

First Steps in implementing PortCDM - Establishing a data sharing environment

by¹

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On behalf of the International PortCDM Council

Introduction

Port Collaborative Decision Making (PortCDM) is a concept to support those engaged in managing or executing port call operations. It aims to improve efficiency and effectiveness by providing a framework for data sharing and enhanced collaboration. The PortCDM maturity model defines the incremental steps required to establish PortCDM successfully as part of a port's operations. The capabilities required at each level are indicated in Figure 1.

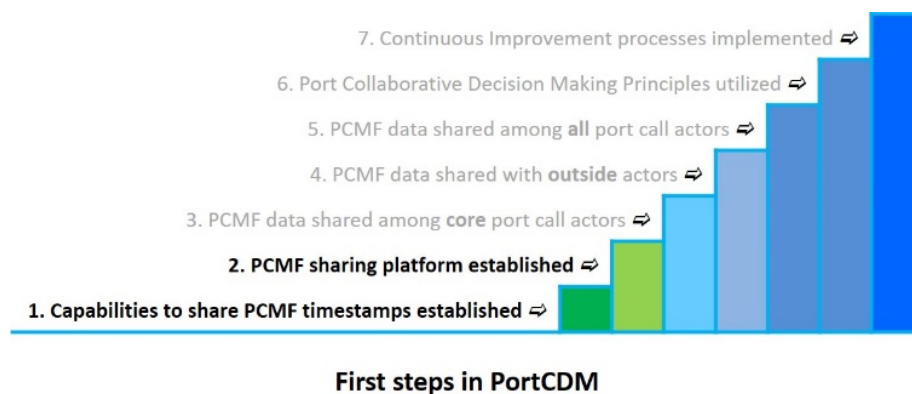


Figure 1: First steps in implementing PortCDM in port environments

Building upon the previously published concept note on PortCDM maturity levels² and a concept note on how to achieve compliance in collaboration and data sharing with PortCDM,³ this note provides practical advice on how to begin the PortCDM maturity journey focussing on levels 1 and 2 of the maturity model.

Our note is based on experience gained in implementing PortCDM in the ports of Limassol, Barcelona, Valencia, Sagunto, Gothenburg, Brofjorden, Umeå, Waasa, and Stavanger, as part of the recently completed PortCDM testbeds, which, in turn, was part of the wider STM validation project. We explain how to introduce

¹ Participating authors are all belonging to organizations that are participants in the International PortCDM Council (IPCDMC)

² Lind M., Andersen T., Bergmann M., Watson R.T., Haraldson S., Karlsson M., Michaelides M., Gimenez J., Ward R., Andersen N-B., Gonzales A., Holmgren B., Zerem A., Rauer F., Sahlberg H., Lindberg J. (2018) The maturity level framework for PortCDM, Concept Note #13, STM Validation Project

³ Lind M., Bergmann M., Andersen T., Haraldson S., Ward R., Andersen N-B., Michaelides M., Watson R.T., Ferrus Clari G., Zerem A., Rylander R., Gimenez J., Karlsson M. (2019) Achieving compliance in collaboration and data sharing with PortCDM, Implementation note #1, International PortCDM Council (IPCDMC)

a data sharing environment for collaboration through the exchange of essential data between port call actors. These first two steps pave the way for overall enhanced efficiency of port call operations by creating the basic technical and collaboration capabilities upon which the higher maturity levels and more advanced organizational collaboration depend.

Reaching maturity level 1

– Establishing the capability for creating and sharing PCMF data in S-211 standardized format

The first and most fundamental level of PortCDM maturity requires that port call actors have appropriate systems in place to digitally share relevant event and resource requirements data with other actors during port call operations. To do this, each participating actor needs to establish a mechanism to send and receive these data using the internationally recognised port call message format, S-211,⁴ as well as standardized interfaces for their provision and consumption.⁵ The ability to generate S-211 format data enables key events and progress data (described as states, for instance - *arrival of vessel to traffic area*) to be captured and made available to other interested parties to enable better planning and use of resources. A particularly important issue is that the chosen mechanism enables the data to be kept up-to-date and made available to authorised recipients in real-time, or in near real-time, and as automatically as possible.

Most ports have multiple computerized information systems of different forms in use tailored to their needs. These may be systems targeting the port community that enable port actors to share data for a particular purpose (such as the exchange of administrative data and/or data desired by maritime authorities) or dedicated information systems for particular key port call actors. Whether the existing systems are suitable or can be enhanced must be determined on a case-by-case basis. It will depend upon a variety of factors including who owns and controls the existing systems, whether the data in the systems are kept up to date in near real-time, and whether access can be provided to a wide range of PortCDM actors.

Irrespective of whether an existing system is potentially available or not, the first action is to define the needs of each actor, including the requirements of PortCDM as defined below. Subsequent to this, the next action is to implement the necessary tools, including data sharing capabilities to fulfil those needs. This may be done either by enhancing or adding to existing systems, or by implementing a bespoke system when no sufficiently advanced computerized information system is available as a starting point, which may be the case, particularly in smaller ports.

To develop the capabilities for providing standardized data as a first step towards PortCDM maturity, port call actors should review the list of data items that can be communicated in S-211 (see appendix 1), and identify which matching sources are already available within their existing information systems. This review may also identify additional data items that are not currently included but would be useful in future. Once this is done, it will be possible to map the relevant data about port call events held in the existing systems to the corresponding data element constituents in the S-211 data schema (Figure 2) and vice versa.

⁴ <https://www.ipcdmc.org/standards-and-guidelines>

⁵ The principles of the APIs used for providing and consuming S-211 data follows the generic principles of S-100 Online Data Exchange – Part 14 (https://www.iho.int/iho_pubs/standard/S-100/S-100_Ed_4/S-100_Ed%204.0.0_Clean_17122018.pdf)

The next step for those wishing to share data under the PortCDM concept is to set up an automatic *connector*.⁶ This is a piece of software, which can retrieve relevant data from the source system, map the data to the S-211 standard format, and then make it available for consumption by other PortCDM enabled actors. During the PortCDM validation test beds, a number of different PortCDM connectors were developed, enabling data from port community systems, national single windows, systems of service providers and ship agents, AIS based data sources, and other sources, to be exchanged in standardized S-211 format using readily available fixed and/or portable devices and equipment.

A wide range of PortCDM compatible applications were also developed to enable port call actors both to view aggregated PortCDM data and to manually submit port call messages in cases where these had not been available previously for machine-to-machine exchange (Figure 3).

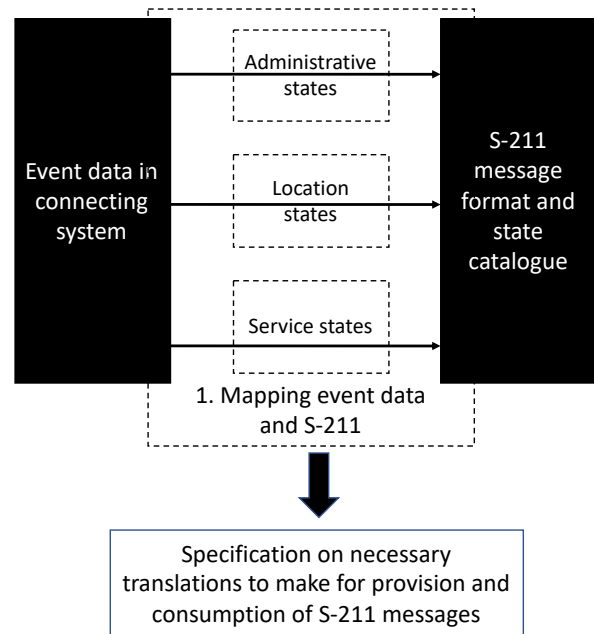


Figure 2: Translation of event data from connected system in the provision and consumption of S-211 format

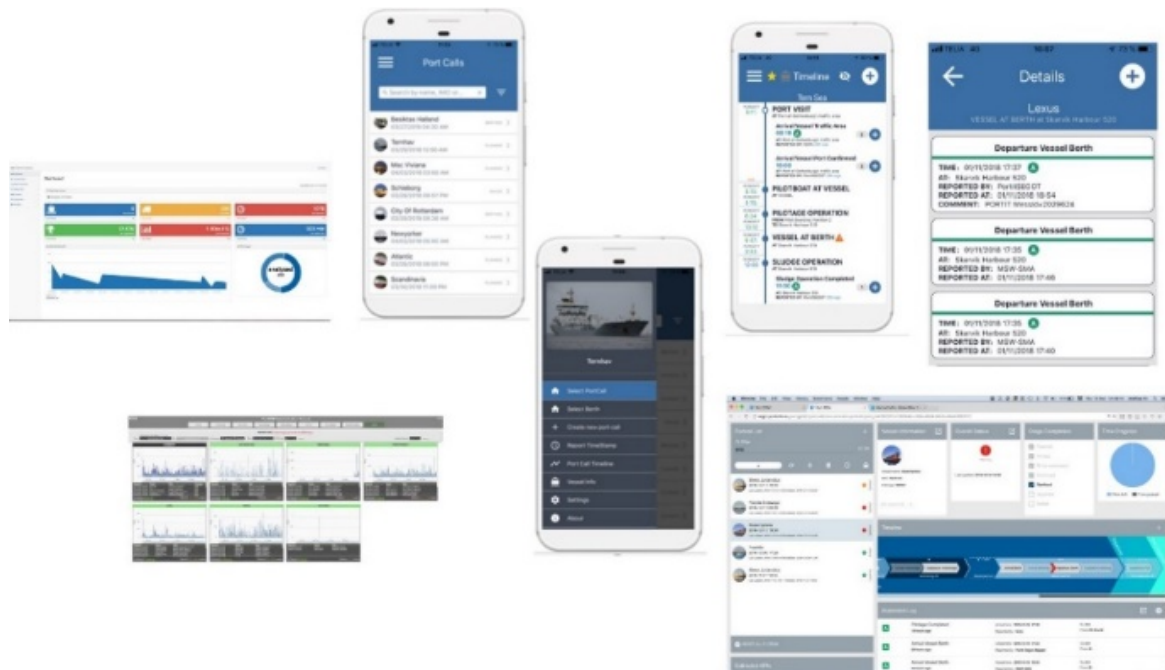


Figure 3: Web and mobile apps and API's were developed and made available for data sharing during the PortCDM validation project

In most cases, it should be possible to adapt existing software components to minimise the effort required to exchange data in standardized S-211 format. Further relevant technical details can be found at <https://specifications.portcdm.eu>.

⁶ In this context, an automatic connector is conceived as piece of software which can submit and retrieve relevant data to/from the source system, convert/decode data to/from S-211 standard format and submit it to standardized PortCDM submission API / expose it for consumption by other PortCDM enabled actors.

Reaching maturity level 2

- Developing a PCMF platform for data sharing and collaboration

For an individual port call actor who has the relevant digital data, the implementation of appropriate connectors should allow their systems to be compliant with maturity level 2 of PortCDM.

However, for PortCDM to succeed, each actor's compliant system must be able to access a common data sharing platform, which can be accessed by all port call actors in order to share S-211 format data using their connectors. More information on such a platform is covered later in this note.

To start the process, an initial community of committed port actors must gather and agree to share data. These actors will be the leaders in the port, who are already enthusiastic about PortCDM and appreciate the benefits that it offers. Once the process is started, others can be expected to follow.

This initial group of leaders are most likely those who will lead the further development of PortCDM in their port area by encouraging a data sharing culture (levels 3 to 5) which in turn will lead to a fully collaborative PortCDM environment (levels 6 and 7). How to reach these levels will be covered in subsequent implementation notes.

As well as S-211 data creation and sharing capabilities, the technical and operational framework that will underpin a local PortCDM implementation must be established by the actors involved. This will include how the required data sharing platform will be created and managed.

The different actors need to gather and establish a vision of their common interests, so that everyone can identify and agree on their interdependencies and the potential key break points in the port call process, where data sharing would be most beneficial. Furthermore, they should agree on the level and quality of the data to be shared. The necessary capabilities of a data sharing platform for collaboration are depicted later in this implementation note.

During the very successful validation of PortCDM, the necessary interaction, discussion and conclusions were reached using the *Living Lab* methodology, which is now briefly explained. Given its success in the validation of PortCDM in nine ports, we strongly recommend applying this methodology for any port community that wishes to establish PortCDM capabilities.

Living Lab methodology

A Living Lab is a research concept that establishes a collaboration arena for representatives of all key actors that subscribe to the idea of developing or changing a process. A Living Lab should include all actors who can potentially affect the planning and the realisation of the process under consideration. In the case of the PortCDM project, the participants in the nine ports provided both the practical business knowledge and the local experience crucial for enhanced collaboration and data sharing to be developed in their particular port.

To ensure a successful technical implementation of PortCDM it is important to involve all actors, who can facilitate access to data sources via automated connectors. This means that actors with knowledge of the system architecture within and between a respective actor's operational systems, need to be involved and associated with the work of the Living Lab to map data and test connectivity. The data source representatives could be staff members from the port operator's IT department or system suppliers.

In the large validation effort of PortCDM, the Living Lab participants were sub-divided into three sub teams: a business, a technical, and a concept team. The business team participated in meetings and provided operational knowledge regarding requirements, and it was also involved in utilising and validating the PortCDM implementation. The concept teams followed the development by attending meetings and

interacting with a Living Labs coordinator in their respective ports to ensure generic knowledge development based on local implementations. The technical team had one local technical coordinator involved in each Living Lab to transform the operational needs into technical requirements ensuring a successful local (technical) implementation.

In future implementations of PortCDM in different ports, we believe that a concept team at the regional or local port level may not be required. This is because the now-established International PortCDM Council (IPCDMC) can provide operational and technical guidance for developing PortCDM maturity and criteria for PortCDM compliance through its PortCDM solutions and guidelines documentation. Accordingly, the IPCDMC is fulfilling the role of the concept team.

In order to facilitate, orchestrate and move the Living Lab process along, it is necessary to have a Living Lab coordinator. Besides having knowledge about the basic principles of PortCDM, this coordinator should have a good knowledge of the local port and should have good relationships with all port actors involved. Living Lab meetings should be planned to occur regularly and frequently in order to consolidate and strengthen collaboration by building trust among participating actors and in that way facilitate digital collaboration. Living Labs can also be used to develop collaboration for the higher PortCDM maturity levels. During the PortCDM validation testbeds, meetings were held regularly in each port. However, the number of meetings varied depending on the established relationships, the actor engagement, and the IT-maturity level reached. One important insight was that the use of the Living Labs approach facilitated meetings and understanding among the port call actors that had rarely happened before in any of the nine ports involved.

Living Lab Process

During the Living Labs process various themes and deliverables should be discussed with the purpose of ensuring the sharing of all necessary data leading to benefits among the actors involved.

It is suggested to start with the definition of the common goals and identify the common objects of interest. To facilitate this, a scenario-based approach can be used, taking a typical port call as its basis. The scenario should at least reflect a ship bound for the port, arriving at the port, arriving at its berth, completing its purpose of call, departing from its berth and departing from the port. Furthermore, it should include all the information that needs to be shared among the actors, together with an identification of the challenges and the collaboration required to make the port call successful.

Through the work with the scenario, actors' roles and interdependencies are identified, as well as a common understanding of their respective roles in the port call process. This means the identification of data to be shared and for what purpose, as well as actors' intentions for using these data. Having this knowledge is an important ingredient for lowering the threshold of actors' willingness to share data. The main objective initially is not documentation as such, but rather to develop a common understanding among the participating actors by defining the process of sharing knowledge and the interaction patterns.

Once the common understanding is established, it is necessary to perform a detailed analysis of all the exchanges of communication necessary in order to effectively handle a port call process. This is needed in order to identify the data, which will eventually be shared via the S-211 format. We propose that this is done as a three-stage process:

1. Process modelling. This does not need to be a formal process-modelling process. Instead, we propose that a detailed account of all communication steps in a port call process from the ETA (or from the initiation of the plan to make a port visit) of a ship to the final departure is compiled. We believe that it is important to record this as a sequential process (what has to come before what),

what theoretically is called a ‘precedence graph’, since the sequence of events is crucial; for example, a pilot must be contacted before a pilot can board the ship.

- Documenting the sequence of events can be achieved most effectively using a spreadsheet graphic, like the example shown below, where events are listed in the first column. The other columns show the different actors involved. We believe that this is an excellent form of documentation, which is very easy to update:

ACTIVITIES IN A PORT CALL	VESSEL	AGENT	PILOT	Q INSPECTOR	LINESMEN	TUG BOAT	VTS
Agent notification for arrival							
Pilot Booked							
Pilot makes bookings							
Q inspector booked							
Tug Booked							
Linesmen booked							

- Once the spreadsheet is finalized and agreed upon, it is possible to develop a so-called organisational *metro map* as shown in figure 4. While the metro map in figure 4 is a generic map, a specific metro map from the port of Limassol is shown in appendix 2.

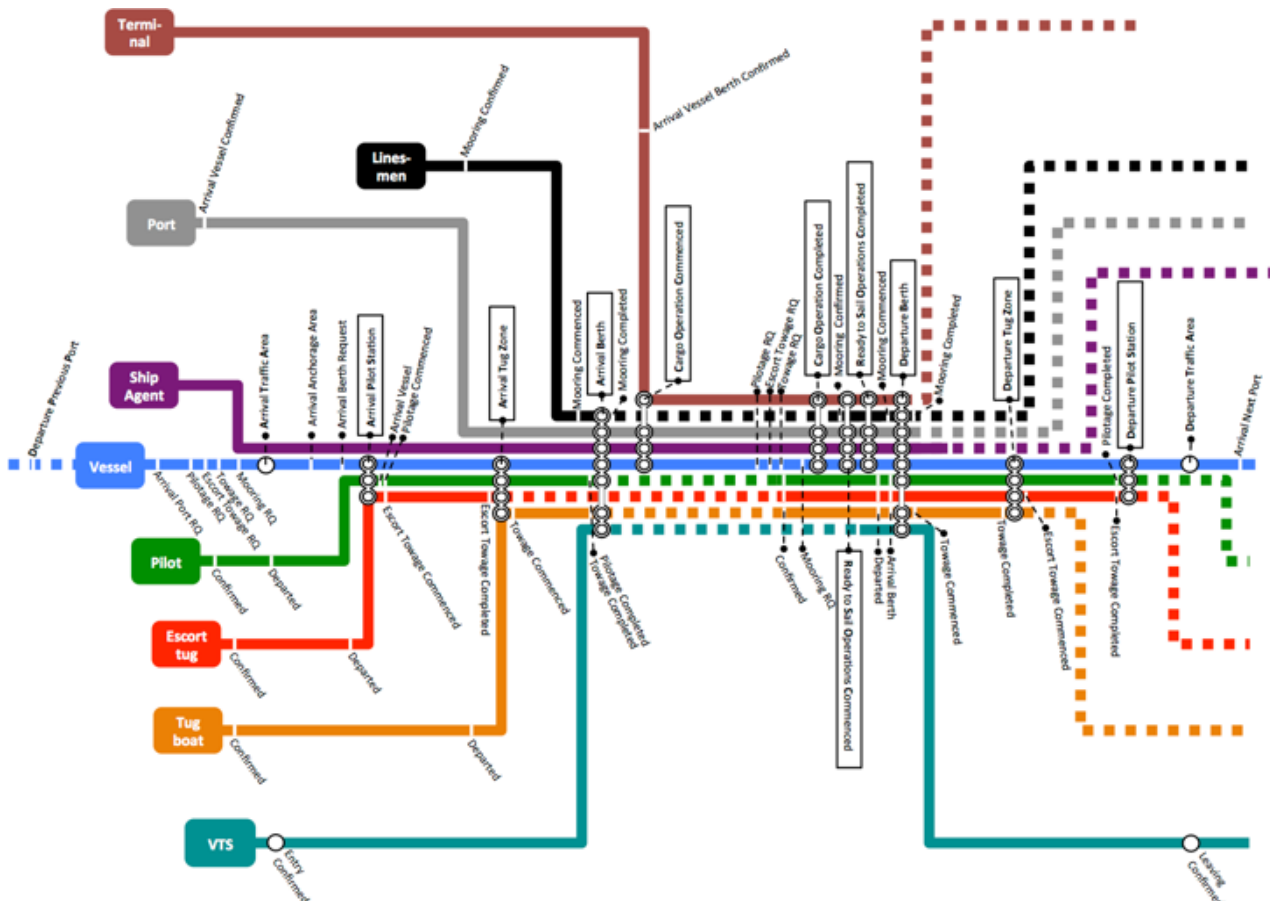


Figure 4: Typical *metro map* showing status and coordination points in a port call process⁷

During the PortCDM validation project the metro map was consistently found to be useful in clearly showing the key data exchanges in the local port call process. In particular, its development helped to identify key actors, their roles and the occasions when the activities of one actor impacts upon another in the port call

⁷ Lind, M., et al., *Overcoming the inability to predict - a PortCDM future*, in 10th International Harbour Masters' Association Congress – Global Port & Marine Operations. 2016: Vancouver, Canada.

chain. Most importantly, the metro map explicitly highlights the involved actors' common need for data sharing to improve the port call process. The metro map makes it abundantly clear that unless all actors collaborate and coordinate regarding each event, there is likely to be a waste of resources.

The metro map can be seen as a holistic overview of important coordination points, physical and digital, divided into nautical service events, stationary service events and locations events, for which the different actors involved in a port call need to coordinate. The activities of a particular actor are like a subway line. An event is like a station on the subway line, where the events of different actors must be coordinated. It could also be seen as an interchange or a hub. So, for example, *Pilot Boarding Area*, is seen as a hub station on the metro map (represented as white round circles), where a pilot and the ship to be piloted need to be at the same location at the same time in order for pilotage to take place on time.

There are several generic metro maps available, based on the type of calls and objectives for the collaboration, such as port calls for cruise, container, and oil tankers, or for data sharing for Port-to-Port.

Developing the PortCDM data sharing platform

The key component is a data sharing platform. This important element ties the individual S-211 data capabilities of individual actors together by providing a centralized platform through which all authorized actors share relevant data in an automated, secure, and efficient way.

A PortCDM data sharing or connectivity platform environment needs to support the *capabilities* of:

- enabling provision of data (event timing and resource requirements) through PortCDM submission services
- distributing data provided by each actor / platform to other relevant PortCDM actors
- associating data from multiple actors to the same port call by using a universal port call identifier, defined as Maritime Resource Name (MRN)⁸
- inter-linking data associated to the same port call in a holistic structure of related events (a so-called port call structure building upon the port call ontology⁹) for enabling the emergence of common situational awareness among connected actors¹⁰

It is likely that different actors in a port will be very different with respect to the maturity of their IT capabilities. This will influence what technology is available and what additional technology might be required. In some ports, its community of actors might already be connected through systems that have been installed for purpose other than PortCDM. Some of the data that these existing systems contain can feed the connectors. However, as mentioned earlier, whether these existing systems could easily be re-configured to act directly as the original source of the data for connectors or as PortCDM data sharing platforms must be assessed on a case-by-case basis.

An existing data sharing environment can assist in supporting the four data sharing requirements listed previously by supplying data to the complementary PortCDM data sharing platform. The principle of “*enter*

⁸ <https://mrnregistry.org/>

⁹ Lind M., Haraldson S., Ward R., Bergmann M., Andersen N-B., Karlsson M., Zerem A., Olsson E., Watson R., Holm H., Michaelides M., Evmides N., Gerosavva N., Andersen T., Rygh T., Arjona Arcona J., Ferrus Clari G., Gimenez Maldonado J., Marquez M., Gonzalez A. (2018) Final PortCDM concept description incl. generic specification of identified services - Improving port operations using PortCDM, STMVal_D1.3 (www.stmvalidation.eu/documents)

¹⁰ This capability would not come into use until higher levels of PortCDM maturity is reached when actors utilize the capabilities of sharing data as the basis for deriving common situational awareness for the efforts of coordinating and synchronizing port call operations according to the principles of PortCDM.

once, use many times” is very important, so as to avoid unnecessary efforts and to ensure that consistent data is shared throughout the ecosystem. This is necessary to provide opportunities for synchronizing, when a particular event is about to happen or has happened.

Where no digital data sharing environment exists within the community of port call actors, either because everybody acts in isolation or because the operations of the port are managed mostly on a manual basis, a digital data sharing platform is required to facilitate collaboration. Not only does this provide the opportunity for ports to enhance collaboration between actors within the port, it also enables them to be better connected to the wider maritime transportation chain by introducing standardized internal and external data sharing capabilities.¹¹

In Figure 5, the targeted capabilities for data sharing are depicted in the left part of the figure while the right part indicates two different situations. The first situation is one, where a data-sharing environment already exists. In the second situation we see a situation where a data-sharing environment is absent and where actors’ IT systems are isolated islands. As shown in the figure, for the first situation a complementary data sharing platform might be sufficient, while for the second situation it becomes necessary to introduce a *new* platform for data sharing.

Finally, in order for a connectivity platform to be available for new entrant actors and others, including ships and hinterland carriers, the data services for providing and consuming standardized data as well as for the consumption of the port call structures need to be available in an open registry of PortCDM services.

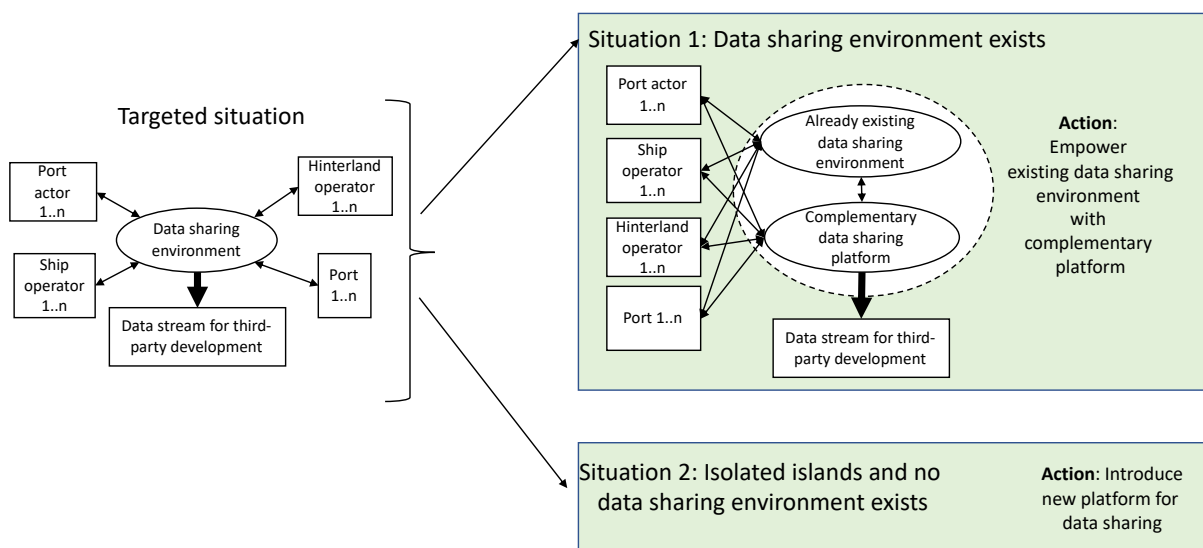


Figure 5: Different strategies for establishing PortCDM data sharing capabilities

It is also recommended that the essential characteristics of the PortCDM implementation be captured in a separate documentation accessible for all participants in the PortCDM implementation. The International PortCDM Council (www.ipcdmc.org) should keep some kind of registry of the PortCDM maturity level of all ports interested in using the PortCDM standards and tools.

The leadership role

¹¹ If port call actors are not using any IT support in their operations it might be the case that dedicated (front-end) tools are needed, as depicted in figure 2 above, for the individual port call actor to enhance capabilities of providing and consuming time stamp data as well as establishing a shared common situational awareness

The principal challenge in implementing PortCDM is that an existing port ecosystem comprises of many independent actors, each of which is governed by its own business logic. In order for a port to be effective, there are a huge number of rules, agreements and norms regarding how to coordinate a port call. Because it works (albeit, not necessarily optimally), the current overall system might appear to be in balance. However, when a new concept for collaboration and the digitally sharing of data, such as PortCDM, is introduced in a port, then the current balance needs to be adjusted. Accordingly, a number of the current rules, agreements, and norms will have to change to make the overall processes more efficient.

It is likely that the costs and benefits of any changes might be unevenly distributed among the actors. As a result, the establishment of any change could encounter initial resistance from some actors, who might not see any immediate benefit to them, while other actors destined to benefit might only be lukewarm due to uncertainty regarding implementation costs, risks, and long-term benefits. Other actors again may simply feel comfortable with the status quo and be unwilling to adopt changes. In this context, leadership by word of mouth or by example is vital. This was why the validation of PortCDM concentrated on providing practical demonstrations of the various benefits of PortCDM – within and between ports.

The success of introducing PortCDM builds upon the principle that all actors should have equal opportunity to join the effort of collaboration and data sharing. Obviously, not all actors necessarily need to be equally engaged, but there is no doubt that the largest benefits are obtained when all actors are linked to the platform and support collaboration and data sharing. Ultimate success will depend upon managing a trustworthy development of relationships between all the actors that constitute the ecosystem of the port. In this sense no actor is to be conceived as superior to any other. It is therefore a need to establish collaboration among the community of port call actors, where different actors would take different roles and different levels of engagement. The importance of having the more engaged actors participating in this first collaborative effort should not be underestimated.

It is also important that PortCDM is driven by commercial imperatives, not ideology. Accordingly, the most active and leading actors must:

- Be in a position to develop a positive business case for how things could be organized much better for them. This would include the role of the other actors participating in the port call process. For example, experience from the PortCDM validation project shows that even though an ETA was declared in advance and as such short turnaround time would be expected, time at berth for the same type of ship could vary from 7 to 31 hours in the same port. It is evident that such a high level of variability can result in difficulties in planning and the efficient utilization of resources.
- Be prepared to invest efforts to organize and convene meetings, such as *Living Labs* and obtain or develop supporting technology
- Be in a position to influence others to join in the effort
- Understand position and challenges of clients, customers and partners, and take an active role in creating win-win situations based on transparency and common situational awareness

If the conditions are met, then engaged actors can be expected to share the effort, driven, at least in part, by their self-interest. It may be beneficial to assign a leadership role to someone who is credible to the port community and who has the task of unifying it on the objectives of the implementation of PortCDM. This includes building trust within the community, identifying the digital technology requirements and skills capabilities of each actor, and establishing an appropriate data sharing platform.

More information

Like the guidelines and advice available at IPCDMC¹² on general concepts, this note has been elaborating on for the PortCDM maturity levels 1 and 2. Other PortCDM maturity levels will be elaborated in further implementation notes.

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www.ipcdmc.org

PortCDM brings sea transports to become an integrated part of the global transport chain by providing means for ports by enhancing their capabilities in collaboration and data sharing. The International PortCDM Council (IPCDMC) is an independent association with global reach providing international standards and guidelines for regional and local implementations of PortCDM.

Detailed information on various aspects of the PortCDM concept can be found in the series of previously published concept notes posted at www.stmvalidation.eu and/or www.ipcdmc.org.

¹² <https://www.ipcdmc.org/>

APPENDIX 1

Port call messages as port call data items

S-211 Port Call Messages carry time related information related to the port call process to facilitate collaborative decision making between involved parties, referred to as actors.

Overall structure

S-211 Port Call Messages consist of a payload representing a specific type of PortCDM state and some meta data describing the time the message was sent, who sent it, which port call it belongs to and a unique message identifier. It can also hold references to incoming and outgoing vessel voyages.

How does Port Call Messages relate to PortCDM States?

States in PortCDM represent things that need to happen during a port call to perform the port call and achieve the value that the port call delivers to stakeholders in the port call, like cargo owner, transport operator, port terminal and a number of other actors involved in the port call. Time related information regarding states are communicated by using Port Call Messages in a format called S-211. To determine the mapping between the many potential states that S-211 can express and the actual states in use, there is a state catalogue which, on the technical level, is an XML file containing these states, their mappings and descriptions of the meaning of each state.

State types

There are three types of states

1. Location states that describe arrivals to and departures from different places, like berth or anchoring area. It does so, not only for the ship making the port call, but can also describe things like a tug boat arriving to tug zone or a pilot boat arriving to the ship.
2. Service states that describe services performed as part of a port call in terms of commencement and completion. If a ship is bunkering during a port call, for instance, this would be represented by the state “bunkering commenced” later followed by the state “bunkering completed”
3. Administration states that describe the administration of services that are part of a port call. Ordering of pilotage is one example (state = “pilotage requested”) and confirmation of such ordering another (state = “pilotage request received”)

Connecting states to S-211

Each type of state has a set of defining coordinates, fields that are used to uniquely identify each state in S-211 terms.

Location state

- referenceObject – what is arriving or departing. Most often the ship (VESSEL)
- timeSequence – is it arriving (ARRIVAL_TO) or departing (DEPARTURE_FROM)

- location type – fromLocation or toLocation type, as decided by the time sequence. Can be a number of different location types, berth (BERTH) is one

Hence, a ships arrival to berth, represented by the PortCDM state Arrival_Vessel_Berth is expressed in S-211 by a PortCallMessage containing a locationState element with the three fields mentioned above set as follows

- referenceObject: VESSEL
- timeSequence: ARRIVAL_TO
- toLocation (since this has timeSequence ARRIVAL_TO): BERTH

This is described in the State Catalogue as

```
<LocationState>  
  <StateId>Arrival_Vessel_Berth</StateId>  
  <Name>Arrival Vessel Berth</Name>  
  <Description>Vessels arrived to assigned berth</Description>  
  <TimeSequence>ARRIVAL_TO</TimeSequence>  
  <ReferenceObject>VESSEL</ReferenceObject>  
  <LocationType>BERTH</LocationType>  
</LocationState>
```

Please note that the toLocation can refer to any specific berth within the port, as long as it is a berth and not some other type of location. If timeSequence is DEPARTURE_FROM, of course, the relevant location is fromLocation.

Service state and Administration state

Since Administration states refer to the same services as Service states, they share the defining coordinates. The only difference is the allowed values for timeSequence.

- serviceObject – which service are we referring to? Examples can be towage (TOWAGE)
- timeSequence – where are we in the process of this service? For a Service state, this is either commenced (COMMENCED) or completed (COMPLETED). For an Administration state it can be requested (REQUESTED), denied (DENIED) and a few others

Ordering of towage is represented by a Towage_Requested state, expressed in S-211 with a administrationState element with the following fields set as shown:

- serviceObject: TOWAGE
- timeSequence: REQUESTED

Please note that Administration state does not have a timeType, since it would always be actual.

The start, or estimated start, of said towage is represented by a Towage_Commenced state, expressed with a serviceState element as follows:

- ServiceObject: TOWAGE
- timeSequence: COMMENCED

More information

Detailed technical information on the S-211 Port Call Message Format, its XML schema and the corresponding PortCDM State Catalogue can be found at <https://specification.portcdm.eu>

APPENDIX 2

MetroMap – Port of Limassol

