30th of March 2019

(Concept Note #22)

Substantial value for shipping found in PortCDM testbeds

by

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Abstract

PortCDM,[1] as an enabler of the Sea Traffic Management (STM) concept, including the Port Call Message Format PCMF (soon to be recognized as international standard S-211) for communication, has now been implemented and validated in four ports in the Mediterranean and five ports in the Nordic region. The results are positive, and all actors report constructive implications. Accordingly, there is a considerable potential benefit to be achieved by a global implementation of PortCDM in all ports, irrespective of the current port administration system.

We learned from the testbeds that, despite a variety of approaches to port administration, there are clear advantages of implementing the PortCDM in conjunction with current information systems and operating procedures

This concept note briefly summarizes the challenges addressed by PortCDM, and how it provides value on four different levels, 1) within a port, 2) among ship operators and ports, 3) between port and hinterland operators, and 4) between ports of departure and arrival.

Finally, this concept note reports on the experiences of the testbeds, where PortCDM has been implemented and validated. The impressive result is that predictability could be improved by at least 25% for 2683 port calls, 50% for 678 calls and 75% for 229 calls. Such increased predictability has a large number of benefits for all actors, and the concept note concludes with an overview of these benefits for each actor in the port.

Challenges of optimizing and synchronizing port call operations

The maritime transportation ecosystem is highly distributed and fragmented, and there is no central coordinating actor. Furthermore, there are often competing actors for some services, who are required to collaborate and coordinate.

Due to the number of port calls conducted per year, one might expect that port calls would be repetitive and routine, making it easy to forecast the different time and spatial dimensions associated with the events of a port call. However, as can be seen in the AIS data analysis in appendix 1, irrespective of the type of transport, the type of port, the time spent in port is not the same and does not seem to follow a clear pattern.[2]

The top diagram in appendix 1 shows that a container ship in a Scandinavian port spends between 10 and

[1] 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

[2] However, the same reasoning does not apply for ships on regular schedule, such as ferries following a fixed schedule, ferries carrying cargo and the cruise ship calls in which plans are made well in advance.

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30 hours for a port call, while it spends between 7 and 23 hours in a typical East Mediterranean port. Accordingly, worst-case turnaround in a port is approximately three times as long compared with the fastest port. We see the same patterns in the two smaller diagrams below for tankers and RoRo ships.

The irregular patterns revealed in the three figures in appendix 1 show that trying to forecast the turnaround time for any particular ship's visit is very difficult. This means in turn that it becomes equally hard to forecast a particular ship's time of departure or plan when other ships can enter a port and find a vacant berth. Irregularities or variations can stem from differences in the purpose of call, the number of involved actors, competing assignments in relation to a particular port call, differences in the quantity of cargo to load and/or discharge, lack of standardization in processes and data sharing resulting in inefficient collaboration, as well as background factors such as traffic density or weather, among others.

The absence of a clear or predictable pattern in port call operations results in the need to manage port calls individually. Optimization at the port level can be achieved if port calls are managed under PortCDM principles. However, if you only optimize a single or a sub-set of all port calls it may lead to disturbances and sub-optimizations for other port calls due to limited/shared resources and negatively impact a port's overall efficiency in the long run. This means that all involved actors must inform each other about plans and disruptions, thereby allowing downstream port call actors to coordinate more effectively.

Through PortCDM, it is possible to ensure that everyone is kept informed in real-time through a **common, digital, real-time situational awareness picture** prior to, during, and after a particular port call.

Put differently, the three diagrams in appendix 1 show that without full knowledge of every significant intention and progress for the visit of each ship to a port, it is very difficult to predict when the many different activities of a port call will take place and how much time the ship will spend at a berth. However, if every actor provides relevant progress and intention data to the PortCDM environment[3] as soon as it is known, all actors that provide services later on in the port call process will have a better chance of synchronizing the use of their resources.

How PortCDM provides value

Fundamentally, the development of PortCDM has been driven by the vision that enhanced data sharing among all relevant stakeholders will lead to enhanced digital collaboration and more reliable operational outcomes in the maritime transportation chain/network. In order for the actors in a port to provide value, there needs to evolve a mature collaborative culture, which is enabled by digital collaboration tools/technologies.

First, PortCDM provides an internationally harmonized messaging format. By having all actors adhere to this format, PortCDM enables different stakeholders to share, in real-time, data related to intentions (estimated, planned) and outcomes (actual) of port call events. In this way, the business case of PortCDM as an enabler of just-in-time arrivals and departures as well as shorter turnaround times, has laid both the foundations for a unified messaging format (the S-211 port call message format)[4] and for forming port call structures[5].

[3] Lind M., Watson R.T., Ward R., Bergmann M., Bjørn-Andersen N., Rosemann M., Haraldson, S., Andersen T., (2018) Digital Data Sharing: The Ignored Opportunity for Making Global Maritime Transport Chains More Efficient , Article No. 22 [UNCTAD Transport and Trade Facilitation Newsletter N°79 - Third Quarter 2018] (https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=1850)

[4] 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

[5] 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 (stmvalidation.eu/documents or directly to the report:

Standardized message formats enable data from diverse sources to be compared, correlated, and compiled into a holistic picture of a port call.

PortCDM 's unified message format (S-211) supports the digital exchange of data related to a port call, elements of its system of record, to promote coordination among port actors and situational awareness by enabling actors to benefit from the data provided by other actors. Its flexible design supports the recording of planned and completed events. Its extensible nature means it could also include agreements on the provision of services. As a port call occurs across space and time, PortCDM records spatial-temporal attributes and other data for each event planned or executed during a port call.

Second, if properly implemented and utilized, PortCDM can provide all actors associated with port call process a system of records[6]. These systems of records, for which standards need to be established, can assist in any decisions regarding existing or future port call plans. Through the establishment of the system of records, authorized actors will be able to obtain a common situational awareness for enhanced planning. Thus, all actors can become informed at an early stage about upstream disruptions potentially effecting their operations and those further downstream.

To ensure transparency throughout the sea transport chain berth-to-berth, PortCDM is built around four collaboration arenas:[7]

- *within the port* to facilitate just-in-time operations between all port call actors in order to serve visiting commercial carriers (ships and hinterland vehicles)
- *among ship operators and ports* to enable continuous updates of plans and progress in both sea and port operations
- *among different ports actors and hinterland carriers/hinterland operators* to enable continuous updates of plans and progress in both hinterland and port operations
- *between the departing and arriving port* to enable shared situational awareness regarding downstream port visits

The different systems of records in PortCDM document all relevant activities for a ship's port visit and other visits of episodic tight-coupled actors, such as hinterland carriers.[8] By using data analytics, these systems of records can be used to advance efficiency and synchronize the series of events associated with the visit of a particular to a port.

Value to different stakeholders

PortCDM's system of record is a digital intermediary between "those who know" and "those who need to know" about a port call process. PortCDM derives its effectiveness from

- Using a unique identifier for the port call of each ship
- Using standardized message format (S-211) for recording and sharing event data
- Enabling real-time sharing of planned and executed event data by port actors

https://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20190330101215/STMVal_D1.3-Improving-port-operations-using-Port-Collaborative-Decision-Making.pdf)

[6] 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

[7] Lind, M., Haraldson, S., Karlsson, M., & Watson, R. T. (2015) *Port collaborative decision making – closing the loop in sea traffic management.* Paper presented at the 14th International Conference on Computer Applications and Information Technology in the Maritime Industries, Ulrichshusen, Germany.

[8] Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Enabling Effective Port Resource Management: Integrating Systems of Production Data Streams, Concept Note #3, STM Validation Project

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PortCDM can support a range of different activities for port actors as shown in figure 1 where we have shown a number of the key decisions made by different port stakeholders. These decisions vary from the obvious like 'Port and berth optimization' to decisions that are more futuristic like 'e-Berthing'. The latter is concerned with powering a ship with electric power whilst in port to avoid burning polluting diesel fuel.

As such, PortCDM can provide the basis for both managing the present, i.e. the port call of a ship and other episodic tight-coupled actors, and for planning the future capacities and capabilities of a port.

In summary, at the core of PortCDM it is the ability to build and provide a common situational awareness for all authorized actors. The common situational port call awareness, which is enabled by PortCDM through the transmission of data in the standardized, internationally recognized message format, allows all actors involved to get the complete picture of the different port call events as well as the different actors' intentions.[9]

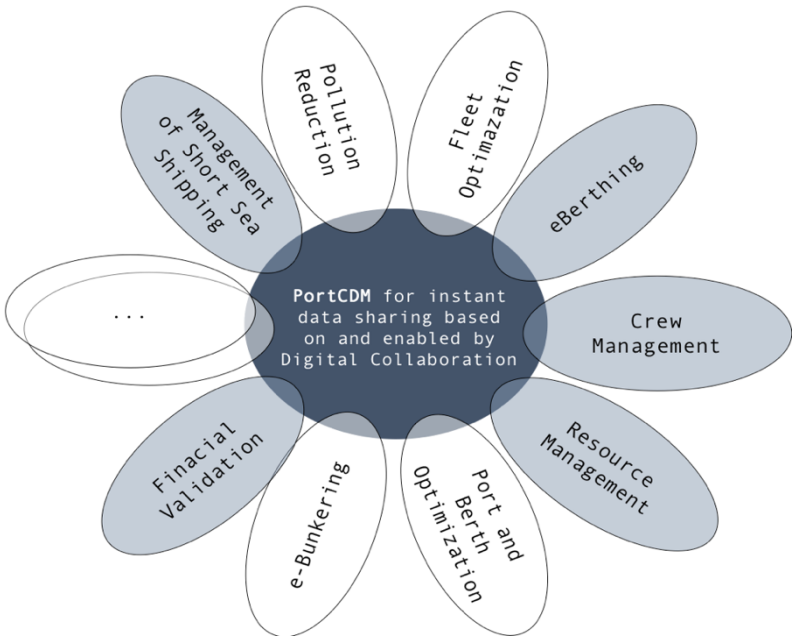

Figure 1: Different areas of application of PortCDM

When actors share data,[10] it is possible to provide the following operational services:

- *Port call monitoring* to provide the actors with an overview of the timing of port call operations and utilization of resources and infrastructure (waterways, berths etc.).
- *Port call coordination*[11] to support the actors in coordinating their operations (in time and space) in relation to other actor's plans and outcomes.
- *Port call synchronization* to support the actors in synchronizing their operations in relation to other actors' plans and outcomes in conducting operations at the same time and place.
- *Port call improvement and innovation,* to provide the actors with the basis for fine-tuning and improving the port call process based on an analysis of conducted port call operations.

Notifications and warnings are associated with the first three operational activities providing capabilities to deliver just-in-time services as based on a high degree of predictability.

[9] Lind M., Bergmann M., Watson R., Haraldson S., Karlsson F., Andersen T., Ward R., Bjorn-Andersen N., Sancricca M., Gerosavvas N., Heidecker A., Lane A., Gimenez J., Ferrús Clari G., Gonzales A., Márquez Richarte M., Voskarides S., Pouros G., Deosdad I. (2018) Extending the efficiency boundary from ports to hubs: A new role for container terminal operators, Concept Note #15, STM Validation Project

[10] Lind M., Haraldson S., Mellegård N., Karlsson M., Clari G., Deehan S., McBride J. (2015) Port CDM Validation Report, Activity 2 – Defining Sea Traffic Management Document No: MONALISA 2.0 D2.7.1

[11] Lind M., Bergmann M., Watson R.T., Bjorn-Andersen N., Haraldson S., Andersen S., Ward R., Rosemann M., Karlsson M., Zerem A., Skovbakke Juhl J., Sanricca M. (2018) Port Call Efficiency - the benefits of coordination and synchronization, Concept Note #14, STM Validation Project

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Findings from the nine testbeds implementing PortCDM

Within the STM validation projects, PortCDM has been demonstrated and validated in the four Mediterranean and five Nordic test beds. As part of the STM validation project, 43 976 port calls generated 1 696 115 records (on average 38 records per port call) all following the port call message format (forthcoming as S-211 standard). All of these records were generated either through automatic connectors or by actors using stationary and mobile applications providing situational awareness being of different types. The validation results clearly indicated an improvement potential for port call operations by adopting digital data sharing complying with the design principles of the PortCDM concept.

According to the statistics obtained, we could observe various inefficiencies with respect to the amount of time that ships spend waiting to be served (figure 2). For example, on average container ships in a harbour spent about 70% of their time at berth, while only 58% of their time is spent doing operations; so, the remaining time can be considered as idle time.

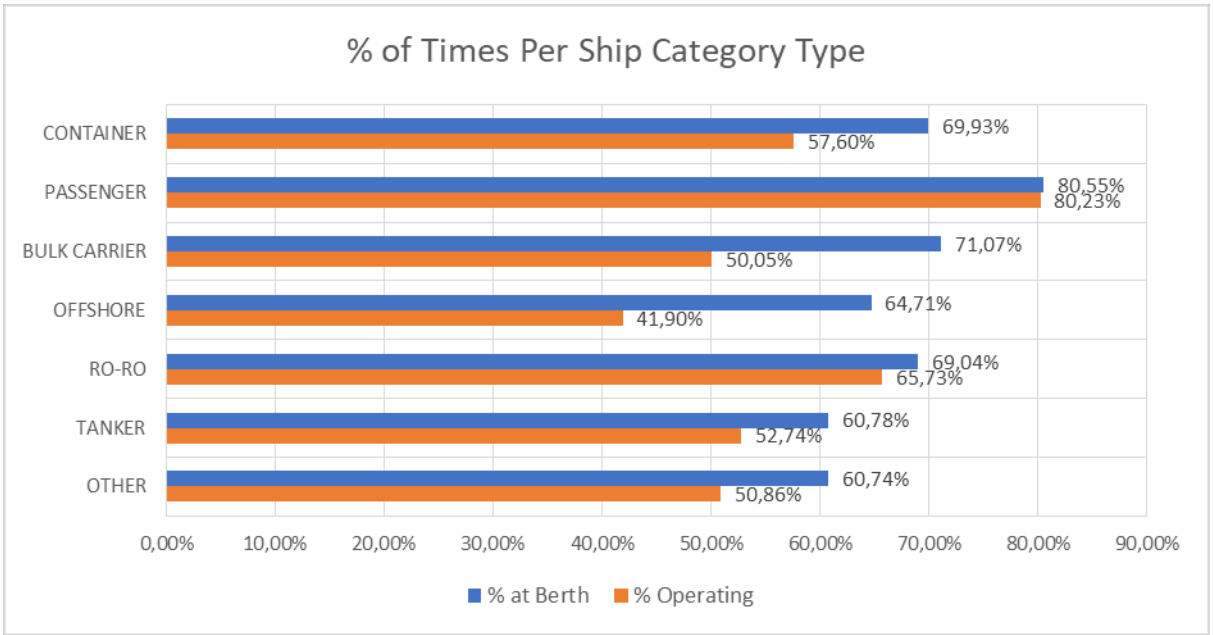

Figure 2: Average time per ship category taken from the test beds

Further analysis of the predictability[12] regarding the four critical states (Arrival Traffic Area, Departure Traffic Area, Arrival Berth and Departure Berth), shows an improvement potential for a large number of port calls, in some cases reaching up to 90%. For example, for Arrival Traffic Area predictability the results indicated that predictability could be improved by at least 25% for 2683 port calls, 50% for 678 calls and 75% for 229 calls.[13]

Similar improvement potential was also observed for the other three critical states. From Figure 3, it becomes evident that the overall average predictability decreases as we progress through a port call (i.e. from Arrival Traffic Area, to Arrival Berth, to Departure Berth to Departure Traffic Area.) This clearly indicates

[12] Predictability is defined as the degree to which a correct prediction or forecast of a state has been made. Predictability is the expression for the capability to forecast the when a particular event occurs. Predictability has been calculated according to the following formula as follows: $PRED_{RAPP}$ = 1 – [Deviation of estimate from actual / Time estimate was reported before the actual time]

[13] 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, *forthcoming report*

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that the improvement potential for predictability is greater for the later stages of a port call.

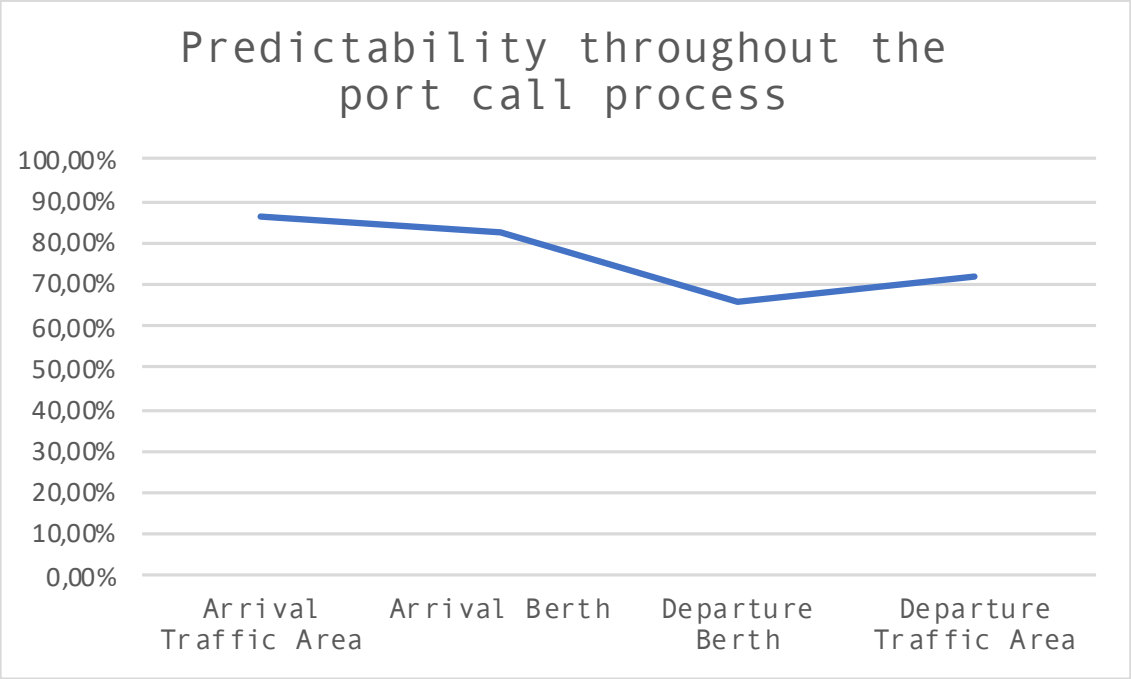

Figure 3: Predictability through the port call process based on the analysis of 43 976 port calls (out of 1 696 115 port call messages)

Port call synchronisation improvement potential

The validation results indicated an improvement potential of port call synchronisation by the use of digital data sharing between a ship and the intended port of arrival complying with the design principles of PortCDM.

More specifically, several use cases were reported that clearly illustrated the benefits of sending a Recommended Time of Arrival (RTA) to a ship that has previously shared its planned time of arrival with the port. The identified challenges in successfully completing the process involve:

- a reluctance to send an RTA because of the competitive nature of ports, (by following a first come, first served principle);
- inability to commit to an RTA because of congestion at berth and uncertainty in planning;
- late sharing of the planned time of arrival by the ship making the sending of an RTA obsolete; and
- non-acceptance of the RTA by the ship.

Since this port call synchronisation procedure was only implemented for a few port call instances so far, more testing is needed to clearly demonstrate the benefits and any remaining challenges. It would seem, however, that the development of a collaborative culture between the various actors at a port for mutually agreeing on important things like a ship's RTA, is currently the most important prerequisite to making this happen.

Implications for different stakeholders

Different stakeholders have made statements in relation to common situational awareness and enhanced capabilities of coordination in the port call processes (for some summaries, see appendix 2). They clearly

point to the benefit of being informed about other actors' plans and progress – both within the port and from external sources (such as ship movement and progress in upstream ports).[14]

Significant business benefits were identified for the different types of stakeholders. Those beneficial effects are identified in the following table:

For shipping companies /ships	**For shipping agents**
• saved bunker due to just-in-time arrivals • saved bunker due to just-in-time departures avoiding chasing the time window at the next leg • fleet optimisation and saved bunker due to shorten Total Turnaround Time (TTT)	• enhanced basis for planning and easier coordination of port call operations • less time spent on chasing different actors, more time for other services to the ships.
For terminals operators	**For VTS operators**
• enhanced possibilities for berth management • enhanced capacity utilisation (resources and infrastructure) • better planning horizons for approaches to be served	• possibilities to digitally log entrance and departures. • better coordination of ship movements. • increased capability to synchronise the traffic dependent on the status in the port
For port authorities	**For port control / pilot planning, tug operators, mooring companies, and service providers**
• safe and efficient port approaches • long- and short-term overview of port visits	• enhanced basis for planning • optimised capacity utilisation • enhanced capacity utilisation (resources and infrastructure)
For hinterland operators	**For digital service providers**
• enhanced capacity utilisation (resources and infrastructure) • better planning horizons for loading / offloading of @ ports • enhanced predictability	• low entry barriers to provide digital innovations • enhanced capabilities in existing systems by be connected to the "outside"

A bright future

Port administration is an information intensive business, and digital data sharing of intentions and completed actions is the foundation of port efficiency and high levels of resource utilization. The Nordic and Mediterranean testbeds have documented that PortCDM is very valuable for all port actors. PortCDM is the keystone for building the port of the future characterized by fast ship turnaround, high-quality services, and efficient resource utilization. Competition will ensure that those ports who raise their capital productivity beyond the industry's norms will capture more business. The future belongs to those who take bold steps to

[14] 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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ensure they are digitally connected and data competent.

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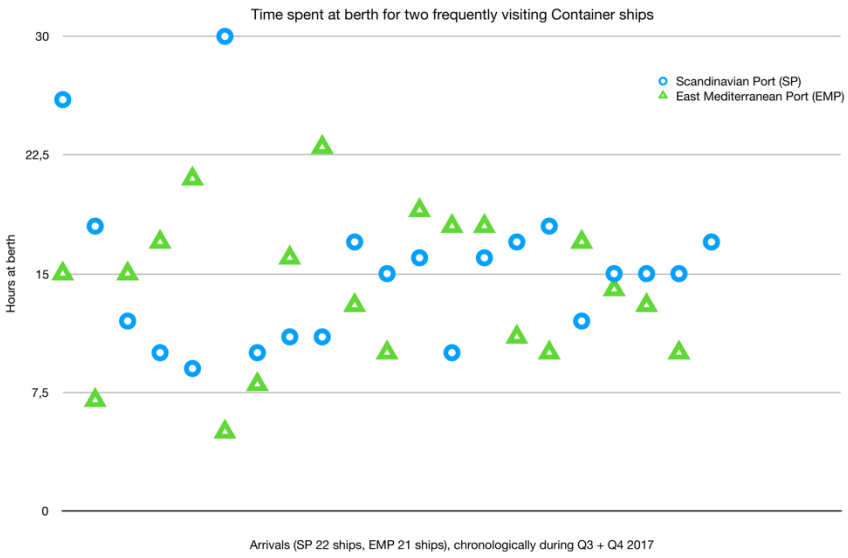
Appendix 1: AIS data showing the time spent at berth for the same types of ships visiting the same ports on multiple occasions distributed over container ships, tanker ships, and ro-ro ships



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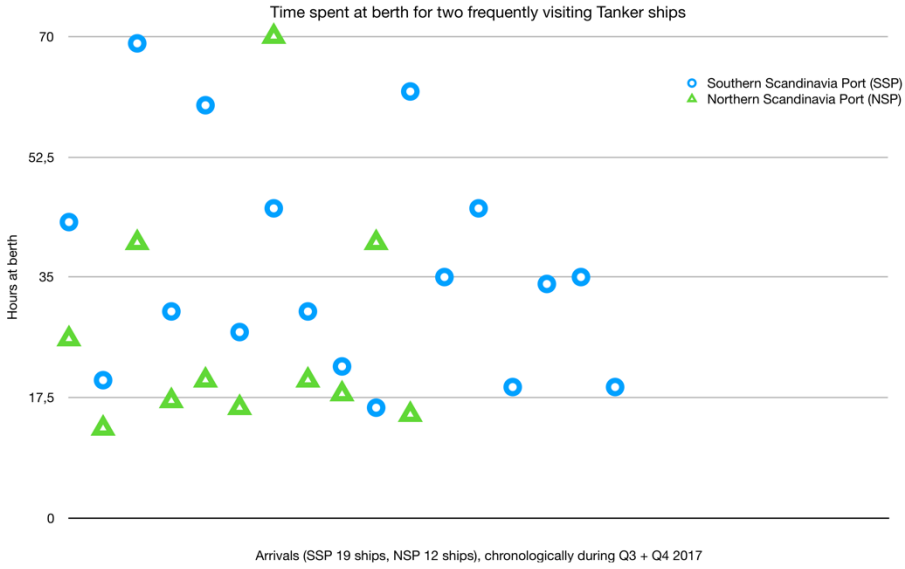

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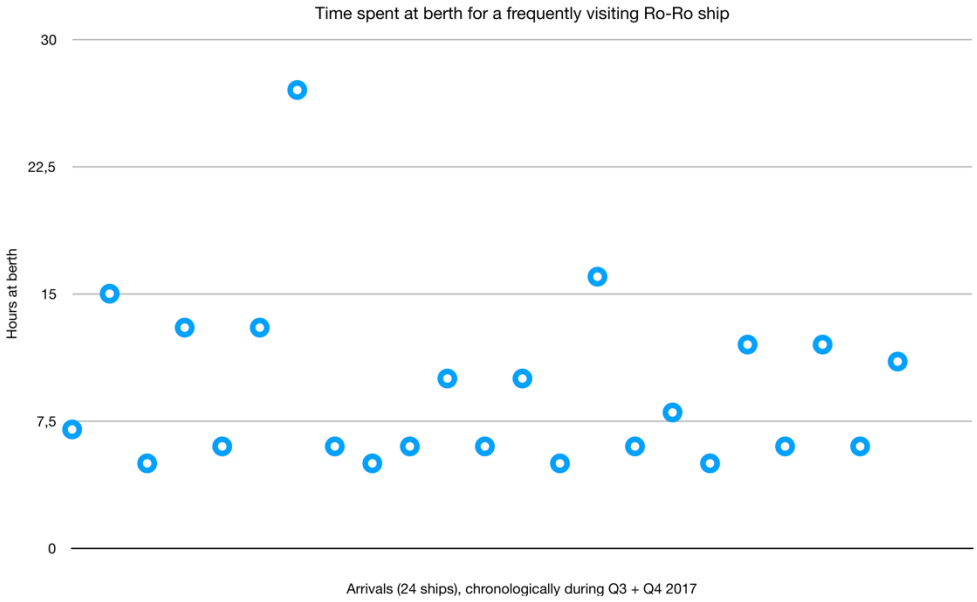

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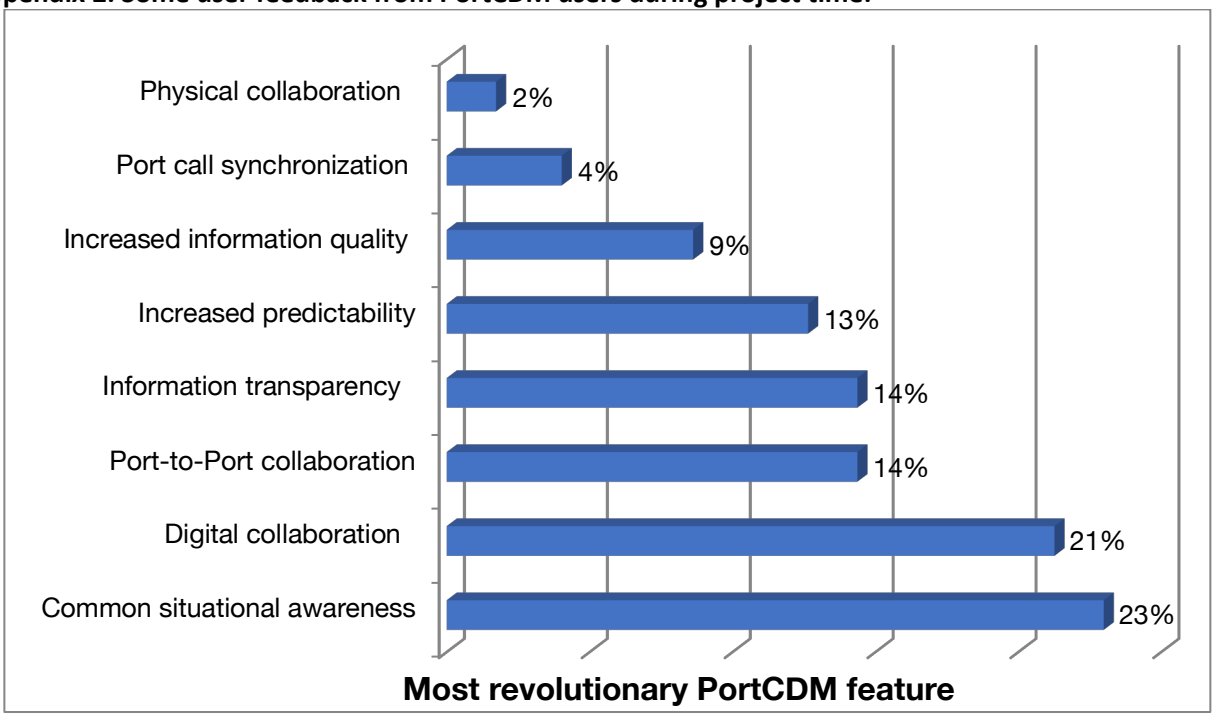
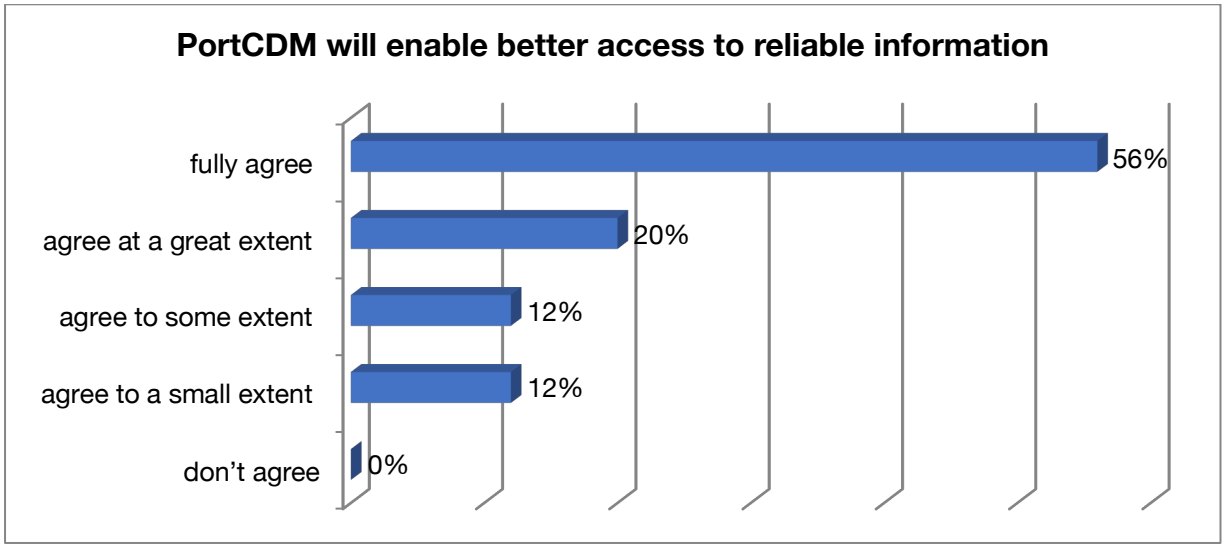
Appendix 2: Some user feedback from PortCDM users during project time:





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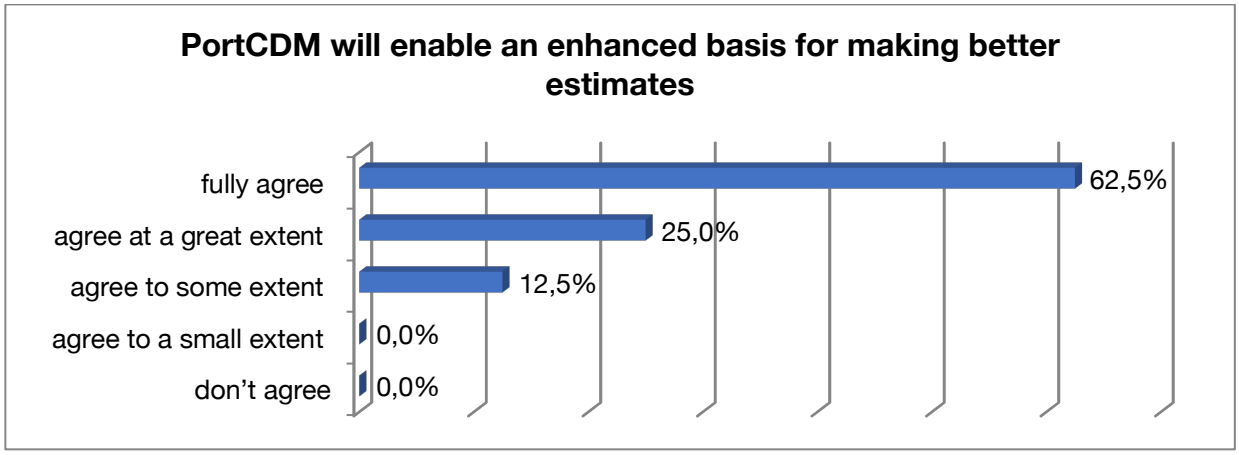

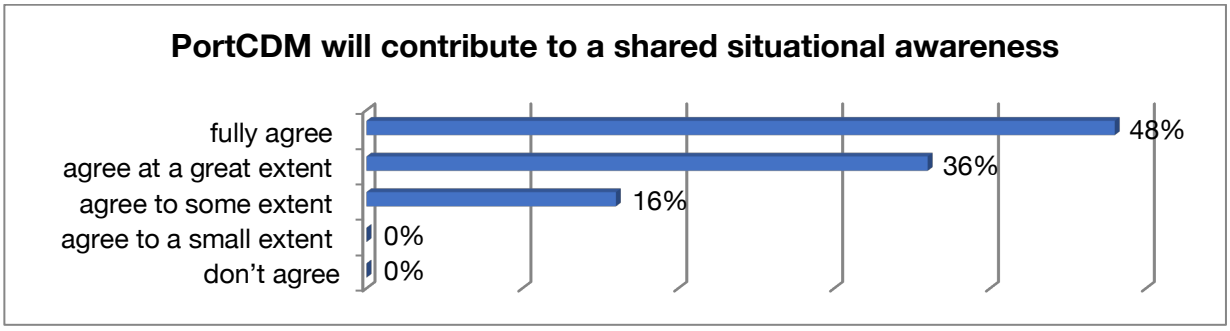

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