Voyage model, voyage order and voyage performance reports

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MARITIME ITS

Intelligent Ship Transport System

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Executive Summary

The Smart Maritime Network has published a data set for noon reports [10] that has also been incorporated into the IMO Compendium and the IMO Reference data model [1]. This is currently also being added to the ISO 28005 standard [2] as a technical alternative to implement noon reports.

This report has been written to provide some additional background for the use of voyage orders and voyage performance reports (VPRs), the latter a suggested more generalized name for noon reports. The purpose of this report is to expand on the descriptions provided by the Smart maritime Network and IMO and to suggest some improvements to the management of VPRs.

The main contributions from this report are:

1. Definitions of the different concepts used in conjunction with voyage orders and VPRs. This is in section 1 with details in section 5. This is important to provide a consistent understanding of all concepts related to VPR.
2. Background for how ship to shore voyage orders and VPR transmissions are and may be performed in the future. This is in section 3. The main point here is that communication may not always go directly from ship to external parties but will in many cases go through a ship operator. Also, a more complete picture of the necessary message exchanges is provided.
3. Background for how VPRs can be used in the context of performance reporting to charterer as well as authorities. This is contained in section 4. This is mainly related to charter party performance, the MRV regulations from EU and UK and the DCS regulation from IMO.
4. Suggestions for how voyage order and VPR management should and can be automated. This to reduce workload for crew but also to improve quality of reporting. This is described in section 6.
5. An overview of relevant international standards and arguments for why standards are important in the shipping industry. This is in section 7. In this report we propose to use ISO 28005 for VPR reporting and ISO 19847/8 for ship internal data acquisition.
6. Some suggestions for structural improvements in voyage order and VPR data models. This is in section 8. This is linked also to consistency in terminology and modelling.

The report is written as part of the ISTS project and will also detail some of the demonstration requirements for that project.

The content of the report is based on the author’s interpretation of the different referenced document. It does not necessarily give a completely correct description of how the system should be implemented.

1 Definitions and abbreviations

1.1 Introduction

See also section 5 for more detailed definitions. References to the relevant subsections are included in the short definitions.

Note that the term voyage is used with different meanings by different organizations such as EU, IMO, IALA and IHO. Typically, there is a lack of distinction between voyage, passage or other logical sequences of legs. In this document, we will use the definitions given in this section unless otherwise noted.

1.2 Definitions

Action point: A point on a leg that specifies an action to be taken.

Anchorage: An area in which vessels anchor or may anchor [17].

Arrived ship: The definition of an arrived ship will to some degree depend on the charter party, but generally it is defined as when the ship is at the immediate and effective disposition of the charterer at the destination to which it has been ordered [7][7]. This includes that the ship has tendered a valid notice of readiness (NOR). Dependent on contractual details, arrived ship may or may not mean that the ship has arrived in the port, is berthed, has cleared customs or has been cleared for health concerns (free pratique). Note, however, that the concept of virtual arrival time allows the ship to tender NOR before being at the port entrance or in the port.

Berth: A place, generally named or numbered, where a vessel may moor or anchor [17].

Bunkering message: A message sent from or on behalf of a ship that specifies how much bunker that has been taken onboard and the environmental characteristics of the resulting fuel types that the ship will henceforth use.

Demurrage: A delay in loading or discharge of cargo beyond laytime, where the delay cannot be blamed on the ship owner. This will normally lead to a payment from charterer to owner.

Despatch: Opposite of demurrage: If loading or discharge is faster than laytime, the owner may have to pay charterer for reduced ship lease time.

Deviation: This is a type of exception. A deviation is a period, always associated with a distance, where the ship has not kept to the planned schedule. This may, e.g. because weather was so bad that speed had to be reduced or that the ship had to detour, e.g. to land a sick crew member. Also, participation in SAR operations will be considered a deviation. See also section 5.3.3.

Distance: Sailing distance through a leg can be planned, over ground or through water. See 5.2.6 for a detailed discussion.

EOSP: End of Sea Passage, the point where the ship slows down to prepare for a change in operational mode from sea passage to, e.g. anchorage, pilot pickup or port approach.

Exception: An exception from the operational mode that has been planned for a specific part or leg of a passage. An exception can be a deviation or an exclusion.

Exclusion: This is a type of exception. An exclusion is a period, normally associated with a distance, where the operational profile of a segment has been exceeded, but where the overall schedule continues to be kept. An example is a period of bad weather where the ship must use more engine power and fuel than normal to keep the planned speed. See also section 5.3.2.

FAOP: Full Away on Sea Passage, the point where the ship is sailing at contract speed and where a sea passage starts.

Harbour: A natural or artificially improved body of water providing protection for vessels, and generally anchorage and docking facilities [17].

IMO Compendium: An implementation independent reference data model used to harmonize semantics and formats for information elements that are relevant for maritime single windows, just in time arrival and other functions covered by IMO activities [1]. Standards from UNECE and ISO provide technical implementation of the IMO Compendium model.

ISO 28005: The International Organization for Standardization (ISO), through its technical committee 8 (TC8 – Ships and marine technology), publish the ISO 28005 series of standards that implement the IMO Compendium [2].

Laycan: This is the time window when the ship can arrive for cargo operations without penalties. The ship needs to tender NOR within the laycan window.

Laytime: The time allocated to loading and discharge of cargo in the charter party once NOR has been tendered.

Leg (Voyage leg): The captain's sailing plan will normally divide a passage into several legs. The waypoint that links two legs in a passage will normally include a course adjustment. See also section 5.2.5. IHO defines a leg as (1) Each straight section of a traverse. (2) One part of a craft's track consisting of a single course line. (3) In ECDIS, a line connecting two waypoints [3].

Monitoring plan: Both DCS and MRV requires the ship operator to have an approved plan for monitoring and reporting fuel use and distance sailed. See also section 4.

Noon report: See voyage performance report (VPR). VPR is used as a generic term in this document.

Notice of readiness (NOR): The NOR is a document used by the Ship Master, to notify his or her ship's readiness, in every respect, to load and/or unload the goods during the period of the charter. This triggers the commencement of laytime.

Passage: Defines one main part of a voyage, normally as a sequence of legs or ship operations between the last berth of one port call to the first berth of the next port but may in some cases start or end at sea or at anchorage. See also section 5.2.2.

Passage plan: This is the plan made by the ship's master as part of the SOLAS voyage planning requirements [14]. Note that IMO calls this a voyage plan in the quoted reference. In [15], this is called a route plan. The term route plan, which is used in a more general sense for a passage or part of passage, is the name used in S-421 (see section 7.6).

Port: Any port, terminal, offshore terminal, ship and repair yard, or roadstead which is normally used for the loading, unloading, repair and anchoring of ships, or any other place at which a ship can call. The word “port” also embraces geographically, a city or borough which serves shipping interests [17].

Port facility: A port or a part of a port that is individually secured according to the ISPS code.

Port Log: A log of events during the ship’s port stay that is used to evaluate claims related to the charter party, e.g. demurrage or despatch. Also called statement of facts.

Sea Passage: This is a part of a passage where all movements of the ship are in open and unrestricted sea. This excludes passages in restricted or controlled seaways like channels, rivers, canals or ports. A sea passage will normally start at FAOP and end at EOSP.

Segment: This is a continuous sequence of legs where all legs have the same contractual and reporting obligations. A sea passage from FAOP after the Suez channel to the EOSP before the start of the Straits of Malacca and Singapore will consist of several legs, but all are usually considered as sea passage legs with the same speed and fuel guarantees. The segments are not normally defined explicitly in voyage orders or VPR but are implied by the voyage leg type. See also section 5.2.5.

Ship operation: This is an operation performed by the ship that does not involve a movement of the ship as in a leg, i.e. constant speed and heading. This may be that the ship is anchored, is performing ship-to-ship operations or that it is inside the port and moving to, from or between berths. For the master's passage planning, ship operations involving movement to, from or between berths may be described as legs in, e.g. the ECDIS. However, for the purpose of this document, these are ship operations.

Ship to ship operation (STS): Ship to ship operation is the transfer of cargo between seagoing ships positioned alongside each other, either while stationary or underway. This is normally done for oil or gas but can also involve other types of cargo or passengers. Bunkering, e.g. at anchorage may or may not be considered an STS operation.

Statement of facts: See port log.

Terminal: A number of berths grouped together, providing facilities for handling a particular form of cargo, e.g. oil terminal, container terminal [17].

UNECE MMT-RDM: The United Nation Economic Commission for Europe publish the Multi-Modal Transport Reference Data Model (MMT-RDM) that implements the IMO Compendium [4].

Virtual arrival: The concept whereby a vessel is requested to arrive later to a port than she could reach steaming at full speed The charterer agrees to accept the vessels NOR at the time that the vessel would have arrived at the port had she steamed at full speed but the vessel is allowed to steam at a lower speed, saving fuel, and arriving at the port at a designated time which will normally be when the port/berth is ready to receive the ship [8].

Voyage: A specific itinerary for a ship, normally defined by the owner or the charterer, and typically linked to one specific commercial operation. See also section 5.2.1.

Voyage leg: See *Leg*.

Voyage number: This is a code, not necessarily as a number only, identifying a specific voyage. It is assigned by the voyage planner. There may also be passage codes referring to the different passages that the voyage consists of. See also section 5.2.1.

Voyage order: A message sent to the ship's master defining the characteristics of a voyage that the ship is to take.

Voyage Performance Report (VPR): A report from the ship, reporting on performance of the ship related to charter parties or other controlling documents. VPR is also more commonly called "noon reports". A VPR will be sent with approximately 24-hour intervals, dependent on how crossing of time zones is handled onboard. They are also sent at the start or end of a segment.

Waypoint: A connection between two voyage legs.

1.3 Abbreviations

CII Carbon Intensity Index [20]

DCS IMO Data Collection System [20]

EEA European Economic Area (EU + Norway, Iceland and Lichtenstein)

ECDIS Electronic Chart Display and Information System (on ship bridge)

ETA Estimated time of arrival

GNSS Global Navigation Satellite System

GT Gross Tonnes

IALA International Association of Aids to Navigation and Lighthouse Authorities

IHO International Hydrographic Organization, https://iho.int/

IMO International Maritime Organization, https://www.imo.org/

IRDM IMO Reference Data Model

ISO International Organization for Standardization, https://www.iso.org/home.html

ISTS Intelligent Ship Transport System (project), http://ists.mits-forum.org/

ITPCO International Task Force on Port Call Optimization, https://portcalloptimization.org/

JSON JavaScript Object Notation [21]

M/E Main Engine

MMT-RDM Multi-Modal Transport Reference Data Model (by UNECE) [4]

MRS Mandatory ship Reporting System

MRV EU Monitoring, Reporting and Verification [5]

NOR Notice of Readiness

OT Operation Technology (control systems and similar)

PTA Planned time of arrival, i.e. agreed time of arrival between port and ship

ROB Remaining on board

RPM	Rotations per Minute (of propeller)
S-100	The new IHO system for description of electronic charts and overlays
S-421	Route Exchange Protocol – part of S-100
SAR	Search and Rescue (operations)
SEEMP	Ship Energy Efficiency Management Plan
SOLAS	IMO Convention for Safety of Life at Sea
STCW	IMO Convention on Standards of Training, Certification and Watchkeeping for Seafarers
STS	Ship-to-ship operation, normally cargo transfer
SVD	Standardized Vessel Dataset [10]
UNECE	United Nation Economic Commission for Europe, https://unece.org/
VPR	Voyage performance report
VTS	Vessel Traffic Service
XML	Extensible Markup Language
WCO	World Customs Organization

2 Introduction

2.1 Scope

This document describes the possible use of the voyage performance reports (VPR) in analysis of charter party performance as well as various other performance measures related to, e.g. MRV and DCS. VPR is also called "noon reports". This document will look at possibilities for automated noon reporting and automated processing of voyage orders and related documents. This is part of the effort to reduce the administrative workload for ship crew.

This document will also suggest a high-level data model for the ship's voyage that may be used in the context of more automated processing of such reports. Some background material will be provided to explain why this model is proposed.

This document gives a brief overview of some aspects of reporting requirements related to MRV, DCS and charter parties. This is not a complete description of any of these mechanisms and the actual definition of VPR contents to satisfy requirements from any of these mechanisms require more insight than can be got from this document alone.

2.2 Background for the report

This report is produced by the ISTS project. ISTS covered general digitalization of ship transport, but the focus has been on just in time arrival and departure, and the interface between ship and port. However, these interfaces will also be dependent on the relationship between charterer and owner.

The basis for this document is work done by the Smart Maritime Network in developing a data set for voyage performance reporting [10] which has been further developed as an input to the IMO FAL Committee's work on the IMO Compendium [19]. Part of the background is also the Energy LEAP vessel emission reporting standard [20]. All these reports are useful background for understanding the principles behind the VPR.

The IMO Compendium is a central focus point for digitalization in the maritime domain and is also a reference for ISO 28005 [2] and UNECE MMT-RDM [4] specifications. ISO 28005 will eventually also include the VPR functions described in this report in the ISO 28005 XML framework.

2.3 Structure of this report

This report is structed into several main sections as follows:

1. Section 1 contains brief definitions of terms and abbreviations.
2. This is the general introduction and overview.
3. Section 3 provides a brief description of the ICT framework for messages between ship and ship operator.
4. This section provides background information, including overview of charter party functions, MRV and CSV reporting and just in time arrival. A central part of this is the high level ITPCO port call process.

5. This section elaborates on some of the central voyage and event related definitions.
6. This section describes why and how processing of voyage orders and VPR can be automated.
7. This section gives an overview of relevant standards for voyage orders and VPR.
8. This section provides a high-level data model for voyage orders, bunkering message and VPR.

References are listed at the end of the document. References are numbered and marked in the text with the reference number in square brackets, e.g. [1].

3 General ship-to-shore message concepts

3.1 Introduction

This section will look only at messages related to the operational voyage execution. Messages related to administrative requirements, e.g. to maritime single window or VTS are not discussed. Neither are message exchanges related to service or berth bookings.

3.2 Message flow between ship and shore parties

Figure 1 shows a conceptual picture of how some of the main messages are passed between the ship and various shore parties. The figure focuses on the messages sent to and from the ship. A more detailed overview of shore parties is shown in Figure 2.

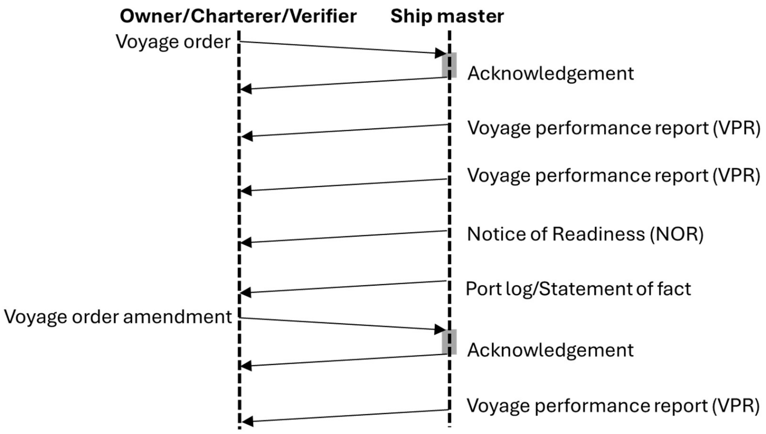

Figure 1 - Main message exchanges between ship and shore parties

The actual message exchange pattern will depend on the ship's trade and contractual obligations. However, the most important messages illustrated here are:

- **Voyage order:** These are the instructions to the master on how to perform the voyage. The voyage order should define all voyage parts, operational modes and reporting expectations related to them. Sometimes, the voyage order may also be the result of weather routing or other voyage optimization functions. It may also contain guidelines or rules for further optimizations during the voyage. This is outside the scope of this report.
- **Voyage order acknowledgement**: It will normally be necessary to get an explicit acknowledgement from the ship's master that the voyage order is accepted. The master has the ultimate responsibility for the ship's safety and may in principle object to the whole or parts of the voyage order.
- **Voyage performance report (VPR)**: These are the daily or event-based reports on the performance of the ship on the voyage. These are also called noon reports.
- **Notice of readiness (NOR)**: This is a report to the charterer, terminal and other parties saying that the ship is ready to discharge or load cargo. This will start the laytime period.

The report is important in terms of getting correct payments based on the charter party rules.

- **Port log/statement of facts**: This report is used to verify that charter party guarantees related to cargo loading and unloading were held. The report includes time stamps for all significant events related to cargo operations. It will normally have to be agreed on between the terminal and the ship before being sent. The port log is not discussed further in this document.
- **Voyage amendment**: It is not uncommon that a voyage is changed when the ship is already under way. In this case an amended voyage order should be sent with the master's subsequent approval and acknowledgement.

This document will mainly look at the voyage performance report. An overview of the necessary components of the voyage order will also be included.

This document will also briefly describe the possible content of a bunkering message that can be sent from the ship when new fuel is bunkered. This message is not shown in the sequence diagrams in Figure 1and Figure 2.

3.3 Different shore parties for different reports

Figure 2 shows a more detailed picture of how specific reports can be distributed to the different shore parties. As for Figure 1, this figure only indicates some of the possibilities. The actual message flow will depend on several factors, e.g. organizational principles, contractual obligations etc.

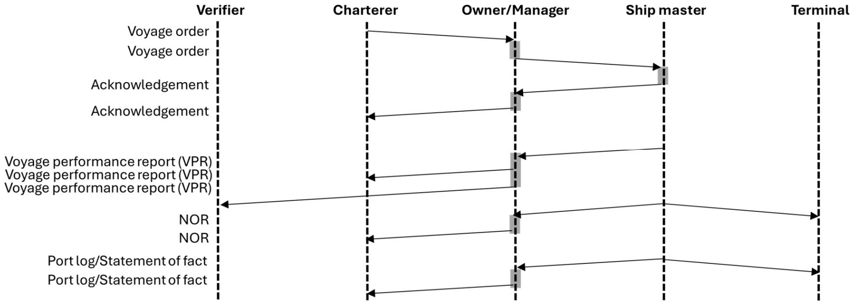

Figure 2 - Examples of message flows between ship and other parties

The figure shows the owner or manager as a main clearing house for most reports, and this is not an unlikely scenario. This would allow the ship to send and receive all messages via a permanent, secure and controlled data channel, which can significantly reduce cyber risks for the ship (see also section 6.2). However, this is only one possible scenario.

The parties shown in this figure are:

- **Ship master:** This is the person on the ship that is responsible for the correctness of reports sent by or on behalf of the ship and its master.

- **Terminal:** The terminal, and often the port authorities, are important parties in coordinating cargo loading and discharge. NOR is usually sent to the terminal, but neither the terminal nor the port is today normally part of the VPR reporting. See section 6.7 for a discussion of this issue.
- **Owner/manager:** This may be a central clearing point for reports from the ship. As reports to charterers and verifiers may have significant economic consequences for the owner, it may be wise to verify reports from the ship before forwarding them to these parties.
- **Charterer:** The charterer will often want to receive performance reports to verify that the voyage is executed as planned. The charterer is also normally the originator of voyage orders.
- **Verifier:** The DCS and MRV system requires third party verification of performance reports. This may require that the verifier also gets copies of the voyage performance reports.

This is not a complete picture of all shore parties but shows the most relevant in the context of voyage performance reporting.

4 Governing regulations and contracts

4.1 Introduction

The VPR is used to keep track of ship performance in relationship to various regulations and contractual obligations. The original obligation for the noon report could be said to be the SOLAS requirements to report daily from the ship to the Company [16], but various other uses for this report has also emerged. Corresponding obligations and possible reporting requirements are briefly described in the following.

Note that some details in DCS and MRV reporting are connected to mandatory management plans, the SEEMP for DCS and an approved monitoring plan for MRV. These plans will be approved by authorities or third parties and will determine some of the details of the actual reporting data, e.g. how passage in ice or other types of exceptions are handled.

4.2 MRV requirements

This section provides an overview of some features of the EU Monitoring, Reporting and Verification regulation [5] (MRV). It is not a complete description. The original regulation has to be read to fully comply.

MRV defines how ship owners need to calculate per voyage emission data and later aggregate that up to total emissions per ship and year. The regulation applies to all ships above 5000 GT that call in EEA ports. Although UK is not part of EEA a national MRV regulation is in place in UK that is almost identical to the EU MRV [6]. The main difference is related to reporting voyages to and from ports in UK Overseas Territories or Crown Dependencies and the dates of going into force. Other similar reporting requirements can also be found in other countries.

The monitoring principles must be described in a verified monitoring plan. MRV has two types of emissions reporting for respectively voyages and port stays, as described in the next sub-sections In addition, one will also need information about the fuel that has been bunkered and used. Some background for that can be found in section 8.3.

The MRV is connected to the owner's emission monitoring plan and reporting related to emissions will to some degree depend on that. However, in most cases, the reporting basis will be the actual consumption of different fuel grades, including the use of boil-off LNG.

The owner may include passage through ice as a special emission calculation case. In that case, start and end of passage through ice needs to be reported for voyages.

4.2.1 Voyage reporting

Voyage reporting is for all voyages starting or ending in EEA or UK ports. The start of the voyage is when the ship is leaving the last berth after having discharged and/or loaded cargo. The voyage ends when the ship has arrived at the first berth where cargo is discharged or loaded in the next port. Intervening port calls, e.g. for bunkering or crew replacement are considered part of the voyage. The same applies to ship-to-ship transfers outside port areas as they are also considered part of the voyage. However, ship-to-ship transfers that results in a change in the cargo carried on the ship, need to be considered by calculating an average cargo volume carried on the voyage. Stops at anchorage or drifting, e.g. while waiting for port access, will also be part of the voyage.

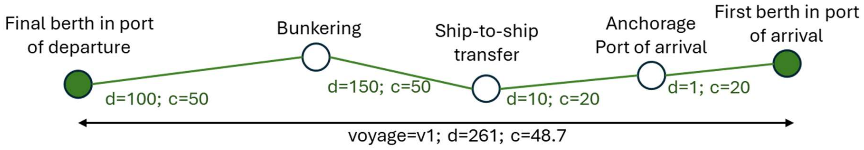

Figure 3 - Example of MRV voyage

Some of these issues are illustrated in Figure 3. The labels show sailed distance (d=) and cargo carried (c=) on the different legs. The calculated distance and mean cargo carried is shown on the final voyage summary at the bottom. This means that a voyage as defined in the MRV regulation can contain several different operations.

4.2.2 Port emission reporting

All emissions while in an EEA port must also be reported. This will include all activities from the end of the previous voyage to the start of the next voyage. This may include repositioning within the port and even loading or discharge of cargo.

4.3 DCS requirements

This section provides an overview of the IMO Data Collection System (DCS). It is not complete and should not be used as basis for ensuring DCS compliance.

The main difference between DCS and MRV is that DCS focus more on the ship's technical performance over the year, while MRV focus more on the transport work that the ship does per voyage. They are similar in many aspects, but differ in the following points:

1. It is not necessary to report cargo onboard as the ships dead weight or similar general measures are used in all calculations, rather than the actual cargo carried.
2. In-port consumption and duration are not required to be reported explicitly. Consumption while in port goes into the overall consumption figures for the ship during the year.
3. In DCS, it is generally understood that distance travelled is all sailings when the ship is operating under own propulsion, also in port [12]. However, for berth-to-berth repositing in port, the impact on the final CII will normally be minimal so in many cases it will not be reported as sailed distance.

This means that DCS reporting is almost a subset of MRV, so preparing systems for MRV will also cover most DCS requirements. The processing of the data before being reported onwards to flag state authorities will be somewhat different.

4.4 Charter party requirements

The charter party comes in numerous forms, dependent on trade and type of charter [11]. The charter party is an agreement between the charterer that rents a ship for some purpose and the owner of the ship. Normally, the charter party will include some performance guarantees, e.g. a guaranteed minimum operational speed and maximum fuel consumption, if the charterer pays for the fuel. The charter party can also include various deadlines for arrival in port, for cargo loading and discharge, and possibly also other elements.

Fuel and speed guarantees will normally only apply to the sea passage. Passages through channels like the Straits of Malacca and Singapore are normally not covered by the guarantee. Likewise, the guarantees are only applicable in reasonable weather conditions. Thus, reporting of adverse weather will normally be part of the VPR.

The VPR will be used by the charterer to check that the conditions in the charter party is fulfilled by the ship. This relates, e.g. to sailing speed and fuel consumption and will normally also include estimated arrival and departure times in ports. Actual arrival and departure times may be reported by other means, e.g. by the ship tendering a "notice of readiness" on arrival or through a "statement of facts", covering all important time stamps related to the port call and cargo operations.

4.5 Reporting port stay, anchorage or ship-to-ship operations

The ship can also be engaged in operations that cannot be defined as part of the sailing as defined, e.g. in DCS or MRV. This includes, e.g. the various berth calls that may happen inside one and the same port, stay at anchorage outside the port or ship-to-ship operations. These operations will in part be characterized by the type of passage the ship is engaged in.

For reporting purposes, it is convenient to define these operations as distinct from the actual sailing of the ship.

While MRV and DCS require little details of the port stay, a charter party may require that the port stay is defined as a list of berths the ship is expected to call on and the corresponding laycan for each. This will depend on the type of charter and passage. MRV will require that fuel consumption during the port stay is recorded separately. DCS may include sailing distance and cargo on each berth-to-berth movement.

5 Voyage, ship operations and event related definitions

5.1 Introduction

The concepts of a voyage, passage or voyage leg are not well defined among the different organizations that deal with maritime regulations and specifications. The concepts even vary in meaning between documents published by the same organization. This section will define more consistent terms that will be used in this document.

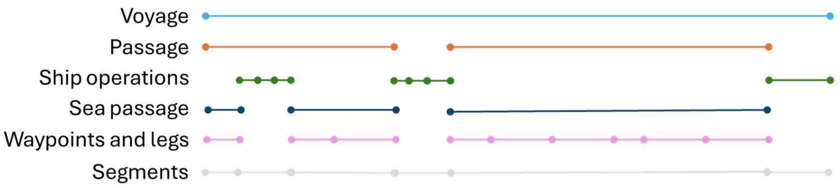

Figure 4 - Hierarchy of voyage, passage, leg and ship operation

Figure 4 shows the hierarchy that will be used in this document. The top level is a voyage that can consist of one or more passages and ship operations. Sea passages will be the parts of the passages that are not ship operations. Each passage will consist of one or more legs and, possibly intervening ship operations. Passages will normally be from berth to berth and will start and end with legs. One leg is a part of a sea passage where the ship sails with approximately the same heading and speed throughout the whole leg. Waypoints are the endpoints of legs. Port stays related to cargo handling are not normally part of a passage but can be included as ship operations between sea passages.

Note that the master's passage planning may represent some ship operations as legs in the ECDIS or a passage planning system, e.g. for ship operations representing a channel passage. This may also be the case if the ship reports voyage legs and waypoints to a mandatory ship reporting system or represents a planned voyage or passage in the S-421 format (see section 7.6).

The concept of segment is not directly used in the model but is used as a term for ship operations or legs where contractual or reporting obligations are the same.

The following sections will give more detailed definitions.

5.2 Voyage related definitions

5.2.1 Voyage

The voyage is defined by whoever provides orders to the ship and may consist of one or more passages and ship operations. Normally, a voyage will include at least two port calls, one for loading and one for discharge of cargo. Repositioning of the ship before the first loading port may also be included. However, this may be treated differently in different organizations and in different monitoring plans.

Dependent on the type of voyage, the structure of the voyage can be very different, as is shown in the following examples:

- **Voyage charter:** A single cargo to be transported on a chartered ship for a single voyage, e.g. a bulk or break-bulk transport. The voyage may be from where the ship was positioned when starting its trip to the port of loading until cargo has been discharged at the port of discharge. Thus, the first passage may be from a sea position or at anchor. The following passage will be the actual cargo transport.
- **Bulk liner shipping:** This can be a regular schedule of roundtrip voyages, each consisting of a laden passage from a port of loading to a port of discharge, followed by a ballast passage back to the port of loading.
- **Container shipping and short sea feeders:** Many container voyages start in one large port in Asia or USA and call on several ports when arriving in Europe. Short sea feeders will similarly start in one large port and then call on several smaller ports before returning to the large port. Thus, these voyages will often be a rotation of passages starting in one port, calling on several other ports, before returning to the starting port.
- **Short sea feeders, break bulk and parcel tankers:** These will often call on several terminals in the port to load or discharge different types of cargo. For short ship feeders this normally applies only to the large port starting and ending a rotation. A voyage may involve one or more start and end ports. Thus, the voyage may consist of one or more passages, each with one or more port and berth calls in the start and end of each passage.
- **Cruise:** This will normally be like the container shipping case with a rotation to several ports from a common start and end port.
- **Ferry:** The voyage can be defined in several ways, e.g. as only one voyage per day with many passages back and forth. For longer distances, a voyage may be defined like the bulk liner shipping case.

This document defines a voyage as a sequence of port, calls, ship movements and other ship operations, e.g. ship-to-ship transfers, that have been defined and given a voyage number by a ship operator.

5.2.2 Passage

A passage is here defined as ship movements from the last berth of a port call to the first berth in the next port. In some cases, a berth may be replaced by an anchorage, a position for ship-to-ship transfer or other positions that are used as start or end of a voyage. The master is responsible for safe planning of the passage (or voyage as it is celled by IMO [14]) e.g., by dividing it into several legs, each with a specific operational mode, including speed and heading.

Operations internal to a cargo loading or discharge in the port will not normally be part of the passage. These operations may include several different berths as discussed in section 5.2.1.

As can be seen from the discussion on MRV and DCS in section 4 as well as in the definitions of voyage planning in IMO, the implicit definition of voyage in these systems are more like passage as defined here.

5.2.3 Sea passage

This is a part of a passage where all movements of the ship are in open and unrestricted sea. This excludes passages in restricted or controlled seaways like channels, rivers, canals or ports. A sea passage starts with the waypoint FAOP and ends at EOSP.

5.2.4 Segment

A segment is not a formal part of the voyage related messages but is included here as a convenient way of referring to a part of the voyage where contractual constraints and/or reporting requirements are the same. This means that voyage performance reports will be sent at the start and end of segments as well as during the segment if it has a long enough duration to warrant that noon reports are sent.

A segment is defined as a part of a voyage where certain external constraints define how the ship is expected to operate and perform over the whole segment. Thus, a segment may be a sea passage where certain expectations to nominal speed and fuel consumption are described in the charter party. It can also represent a channel passage where speeds cannot be guaranteed due to the traffic in the channel, or it can be part of a port operation.

The definition of a segment needs to satisfy the requirements from the reporting constraints that exists. From the discussion in section 4 it is probably the MRV and the charter party that will define the most important requirements to the segments:

1. The charter party often has fuel consumption and speed guarantees that apply to sea passages, e.g. from pilot point to pilot point. Sailing in congested waters, e.g. as in the Straits of Malacca and Singapore will normally be excluded from such guarantees as is also sailing in adverse weather conditions.
2. The MRV requires emissions to be calculated for the sea voyage, including sailing between first and last berth and the start and end of sea passages. Port stays are separately calculated from first to last berth stay in a given port.

There is quite a bit of flexibility in how, e.g. channel passages are handled in a segment. One can define the channel passage as a segment, or one can treat the channel passage as an exception (exclusion). However, it may in most cases be useful to treat the channel passages as separate segments. This may also make it easier to give more specific instructions to the captain for how the passage should be performed.

Figure 5 shows how this could be arranged on a sailing from Barcelona in Spain to Ho Chi Minh City in Viet Nam. This could be described as five main sailing segments, three sea passages (black) and two channel passages (red). The sea passages would be defined from FAOP outside Barcelona to EOSP outside Port Said, from FAOP outside Suez to EOSP at entrance to Straits of Malacca and finally from FAOP outside Singapore to EOSP outside Ho Chi Minh. The channel passages would be from EOSP before the respective channels to FAOP after the channels.

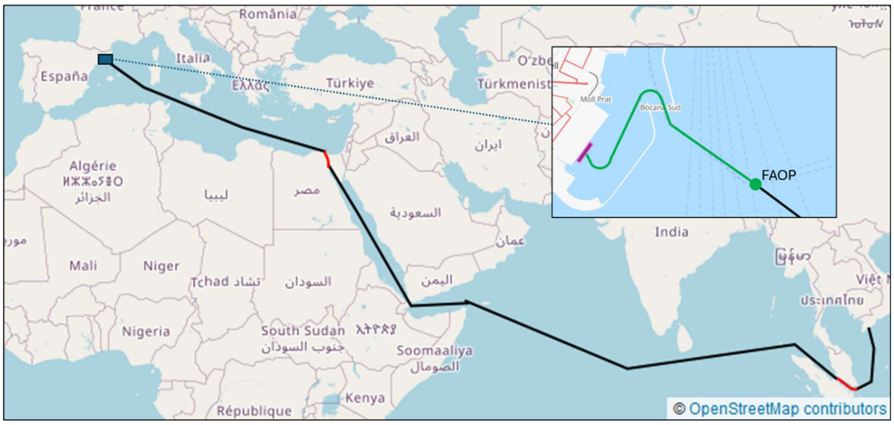

Figure 5 - Possible set of segments from Barcelona to Ho Chi Minh City

In addition to these sea voyage segments one would need to describe two segments for each of the port calls as illustrated in the inset of Figure 5:

1. One segment covering the stay in the departure or arrival port up to leaving the final berth or from after entering the first berth (purple).
2. One segment covering the sailing from end or start of sea passage to first or last berth (green).

Other ways to organize the segments can also be defined, e.g. to cover in-house specific reporting requirements.

Segments need not occur as explicit objects in voyage orders or VPR. They would be implied by different sequences of legs and ship operations with the same reporting obligations.

5.2.5 Leg (Voyage leg)

As discussed in section 5.2.2, the captain is required to plan the execution of each passage before leaving the departure port. This will typically be to divide the passage into several voyage legs and ship operations, where each leg is defined by a stretch of reasonable straight or great circle sailing or more general manoeuvring at port approaches and near berth.

Each part of the passage where the ship is sailing by own power can be a leg. IHO defines a leg (on an ECDIS) as a line connecting two waypoints [17], i.e. the heading remains close to constant during a leg. This means that approaches to arrival berth from EOSP and likewise departure from final berth to FAOP may not be defined as legs as defined in the context of the noon report. It may be more useful to define them as ship operations.

A leg is always completely part of exactly one segment, passage or voyage. It cannot cross the boundary between two of these voyage elements.

A leg is a special version of a ship operation that has a distance associated with it.

5.2.6 Distance

A planned distance in a voyage is a planned sailing trajectory between two points. Normally, it is either a rhumb line or a great circle line. A rhumb line or loxodrome is a line where the heading is always the same. A great circle line is shorter but will continuously change the heading, thus making it more complex, e.g. for an autopilot to keep the ship on course.

The sailed distance can be measured through water or over ground. A correct measurement requires continuous integration of the respective speeds through water or over ground into a total sailed distance. Both these distances will generally be different from the planned distance as the ship never exactly follows the planned track. Distance through water may be shorter than planned distance if the current gives the ship extra speed while the distance over ground always should be longer.

5.2.7 Waypoint

This is usually the start and end points of a leg. IHO defines waypoint as "In ECDIS, in conjunction with passage planning, a geographical location (e.g. latitude and longitude) indicating a significant event on a vessel’s planned route (e.g. course alteration point, calling in point, etc.)" [17].

5.2.8 Action point

During passage planning the master or others may introduce points on a leg where some action is required, e.g. reporting to a VTS. This is not a waypoint and is not normally used in voyage performance monitoring but the term is included here for compatibility with S-421 (see section 7.6).

5.2.9 Ship operation

This is an operation performed by the ship. This can be a voyage leg or another operation that is not defined as a leg. This may be that the ship is anchored, is performing ship-to-ship operations or that it is inside the port and possibly moving between berths. Also, on sea manoeuvres related to dynamic positioning or STS would be classified as ship operations.

A voyage leg in the master’s passage plan is also a ship operation as defined here.

5.3 Exceptions

5.3.1 Introduction

An exception is a period and distance during one or more legs in the same segment, that represents a deviation from the operational mode that has been planned for those legs. An exception means that contractual or reporting obligations may not have been met. An exception can be a deviation or an exclusion, as explained in the following. Suggested codes for exceptions are listed in Table 4.

Note that some charter parties do not require detailed reports of exceptions but rely on general contractual exceptions such as long periods of strong wind or high sea states.

5.3.2 Exclusions

An exclusion is an exception from a segment where the ship is still able to maintain its schedule, but where external conditions are such that performance guarantees, e.g. for fuel use cannot be given. The typical example would be sailing in ice or in strong winds at nominal speed, but where fuel use will be higher than during normal sailing conditions. If the speed must be reduced, the exception should be reported as a deviation.

5.3.3 Deviation

A deviation is an exception from a segment where the schedule of the ship changes. This may be due to a reduction of speed, e.g. due to bad weather or ice, or a detour caused by some unforeseen incident.

The deviation will normally be measured from where and when the ship started the deviation to a point and time where the ship is in a position not less favourable to the charterer than when the deviation started.

Figure 6 shows an example of a deviation where the ship unexpectedly called on Port Klang during transit through the Straits of Malacca. The deviation will be from the start to end of the green dashed original voyage plan. The total time lost, minus the planned sailing time for the dashed green line, will normally lead to a reduction of the charter hire, and any excess fuel use compared to the planned sailing, may also cause a corresponding penalty for the ship owner. The actual terms are specified by the charter party.

Figure 6 - Example of deviation

Another typical deviation is caused by reduced speed during a part of the segment. This will be reported as the stretch where the ship's speed was under the ordered speed. Additional time may lead to reduction of charter hire as will any increased fuel use.

5.3.4 Duration and cardinality of exceptions

Both deviations and exclusions can in principle occur several times over a 24-hour period. Thus, one should have the possibility to report more than one exception per VPR. On the other hand, the duration of an exception may also be more than 24 hours, so the same deviation or exclusion can be reported as ongoing across more than one VPR.

5.4 Definition of modes, sub-modes and events

5.4.1 Introduction

Each leg and ship operation will have one main mode as discussed in section 5.4.6, e.g. a part of a sea passage segment or an operation in conjunction with port approach. In addition, it can have exceptions or sub-modes. Exceptions are parts of the mode where the contractual or monitoring requirements related to the main mode is not valid. A sub-mode is a more detailed description of operations that still includes the guarantees of the main mode.

Figure 7 shows two main segments of a voyage, respectively a sea passage segment and a port approach segment. The sea passage consists of a number of legs with the same contractual and reporting requirements but with one exclusion (see 5.3.2) where weather was bad enough to deviate from charter party guarantees. The port approach segment consists of three sub-modes (see 5.4.4), respectively manoeuvring to anchorages, anchoring and a river passage, presumably to the port.

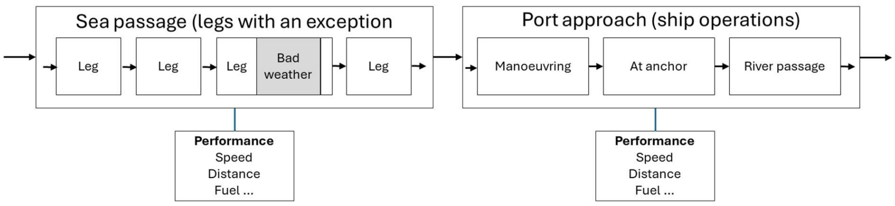

Figure 7 - Two segments, their modes and sub-modes

Each of the modes and the sub-modes have a duration and will start and end with an event. This is indicated with the arrows, where the start of the arrow represents an end event for the previous mode, and the end of the arrow represents the start of the next mode. Some events will also be associated just with a point in time such as sending a report to shore. In the following, the event structure, modes and sub-modes will be described in more detail.

Note that the voyage performance parameters are directly associated with the main operational mode of the segment. This is in line with how the voyage should be divided into segments with identical reporting constraints.

5.4.2 The general event model

ISO/IEC 19987 [18] defines a general event data structure for trade and transport. These events have four main dimensions or attributes:

- **What:** What object the event is related to. For the purposes of this document, the object will always be the ship.
- **When:** When the event happened. This is a normal time stamp with local time information, e.g. UTC offset or time directly in UTC.
- **Where**: The location where the event happened. This may be a geographic position as latitude and longitude or some other location identifier.

- **Why**: The occasion that caused the event to happen. This may have a retrospective part, e.g. the segment mode that was terminated and a prospective part, e.g. the new segment mode that starts.

In addition to events that are associated with the start and end of legs and modes, there may also be other events that, e.g. mark start or end of exclusions or sub-modes. These events will implicitly also define a duration in time and space of the related modes, sub-modes or exclusions. Some events are associated just with a point in time, e.g. when a special report is sent to shore.

The VPR will normally be sent at the end of the last leg of a segment which is also the start of the next. In addition, it will also be sent as a daily report for longer segments.

5.4.3 Different types of event time stamps

All events are associated with a time, but dependent on the event being a planned or actual event and if it is a result of internal decisions on the ship or external requests to the ship, the type of time stamp will vary. In general, the following types of time stamps are used [1]:

- **Estimated (E):** This is the estimate for when the event will take place. This is typically used in the planning phase or during the voyage to update previous estimates.
- **Requested (R):** If the event is related to an external party, e.g. start of pilot operations, the requested time is when the service provider requests the ship to start the operation. The request may also come from the ship to a service provider.
- **Planned (P):** When a requested time is confirmed by the other party, the time stamp becomes a planned time, i.e. an agreed-on time where both parties expect the event to take place.
- **Actual (A):** This the actual time the event took place, after the operation or mode change has taken place.

Normally, one expects that the estimated time is sent to the external party and that the external party replies with a requested time. If this is accepted by the ship, the ship will return a planned time. In principle this may take place as a negotiation with the ship returning a new estimated time instead of a planned time. This is illustrated in Figure 8. Here, the labels "service provider" and "service user" may represent both the ship and the external party, dependent on the type of service.

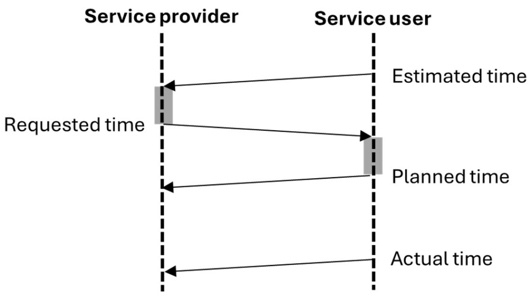

Figure 8 - Four types of time stamps

If the time stamp is not related to an interaction with a service provider, the type of time stamp will normally go directly from estimated to actual, possibly after being reported as planned.

Note that requested and planned times also may change due to unforeseen circumstances. In that case, the negotiation of requested and planned times needs to be done again.

5.4.4 Events and operational modes

Changes in the operational mode of a ship will always be associated with internal or external events. As an example, the ship will change from under way at sea to, e.g. port approach when the captain gives the order to reduce speed before the pilot pickup point. Pilot pick-up may be the first sub-mode of port approach and likewise, there may be a sub-mode change when the pilot is at the bridge and the captain gives the order to speed up again.

Figure 9 shows these two events at the bottom of the figure, associated with the relevant mode or sub-mode changes. The action, below the event line, is here indicated as respectively send a report for the main mode change or record for the sub-mode change. The record of the change in sub-mode may be included in a later report associated with port call. This type of event needs only be identified as a mode change event, when the old and new mode represent different reporting or performance expectations.

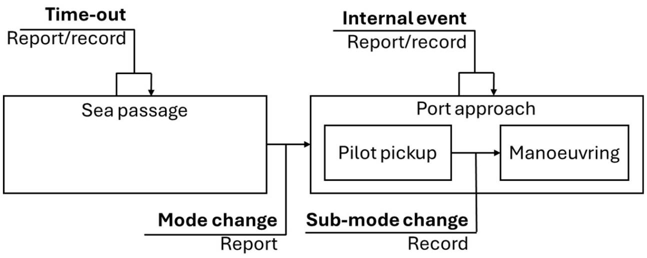

Figure 9 - Events and modes

Another type of event is typically time driven and is indicated as "time-out" in the diagram. The most common is that a day has passed and that it is time for a new noon report. Other internal events can be that the estimated time of arrival has been recalculated and updated or that the ship enters or leaves a special area that needs to be recorded or reported.

5.4.5 Interchangeable legs and ship operations

In many cases, legs and ship operations are interchangeable. The main difference is that legs can always be drawn in a planned passage while a ship operation may not be. However, ship operations, such as channel passage, may also be in the planned route. Thus, the user of these concepts should carefully define what constitutes a leg or ship operation.

In both cases, legs and ship operations are characterized by having a duration and that they are started and ended by an event.

5.4.6 Codes for modes, sub-modes and exceptions

What is a mode or a sub-mode will vary, dependent on contractual and reporting obligations. However, Table 1 and

Table 2 list codes that are normally expected to be used for modes for sailing and non-sailing operations respectively. Table 3 lists codes that are expected to be used for sub-modes. Many of these can be used both for sailing and non-sailing operations. Some exclusions listed in Table 4 may also sometimes define a mode or sub-mode, e.g. passage through ice.

Modes, sub-modes and exceptions define characteristics of how a ship operates. The relationship is illustrated in Figure 10. The illustration reflects the general definitions of the concepts as presented in this document.

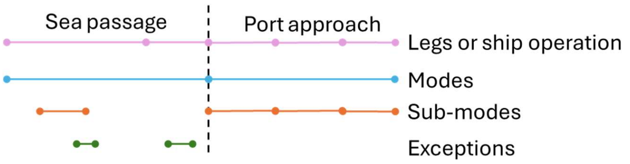

Figure 10 - Relationships between modes, sub-modes and exceptions

The figure shows two main modes, sea passage and port approach. Sea passage made have sub-modes, e.g. related to passing through a ship reporting area while port approach typically consists of several sub-modes, e.g. pilot pick up, anchorage, approach and berthing. Often, all these sub-modes will have the same reporting obligations and will be considered one mode. Exceptions are normally only associated to sea passage, but this depends on details in the contracts.

Thus, modes are defined as characteristics of a consecutive sequence of legs or ship operations ("a segment") related to the overall reporting or monitoring obligations for a voyage. Sub-modes represent the same obligations as the mode, but may add more details to what operation the ship was engaged in. An exception is a part of the segment where the mode obligations cannot be fulfilled due to external or internal temporary constraints.

As both sub-modes and exceptions are related to the main obligations defined by the mode, one should always let sub-modes and exceptions be fully inside the overreaching mode, i.e. not cross the mode boundaries. However, the operational state represented by, e.g. a sub-mode may extend over the mode boundary, but in such cases a new sub-mode period should normally be started when the new mode starts.

Table 1 lists the modes that normally will be used for sailing operations.

Table 2 lists the main modes that are relevant for non-sailing ship operations. Codes from both tables may in some cases be used interchangeably, dependent on how the monitoring plan counts consumption and distances.

The first and second column corresponds to codes specified in the code list for the IMO proposal for noon reports, data element IMO 0598 [19]. Codes from OP50 and higher have been added as additional codes here to complete the list.

The modes will in general correspond to one specific reporting requirements or charter party condition that requires, e.g. sailing distance, time and fuel use to be explicitly reported. This is included in the three right-most columns where charter party (CP), MRV (MR) and DCS (DC) requirements are indicated. An S means that this mode should be included in calculation of fuel use during sea passage. An E means the same as S, but that other calculations may be done to compensate for exceptional circumstances. A P means that this shall be counted against fuel consumption in port. This coding is only indicative. The actual classification will depend on the organization's monitoring plan and the explicit charter party requirements.

Table 3 lists modes that are normally used as sub-modes within a main mode. These will not normally need reporting of explicit distance and fuel use, but may in some cases, e.g. impact on emission or cost calculations by a pro-rata reduction or increase in emissions or fuel use.

Table 1 - Mode codes for sailing operations

Code	Mode	Description	CP	MR	DC
OP01	Sailing	Ordinary sea passage at contract speed	S	S	S
OP04	In ice	Ship is sailing in ice	E	E	E
OP05	Manoeuvring	Ship is manoeuvring, e.g. to anchorage/pilot		S	S
OP50	Port approach	Approaching first berth after sea passage		S	
OP51	Port departure	Leaving from last berth before sea passage		S	
OP53	Canal	Passage through canal, e.g. Panama		E	E
OP54	Channel	Passage through channel, e.g. Malacca Strait		E	E
OP55	River	Passage through a river		E	E
OP57	Port movement	Moving between berths inside port		P	
OP99	Other	Other operation		S	S

Table 2 - Mode codes for non-sailing ship operations

Code	Mode	Description	CP	MR	DC
OP02	At anchor	Ship is at anchor		S	
OP03	DP	Ship is doing dynamic positioning at sea		S	
OP14	In port berth	Moored at berth		P	
OP16	Laid up	Ship is laid up and not in operation			
OP17	Dry dock	Ship is in dry dock			
OP18	Wet dock	Ship is in wet dock			
OP21	Drifting	Ship is drifting		S	
OP99	Other	Other operation			

Table 3 - Sub-mode codes

Code	Mode	Description
OP06	Waiting	Ship is waiting, e.g. for port access
OP07	Tank cleaning	Cleaning tanks
OP08	Purging	Purging tanks
OP09	Gas freeing	Gas freeing tanks
OP10	Discharging	Discharging cargo
OP11	Loading	Loading cargo
OP12	Gassing up	Gassing up
OP13	Cooling down	Cooling down
OP19	STS	Ship to ship operation
OP58	Ballast exchange	Ship is doing ballast water exchange
OP59	Pilot pickup	Picking up a pilot
OP60	Pilot drop-off	Dropping off a pilot
OP61	Pilot onboard	Pilot is onboard
OP62	Fuel changeover	Changing fuel
OP63	MRS	In ship reporting area
OP64	VTS	In VTS area
OP65	In special area	-Operation in special area
OP67	Off-hire	Not under charter party
OP99	Other	Other operation

Table 4 lists codes for cases that are normally defined as exceptions (see 5.3). These are periods that excludes the ship from certain obligations related to fuel or time use, that are not considered normal operational conditions. OP22 should not in general be used as it only specifies that this is a deviation rather than the reason for it.

Table 4 - Codes for exceptions

Code	Mode	Description
OP04	In ice	Ship is sailing in ice
OP22	Deviation	Deviation from planned operation
OP23	Emergency	Emergency operation excluding SAR
OP63	Heavy weather	Heavy wind or waves as defined in charter party
OP64	SAR	Participation in search and rescue operations
OP65	Technical problem	Technical breakdown, e.g. in engine
OP66	Medical emergency	Medical support for own crew
OP99	Other	Other operation

5.4.7 Codes for events

Performance reports are normally sent at end and start of a segment and at noon for segments of long durations. This means that the main reason for the event that caused a report to be sent can be determined from the previous and new modes of operation. This is also illustrated in Figure 10. The event codes listed in [19] does not take this into consideration and adds also the mode change to the event codes. Many of these codes are therefore redundant and can be replaced by just mode changed (EV50) or noon report (EV16).

However, there may also be other causes for sending a report. Table 5 lists the most common reasons for sending a report including the two event codes already mentioned.

Table 5 - Codes for events

Code	Event	Description
EV01	Enter (Arrival)	Entering a new mode
EV02	Leave (Departure)	Leaving a mode
EV50	Changing mode	Sent when one segment ends and next starts.
EV16	Noon report	Sent within a segment.
EV21	ETA update	Additional message to update ETA.
EV30	Performance snapshot	Additional message to report technical details.
EV24	Change destination	Amended voyage order in effect.
EV99	Other	Other reason why a message is sent.

The first and second column corresponds to codes specified in the proposed code list in the IMO input document for the noon report, code list for IMO 0597 [19]. Codes from EV50 and higher have been added as additional codes here to complete the list of modes and their corresponding events.

6 Automating VPR processing

6.1 Introduction

The original purpose of the noon report could be said to be to satisfy SOLAS requirements for the master's daily reporting to Company [16]. However, the VPR has, as is discussed in section 4, also other uses. This has led to the VPR being a comprehensible report, and much larger than originally specified in SOLAS. This can lead problems of additional administrative chores for the master or other crew onboard. One solution to this is to automate as much as possible the processes related to sending the VPR. Automation will also, if implemented correctly, increase the quality of reported data and can be used to reduce redundancy in the reporting, which is often the case in today's reporting specifications.

On the land side, one should also try to link the voyage order more closely to the VPR. The voyage order is the instructions to the master on what contractual and other constraints that apply to a specific voyage. Hence, for charter party performance analysis, as well as MRV and DCS reporting, instructions in the voyage order are linked directly to the data that should be reported. This applies particularly to the definition of legs and ship operations in the voyage order.

This section will provide an overview of these issues and some proposals for how a more automated system can be devised for both shipboard and land use. It will be assumed that full electronic processing of voyage orders and VPR can be implemented and that standards, as discussed in section 7, are in use.

6.2 Relationship between voyage order, bunker message and VPR

It can be very useful to see the voyage order and the VPR in context. In principle, the voyage order defines the context for the voyage and the requirements to each voyage leg and ship operations planned during the voyage. This could be expressed as the events related to the start and end of each leg and operation. The order will also contain instructions related to the contractual and regulatory constraints, e.g. speed orders, fuel types to use and other related instructions. The VPR shall provide regular updates on the progress of the voyage, as specified in the voyage order, and data on how the requirements to legs and operations are fulfilled. This is illustrated in Figure 11.

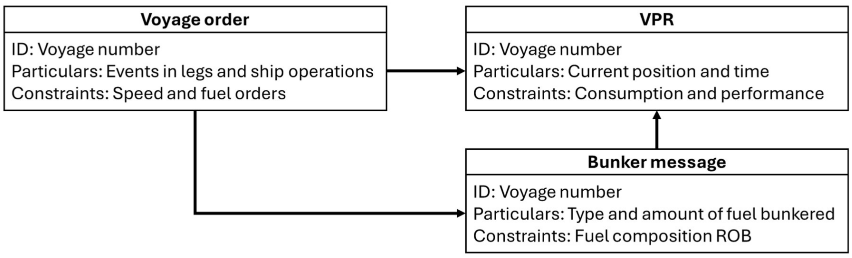

Figure 11 - Link between voyage order, bunker message and VPR

If the voyage order and the VPR is implemented as computer readable electronic documents and defined in a common context, this will make automatic processing of both orders and VPR much easier. One can, e.g. automate much of the production of a VPR if the voyage order is available and likewise, on land, one can automate the processing of VPR and provide more accurate monitoring information about the progress of the voyage. This related to all relevant requirements from charter, authorities and ports.

The bunker message can report on what fuel was bunkered and the resulting composition of the fuel that remains on board. Each remaining fuel quality can be given a unique code, thus avoiding that the VPR has to repeat all this information. The bunker message would also contain the bunker delivery note references and other necessary administrative information.

6.3 Typical ship-shore connectivity

Ships, at least those operated from the developed countries, are increasingly using digital means for communication between ship and shore. Exactly how this is done varies, but a typical schematic is shown in Figure 12.

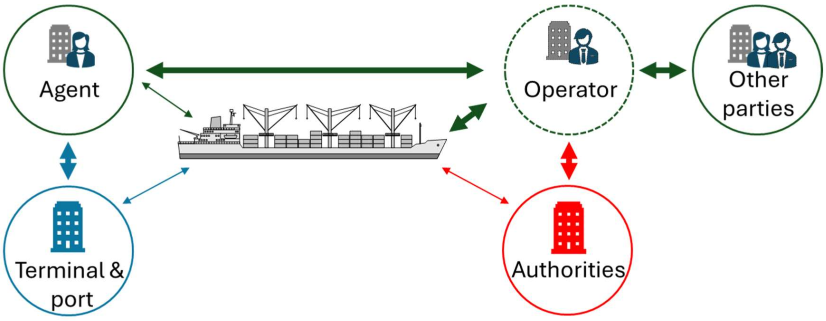

Figure 12 - Typical ship-shore connectivity

The ship does some of the communication directly to external parties such as the agent, authorities, ports or terminals, but most of the data communication is sent through the ship operator. This may be the owner, the manager or in some cases also the charterer. Whoever is the operator will often handle most of the communication to the other shipping parties. The communication between ship and operator will typically be through some kind of cloud solution or by direct and sometimes proprietary data protocols.

The reasons for this solution are, e.g. to reduce costs by using more efficient satellite communication between two main parties, to reduce the exposure of the ship to cyber security threats and to reduce the complexity of onboard ICT systems.

Today, much of the communication to parties in foreign ports will be handled by the ship agent. This communication will also often go first from the ship to the operator. Communication with other authorities, e.g. flag state or third-party validators of MRV or DCS reports, will often be handled by the operator directly.

This picture may change as digitalization of the maritime sector increases. For certain operations, such as just-in-time arrival and departure, it is expected that the direct participation of the ship will increase in the future.

6.4 General message flows and equipment requirements

The exact design of an integrated and automated system for voyage orders and VPR varies considerably. However, a few general principles are illustrated in Figure 13. Here, the ship side is to the left of the dashed line and the shore side systems to the right.

On the shore side one would need a voyage management system that can convert contractual obligations, e.g. the charter party, and monitoring principles as defined in the management plans into a voyage order for the ship. This process may also include various forms of voyage optimizations, e.g. to reduce energy consumption or to protect cargo.

The output from this system is a voyage order containing a detailed voyage plan. The level of detail is dependent on how much freedom the ship master has to specify the passage plan. As shown in Figure 1, the ship's master will respond with an acknowledgement. Figure 1 also illustrates the possibility of amending the voyage order at some point, in which case a new acknowledgement is needed.

The inputs to the system from the ship are the VPR messages that report on the progress and performance of the voyage and the bunker message that specifies bunkered volumes and types of fuels. The latter may have to be complemented by fuel analysis reports from third parties so that the exact composition of the remaining fuel on board can be determined.

The VPR can be used to automatically monitor progress and performance as compared to contracts and plan, and if desired, generate alarms if some threshold of deviation is exceeded. Together with the fuel information, these reports will also be sent onwards as monitoring reports to a "verifier", as also described in Figure 1.

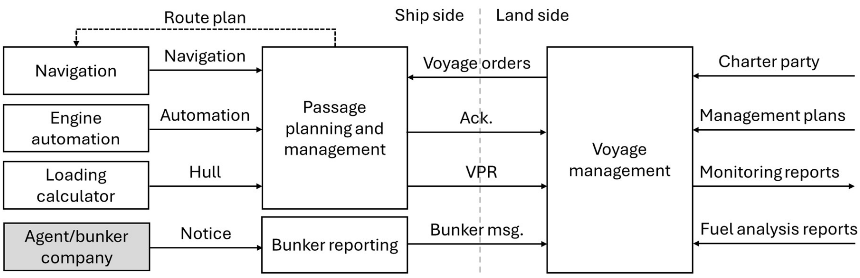

Figure 13 - Conceptual design of voyage management systems on ship and on land

On the ship, one will need a corresponding passage planning and management system. This should be able to receive voyage orders and provide input to the ship master which allows him or her to either develop the detailed voyage plan or to accept the received plan as safe and manageable. The resulting passage plan may be developed independently, e.g. in planning mode on an ECDIS, or it can be transferred to the track pilot and ECDIS on the bridge, to be used directly in passage execution.

The voyage planning and management system should also be able to receive data from various automation systems to generate the technical performance information that is to be included in the VPR. This is typically sailed distance through water and over ground, time elapsed since last report and through that, corresponding speeds, draughts, fuel consumed as well as various other technical parameters related to the condition of the hull and propeller. The actual systems that supply this data may vary between ships. The figure only shows some examples. See [19] for details on the information that is to be included in the report and Table 6 for some examples of where the data can be got from. Note that "engine automation" in the figure can represent several different systems such as main engine automation, auxiliary engine automation, power management, etc.

The exact details of how the bunker message is generated will vary significantly. Normally, the determination of fuel quality will involve a third-party fuel analysis company while the calculation of the quality of the remaining fuel onboard also needs to consider the volumes of fuel that was already onboard and how much fuel that was bunkered. Different parts of this processing and data retrieval may be with the ship's agent, the bunker supplier, the ship or the ship operator. Thus, the figure is only an indication of the existence of such a process.

The VPR process could in principle be fully automatic, but it should probably be integrated with work processes related to the master's regular assessment of voyage progress and any need to update ETA or change the voyage plan. This would also allow the master to approve the report before it is being sent.

6.5 Automating processes onboard

One main purpose of this system is to minimize the workload on the crew and personnel on land related to the processing of VPR. For voyage orders and bunker messages, there will still be a need for manual intervention, although this can also be reduced by increased automation.

Given that digital connectivity and standards are in place (see section 7), much of the VPR processing can be done automatically and even, in some cases, completely without human intervention - if desired. This is illustrated in Figure 14. A brief description of the pseudocode is given in the following.

Trigger: Noon or change in segment (or manual).

1. Collect aggregated data since last report from the different shipboard systems.
2. Generate monitoring information, status and predictions for voyage.
3. If required, alert master to new monitoring information.

   Manual: Master checks monitoring data and, if necessary, updates ETA and voyage plans.

5. Send VPR to shore.

Figure 14 - Pseudocode for automated VPR generation onboard

Given online connectivity to navigation system it is possible to detect when segments end, e.g. by monitoring the position or the time. Noon reports can trivially be triggered by time. This can start an automated process where relevant data is collected from the different automation and planning systems and to generate an automated status and monitoring report.

If necessary, the master can be alerted to verify the status report and send the VPR. This may also include updates to ETA and voyage plan, if necessary. In some cases, this step can be skipped, and the report can be sent automatically.

Not all information may be available from onboard digital system, but for modern ships, most of it will. However, it will normally require connection to several different systems on the ship. Some examples of information that are available from the different OT-systems onboard, with reference to the proposed IMO data element number from [19], are shown in Table 6. Data that cannot be acquired automatically must be entered manually. This will in any case apply to data, e.g. related to exceptions and general comments to the voyage execution. The right-most column indicates if the data can be acquired automatically or not.

Table 6 - Examples of data collection for VPR

Code	Data element	System that may provide data	Aut.
IMO0600	Elapsed time	Voyage monitoring system	A
IMO0601/602	Ship position	Navigation	A
IMO0605	Voyage leg identifier	Voyage order in monitoring system	A
IMO0607	Deviation description	Manually entered	-
IMO0612	Distance through water	Navigation	A
IMO0617	Speed propeller	Engine automation (RPM * pitch * minutes)	A
IMO0357	Ship draught	Loading computer	A
IMO0452	Total ballast water	Loading computer	A
IMO0625	Wind force	Navigation	A
IMO0630	Sea direction	Manually entered	-
IMO0647	Generator production	Engine automation	A
IMO0670	Fuel consumed by M/E	Engine automation	A

6.6 Reducing redundancy in data sets

When automated processes are used to generate the VPR, one should avoid having redundant data elements in the VPR message. There are several redundant elements in the proposed data set [19] and this is probably due to a historic need to cross-check manually entered data. Some examples are listed in Table 7.

Table 7 - Potentially redundant data items

Code	Data element	Can be calculated from
IMO0600	Elapsed time	Difference between time stamps on reports: IMO0603
IMO0615	Distance to next port	Calculated from current position IMO0601/2
IMO0623	Bad weather hours	Should be reported as exception IMO0607-11
IMO0019	Cargo information	Should remain the same over a passage

It may be desirable to remove such redundancies to reduce reporting volumes as well as reduce the need for the receiving computer system to cross-check information for consistency. Any inconsistencies in received data, although caused by programming errors or misunderstandings in data entry, will also require human intervention on the receiving side to correct the errors. This will add to the workload for involved personnel.

6.7 Use of system in other applications

The VPR will normally contain an updated ETA for the next port. This can in principle be used to negotiate a new PTA in the port, if the ship participates in a just-in-time arrival process. The onboard system could also be used to send required reports based on instructions in the voyage order. This could include reports to port state authorities through a maritime single window, mandatory ship reports to VTS or reporting systems or NOR messages.

These issues will not be further discussed in this document.

7 Standards for VPR implementation

7.1 Introduction

For efficient and sustainable integration of systems on board the ship, it is necessary to establish standard protocols for communication between the systems. Without standards, both engineering and long-term maintenance will be expensive. The good news is that suitable standards already have been published. The not so good news is that these standards are only in limited use in the industry.

This section will go into more details on a possible realization of the onboard systems shown in Figure 13 and give a brief description of the standards that can be used to implement this.

7.2 An example of a detailed onboard system description

In the ISTS project, a conceptual and limited demonstration of a noon report system will be done. This is based on the system design shown in Figure 15. The lines show the interconnections between systems. The colours on the lines show the protocols that are used in the demonstration. The dashed lines show possible future developments in standardization.

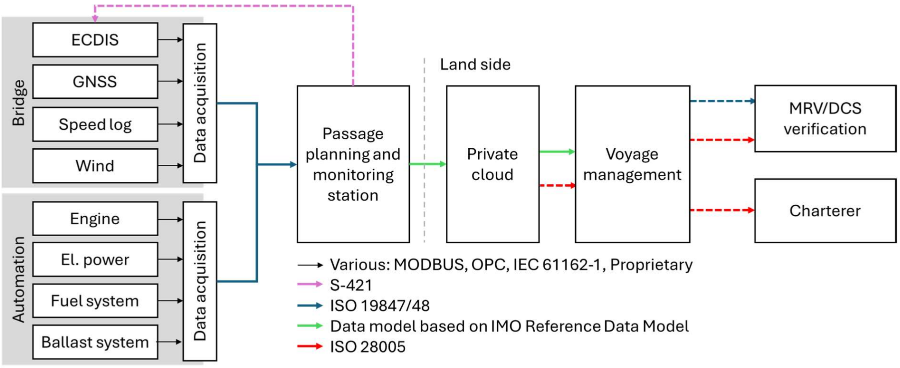

Figure 15 - Detailed representation of a demonstration system

The baseline in the concept is a data acquisition system that collects operational data from the navigation and the automation systems. This delivers data according to the ISO 19847/8 standards (see section 7.5).

A passage planning and monitoring system can be used both to plan passages and to monitor the execution when the passage has started. It is connected to the ECDIS and may transfer the planned routed directly to the ECDIS for further use in auto- and track-pilots on the bridge. Currently, this is in a proprietary format but may use S-421 in the future (see section 7.6). As part of the normal monitoring function, the planning station will also generate VPRs and transfer those to shore.

The planning station is connected to a cloud solution that transfers the VPR to the ship operator's office. The format is currently in JSON but may change to ISO 28005 in the future (see section 7.4). The data files will in any case be compliant with the structure of the IMO Reference Data Model, so transmission format is of minor importance (see section 7.3).

The receiver in the operator's office is a voyage management system. This will in turn be able to forward the VPR to a third party that is doing verification of the MVR and DCS reports, as well as to a charterer, if that is necessary. Some of the third parties are already accepting reports in ISO 19848 format but is expected that also ISO 28005 may be used for this. The charterer will most likely receive reports in ISO 28005 format.

The demonstration will not include the voyage order as no official format for that have yet been agreed on.

7.3 IMO Reference Data Model

At their 43rd Plenary meeting in April 2019, the IMO FAL Committee approved the revised and updated IMO Compendium on Facilitation and Electronic Business, to support harmonization and standardization of electronic messages for exchange of information when ships arrive at and depart from ports. This IMO Compendium was a fully electronic update of the paper-based IMO Compendium that was last published in 2013 [22]. The new compendium was a result of a cooperation between IMO, World Customs Organization (WCO), UN Economic Commission for Europe (UNECE) and ISO on developing a harmonized IMO reference data model (IRDM) that could be used to ensure semantic interoperability between the ISO 28005 standards [2], the UNECE Multi-Modal Transport Reference Data Model [4] (MMT-RDM) and the WCO Data model [23].

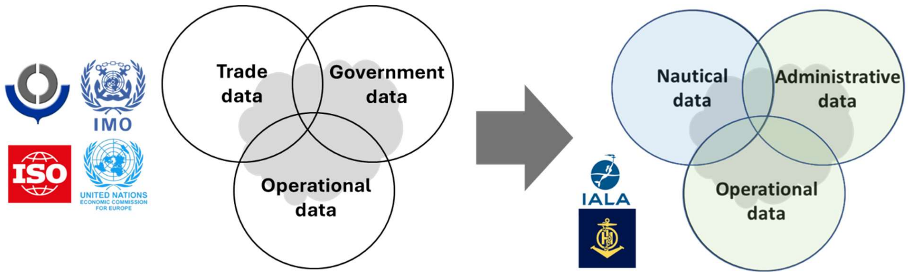

Figure 16 - Conceptual structure of IMO Compendium

Originally, the IRDM was composed of the intersection of data sets from the operational (ISO), trade and transport (UNECE) and government (WCO) domains, which represented the main interests of the IMO FAL Committee at the time. However, from around 2022 it became obvious that we also had to include the nautical domain. The nautical domain is in the scope of the IMO Maritime Safety Committee (MSC) and typically implemented as technical standards by IHO and IALA. Thus, the conceptual model is now more akin to the right side of Figure 16, where also IALA and IHO contributes to the model. This will ensure necessary semantic interoperability with the new series of S-100 nautical standards that are already being published (see section 7.6). The IRDM will not include all parts of the IHO data model, but only those elements that are common with the operational and administrative domains.

The IRDM is not normally suitable for direct implementation and will need some additional processing before being published as a technical standard. Each of the original contributing organizations have published a mapping between the IRDM and their respective standards. These mappings are available via the IMO web pages [1].

7.4 ISO 28005 - Operational data for ship shore transmission

ISO 28005 [2] is an XML implementation of the IRDM developed by ISO TC8 (Ships and maritime technology). The standard consists of two main components:

1. A transport protocol based on plain HTTPS and HTML multi-part messages. This allows implementation of relatively simple and general APIs as illustrated in Figure 17. The multipart message has one general header but allows the use of different formats in the main message body. It also allows the use of additional attachments to include pictures, PDF data sheets or other non-XML information. Digital signatures can be added to ensure authentication, integrity and non-repudiation of transmitted information. This is contained in part 1 of the standard.
2. A data model that can be used to assemble different data message bodies, dependent on the service that is being negotiated. The data model allows several hundred XML tags to be added arbitrarily to the message body to define content that is suitable for either administrative reporting, ship service ordering or any other process that the API can support. The data model consists of a few elements from part 1 and the definitions in part 2 and 3 of the standard.

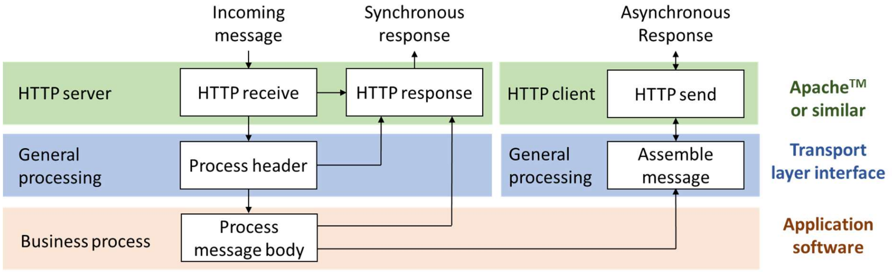

Figure 17 - General ISO 28005 structure for processing transport protocol message parts

A new and revised version of part one of the standard will be published in 2024. Part 2 was published in 2020 and part 3 will be published in 2024. The plan is to merge the data model into a more streamlined maintenance scheme for the message body components. This will be done in 2025 but will not change already published specifications. Table 8 shows some of the data elements that are already defined in the data model.

Table 8 - Examples of noon report data items and ISO 28005 mapping

IMO number	Data element	ISO 28005 identifier
IMO0603	Ship reporting date time	/EPCMessageHeader/MessageCreatedTime
IMO0142	Ship name	/EPCMessageHeader/ShipID.ShipName
IMO0191	Voyage number	/EPCMessageBody/VoyageNumber
IMO0109	Port of arrival, name	/EPCMessageBody/PortOfArrival/Location/Name
IMO0621	Ship draught forward	/EPCMessageBody/ArrivalDraught/ForeDraught

The slashes represent delimiters between XML tags. As one can see some of the data elements are located in the message header and some in the message body.

7.5 ISO 19847 and ISO 19848 - Technical ship data collection onboard ship

ISO 19847 [24] defines a general-purpose ship data server, mainly for automation and navigation data. A high-level overview of the design is shown in Figure 18. It consists of a data collection input function that listens in on different protocols, dependent on the type of network it is connected to. Data is stored in a database and made available to external data users through different mechanisms. FTP and HTTP shall be supported, but data users may also be able to use other protocols as exemplified in the figure.

ISO 19848 [25] defines unified rules for developing machine and human readable identifiers and data structures for shipboard machinery and equipment, with the objective to facilitate exchange and processing of sensor data from ships. This includes a data channel concept and a time series concept. A data channel is a description of a specific data source, a time series is a collection of data sampled at specified times. The standard gives rules for naming of time series and channels. It also specifies message or file formats and other data related issues. XML, JSON and CSV as data transmission formats for the data users are defined, but other formats are allowed. ISO 19848 files can be transported as a message body in ISO 28005.

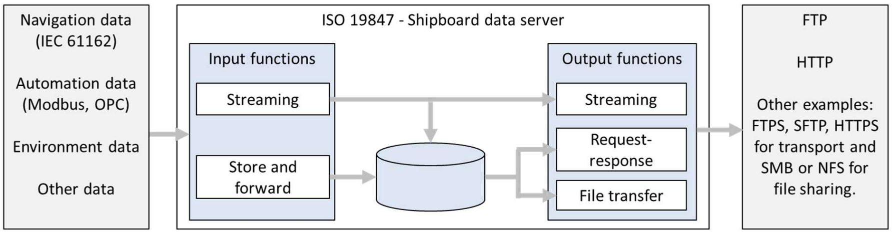

Figure 18 – The ISO 19847 general architecture

Table 9 shows an example of some of the data elements defined in the Smart Maritime noon report data set [10] and how it is mapped to ISO 19848 tags. This also shows the mapping to the IRDM data item number.

Table 9 - Examples of noon report data items and ISO 19848 mapping

IMO number	Data element	ISO 19848 identifier
IMO0603	Ship reporting date time	jsmea_voy/DateAndTime
IMO0142	Ship name	jsmea_nav/ShipInformation/ShipName
IMO0191	Voyage number	jsmea_voy/VoyageInformation/VoyageNumber
IMO0109	Port of arrival, name	jsmea_voy/PortInformation/Arrival/PortName
IMO0621	Ship draught forward	jsmea_voy/DeadweightMeasurement/DraftFore

One should note that the naming scheme used by ISO 19848 allows a hierarchical structure in tag names by using the slash delimiter. This means that one can easily extend the data set.

7.6 S-421 or IEC 61173-1 - Route plans

The S-100 Universal Hydrographic Data Model has been developed by IHO as a more modern replacement for the existing ECDIS chart formats. S-100 is intended as a general-purpose framework for development of digital products and services in the hydrographic, maritime and GIS communities [26].

One of the S-100 products that may be of interest in context of VPR and voyage orders is the S-421 specification for route plans [27]. As has been discussed elsewhere in this report, important parts of both voyage orders and VPR is the descriptions of ship operations and legs that define the ordered voyage, which could be transferred as S-421 objects. This is something that must be developed, but one obvious sue of S-421 is to transfer the planned route to the ECDIS and the rest of the ship systems as discussed ins section 7.2.

7.7 Cyber security

This report will not go into details on cyber security but mention a few issues that needs to be considered. All these issues are based on reducing the attack surface for the ship. The reason for that is mainly that the ship normally has limited crew expertise in cyber protection and is in many ways more vulnerable against attacks than more robust shore-based institutions. Thus, moving the perimeter for attacks to shore is normally a good idea.

1. Connectivity between ship and the external internet will increase the possibilities for hostile attacks. One possible solution is to use a secure link between ship and ship operator for all communication and then let the operator take care of external communications. Another solution is to only use outgoing connections from the ship and base the return of responses from external parties on the ship polling those parties.
2. It is of critical importance to protect OT-networks on the bridge or in automation systems from hostile attacks. Such attacks can be independent of the ship being isolated from the internet or not, as shown by the Stuxnet attack. Thus, proper design of data acquisition gateways as shown in Figure 15 is very important.
3. It is also possible to execute cyber-attacks by compromising the content of, e.g. voyage orders or other data messages from shore to ship. If the processing of these messages is automatic it will not necessarily be possible to detect illogical or dangerous content. Thus, using digital signatures to ensure authenticity of sender and integrity of data is necessary.

There are many more cyber-security issues to consider, but the above is some issues that are particularly relevant for VPR systems.

7.8 Missing standardization

As has been mentioned before, the main problem may not be lack of standards, but rather that existing standards are not used. There is a tendency in the sector to deploy local specifications rather than using standards, which is a problem for a mobility sector with a strong international presence. Ships in international trade can call on about 3000 different ports [30] and as digitalization increases, lack of international standardization will become a serious problem. International shipping is a relatively small sector with less than 110 000 ships larger than 100 GT in international trade. It is arguably too small to rely on an evolutionary approach to standardization as we see, e.g. in the smartphone domain where we ITU estimates that around 65% of the world's population owns a mobile phone and uses internet access, i.e. possibly more than 5 billion smart phones [29]. Thus, a more organized approach to standardization is needed.

However, although we have several standards that can be used, these are not always complete enough to cover all requirements for more specific applications. There is a need to continuously develop and maintain these standards. Preferably, this should be done through the main recognized international organizations like IMO, IALA, IHO, ITU, ISO, UNECE and IEC, but also other regional or more specialized organizations will play important roles.

For VPR, the specifications developed by the Smart Maritime Network [10] has been taken up by IMO's EGDH and is now incorporated in the IMO Compendium [1]. This data model sub-set will also be incorporated into ISO 28005, and that standard will include the necessary data elements within 2024 or 2025. However, there are some possible structural improvements that may be necessary that is discussed in section 8.

One should also consider including the voyage order in the standardization activities as the voyage order and VPR are closely linked and a standard for the order may also simplify automated processing of the VPR data.

8 Proposed changes in data models for VPR

Commented [ØJR1]: Legge inn bunkering rapport

8.1 Introduction

The process of incorporating the noon data report into ISO 28005 is currently ongoing, based on the data set developed by the Smart Maritime Network and as incorporated into the IMO Compendium. This section will briefly outline some possibilities for improved structuring of the ISO 28005 data model. This does not necessarily require changes in the IMO Compendium. The discussion will also include a draft outline of a voyage order.

This section will not include a detailed proposal for a data model but will highlight the main structural issues that should be considered.

8.2 A voyage order model

Figure 19 shows a possible data model for a voyage order. The voyage is identified by what ship that undertakes the voyage and the assigned voyage number. It will have a departure and arrival port if the voyage is defined according to the MRV reporting requirements. Some voyages may not have these, e.g. if the voyage represents a repositioning of a ship between two voyage charters or if the voyage is a rotation between many ports.

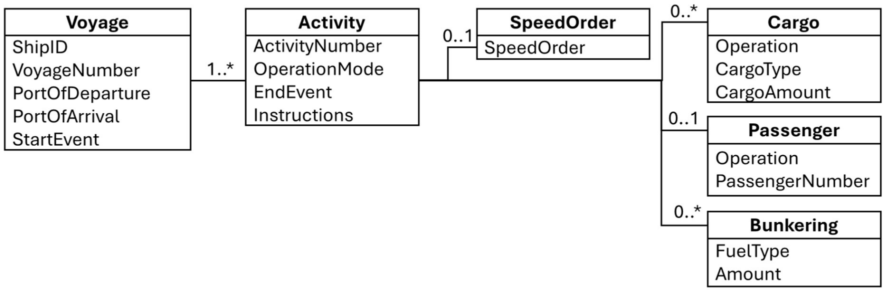

Figure 19 - Voyage model

The voyage consists of a sequence of activities, either legs or ship operations. These should form a time-wise continuous sequence of activities. Activities will have one main operational mode and will be delimited by a start event and an end event. The start event for each activity should be the end event for the previous, except for the first, where the start event is specified in the voyage object. These events will define the time and/or location where the activity starts and ends.

Each activity may also include additional instructions to the captain. Dependent on the operation mode, there will be associated speed orders (for sea legs), or orders for bunkering, cargo or passenger management (for port operations). There may also be other operational instructions, e.g. related to pilotage or use of tugs.

In this model, the integrated concept of an event as described in section 5.4.2 has been used. Thus, the event itself only defines the start or end time and/or location, while the activity defines the event type beyond the fact that each new activity starts where the previous activity ends.

8.2.1 Speed orders

For sea passages, the voyage order will normally also contain an order to the captain on how the speed should be set. Some common speed orders are listed in Table 10. Suggested codes are listed in the left-most column.

Table 10 - Some possible speed orders

Code	Order	Description
SO01	Not specified	At captain's discretion
SO02	Arrival	To arrive at destination at specified time
SO03	Ordered	Speed as ordered
SO04	MCR	Maximum continuous rating

8.2.2 Other orders

Other orders will be design according to what information that is needed. For cargo and passenger orders, this may be the terminal and berth to use, the amount to load or discharge and the type of cargo if appropriate. If the segment already specifies the terminal and berth, these may not be necessary. Bunkering and other services require similar information.

8.3 Bunkering message model

In general, the bunkering report says when fuel was bunkered, what volumes and types and what is the remaining composition of the fuel on board. In addition, it will normally contain a reference to the associated bunker notice. Figure X shows a conceptual model of the report may look.

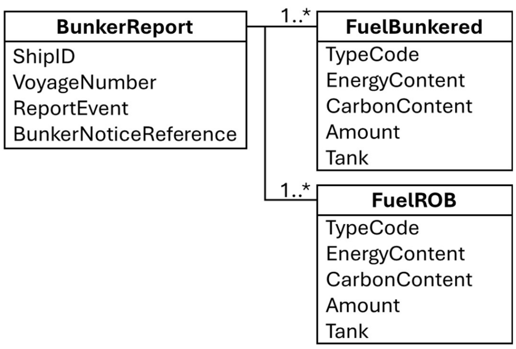

Figure 20 – Conceptual bunker report

The fuel bunkered lists all fuel types bunkered and what type it is, based on a list of predefined codes. It may also contain analysis results on, e.g. energy and carbon content. The remaining on board object lists the resulting composition of the fuel in the tanks and assigns a possibly proprietary and local code to it, to be used in further consumption reporting.

8.4 A VPR model

A VPR as described in this document will always be related to a voyage order. This means that the report itself can be simplified relative to the descriptions in [10] and in the IMO Compendium, as much of the information is in the order. However, it may be useful to include the full data set if the report goes directly to verifier (see section 3.3), if the verifier does not have access to the original voyage order.

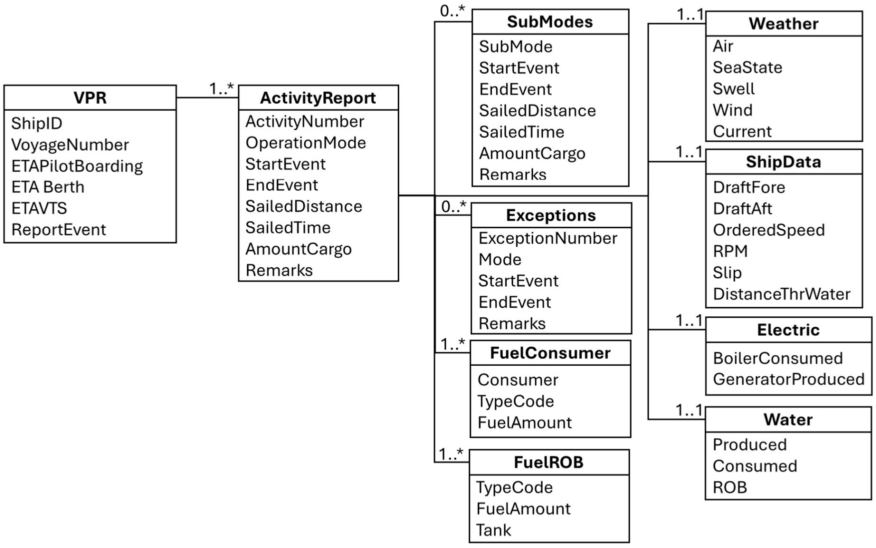

Figure 21 - Simplified VPR structure

Figure 21 shows a suggested and simplified main structure of the VPR report. Only some examples of data attributes are included in each object.

The main object points to the voyage order and includes the ship identity to make the report unambiguous. It also contains updated estimated arrival time for the next port of call as well as the reason for the report being sent (start/end, noon, other). The duration is not included as it is assumed that reports form a continuous timeline.

The activity report can contain several activities, dependent on what caused the report to be sent. Each activity contains the activity number from the voyage order, the main operational mode during the report, ETA for end of segment, sailed distance and time, the cargo onboard and any remarks.

8.4.1 Sub-modes

If required one can provide more detailed information about operations performed during the activity by listing one or more sub-modes.

8.4.2 Exceptions

This is a list of exception, i.e. deviations or exclusions. The identification number can be used to link longer lasting exceptions through several reports.

8.4.3 Weather

Data on the sea and weather during the period. This is mainly useful for reports that cover sea operations.

8.4.4 Ship data

This is data on the ship, both static and dynamic. Static data may not be required as it remains constant and can be got from other sources by the receivers of reports.

Slip is the percentage difference between speed through water and the theoretical speed given by the engine RPM and the propeller pitch.

8.4.5 Fuel consumer

This is a list of fuel consumers and how much and type of fuel they have used in the reporting period. The type code is from the bunker report.

8.4.6 Fuel ROB

This is a list of fuel remaining onboard. The type code is from the bunker report.

8.4.7 Water

This is an overview of potable water onboard.

8.4.8 Electric

Electric power generated and consumed.

References

[1] IMO Compendium on facilitation and Electronic Business, https://imocompendium.imo.org/public/IMO-Compendium/Current/index.htm

[2] ISO 28005 Ships and marine technology – Electronic Port Clearance. Part 1: Message structure and transport protocol, Part 2: Core data elements.

[3] International Hydrographic Bureau (IHB), Hydrographic Dictionary, Part I Volume I, English, S-32 Ed. 5, 1994.

[4] UNECE Multi-Modal Transport Reference Data Moel (MMT-RDM), https://unece.org/trade/uncefact/rdm

[5] MRV – Monitoring, Reporting and Verification (EU and UK), https://www.dnv.com/maritime/insights/topics/mrv/index.html

[6] Guidance MIN 669 (M+F) Amendment 1 - Reporting emissions data into the UK MRV regime, https://www.gov.uk/government/publications/min-669-mf-amendment-1-reporting-emissions-data-into-the-uk-mrv-regime/min-669-mf-amendment-1-reporting-emissions-data-into-the-uk-mrv-regime

[7] Definition of arrived ship, https://www.handybulk.com/arrived-ship/

[8] Just In Time Arrival Guide, Barriers and Potential Solutions, Global Industry Alliance and IMO, 2020. https://wwwcdn.imo.org/localresources/en/OurWork/PartnershipsProjects/Documents/GIA-just-in-time-hires.pdf

[9] IMO Resolution MEPC.278(70), Amendments to MARPOL Annex VI (Data collection system for fuel oil consumption of ships)

[10] Smart Maritime Network, Standardised vessel data set (SVD) for noon reports, https://smartmaritimenetwork.com/standardised-vessel-dataset-for-noon-reports/

[11] BIMCO Contracts and clauses (not all charter parties, but many), https://www.bimco.org/contracts-and-clauses/bimco-contracts

[12] DNV guidelines to IMO DCS – Data Collection System, https://www.dnv.com/maritime/insights/topics/dcs/FAQs-IMO-DCS/

[13] STCW Convention, Annex 1, Part A, Chapter VIII/2 - Voyage planning.

[14] IMO Assembly resolution A.893(21) , adopted on 25 November 1999, Guidelines for voyage planning

[15] Resolution MSC.530(106)/REV.1, performance standards for electronic chart display and information systems (ECDIS).

[16] SOLAS Convention, Chapter V - Safety of navigation, Regulation 28 - Records of navigational activities and daily reporting.

[17] IHO Hydrographic dictionary S-32: http://iho-ohi.net/S32/engView.php

[18] ISO/IEC 19987:2017 Information technology - EPC Information Services (EPCIS) Standard.

[19] IMO FAL 48/6/5, IMO data set on Noon Data Reporting, Submitted by Singapore, UNECE, ISO and BIMCO, January 19 2024.

[20] Energy LEAP Vessel Emissions Reporting Standard, version 1.0, November 2023. Available from https://www.energyleap.org/energy-leap-publishes-vessel-emissions-reporting-standard-vers-1-0/.

[21] ISO/IEC 21778:2017 Information technology — The JSON data interchange syntax

[22] IMO FAL.5/Circ.40, Revised IMO Compendium on Facilitation and electronic trade, 4 July 2013.

[23] WCO Data Model, https://www.wcoomd.org/datamodel

[24] ISO 19847 Ships and marine technology — Shipboard data servers to share field data at sea.

[25] ISO 19848 Ships and marine technology — Standard data for shipboard machinery and equipment.

[26] IHO S-100 Universal Hydrographic Data Model, https://iho.int/en/introduction-0

[27] IEC 63173-1 Maritime navigation and radiocommunication equipment and systems - Data interfaces - Part 1: S-421 route plan based on S-100.

[28] UNCTAD Review of Maritime Transport 2023, https://unctad.org/publication/review-maritime-transport-2023

[29] ITU, Measuring digital development - Facts and Figures 2023, https://www.itu.int/hub/publication/d-ind-ict_mdd-2023-1/

[30] Lloyd's List, Ports. https://directories.lloydslist.com/port