Aalto University
School of Engineering

MEC-E2000 Marine and Ship Systems Engineering

Lecture 8: Deck Machinery and Cargo Handling Systems

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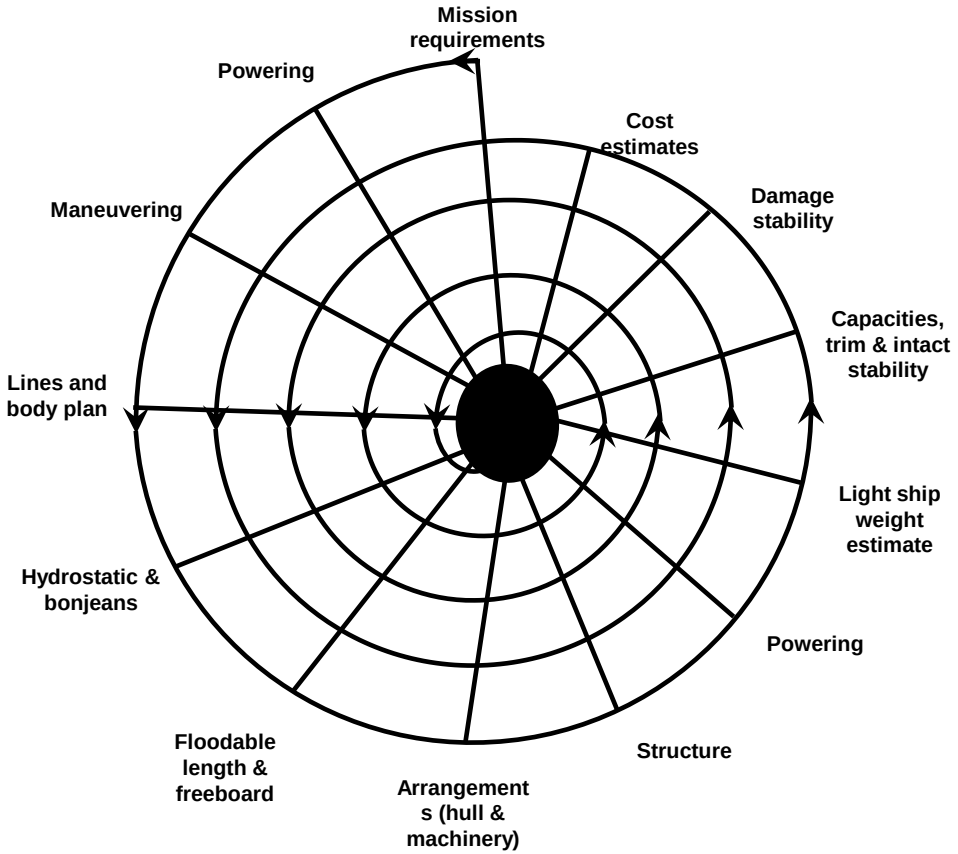
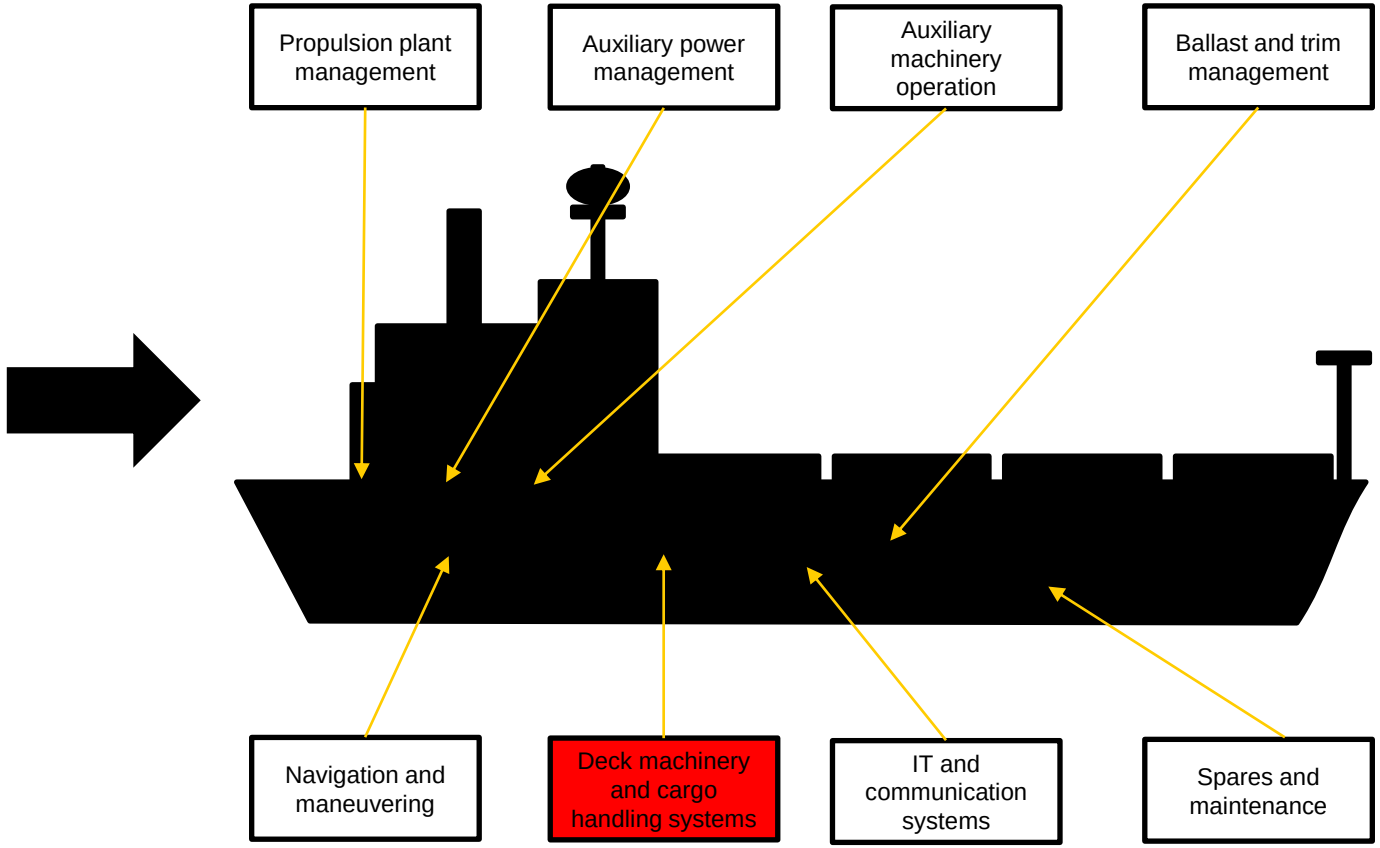
The perspective and evolution of ship systems in ship design



The traditional ship design spiral by Evans 1959

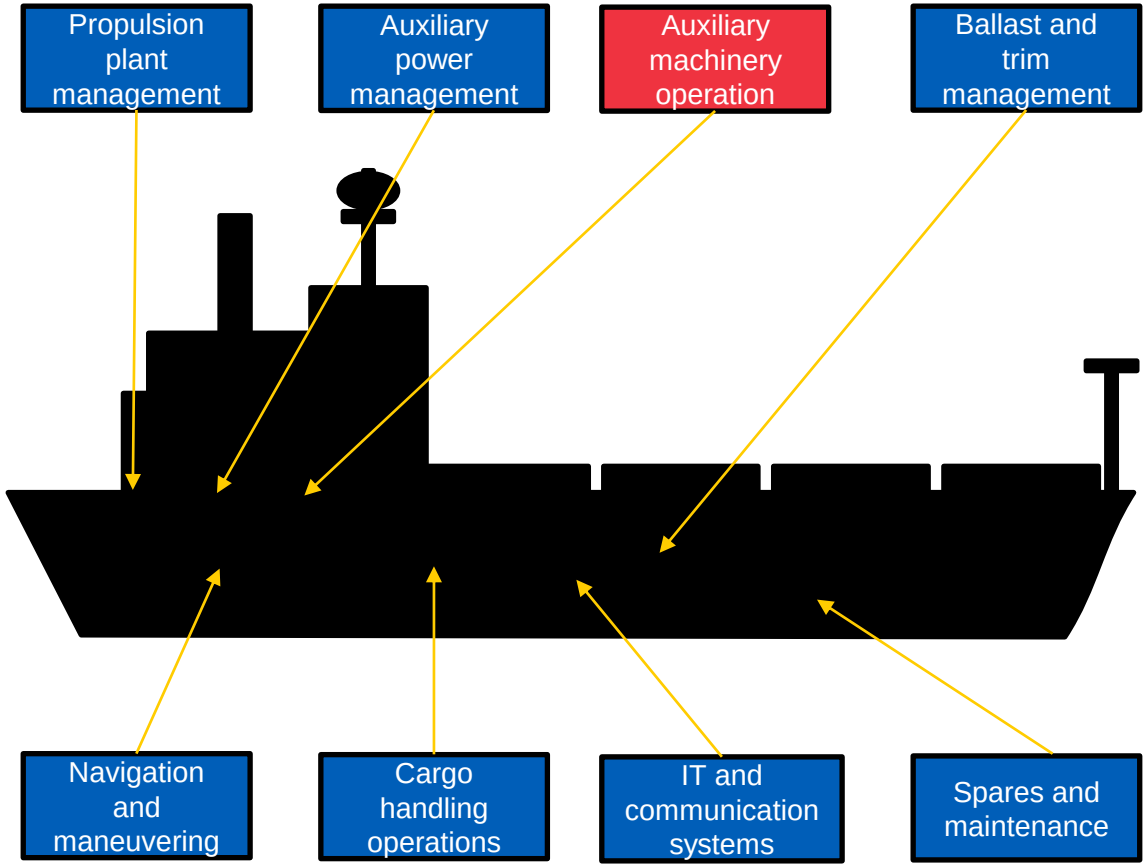


The design of the next generation of digital ships by Martin Stopford 2018

Auxiliary marine machinery (from lecture 6)

Ships are large, complex vehicles which must be **self-sustaining** in their environment for long periods with a high degree of reliability.

Machinery, other than the main propulsion unit, is usually called 'auxiliary' even though **without some auxiliaries the main machinery would not operate for long**.



The design of the next generation of digital ships by Martin Stopford 2018

Fundamental aspects of auxiliary machinery (1)

Marine machinery is designed to ensure the proper functioning of a ship's main engines, piping systems, and equipment.

Auxiliary marine machinery includes pumps, compressors, and blowers for circulating fuel and the fresh water and seawater for supplying air to the starting system of the main engine, for cooling refrigerated holds, and for air-conditioning various parts of the ship and for refrigeration machinery.

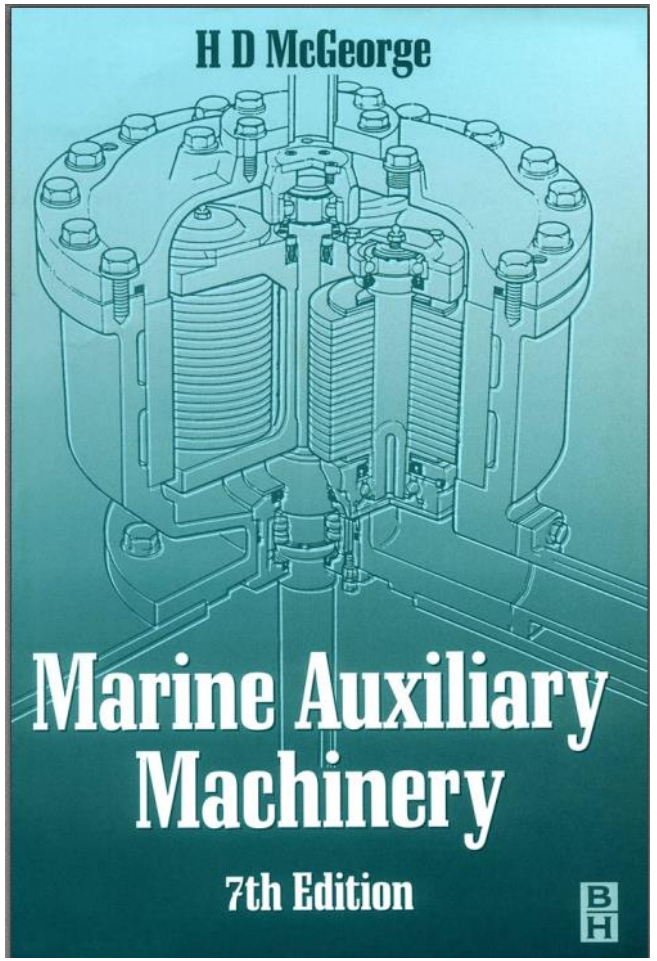
Auxiliary main items

- Air compressors
- Heat exchangers
- Distillation equipment
- Oil/water separators
- Sewage treatment plants
- Incinerators

Fundamental aspects of auxiliary machinery (2)

Auxiliary marine machinery

- Main propulsion services and heat exchangers
- Machinery service systems and equipment
- Valves and pipelines
- Tanker and gas carrier cargo pumps and systems
- The propeller shaft
- Steering gears
- Bow thrusters, stabilizers and stabilizing systems
- Refrigeration
- Heating, ventilation and air conditioning
- **Deck machinery and cargo equipment**
- Fire protection
- Safety equipment
- Control and instrumentation



HD Mc George
7th Edition, 2002

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Deck machinery and cargo handling systems

Purpose

To remain **competitive** in the world of shipping, vessel operators must keep their port time for loading and unloading operations to a **minimum.**

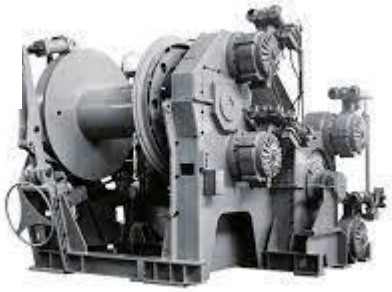
Fast, reliable, and efficient cargo-handling gear, deck machinery, and cargo access equipment are essential to provide a competitive edge by **reducing costly port time.**

These allow an efficient closing of the ship logistic chain and aim.

© Intercargo

Deck Machinery

Any machinery on the decks of a ship; includes anchor windlass/mooring winches, aft anchor winches, chain stoppers, vertical capstans, towing winches, tugger winches and positioning winches.



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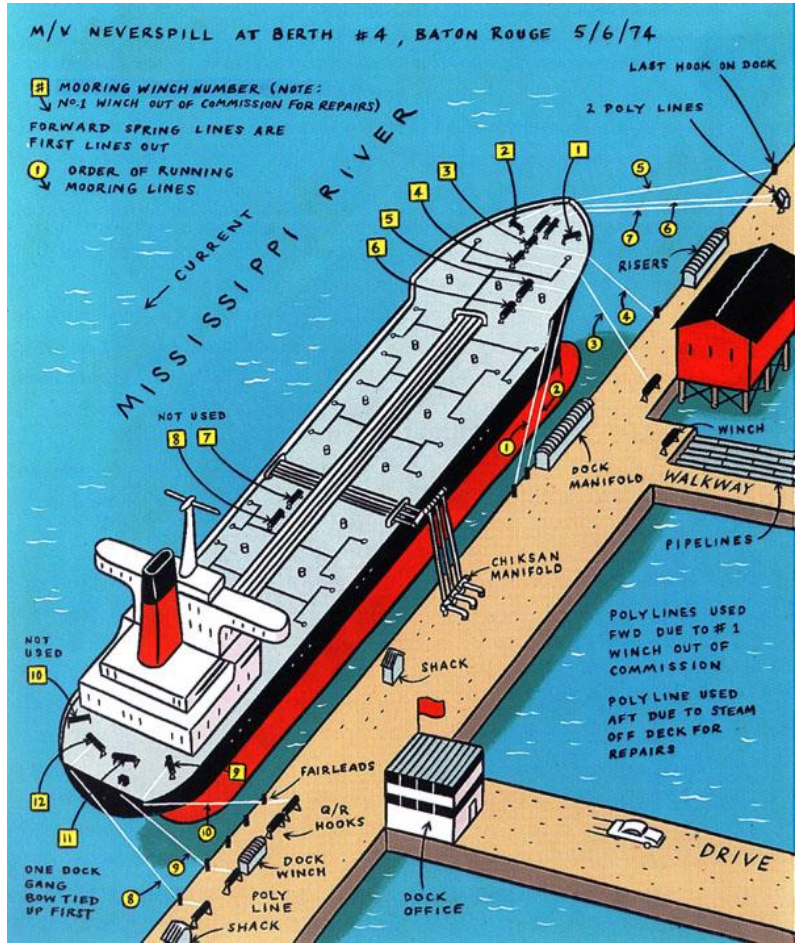
Mooring operations (1)

Mooring is a procedure to anchor the ship to a fixed or floating element and keep it connected during loading or unloading operations. Safe mooring must withstand several forces, such as **wind, the current, the tide and waves**.

The operation of mooring a vessel has traditionally required the attendance of a **large number of deck crew** fore and aft. Supervision of the moorings was also necessary to maintain correct tension through changes due to the tides and the loading or unloading of cargo.



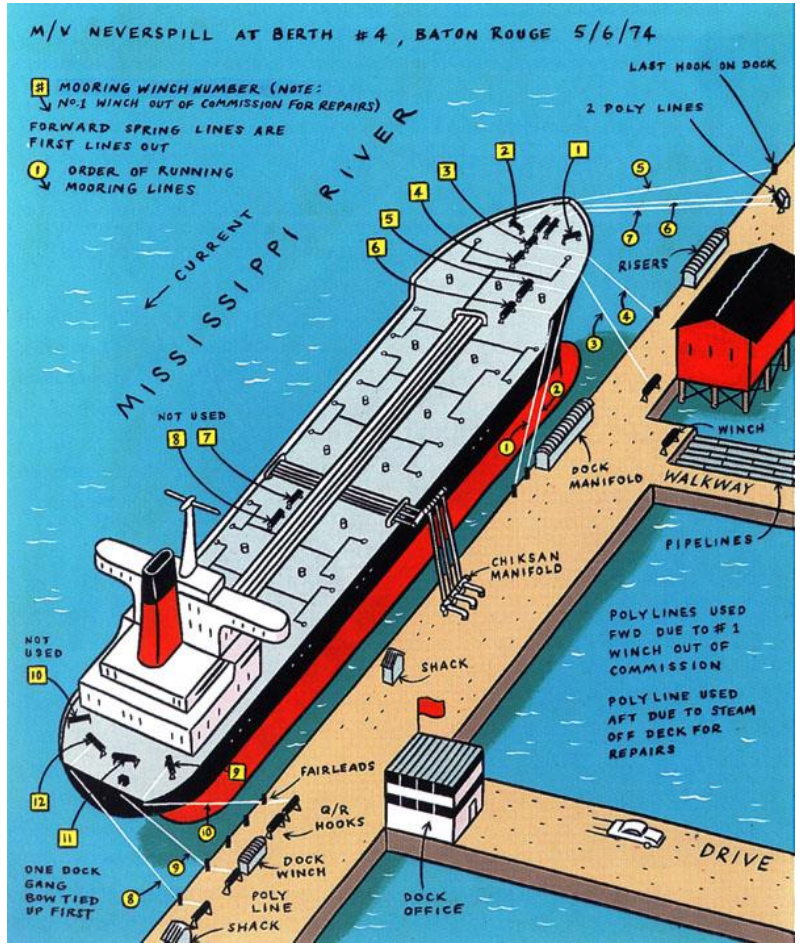
Ship mooring overview

Mooring operations (2)

There are three alternatives: stern-to, bow-to and side-on mooring.

The purpose is to prevent longitudinal movement (surge) of the ship while in berth.

The introduction of steel hatch covers not only speeded up the operation of opening and closing the covers but also reduced the number of personnel required for the task.



Ship mooring overview

Mooring equipment (1)

Mooring winches provide the facility for tensioning the wire up to the stalling capacity of the winch.

Anchor windlasses control the running anchor and cable,

Chain stoppers,

Fairleads, guide a line, rope or cable around an object, out of the way or to stop it

Capstans, the driving machinery is situated below the deck and the cable lifters are mounted horizontally.

Mooring equipment

Mooring equipment (2)

All mooring system's components are determined by vessel type and size, as are other aspects of the project. They are also influenced by regulations applied to each case and by the rules from the classification society chosen by the ship-owner (Villa-Caro et al. 2018).

However, the are not standardized design requirements for the equipment that operates the mooring lines and winches. Ship-owners and loaders add a further dimension as they fulfil their own requirements.

© DNV GL

Mooring equipment (3)

The ISO -TC 8 Technical Committee on Shipbuilding and Marine Structures.

ISO 3730 (2012) “Shipbuilding - Mooring Winches” for designing and testing the mooring winches cites rules related to winch components and other mooring system elements.

Complementary regulations exists such as “Welded Steel bollards and to ropes and cables” (ISO 3913, 1980); “Steel wire ropes” (ISO 2408, 2004); “Fiber ropes” (ISO 1141, 2012)

© BS ISO 3730:2012

Mooring equipment (4)

The demands depend (increase and decrease) on the type of vessels and regulations associate to the ship operations.

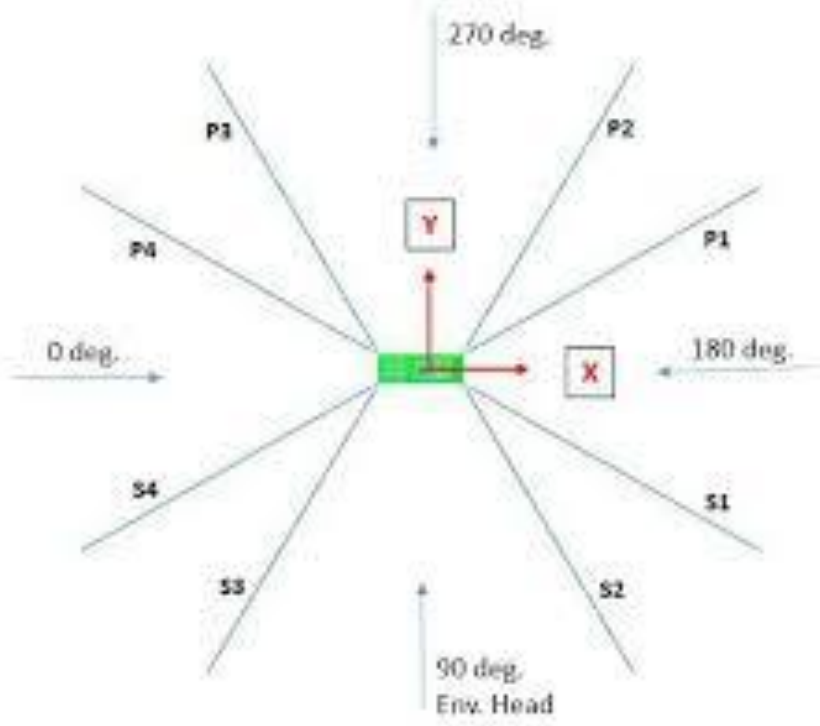
The Oil Companies International Marine Forum (OCIMF), whose has strict demands to ensure and promote marine safety by means of responsible development for tankers and terminals, has established in its “Mooring Equipment Guidelines - MEG3”

How mooring systems are designed/selected

A process mainly responsibility for the ship owner to take into account the **elasticity of the mooring lines** and how the moored ship is subject to the action of the **wind, currents and forces of the waves.**

With this information, the designer can choose and position mooring equipment and fittings on board and along the quay.

Static calculation methods are used on mooring systems.



Konatra 2019

Mooring systems analysis

The efficiency of a mooring system should be assessed in terms of its ability to restrain ship motions.

It is important for motion criteria to be suitably defined by considering port requirements or the reference values for safe working conditions found in similar vessels and port operations.

Aspects to be determined:

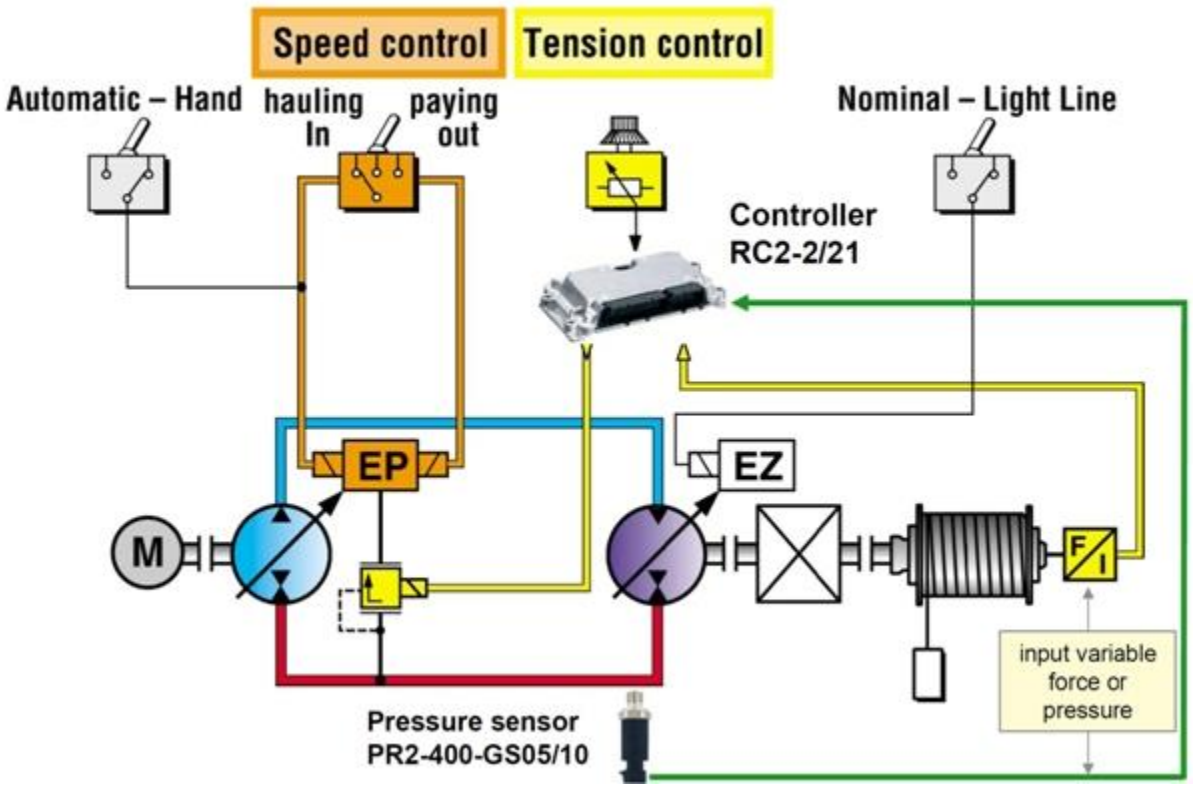
- **Wave conditions** (pressure and acoustic sensors, and numerical models)
- **Interaction of ship with incident waves** (physical and numerical models) see Hirdaris et al. 2014
- **Stiffness, friction and damping** parameters (statistical procedures e.g. FEM)
- **Line/ropes** characteristic analysis**

Winches

Effect on winches system solutions:

Constant tension winches automatically maintain the tension of the mooring line.

Hydraulic power uses pressure to work the winch, a simple way to control the tension on the mooring line.



Hydraulic operated winches

Fenders (complementary for mooring)

Devices used to prevent damage in vessels and/or berth structures with a

dual function:

1. Absorb the impact energy during berthing
2. Reduce vessel motions during unloading operations by acting with a suitable line arrangement.

Influencer parameters:

- Ship size, berthing method, location, tidal range and water depth

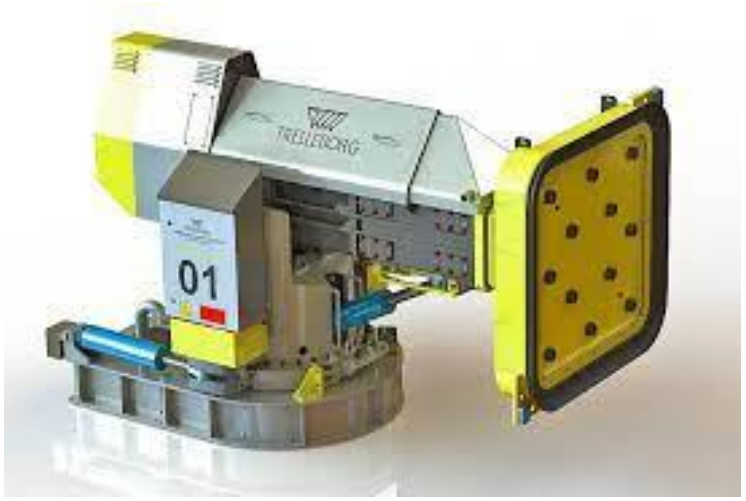
Fenders onboard and on the quay

Novel systems for mooring

Tow main innovative proposals:

1) Vacuum

Uses automated vacuum pads that connect to and release vessels in seconds



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2) Mechanical arm

Connects and hold the ship to a fixed location in the quay

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Group discussion (1)

10-10 mins

Discussion per groups (ship concepts)

- Based on the mission of your concept, identify critical aspects for the mooring of your ship concept?
- In your concept, do you identify any compromising characteristic to support mooring and cargo handling operations?
- What are the general characteristics of the mooring system that you foresee for your concept?

Cargo handling equipment (1)

It refers to equipment used for loading/discharging operations: e.g. cargo cranes, side-loading system with conveyors, side shifters, elevators, belt conveyors, ro-ro cargo handling gear and cargo pumping systems.

Cargo handling equipment varies depending upon the type of cargo.

- **Tankers** are fitted with pumping systems and pumps, with small cranes to handle hoses from shore, and with tank cleaning machines and inert-gas generating systems.
- **Dry-bulk carriers** depend on shoreside facilities for cargo loading and discharge, but some bulk carriers have self-unloading features with conveyors below the cargo holds, or with cranes on deck.
- **Reefer vessels** are designed with refrigerated cargo holds fitted with large cargo-refrigeration systems.

Cargo handling equipment (2)

- Deck cranes
- Cargo winches
- Cargo access and maintenance

Cargo cranes

Shipboard cranes of various types and capacities are still required for multi-purpose cargo vessels, geared bulk carriers, feeders, reefers, heavy lift vessels and some forest product carriers.

The use of cargo cranes is relevant for ship-to-ship cargo handling, and for ship-to-port cargo handling. In port, cargo is loaded by conveyor and spouts, or by crane and grab. Some bulk carriers are geared (usually a crane is located between each hatch) to allow the loading and unloading of cargo at berths without the need for shore equipment.

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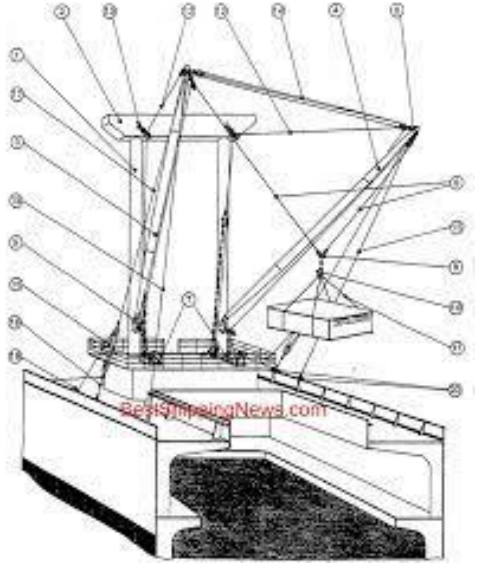
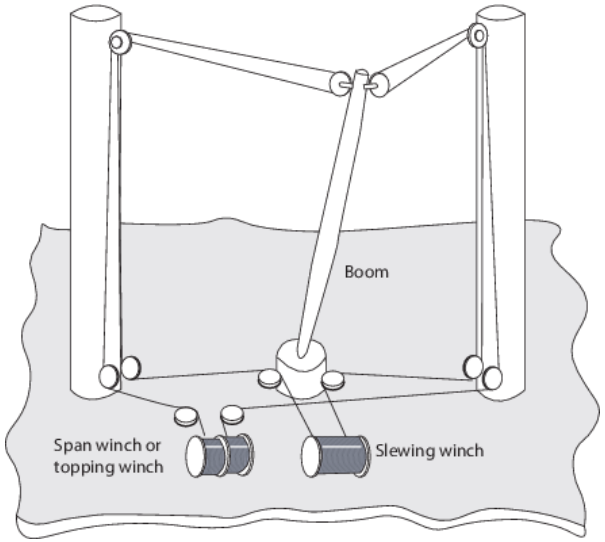
Cargo winches

Cargo winch (lifting winch or heavy duty hoisting winch) is a motor-driven hoisting machine for cargo having a drum around which a chain or rope winds as the load is lifted.



Most older ships have winches in conjunction with **derricks** for working cargo. The derricks may be arranged for fixed outreach working or slewing derricks may be fitted.



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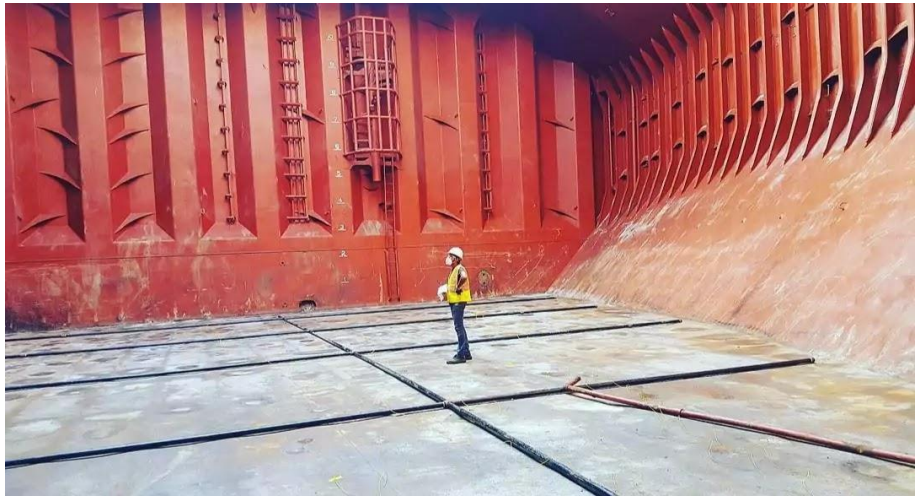
Cargo access and maintenance (1)

Cargo access should be properly planned in design development and ensured during ship operation. This an element that should be also planned together in a maintenance program.



The means of access to cargo vessel should be checked to ensure that it is safe to use. This means are subject to inspections and their conditions and accessibility is constantly evaluated. This includes elements such as tanks, hatch covers, ladders and related equipment to operate cargo handling.

Cargo access and maintenance (2)

In a **bulk carrier**, hold maintenance should be included in the ship's planned maintenance as part of a formal inspection and defect reporting system.

This includes a check-in of:

- Holds framing damaged and tripped brackets
- Hold bulkhead coatings
- Hatch covers, trackways, compression bars, channel drainage, hatch rubbers, cross and side cleats.
- Hatch and hold vents and watertight lids, including access hatch
- Hold ladders, platforms and hand rails
- Bilge wells, including bilge covers, strum boxes, and bilge well valves,
- Lights and light fittings

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Group discussion (1)

10-10 mins

Discussion per groups (ship concepts)

- Based on the mission, identify critical aspects for selecting cargo handling equipment ?
- Can you list cargo handling equipment needed for your concept?
- Has cargo handling equipment a representative impact in the design of your concept? And why?

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Maritime Engineering Collaborative Education Framework - Finland and Latin America

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MARENGEDU-FINLAT

A collaborative education framework

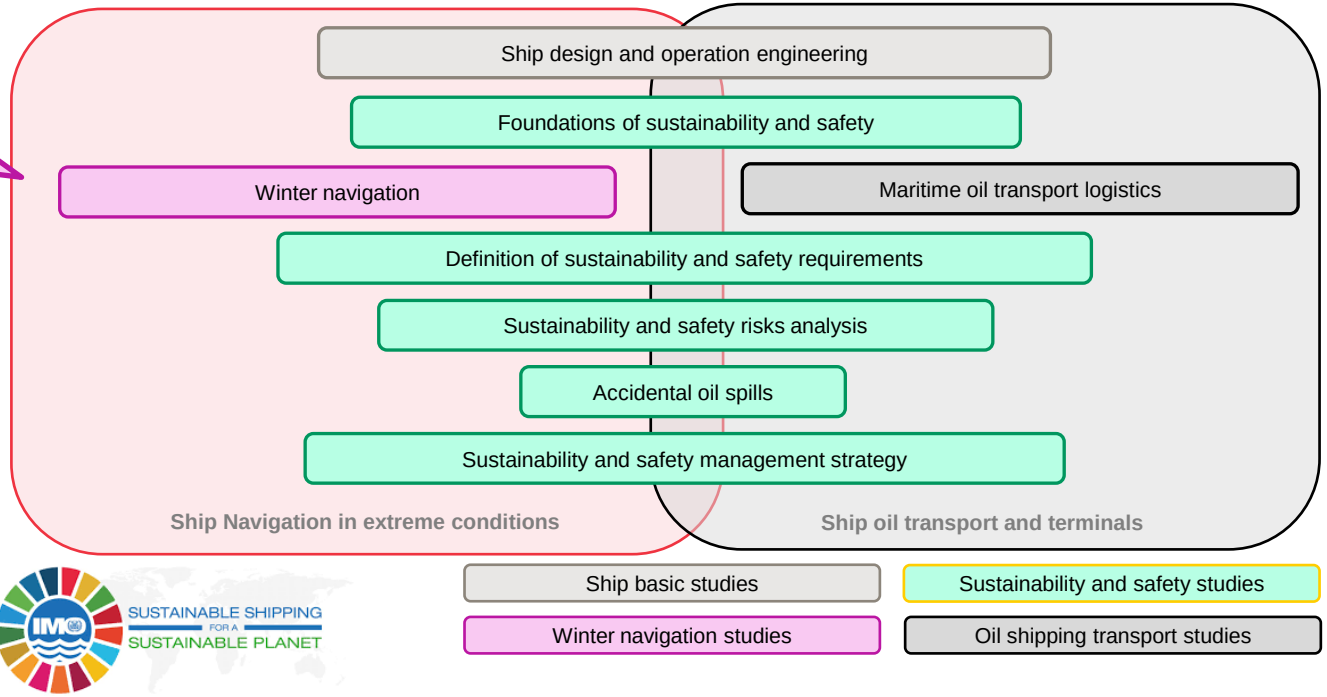
The framework focuses on establishing **collaboration between Finland and Latin America** in studies of **sustainability and safety for ocean engineering with a special focus** the **needs of the maritime clusters in Finland, and Latin America (Mexico and Argentina)**.

The project offers scholarships for exchanges for students interested in learning about sustainability, safety and ocean engineering with a focus on critical domains relevant to Finland and Latin America

Plan for the exchanges

- **Aalto (Fin) to ITBA (Arg)**
  - 1*-2 exchange students (2 semesters)
- **ITBA (Arg) to Aalto (Fin)**
  - 2*- 3 exchange students (3 semesters)
- **ITCM (Mex) to Aalto (Fin)**
  - 1*-2 exchange students (2 semesters)
- **UCOL to Aalto (Fin)**
  - 1*-2 exchange students (3 semesters)

Main subjects covered in relation to sustainability and safety in maritime engineering and the focus on two application domains (winter navigation and oil maritime transport



SUSTAINABLE SHIPPING FOR A SUSTAINABLE PLANET

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Thank you