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Port Collaborative Decision Making Description

Co-financed by the European Union
Trans-European Transport Network (TEN-T)
## Document Status

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1 General Information

The Sea Traffic Management (STM) concept has been introduced by the MONALISA 2.0 project. An overview description of STM can be found in the document “Sea Traffic Management – a Holistic View.”

Within STM, four enabling strategic concepts have been identified as crucial for reaching the target values. These are:

• Port Collaborative Decision Making (PortCDM), in which the process for arrivals and departures is made more efficient through information sharing, common situational awareness and improved processes;

• Strategic Voyage Management (SVM), which deals with route planning, route exchange and route optimization before the voyage has started;

• Dynamic Voyage Management (DVM), which deals with route planning, route exchange and route optimization whilst the ship is on its way;

• Flow Management (FM), which includes services that will support both land organisations and ships in optimizing overall traffic flow through areas of dense traffic and areas with particular navigational challenges.

These are all enabled by:

• Information sharing by Sea System Wide Information Management (SeaSWIM), which intends to be a common framework for information sharing and service distribution for maritime activities.

This document focuses on the definition and operational services included in the PortCDM concept.

For a common, up-to-date list of abbreviations and definitions, please see The MONALISA 2.0 Definitions and Abbreviations List (STM Wiki, 2015).
2 Introduction

2.1 Background

One objective of Sea Traffic Management (STM) is to increase the efficiency of operations during sea voyages and in ports. The benefit is the maximized utilization of port facilities and resources and the minimized use of energy to steam between two ports, constrained by safety considerations. It has been estimated that the bunker cost to steam between two ports constitutes between 35-70 % of a voyage’s total cost (Stopford, 2009; Wigforss, 2012). From a port-to-port (gate-to-gate) perspective, the actual sea voyage is estimated at 27% of the full cost (Anderson & Wincoop, 2004) (see Figure 1).

![Figure 1: Cost distribution of sea transport (Lind et al, 2015a)](image)

Overall, STM will contribute to environmental sustainability, operational efficiency, and high levels of safety during sea transports (berth-to-berth). Essential for reaching tangible effects within these areas is the ability for optimal performance of ports. Such optimized performance can be reached by having an ability to predict requested resources to be provided by different actors. Consequently, a high degree of predictability in port calls (covering events related to arrival, cargo operations and departure) is vital to enable just-in-time operations. In order to enable port calls with fast turn-arounds, continuous interactions between port actors as well as shipping companies/shipping operators are essential. Key enablers are green steaming and a high degree of predictability resulting in just-in-time operations, minimal waiting times, and optimal resource utilization (see Figure 2).
PortCDM relies on continuous interactions between the maritime actors involved in a port call. As each port is a multi-organisational actor, this concerns interactions between different actors within the port, between the port as a whole and its surroundings, and between different ports.

In order to ensure environmentally sustainable solutions, green steaming is preferred when appropriate. Green steaming is the approach adopted for slowing down the last miles of the sea voyage before reaching the port of destination due to an agreement with the port of when to berth (cf. Watson et al, 2015) (cf. 2.3.6 below). This can enable a substantive reduction of fuel consumption and consequently a reduced environmental impact. This is well in line with approaches to virtual arrival. Virtual Arrival is “a process that involves an agreement to reduce a ship’s speed on voyage to meet a revised arrival time when there is a known delay at the discharge port” (OCIMF, 2010, pp.6). In terms of operational efficiency, affected stakeholders, such as the ship itself, shipping companies, ship operators, towage companies, pilot organizations, terminals, and the port, need to coordinate closely to execute each step of a sea voyage. Thus, four major objectives of STM, in which PortCDM plays a key role, are to:

- Provide a basis for best routing, resulting in optimal voyages which optimize the use of energy or have the most cost-efficient routing.
- Synchronize the port call between ship arrival and port readiness in order to enable Green Steaming in the latter stage of a voyage.
- Enable a fast turn-around process by giving a port’s various service providers the information to permit just-in-time operations.
• Synchronize the processes related to departing and arriving ships and port readiness.

One essential need is, therefore, that actors involved in a port call share information about different states (e.g., ETA, desires of when a certain state is to be reached, commitments related to certain terms of condition, and the changes of the different states that have occurred). Inspired by the aviation industry (Airport CDM), http://www.euro-cdm.org, this collaborative approach to information sharing and decision-making has been coined PortCDM (Port Collaborative Decision Making).

There are several similarities between Airport CDM and (sea) PortCDM, including:

• Airport and Port Collaborative Decision Making (PortCDM) aim at improving Traffic Flow and Capacity Management by reducing delays, improving the predictability of events, and optimizing the utilization of resources.

• Airport and PortCDM allow Airport/PortCDM Partners to make the right decisions in collaboration with other Airport/PortCDM Partners, by knowing each other’s preferences and constraints as well as their actual and predicted situations.

• The decisions made by the Airport and PortCDM partners is facilitated by the sharing of accurate and timely information and by adapted procedures, mechanisms and tools.

The Airport Collaborative Decision Making (A-CDM) is developed and designed in a joint venture between the Airports Council International Europe (ACI EUROPE), EUROCONTROL, and the Civil Air Navigation Services Organisation (CANSO). The A-CDM concept builds upon improved real-time information sharing between airport operators, aircraft operators, ground handlers and air traffic control. The concept involves implementation of a set of operational procedures and automated processes that aims to improve the operational efficiency of all airport operators by reducing delays, increasing the predictability and optimising the utilisation of resources. European Air Traffic Flow Management is enhanced by a close coordination with CDM Airports; this consists mainly of sharing predefined time elements which address predictability and updates of actual events at the airport.

(Sea)PortCDM needs to develop a distributed coordinating structure to support maritime operations in the best way and respond to market forces. In this way, PortCDM can contribute to improved real-time information sharing between relevant actors on ship and at port including the presence of competing autonomous agents.

Ports do not exist in isolation. Without shipping companies, ports and cargo owners (transport buyers) have no reason to exist. The same goes for shipping companies – they depend on cargo owners and port operators. For the purpose of defining Sea Traffic Management within MONALISA 2.0, this phenomenon of stakeholder/actor relationships has been coined an inseparable trinity (Figure 3).
2.2 Context and Scope

The final departure of a ship is often a result of negotiation between port actors and the ship/cargo owner. For example: a cargo handling is planned to be completed the next day and all parties are informed accordingly; but if some part can gain economically by having the ship sail as soon as possible, they can decide to bear the cost for the stevedores overtime (OT) and have the ship sail later the same evening instead. Many negotiations of this kind take place today. PortCDM is a means for sharing information about such re-planning and the subsequent consequential actions.

PortCDM is a response to deficiencies conceived in the following problem areas:

- Information harmonization:
  - Each actor has its own conception of a time stamp and has its own understanding of a certain state change (e.g. ETA).

- Information redundancy:
  - Multiple sources of the same information.
  - Unclear picture of which actor’s time stamp should become the governing one.
  - Multiple reporting among the actors of the same information.

- Information reliability and actuality:
  - Insecurity of whether one actor’s information about a state change is reliable.
  - Real-time data is not used for coordination.

- Predictability:
  - Low ability to predict the time of occurrence of, and necessary resources for, different forthcoming process steps due to the lack of communication regarding different state changes.
  - The lack of shared port call information among actors.
  - Low ability to predict the estimated time of departure, which can lead to a domino effect.
• Administrative burden:
  o The long-term and operative synchronization of the port call is based on time-consuming and inefficient manual dyadic interaction.

• Waiting times:
  o Badly coordinated port calls result in unnecessary waiting times for different actors, thus making available resources idle.

As Port and Maritime Authorities, VTS, health inspectors, customs, and the police, due to ISPS regulations or other reasons, provide permission to enter or leave the port, such conditions need to be reflected and influence the estimate of when a particular state can occur. Added to this mix are actors of both major influence—such as pilots, agents, terminals, and tugs—and of minor influence, such as linesmen. Even though linesmen have a minor influence, their role is important in enabling an arrival to, and departure from, the berth. Other factors, such as tidal windows, are in many ports another influential factor for when certain states can occur. To summarize, many influential factors (regulations and incentives) need to be shared among the different actors in order to optimise arrivals and departures.

Coordination requires that the destination port communicates its resource availabilities to approaching ships and matches this with ships’ needs. Such an integrative approach would close the loop in STM, expanding and acknowledging the need to interact with the port of destination to enable efficient and sustainable sea operations. Due to the non-uniformity of ports operations, the question of what to communicate and how digital collaboration could be established (inside the port and in relation to other actors) is unresolved. STM enables ports to subscribe to information about upcoming port calls. A port call message should be initiated automatically as soon as the port of destination is decided upon by the shipping company and entered into the ship’s navigation system by the captain.

A port call encapsulates the activities performed prior, during, and after the (physical) turn around process (Figure 4) (cf. Lind et al, 2015a). A port call process is initiated by the first ETA-announcement about a ship steaming to the port, and is often bundled with a port call request. Thus, port calls are, information-wise, initiated well before the actual physical approach.
The ability to accurately predict times for when diverse operations should occur in port calls is made difficult by the numerous actors involved and the lack of situational awareness. It should also be emphasized that the willingness to share information with others parties is low due to the market characteristics of maritime transport. It is often claimed that the sharing of data might create a competitive disadvantage. However, real-life tests of PortCDM reveal that the sharing of real-time data (related to states in the port-call process) provides a solid basis for establishing a common situational awareness amongst actors to optimize their operations and thereby enable an efficient turn-around process. By knowing others’ intentions and performances related to states in the port call process, just-in-time operations can be performed and wait times reduced to a minimum. The resistance to sharing data is thus possible to overcome when it becomes clear that only partial information need be shared and that the benefit from sharing the data is great. Sharing state-related information by putting that information in a larger perspective is important for increased efficiency and competitiveness for each stakeholder.

PortCDM enables ports to be efficient in their operations; at the same time, shipping companies are given a good basis for optimizing sea voyages by being enabled to come to an agreement with the port of when to arrive as early as possible in the planning process. In the realization of STM, the integration with ports is vital. Thus, each ship needs to clearly communicate its intentions and needs as soon as possible in order to enable the port a complete picture of future resource demand so that it can plan accordingly.

Physically, a port approach is initiated by a ship reaching the traffic area outside the arrival port, and concluded by a ship’s departure from the same port after fulfilling the purpose of its visit. During a port call there are numerous actors engaged in enabling an efficient, smooth approach. This requires providing sufficient data, constituting images of situational awareness, in order for potential and involved actors to plan and optimize their operations. Given all these requirements, a port call needs to be initiated well in advance of the ship’s physical arrival to the port. However, how information about intentions, needs, and changes can be shared amongst involved actors well in advance of the port approach is an unresolved issue. Today there are numerous systems that partly enable such objectives, as, for example, Single Window, Port Control Systems, and Port Community Systems. None of these, however, provides a common approach to the real-time sharing of information which
covers the whole port call and the emergence of situational awareness as the foundation for distributed coordination. PortCDM information services build on information regarding existing systems and complement these systems by enabling the extraction of information from PortCDM services.

Even if the number of port approaches has decreased due to the increased capacity of individual ships, many approaches are performed without a reliable measure of when a ship can leave the berth. This often causes delays for new arrivals to the berth, and can lead to escalated delays in the port-planning operation. In order to increase the predictability of the estimated time to berth for a certain port approach, one important issue concerns when the former ship occupying the berth can vacate the space for the next approaching ship. It has been acknowledged that the ETA (to the traffic area/port limits) for a ship corresponds most of the time with the actual time of arrival. The problem much of the time centres on the inability to predict when the berth will be available for the ship.

2.3 The Fundamentals of PortCDM and Expected Outcome

2.3.1 The Port Call with Desired States

PortCDM is a concept for increased digital collaboration among actors involved in a port call. PortCDM is defined by a number of services facilitating actors’ collaboration prior, during, and after a port call. The foundational logic in PortCDM is defined by a port call process instance, state chart, actor collaboration principles, and standardized information exchanges and message formats.

The Port Call Process Instance is used as the backbone in the collaboration, capturing the main activities or events applicable for a specific port call. The Port Call Process Instance also reveals the actual dependencies amongst the activities or events identified. A port can have several port call instances due to different cargo types, ship types, and other aspects stressing divergences in the port call logic. A configured Port Call Process Instance is created when the port call is initiated and is valid through the entire port call lifecycle. The Port Call Process Instance is also used to identify involved actors in a specific port call.

Based on the Port Call Process Instance, relevant states are identified and mapped into a state chart capturing interrelations and conditions for interpretation and use. A common measurement system of states and coordination points thus constitutes a core element of PortCDM. A state represents the condition of a social or physical fact, such as a requested tug by someone directed to someone else (social fact), or a ship being present at a particular geographical spot at a particular time (a physical fact). The effect of every action is a state transition (Dietz, 2001). A particular transition (e.g., requesting pilotage by the ship agent from the pilot organization at a particular point in time) is an event. Consequently, states are events that actors involved in the port call are able to estimate. States are important milestones in a port call and are sequentially described and clustered into coordination points. A coordination point is a critical point in a port call with the need for a high degree of organisation since it is dependent on the performance and coordinated action of several actors—for example, the arrival to a pilot station, which requires the
simultaneous arrival of the ship, the pilot, and sometimes one or more tugs. These types of consolidating states are referred to as coordination points. The state chart is used to identify the information exchanges among involved actors in a port call and its position in a port call process. Both the Port Call Process Instance and the State Chart are used as a basis to define the collaboration logic, e.g. who the collaborating actors are, when collaboration should take place, and what to collaborate about.

In order to ensure that different actors are striving to reach a certain state (in time and place), there must be a common understanding of the conception of different states. Further, in PortCDM the dependencies between different states and coordination points during a port call related to different actors are the basis for enabling the planning and realization of just-in-time operations.

This means that a port, often the port administration, needs to ensure that its port and the actors involved in its activities are prepared for arriving and departing ships so that port operations related to those ships can be executed as efficiently as possible (i.e. they can ensure a fast and efficient turn-around process). The same goes for hinterland transportation (both inbound and outbound), which means that ports have dual, inter-linked turn-around processes. This requires the coordination and planning of the integration of different operational processes within and outside a port. Important coordination input for such planning, that have their origins with actors operating outside the port is, for example, information about when the ship is about to reach the port.

PortCDM thus builds upon visualizing desired states to enable different operators to act in such a way that the port call (arrival, at berth, cargo operations and departure) can be performed as just-in-time as possible. The overall goal is that involved actors can trust the prediction of when a certain state will be reached, and thereby optimize their performance in time—not too early, not too late—as well as with their optimal capacity. In PortCDM, so far the interface to the port has been identified in relation to ships’ operations. This, among other effects, is to enable green and optimal steaming.

The design idea is formed by shared information: at the initiation of the sea voyage (by the voyage order and first route planning), different PTAs (planned times of arrival) and ETAs (estimated times of arrival) to waypoints and the destination are made available via SeaSWIM (as a representation of a common data sharing and service distribution environment) (Lind et al., 2015b). The destination port subscribes to this data and sets up an instance of a network of inter-related states (cf. Figure 5) to be reached for the particular port call with status objects that need to be “green,” it also indicates availability at the time of arrival to port.
Figure 5: States and coordination points for the port call process (Lind et al, 2015ab)

Figure 5 depicts possible states and their dependencies on a port call constituting the basis for the process example. Of course, not all states depicted in this generic diagram will be used in every port. Ideally, many of these states should occur in parallel and in sequence for milestones to be reached smoothly. The different states also depend on each other time-wise; for example, booking a pilot should be followed by the pilot’s confirmation, and a terminal needs to confirm when it is ready to receive a ship at berth based on the ship’s ETA.

2.3.2 Continuous Sharing of Intentions and State Changes

To reach the full effects of STM and thereby enable sustainable sea transport processes, high accuracy (based on accurate estimations) related to berthing, unloading, loading, and departure, becomes necessary. Successful planning for the actual sea voyage can be established by enabling high accuracy on the arrival, port operations, and the departure. In order to ensure a reliable collaboration of high quality information sharing however, conditions and rules for information access and information usage must be determined and specified. Such information-sharing principles and their framework should replicate actors’ agreements of shared data and data utilization for different purposes. Access control and information management are thus key to ensure a high quality and reliability in information shared among actors.

PortCDM builds upon the logic that communication about upcoming port approaches and the changes to these plans are made as early as possible (both from the ship and the port’s point of views) (Lind et al, 2015a). In order for a port to optimize its operations, it is thus essential to receive real-time information about the status of different operations/transports (together with updated estimates) that affect the operations within the port. This means that the same measures function both as a coordination mechanism for optimizing port operations (and creating readiness for
managing necessary loading/unloading operations), and as boundary objects towards other actors outside the port for their optimization. These boundary objects are relational measures for enabling collaboration/optimizing between different areas of operation. To enable optimal just-in-time operations, intentions and state changes need to be shared among involved actors.

Different planning horizons are associated with different levels of tolerance for deviation between the estimated and actually-reached states (the outcomes) (see Figure 6). The deviation should diminish with time: the closer to the Execution Phase, the smaller the tolerance for deviation should be, until the actual moment of occurrence is reached for a certain state. This allows for a planning process with different time horizons (i.e., long-term, mid-term, and short-term), to be performed optimally, as it is based on the information about the interval of the outcome (e.g., a time span of the reaching of a certain state). Sea transportation is a multi-organizational business with numerous actors positioning and coordinating their performance in relation to different coordination points. Related to STM, PortCDM closes the loop in the transport chain by establishing conditions which can increase the sustainability of sea voyages. STM will be realized by sharing information about status and values related to the identified coordination points (e.g. states) for a particular voyage.

Figure 6: Acceptable deviation between estimate and actual occurrence (in different time slots) (Haraldson & Lind, 2005)

In order to avoid re-planning multiple times due to small changes such as updates on the estimates of when a certain state is to occur, PortCDM provides a built-in inertia by using thresholds for when counter-actions (i.e., updated commitments) are needed. The thresholds to be applied have their bases in time frames of when different actors can perform their operations. Analytically, the different time frames of when a particular actor can perform its operations should overlap, as long as it is
still possible to perform the operations due to changes in estimates (e.g., an earlier or delayed approach to the traffic area/port limits).

2.3.3 Minimized Administrative Burden by Deriving Information from Diverse Port Systems

To enable a decreased administrative burden in its introduction, PortCDM needs to be interrelated with existing systems to ensure a single point for reporting/providing intentions. This could be enabled by a systematized structure of the related principles of data-sharing between relevant systems (cf. Figure 7), enabled by implementing connectors into different systems. These connectors are then further utilized in different information services which withdraw and/or distribute information from/to connected systems. As further elaborated below, this information is to be transmitted between the different systems and the PortCDM information service system by a standardized port call message format and in a SeaSWIM-compliant way.

![Diagram](image)

*Figure 7: Integration with port information environment (Lind et al, 2015b)*

2.3.4 Nomenclature for Time Stamps

Important enablers for collaboration are standardized APIs, the common nomenclature for information messages and in the common measurement system. These are the standardized message formats for port calls. PortCDM relies on continuous interactions between the maritime actors involved in a port call. As claimed above in section 2, interactions are constituted by intentions about actions to perform, as well as achieved states and coordination points. Interactions are
comprised of inter-related actions that come in pairs of initiatives and responses (cf. Linell, 1998). A message is constituted by a message part (the propositional content) with a communicative intent (illocutionary force), issued by a communicator and directed to one or several addressees; this results in a communicative state (Austin, 1962; Searle, 1969). An example would be a ship operator (the communicator) issuing a planned time of arrival to a certain geographical location (the message part), with the intent to request cargo operations (communicative intent), addressed to the agent (the addressee). The communicative state established is that a plan for a port call has been agreed upon among several actors. Communicative acts are multifunctional, meaning that a communicative intent might well be an expression for another intent; the plan for a port call also means that the ship operator intends to be at a location at a particular time. Further, a first message serves as a trigger for a response to become a new initiative. The logic of inter-related initiatives and responses constitute interactions (see Figure 8 below).

Figure 8: Messages constituting interaction patterns as initiatives and responses (Lind et al, 2015b)

Portcall Message Standard Format

In the standards of different time stamps, set by, for example, BIMCO and FONASBA, the estimated time of arrival (ETA) is a typical one. A Time_Type (ET), a Time_Sequence (A), and a Location (e.g., the pilot station), constitute the ETA as a timestamp. Naturally, the ETA also refers to a certain time of occurrence and to a particular reference object (e.g., the ship) (cf. Lind et al, 2015a). The message incorporates the communicative intent/communicative state by the time communicative intent. Because the ETA is what the on-board systems aim towards, due to diverse contextual factors (such as other traffic and weather conditions), the planned time of arrival is used as the timestamp for the effort the ship makes to match its ETA. The following time types have been identified as important for enabling efficient coordination of the port call:

- ET - Estimated Time: The times at which a particular actor aims to be at a certain location / perform operations.
• AT – Actual Time: The time when an actor is at a certain location / performs operations. The actual time is used for evaluation based on the actual occurrence related to planned and/or estimated times. Actual times can also be used for billing, logbooks and/or statements of facts.

• RQ – Requested time: The time requested for another actor to perform operations.

• CO – Confirmed time: The time confirmed/committed to by another actor to be at a certain place / perform operations.

In the message, therefore, the communicative intent / state is captured by the following types:

• PT – Planned Time: A status indicating that a particular actor has committed to be at a certain location / perform certain operations.

• RQ – Requested time: A status indicating that an actor has requested times regarding a certain location/ time for performing certain operations.

• CM – Committed Time: A status that indicates that an actor has committed to be at a certain place / perform certain operations.

• CD – Communicated Time: A status indicating whether the time has been communicated to other actors, with or without any response.

• RE – Recommended Time: A status indicating a time recommended for another actor to be at a certain location / perform operations.

Two sets of time sequences have been identified in order to reflect if the subsequent category is a certain location or a service/process. The first set of time sequence is used to define the events for a certain location, using Arrival or Departure. The latter set defines services and/or administrative processes as started and/or completed. This also means that International Ship and Port facilities Security codes (ISPS) as well as Police Go Ahead (GA) can be reflected as parts of the states in the port call process.

In Table 1 below, we summarize different variances of the categories used for expressing a certain state based on the timestamp. Timestamps are thus combinations of the instances of the different categories expressed in the proposed nomenclature (building on Lind et al 2015a). This nomenclature includes the categories necessary for a port call message. In Table 1 (below), the variances for the different categories are summarized.
Table 1: Instances of categories constituting the timestamp (based upon Lind et al, 2015ab)

<table>
<thead>
<tr>
<th>Time Type</th>
<th>Time Sequence</th>
<th>Location/Service/Adm</th>
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<th>Reference Object</th>
<th>Information Provider/Consumer</th>
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<tr>
<td></td>
<td></td>
<td>PA [Port Area]</td>
<td>SH [Shared]</td>
<td>SD [Stevedore]</td>
<td>PA [Port Authority]</td>
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<tr>
<td></td>
<td></td>
<td>AA (Anchoring Area)</td>
<td>CD [Communicated]</td>
<td>TE [Terminal]</td>
<td>PC [Port Control]</td>
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Bringing the Communicative Act and Digital Data Streams to a Port Call Message Standard

To establish a standard format for messages, the following format is being used: **who** (information provider) *has said* **what for which purpose** (message) *to whom* (addressee/information consumer) *at what time* (time reported) *being at what location* (reported location).

To adopt this to STM and PortCDM it is further essential to include the source of the information and associate the call with the unique voyage identifier, as proposed in MONALISA 2.0. For the purpose of tracking the different port call messages, a unique port call identification and a voyage identifier is used. In the port call message, the time that the message concerns as well as the time reported is included. The information consumer is built upon the same instances as the information provider.

Building on the elements of digital data stream segments (cf. Watson, 2014) and stressing the communicative intent / state (Austin, 1962; Searle, 1969) in the interactions (Linell, 1998), a port call message is thus constituted as follows (cf. Figure 9):
2.3.5 Deriving Messages from Existing Systems

The main purpose of PortCDM is to go from a situation which is rather unstructured and that, to a large extent builds upon dyadic interactions, to a situation where the communication is standardized and the sharing of updated information is in one dyadic interaction instantly spread to other actors (see Figure 10).

This also has the benefit of enabling more efficient information distribution by avoiding multiple dyadic interactions, as well as that of making it possible to have a single point of registration. Dyadic interactions are however acknowledged.

PortCDM does not manages different assignments between different actors, but rather derives information from existing systems and uses that as a basis for providing information services for planning, efficient realization, and evaluation. At the core of PortCDM is the goal to enable situational awareness derived from multiple information sources.

Figure 11 (below) depicts how on-going interactions between different actors are captured in diverse systems, such as ship management systems, Single Window, SafeSeaNet, Port Management Systems, and planning systems for different actors,
and then gathered for the provision of PortCDM information services. These information services are then further used in different PortCDM application services which support operational services.

![Diagram of Port Call Message Format]

*Figure 11: Deriving data from existing systems using the Port Call Message Format for PortCDM information services used in application services (Lind et al, 2015b)*

### 2.3.6 Positioning Interactions for the Optimal Port Call and Green Steaming

It has been noted in Holm (2015), that green steaming is an appropriate way forward to save bunker fuel. The analysis shows that of the approaching ships during August 2014, 17% anchored outside the port waiting to get access to port services (this figure would be even higher for congested ports). By enabling communication between the ship and the port prior to the arrival about when berthing can take place, the ship can slow down in the latter part of the voyage, i.e. it can perform green steaming. The same analysis also shows that by factoring in the average anchoring time of these ships, 18 hours, they could have slowed down by 2.8 knots (on average) the last 227 NM by taking into consideration the speed profiles of the particular anchoring ships. It is important to note that this analysis is made using the actual speed profiles of the ships (based on AIS data), which is why aspects such as the optimality in catalyst operation and propeller performance for the specific ship are taken into consideration. The analysis does not, however, take different reasons for anchoring into consideration.

Using PortCDM to enable just-in-time operations is highly possible for two reasons; PortCDM enables port actors to set up a readiness to handling the incoming ship...
efficiently, and interaction between the ship and the port is enabled via PortCDM information services (See Figure 12 below). In the figure below, Planned Time of Arrival (PTA), as the goal value in the Electronic Chart Display & Information System (ECDIS), is established at the beginning of the voyage, and then changed during the latter part of the voyage due to recommendations made by the port (RTA). Estimate Time of Arrival (ETA) is used to show the deviation from the Planned Time of Arrival (of the ship), but it is also used for providing diverse actors with information about when the ship is estimated to be at a particular location. This information, together with information about actual occurrences (ATA), is derived from ECDIS. Whether the PTA or ETA is distributed to the ship agent (potentially via the shipping company), it is ensured by the access management and collaborator nomination services enabled by SeaSWIM, as a concept of Sea Traffic Management.

![Diagram](image)

**Figure 12: Interaction between ship and port for optimized just-in-time approach (based upon Lind et al, 2015b)**

### 2.3.7 Situational Awareness for Involved Actors in the Port Call

The coordinated port call builds upon a series of inter-related requests and commitments made by different actors (cf. the CFA-schedule according to Winograd & Flores, 1984). The port is to be conceived of as a multi-organisational business network (cf. Haraldson & Lind, 2010) where each actor needs to coordinate its efforts. In the left part of Figure 13 below, a typical assignment logic for a port, i.e. inter-related communicative acts, between core actors is depicted. The ship agent constitutes the interface to the shipping company and the ship. These interactions differ depending on how far away in time the port call is expected to occur, as, for example, port operators such as pilots, tugs, and linesmen commit to their task rather soon before the physical port approach, the ship agent needs to confirm with
the terminal that there is room for the port call. Readiness for an upcoming port call is based on the communicative acts of **requests** and **commitments**, based on **shared information** reaching **agreements**. During the port call, the state of **actual** expresses that a certain state has been reached (ATx); a **report of completion**. A request could be based on a recommendation derived by the main actor (or the co-ordinating actor) of the multi-organizational business network (cf. Haraldson & Lind, 2010) constituting the port.

![Figure 13: Typical assignment logic during port call (from current situation to PortCDM enabled situation)](image)

Introducing PortCDM (see right section of Figure 13) still means that an assignment logic must be established for the planning and realization of the efficient port call. It is essential to see that there will be a shift from dyadic interactions; that is, agreements between two actors. Instead interactions and new agreements could instantly be shared by the PortCDM publishing services. Other involved actors could then subscribe to certain events and get information when there is a change that is of interest to that actor.

This means that PortCDM builds upon capturing and visualizing different communicative states of a particular state and/or coordination point. Derived from the discussion above, this means that a certain time type, i.e. estimated, planned, actual, and recommended, could be requested, committed, shared, and agreed. Messages which relate these communicative intentions to each other resolve in patterns that most often are unique for each port due to contextual factors, the port characteristics, and the role that different actors undertake.
3 Service Descriptions – Operational Services

3.1 Operational Service: Port Call Synchronization Service

**Objective:** Coordinate the vessels approach with port of readiness. Enable the vessel to set the accurate speed for just-in-time approach to the "service meeting point" e.g. traffic area/pilot station. Enable each involved Port Call Service Provider to plan in advance enabling optimized turn-around times and optimized resource utilization.

**Description:** The synchronization is enabled by coordinating service planning and realization (requested needs and available capacity) for involved actors, using information about service realization (time, spatial and infrastructure) as the basis.

**Service provider:** Port Authority or Company/ Private Service Provider

**Area of operation:** Berth to Berth

**Using:**
* Port Call Optimization Service (O-Service)
* Port Call Planner (I-Service)
* Actors’ distribution of intentions of providing operational services providing indications of when the port is ready to take the port call.

The Port Call Synchronization Service has the objective to coordinate the ship’s approach with a port in a state of readiness. The service enables the ship to adjust its speed for a just-in-time approach to the agreed service meeting point (e.g. traffic area/pilot station/berth) and for involved Port actors to plan well in advance. Hence, the Port Call Synchronization Service enables optimized turn-around times and optimized resource utilization.

The synchronization is enabled by coordinating service planning and realization (requested needs and available capacity) for involved actors, using information about service realization (time, spatial and infrastructure) as the basis. The service is therefore applicable throughout the entire port call process (berth-to-berth), encapsulating communicated times for service requests and utilization.
### 3.2 Operational Service: Port Call Optimization Service

**Objective:** To coordinate and adjust actions related to other actors’ shared intentions and performances, based on the set of states for a particular port call.

**Description:** An optimization service for planning and on-going activities for actors involved in a port call, based on an instantiated generic port call process.

**Service provider:** Port authority or company/private service provider

**Area of operation:** The turn-around from arriving to the traffic area / pilot station, to departure from the traffic area / pilot station.

**Using:**
- Port call synchronization service (O-Service)
- Port Call Manager (I-Service)

The Port Call Optimization Service has the objective to coordinate and adjust actions related to other actors’ shared intentions and performances, based on the set of states for a particular port call. The service facilitates planning and on-going activities for actors involved in a port call, based on a port call process instance. A Port Call Optimization Service advises actors and suggests actions based on process knowledge and actors’ intentions and performances, which allows actors to communicate and thereby optimize their performances. Different scenarios are outlined and simulate subsequent effects based on variable input parameters.

The service is applicable throughout the entire port call process (berth-to-berth), encapsulating communicated times for service request and utilization.
3.3 Operational Service: Port Call Monitoring Service

**Objective:** To provide situational awareness for upcoming and on-going port calls and actors’ performance, to enable involved actors to monitor particular (and/or parts of) port calls (based on each actors’ accessibility to provided information).

**Description:** This service provides real-time images of the status (desired, committed, fulfilled actions by different actors) of upcoming and on-going Port Calls. Provide basis for monitoring, coordination, and optimization.

**Service provider:** Port authority or company/private service provider

**Area of operation:** The turn-around from arriving to the traffic area / pilot station to leaving from the traffic area / pilot station after loading/unloading

**Using:**
- Port Call Synchronization Service (O-Service)
- Port Call Optimization Service (O-Service)
- Port Call Manager (I-Service)
- Update state (I-Service)

The objective with the Port Call Monitoring Service is to provide a basis for common situational awareness for upcoming and on-going port calls and actors’ performance, to enable involved actors to monitor and be informed by a (and/or parts of a) particular port call, based on actors’ access rights to the provided information.

A Port Call Monitoring Service is based on the port call process instance and the state chart; situational awareness is created by indicating status through real-time images about the status of upcoming and on-going port calls and/or aggregations of port calls.

The information represented in a view differs depending on actors’ preferences, role and access rights. A Port Call Monitoring service can be used as a basis for monitoring, coordinating, and optimizing performances related to specific port calls and/or different aggregations of port calls. In the configuration of the service, a set of indicators (green, yellow or red) are selected and the rules and conditions for the application are defined; e.g. acceptable deviations for certain time stamps related to specific time slots, mandatory information for certain process steps, criteria for quality determination for retrieved information, etc.

The Port Call Monitoring Service is applicable throughout the entire port call process (berth-to-berth), encapsulating estimates and actuals for certain states such as actors’ intentions and performances.
3.4 Operational Service: Port Call Improvement Service

Objective: To evaluate and propose means for optimizing future port calls.

Description: This service uses conducted port calls as a basis for evaluation to establish means for optimizing future port calls. Generic process definitions of the port call are updated and then used as the basis for future port call instances.

Service provider: Port authority or company/private service provider

Area of operation: The turn-around from arriving to the traffic area/pilot station, to leaving from the traffic area/pilot station after loading/unloading and the information exchanges related to the port call.

Using:
- Port call Optimization Service (O-Service) → to match the plan with the outcome
- Port call Monitoring Service (O-Service) → to capture different images over time
- i-services: ETAT Evaluator, RootCauseAnalyser, WaitingTimeStatistics, Process Manager, Port call status

The objective with the Port Call Improvement Service is to evaluate and propose means for optimizing future port calls. The service uses conducted port calls as a basis for evaluation to establish means for optimizing future port calls. Generic process definitions of the port call are updated and then used as the basis for future port call instances.

The Port Call Improvement Service is applicable throughout the entire port call process (berth to berth), encapsulating estimates and actuals for certain states, their intentions and performances as a basis for evaluation and, hence, suggestions for improvement and refinements.

4 Relation to other STM Concepts

The Sea Traffic Management (STM) concept relies on the unused potential in sea transports to increase efficiency through enhanced collaboration amongst involved actors. STM merges together the concepts of e-Navigation, e-Maritime and single windows reporting principles. Enabled by digital innovations, the STM concept, as a distributed service-oriented approach to Green Routing, Green Steaming, and Optimized Resource Utilization, is proposed. STM enables just-in-time operations for different actors engaged in sea transport related actions; it builds upon four concepts: Strategic Voyage Management (SVM), Dynamic Voyage Management (DVM), Flow Management (FM), and Port Collaborative Decision Making (PortCDM) (see Figure 14 below). SVM concerns strategic decisions about the voyage, such as the route to take and in which order to visit different ports dependent on diverse contextual factors. DVM focuses upon providing support for the optimized realization of the route, while FM supports the optimal coordination of multiple ships in congested geographical areas. In PortCDM, integration with the port is enabled. The
The purpose of PortCDM is to provide a basis for the collaboration between key actors within the port and towards its surrounding, and to support just-in-time and green operations (cf. Lind et al, 2015ab).

Figure 14: The four concepts of Sea Traffic Management and the expected contributions (Lind et al, 2015b)

The operational services described in the former section rely on different informational services. In the process diagram, depicted in Figure 15, these information services and their interdependencies are depicted. In the same Figure, the relationship between different actors is shown and this forms the basis for deriving the relationship to other concepts.
5 Discussion

PortCDM as an enabler for collaboration is based on the access to and the sharing of (real time) port call-related data. PortCDM is based on the assumption that the more actors that collaborate and share high quality and relevant data in real time, the better the effects will be. There are challenges concerning both actors’ willingness to share relevant information and sometimes to receive the right data in digital form. Since PortCDM is dependent on data from several actors, a service for manual data input is necessary to complement data sources not retrievable in digital form.

The effects of PortCDM increase with the number of actors applying it, which is why the number of PortCDM partners is a key challenge to gain maximal effects.

6 Conclusions

Sea transports have origins and destinations. In order to reach the performance targets of Sea Traffic Management, integration with ports is, to some extent, necessary. PortCDM serves thus as an essential mean for closing the loop in STM. Ports are arrival and departure hubs that create requirements for fast turn-around processes and actions. Ports are multi-organizational businesses with multiple actors co-producing value. The existence of multiple actors requires (distributed)
coordination. In such an environment, such cooperation relies on information-sharing between involved actors. In this description, we have elaborated on the constituents of such interaction to enable high predictability and thereby high punctuality (which can reduce waiting and anchoring times); thus, a high capacity utilization which can create the means for governing with high berth productivity. Such performance metrics would enable green and optimal steaming and thereby close the loop in the transport chain. Digitizing port operations with CDM can thus enhance the efficiency and sustainability of shipping.

PortCDM utilizes digital data sharing and collaboration between key actors engaged in the port call process to reach a desired efficiency. Taking a distributed approach to service development, dissemination, and discovery enables this. To encourage such distributed development, incentives for third-party developers need to be ensured. Two essential components become apparent: that beneficiaries acknowledge that the services that are brought into the ecosystem are credible, and that there exist standards which enable the wide-spread distribution and consumption of the services. Credibility is to be reached by a federated approach to govern service distribution, e.g. by issuing criteria for which services are qualified as STM- and PortCDM-compliant, and service realization by processes for monitoring and quality assurance. The governance of such a service ecosystem, which enables a high degree of integrity for involved participants, must ensure that the information provider remains the information owner who can regulate access to the information provided.

Standards are necessary for ensuring that the services being developed are applicable to a wide variety of users. For the purpose of reaching the effects of STM, two standard formats are essential: the route exchange protocol and the port call message standard (which are to be integrated with existing reporting formats in, e.g., Single Window and FAL). Standards come in different versions, and to establish conformity between different ports, these standards’ development must be facilitated. This also concerns the exposure of template services to be adapted to different ports and to serve as a driver for a proactive development of port call processes. Inspired by the European Airport CDM council, a European PortCDM council has been proposed to be established for the continuous development of standards, approval of new/refined services, and to share templates of service innovations.

7 References


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