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## MariEMS Learning Material - E-Navigation and Weather Routing

This is the 16th compilation by Professor Dr Reza Ziarati on the work of the EU funded Erasmus + MariEMS' partners and material researched by Chief Engineer Mohammed Haque. The material is composed from Chapter 16 of the learning material.

**16. Just In Time (JIT) and Virtual Arrival (VA)**

**16.1 Definitions**

**Just In Time (JIT):**

Just in Time (JIT) concept and practices originate from the manufacturing industry where it is used to improve business performance via reducing the inventory levels and associated costs. This concept then moved to other industries and today normally refers to process improvements for the reduction of the unnecessary and idle periods of capital assets. In the case of shipping, JIT normally refers to process improvements that reduce the unnecessary waiting and idle periods of ship operations.

**Itinerary optimisation:**

A ship itinerary optimisation refers to deciding on the best ship operation schedule/profile for a certain purpose via adjustments to voyage durations; thus voyage average speeds. Itinerary optimisation for energy efficiency normally means the choice of ship schedules that would yield an overall lower ship average speed and fuel consumption. Itinerary optimisation for energy saving may conflict with the commercial aspects of shipping as dictated by the market dynamics and the wishes of shipping clients (cargo owners or passengers).

**Voyage management:**

Voyage management refers to all ship management activities that lead to the optimal planning and execution of a voyage. To ensure best-practice voyage management, all aspects of planning, execution, monitoring and review of a voyage are included in this concept.

**16.2 Current Practices**

It is well known that ship speed reduction leads to fuel economy. Speed can be reduced during the voyage, if the amount of time in passage can be increased or the ship itinerary could be optimised. Thus improved itinerary and optimal voyage management are regarded as two major areas that could be used for this purpose. A ship's movement commercially is influenced by many factors, some of which are listed below:

- The requirements of the cargo owner (mainly shipper or charterer) on when and where the cargo should be loaded and discharged. This is normally mentioned as the most likely reason for changes to the ship operation plan, schedules and time tables.
- The slotting issue in ports in terms of berth or cargo storage availability. Early arrival and competing for early loading/discharge is common industry practice.
- Regulatory issues that may lead to delays, prevention of entry to certain ports or ship detention for some period of time. The lost time normally recovered later via over-speeding.
- Technical failures that require fixing while in port or at anchor (reduces ship availability).
- Lack of business (cargo), resulting in short or long idle periods.

Itinerary optimisation, proper voyage planning and voyage execution are areas of interlink between shore managers and ship's masters. As such, the link between the shore managers (charterer and ship operator) and the ship's master is critical for optimal ship operation management. In practice, the simplest models of working relationship are normally established between the above parties. For example, the shore-based managers specify the ports of call and timings. In some cases, they change their orders and ship itinerary while the ship is underway. The master then decides how to move and at what speed in order to meet the above timings. Normally, the master tries to reach the port of destination as soon as possible within the contractual limits. The above processes generally lead to the following anomalies:

- Ship voyage speed is normally maximised with an early arrival at the next port.
- Total ship stay in ports and waiting in anchor is normally maximised.

This practice is not energy efficient. To make it efficient, the shore-based manager and the vessel's master should be given the responsibility to do the opposite; maximise the sailing periods and minimise the waiting periods. Unfortunately, itinerary optimisation and voyage management could easily be sacrificed by either poor planning or poor execution due to commercial and other nontechnical pressures. The improvement to ship itineraries requires efforts to be made by all the parties involved. For this purpose, the collaboration and coordination of the following bodies are essential:

- Charterer operation department: The charterer is ultimately responsible for decision making on the ship itinerary and overall steaming speed. Orders issued by the charterer to the ship are normally the basis for master's decision on ship movement.
- Ship master: The master, based on the orders received, operates the ship and ensures that the designated dates and times are achieved; within the terms of the charter party. The master can play a major role in improving the ship itinerary via more interaction with the charterers/owners decision makers.
- Port authorities: The Port authorities influence the plans drawn up by both the commercial department and master through the management/planning of the port operation.

It is the interaction between the above parties that leads to the actual (achieved) ship itinerary. Better communications, coordination and awareness of the impact of their decisions on ship fuel consumption could improve operations.

### 16.3 Just In Time (JIT)

Contrary to the current practices as described above, Just-In-Time (JIT) operation represents the optimal ship's operation management from the perspectives mentioned. The JIT operation differs from slow steaming as the aim of JIT is not to go for drastic slow steaming but use all the measures possible within the voyage constraints (e.g. weather, charter party contracts, etc.) to reduce the voyage speed and thereby save fuel.

The main purpose of the JIT operation is to ensure that the ship's operations are performed according to a "planned and optimised itinerary" with minimal time deviations. This means that vessels should never leave ports late or arrive in port of destination earlier than the planned itinerary. This will lead to the overall efficiency of the ship and port operations and to significant ship energy efficiency. The JIT operation benefit arises from the ship's less waiting times and more passage time; thereby scope for speed reduction and thereby fuel efficiency.

#### 16.3.1 Best Practice

To approach the JIT operation, there is a set of good practices that ships and ship managers could follow. It is proposed that the following sets of guidelines should be observed for this purpose:

- Avoid waiting periods in all phases of a voyage or modes of operation (loading, discharging, bunkering, early arrival, late departure, etc.).
- 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 in support of JIT operation.
- Improve cargo handling operation and avoid delays at berth to the extent possible. Cargo handling in most cases is under the control of the port and optimum solutions matched to ship and port requirements should be explored.
- Operate at constant shaft RPM while enroute and avoid sprint-loiter phases.
- 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 water if possible.
- Measure, monitor and report the 'ship duty cycle' in terms of time duration in various phases of operation, including period of times in passage, port, waiting, bunkering, etc.
- Perform benchmarking of the 'ship duty cycle' against the fleet and similar ships; this will help with continuous improvement.

### 16.3.2 Barriers to JIT

The JIT operation is hampered by a significant number of major constraints. The following gives the list of constraints put on the master as far as the execution of the voyage is concerned:

- **Contract of carriage (e.g. charter party) constraints:** These include clauses on various aspects of ship operation that practically restrict some aspects of voyage management for energy efficiency. Charter party contracts, for example, normally put most of the power for ship speed management in the hands of the charterers. Financial impacts of deviation from charter party can be significant; thus ship managers would do everything possible to avoid for example late arrival.
- **Weather constraints:** The weather along the route has impacts on the voyage management and vessel itinerary. To limit this impact, weather information and weather routing can be used.
- **Route constraint:** The route of the vessel may involve channel crossings, passing through pirate areas and the need for operations such as bunkering.
- **Port constraints:** Various ports impose various constraints on vessels. One major aspect is the competition between ships to arrive at port of destination in order to beat the queue. The system that dominates now is that most ships try to arrive early to the port in order to give their notice of readiness and stay in the berth queue.

- **Other ship/owner/charterer specific constraints:** These are specific constraints that may apply to various parties involved in ship operations including for example unexpected failures, delay in bunkering, etc.

All the above basically work against the JIT operation. They need to be avoided via improvement to the ship operation, charter party terms and conditions, staff culture, use of modern information technologies (e.g. see Section 6 on e-navigation) and systems such as weather routing and voyage monitoring systems.

## 16.4 Virtual Arrival (VA)

### 16.4.1 Introduction

One major initiative for the removal of some of the Just-In-Time barriers that were explained in the previous section, is the adoption of the "Virtual Arrival (VA)" concept that has been introduced in recent years, mainly in the tanker segment. VA aims to reduce waiting times and achieve longer passage times and thereby reducing the ship's voyage average speed. A significant level of energy saving is expected with virtual arrival [Intertanko and OCIMF 2010]. It is worth mentioning that port related air emissions are also reduced significantly via this initiative. The justification for VA is that it is not efficient for a vessel to steam at full speed to a port where known delays to cargo handling / transfer have already been identified. By mutually agreeing to reduce speed to make an agreed arrival time, the vessel can avoid spending time at anchor, awaiting a berth, tank spaces or cargo availability. Emissions can thus be reduced, congestion avoided and the safety improved in port areas. For VA to succeed, there is a need to establish an "agreement or contract" between the parties involved in ship operations (e.g. ship operator, ship owner, charterer, port, etc.). The contract aims to remove the barriers that are currently in place by existing charter party contracts and also facilitates the sharing of any financial benefits that result from VA implementation. As part of the agreement, all the parties will commit to reduce a vessel's speed during the voyage in order to meet a revised arrival time when there is a known delay at the destination port, cargo delivery date, etc. The reduction in speed will result in reduced fuel consumption, thereby reducing GHG and other exhaust emissions. The VA agreement, by virtue of reducing emissions and costs, is of mutual benefit to vessel owners and charterers. Furthermore, by minimising vessel waiting times, a reduction in emissions and improved safety within the port areas are also realised.

### 16.4.2 Virtual Arrival process

Figure 16.4.1 shows the steps that are involved when VA processes are agreed [Intertanko and OCIMF 2010]. The implementation of these steps is essential to the success of VA objectives.

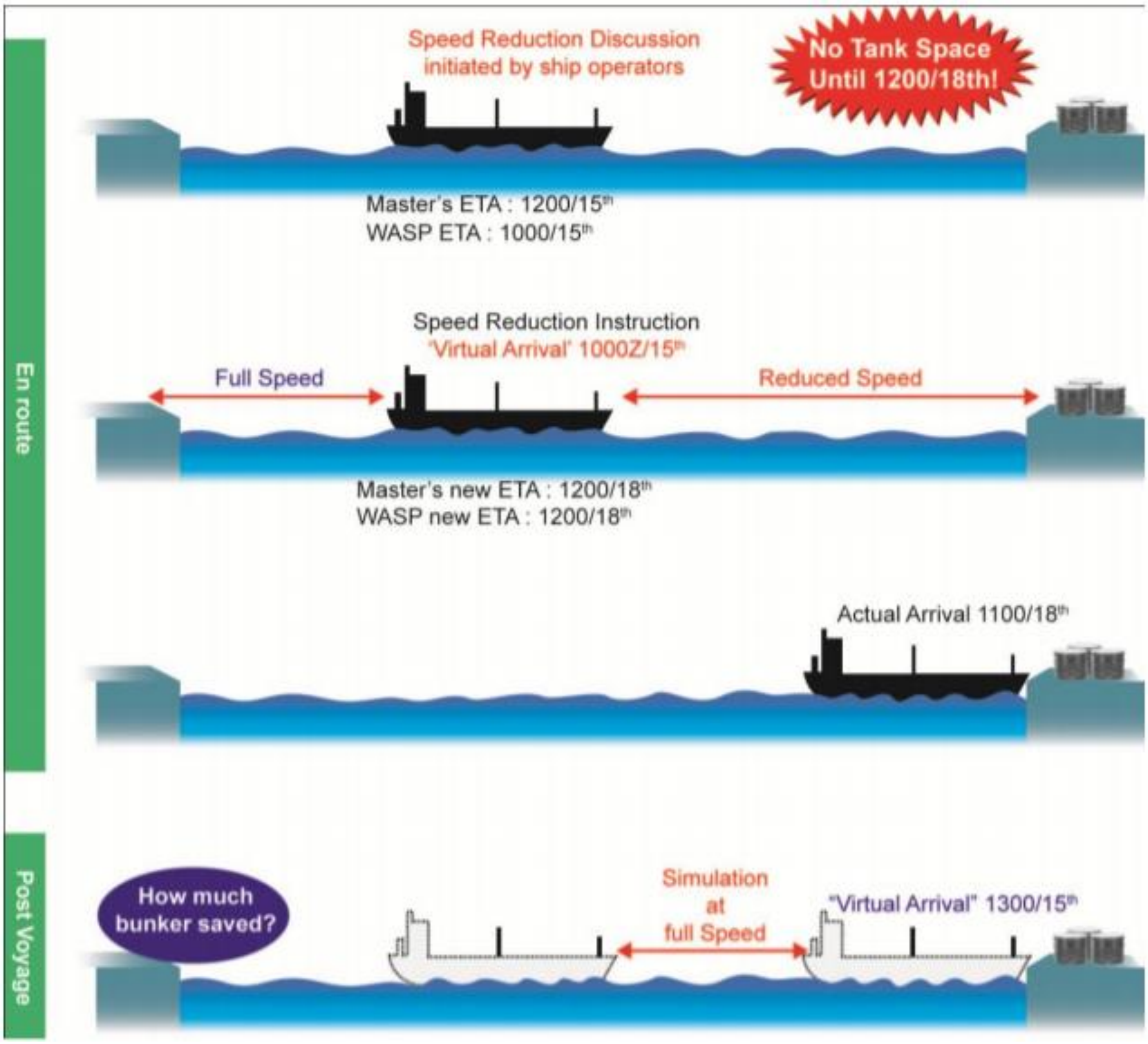


*Figure 16.4.1 - Virtual Arrival processes [INTERTANKO and OCIMF 2010]*

Accordingly, the processes may be described as below:

- **Identification of a change in itinerary:** The main part of the process is to identify a delay at the next port of destination, for example, due to congestion at the berth or lack of receiving cargo spaces
- **Agreement to new itinerary:** The next step is for parties involved including the vessel owner/operator and the charterer and possibly port to agree on the change of itinerary. In particular the port, charterer and owner/operator agree to a 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.

VA is intended to be a dynamic and flexible process and, thus if conditions change during a voyage, the orders can be revised to enable the ship to achieve, for example, a new arrival time. Therefore, the above processes are best supported by ship scheduling software systems accessible to all parties to VA agreement in order to facilitate better control and monitoring. The following summarizes the steps that are typically involved when implementing the Virtual Arrival process [Intertanko and OCIMF 2010]:

1. Before a vessel's departure from the load port, or while enroute to the destination port, a delay is identified at the destination port, for example, due to congestion at the berth or lack of receiving space.

2. In view of the known delay, the vessel owner/operator and the vessel charterer may agree to consider entering into a Virtual Arrival agreement for the voyage.

3. The ship owner/operator is requested to provide ship performance information to enable an initial assessment of the voyage to be made based on the service speed of the ship.

4. The charterer and owner/operator agree a Required Time of Arrival5 at the destination port and agree on the methodology for calculating voyage data and the associated reporting requirements, or alternatively agree on a WASP6 to be used for calculating voyage data and to provide supporting reports.

5. An agreement to undertake Virtual Arrival is implemented using an agreed charter party clause.

6. The initial report should include:

    a. The methodology to be used to determine speed and consumption calculation

    b. The calculated Estimated Time of Arrival (ETA), based on normal service speed

    c. The calculated ETA, based on normal service speed and anticipated weather, the "Virtual Arrival" ETA

    d. The Required Time of Arrival (RTA)

    e. The speed or RPM to achieve RTA

    f. The bunkers on board at the Virtual Arrival decision point

7. The vessel reduces speed in order to make the RTA.

8. On completion of the voyage, if agreed, a WASP or an entity that specializes in weather and or vessel performance analysis produces a final report providing the post-voyage analysis and data to support confirmation of the vessel's Virtual Arrival time and the calculations of the fuel saved and emission reductions.

9. In finalising the Virtual Arrival time, an assessment is to be made of the impact of the weather, sea and current conditions on the voyage by comparing the actual weather encountered with that anticipated when establishing the provisional Virtual Arrival ETA.

10. The agreed time of Virtual Arrival, the "Deemed Arrival" time, is used as the time when considering demurrage exposure.

Based on the above process and for VA to work, significant level of activities is required and uncertainties in various estimation processes exist. This makes use of VA a difficult process in practice; however, industry should make all it could to resolve relevant barriers to VA.

### 16.4.3 Virtual Arrival agreement

To facilitate the implementation of the VA, there is a need for contractual arrangements either as part of the current charter party agreement or a new agreement. This new arrangement is referred to as "VA agreement". As part of the VA agreement, the charterer and owner/operator will be able to change the "Required Time of Arrival" at the destination port (or new ship itinerary) and also agree on the methodology for calculating voyage data and the associated reporting requirements. For estimation purposes, the parties to a VA agreement may choose service providers such as the weather routing service providers to support the implementation. At the end of the voyage, or based on the terms of the VA agreement, the voyage estimates are made and the financial and contractual arrangement is settled. To reduce post-voyage disputes, it is important that there is a clear understanding of, and agreement to, the method of calculation of the vessel's voyage performance, the speed and other data to be used, the reports to be issued and the timing of these reports. Therefore, the charter party agreement will need amending to allow for the additional VA agreement. It should be noted that VA aims to create win-win scenarios for all parties that have influence/impact on the ship itinerary and operation via creating not only workable methodologies but also shared financial incentives.

#### 16.4.4 Other benefits of Virtual Arrival

The adoption of VA has benefits beyond those associated with fuel savings. Its effective implementation requires good cooperation and a dialogue between the vessel owner/operator and the charterer; this serving to remove many of the commercial obstacles in reducing emissions that have hampered some past initiatives. Such obstacles have been associated, for example, with third party and contractual implications; the fact that the party paying for the fuel may not be the technical operator of the ship and the lack of flexibility for speed adjustment. The improved cooperation between vessel owners/operators and charterers also has benefits associated with overall voyage planning. For example, parties can agree that some of the available time may be used for planned maintenance activities, statutory surveys, crew changes or vessel storing. The improved planning of in-port activities that is possible through the early identification of an agreed arrival time may also assist in reducing crew fatigue. Operations can be planned well in advance and uncertainties associated with waiting time and periods at anchor are reduced. Just in Time operation heavily depends on improved port operations. When it comes to port operations, among others, the berth operation is closely related to the schedules of ship's arrivals and the next major concern is the turnaround time of ships in port. The best operation will include the provision of on-arrival berthing services to shipping lines; thus minimizing ship's waiting times. As discussed earlier the JIT operation will help port with reduced air pollutants from ships, thus improved local air quality.

### 16.5 Potential for Energy Saving

For a review of the current ship operational profiles and their analysis, refer to Reference [Charlotte Banks et. al.] that presents a research in this area. According to work done by these researchers, the percentage of time spent in port and sailing in either ballast or laden each year are calculated for a number of ship types and ship sizes and documented. An overview of the findings is given here. Figure 16.5.1 shows the "time loaded", "time in ballast" and "time in port" for a number of ship types. It demonstrates that in the case of bulk carriers, they spend the least amount of time in port (similar to that of the case for container ships). They also have a comparatively high loaded utilization levels compared to the case of Handy size tanker ships which only spend around 40% of the year under loaded conditions.

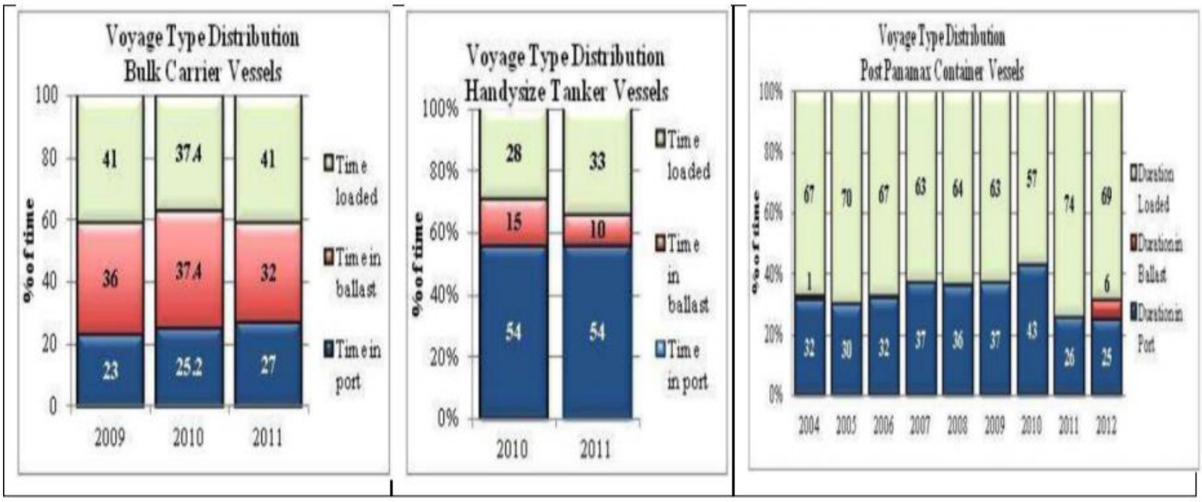


***Figure 16.5.1 - Voyage profiles for typical bulk carriers, tankers and containerships [Charlotte Banks et. al.]***

The same reference shows that the larger tankers spend less time in port: the average is 54% for Handysize, 42% for Aframax and 32% for Suezmax over the years. The proportion of time spent loaded also increases for the Suezmax case vessels with an average of 33.8% over the years, compared to 30.5% for Handysize and 30.6%, for Aframax tankers. The Handysize tankers demonstrate reduced time in ballast (average of 12.5%) compared to Aframax (average 26.7%) and Suezmax (average of 33%) case tankers. These trends are expected with the type of operation for each ship. For example, Handysize tankers tend to offer services for transporting refined products; generally on shorter and more costal routes. It can be shown that normally a Handysize tanker makes more voyages in one year resulting in more port stops and the voyage days are shorter in comparison to the Suezmax tankers. Dependent on the geographical location of the ports and the availability of products to transport, this may be the reason for the Handysize tankers being able to reduce the amount of time they operate in ballast condition. On the contrary, the Aframax and even more so the Suezmax tankers tend to make longer voyages. Whilst this means that they spend a lesser proportion of time in port, the ballast leg appears to increase: this will particularly be the case when operating between locations with high oil production and no oil production.

The first difference between the containers vessels and the tankers and the bulk carriers, is that they do not operate with a ballast leg. Also, evidence shows that Post-Panamax plus container vessels spend less time in port and a larger percentage of time sailing: a likely influence of operational route. It can be argued that the amount of port time varies and this will greatly depend on many logistical issues, such as: ship arrival, berthing availability, unloading/loading resources and personnel, cargo readiness, commercial voyage agreements, ship inspections and certificates, etc. Despite certain delays being inevitable due to the long and complicated logistic chains, there are certainly elements that can be improved to increase the utilization (days sailing laden, cargo loaded) of ships. This includes the installation of efficient port resources as well as early and good communication and resource management between all stakeholders involved. For example, where an inevitable inefficiency is observed (such as a port delay), then good communication and management can allow for alternative operational energy efficient measures to be implemented, such as just in time arrival as advocated by VA. This piece of research clearly shows a significant potential for improvements.

**16.6 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. INTERTANKO and OCIMF 2010 "Virtual Arrival", a 2010 publication, http://www.intertanko.com/upload/virtualarrival/virtualarrivalinformationpaper.pdf viewed Nov 2016.
3. Charlotte Banks, Osman Turan, Atilla Incecik, G. Theotokatos, Sila Izkan, Catherine Shewell, Xiaoshuang Tian, University of Strathclyde, "Understanding Ship Operating Profiles with an Aim to Improve Energy Efficient Ship Operations", Low Carbon Shipping Conference, London 2013. Available on: http://www.lowcarbonshipping.co.uk/files/ucl_admin/LCS%202013/Banks_et_al.pdf. Viewed Nov 2016.