

Module 3:

From Management to Operation



IMO Train the Trainer Course

Name of the Presenter

**Affiliation of the presenter,
City, Country**

Energy Efficient Ship Operation

**Venue, City, Country
Day xx to Day yy, Month, Year**

Content

- Overview of ship management and operations
- Shipping legal frameworks and energy efficiency
- Fleet optimisation and slow steaming
- Ship loading and ship capacity utilisation
- Just-in-time operation and Virtual Arrival
- E-navigation developments and weather routing

Shipping Management and Operations Overview

Shipping company organisation

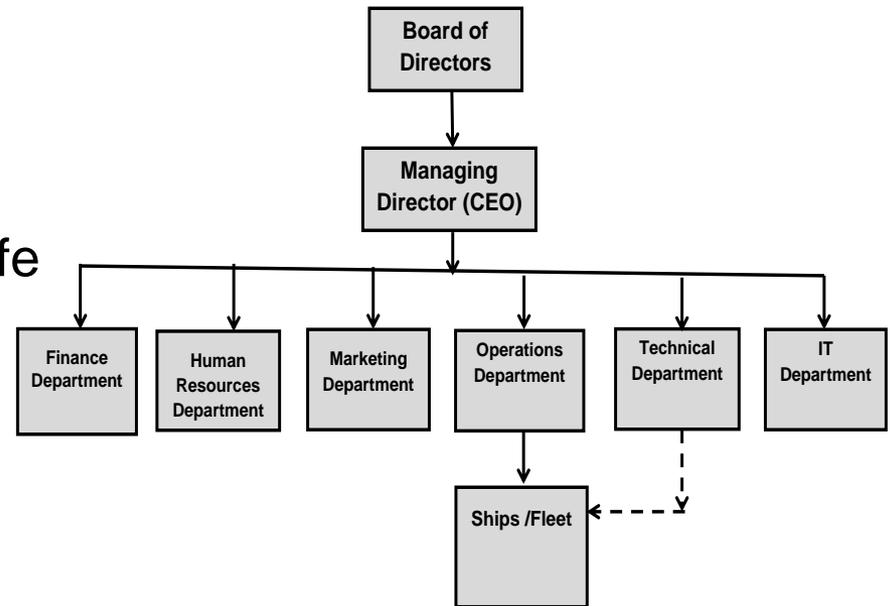
➤ A shipping company have a number of departments; two are important to our subject.

➤ **Operations department (fleet management): Main role**

- Maximise the economic and safe deployment of the ships (planning, scheduling, etc.)
- Coordination with other departments, ships, charterers, ports, agents, etc.

➤ **Technical Department: Main role**

- To keep the ships in a seaworthy conditions.
- Ships' maintenance and repairs
- New building projects, etc.



Characteristics of shipping companies

- Not all shipping companies are the same from:
 - Business aspects
 - Ship types and cargo carried,
 - The way they are managed, etc.
- **Business characteristics:** Liner, tramp, industrial, owner, operator, manager, etc.
- **Fleet characteristics:** Ship types and sizes.
- **Cargo characteristics:** Liquids, bulk material, containers, packaged, etc.
- Ports they use and their impacts on ships

Shipping segments

- Shipping segments by geography of operation:
 - Deep-sea shipping
 - Short-sea shipping
 - Coastal shipping
 - Inland waterways.

- Shipping segments by operation
 - **Liner operations:** Liners operate according to a published itinerary and schedule similar to a bus line.
 - **Tramp operations:** Tramp ships follow the available cargoes similar to a removal van.
 - **Industrial operations:** Usually own the cargoes and control the vessels used. They operate within a wider company business framework, thus differ from other two segments.

Ship/fleet planning

- Planning takes place at a number of levels.
- **Business planning:**
 - Longer term planning / decisions
 - What shipping segment? Which area of operation? What type of cargos? Partnership with other players? etc.
 - Choice of ship types and sizes
- **Commercial planning:**
 - Medium-term planning / decisions
 - Focus is primarily on optimal routing, scheduling, operations, etc.
- **Routine (operational) planning:**
 - Deals with a variable operational/commercial environment.
 - Decisions have only short-term impact
 - This could happen in part of the tramp shipping segment.

Speed selection and cruising speed

- Choice of ship speed is a crucial commercial and operational decision
- Ships normally are not operated above design speed and also have a minimum speed to ensure safety.
- The term fleet deployment refers on how best a fleet could be used.
- Selection of speed is part of the deployment aspects.
- Speed selection is normally a main issue for liner and industrial operators.
- It impacts their level of service, number of ships deployed, etc. with consequences on the profitability of the business.

Other important operational aspects

➤ **Regulatory compliance:**

- Fleet must comply with regulatory requirements.

➤ **Maintenance management:**

- Scheduled maintenance in a port or a shipyard
- Surveys by classification society in a shipyard.
- Unplanned maintenance
- Shrinking size of crews and how to deal with maintenance

➤ **Fuel procurement:**

- A significant cost of the ship operation
- Depending on who pays for fuel, a variety of activities takes place for procurement of fuel with correct quality, quantity and price levels.

Other important operational aspects

- Ship port visits and operations
 - A major operation of the ship.
 - Significant level of coordination needed with ports.
 - Choice of ports are part of business or commercial planning but port calls coordination is part of routine planning.

The role of the management in reducing GHG emissions

- Shipping company management have the biggest impact and responsibility for reducing GHG within the fleet



Fuel saving a win-win scenario for ship operation economy and the environment

- Reducing ship generated GHG can be a win-win situation for all involved.
- It can reduce operational costs as well as protecting the environment.



Incentives for operators to save fuel

- The incentives for reducing GHG will include reduced fuel costs, maintenance costs and down-time in port.
- There is an issue referred to as “**split incentives**” that impacts efforts for GHG reduction.
- This will be discussed later.



Shipping Contracts and Energy Efficiency

Questions on shipping contracts and their impact on GHG emission

Main questions:

- What are the main types and features of shipping contracts?
- How contract-type may influence ship owner / operators incentive to reduce GHG emission?
- How contract-type may influence shipmaster behavior in managing the ship?

Are these true or false?

- The current shipping commercial framework has not been developed to facilitate GHG reduction policies; but to facilitate trade and establish fair contractual relationship between partners.
- Ship and fleet management is constraint by the above shipping framework

The main types of shipping legal frameworks and contracts of carriage

- Common Law
- Hague Visby Rules
- Bill of Lading
- Charter party
- Reasonable Dispatch
- Deviations
- Jurisdiction



- Under common law, there are four basic obligations on the carrier:
1. The carrier must deliver the goods in the same condition as when they are shipped. Four exceptions;
 - Act of god
 - Act of Queens/Kings enemies
 - Loss or damage resulting from inherent vice of the goods.
 - Loss resulting from jettison (through away cargo for ship safety)
 2. The carrier has an absolute duty to provide a seaworthy ship.
 3. The carrier undertakes to proceed on a voyage without unjustifiable “deviation”. If so, the carrier is liable for losses.
 4. The carrier must complete the voyage with “reasonable dispatch”. If there is undue delay, the carrier is liable.

Common law

- The term “reasonable dispatch” defines the normal obligations of a carrier to transport shipments.
- The term is found in most of standard bills of lading. The term generally means obligation to “sail without unreasonable delay”.
- This is the area that could have impact on efforts for saving energy or reducing GHG emissions as will be discussed later.



Hague-Visby Rules

- With contracts under common law:
 - The carrier may limit or exclude its liability
 - The buyer/shipper may end up with no right to dictate other terms.

- To remedy this, the Hague Rules as amended by the Hague-Visby Rules were agreed internationally.

- These rules preserve the four common law obligations in a less strict form and protects the buyer / shipper by ensuring carriers' liability.



Hague-Visby rules

- The **Hague–Visby Rules** are for the international carriage of goods by sea.
- They are an updated version of the original **Hague Rules**.
- The premise of the Hague–Visby Rules is that, to protect the interests of the shipper, the law should impose some minimum obligations upon the carrier.

- Under the Rules, the carrier's main duties are to:
 - "properly and carefully load, handle, stow, carry, keep, care for, and discharge the goods carried"; and to
 - "exercise due diligence to ... make the ship seaworthy"; and to
 - "... properly man, equip and supply the ship".

Bill of Lading

- The bill of lading is a legal document that governs the relationship between the shipper and the carrier
- There are a number of bill of lading types; for example:
 - “Endorsed order bills of lading” can be traded as a security or serve as collateral against debt obligations.
- Therefore a bill of lading is:
 - A standard form document.
 - Could be transferable by endorsement.
 - Is a receipt from the shipping company.
- The bill of lading therefore may perform 3 functions:
 - Evidence that the goods has been received by the carrier.
 - Evidence of the actual contract of carriage.
 - Document of title to the goods.

Contracts of carriage or charter parties – topics

Topics to discuss

- Voyage Charters
- Arrived Ship
- Demurrage
- Time Charters
- Speed and fuel warranties
- Demise Charters
- Contracts of Affreightment



Charter party

- “Charter party” or “charter”: Is a contract by which the ship owner lets the ship to another person.
- The content will include legal and commercial aspects plus additional conditions on how the ship will be used or operated.
- Thus a charter-party governs the relationship between the ship-owner and the charterer.
- Charter party normally deals with the hiring of full ship while a “contract of affreightment” deals with carriage of goods forming only part of the cargo and coming under a bill of lading.
- Charter parties are highly standardized and are grouped into three main types
 1. Voyage charter
 2. Time charter
 3. Demise or bare boat charter

Voyage charter

- A voyage charter is a contract of carriage for one or more voyages.
- The ship remains under the control of the owner including manning, maintenance and navigation.
- Fuel cost is normally paid by the owner (could be other ways).
- Cargo carried may also have a bill of lading; thus may be covered by the Hague-Visby Rules.
- The contract will normally have a 'due dispatch' clause.
- There are also a number of days 'lay days' agreed in the contract for the loading and discharge of the cargo.
- For the commencement of lay-time three things are required;
 - The vessel must be fit to load or unload.
 - She must be an 'arrived ship'.
 - The 'notice of readiness' to load or discharge must be given to the charterer.

Voyage charter

- Under a typical voyage charter-party the ship operator decides on cruising speed so as to arrive at the port at the due date.
- For a ship to be an 'arrived ship' the master must tend his/her "notice of readiness".
- When arrived and once 'lay days' are used up, from then the ship owner is entitled to 'demurrage'.
- Based on the above arrangement, the incentive is for the ship owner to sail the ship fast to be sure the become an "arrived ship" early so that the lay days start to count.
- The frequent outcome of this process is that ships will steam at unnecessary high speed to arrive as early as possible.
- This often results in the ship sitting at anchor or alongside for long periods.
- This process works against energy efficiency.

Time charter

- The ship is manned and navigated by the owner but her capacity is let to the charterer for a specified time.
- Charterer has:
 - No ownership responsibility.
 - No ship management responsibility.
 - No ship maintenance responsibility.
- It is normal that the charterer pays for the fuel and port costs but the ship owner must take care of the other operating costs.
- Time charters will normally have a speed and fuel warranty clause stating the speed and fuel consumption of a ship.
- Under time charter, the charter can exercise control on the way ship is used or operated.

Demise charter

- This is a charter party in which the charterer takes control of a ship as if it is his own ship.
- It is sometimes known as a 'bare-boat' charter party.
- In such a charter-party, the master and the crew are like the charterers employees.
- The demise charterer is for all practical purposes the temporary owner of the ship.
- The “demise charter” arrangement is another good example of the ‘split incentive’ as the owner will not be willing to invest for energy efficiency.
- However, in such cases the charterer will have more control, thus will have more incentive to achieve operational energy efficiency or press the owner to invest.

Charter party and split incentives

- The charter party in any form (time, voyage or demise) is a good example of the '*split incentive*' problem.
- The owner:
 - Due to the contractual requirements, will tend to over steam during the voyage.
 - Normally does not pay for fuel, thus will have no incentives to save fuel.
- The charterer:
 - Pays for the fuel but has no investment control on ship; so no incentives to invest in somebody's else ship.
 - Has no significant operational speed controls especially for voyage charter due to nature of contracts.
- The above act as a major barrier for energy efficiency activities.

Contract of affreightment

- In this type of contract, a ship-owner agrees to move a specified quantity of cargo over a specified period of time from one port to another without designating a particular ship.
- The ship owner pays for the voyage costs and the vessel.
- Contracts of affreightment are often set for a period of few or several years.
- Such contracts are often used in the bulk cargo trades.
- The contracts of affreightment could include aspects of time or voyage charter party terms depending on type of arrangement between carrier and the shipper.
- Depending on the contract, these types of contract may lead to split incentives.

Impact of shipping contracts of carriage and possible conflicts of interest

- When the charter party and bill of lading are different
- Jurisdiction



Shipping contract and energy efficiency

- To save energy, it is well known that reducing **ship speed** is very effective.

- As indicated under charter party, current shipping contracts leads to:
 - Split incentive.
 - Provides incentives for fast steaming
 - Act as barrier to upgrading ship technologies
 - Act as a barrier to improving ship operations

- A case example of slow steaming and related legal issues follows.

Legal case example: Slow steaming

- Slow steaming is very effective in reducing a ship's fuel consumption
- Its practice may be problematic within the current shipping legal / contractual framework, in particular for certain ship types and trades
- Legal issues:
 - Any “unreasonable delay” could lead to a legal case against carrier.
 - The general rule is that the ship owner bears the risk of any delays unless covered by an “exception clause”.
 - If the carrier intentionally proceeds by slow steaming, he may be committing a “deviation”.
 - By law, this “deviation” is not allowed for fuel saving.
 - It is, therefore, important for a ship owner and a charterer to incorporate suitable clauses to the charter party.

Slow steaming case examples

- Under a time charter, the charterers may give the owners instructions to slow steam.
- The main legal issues relate to slow steaming in this case are:
 - The ship owners' obligations to ensuring the safety of the vessel, crew and cargo.
 - The ship owner obligations towards third parties, such as bill of lading holders.
- There have been some efforts by industry to deal with all these legal issues.

BIMCO Clause

- BIMCO has been developing relevant clauses for the charter party.
- In the past, a time charter clause and a voyage charter clause for slow steaming were published by BIMCO.
- These are suitable for the liner, tanker and dry bulk trades.
- The legal status of the BIMCO clause and its practical use within existing charter parties is not yet clear.



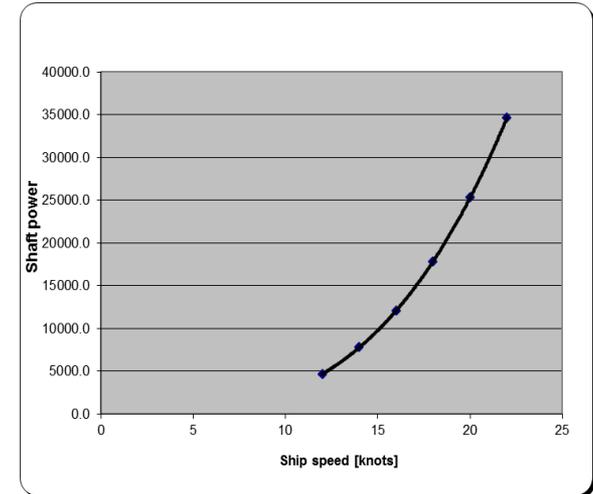
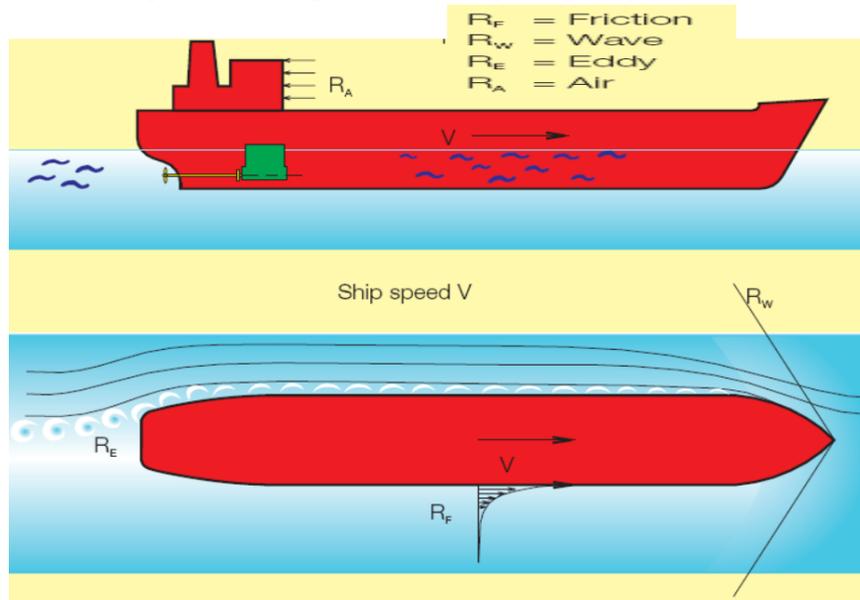
Fleet Optimisation and Slow Steaming

Ship speed terms commonly used

- **Design speed:** Technically speaking, a ship is designed for a specific operating speed (design speed).
- **Slow steaming:** This term refers to running a ship at a significantly lower speed than its design speed.
- **Ship economic speed:** It generally means a speed at which the ship transport as a whole yields the best financial results under the given constraints of engine power, sea conditions, port and waterways dues, and other commercial / financial requirements of the charterer.
- **Service speed:** The origin of this term is to do with relationship between charterer and ship owner and refers to the average speed maintained by a ship under normal load and weather conditions.
- **Maximum speed:** This term defines the maximum speed of a ship that the ship-owner claims the ship practically can achieve.

Power and speed relationship

- Resistance \propto (ship speed)²
- Propulsion power = Resistance * (ship speed)
- Propulsion power \propto (ship speed)³



Typical ship speed-power curve

Wave resistance R_W : $R_W = C_W \cdot \frac{\rho_S}{2} \cdot V_S^2 \cdot S_S(N)$;

(Still) Air resistance R_{AA} : $R_{AA} = C_{AA} \cdot \frac{\rho_S}{2} \cdot V_S^2 \cdot S_S(N)$;

Friction resistance R_F : $R_F = C_F \cdot \frac{\rho_S}{2} \cdot V_S^2 \cdot S_S(N)$; and

Eddy-making resistance : $(C_r - C_R - C_{AA} - C_F) \cdot \frac{\rho_S}{2} \cdot V_S^2 \cdot S_S(N)$;

where :

S_S = wetted surface area of the hull(m²)

V_S = ship speed (m/s), Note: 1 knot = 0.5144444 m/s

ρ_S = mass density of seawater, $\rho_S = 1,025.0 \text{ kg/m}^3$

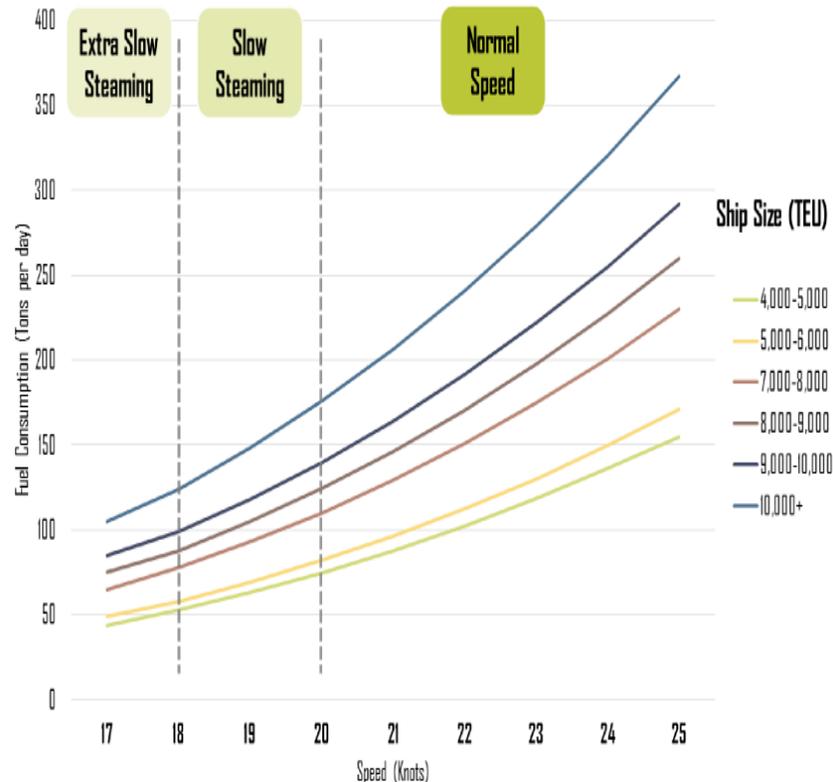
Ship fuel consumption versus speed

- *Propulsive power \propto (Ship speed)³*
- *Fuel consumption \propto (Ship speed)³*
- *Distance travelled \propto Ship speed*
- ***Fuel consumption per nautical mile \propto (Ship speed)²***

Impact of speed on fuel consumption

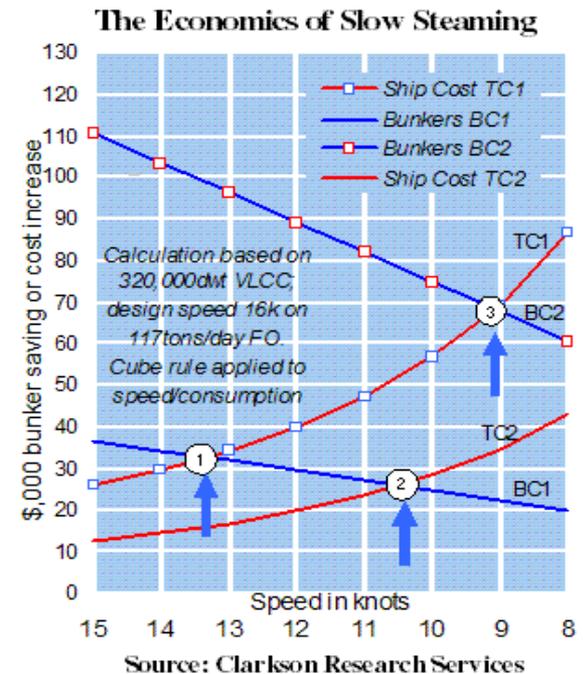
Different levels of slow steaming

Impact of ship size on fuel consumption



Economics of slow steaming

- What is the optimal speed for slow steaming?
- Answer should be based on overall ship costs versus speed.
- The diagram by Clarkson is for a VLCC.
- Slow steaming is highly effective in reducing a ship's fuel cost; more so at high fuel prices (compare blue BC2 to BC1 trends).
- At higher fuel prices, more aggressive slow steaming is beneficial (compare points 1 & 3).
- For low charter rates, and at a fixed fuel price, more aggressive slow steaming is beneficial (compare points 1 and 2).
- When fuel prices are high and charter rates are low, more aggressive slow steaming will be beneficial.



In the calculations, the need for deployment of more ships are included.

Slow steaming advantages and disadvantages

Slow steaming benefits

- **Charterer**
 - Lower fuel consumption
 - Lower bunkering frequency

- **Technical operator**
 - Lower average engine load
 - Lower yearly cylinder oil consumption

- **Ship's crew**
 - Lower bunkering frequency
 - Longer time between ports

- **Environment**
 - Lower NO_x per voyage
 - Lower CO₂ per voyage
 - Lower SO_x per voyage

Slow steaming disadvantages

- **Charterer**
 - Longer voyage time and higher charter fees per voyage.
 - Need for additional ship to deliver the same amount of cargo

- **Technical operator**
 - Higher machinery working hours
 - Tendency for faster ship's hull fouling.
 - Higher maintenance costs due to engine operation at low loads.

- **Ship's crew**
 - More maintenance work linked to engine low load operation
 - Longer periods away from ports.

- **Environment**
 - Likely to have higher CO
 - Likely to have higher PM

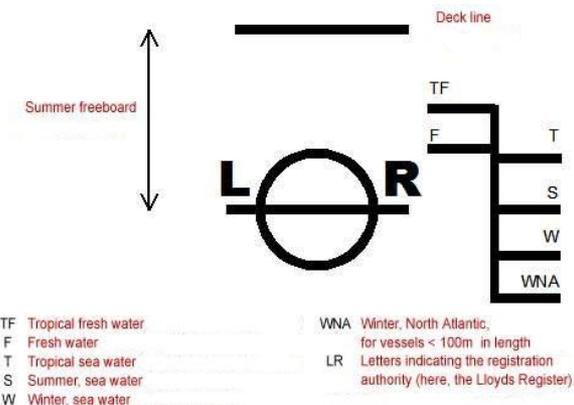
Ship owner technical considerations

- Main engine operational limits (minimum load for safe engine operation).
- Economiser performance and reliability (economiser fouling, not enough steam production)
- Turbocharger operation, performance and maintenance (fouling, lack of energy for turbo operation, possible need for operation of auxiliary air blowers, ...)
- Propeller performance (not optimal condition).
- Hull paint type and fouling rate (increase in fouling, impact on performance of hull coating, ...)

Ship Loading and Capacity Utilisation

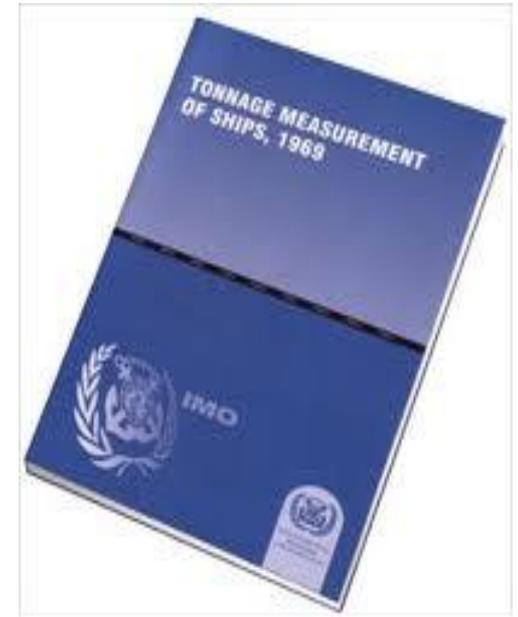
International load line convention

- The International Load Line regulations require that every ship is issued with a **Load-Line certificate** every 5 years.
- The certificate is subject to annual and intermediate surveys.
- The Load Line is placed mid-way between the forward and after perpendiculars.
- It gives the draft of the ship that is the legal limit to which a ship may be loaded.
- A ship may have multiple load lines.
- This will result in the ship carrying less cargo when using lower draft load lines.
- Depending on load line chosen, amount of cargo carried and port dues will vary.



International load line convention

- The IMO 1969 International Tonnage Convention is used to measure the gross tonnage of ships.
- The gross tonnage is normally used to calculate, amongst other things, the amount of port dues that a ship has to pay.
- The cost of port dues can be very significant over the ship's lifetime.
- If a ship is operating on the following condition, then it may use lower certified GT to reduce its port dues:
 - Visit to ports with a draught restriction
 - Lack of transport demand
 - Where the cargo has a high volumetric value



Ship loading: Importance of ship capacity utilization

- **Ship Load (capacity) Factor:** Actual cargo load divided by design deadweight (for bulk cargo).
- The above definition will be based on cargo TEU for containership or meter-lane for ro-ro ships.
- Ship must operate with a high load factor to be energy efficient.
- High load factor means lower fuel consumption per unit of cargo.
- Ships may operate without utilizing their full cargo loading capacity because of:
 - Poor design
 - Lack of transport demand
 - Loading aspects and other operational aspects.

Ship loading: Proper cargo weight and cargo arrangement on-board

- The importance of accurate weight declaration and cargo arrangement on-board
 - Route and ballast plan
 - Container packing
 - Accurate weight of the container
 - Pre calculation of optimum trim and ballast
 - Distribution of cargo on board

Ship stowage factor

- **‘Stowage Factor’ for bulk cargo:** If a cargo is light for its volume, then the holds may be full but the ship may not be down to its load line marks.
- The “stowage factor” indicates how many cubic metres of space is needed for one metric tonnes of cargo.
- In other words, stowage factor is the volume to weight ratio of a cargo.
- This is very important factor when loading bulk cargos.
- In such a case, the ship’s master and chief officer calculations are important for full utilization of ship capacity if the cargo is light.

Technology upgrades and ship capacity

- In case of ship technology upgrade, the following questions need to be clarified are:
 - Will this additional equipment alter the ship gross tonnage?
 - Will this additional equipment alter the ship's lightweight?
- If the equipment increases the gross tonnage, there will be a financial penalty over the whole of the life time of the ship with port dues.
- If the lightweight increases, this increase in lightweight will equally reduce the ship deadweight capacity.
- This is not good for ship energy efficiency.
- In summary, new equipment must not increase ship lightweight or gross tonnage significantly.

Ship loading aspects

- The distribution of cargo onboard and the amount of ballast needed to maintain adequate stability, particularly with ships that carry a large amount of deck cargo is critical.
- Also information on the ship's optimum trim and optimum amount of ballast onboard for a particular voyage is needed.
- Trim adjustment is impacted by ship loading practices.
- Ballast aspects: Ballast water is needed for stability, trim, or to keep the propeller and rudder submerged. Optimization of the amount is important for energy efficiency.

In summary, ship capacity utilisation and loading of the vessel with due consideration for energy efficiency provides good opportunities for energy saving.

Just In Time and Virtual Arrival

Just in Time and Virtual Arrival - Definitions

- Just in Time (JIT): Concept and practice originate from manufacturing industry. In that industry, it is used as the main method to **reduce the inventory** levels and associated costs.
- In case of shipping, JIT normally refers to process for reducing the **waiting and idle periods of ship operations**.
- JIT applies to both ship's **passage and port** operations.
- For **voyage optimisation**, all aspects of planning, execution, monitoring and review of a voyage are included in this concept.
- **Virtual Arrival** is a new operational concept that aims to remove barriers to JIT operation and reduce port-level delays.

Just in Time and Virtual Arrival – Why ship's waiting / inactivity?

- The commercial ships' movement is influenced by many factors (below bullets).
- The requirements of “**cargo owner**” (mainly charterers) on when and where the cargo should be loaded and discharged.
- The **slotting issue in ports** in terms of berth availability or cargo space availability. Early arrival and competing for early loading/discharge is common industry practice.
- **Regulatory issues** that may lead to prevention of entry to certain ports or detention for some periods of time. The lost time is later on normally recovered via over-speeding.
- **Technical failures** that leads to loss of ship availability.
- **Lack of business (cargo)**, resulting in short or long idle times.

Just in Time and Virtual Arrival – Main players?

- The improvement to ship itinerary requires efforts by all parties involved.
- Charterer (operation department): The charterer is ultimately responsible for decision making on ship itinerary and overall steaming speed. Orders issued by the charterer to ship are normally the basis for ship movement.
- Ship master: The master, based on orders received, will operate the ship and will ensure that the designated dates and times are achieved, within the terms of the charter party.
- Port authorities: They would influence the plans drawn by both charterer and master through planning of the port operation.
- It is the interaction between the above parties that leads to the actual (achieved) ship itinerary.

Just in Time and Virtual Arrival – Best practice for improvements

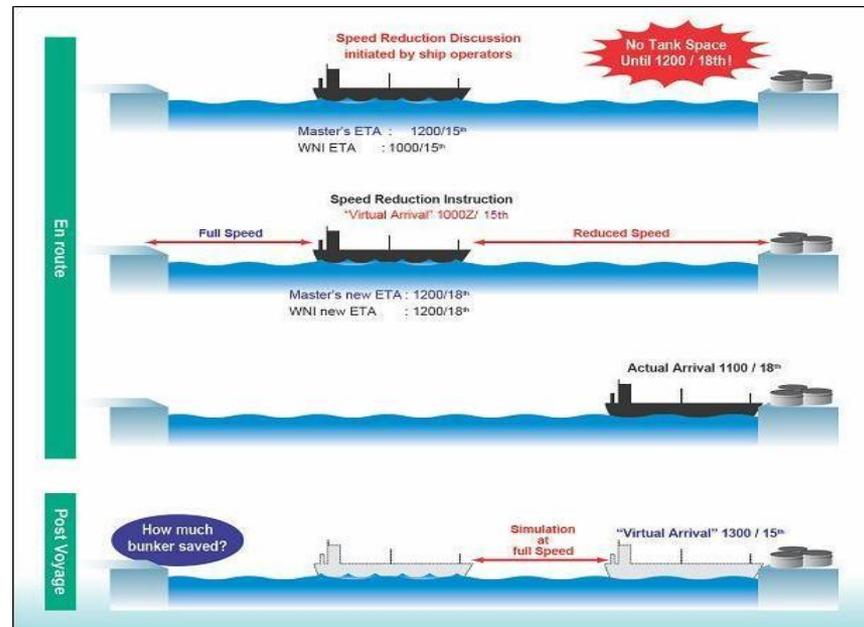


- Avoid **waiting periods** in all phases of a voyage or modes of operation.
- Aim for early **communications** with the next port in order to give maximum notice of berth availability and facilitate the use of optimum speed.
- Encourage good **communications** between fleet department, master and charterer.
- Improve cargo handling operation and avoid **delays at berth** to the extent possible.
- Operate at constant shaft RPM while en-route.
- When leaving ports or estuaries, increase the shaft rpm gradually in harmony with increases in ship speed.
- Avoid going fast in **shallow waters**. Reduce speed in shallow waters, if possible.

- **Charter party constrains:** These include clauses on various aspects of ship operation that practically restricts efforts for energy efficiency.
- **Weather constraints:** The weather impact is well known. To limit this impact, weather information and weather routing can be used.
- **Route constraint:** The route of the vessel may involve channel crossing, passing through pirate areas and also need for operations such as bunkering.
- **Port constraints:** Various ports impose various constraints on vessels. One major aspect is the competition between various ships to arrive at port of destination in order to beat the queue.
- **Other ship/owner/charterer specific constraints:** These are specific constraints that may apply by various parties involved in ship operation.

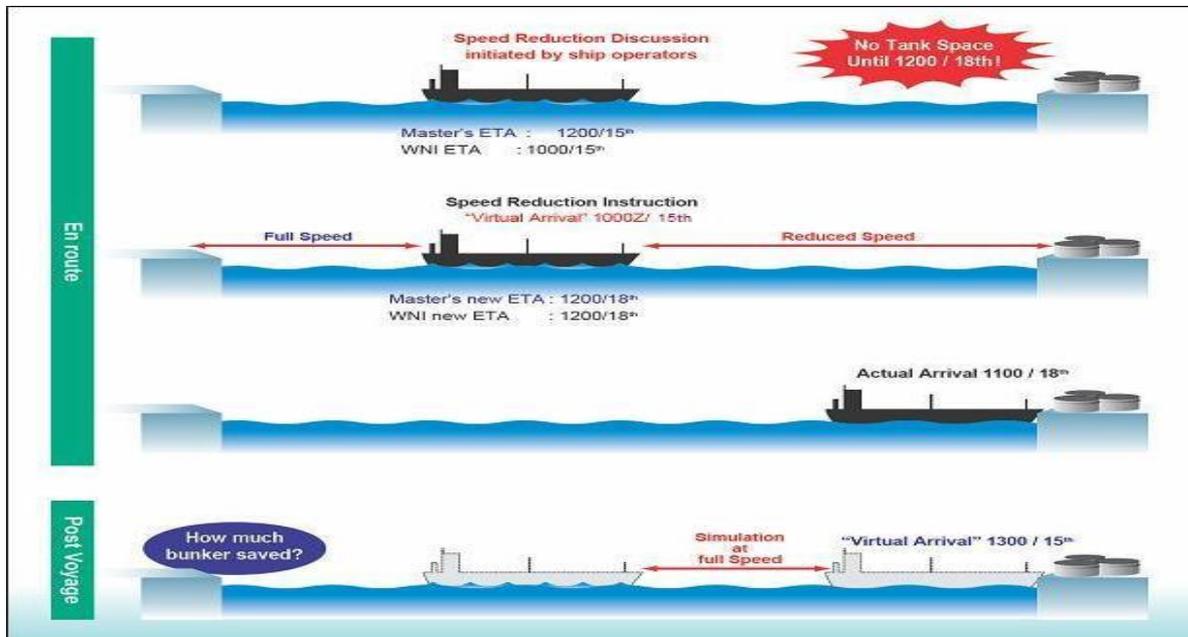
Just in Time and Virtual Arrival – Why Virtual Arrival?

- Virtual arrival aims to reduce waiting times and achieve longer passage time and thereby reduced ship's voyage average speed.
- A significant level of energy saving is expected with virtual arrival.
- This could also reduce the port-area emissions significantly.



Just in Time and Virtual Arrival – VA Processes

- **Identification of change in itinerary:** Mainly with port of destination.
- **Agreement to new itinerary:** The next step is for all parties to agree on change of itinerary. This will give the new “Required Time of Arrival” at the destination port.
- **Speed adjustment:** As a result of the newly agreed Required Time of Arrival (or itinerary), the ship’s speed or the engine RPM is reduced.



Just in Time and Virtual Arrival – Need for Agreement on VA

- To facilitate the VA, there is a need for new contractual arrangements either as part of the current charter party or a new one (VA Agreement).
- As part of the VA Agreement, charterer and owner/operator will be able to change the Required Time of Arrival or ship itinerary.
- They can also agree on the methodology for calculating voyage data and the associated reporting requirements.
- At the end of the trip or based on terms of VA Agreement, the voyage estimates, financial and contractual aspects will be settled.
- To reduce post-voyage disputes, agreement should be in place for:
 - The method of calculation of the vessel's voyage performance
 - The speed and other data to be used,
 - The reports to be issued and by whom and the report's timing.

Just in Time and Virtual Arrival – Other benefits

- Fuel saving is the main purpose. Other benefits listed below.
- **Pollutants reductions:** In proportion to fuel consumption reduction.
- **Releasing ship for other activities:** For example additional time can be used for planned maintenance activities, statutory surveys, crew changes or vessel storing.
- **The improved planning of in-port activities:** Operations can be planned well in advance and uncertainties associated with waiting time and periods at anchor are reduced.
- **Port benefits:** Virtual arrival, by virtue of reducing waiting in port area, has many benefits to ports including less port congestion, less emissions, reduced noise and enhanced safety.

Just in Time and Virtual Arrival – Tools for support of VA

- **Weather routing:** Weather routing service providers can play a verifier role for route related coordination and calculations.
- **Voyage performance analyser:** There are systems that can routinely measure ship speed, shaft propulsion power and environmental conditions. These systems could be used for monitoring voyage performance.
- **ECDIS (Electronic Chart Display and Information System):** The electronic chart and information system could be used by means of integrated information for voyage management purposes.
- **System communications:** Integration of port and ship management systems for communications for port slotting.

E-Navigation and Weather Routing

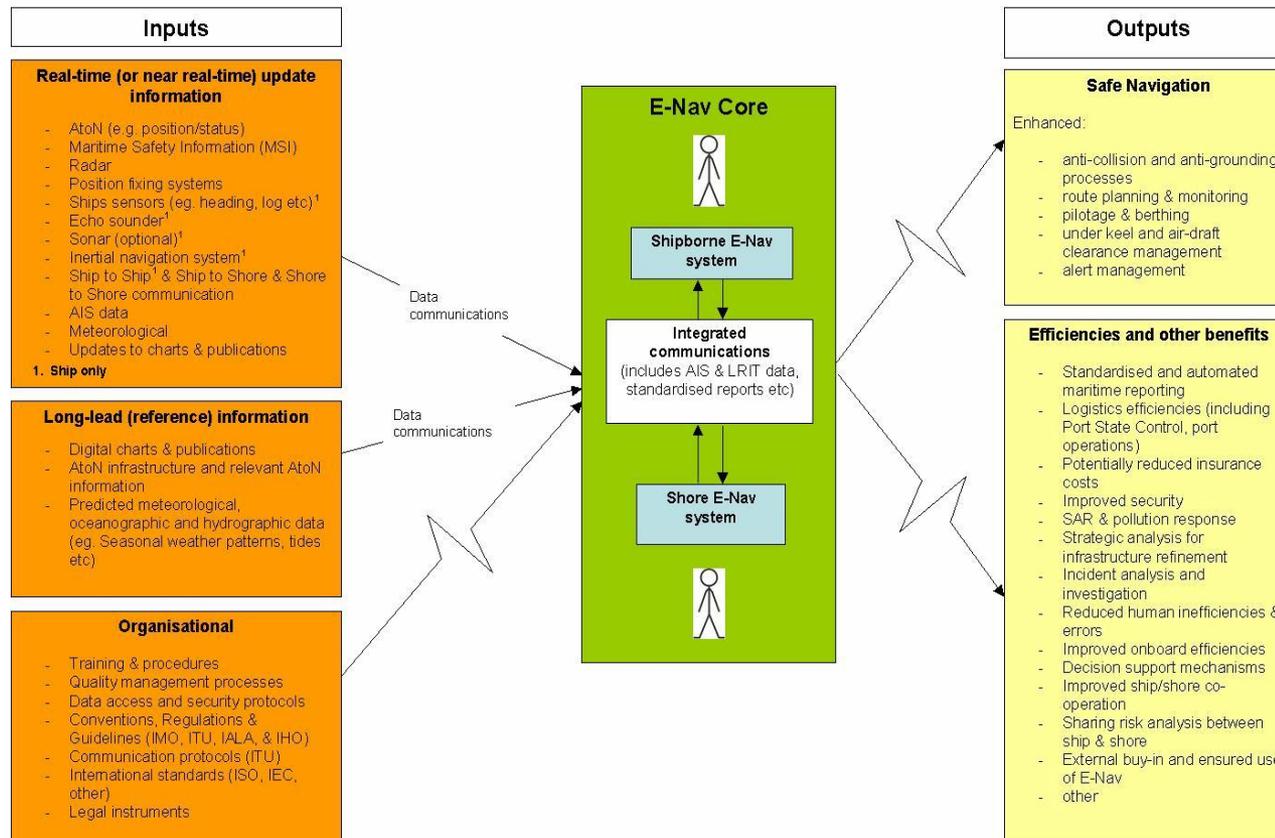
- IMO MSC (Marine Safety Committee) has set a strategy on five solutions to provide a basis for supporting e-navigation:
 - S1: Improved, harmonization and user friendly bridge design;
 - S2: Means for standardized and automatic reporting;
 - S3: Improved reliability, resilience and integrity of bridge equipment and navigational information;
 - S4: Integration and presentation of available information in graphical displays received via communication equipment; and
 - S5: Improved communication of VTS service portfolio.
- The solutions S2, S4 and S5 are designed to improve communication between ship and shore for safety purposes.
- These initiatives will have implications for ship energy efficiency through **better routing** and **reducing delays**.

- IALA (International Association of Marine Aids) defines the e-navigation as:
 - “The harmonised collection, integration, exchange, presentation and analysis of maritime information ... by electronic means to enhance berth to berth navigation for safety and security at sea and protection of the marine environment”.
- The implementation of e-navigation involves the development of onboard navigation systems that integrate all relevant ships sensors and supporting information.
- ECDIS is the main item of the broader e-navigation initiative that has evolved as a result of IMO activities.
- The IMO considers the implementation of e-navigation in the world’s fleet as a long term objective rather than a short term fix.

E-Navigation model

- The IMO and IALA have provided the following e-navigation model to describe the overall concepts and outline the basic elements of the system.

A Descriptive Model for E-Navigation

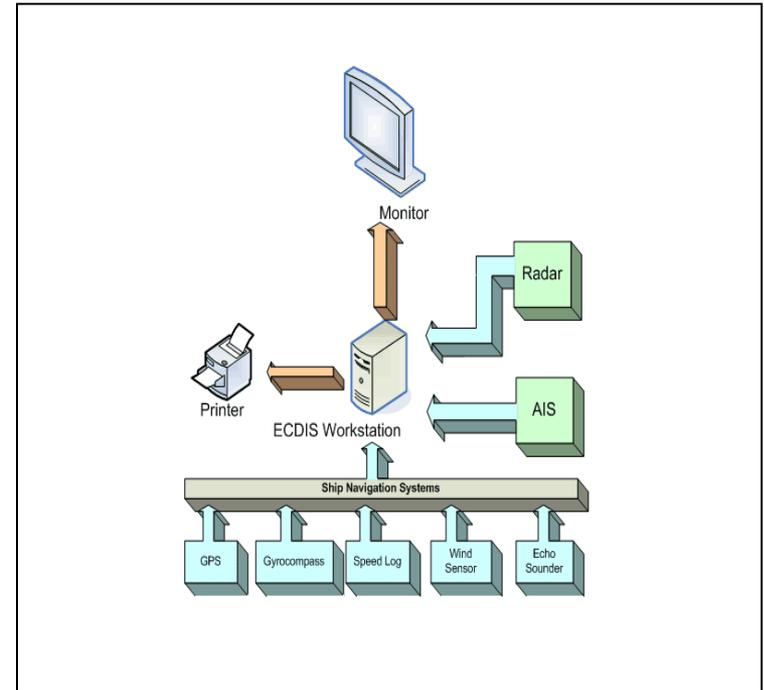


E-Navigation related tools

- Voyage performance analysis: This system measures ship speed, shaft propulsion power and external environmental situation and help with voyage management.
- ECDIS (Electronic Chart Display and Information System): The electronic chart and information system has the potential for improving navigational practices.
- Autopilot precision and effectiveness: A more adaptive autopilots that can provide better automatic steering actions to prevailing weather conditions and sea state.
- Maneuvering assistance tools: With the introduction of modern information and communication technologies, more and more assistance tools have been introduced additionally to standard mandatory navigational bridge equipment.
- Integrated navigational systems: This can achieve fuel savings by keeping cross track error to a minimum while in passage. This technology has been brought about by extremely accurate GPS position information.
- Computerized maneuvering assistance tools: This takes into account the prevailing environmental conditions such as wind and current, ship condition, current course, speed, draught and the trim of the vessel.
- As can be seen, e-navigation provides significant new opportunities for optimizing navigation actions in favour of safety and environmental protection.

ECDIS purpose

- The core functionality of ECDIS is the move to electronic charts.
- The ECDIS uses the approved electronic charts and reproduces an image on a display system.
- Through e-navigation, ECDIS could support additional features if need be for example:
 - Passage planning with dynamic real time monitoring
 - On-line monitoring of ships' routes.
 - Built-in decision support system to assist both the masters and officer.
 - Berth-to-berth management options, etc.



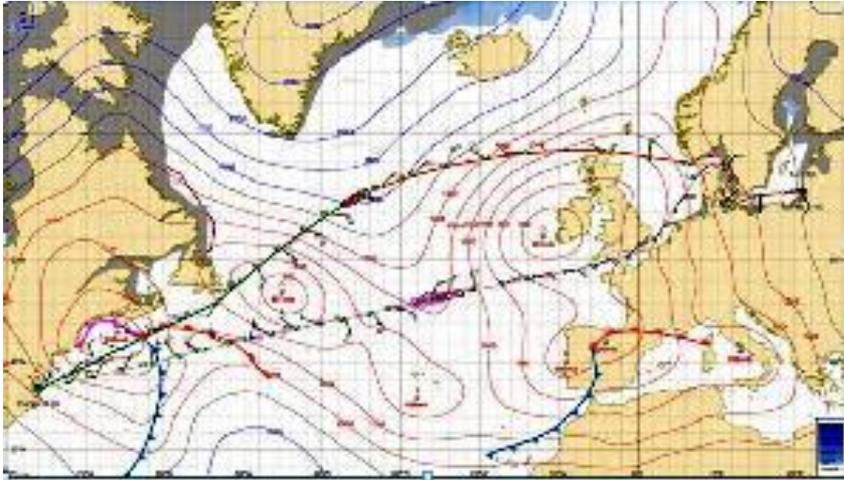
Concept of ECDIS and its integration with other system [Fredrik Larsson]

ECDIS and GHG emissions??

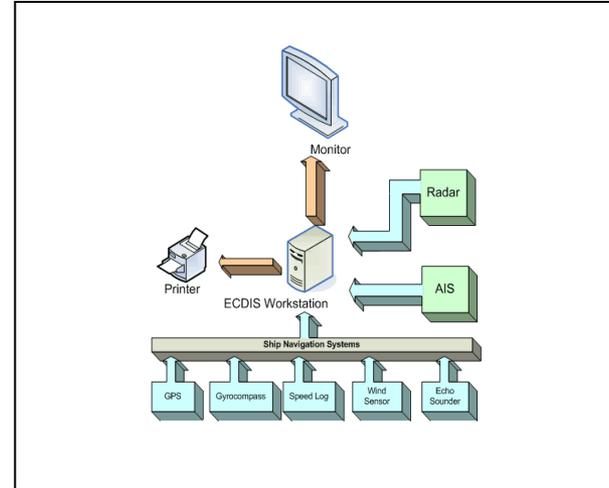
- The ECDIS main advantage over the traditional paper plot method of getting from A to B is that:
 - It is capable of accurately plotting and monitoring the **ships position in real time**.
- An ECDIS has the ability to be linked to an advanced automatic pilotage system.
- This combined system can improve the vessels ability to keep on track and alter course to minimize the **distance travelled**.
- An ECDIS can give a more **accurate and quick method of calculating estimated time of arrivals (ETAs)**. This information can help with better voyage management.
- This tool can also be used when slow streaming or for weather routing.
- In summary, the ECDIS within an e-navigation framework can improve **route planning and execution** and **reduce delays**, thus impact fuel consumption.

Weather Routing and other Tools in Support of E- navigation for Energy Efficiency

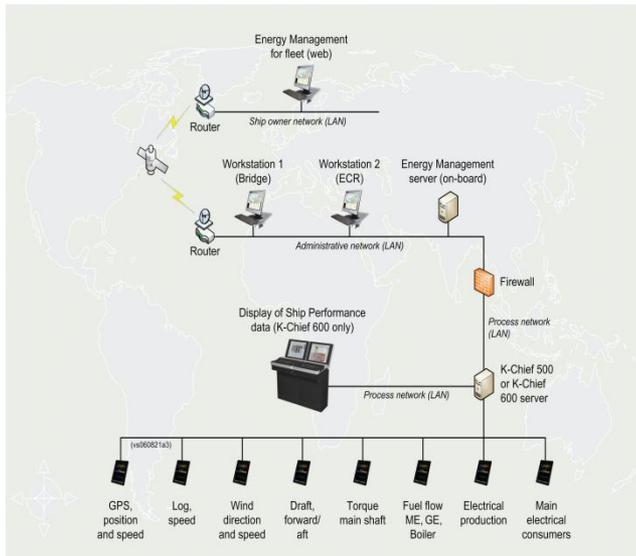
Tools to support energy efficient ship operations at sea



Weather routing: http://www.enav-international.com/issues/articles/id1252-Strategic_Weather_Routing.html



ECDIS [Fredrik Larsson]



Ship and voyage analyser

[[http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/AB963D5AB36A752DC1257AF5004150D4/\\$file/376812.pdf?OpenElement](http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/AB963D5AB36A752DC1257AF5004150D4/$file/376812.pdf?OpenElement)]



Advanced autopilot system

<http://www.nauticexpo.com/prod/navitron/product-25387-331404.html>

Impact of weather on ship performance

- The following table shows the fuel consumption increase (%) for different water depths D and speeds x .

X	D	Increase (%)
10	8	5
10	10	3
10	100	0
17	8	20
17	15	10
17	100	0
20	8	30
20	15	20
20	100	0

- The following table describes a typical and approximate relation between increased wind strength, direction, and increased fuel consumption for each unit of Beaufort.

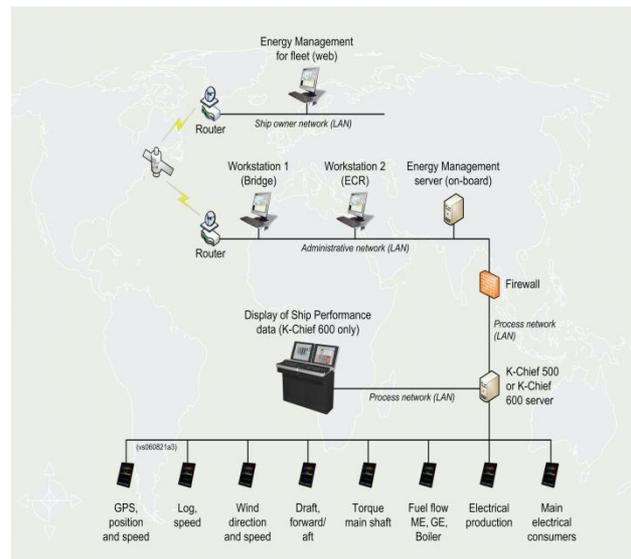
w_d	Type	Increase (%)
315-360, 0-45	Head wind	4
45-135, 225-315	Side wind	2
135-225	Tail wind	1

Weather Routing

- The fuel consumption for a ship not only depends on speed, but also on water depth and weather conditions.
- The optimal speed distribution along the route can be calculated in advance, if a weather forecast is available.
- Weather routing develops an optimum track for ocean voyages based on weather forecasts, sea conditions, and a ship's individual features for a particular transit.
- Within specified weather limits and sea conditions, weather routing aims to maximize safety and crew comfort, minimize time underway and minimize fuel consumption.
- To provide the above, “[weather routing service providers](#)” are now supporting ship operations.

Ship and voyage performance analysers

- Ship and voyage performance analyzer:
 - There are systems that can routinely measure ship speed, shaft propulsion power and environmental conditions. These systems could be used for monitoring various aspects of ship and voyage performance.
 - They could also help to identify reasons for poor performance, deviations in speed and so on.



Ship and voyage analyser

[[http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/AB963D5AB36A752DC1257AF50041E9D4/\\$file/376812.pdf?OpenElement](http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/AB963D5AB36A752DC1257AF50041E9D4/$file/376812.pdf?OpenElement)]

Advance autopilots

- Autopilot – new generation
 - The new generation of Autopilots is under development or already available on the market.
 - Sophisticated autopilot systems provide technical facilities to also adapt the steering actions to prevailing weather conditions and especially the sea states, even automatically.
 - Those systems are providing dedicated functions such as 'precision' and 'economy' modes:
 - An Autopilot operating in Economy mode reduces rudder movements and consequently contributes to fuel savings.
 - On the other hand, using Autopilot in the Precision mode allows for the best accuracy and ensures safe navigation.

Summary learning points

- As a result of this module, the following was fully reviewed with specific reference to shipping energy efficiency:
 - Ship management and operations
 - Shipping legal frameworks and energy efficiency
 - Fleet optimisation and slow steaming
 - Ship loading and ship capacity utilisation
 - Just-in-time operation and Virtual Arrival
 - E-navigation developments and weather routing
- All the above areas provide big opportunities for reduction of ship operations fuel consumption and GHG emissions

Thank you for your attention

For more information please see:
www.imo.org