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The maturity level framework for PortCDM

by

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The critical link

Because ships move about 90% of the world's goods, seaports play a critical role in inter-modal transport.[1] [2] As key linkage points in inter-modal chains, ports are an integral element of the many regional and national transportation systems. Their contribution to efficient transport operations can be improved by standardized operations and messaging for collaboration and communication with their hinterland partners and other key stakeholders. Digitization is an opportunity for enhancing capabilities among connection points and connectivity among stakeholders engaged in the maritime sector.[3] [4] [5]

The STM (Sea Traffic Management) concept aims at increasing efficiency and safety of the maritime transport chain berth-to-berth through digitizing key aspects of this mode of transportation.

Until now, there has been no unified standard for communicating plans and outcomes of operations within ports, between ports, between ports and ships, between ports and

[1] Lind M., Watson R.T., Bergmann M., Ward R., Andersen N-B., Jensen T., Haraldson S., Zerem A., Rosemann M. (2018) Digitizing the maritime eco-system - Improving door-to-door coordination via a digitized transport chain, Concept note #11, STM Validation project

[2] Lind M., Watson R.T., Bergmann M., Ward R., Andersen N-B., Haraldson S., Rosemann M., Andersen T., Delmeire N. (2018) Process completeness for effective maritime ecosystems, Concept note #12, STM Validation project

[3] World Bank (2007) Port Reform Toolkit, Module 3: Alternative Port Management Structures and Ownership Models, The International Bank for Reconstruction and Development / World Bank

[4] Gonzales F., Sanchez R. J., Garcia-Alonso L. (2016) The adaptation process in port governance: the case of the Latin Countries in South America and Europé, Journal of Shipping and Trade, 1:14

[5] ESPO (2016) European Sea Ports Organisation: Trends in EU Ports Governance 2016. European approach

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shipping companies, and between ports and hinterland operators.[6] In this concept note, we describe a framework for classifying maturity in port collaboration in the maritime sector. The work is based on findings derived from the introduction and application of Port Collaborative Decision Making (PortCDM) in the 13 ports participating in the STM Validation project, in particular Barcelona, Gothenburg, Limassol, Sagunto, Stavanger, Kvarken ports (Umeå and Vaasa), and Valencia.

A port call has three processes; the arrival (taking both pre-arrival and arrival into account), the port visit itself (where all the required services are provided to the visiting ship whether anchored or at a berth), and the departure (taking both departure and post-departure into account). A successful implementation of PortCDM supports these three processes by predicting and tracking the times and locations of all significant port visit event activities.

With the implementation of this concept – in essence by connecting ships and ports at an early stage – collaborating stakeholders can increase their operational efficiency. This means that ships can optimize their voyage plans and reduce idle time. Moreover, port actors can better plan their activities by knowing with high reliability and precision the timing of an activity. All these productivity gains create added value for each of the involved actors and the maritime transport chain in general. The desires are to get port operations more integrated into the logistic transport chain in which maritime transports constitute one link. Ports are intermediaries connecting different means of transports by enabling inter-modal shifts

Port calls at PortCDM Ports

The ports mentioned previously have matured their PortCDM capabilities as they have learned from each other. PortCDM was introduced to Gothenburg and Valencia during the spring of 2014 within MONALISA 2.0 and additional ports began participating during the spring of 2016 within the STM Validation project. All ports benefitted from a series of Living Lab workshops to enhance cooperative trust among the port call actors to create the foundation for digital collaboration.

There are several stages involved in the development of a successful PortCDM environment

[6] Lind M., Bergmann M., Watson R.T., Haraldson S., Park J., Gimenez J., Andersen T., Voorspuij J. (2018) Towards unified port communications – from a project format to a global standard, concept note #9, STM Validation project

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Stage 1: Setting the foundations

The basic foundation that enables enhanced coordinative capabilities and enhanced common situational awareness is the use of a unified messaging format (the Port Call Message Format according to s-211) and a data-sharing platform used to distribute port call messages in real-time. Such a platform, implemented as a demonstrator for the validation of PortCDM as an enabler of STM within the STM Validation project, was introduced at Barcelona, Gothenburg, Limassol, Stavanger, Valencia, Segunto, and Kvarken ports (Umeå and Vaasa). This platform had capabilities for receiving and sharing port call messages in real time among connected stakeholders. For the purpose of validation of PortCDM, two front-end tools were included with this platform to provide common shared situational awareness, one for stationary and one for mobile use. The front-end tools also enabled manual data to be input as a complement to automatic connectivity.

Stage 2: Enhanced coordination through data sharing in bringing a ship to and from the berth

One of the main concerns of the port call process is berthing a ship (alongside or at anchor, as required[7]) at the expected time to enable the purpose of the call. This is also the end-state of the arrival process. The completion of the operations performed at the berth (the stationary services, resulting in a "ready-to-sail" state) is the springboard for the departure process. Two essential coordination points in the arrival process are the arrival time of the ship to the port area or pilot pickup point, and the ship arriving at its anchorage or securing at its berth. Supporting the arriving vessel requires provision of services from multiple actors. A predictable departure from a berth or anchorage area provides a basis for the port's planning of when to receive and serve the next ship.

To achieve enhanced coordination in the arrival and departure processes, the different events and actors must be identified. In the participating ports, Living Lab workshops were conducted. These workshops gathered information on shared data, how and when they were shared among the actors in the arrival and departure process and placed on a timeline. With these data, the events different actors needed to coordinate their activities could be precisely specified. These events were presented as coordination points on a

[7] Either if congestion cannot be avoided or that the service provision will be conducted to ships at anchor

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"metro map"[8] (see Figure 1). Living Labs revealed the core actors, which data they needed to enhance their ability to better coordinate the arrival process, to increase predictability, and to avoid unnecessary waiting times.

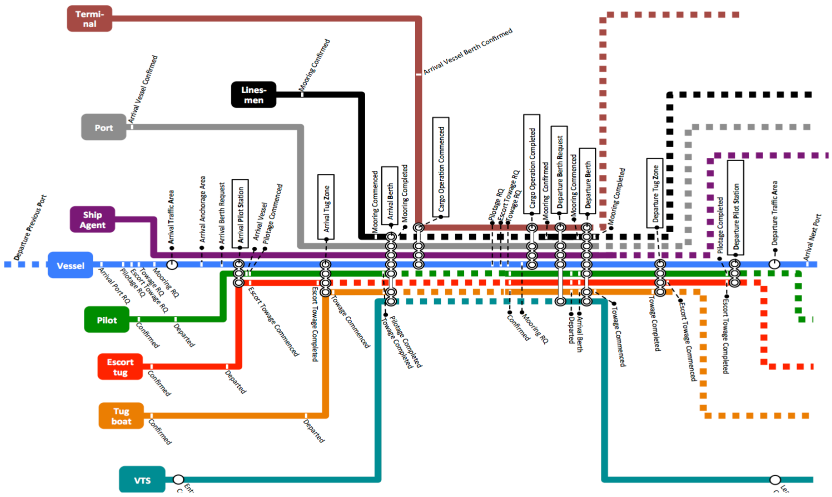

Figure 1: Picture on Port Call Metro Map

The workshops identified the needs of the involved actors for real-time data sharing. To ensure all the involved actors had the same conception of different time stamps, and a common view on events, states and capabilities, data needed to be shared in a common format. The continuous and automatic distribution of port call messages among the various actors became a critical requirement in fulfilling these needs. Actors identified for coordinating and/or bringing the ship to/from berth/anchoring locations were Shipping Agents, Port Authority (Port Control), Pilots, Tug Operators, Mooring crew, and Terminals.

Stage 3: Enhanced coordination through data sharing to realize a port visit

In order to reach a higher level of predictability in the timing and the deployment of services required during a port visit and the departure process the data needed to be shared among the involved actors had to be determined.

Events for services, which might be provided either at anchorage or alongside, were identified during Living Labs workshops. Also identified were those various actors that were operating with different understandings of supposedly identical time stamps, i.e. to identify those actors that were using the same time stamps (independent of its origin) for their coordination of their actions. After introducing PortCDM at the ports, the understanding between the actors providing stationary services became much more aligned. The data for better coordination was more visible (see 'metro map' in Figure 1). It

[8] Lind M., Haraldson S., Karlsson M., Watson R.T. (2016) Overcoming the inability to predict - a PortCDM future, 10th IHMA Congress – Global Port & Marine Operations, 30th May – 2nd May 2016, Vancouver, Canada

also became clear that improved data sharing could advance situational awareness and coordination. The following key events and operations associated with a port visit were identified: mooring, unmooring, bunkering, cargo, forklift, gangway, garbage, lube oil, post cargo survey, pre- cargo survey, provision, ready to sail, security, slop, sludge, tours, and water.

Stage 4: Connecting outside actors for enhanced situational awareness

PortCDM builds upon both internal and external collaboration. As PortCDM is an enabler of STM, collaboration with ships, other ports, and with hinterland operators is brought into focus.

Previously in this note, we have pointed out that there are multiple actors involved that can have an impact on a vessel's timely arrival and departure. Connecting those actors enhances situational awareness for the core actors in a port call, gives those newly connected actors a better planning horizon, and the possibility of better informing the remaining actors on when they might provide their services.

Sharing real-time data about a delay or the early completion of an event allows all the actors to re-schedule their operations and make any necessary adjustments, not only for that specific port call, but also for other port calls that might be affected as a result of those changes, and as such, improving the efficiency of their activities.

To fully validate the goals of PortCDM, it was necessary to establish collaboration with third-party actors (for example, tour companies), and other key actors interacting with the port and ship domains. During the Living Labs workshops, it became clearer that information from a range of actors is important for coordinating port calls and achieving just-in time operations. What is more, information about different actors' intentions and locations was often lacking, which results in delays.

When you have actors sharing data digitally in real-time using a standard, such as PCMF, you can start sharing important data about a ship with the next port of call to give its actors a better basis for planning and resource efficiency. The importance of port-2-port communication, especially under short sea shipping constraints has been highlighted in concept note 5 "*Port-2-Port Communication Enabling Short Sea Shipping: Cyprus and the*

Eastern Mediterranean".[9] Empowered by the STM concept, routes channelled through the route exchange format (RTZ) were used for sharing Targeted Time of Arrival (TTA) from the ship to the port and Recommended Time of Arrival from the port to the ship. In this way, direct connectivity to the STM ships were established, through extracting the arrival time (as PCMF) from the route and presenting the recommended time of arrival associated to the route and a complementary source of arrival time for the port actor's planning of their operations in the port call was established.

Stage 5: Collaborative decision making during iterative re-planning

During all stages of a port call, capturing the whole turnaround process (from arrival in the port area, undertaking the port visit, and the departure), collaborative planning and any consequent re-planning by the various actors involved is vital to address such things as when a ship informs about a delay, or when a berth will not be ready in time due to a delay of operations in another ship's port call. However, such a collaborative decision-making process is dependent upon sharing real-time data to create a common situational awareness.

The cost of continuous re-planning is reduced by sharing relevant data, both in terms of sharing intentions as well as notifying the progress and outcomes of activities as they occur. These events can be captured in a system of records maintained by PortCDM reflecting the progress in the production systems of a port visit.[10] These data should be visible to all the port call actors. Each port's specific requirement should be acknowledged and brought into consideration in the setup of what data to share in a particular port.

The port call message format[11] has been created to enable the standardised distribution of data associated with different types of events.

Stage 6: Continuous improvement established

[9] Lind M., Bergmann M., Haraldson S., Watson R.T., Michaelides M., Herodotou H., Voskarides S. (2018) Port-2-Port Communication Enabling Short Sea Shipping: Cyprus and the Eastern Mediterranean, concept note #5, STM Validation project

[10] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) The skilled collaborators - the winners in a digitized maritime sector, concept note #2, STM Validation project

[11] Lind M., Bergmann M., Watson R.T., Haraldson S., Park J., Gimenez J., Andersen T., Voorspuij J. (2018) Towards unified port communications – from a project format to a global standard, concept note #9, STM Validation project

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The data captured for coordinating port call operations reflecting both the intentions and the actual outcomes of commencing and completing operations can be used to detect points of insufficient coordination. PortCDM has six key performance indicators (KPI's) - duration time, waiting time / anchoring time, predictability, punctuality, berth productivity, and capacity utilization).[12] These are metrics intended to facilitate better coordination. Experience shows that data points shared among the actors prior to and during a port call can be used for such improvement using the mentioned KPI's for measuring port call performance.

Data analysis, using big data methods such as machine learning, can detect areas of improvement for future port calls (e.g., bottlenecks, too short a planning horizon to be able to reduce disruptions, and the mix of locked resources and those reserved for agility).

Purpose of a of a maturity level framework

Harmonization of Operations

To achieve enhanced interoperability within ports and with external actors, two levels of harmonization are proposed; the local level, emphasizing necessary alignments between port call actors within a specific port; and the global level, emphasizing necessary alignment between ports and their external stakeholders in the global maritime transport chain. The objective is not to force universal operating procedures on all ports, but to align expectations and communication, for example, between internationally trading ships and ports.

PortCDM, which has been developed and tested/piloted as part of the MONALISA and STM Validation project, is a key enabler of STM. The following aspects of PortCDM support port operation harmonization:

- Time stamp data from multiple sources associated with a single port call, as well as voyage identifier(s) (inbound, and outbound), enables a holistic view, higher transparency, and enhanced situational awareness
- A unified format for port call messages (S-211[13])

[12] Lind M., Haraldson S. (2016) New KPIs will show how ports become more efficient with PortCDM, STM Validation project

[13] Lind M., Bergmann M., Watson R.T., Haraldson S., Park J., Gimenez J., Andersen T., Voorspuij J. (2018) Towards unified port communications – from a project format to a global standard, concept note #9, STM Validation project

- A set of globally defined KPI's
- A system of indicators and warnings enabling port call actors to coordinate actions and manage disruptions (including conflicting data, unreasonable relationships, missing data)[14]
- A governance structure at the global, regional, and local (port) level:
  - Global: Only the minimum necessary definitions to ensure that key objectives are met
  - Regional: Building on a global governance structure and further defining common ground and agreements within a region (e.g. adapting to regional legal conditions)
  - Local: Implementation as needed locally, compliant with the Global and Regional settings.

These important elements are included in the PortCDM maturity assessment framework.

PortCDM Maturity Levels

Building on the experiences from introducing PortCDM in the STM ports, seven levels of PortCDM maturity have been defined, In order to characterize the maturity of a port's CDM implementation. These levels take into account different models of port governance, individual port call actors, and systems/service/tool providers. Dependent upon a port's characteristics, implementations might differ. For example, there is a great difference in operations and scale for a port managing 40,000 port calls per year or three per week. The PortCDM maturity levels have specific requirements related to the achievement of each level.

During the implementation of PortCDM, each Port has to define its specific conditions and how PortCDM will be accordingly implemented. A local PortCDM compliancy definition will define which port call actors are classified as "core actors", given the local conditions. It will detail the local PortCDM implementation in order to enable certification of PortCDM in accordance with the general compliancy levels and the local PortCDM compliancy definition. The main reason for engaging different actors in a PortCDM

[14] Lind M., Rygh T., Bergmann M., Watson R.T., Haraldson S., Andersen T. (2018) Balancing just-in-time operations – coordinating value creation, Concept note #6, STM Validation project

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implementation is to ensure that core real-time information, from main sources, is shared between actors to enable increased coordination ability within the port.

It is assumed that each level includes all the lower levels; in other words, level 7 will also include all the other levels from 1 to 6. Level 1 and level 2 points at establishing capabilities for information sharing, while level 3 to 6 points at that designated actors really use the PortCDM capabilities established on level 1 and 2 in their operations, while the 7th level of maturity, uses experiences from level 3 to 6 for improvement in future port call operations.

On level 1, the port call standard message format (PCMF), according to S-211, is established as a capability for submission and consumption of time stamps for port call coordination is established using standardized interfaces. On this level capabilities for exchanging data with external actors, such as ships, shipping lines, and fleet operation centre, that are essential for the port's coordination of the port call must be established, since the initiative to initiate port planning in most cases come from there.

On *level 2*, a data-sharing platform has been established within the port for exchanging PCMF compliant timestamps. Port call actors who agree on sharing and consuming timestamps use this platform.

On *level 3*, core port call actors[15] share timestamp data according to PCMF and tools for situational awareness. These data are used to ensure that all actors involved share the same view regarding ongoing and future port calls.

On *level 4*, all actors[16] within the port are using the data-sharing platform for sharing and consuming all states according to the locally adopted principle of access management.[17] Data are shared through machine-2-machine (M2M) or EDI connectivity. Such connectivity builds upon the use of the port call message format (S-211).

[15] Core port call actors are the ones that are essential to bring a ship to/from the berth place, such as VTS, port control, pilot operators, tug operators, linesmen, ship agents, and terminal operators

[16] This would complement with more actors that are engaged in the port call process, such as different service providers (waste, bunkering, sludge, slop, water etc.) as well as to actors in more detail related to the purpose of call (e.g. security, surveyors, customs, tour operators etc.) engaged when ships are at anchor and/or berth.

[17] PortCDM promotes the adoption of the access management principle of 'need to know'. This means that some operations, e.g. cargo operations might not be available to all, while time stamps of initiation and conclusions of the operations are shared among everyone. In this way, events within e.g. cargo operations are just shared between the actors directly involved.

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On *level 5*[18], communications with actors outside the port (e.g., ship-to-port or port-to-port) are channelled through the platform for real-time communication with all port call actors. PCMF compliant standards are used throughout.

On *level 6*, port call operations are coordinated in order to enable collaborative decision-making. All stakeholders represented in a port have agreed to use PortCDM for optimal planning of port calls as well as for taking initiatives if and when required to change existing plans in order to raise (more) overall port operational performance. This is based upon a holistic view of the port call as opposed to individual decision-making based upon the situation of each actor.

On *level 7*, the port is using the PortCDM KPIs and locally defined KPIs to measure and continually improve port call operations through innovations.

Compliance of port actors in meeting levels of PortCDM maturity

In order for a port to be classified as having a particular level in the maturity framework, the different actors must accept the standards and comply with the procedures and requirements.

It is important to realize that each maturity level is based on the operational capabilities that others would expect of a port and its reliability for keeping operations "just-in-time". However, the different maturity levels for PortCDM should not be confused with the capabilities or professionalism at a given port, nor with the port capability of exchanging standardized STM messages (such as e.g. PCMF and RTZ) as components in ship and port synchronization of the port call, as mentioned before: the route exchange format can be used for exchanging targeted and recommended arrival times extracted from the route of the ship.

Maturity levels simply identify a port's level of implementation of PortCDM. In this way, a particular maturity level may be seen as an implementation phase of PortCDM; being the current end state in implementing PortCDM given the local circumstances. Achieving a higher level may come later in the implementation programme.

[18] Level 5 or part of level 5 may be introduced before or at the same time as level 4, if some of the actors start communicating with outside actors before all actors inside the port operation have achieved this level of maturity. To respond to the needs of port call synchronisation coordinative capabilities have on this level been established at the port meeting the demands of providing reliable recommendations to ships

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Determining the maturity level for a particular port should take into account the infrastructure for collaboration and local and global integration in terms of (1) the port as a compound actor, (2) infrastructural and technical capabilities, and (3) capabilities on actor collaboration.

The basic requirement is that the port and its actors can receive and use data, i.e. have established capabilities, based on the port call message format (PCMF) according to the S-211 standard.[19] This foundational capability is the basis for developing the maturity levels of PortCDM. This enables both internal (local) and external (global) port collaboration, thereby expanding planning horizons and enabling each to inform down-stream actors about progress and possible disruptions using a standardized format.[20]

Consolidated framework

The seven layers of maturity may be visualized in the following way in figure 2.

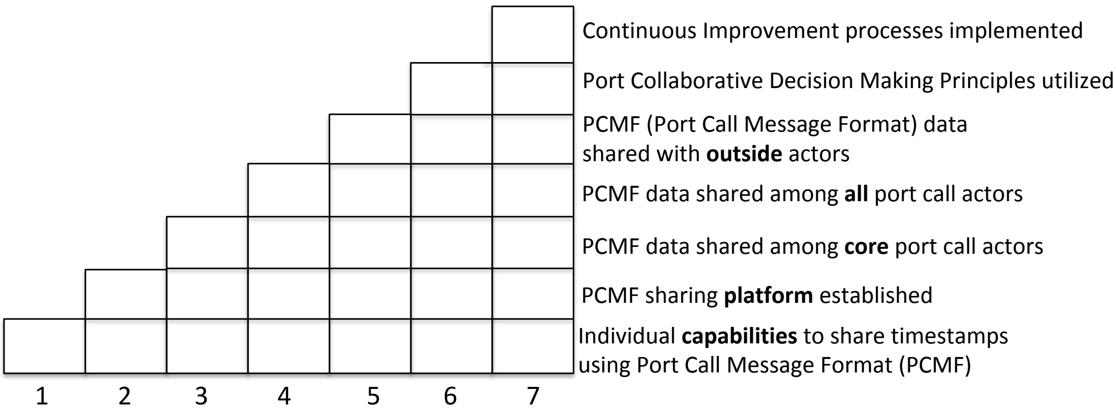

Figure 2: Summarizing the maturity levels (from foundational capabilities (level 1 and 2) to the use of instant message sharing (level 3-5) among all port call actors, to CDM and continuous improvement (level 6 and 7))

Concluding remarks

Progress on turning the PortCDM concept into reality is proceeding apace.

The PortCDM port call message format for event-based data has recently been agreed upon by IALA to be finalized as the S-211 standard. By design, the S-211 message format will also be fully compatible with the functional definitions for nautical port information,

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[19] Within the STM Validation project, a translator, using the voyage information service (VIS) was demonstrated to facilitate the translation between the port call message format (S-211) and the route exchange format (RTZ)

[20] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Port Collaborative Decision Making (PortCDM): An enabler for port call optimization empowered by international harmonization, Concept note #1, STM Validation project

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as proposed by UKHO and IHMA.[21] As a result, this development will enable all actors (including ships) involved to communicate and coordinate plans, outcomes, and changes related to events in port call operations.

Having a standardized and transparent data exchange mechanism covering all planned and actual events will enable actors to achieve enhanced situational awareness. This improvement will, in turn, provide port call actors with improved capabilities for coordinating and executing their operations *just-in-time*, thereby raising their and the port's efficiency and effectiveness.

A framework using maturity levels of PortCDM adoption, as introduced in this concept note, and as a result of efforts within the MONALISA and STM Validation projects, will enable a port:

- To set ambitions and evaluate conditions for the Port to implement PortCDM.
- To identify and communicate what internal and external actors can expect.
- To elicit requirements for System Providers.

Our ancestors learned millions of years ago that cooperation was key to survival, and today the same lesson should still be forefront in our minds. Sharing intentions and working collaboratively is more efficient than working in isolation, and now we can use digital connectivity to raise the intensity of sharing to handle the complexity of modern business. PortCDM aims to do exactly that for the actors in the maritime domain.

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[21] UKHO, IHMA (2018) Functional Definitions of Nautical Port Information

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