MariEMS Learning Material

This is the 18th compilation by Professor Dr Reza Ziarati on the work of the EU funded Erasmus + MariEMS' partners and material extracted from the IMO TTT Course. The material is composed from Chapter 18 of the learning material.

18. Ship Time in Port and Just In Time Operation

18.1 Introduction

International shipping is the most energy efficient mode of cargo transport in world trade but unfortunately is also a major producer of NOx, SOx and CO_2 emissions. The existing measures being EEDI (Energy Efficiency Design Index) for new ships and SEEMP (Ship Energy Efficiency Management Plan) for all ships. With the current debates on further measures and fuel consumption measurement and reporting, new regulations in this area are forthcoming.

When it comes to ports, there have been limited studies on port operation / management and its contribution to ship energy efficiency. The main reason for this may be the lack of IMO's regulatory authorities on ports because the IMO's main focus is on ships and international shipping rather than ports that are mainly regarded as national entities. Despite this lack of regulatory focus, marine ports are important for shipping energy efficiency and in particular they play a major role in delivering an energy efficient ship operation. Thus, their roles and responsibilities and what they could do need to be understood.

As discussed before, there are few effective ways of reducing a ship's fuel consumption. Two main examples are:

- Operating the ship at a reduced speed during passage via Just-in-Time operation. It was shown earlier that speed reduction can bring about significant energy savings.
- Trim optimisation and ballast water management can contribute to significant energy savings.

Port operation has impacts on both of the above cases. For example, when it comes to the energy efficient ship operations, reduced ship speed at sea is closely related to the minimisation of a ship's time in port. A ship's time in port will be referred to here as ship's "port time". Reduction in port time through the high quality port operations allows shipping lines to improve the operational efficiency via reduced ship speed and thus fuel consumption. This calls for examination of all aspects of port operation in order to find practical ways to cut down on ship port time.

One possible way is to make a ship to operate Just-in-Time that involves getting rid of the waiting times in port. This will not only help shipping lines to get the maximum notice of berth availability, but also facilitate the use of optimum ship speed at sea. Further, reduction of berth time by improved cargo handling could be another way to reduce ship time in port. Few studies, however, have been done to identify the relationship between ship time in port and efficient ship operation at sea.

The main goal of this section is to investigate the operational issues on how time in port affects the efficient ship operation in terms of operating costs, GHG emissions and other externalities and methodologies for reducing not only the ship-in-port time but also improve other aspects of ship handling that could reduce a ship's fuel consumption.

18.2 Activities in Port Operations

As shown in Figure 18.2.1, activities in port operations are largely divided into 2 parts: ship related activities and cargo related ones. In the case of import cargoes, the latter consists of activities that are cargo handling in the apron area, transfer to storage, yard storage and gate processing. This diagram is representative of a container ship terminal; however, similar diagrams could be constructed for other ship types to define the activities in port operations.

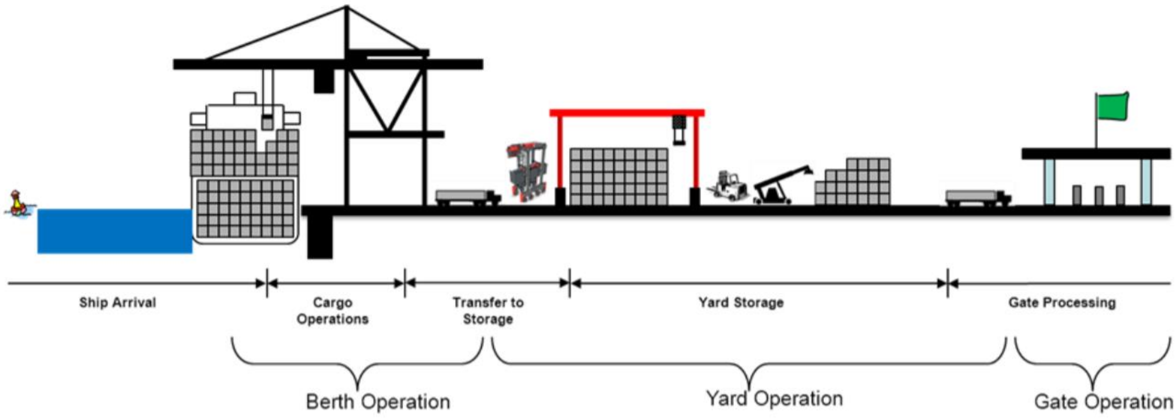

Figure 18.2.1 - Schematic diagram of a container terminal operations

When a ship arrives at the entrance buoy of a port, the pilot comes aboard the ship to help the master in manoeuvres to the designated place. If no berth is available on arrival, the ship is assigned an anchorage area. If the berth is available, the ship is berthed with the help of tug(s), depending on ship size and port's rules and regulations. At this point, line handling services are provided at the berth. In particular, the time when a first line is connected to the pier (or dock) is very important since it is the starting point of the so-called 'berthing time'. The berthing time stops when the last line from the ship let's go of the bollard as it leaves the berth.

When berthed, the Custom, Immigration and Quarantine (CIQ) authorities may board the ship. Usually cargo handling is not made until the authorities have completed their inspections, with the exception of the container shipping business.

In dedicated container terminals, container boxes are unloaded and loaded usually using a gantry crane at the apron where containers are moved to or from storage by In-terminal Movement Vehicles (IMV). Once the container cargoes are unloaded, they are transferred to an assigned slot; this is a space in the yard where storage operations occur. The containers are stored until they are inspected and claimed by the consignee (importers). The containers, then, are moved from the yard onto trucks (or railcars) for their final destinations through the gate operation.

Gate processing includes weighing the container, reviewing paperwork, and conducting a security check. All the above are shown in Figure 18.2.1.

18.3 Impact of Ship's Port Time on Efficient Ship Operation

18.3.1 Ship's (voyage) time:

Time at sea and time in port Tough competition in the last couple of decades has caused container shipping, in particular, to be able to achieve profit only through economies of scale. This has led to larger ships and ever shorter cargo handling times and demurrage. Today, new potential for economisation can only be achieved by reducing operating and fuel costs. Two ways out of this predicament are either to use "slow steaming", meaning a ship's speed is reduced to save fuel, or to deploy even bigger ships, allowing the higher fuel costs to be spread over the additional tonnage. However, increasingly strict environmental requirements in harbours and enroute limit the engine size and thus the size of the ships. When it comes to the operation of container shipping lines, the timetables of the routes are normally fixed. If the ships are delayed in port at some points, they are forced to make up for the lost time by increasing their speeds at sea. As illustrated in Figure 18.3.1, a ship's (voyage) time is composed of 'time at sea' and 'time in port'.

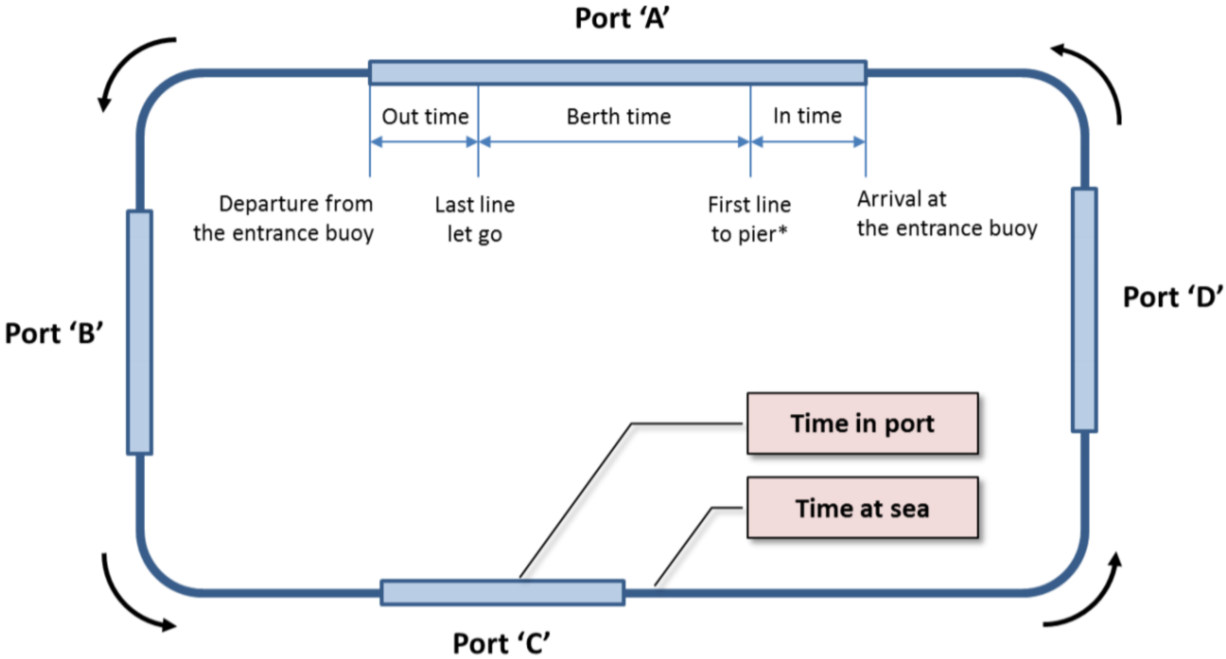

Figure 2.2 - Composition of ship's voyage time in container shipping line

18.3.2 Time in port

Ports are essentially providers of service activities, in particular for vessels, cargo and inland transport. The degree of satisfaction that is obtained on the basis of pre-set standards will indicate the level of port performance achieved. It is obvious that port performance levels will be different depending on the ships, cargoes or inland transport vehicles that are used or served. Port performance cannot be assessed on the basis of a single value or measure. In fact, a meaningful evaluation of a port's performance will require sets of measures; one of which will be the ships' time in port.

Figure 18.3.2 shows the times at which each step of ship's port operation starts and stops as documented in the port, allowing for the calculation of a variety of parameters (or indicators) that the shipping industry uses to calculate performance.

The ship's time in port of a given vessel on a given call is an important concern in an efficient ship operation for shipping lines. The shorter it is, the better it is economically. Port time (or a ship's time in port or ship turnaround time) is the time duration between a ship's arrival at the entrance buoy and ship's departure from the same buoy (see Figure 18.3.2). It can be categorised as the following times:

- **Waiting Time:** The period the ship waits for berth availability.
- **Manoeuvring Time:** periods of manoeuvring in port either to reach anchorage or to reach berth or too leave the port.
- **Berthing Time:** Actual time at birth. Berthing time normally consists of two parts: productive time and idle times (preparation time and arrangement time). The preparation time is the time before starting cargo handling after the ship is berthed, while the arrangement time is the time after finishing cargo handling until the ship is un-berthed. To increase the productivity at the berth, these non-production times must be minimised. Further, to make

productive time more efficient, there should be no stoppage time that is related to breakdown, maintenance, etc.

- **Productive Time:** Actual time from start of cargo handling operation to end of cargo handling operation.
- **Idle Time:** Times in berth where there is no cargo handling operations.

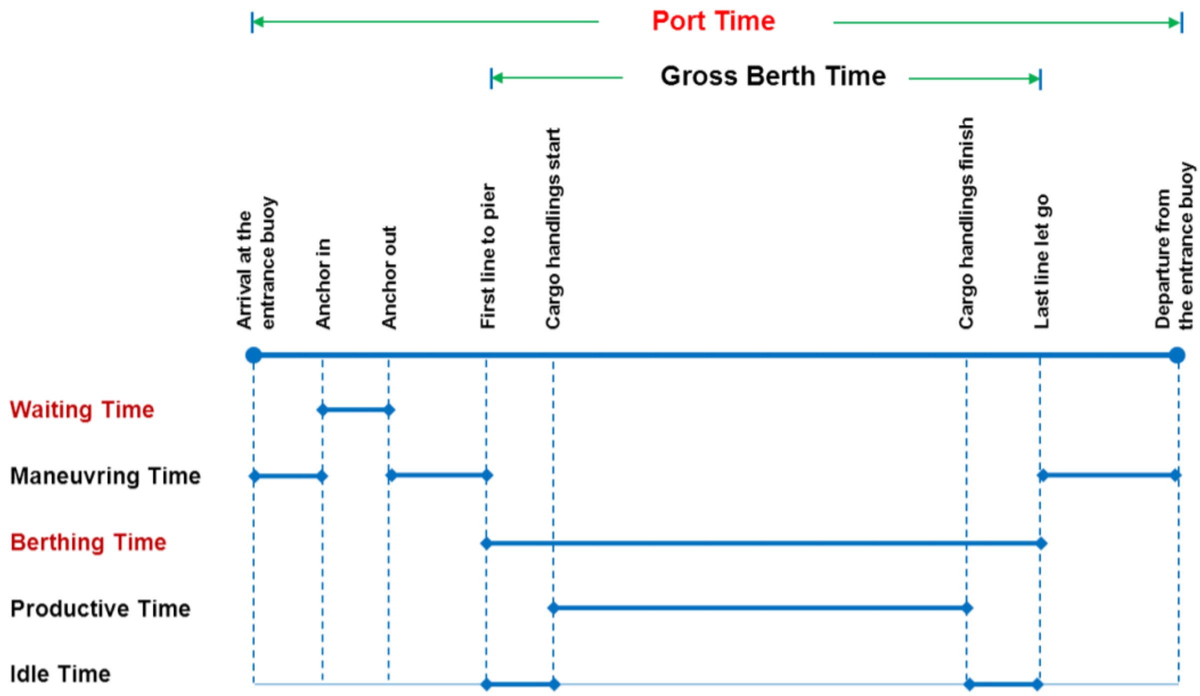

Figure 18.3.2 - Breakdown of ship's time in port

A reduction of any of "these times" will improve the overall productivity of the ship in port. Among these times, in particular 'waiting time' and 'berthing time' must be emphasised since they are crucial criteria in ports facing latent or acute port congestion.

In a nutshell, measures of the duration of a 'ship's stay in port' are key indicators of the service quality that is offered by ports to shipping lines.

18.4 Just-In-Time Arrival/Departure and Improved Cargo Handling

The search for efficiency across the entire transport chain takes responsibility beyond what can be delivered by the owner/operator alone. A list of all the possible stakeholders in the efficiency of a single voyage is long; obvious parties are designers, shipyards and engine manufacturers for the characteristics of the ship, and operators, charterers, ports and vessel traffic management services, etc., for the specific voyage. All the involved parties should consider the inclusion of efficiency measures in their operations both individually and collectively. When it comes to efficient port operations that aim to reduce ship's time in port, as discussed and shown in Figure 18.3.2, 'waiting time' and 'berthing time' are two key components to consider in more detail.

If the ship involved gets a berth on-arrival, there will be no waiting time. In this regard, just-in-time arrival and departure is very important for shipping lines to operate their fleet efficiently. According to "2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)", good early communication with the next port of call should be an aim in order to give maximum notice of berth availability and facilitate the use of optimum speed where port operational procedures support this approach. Optimised port operation could involve a change in procedures that are engaged in different handling arrangements in ports. Port authorities should be encouraged to maximise efficiency and minimise delay.

Regarding the just-in-time arrival/departure of ships, from the viewpoint of ship operators, the reliability of the berthing window is another issue to be looked at. In another words, on-arrival services for ships have to be guaranteed between port authorities and shipping lines. Otherwise, even though ships are already in port, they might have to wait until the berths are available. This will definitely make the time at sea shorter than anticipated, thus increased ship speed in passage will be used to counter act the lost time. This will be counterproductive in terms of efficiency of total voyage time or fuel consumption.

In this sense, the relationships between ship operators and ports must be kept close and their operations harmonised in order to enhance reliability for securing on-arrival services in port. Having a contract for a dedicated (exclusive) terminal with shipping companies on a long-term basis is an exemplary case of resolving this kind of reliability issue.

Just-in-time arrival and departure

Figure 18.4.1 shows that the main activities of the whole container terminal operation can be divided into three operations:

- Berth operation,
- Yard operation
- Gate operation.

This diagram lists specific operations/activities that take place in each phase.

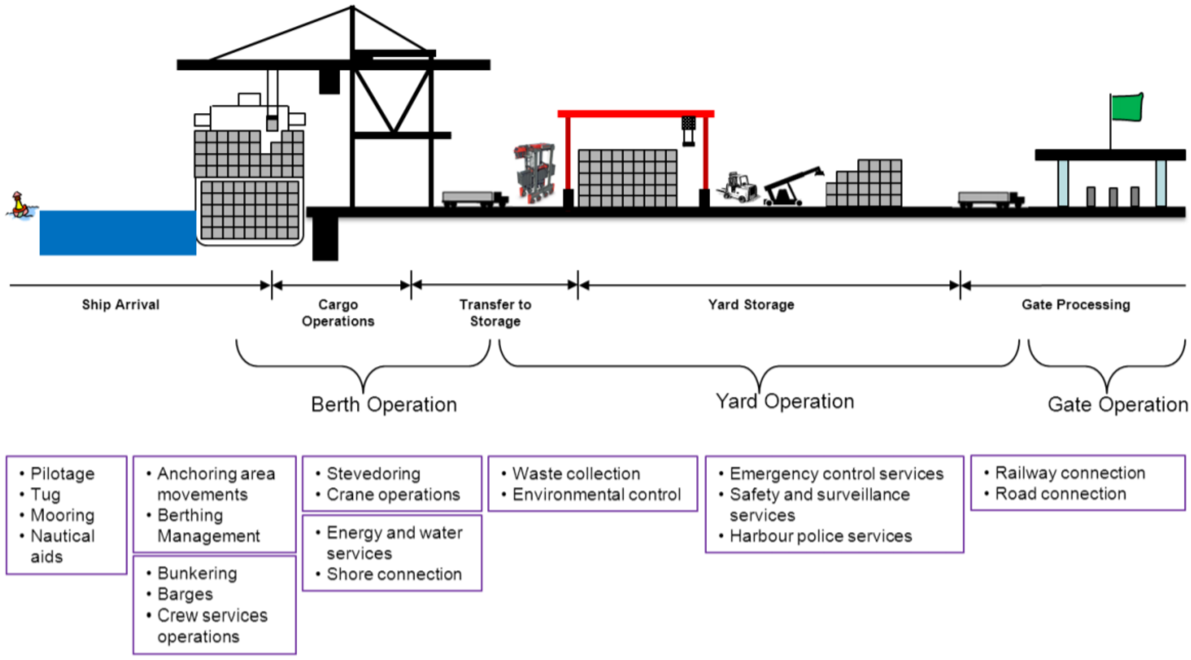

Figure 18.4.1 - Schematic diagram of container terminal operations with activities

The berth operation mainly concerns the schedules of arriving vessels and the allocation of berth space and quay crane resources to serve the vessels. The key concern of the berthing operation is the turn-around time of vessels. It also involves the unloading and loading of containers on-board the vessel that is handled by gantry cranes. To achieve high crane rates (number of containers moved per hour), the planner has to optimise the crane working sequence (a detailed list of crane moves). The yard operation is perhaps the busiest of all the activities in the terminal. The operation involves the unloading of containers from the ships, the loading of containers onto vessels, the shuffling of containers that are out of sequence in the yard block, the redistribution of containers to other blocks (yard shifting) for more efficient loading onto the second vessels and the inter-terminal haulage where containers are moved to other yards in another terminal. The gate operation deals with external freight forwarders. Two activities are involved, namely export delivery where the freight forwarders bring in export containers to the yard or wharf to be loaded onto the vessels, and import receiving, where the freight forwarders receive containers from the yard or wharf to bring into the country.

18.5 Port Operation Management

Each port or terminal has its own port management system for the efficient and effective operation of port, which will be referred to as Maritime and Port Operation System (MPOS) as an example to be explained here. This is a customized management tool that focuses and optimizes the work of "agents", "entities" and "port services on ships" by coordinating the actions, controlling them and allowing them to analyse how best to reduce the cost/time. All the parties concerned, including the ships, must participate in the MPOS from prior to the ship's arrival in the port to the ship's departure from the port. Whenever the ship wishes to enter a port, 'the Request for Berth' is made through Communication Services (normally internet) well before arrival and is confirmed by the MPOS, against the ISPS (International Ship and Port Facility Security) and Dangerous Goods Codes, before issuing the Preliminary Authorization to Berthing. (See Figure 18.5.1)

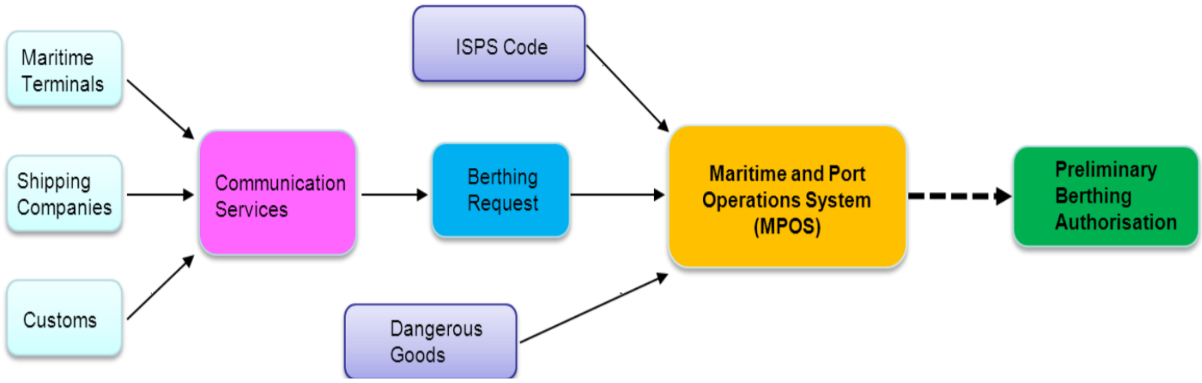

Figure 18.5.1 - Application of berthing request in a typical port management system

After issuing the Preliminary Berthing Authorization, the MPOS compares it with information from the anchoring area and with activities of any anchored or berthed ships, nautical activities inside the harbour, status of maritime signals, maintenance status of berths, and informs the berthing operation to the ship and to the pilot service. It supervises at all times compliance with the Operating Procedures.

The MPOS informs and coordinates all Port Services regarding berthing manoeuvres, informing also the other agents. Furthermore, throughout this phase, the MPOS is capable of performing the control actions and coordination tasks with other agents as shown in Figure 18.5.2.

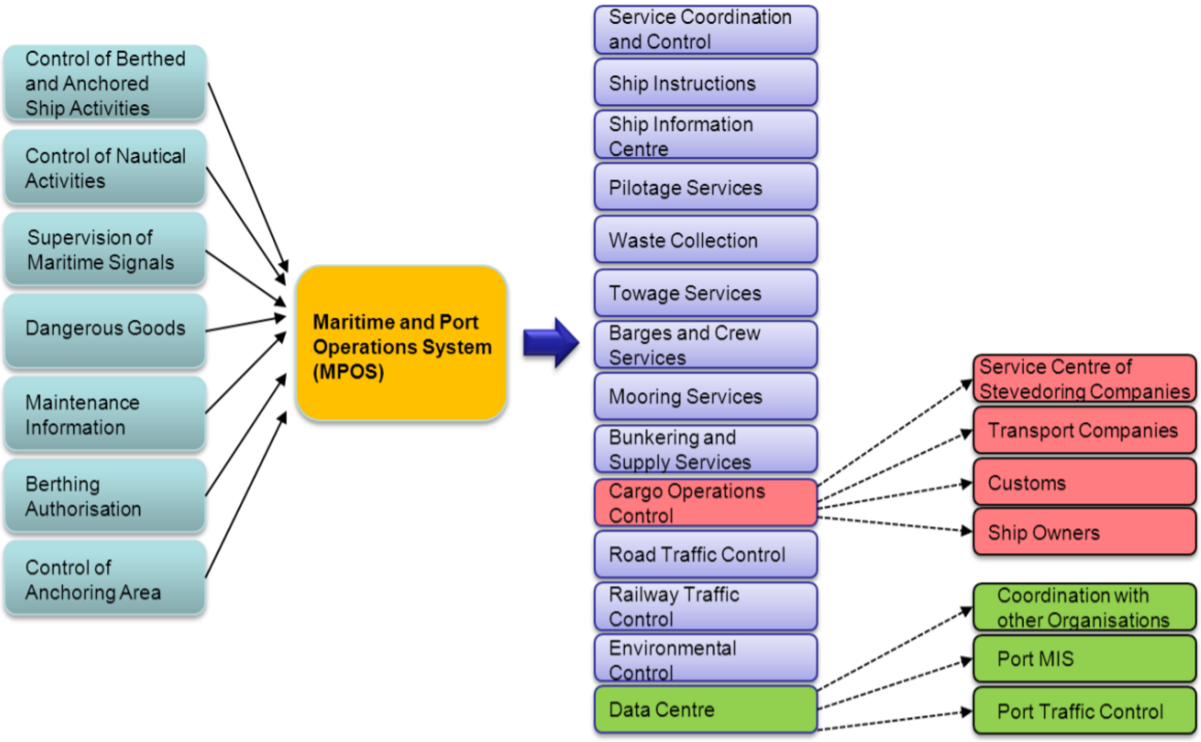

Figure 18.5.2 - MPOS and port services coordination

Generally, the MPOS controls port activities relating to maritime safety and the protection of the marine environment. Typically, the MPOS is part of the port authority organisation and is responsible for ensuring the efficient flow of traffic through port and coastal waters (including allocation of vessels to berths) and—on behalf of the government or port authority—for coordinating all marine services. Major port services that are related to MPOS can be as follows:

- **Pilotage services:** These are services given by maritime pilots that provide an essential and unique service to the shipping industry. Their principal role is to provide critical independent local knowledge and navigational information to vessels and to bring the highest level of ship-handling skills to manoeuvre vessels within their port. The prime obligation of pilots is to provide a critical public safety service by ensuring the careful management and free flow of all traffic within their pilotage area, thus protecting the environment.

- **Towage services:** These are services provided by a small, strongly built powerful tugboat that is used to guide large ships into and out of port and to tow barges, dredging and salvage equipment, and disabled vessels. Tugboat operations are typically carried out by private firms. If the volume of vessel traffic is not sufficient to support a tugboat service on a commercial basis, a port authority may be obliged to provide such a service itself.

- **Line handling services by line boats:** These are the services given by line boats that help the ship to be berthed. When berthing, once the lines from the ship are given to line boats, they approach a berth and try to throw a line to someone on land who ties off the lines at the dock.

- **Mooring services:** These are the services that secure a ship to the designated place, i.e. a berth or a dock or a buoy, or anchoring with two anchors. Mooring services in smaller ports can be provided by the local stevedore. In larger ports, a mooring service is usually performed by a specialised private firm. Especially in a complicated nautical situation (for example, single point mooring buoys, specialised piers for chemicals or gases, or ports with large tidal differences), mooring activities require expert skills and equipment. A port authority may choose to regulate this activity when only one specialised firm exists.

- **Vessel traffic services (VTS) and aids to navigation:** This is a marine traffic monitoring system established by port authorities. VTS is a service designed to improve vessel traffic safety and efficiency and to protect the environment; it offers the potential to respond appropriately to traffic situations emerging in an area. VTS is usually part of a port or a maritime authority. Such services are provided in port areas and in densely used maritime straits or along a national coastline. VTS should be regulated by the competent authority. Responsibility for aids to navigation usually rests with the national maritime authority in port approaches and in coastal areas, and with the port authority in port areas. Often, provision and maintenance of buoys and beacons are contracted out. Because aids to navigation are generally part of an integrated maritime infrastructure, the costs of providing these services are included in the general port dues.

- **The control of dangerous goods:** This is usually performed by a specialised branch of the port authority. The same goes for the handling of dangerous goods in port terminals. The oversight and regulation of the land transport of dangerous goods is normally the responsibility of government.

- **Waste management services:** These are privatised under the strict control of a port authority or another competent body. Proper waste management can be expensive for shipping lines. With high costs, ship masters might be tempted to dump waste into the sea or into port waters. The control of such dumping practices is extremely difficult, especially for chemical cargoes. To spread waste management costs, ports can include all or part of the waste management costs in the general port dues. The transport of waste from the ship to a reception facility also poses a challenge, especially in larger port areas. Port authorities should directly provide or organize the provision of transport barges or trucks for this purpose. The entire waste management system, including personnel and facilities, should be closely controlled by the competent authority. When private firms are engaged in waste handling, the authority should employ experts from its organisation to ensure compliance with all relevant laws, rules, and regulations.

- **Emergency response services:** These are carried out by a variety of public organisations such as the port authority, fire brigade, health services, and police. Some ports have sophisticated tools available to aid in crisis management, such as prediction models for gas clouds. Such tools are often integrated in a traffic centre of the local vessel traffic management system (VTMS). Private firms (for example, tugboat companies) may play a subsidiary role in crisis management in the event that they are equipped with fire-fighting equipment. Larger ports use patrol vessels and vehicles for a variety of public control functions. In some ports, such patrol vessels also have fire-fighting equipment on board. When a port does not have patrol vessels available, a contract with a tugboat company should be arranged to guarantee the availability of floating fire-fighting capability.

- **Control of dredging operations:** These are normally given by a port authority. Often, the port authority or the competent maritime administration does not have enough expertise to exercise sufficient control over both maintenance and capital dredging. Port authorities with large water areas under their control should employ sufficient competent personnel to prepare dredging contracts and oversee dredging operations. Sounding is an activity that should preferably be carried out (or contracted out) by the port authority itself. Dredging is usually carried out by private firms. It might be cost effective for some ports to use their own dredgers, especially when continuous and important maintenance dredging is required.

As the above list of services, ships may need to use the above services in addition to cargo handling service. This then may have impacts on port time of the ships.

18.6 Measures for Avoiding Ship's Waiting Time in Port

18.6.1 Virtual Arrival

Virtual Arrival is a concept for a ship's just in time operation. The main focus is to avoid early arrival and resultant waiting.

18.6.2 Improved cargo handling

Cargo handling is, in most cases, under the control of the port and the optimum solutions matched to the ship and port requirements should be explored. Whatever solutions that might be thought of, they should contribute to increasing the gross berth productivity, meaning faster cargo handling that can lead to reduce the berthing time.

When it comes to container terminal optimization, for example, the integrated planning and scheduling of all the activities of a terminal could be suggested to increase moves per hour and reduce costs. To improve cargo handling, the following planning needs to be improved:

- Berth planning
- Quay crane scheduling
- Prime mover scheduling
- RTG (Robber Tyre Gantry) /RMG (Rail Mounted Gantry) cranes scheduling
- Operational planning, typically day(s) ahead

These activities are closely connected to cargo handling in port where efficient operations can bring about the reduction of ship's time in port as well as giving environmental benefits. Efficient cargo handling in port can definitely be helpful for the environment. A well-planned cargo operation, both in port and on board can reduce the level of emissions from the ship's machinery that leads to reduced energy consumption per transported unit. Ways to improve cargo handling resulting in environmental benefits include:

- The use of an internal movement vehicle that has less fuel consumption per cargo unit
- The introduction of high capacity loading and unloading operations with lower emissions to reduce the ship's time in port
- Safer and easier cargo operations and monitoring
- The application of new technology with advanced software tools
- The use of eco-friendly and user-friendly cargo handling products
- Well trained shore-staff and ship- staff who are keen on safety and environment matters

Quick ship turnaround time in port will ensure slow steaming at sea and this will again contribute to reduce emissions.

18.7 Implication of Just in Time

It is not difficult to make an economic analysis of just in time in relation to various ship costs including fuel costs as well as ship air emissions during passage and in port. Numerous analyses including the one carried out by INTERTANKO and OCIMF on virtual arrival shows the benefits. Based on this study [INTERTANKO and OCIMF (2010)] for a typical ship, Virtual Arrival gives a 43% reduction in the ship's voyage fuel consumption. Off course this number will depend on ship type, size, voyage characteristics and current port times. Nevertheless all indications are that if just in time is realized, the saving levels will be in double digit numbers. Firstly, the fuel consumption and the amount of CO_2 emissions are sensitive to the changes of port time. As port time decreases, the fuel consumption and the amount of CO_2 emissions are sharply reduced (assuming total voyage time is fixed). This result means that port time has a big impact on efficient ship operations. The reduction of port time, or minimization of waiting time through just-in-time arrival and departure, improvement of berth productivity and simplification of the administration process, lead not only to the reduction of the operating cost but also to the improvement of the environmental performance of the shipping industry. In particular, this result tells us why port selection (or choice) is important to shipping lines. In other words, when a shipping line establishes and/or improves their service loop based on the calling ports that have high productivity and efficiency, they can improve their ship operational efficiency by minimizing their operating cost and the amount of CO_2 emissions. Secondly, as vessel size increases, the impacts of the changes of port time on the operating cost and the amount of CO_2 emissions also increase. This result implies why port time is more important to a shipping line that operates larger vessels. Moreover, this result tells us why shipping lines have been focusing on the development of their own container terminals on the major routes. Namely, the larger vessel is more sensitive to unstable port operations and non-production times in port, and this leads to an increase in operating costs and acceleration in the amount of CO_2 emissions. In summary, terminal operators have to improve their operational efficiency. This is because the improvement of operational efficiency leads not only to strengthen their own competitiveness but also to contribute to the reduction of costs and the amount of CO_2 emissions in the liner shipping industry. A simple exercise is provided in the next section to demonstrate the benefits of port operation improvements.

A simple estimated level of fuel saving and CO_2 reductions

Figure 18.7.1 show the actual operation times for a specific ship, denoting that 23.3% of her time is spent in ports (combined berth and anchorage).

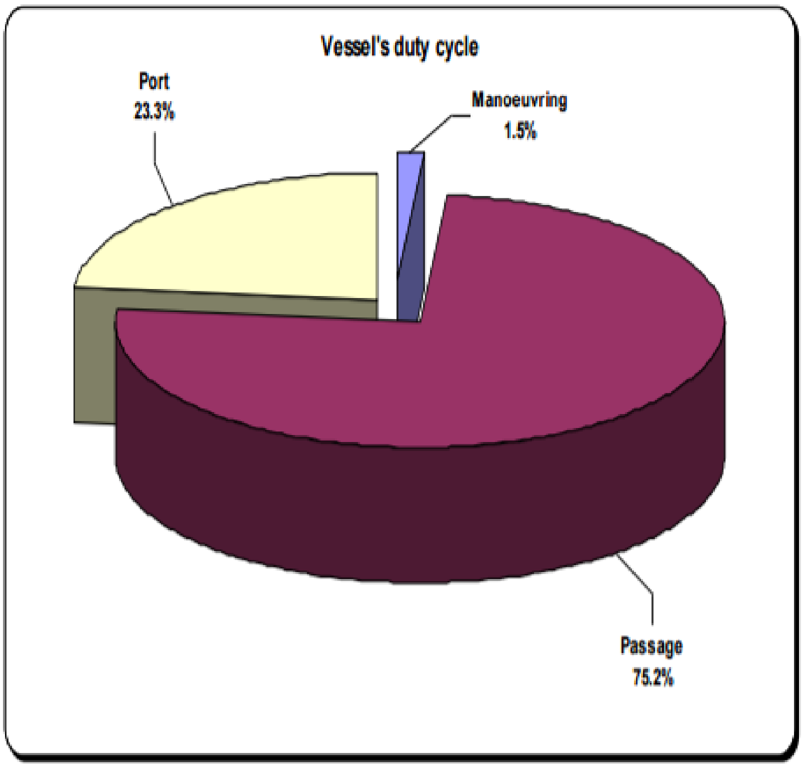

Figure 18.7.1 - Ship's times in passage, port and manoeuvring

The same ship was analysed for number of port calls and just-in-time operations and the required time for just in time operation was estimated. If operated according to port just-in-time, the ship time in port will reduce from 23.3% to 16% (a reduction of about 30% of port time). For calculation purposes, it is assume that the ship would in practice get partial just-in-time operations and thus port time could be reduced from 23.3% to 20.3% in a real feasible scenario. It is further assumed that the extra time gained from better port operation will be used in passage, thus increasing the in-passage periods from 75.2% to 78.2%. This extra time will then be used to proportionally reduce the in-passage ship speed, assuming that the total annual number of port calls will remain the same. The reduced ship speed is then converted to fuel consumption reduction using the well-known cubic relationship between ship speed and required propulsion power. CO_2 Emissions reduction is estimated using fuel consumption reduction and relevant emissions factors. Table 18.7.1 shows the result of this simple calculation in terms of ship fuel consumption reduction; denoting a reduction of more than 1,000 tonnes of fuel consumption per year. This exercise shows how effective the port times could be on overall energy efficiency of a ship and how large gains could be achieved via better port related operations.

Passage operation time in passage, current	75.2% of annual
Passage operation time with less port time (see above)	78.2% of annual
Fuel consumption reduction for same distance (estimated)	7.5%
Fuel consumption and emissions reduction	
Main engine fuel consumption reduction	1,065 MT/year
Boilers and auxiliary engines fuel consumption reduction	Assumed negligible
Net fuel consumption reduction	1,065 MT/year
Net CO_2 reduction	3,400 MT/year

Table 18.7.1 – Estimated ship fuel consumption and emissions reductions

18.8 References and further reading

The following list provides references for this section and additional publications that may be used for more in-depth study of topics covered in this section:

1. "IMO train the trainer course material", developed by WMU, 2013. Viewed Nov 2016.

2. De Monie, G. (1987). Measuring and evaluating port performance and productivity. UNCTAD Monographs on Port Management. A series of monographs prepared for UNCTAD in collaboration with the International Association of Ports and Harbours (IAPH).

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3. INTERTANKO and OCIMF (2010). Virtual Arrival: Optimising Voyage Management and Reducing Vessel Emissions – an Emissions Management Framework. Oil Companies International Marine Forum, Bermuda. Viewed Nov 2016.

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7. Samsung Heavy Industry. (2011). the comparison of the operating costs at different types of container vessel. Sam-Sung Heavy Industry (internal data). Viewed Nov 2016.

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