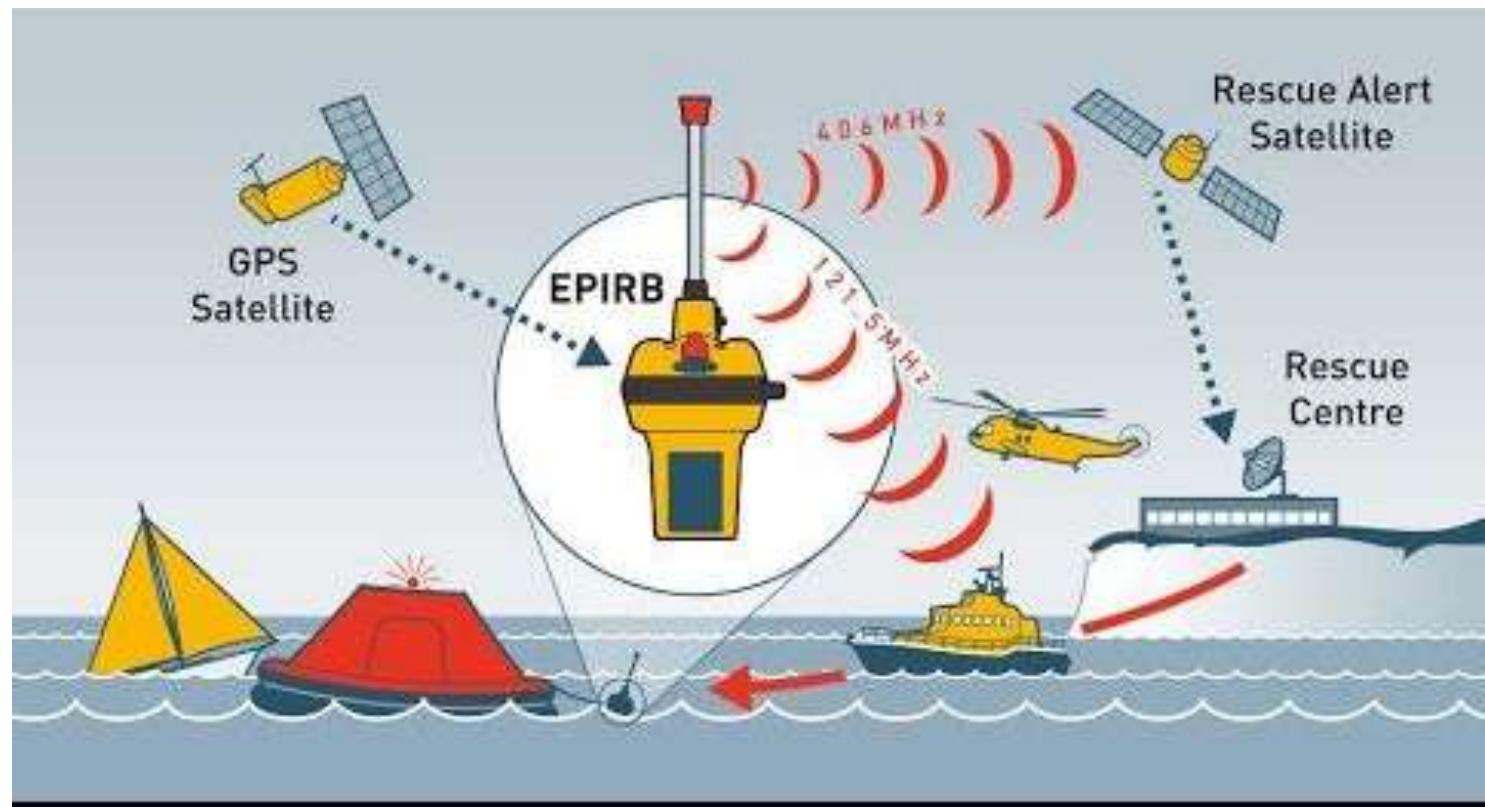
Communication Equipment

EPIRB

-A radio beacon that transmits the vessel's information and location to the COSPAS-SARSAT satellite system.

It operates on several frequencies, including 406MHz, 121.5MHz, and 243MHz.

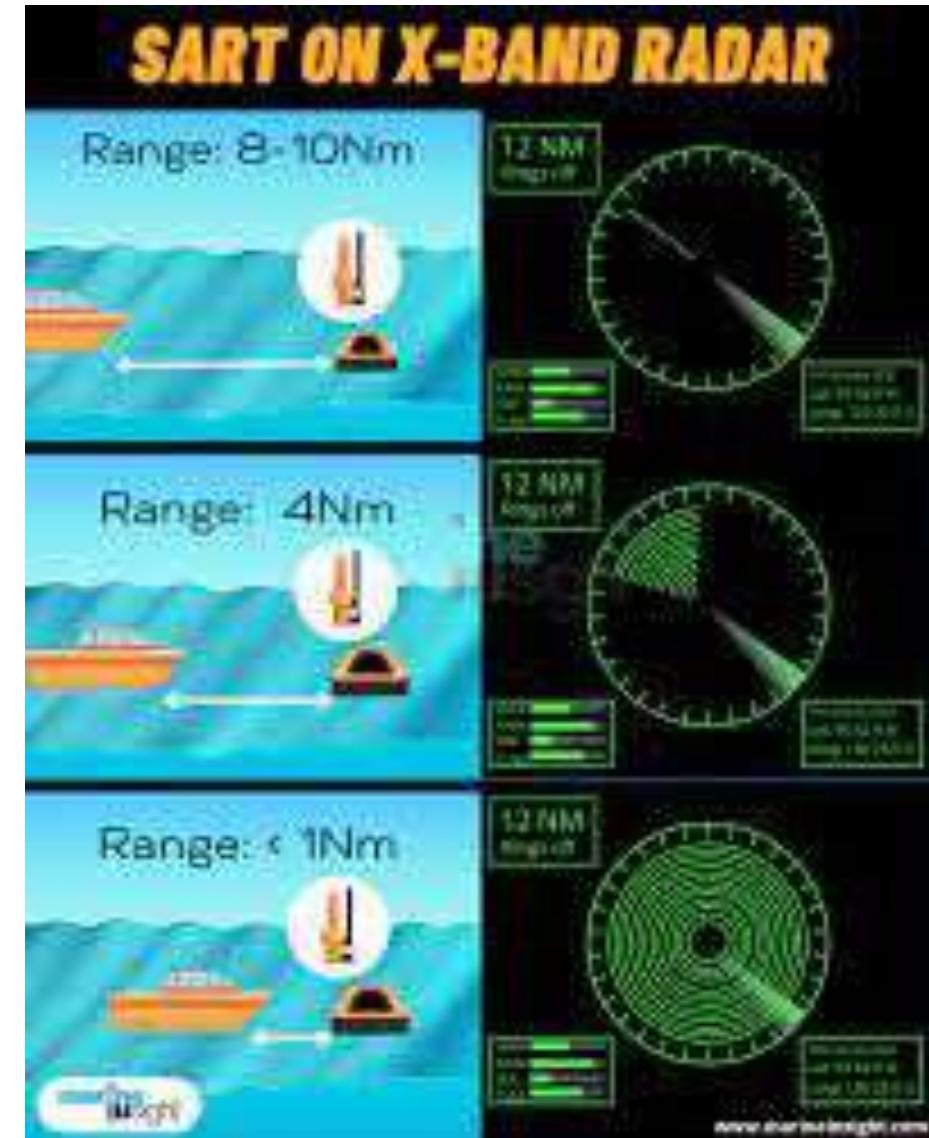
-Usually kept outside the vessel, typically near life rafts or lifeboats, and have a hydrostatic release unit that allows them to float freely in case the vessel sinks.



Communication Equipment

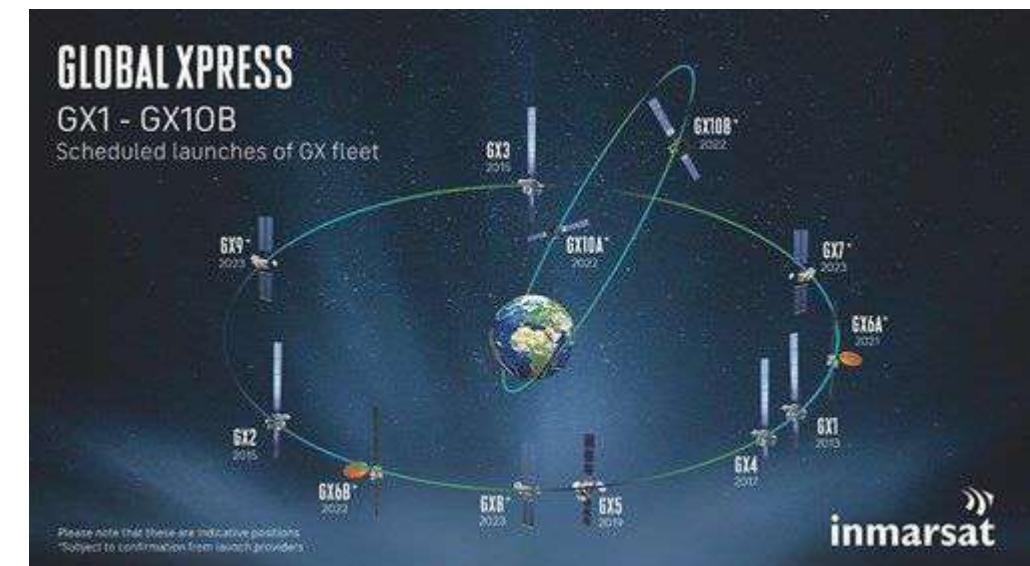
SART

- Devices that produce a distress signal, which can be detected by X-Band radar on other vessels.
- Typically found on a vessel's bridge
- When a SART detects a radar signal, it emits a signal back, indicating a distress situation and the direction from which the signal originated



Communication Equipment

- INMARSAT
- It provides telephone and data services to users worldwide, via portable or mobile terminals which communicate with ground stations through fourteen geostationary telecommunications satellites.[



Communication Equipment

- AIS
- An automated tracking system that displays other vessels in the vicinity.
- operates in the VHF mobile maritime band.
- 40 nm radius



Communication Equipment / Aids

Sea Area	Range	Equipment
A1	20 – 50 NM	VHF
A2	50 - 400 NM	VHF + MF
A3	70° N - 70° S (outside 400NM)	VHF + MF + INMARSAT
A4	Above 70° N or S	VHF + MF + HF

- NM – Nautical Miles
 - Radio with DSC(Digital Selective Calling)
 - -VHF(Very High Frequency)
 - -HF(High Frequency)
 - -MF(Medium Frequency)
 - INMARSAT (INternational MARitime SATellite Organisation)
 - NAVTEX (NAVigational TEleX)
 - **Mandatory in all Sea Areas**
 - EPIRB(Emergency Position Indicating Radio Beacon)
 - SART(Search and Rescue Radar Transponder)
 - AIS

Navigation Lights

- A navigational light is a source of illumination on vessel that gives information and provides awareness on its
 - size,
 - heading (orientation or direction of motion)
 - status,
- to other vessels in its vicinity.
- Lights are used at night time (between sunset and sunrise) and in restricted visibility.
- Depending on the length of the vessel, the required visibility range varies from 1 to 6 NM.

Navigational Lights

- Masthead Light
- It is a white light
- on the fore and aft centreline on the main mast,
- showing an unbroken light over an arc of the horizon of 225°
- and so fixed as to show the light from 22.5° abaft the beam from one side to 22.5° abaft the beam on the other side.



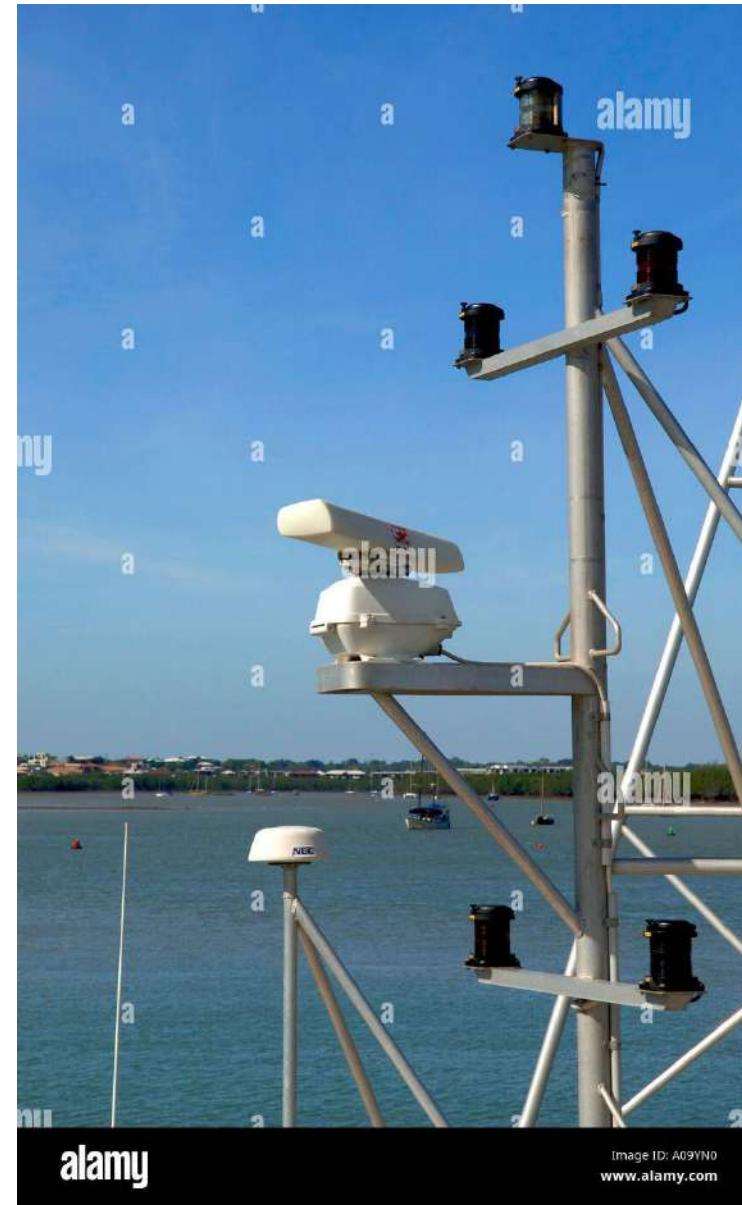
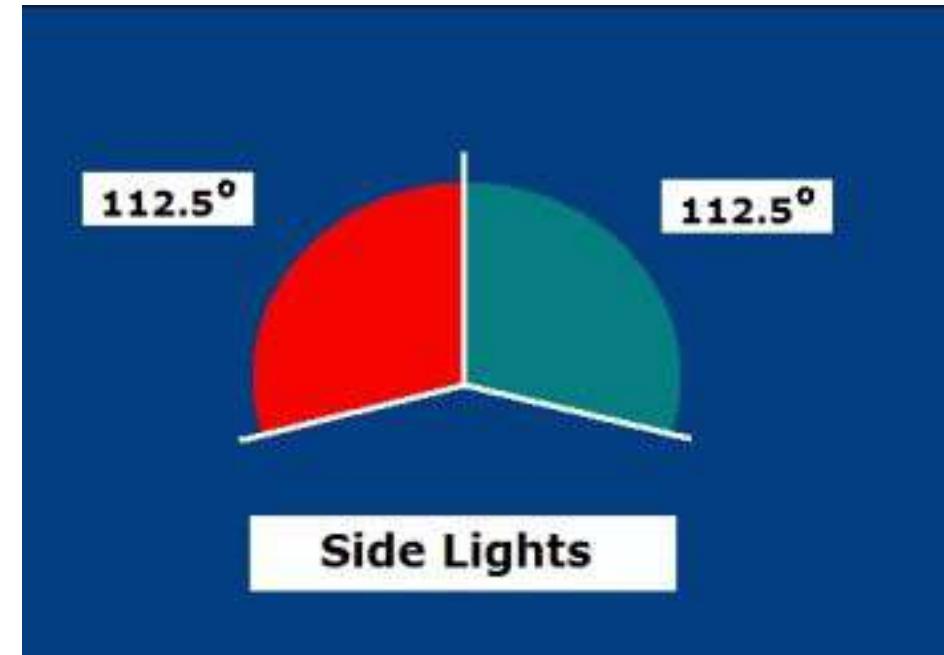


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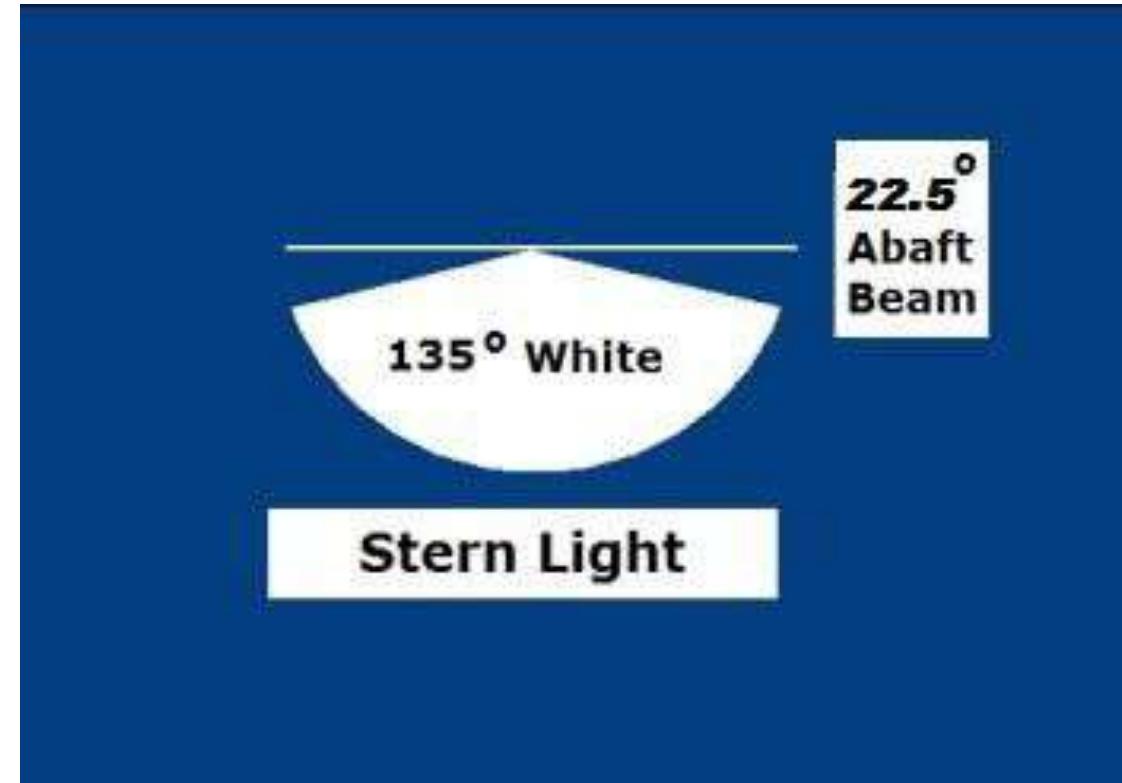
Navigational Lights

- Side Lights
- Sidelights are red (port side) and green (starboard side) lights
- showing an unbroken light over an arc of 112.5°
- from straight ahead towards aft on the respective side of the vessel.



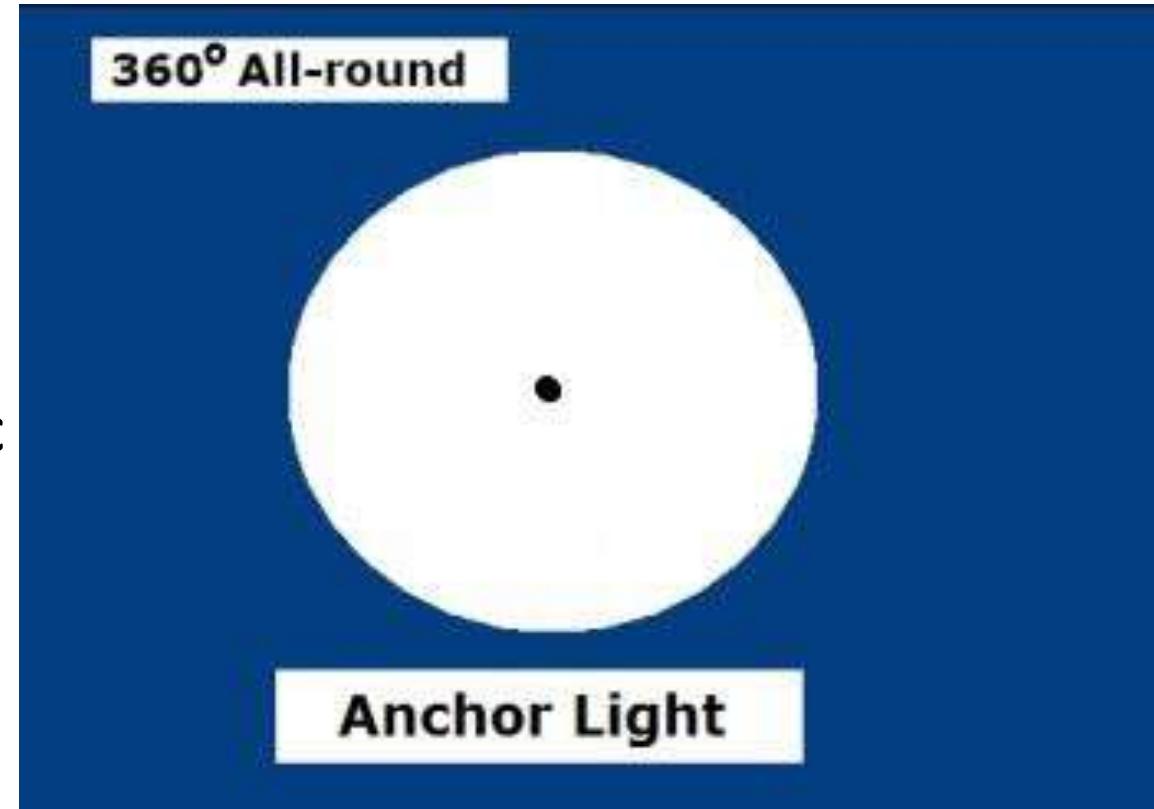
Navigational Lights

- Stern Light
- A white light placed on the fore and aft centreline at the stern,
- showing an unbroken light over an arc of 135°
- from 22.5° abaft the beam from one side to 22.5° abaft the beam on the other side.

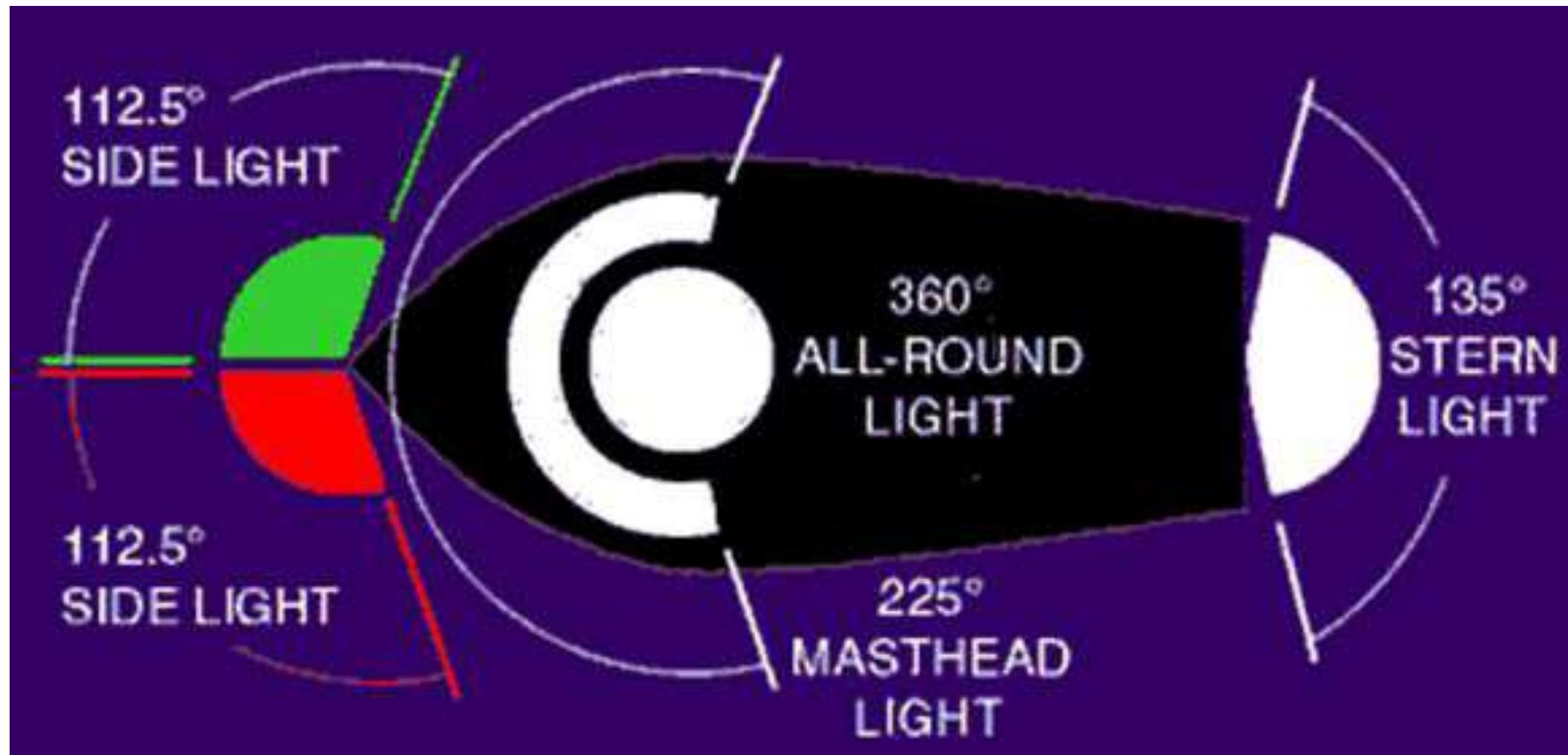


Navigational Lights

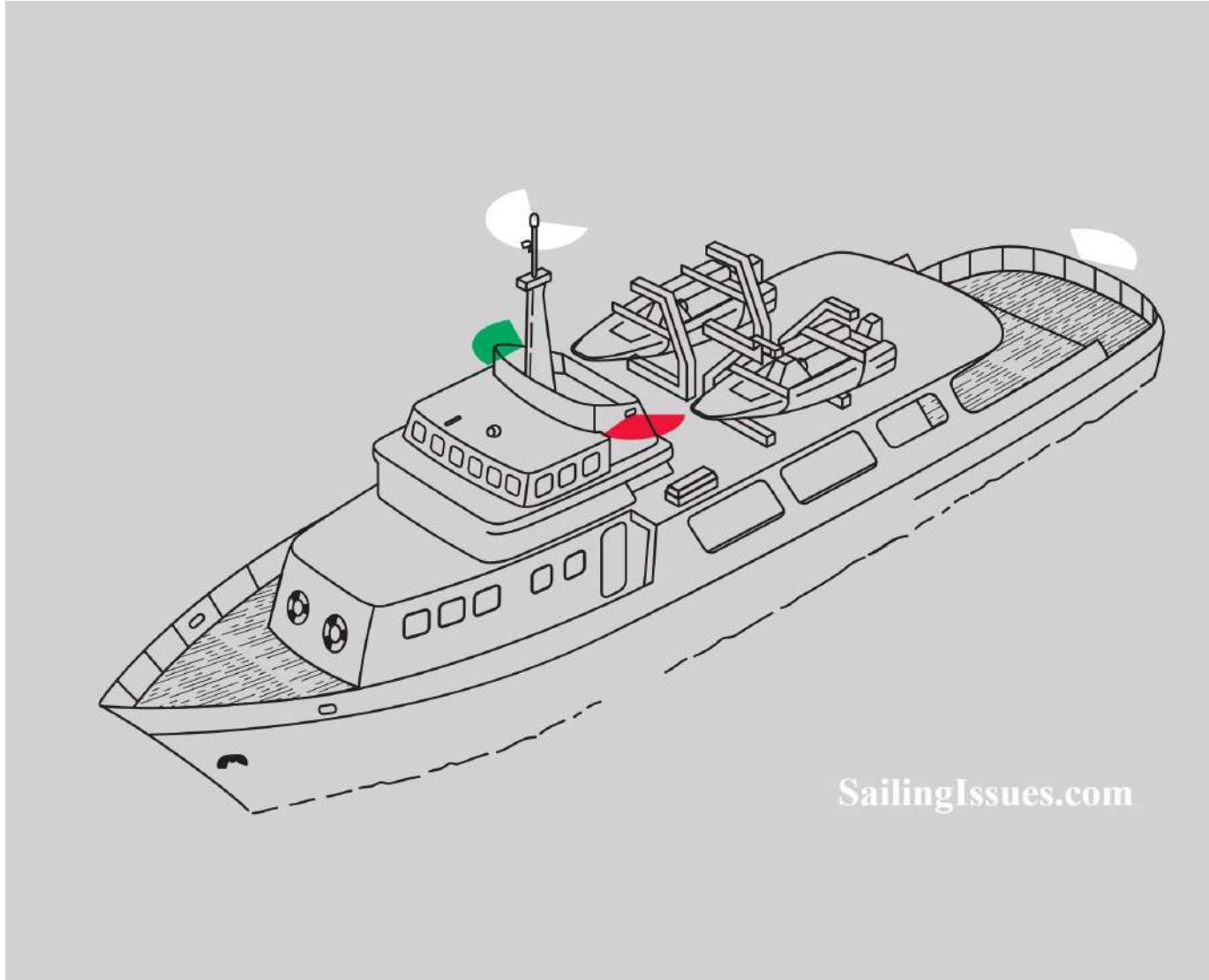
- All Round light (or Anchor Light).
- It is a white light placed on the fore and aft centreline on the main mast,
- showing an unbroken light over an arc of 360 degrees



Navigational Lights



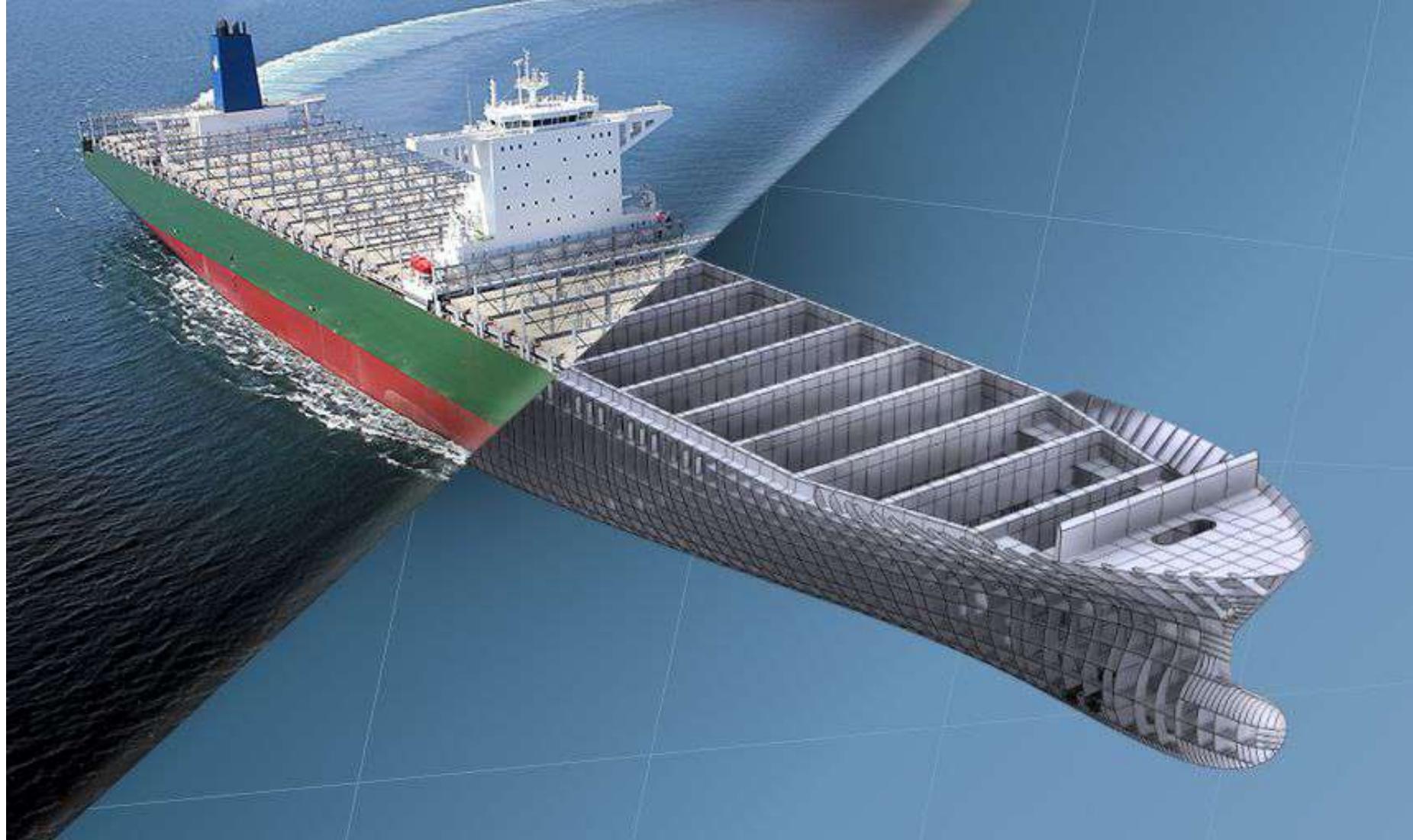
Navigational Lights



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Introduction to Naval Architecture

II SEM – Module 5

Cargo Handling Equipment on Ships

Cargo Handling Equipment

- Types of Cargo
 - Bulk (Ore, grain, coal, fertilisers etc.)
 - Break bulk (crates, bags, boxes, drums, barrels etc.)
 - Container
 - Liquid (Oil, Chemical etc.)
 - Gas (LNG, CNG, LPG etc.)
 - Vehicle (Car, Truck etc)
 - Passenger
 - Fish

Cargo Handling Equipment

- Lifting Equipment
- Handling Equipment

Lifting Equipment

Cargo Handling Equipment

- Bulk Carriers / General Cargo / Container Ships
 - Lifting
 - Derrick
 - Crane

Lifting

- Derrick Parts
 - Mast
 - Boom
 - Ropes
 - Block and Tackle arrgt.
 - Lifting Hook

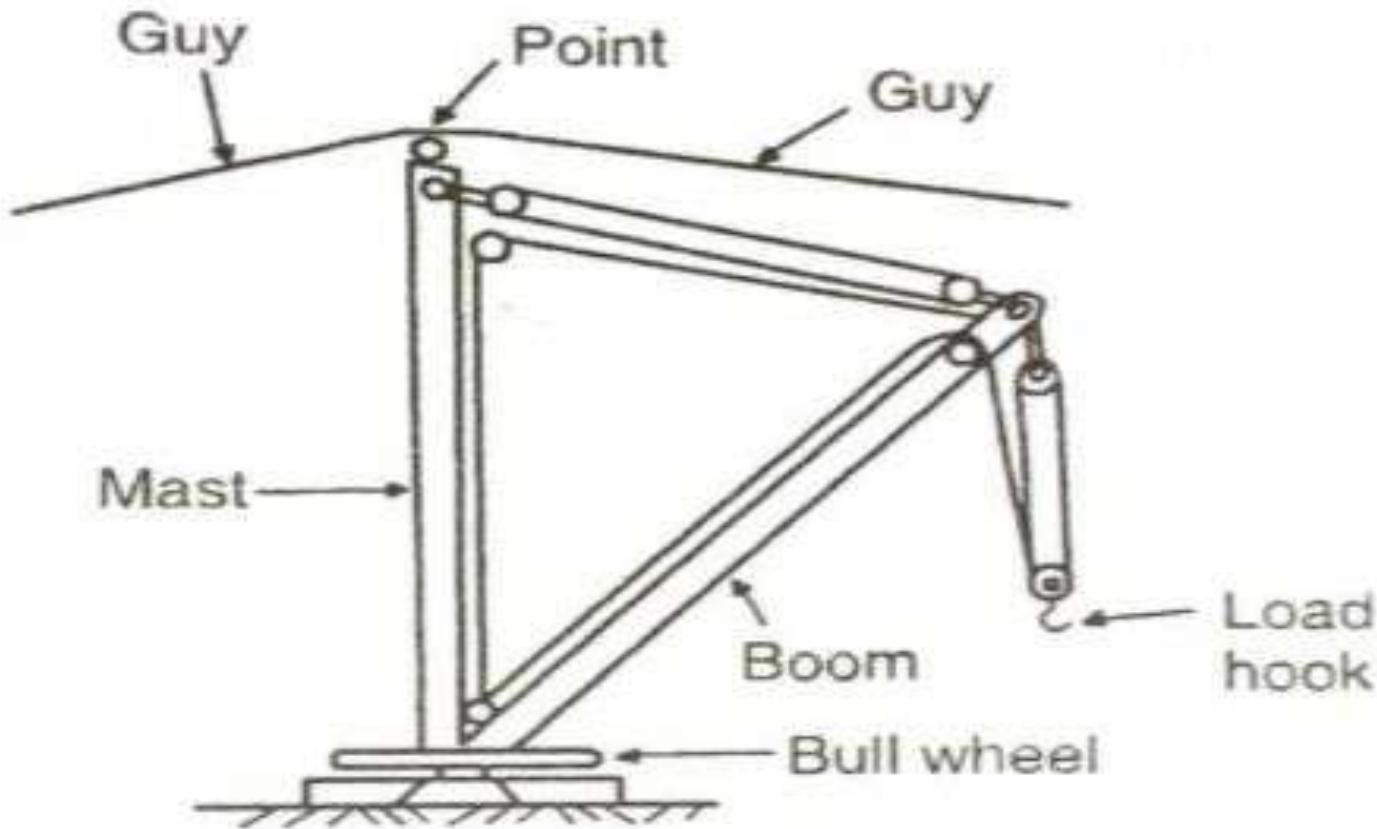


Fig. 2.14. Derrick Crane.

- Derrick



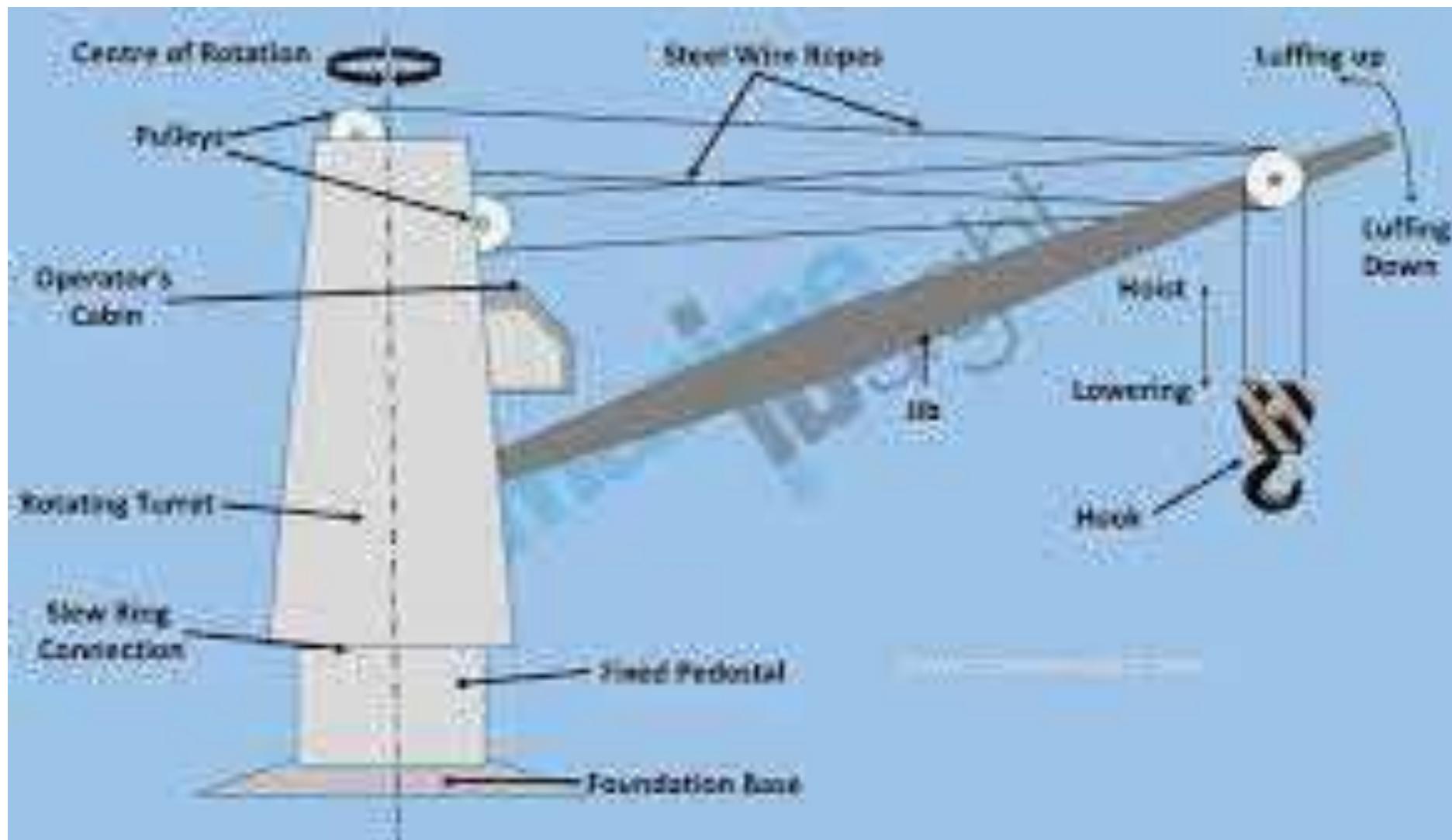
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- **Derrick**



- Crane Parts
 - Pedestal
 - Turret
 - Jib
 - Ropes
 - Hook



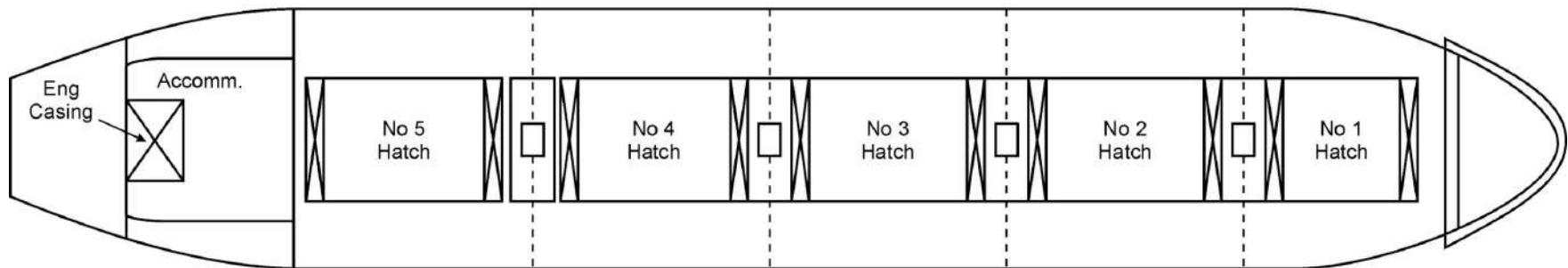
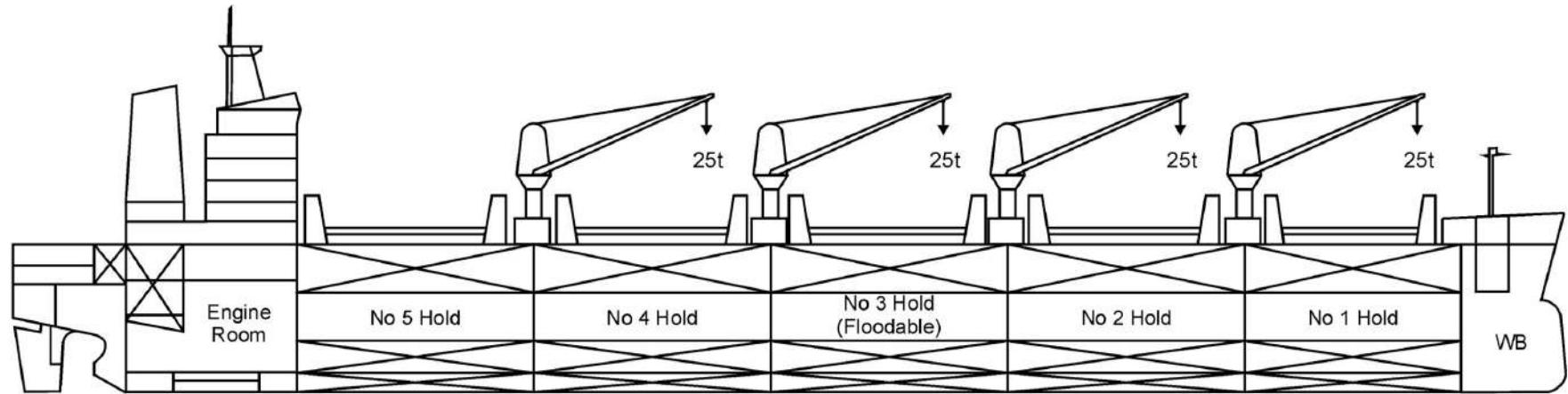
- Crane



- Crane



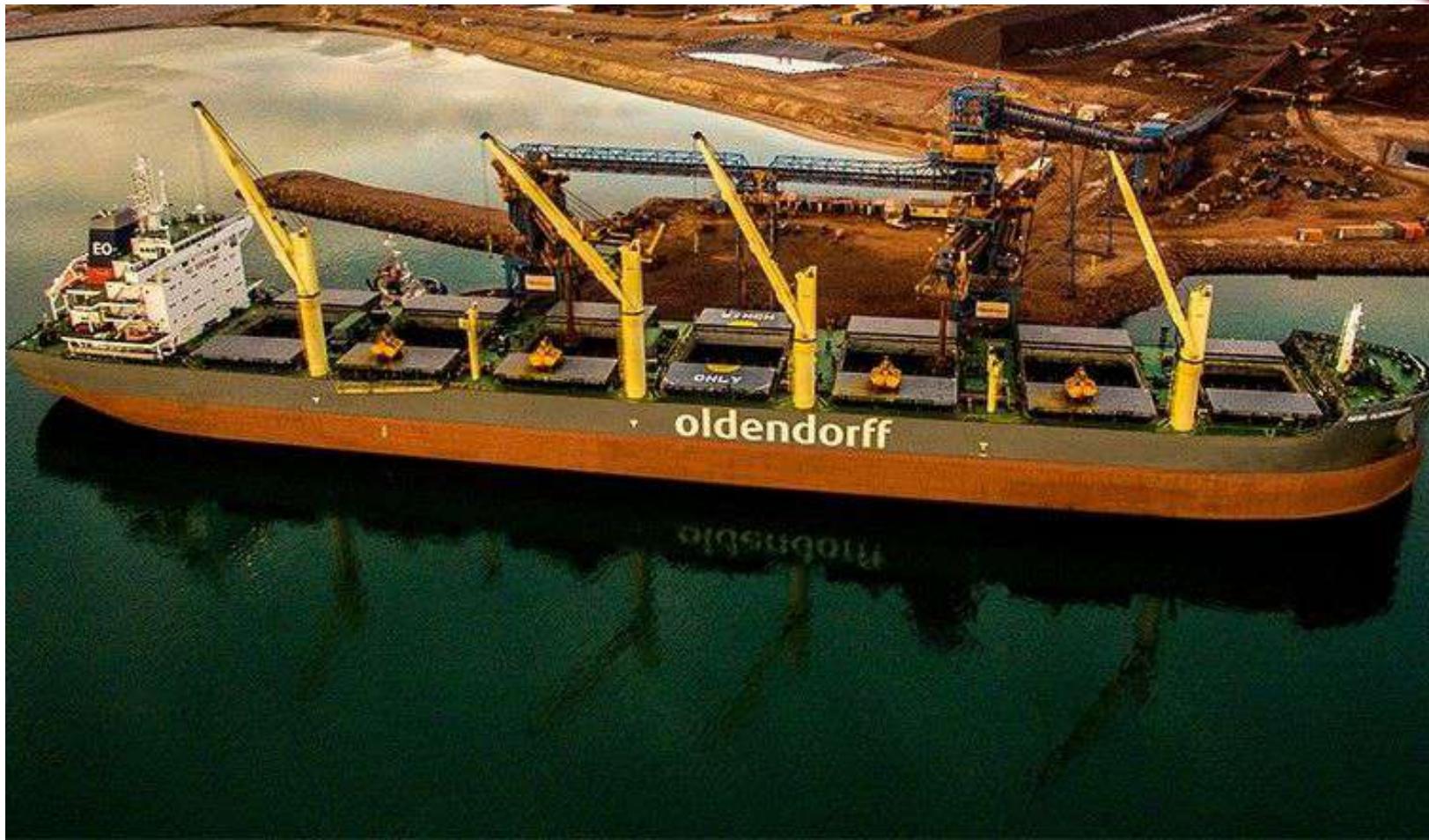
- Crane on Bulk Carrier



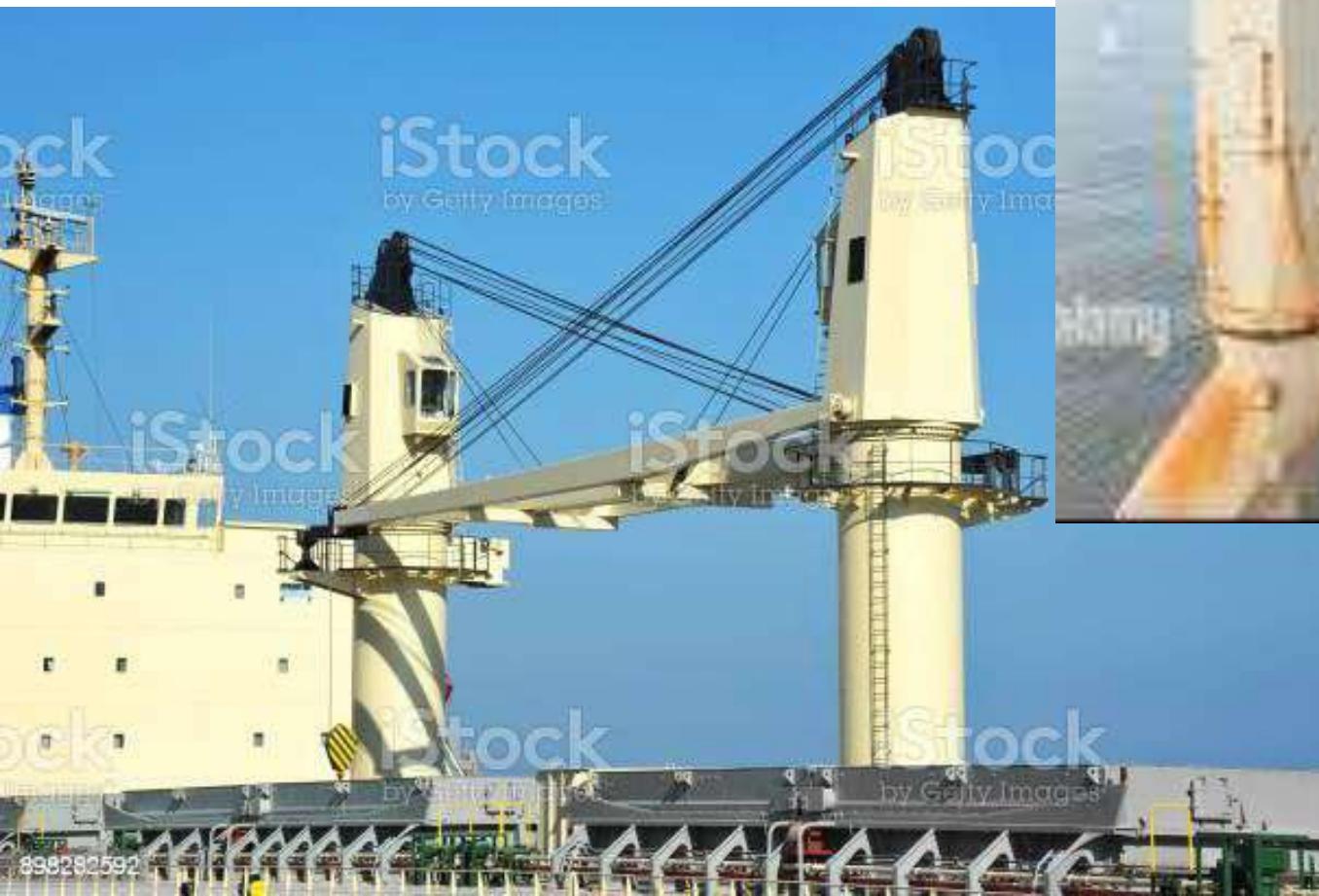
- Crane



- Crane



- Crane



- Crane



- Container Ship



Handling

Cargo Handling Equipment

- Handling
 - Bulk Cargo
 - Grabs / Clamshell Buckets
 - Self Loading / Unloading
 - Tankers
 - Pumps
 - Piping
 - Containers
 - Spreaders
 - Wire Ropes / Slings
 - RoRo
 - Ramps
 - Passenger
 - Gangways
 - Fishing
 - Winches , Nets, Fishing Gear

- Grabs /Clam Shell Buckets



- Grabs /Clam Shell Buckets



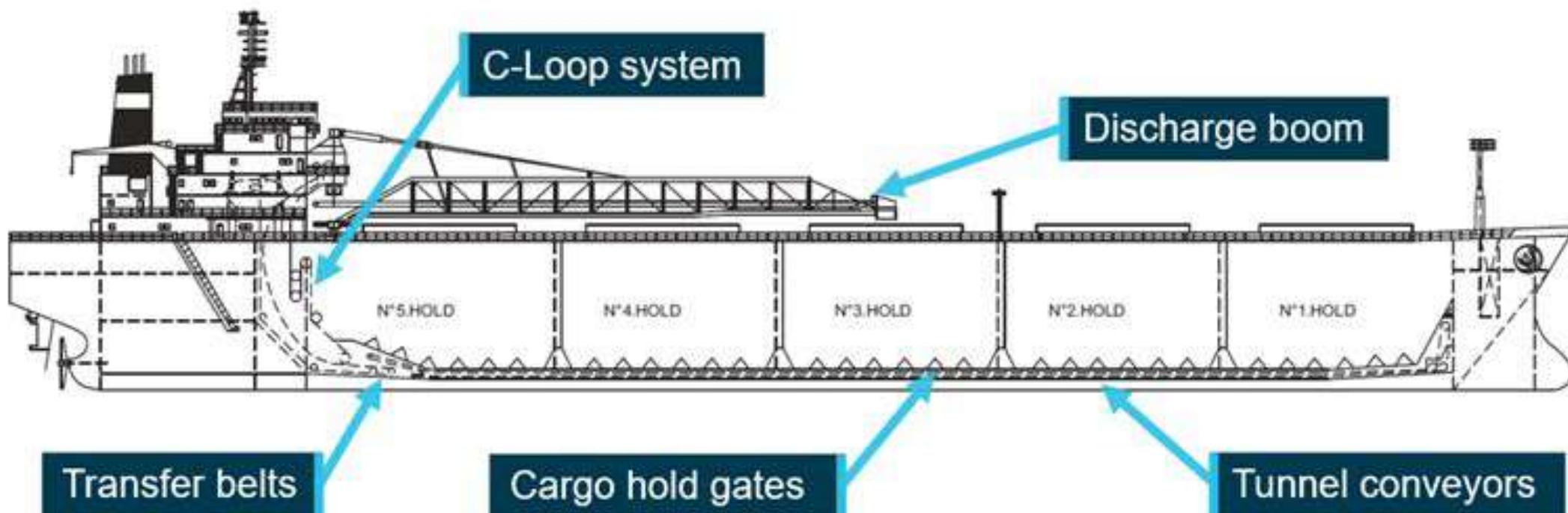
- Grab /Clamshell

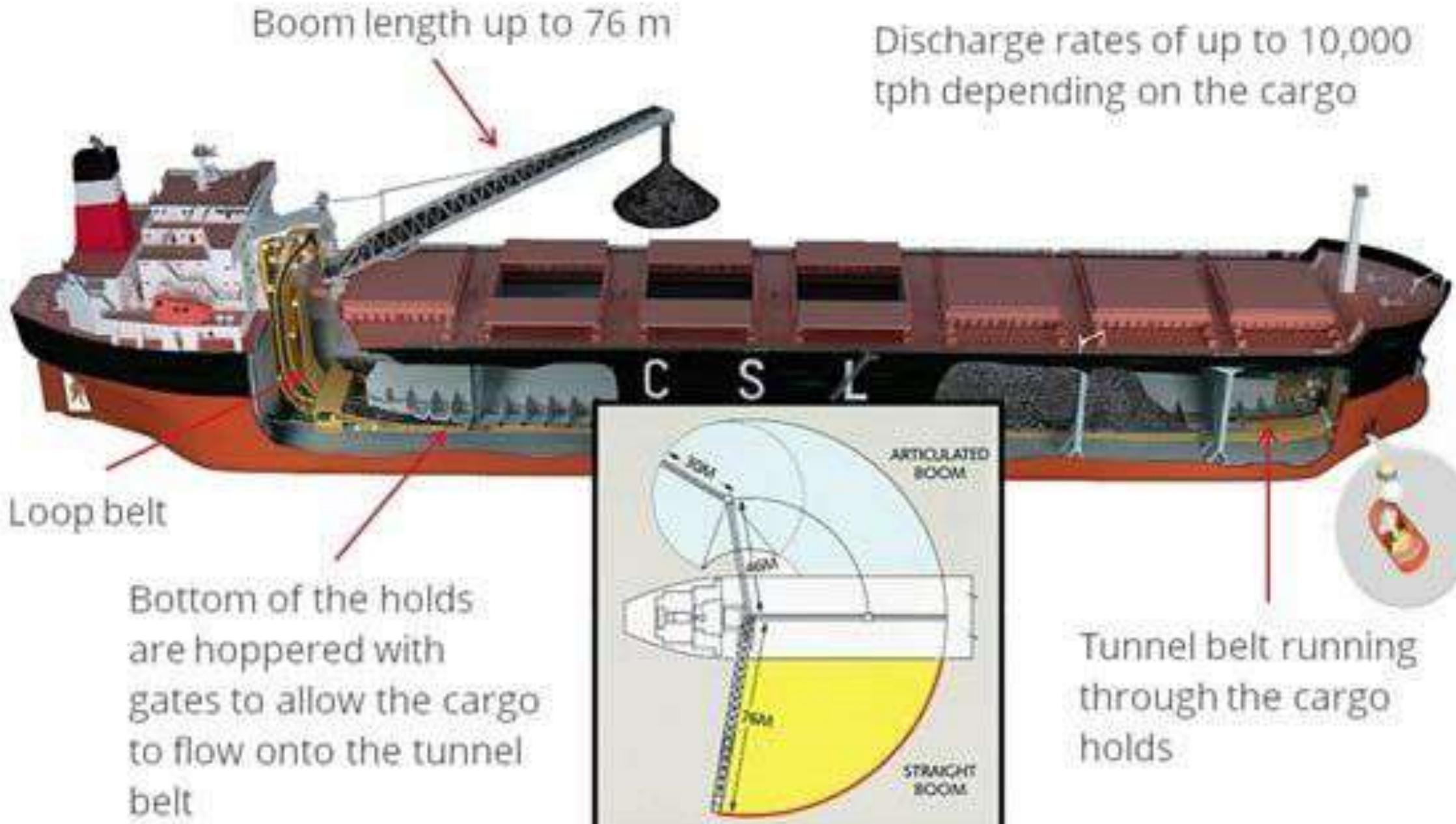


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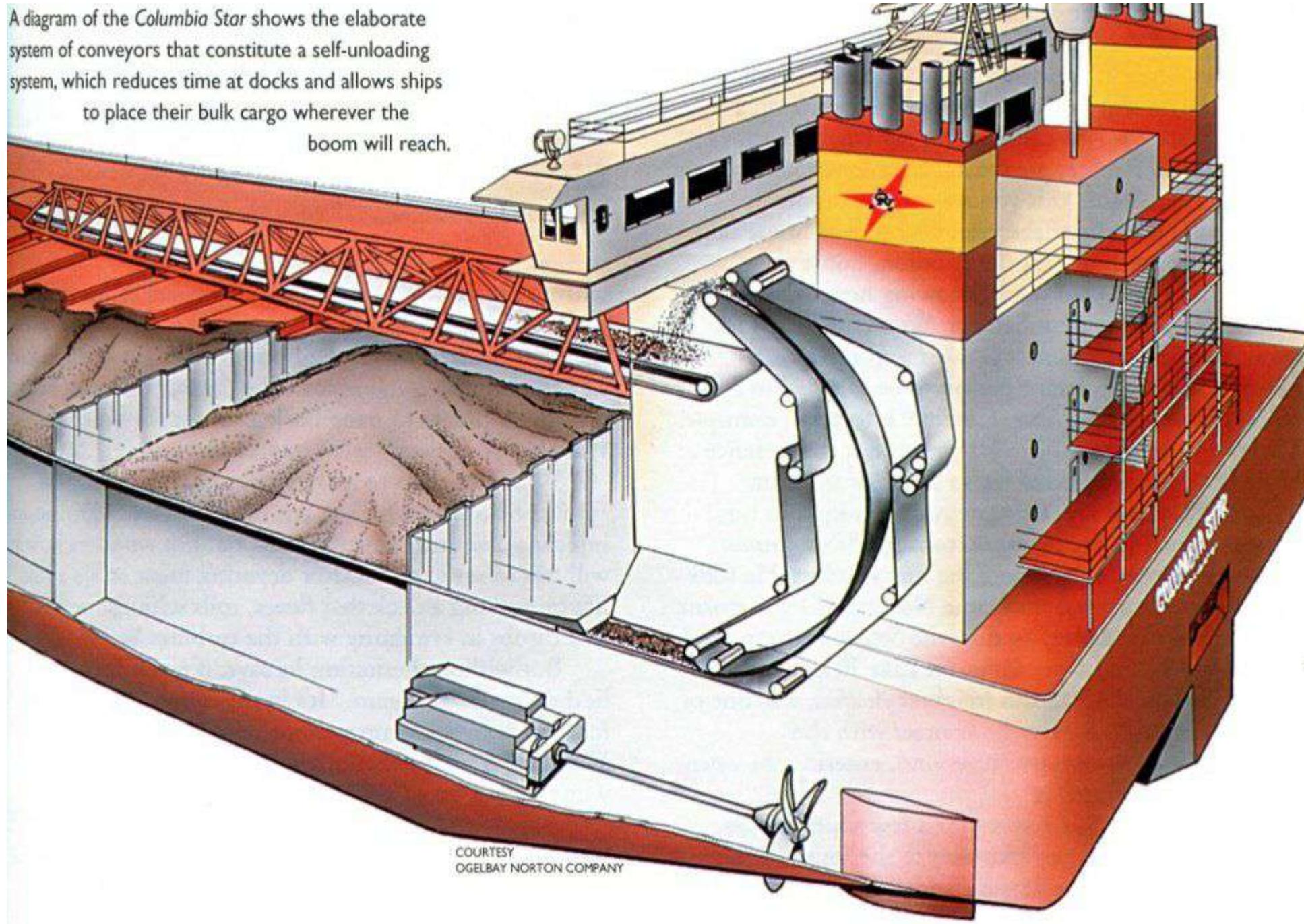
Cargo Handling Equipment

- Self-Unloading





A diagram of the *Columbia Star* shows the elaborate system of conveyors that constitute a self-unloading system, which reduces time at docks and allows ships to place their bulk cargo wherever the boom will reach.



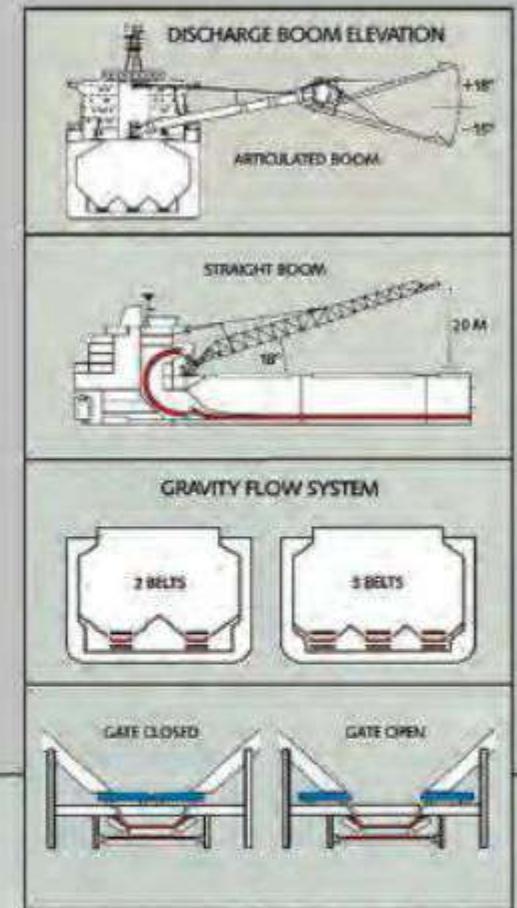
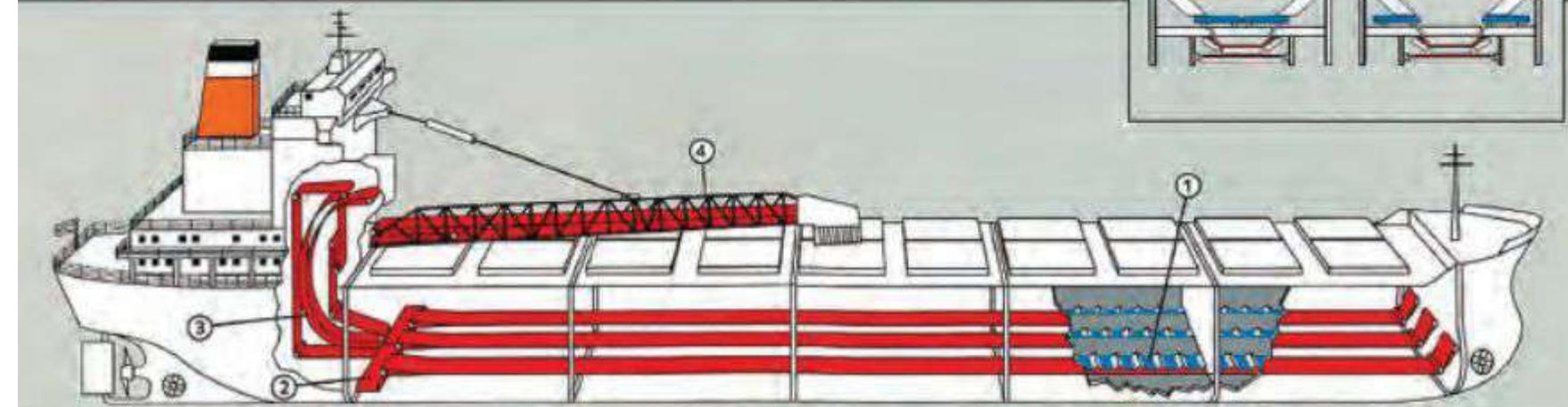
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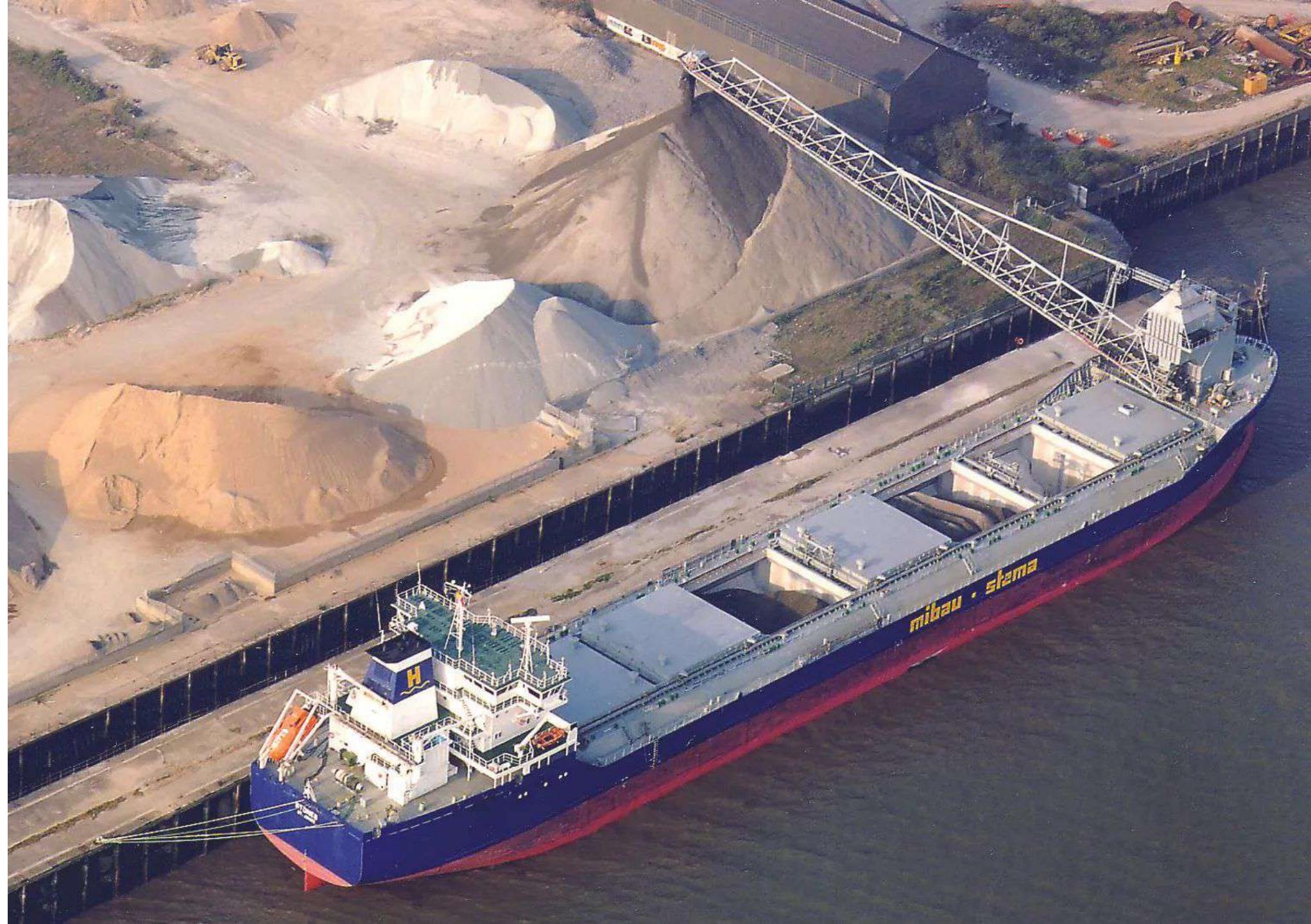
Cargo Hand

- Self Unloader

How Self-Unloaders Work

- 1) Cargo flows by gravity through a series of hydraulically controlled gates onto conveyor belts running from bow to stern beneath the cargo holds.
- 2) From the cargo hold conveyors, the material is fed to shuttle transfers which supply the elevating conveyor belts.
- 3) The cargo is then elevated to the main deck and transferred onto a 76-meter discharge boom conveyor.
- 4) The discharge boom conveyor carries the cargo from the self-unloader to the receiving facility.
- 5) Cargo unloading speed is regulated to match the take-away rate of the receiving hopper and shore conveyor system.







CSL

Cargo Handling Equipment

- Pumps
- Piping



Cargo Handling Equipment

- LNG



Cargo Handling Equipment

- LPG



Cargo Handling Equipment

- CNG

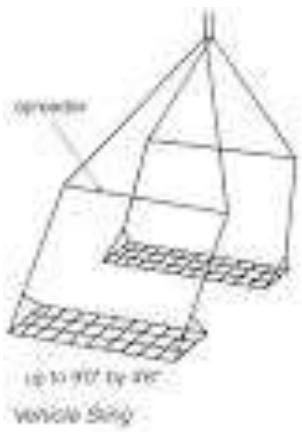


Cargo Handling Equipment

- Spreader (for containers)



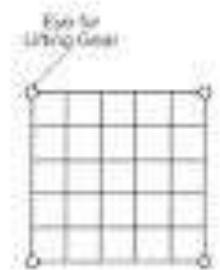
- Wire Ropes / Slings/ Nets



Canvas Sling



Base Lifting Clamp



Cargo Net



Pallet



- Ramps
 - External



- Ramps
 - Internal



- Gangway



- Winches Nets and fishing gear

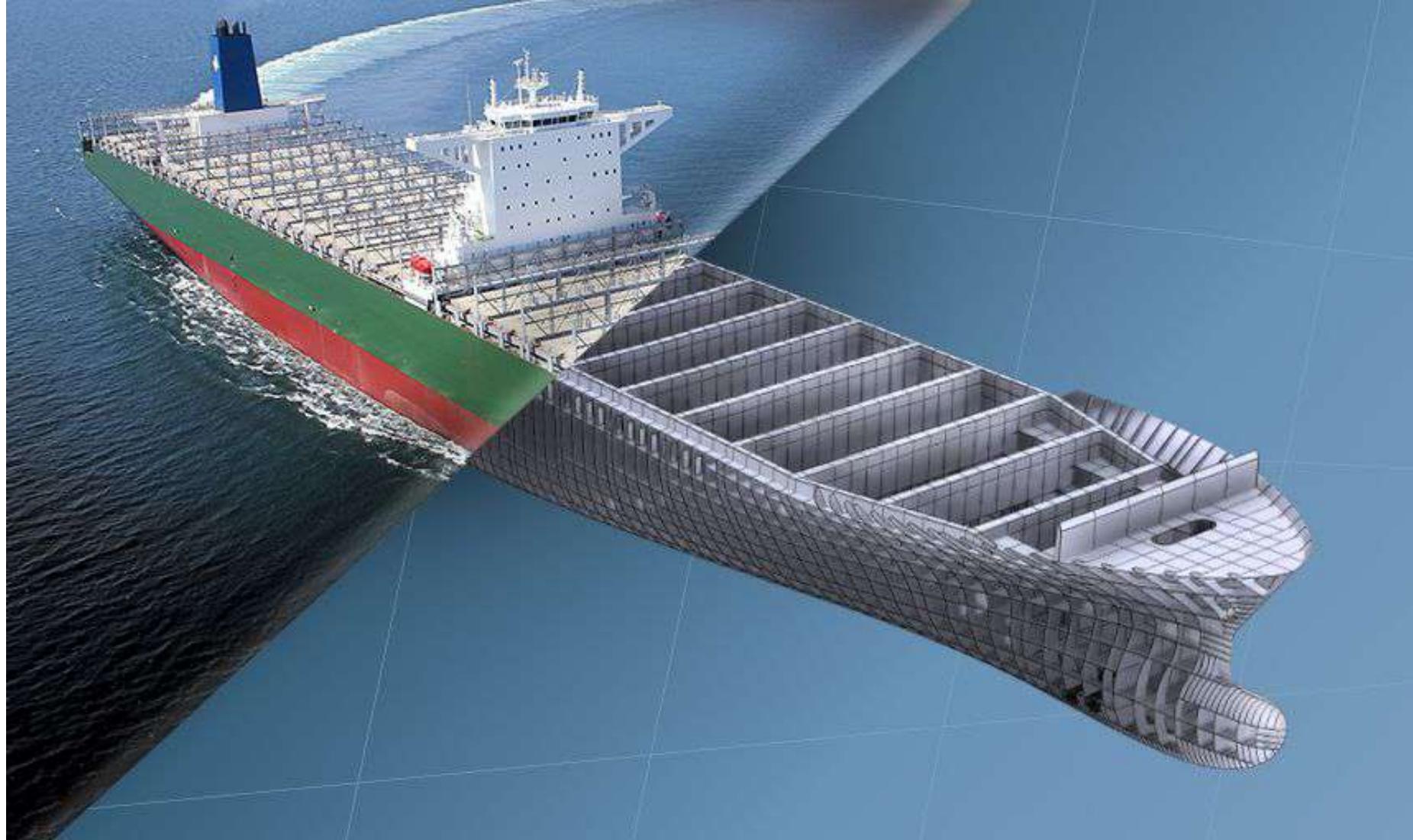


Cargo Handling Equipment

- Hatch Covers
 - Lifting type
 - Rolling type
 - Single Pull
 - Side Rolling
 - Single Panel
 - Twin Panel
 - Folding type
 - Twin Panel
 - Multiple Panel
 - Stacking Type
- Lifting Equipment
 - Derrick
 - Crane
- Handling Equipment
 - Grabs / Clamshell Buckets
 - Self Loading / Unloading
 - Pumps
 - Piping
 - Spreaders
 - Wire Ropes / Slings
 - Ramps
 - Gangway
 - Winches, Nets, Fishing Gear

END

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Introduction to Naval Architecture

II SEM – Module 5

Marine Propulsion Machinery





Marine Propulsion System

- A marine propulsion system refers to the technology that propels any water-borne craft on the water.
- All marine propulsion systems work on Newton's third law of motion whereby any force applied by one object to a second object results in an equal reaction force being applied on the first object.
- In the case of marine propulsion, the propulsion device applies a force on either the surrounding **water** or **air** to create a reaction force on the craft and push it in the required direction. Propulsion devices are
 - Water – Paddles, Propeller
 - Air – Sails, Fans

Device

Propeller

Prime Mover

Engine

Turbine

Motor

Energy Source

Diesel

Steam/Gas

Electricity

Mechanical
Propulsion

$$\eta = \sim 0.98$$



Reduction
Gear

Prime
Mover

$$\eta = \sim 0.96$$

Propulsion
Motor

$$\eta = \sim 0.96$$

Motor
Drive

$$\eta = \sim 0.97$$

Main Power
Distribution

Generator

Prime
Mover

Electric Propulsion

Propulsion Machinery - Types

- Types of Prime movers used to turn the propeller are
 - Engine
 - Diesel
 - LNG
 - Turbine
 - Steam
 - Gas
 - Motor (Electric)
- Other Technologies
 - Water Jet
 - Azimuth Thruster (or Podded Propulsion)

Engine

- Diesel Engine

- Internal Combustion of diesel powers crankshafts that
 - connect directly or through reduction gears to the propeller.

or

- powers electric generators that power the propeller motors
- Most Common and versatile
- Heavy fuel oil (HFO) or bunker fuel, or residual fuel oil is used as fuel
- HFO is the result or remnant from the distillation and cracking process of petroleum.

- Advantages

- Low cost
- Simple
- Reliable

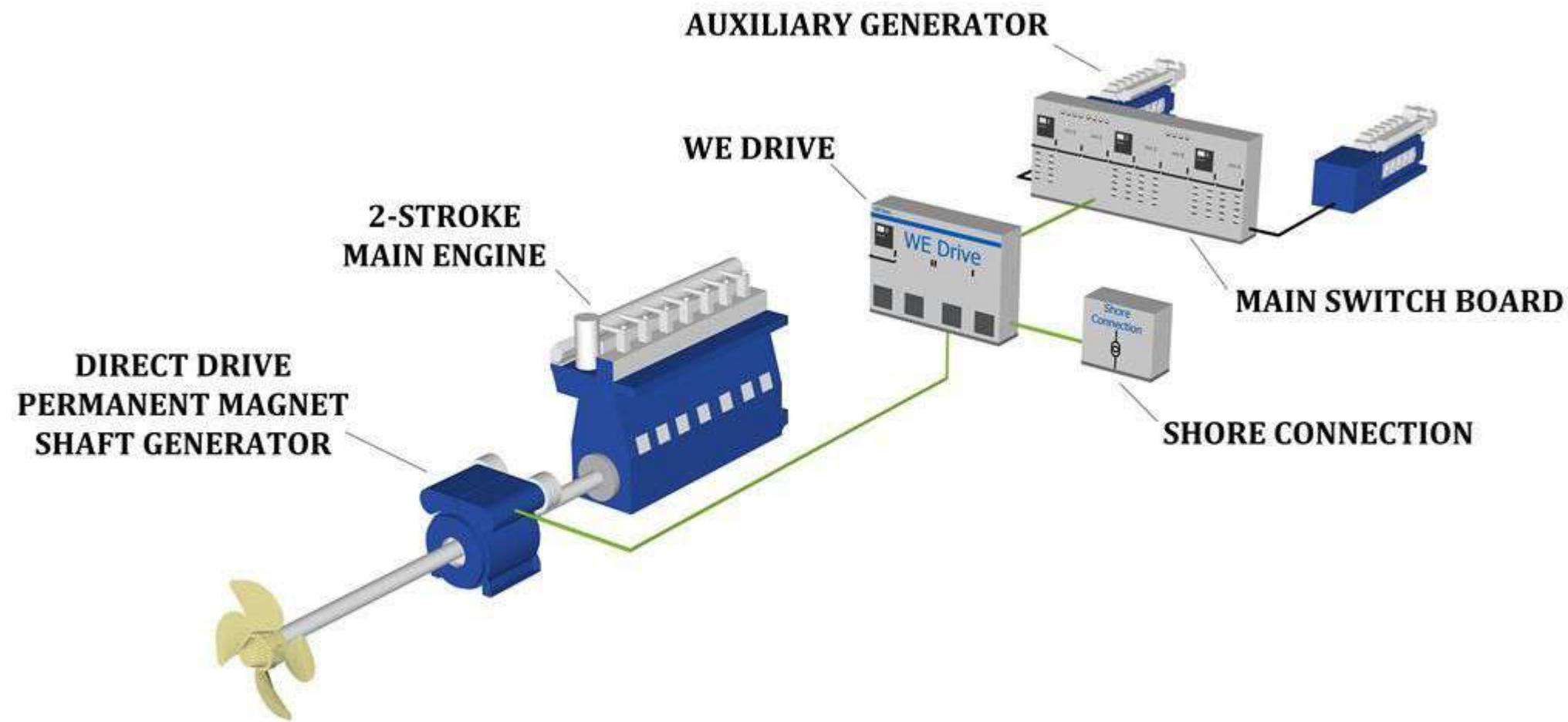
- Disadvantages

- Noisy
- Heavy

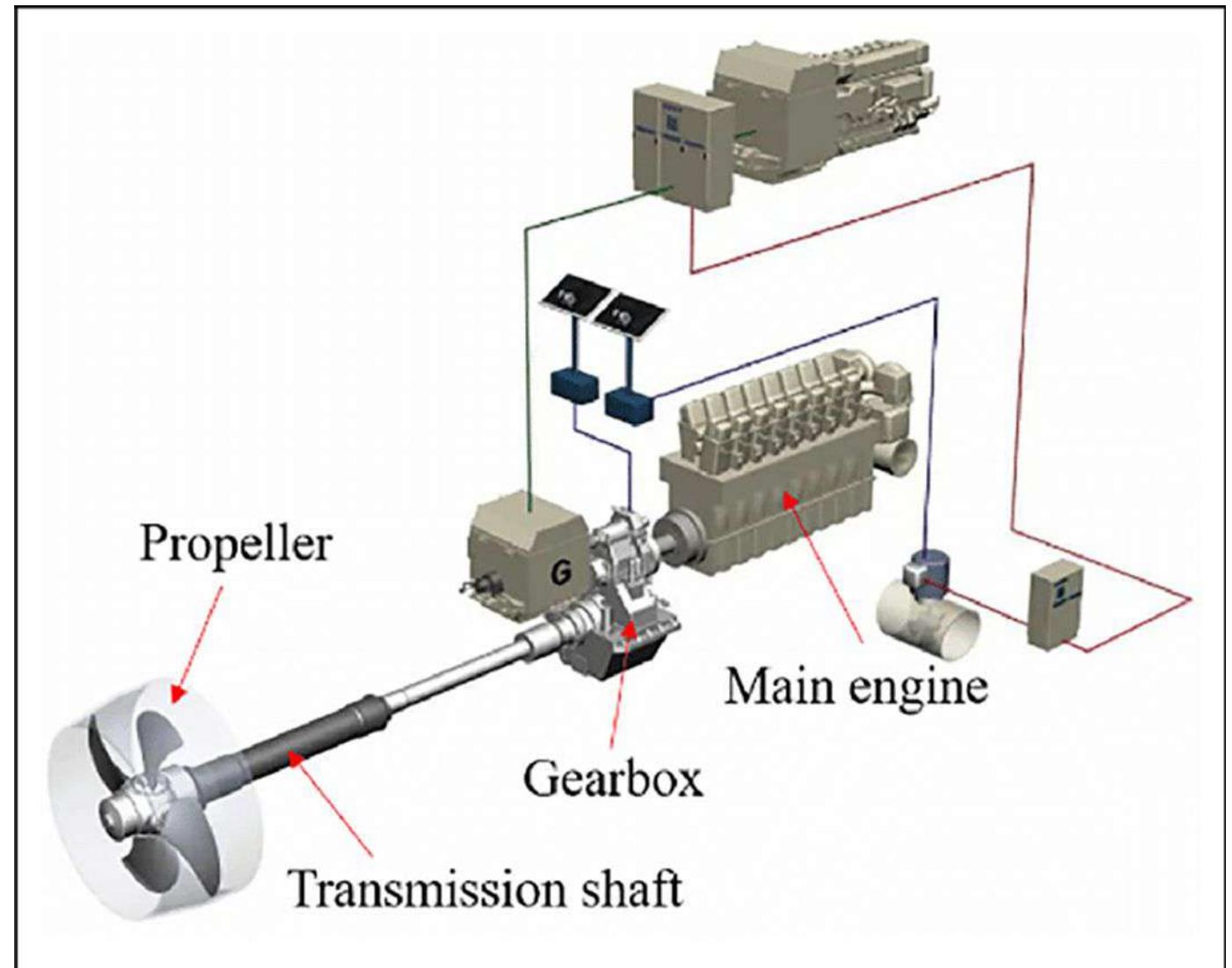
Marine Diesel Engine



Engine Room Layout-Diesel Engine Room



Engine Room Layout-Diesel Engine Room



Engine

- LNG Engine
 - LNG is used as fuel in the ship engine
 - LNG offers various benefits such as low CO₂, SO_x, NO_x and particulate matter emissions.
 - However, methane in the combustion chamber could get released into the atmosphere. As methane is a much more potent greenhouse gas compared to carbon dioxide, LNG could actually exacerbate the climate crisis.
 - Currently, LNG-powered engines are in use on LNG carriers, container vessels, cruise ships, RORO ferries, bulk carriers, supply vessels, drillships, dredgers, and tugboats.



Engine

- Fuels for future marine engines
 - LPG
 - Ammonia
 - Biogas
 - Methanol
 - Synthetic diesel

Turbine

- Steam Turbine

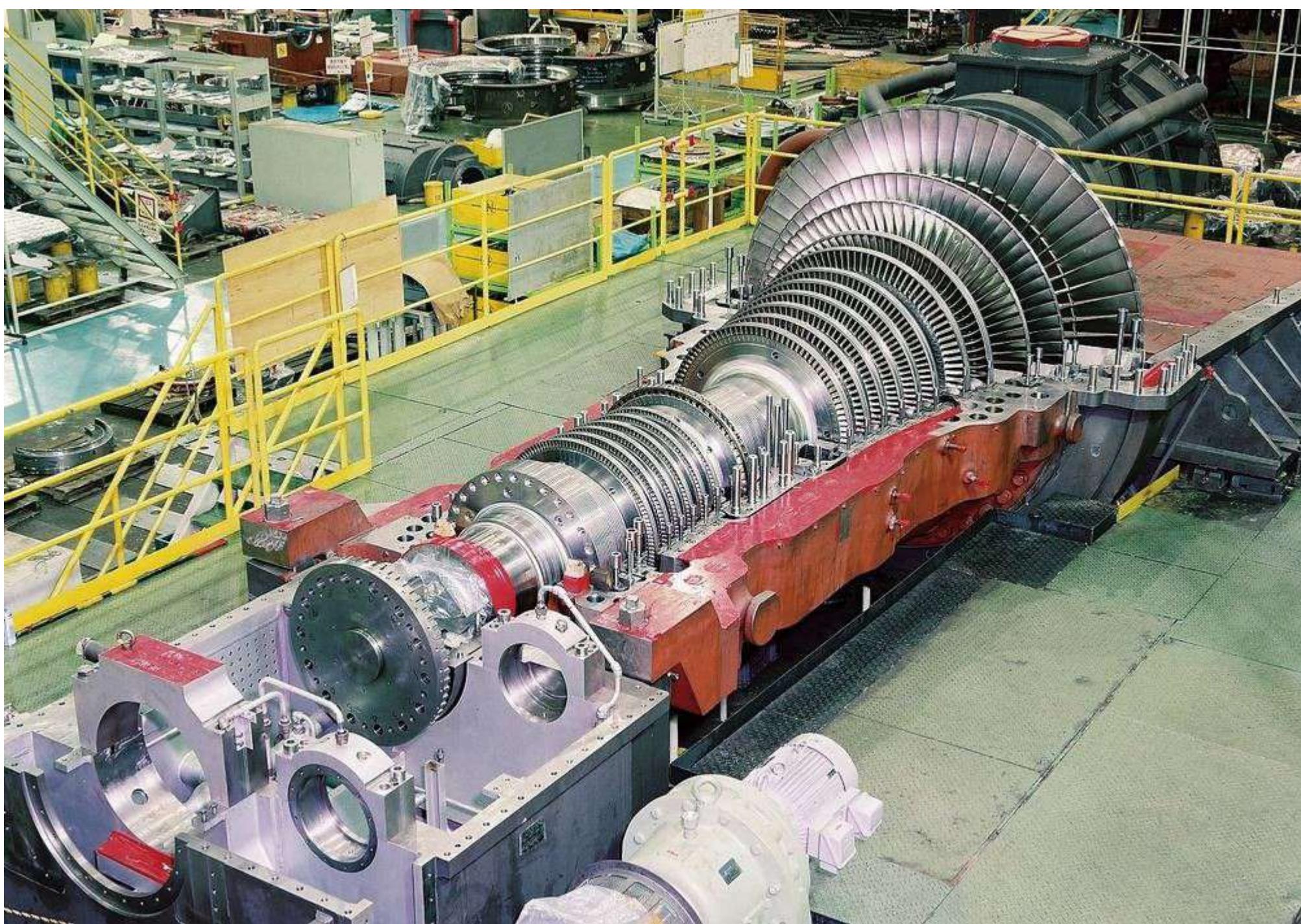
- Steam turbines are the prime movers.
- The turbines may then either
 - power the propeller directly through reduction gears (direct propulsion)
or
 - power electric generators that power the propeller motors (turboelectric).
- Conversion of water to steam by generating heat using
 - Fossil Fuel
 - Other sources

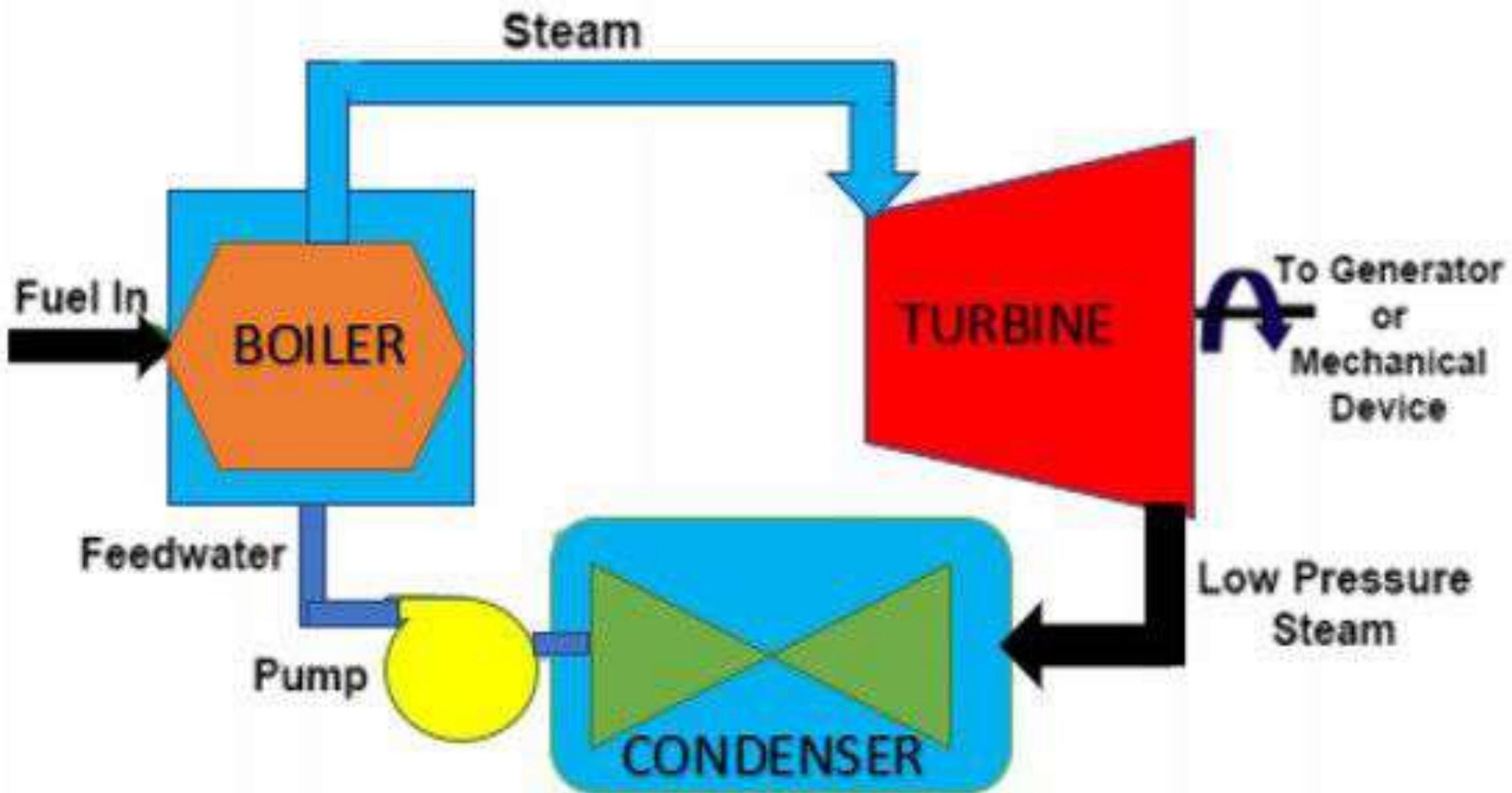
- Advantages

- Reliable
- High Speed

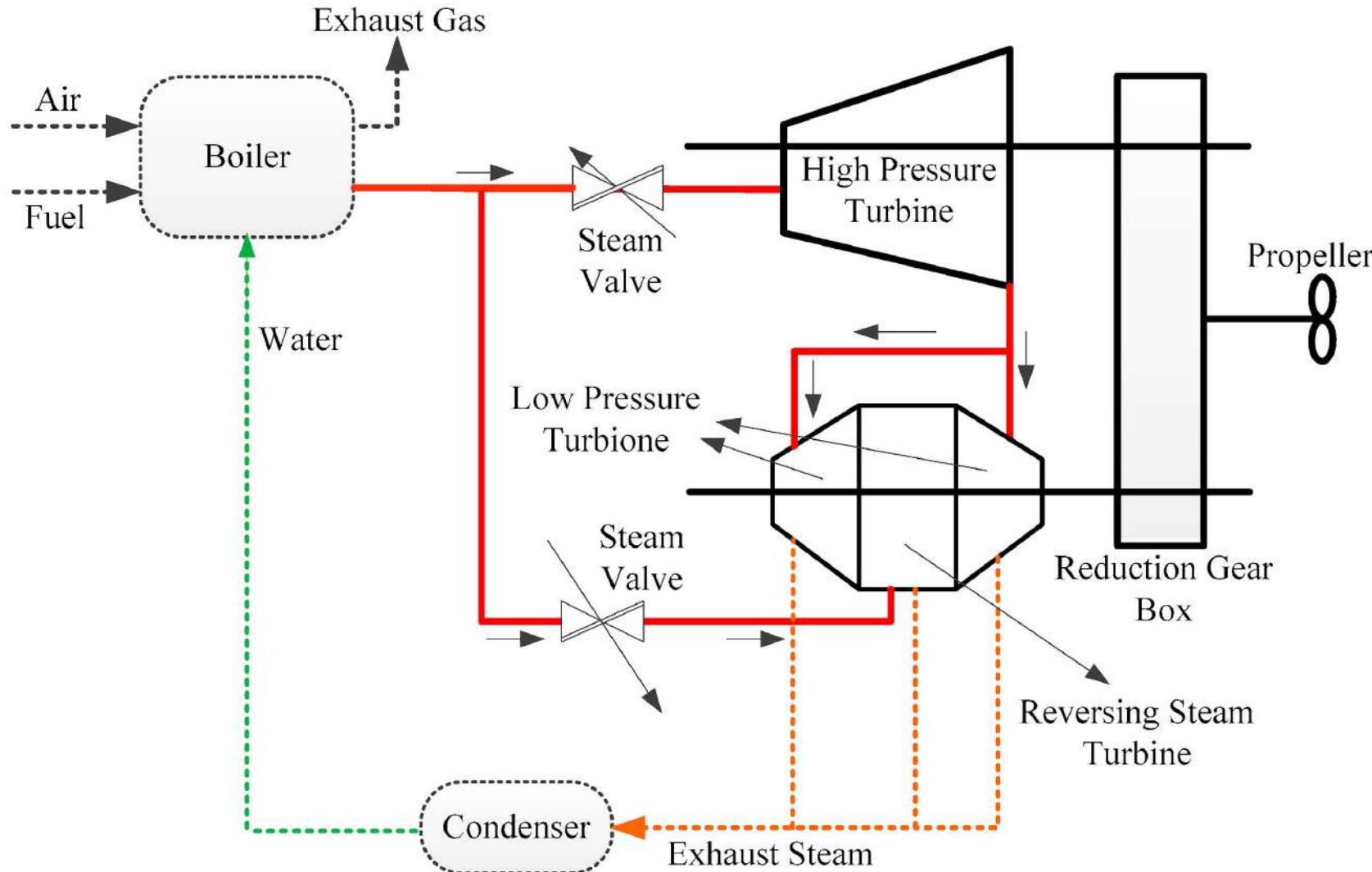
- Disadvantages

- Complex
- Dangerous
- Difficult to maintain





Engine Room Layout-Steam Turbine Engine Room

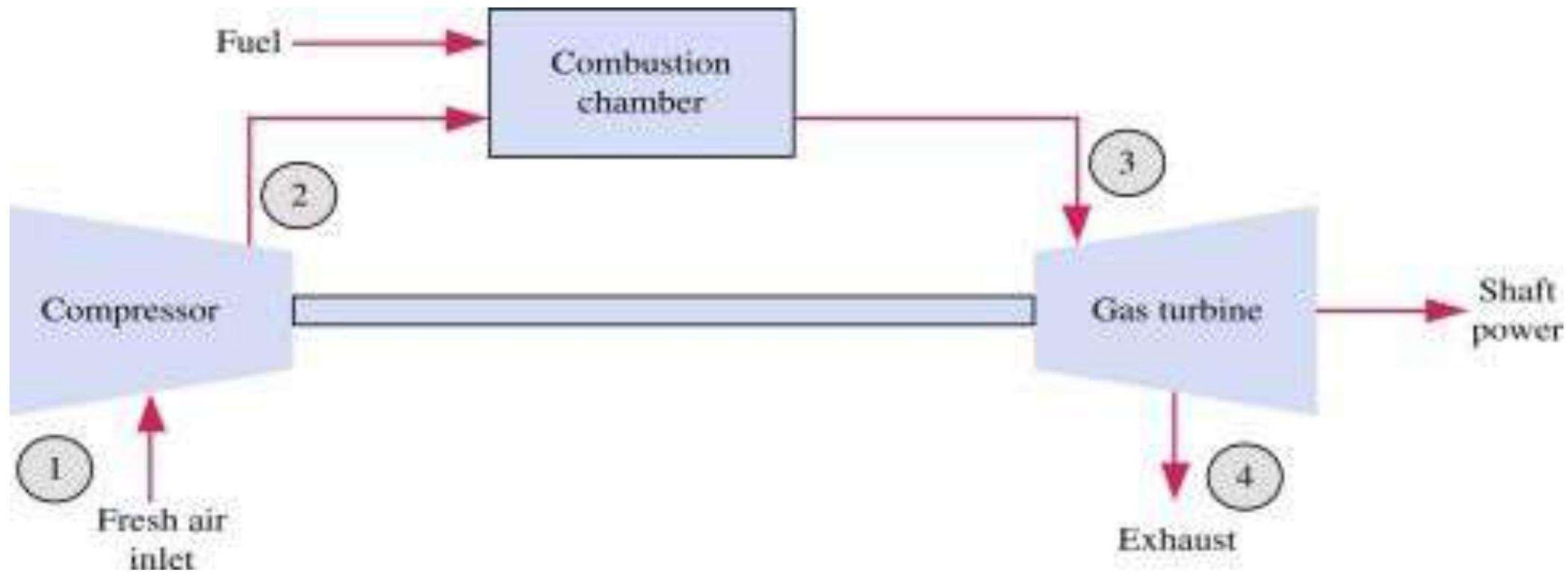


Turbine

- Gas Turbine
 - Gas turbines are the prime movers. using low viscosity petroleum fuel
 - The turbines may then either
 - power the propeller directly through reduction gears (direct propulsion)
 - or
 - power electric generators that power the propeller motors (turboelectric).
 - Mostly used in warships
- Advantages
 - High Speed
 - Reliable
- Disadvantages
 - high initial cost
 - high fuel consumption.
 - Inability to generate power from the cheaper but dirtier Heavy Fuel Oil(HFO).



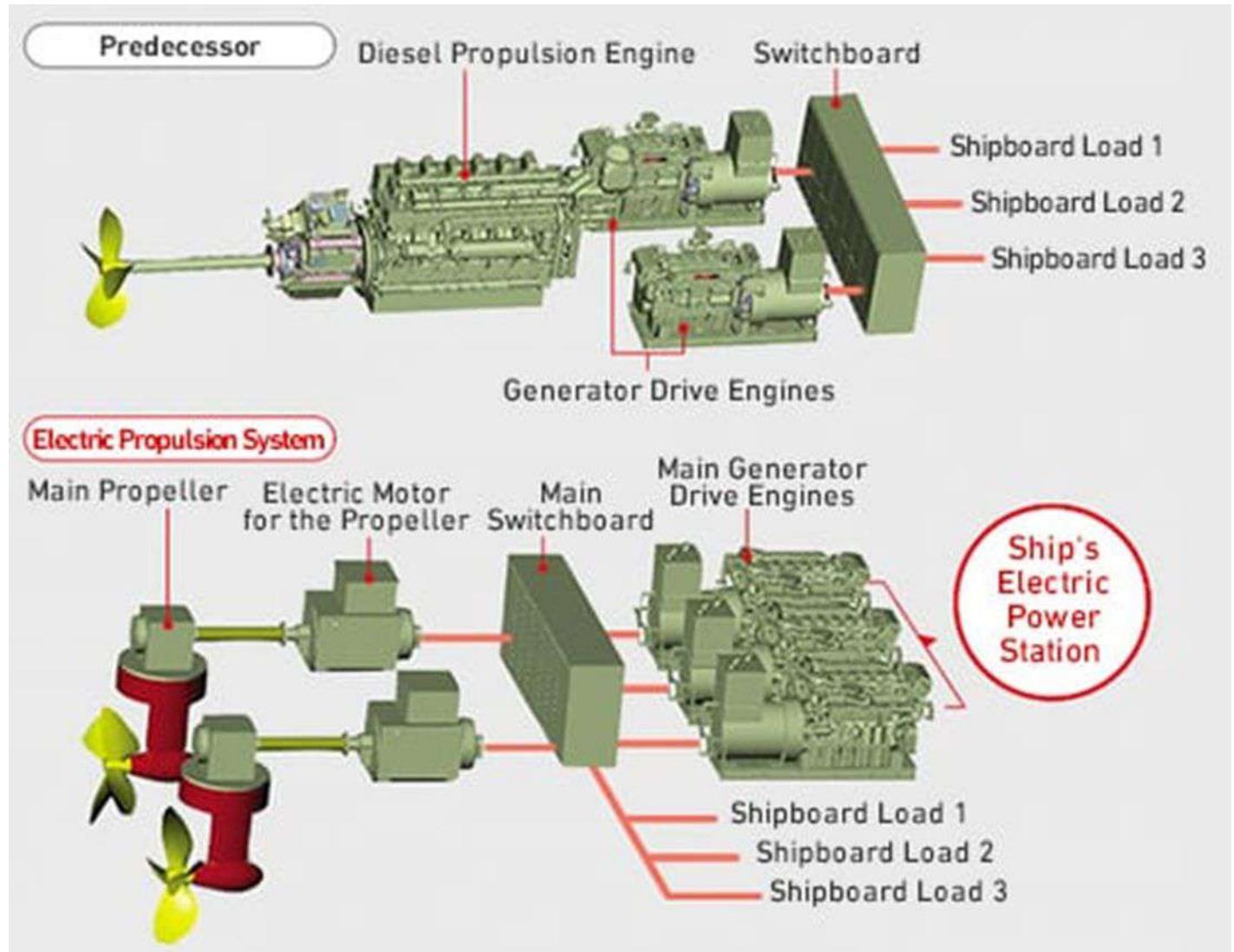
Engine Room Layout-Gas Turbine Engine Room



Motor

- An Electric Motor is the prime mover which rotates the propeller
- Energy Sources for generating Electricity on board
 - Fossil Fuel (Marine Diesel, etc.) – using generators (called Diesel Electric Propulsion)
 - Nuclear
 - Fuel Cell
 - Solar
 - Wind

Engine Room Layout-Diesel Electric Propulsion Engine Room



Energy Sources for generating Electricity

- Fuel Cell
 - Fuel cells generate electricity using an electrochemical reaction.
 - There is no combustion.
 - The main fuel is hydrogen and the waste products consist only of oxygen, heat, and water.
 - This makes fuel cells a very good choice from a sustainability perspective.

Energy Sources for generating Electricity

-Nuclear Power

-These propulsion systems provide reduced fuel costs and superior performance.

-Despite the lower fuel cost, nuclear-powered vessels can be up to 50% faster than fossil-fuel ships.

-The carbon savings from this type of design is also unmatched.

-Nuclear-powered vessels are commonly used in the navy for warships, submarines, and aircraft carriers. They are also used in icebreakers.

- Solar



- Wind

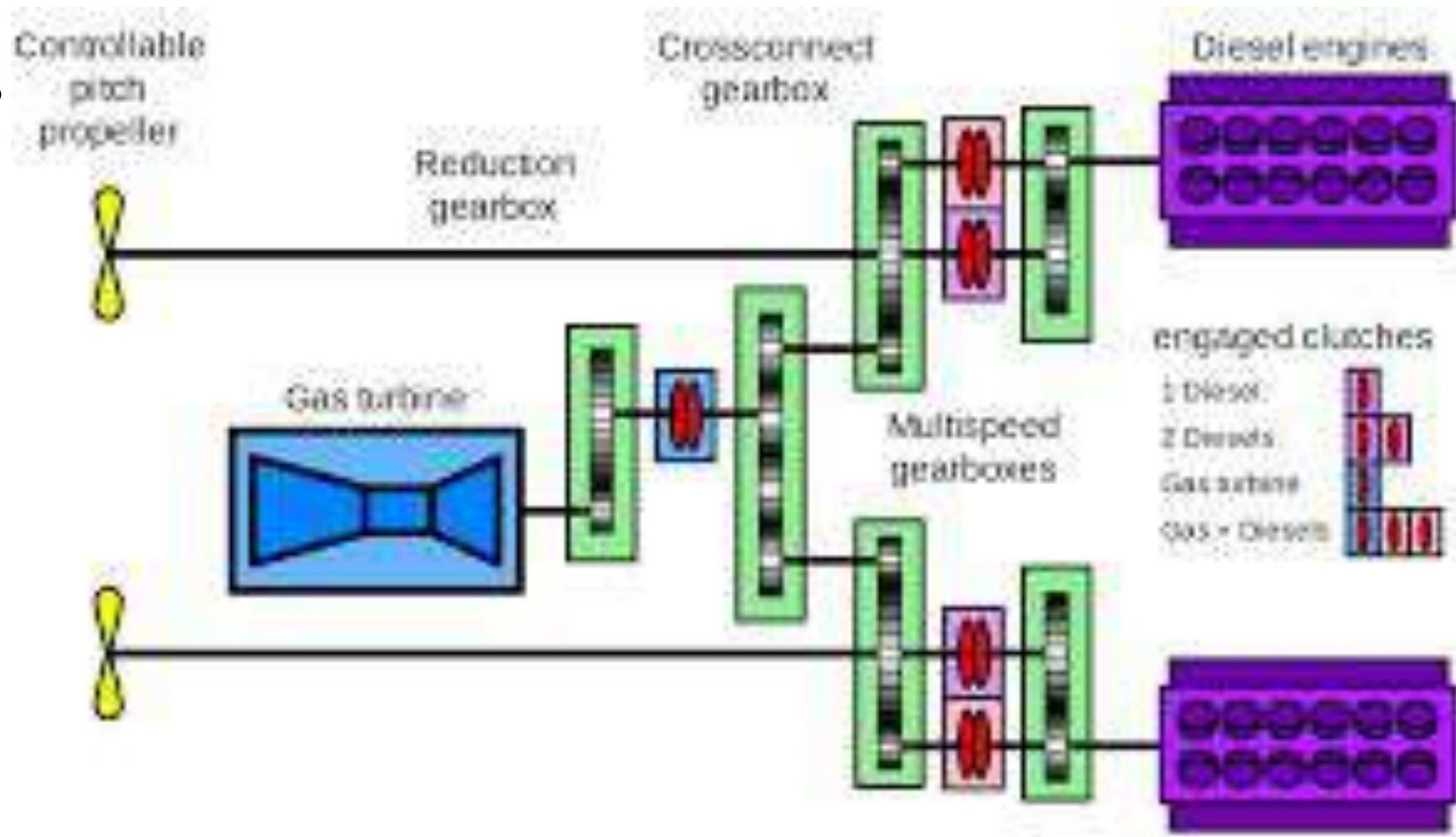


Combination of Prime Movers

- When two different or similar Prime movers are combined to provide propulsion
- Two modes possible
 - “AND” - When both prime movers can be simultaneously used to deliver RPM to the propeller
 - “OR” – When only one of the prime movers can be used to deliver RPM to the Propeller
- Helps improve
 - Redundancy
 - Speed

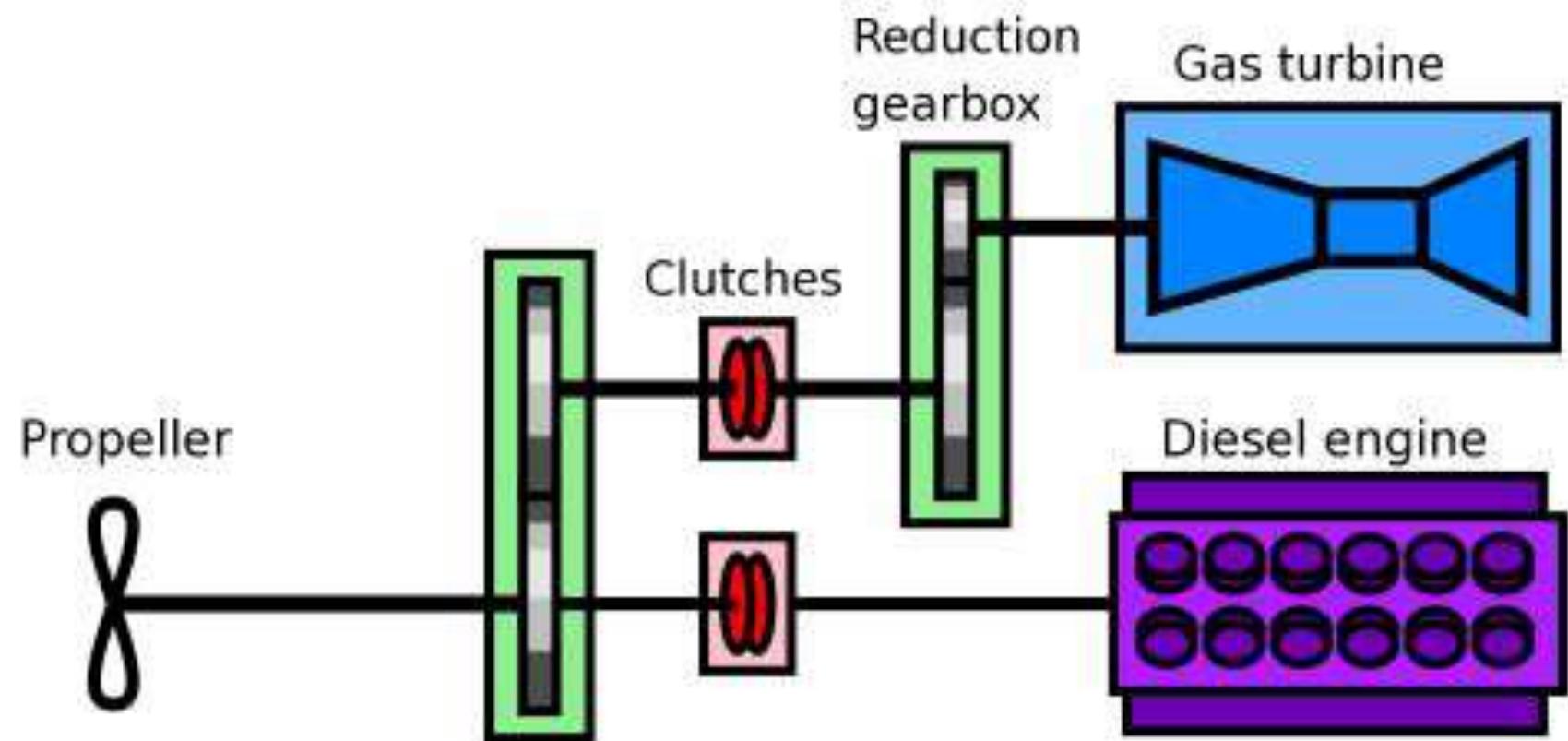
Combined Diesel and Gas(CODAG)

- Diesel Engine and Gas Turbine can simultaneously be used to turn the propeller



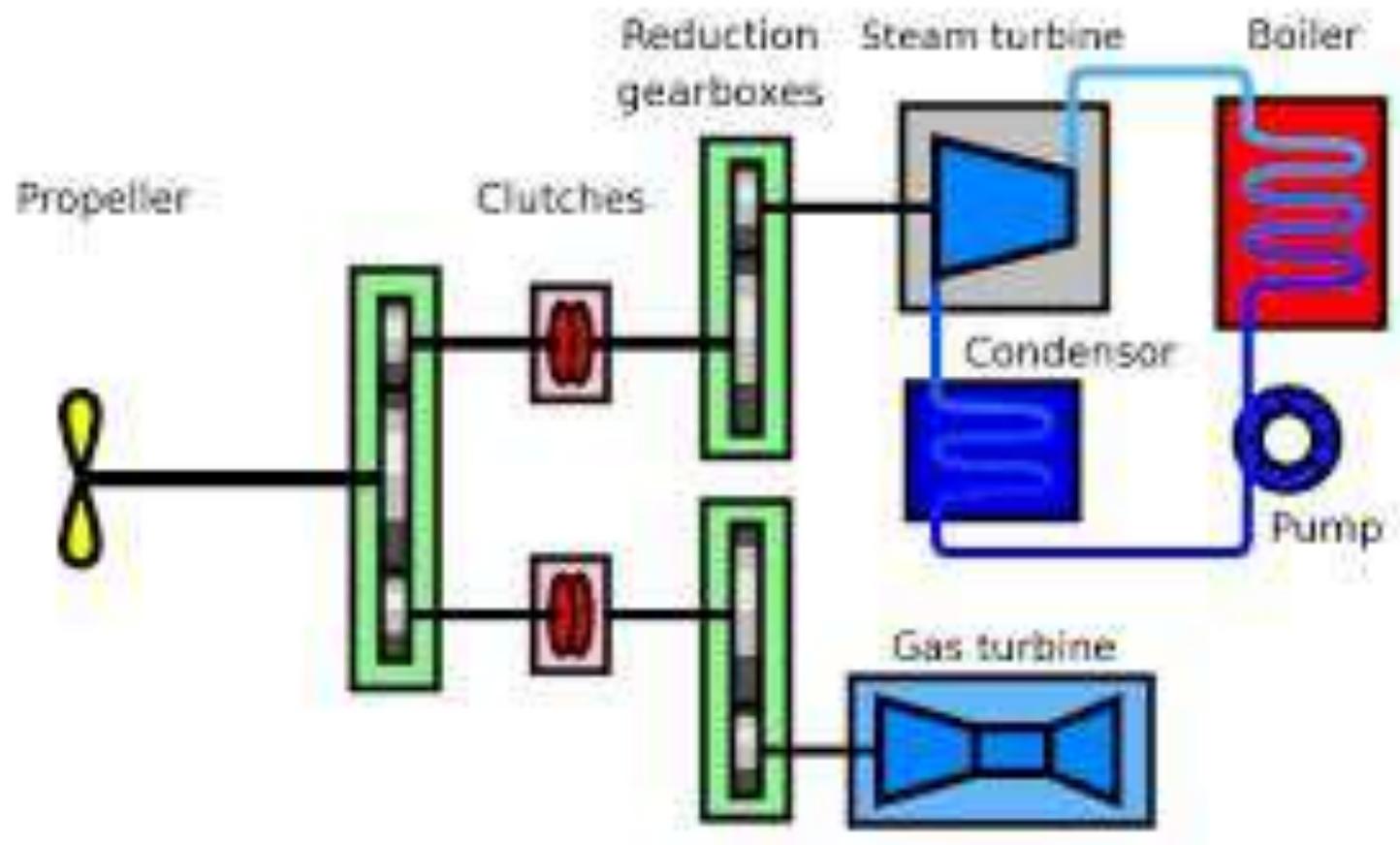
Combined Diesel or Gas (CODOG)

- Either Diesel Engine OR Gas Turbine can be used to turn the propeller



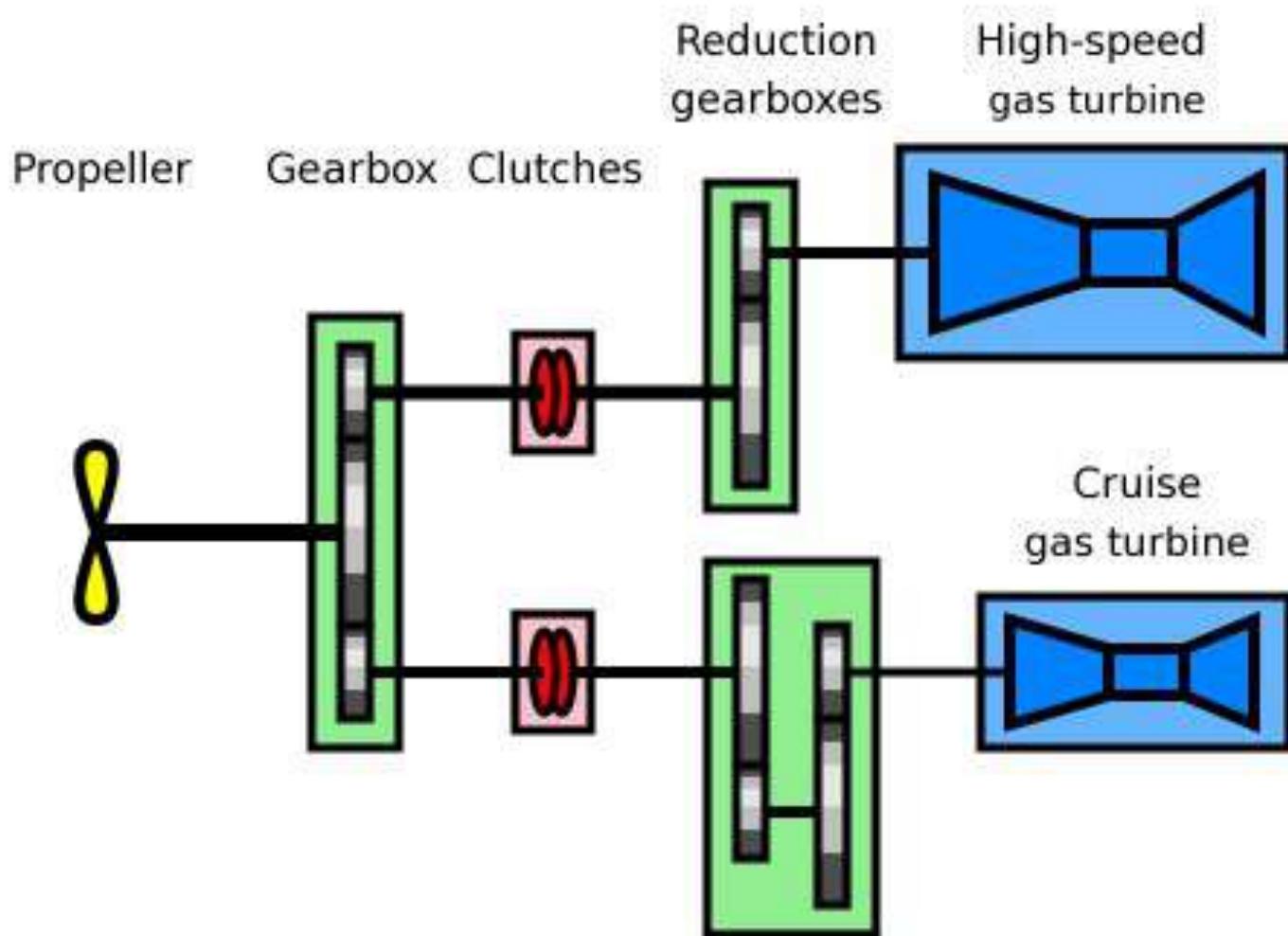
Combined Steam and Gas (COSAG)

- Steam and Gas Turbines can simultaneously be used to turn the propeller



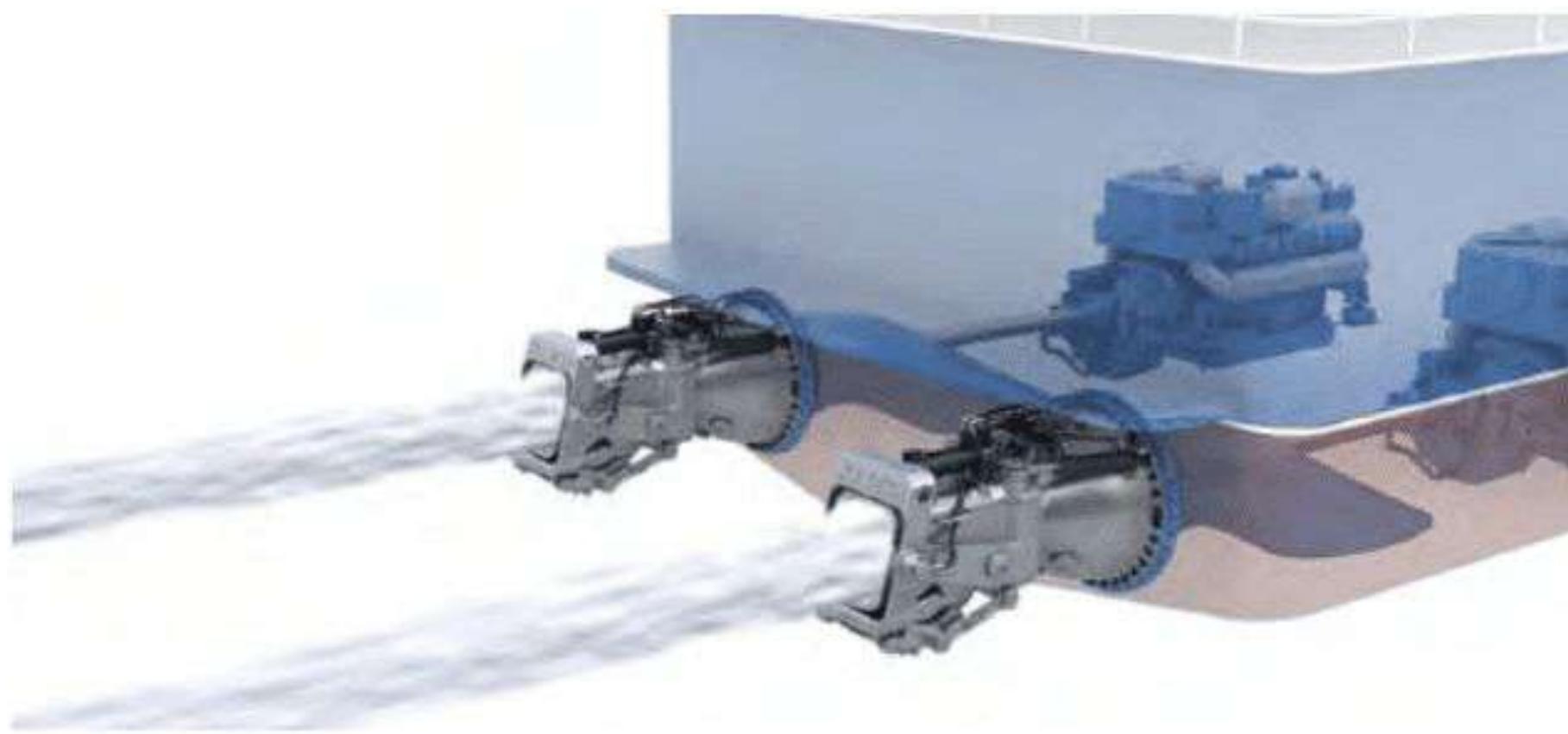
Combined Gas or Gas

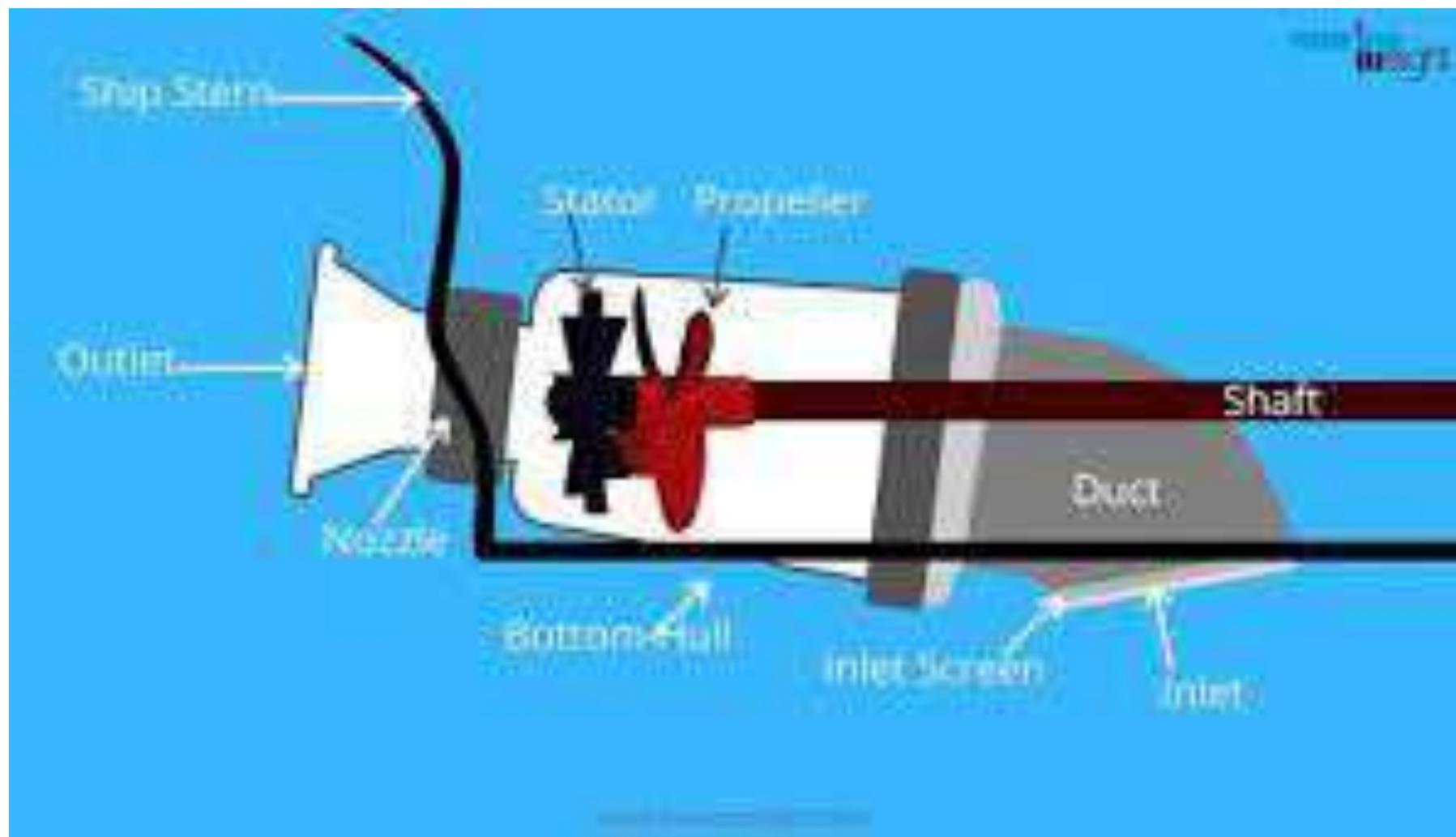
- Ship having two gas turbines.
Either one of the Gas
Turbines can simultaneously
be used to turn the propeller



Other Propulsion Technologies

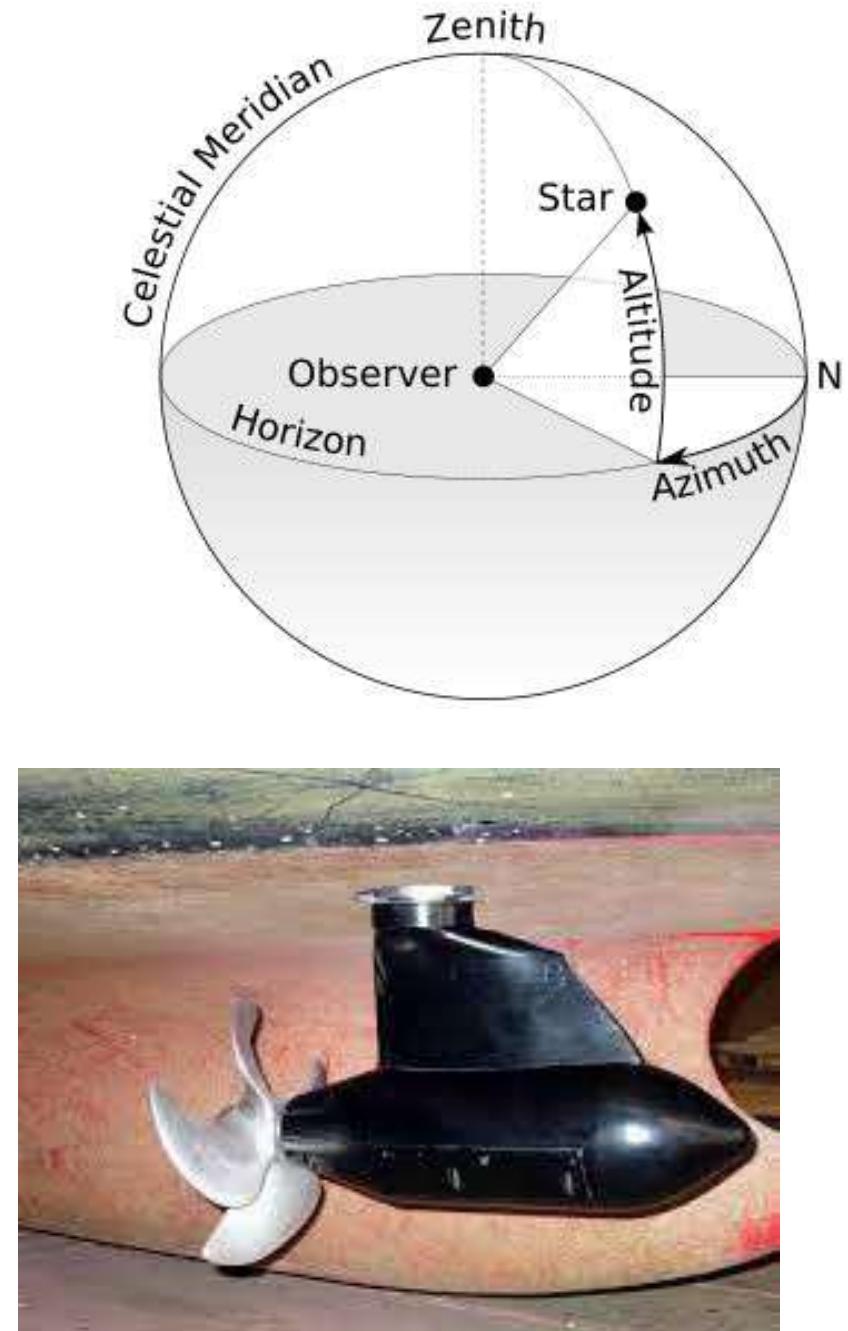
- Water jet Propulsion
 - Uses a high-pressure water jet to propel forward in the water. The water used in the water jet propulsion system is sourced from the surrounding seawater itself.
 - Water jet is created by using a pump powered by electricity to pressurise the water.
 - A water jet system cannot create enough power for large vessels such as oil tankers and bulk carriers. However, it can propel smaller vessels such as naval ships, tugs, trawlers and recreational vessels at very high speeds.

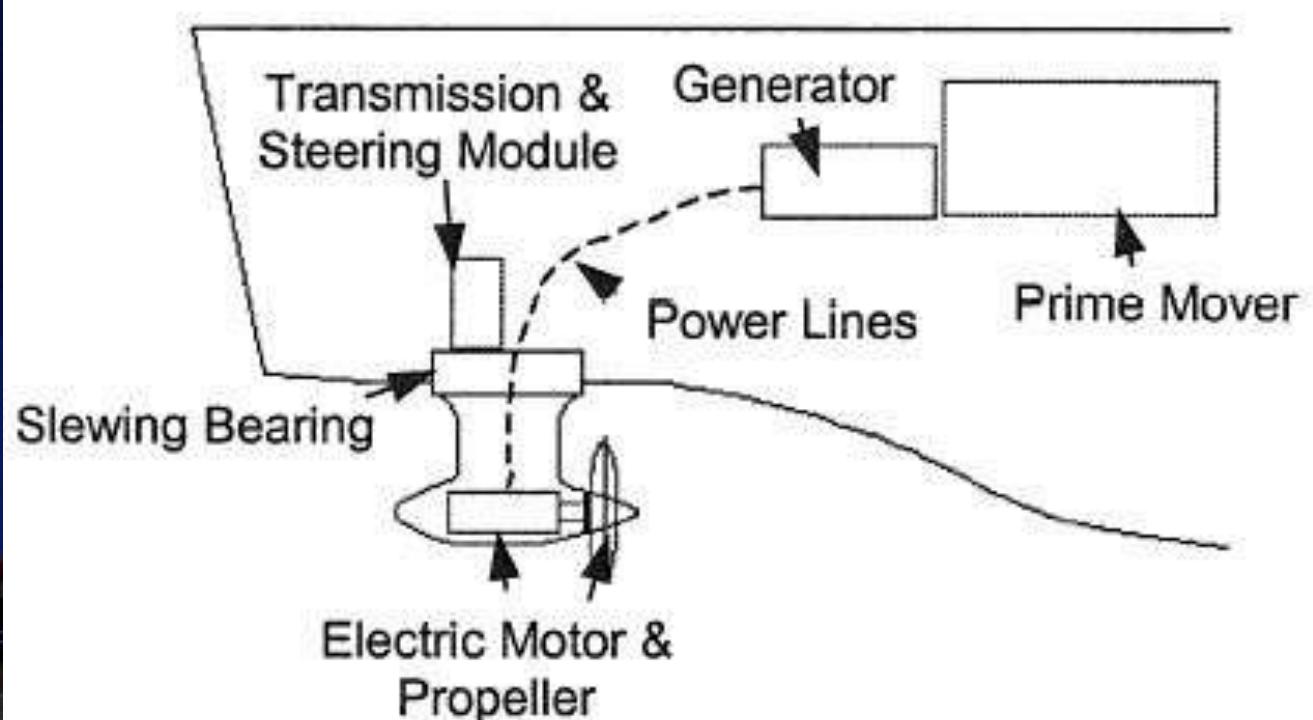




Other Propulsion Technologies

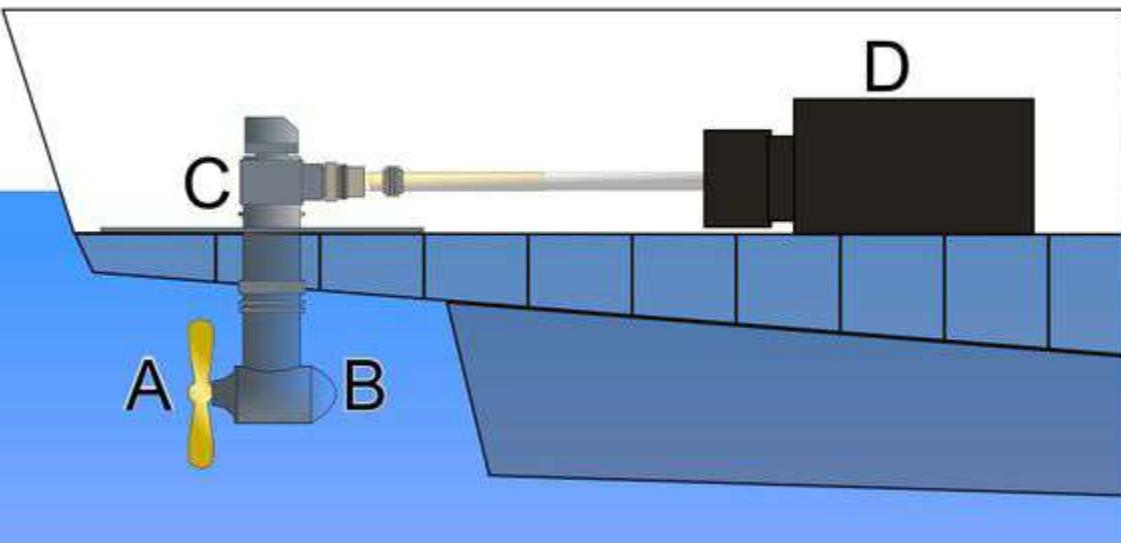
- Azimuth Thruster (or Podded Propulsion)
 - Azimuth means angular measurement
 - Pod means a detachable and self contained unit.
 - An azimuth thruster is a configuration of marine propellers placed in pods that can be rotated to any horizontal angle (azimuth). Thus, rudder is not required.
 - reduced emissions, lower noise and vibration levels and emissions; improved steering maneuvering, and braking capabilities.





- Types of Azimuth Drives
 - L-Drive
 - Z Drive

Z-Drive



L- drive





Kort Nozzle



Twin Propeller



Auxiliary machinery

- Auxiliary – means providing supplementary or additional help and support.
- All Machinery in a ship other than the main propulsion unit comes under the category of auxiliary machinery

Auxilliary machinery

- Pumps
- Compressors
- Blowers
- Heat Exchangers
- Condenser
- Oily Water Separator
- Boiler

END

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