STM_Validation_D1.3
Improving port operations using Port Collaborative Decision Making
2019.03.17
## DOCUMENT STATUS

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<th>Signature</th>
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<td></td>
<td>Activity 1 active members¹</td>
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### Authors

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michaelides Michalis, Evmides Nicos, Gerosavva Neofytos, Herodotou Herodotos, Voskarides Sotos</td>
<td>Cyprus University of Technology</td>
</tr>
<tr>
<td>Andersen Trond, Rygh Terje</td>
<td>Port of Stavanger</td>
</tr>
<tr>
<td>Arjona Arcona Jordi, Ferrus Clari Gabriel, Gimenez Maldonado José,</td>
<td>Valenciaport Foundation</td>
</tr>
<tr>
<td>Marquez Miguel, Gonzales Albert</td>
<td>Port of Barcelona</td>
</tr>
</tbody>
</table>

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Executive summary

Over the last couple of decades and specifically in the last few years, various initiatives have been launched in the maritime domain to overcome the traditional narrow view of focusing exclusively on optimising individual actor-specific processes. However, since most processes are shared among several actors, it is necessary to share information to support collaborative decision-making, and for efficiency reasons, exchange of information has to be in a standardized format.

Secondly, it has become increasingly clear that, as in the aviation sector and more generally across commerce, it is necessary for the maritime sector to go through a digital transformation. Digitalisation will enable collaboration and better-informed decision-making in the maritime industry which, in turn, will substantially improve the overall efficiency, effectiveness and innovation in the international transport and logistic supply chains.

Prior initiatives, including BLAST, MONALISA and MONALISA 2.0 promoted digitalisation to enable data sharing to create improved situational awareness thereby enhancing safety and efficiency of the maritime transport sector. The Sea Traffic Management (STM) Validation project was the logical result. The STM validation project aims to validate the envisioned concepts through sea trials and simulation.

Activity 1 - PortCDM testbeds, is one of five activities in the STM validation project. It has focussed on Port Collaborative Decision Making (PortCDM), a concept inspired by the aviation sector where Airport CDM (A-CDM) is already well established. The concept is now beginning to be embraced by the rail transport sector.

The purpose of PortCDM is to support the port call optimisation process by promoting:

- The extension of the planning horizons through intra port collaboration, ship-to-port collaboration, port-to-hinterland collaboration, and inter port collaboration.
- The sharing of the timing of future events for the coordination of the port call process
- The combination of multiple sources of data for enhanced predictability
- Shared situational awareness by sharing data on the progress of a port call among internal and external involved actors

For this purpose, PortCDM has been developed to meet the needs of a concept that would:

- enable real-time standardised information sharing of time stamps between actors involved in port calls
- enable just-in-time approaches by synchronising the ship’s approach to the port with the port’s ability to serve the ship for its purpose of call
- provide situational awareness as a basis for actors’ coordination of their actions performed in relation to forthcoming and on-going port calls

In this way, PortCDM contributes to the enhancement of integrated operations between actors involved in:

- the port call, avoiding unnecessary waiting times
- managing inbound and outbound cargo/passengers efficiently
- coordinating the ships’ sea voyages and the port approach, reducing unnecessary waiting times (anchoring times) for ship outside the port
- securing a smooth and precise transport timetable from port to hinterland of cargo and passengers
PortCDM is thus an essential part of STM. It develops and utilises standardised data sharing between ships and all relevant port call operators by providing port-call information, mainly timestamps and related metadata to create a joint situational awareness based on shared time stamps. The Port Call Message Format (PCMF) has been developed to enable the different actors to share standardised and interoperable data to gain better situational awareness and improve their operations to increase the efficiency of the port call. It also allows the optimisation of the sea voyage, as the ships get information on when the port can best serve them and, with this information, allows them to sail “Just-In-Time” to reduce fuel consumption and improve their environmental footprint. The PCMF, to be known as standard S-211, was used extensively during the validation project. S-211 is based upon and fully conformant with the S-100 data exchange baseline format that is internationally recognised and endorsed by the IMO as the baseline format for its e-Navigation concept.

The PortCDM concept has now been validated in nine ports clustered into two testbeds - the Mediterranean and the Nordic testbeds. This report describes the result of this validation.

During the validation process, port call actors have interacted in continuously arranged living lab workshops, they have run focus months in which software for data sharing has been utilised for data sharing. This software, working as a PortCDM demonstrator by reflecting the design principles of PortCDM, has consisted both of back-end and front-end services. The validation has been captured both in qualitative analysis through interviews, questionnaires and collaborative reflections and quantitative analysis of the captured data that has been shared in the port environment.

Over 1.7 million timestamps were shared successfully in the ports utilizing the demonstrator, based on the design principles of the PortCDM concept. The principles of PortCDM were implemented successfully in the participating ports.

The qualitative analysis of the results of the PortCDM validation project shows that enhanced situational awareness, provided by the data sharing enabled by PortCDM is of value to participants. The participants pointed out that an increased reliability of ETAs and ETDs for port actions has substantial benefits.

Enhanced situational awareness as facilitated by PortCDM provided port call actors with access to more reliable data and a greater awareness of other actors’ intentions. Enhanced situational awareness was shown to provide positive effects for operations, including:

- Making better estimates for ETAs and ETDs (100% of respondents agreed ‘to some extent’ or ‘more’ with this conclusion)
- Improved work procedures (> 50 % agreed to some extent or more)
- Reduced time spent on information gathering (> 80 % agreed to some extent or more)
- Reduction of administrative workload (> 80 % agreed to some extent or more)

PortCDM is not simply a technical enabler for sharing data based on the standardised PCMF. Importantly, PortCDM is a new and innovative operational concept that suggests and requires a change to the collaboration culture in ports and between port and ship so as to build the necessary operational and cultural foundation for optimal use of the technical concepts to achieve the desired outcomes. This requires attitudinal changes among the actors in the maritime transportation chain.

The validation process took significant effort to foster the required changes in attitude and ways of interacting between the various actors. In particular, the use of living labs was most
successful in getting the actors to appreciate the constraints, perspectives, needs and motivation of others in the chain and the impact of the actions of one on another. This reduced the traditional tendency to restrict the sharing of data resulting in enhanced collaboration and better understanding of the overall situation leading to more effective individual operations.

Not unexpectedly, and in line with proposals to introduce other innovative and novel revisions to long standing but inherently uncoordinated processes, such as the implementation of Airport-CDM (ACDM), any quantitative analysis of the results of the validation project proved to be problematic. Here the first full qualitative analysis was done after the first airports had been implemented ACDM. In fact the implementation of ACDM recommends following phases where the validation is done after the implementation: Information Phase - Analysis Phase - Cost-benefit analysis (CBA) - Implementation Phase – Validation and operation of CDM elements.\(^2\) This was because it was very difficult to establish a comparison baseline in a currently fragmented system that collectively maintains very limited standardised or accessible records regarding the progress of activities such as the port call process - which is at the heart of PortCDM. Nevertheless, the statistical data that was obtained indicated that the predictability of berth arrival and berth departure was likely to be enhanced when port call actors collaborated through data sharing using the PortCDM demonstrator.

As a consequence, the fundamental baseline used for comparison was the absence of a collaboration port call process and the impact of introducing one. The validation project examined what it means to introduce such a collaborative environment.

What was clearly indicated through the variety of feedback mechanisms used in the validation project was that the introduction of PortCDM was strongly supported. No significant adverse criticism was encountered – any negative comments were generally aimed at improving what was being presented during the validation period. Overwhelmingly positive benefits were identified by the ports and actors that participated in the validation project. A number of the ports intend to continue and build upon the PortCDM concept introduced as part of the validation project. As a result, there is high confidence in recommending the establishment of standardised data sharing environments within and between ports as an essential step on the path towards increased efficiency and sustainability.

Building on the consistently favourable support of the PortCDM concept from the participants of the validation project, a range of strategies to promote the PortCDM concept and to encourage the operational implementation of PortCDM globally has been developed.

The International PortCDM Council (IPCDMC), comprising representatives from all the key actors and stakeholders in the maritime transportation chain, was originally established as a support mechanism to the PortCDM validation project to provide user-driven advice on common procedures, standards, data formats, guidelines and guiding principles. It now stands ready to provide governance and coordination for the implementation of PortCDM at the local, regional and global level. The project has defined a strategy of incremental implementation, based on tiered-level approach that enables ports and their actors to implement PortCDM in a flexible way, from a basis level to a comprehensive level, according to a particular port’s situation and requirements. A monitoring framework has also been defined, based on several Key Performance Indicators - duration time, waiting time, berth productivity, capacity utilisation,

\(^2\) [https://www.eurocontrol.int/articles/airport-collaborative-decision-making-cdm](https://www.eurocontrol.int/articles/airport-collaborative-decision-making-cdm)
predictability, and punctuality. These KPIs are purposely based on output performance not on the size or complexity of the infrastructure that supports PortCDM.

While the IPCDMC does not seek to define how PortCDM should be implemented in any given port or in a region, it will provide the necessary over-arching guidance to ensure that any of the implementations meet the overall aims of PortCDM and therefore serve the needs of sea traffic that moves from port-to-port, country and continent.

In summary, the results of the PortCDM validation project show clearly that:

- PortCDM can provide a significant improvement in the overall performance of the maritime transportation chain ecosystem, and
- PortCDM is an important and logical part of Sea Traffic Management overall

Based on a combination of the results of the use of the validation testbed in nine ports on three separate occasions over a period of two and a half years and the qualitative and quantitative analysis of the resultant feedback it can be concluded that:

- **the Port CD M concept and digital data sharing provides significant positive benefits by enabling port call actors to plan, coordinate and synchronize activities more efficiently giving rise to enhanced and more efficient overall port call performance; and**
- **the basic doctrine, procedures and standards for PortCDM have reached such a level of maturity that they can now be used as the foundation for a global implementation of PortCDM.**

**Next Steps.** The key building blocks for the global implementation of PortCDM have been developed during the validation project and are now available; in particular:

- The S-211 Port Call Message Format
- The proven use of living labs to ensure that all involved actors are informed and engaged in the PortCDM process
- The proven use of a metro map for each port to identify the key areas and actors where data sharing is essential to overall improvement
- A PortCDM maturity model that provides the flexible pathway for incremental implementation of PortCDM, according to each port, its scope and its circumstances
- An International PortCDM Council that stands ready to provide governance and coordination for the implementation of PortCDM at the local, regional and global level.

The following activities are now required to implement PortCDM, on a global scale:

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| Encourage / support industry to put the PortCDM principles and the S-211 format into operational use | • Present PortCDM and S-211 in industry events like conferences, workshops…
• Write articles in relevant industry publications
• Collaborate with industry actors intending to create PortCDM/S-211 compliant products or services
• Keep open dialog with implementers and adopt changes as seen fit |
| Promote the emergence of projects that are implementing PortCDM | • Promote and support relevant projects
• Encourage actors and project consortia to include PortCDM functions in projects of relevance |
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<td>PortCDM, such as in short-sea shipping</td>
<td>• Support development of new project ideas which include PortCDM or aspects of it</td>
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<td>Encourage further research on port operations</td>
<td>• Support activities executing further research</td>
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<td>• Review new research on port operations to improve PortCDM concept</td>
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<td>Invite service providers to bring new service opportunities building upon the capabilities the</td>
<td>• Identify relevant service providers</td>
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<td>third-parties can provide to the maritime industry (and by that lowering the thresholds for</td>
<td>• Start discussions to promote the development of services compliant and in support of PortCDM</td>
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<td>new service providers to come into the maritime sector)</td>
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<td>Strengthen the role of the PortCDM Council by encouraging the Council to report upon best</td>
<td>• Participate actively in PortCDM and its working group</td>
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<td>practices identified in existing PortCDM implementations</td>
<td>• Suggest initiation of activities on defining best practices on PortCDM in the Operational Working Group of IPCDMC</td>
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<td>Encourage the establishment of a PortCDM community of users and providers</td>
<td>• Analyse options and potential sponsors for a “PortCDM community”</td>
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<td>• Define details of this idea</td>
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<td>• Recruit actors and support the establishment</td>
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<td>• Ensure leadership is handed to independent actors</td>
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<tr>
<td>Support processes of PortCDM accreditation (for port operations) and certification of services</td>
<td>• Support the finalization of PortCDM Compliancy document by IPCDMC</td>
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<td>(provided by service providers)</td>
<td>• Suggest best way forward and reach agreement in IPCDMC (once established within the Governance WG)</td>
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**Practical next steps for the implementation of PortCDM**

The time is ready for PortCDM to be progressively implemented worldwide. Indeed, several ports involved in the PortCDM validation are continuing to use PortCDM and developing it further as part of their operating practice.

For those actors that now wish to adopt PortCDM, the next practical steps are:

- ensure that the digital data reporting mechanisms being used in their business are interoperable with the S-211 data exchange format
- discuss the mutual benefits of PortCDM with their direct collaboration partners and other actors in their locality
- discuss the mutual benefits of PortCDM with the other actors in their profession and business
- help to establish a local “PortCDM community” to bring all the interested actors together
- participate in the IPCDMC either as a participant or an observer
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1 Introduction

1.1 A connected world is changing maritime practices

Business today is much different to a hundred, or even fifty years ago. Traditionally, businesses carried out transactions in isolation in order to protect the business from competitors and to create a competitive advantage. Working with competitors or even with those with links in the same market was often seen as detrimental as this could disclose critical information and reduce competitive advantage. The way to do business, particularly in maritime, was through cooperation in systems of production (such as the arrangements for unloading the cargo) and through episodic tight coupling (such as the rendezvous with a pilot) but only by exchanging the minimum data necessary for the transaction.

In our connected world, much greater cooperation within and across markets is necessary for survival. Almost all airlines collaborate in alliances and work closely together when setting up code-share flights, even in this very competitive environment. Collaboration in the car industry can result in vehicle designs being shared between competitors. The shipping industry is only now waking up to the concept of cooperation and collaboration, which is greatly supported, even enabled, by the latest developments in digitalisation, Internet of Things (IoT), and advanced inexpensive connectivity.

Digitalisation is now being implemented broadly across many different areas of the maritime field. However, if we look at how the industry adopts digital technologies and explores new opportunities, these seem to be mainly oriented towards granting some level of access to data for different stakeholders stretching all the way from shipping companies, ports, and operators to diverse (digital) service providers; there is much less emphasis on mutually beneficial data sharing. Exchanging only the minimum amount of data creates ignorance gaps resulting in missed detection of opportunities for system wide efficiency.

Each actor in a self-organising ecosystem provides value to the larger value network. In businesses today, high demands are placed upon each participating value provider to ensure a high degree of capacity utilisation. For providers in a self-organising ecosystem, such as the maritime transportation chain, to pursue higher efficiency they need to be informed about related actors’ planned actions and outcomes. Ideally, the sum of all optimisation decisions pursued by each actor in the value chain should contribute to ecosystem optimisation, but this is not always the case. Within the transport sector, the spatial and temporal dimensions need to be captured for planned and actual physical movements and service provisioning. By knowing when, where, and what for each activity, actors are better informed to coordinate their related and often inter-dependent operations.

As the maritime sector recognises the need for digitalisation, improved cooperation, and collaboration through information sharing, various projects and programs have been developed, and some are now being successfully implemented. The Single European Sky ATM Research programme (SESAR) for the airline industry and Sea Traffic Management (STM) for the maritime sector are examples of holistic concepts that were developed over successive phases, where each phase was focusing on a specific aspect of the holistic concept. From the IMO e-Navigation initiative, through projects like BLAST (Bringing Land And Sea Together) or MONALISA - the motorways of the sea project, various stakeholders have formed teams to develop operational models, intended to help the maritime industry to rapidly adopt and implement such innovations.
A core problem for shipping has been a lack of means to share and communicate details and accurate timings of events, primarily due to problems in information exchange during the sea voyage. This has made sea transport something of an isolated industry trailing behind other industries. However, with today's technology, it is possible to increase efficiency by enabling the near real-time sharing of critical data among stakeholders, and at the same time increase safety and security. In the light of the data processing and connectivity efficiencies of digitalisation, sea transport can now be more synchronised and transparent. It has become possible to oversee the full transportation system both during a sea voyage and at the endpoints in port operations. Several initiatives for digitalising the maritime sector have been posited, both conceptually and operationally. These digitalisation opportunities in the maritime sector have also brought opportunities for new business models and new and more effective contracting models.

The scope of STM is berth-to-berth. This means that actors in the whole chain of activities from the berth at the point of origin, through the sea voyage, and to the berth at the point of destination are part of an information chain. For a port to plan its operations with high precision, it needs to be informed about the plans and progress of a ship from its previous port and during the sea passage. Furthermore, the port needs to know the plans and progress of the hinterland transport arrangements that will serve the ship in port. Different elements of STM define service domain concepts to promote (digital) service distribution in the berth-to-berth sea transportation chain. These concepts are Voyage Management, Flow Management, and Port Collaborative Decision Making (PortCDM). These are all supported by Sea System Wide Information Management (SeaSWIM) as the digital infrastructure providing inter-operability within and between the service domains.

The STM concept, originally introduced within the MONALISA 2.0 project to meet the demands of efficient, safe, and environmentally sustainable sea transport berth-to-berth includes a number of concepts. One of those is PortCDM, which has been introduced into the maritime sector to specifically improve the productivity of a port call. PortCDM focusses on facilitating communication and information exchange among all actors in a port call thereby enabling the right capabilities to be made available to serve the port call in the most efficient way resulting in just-in-time arrivals and just-in-time operations in general.

PortCDM is a socio-technical concept that can provide significant benefits by adopting a collaborative culture and collaborative processes within the maritime ecosystem. The PortCDM concept encompasses all port call operations as well as providing technical guidelines for harmonised digital collaboration. Expressed in a different way, PortCDM integrates the practices of e-navigation at sea with e-logistics in ports in order to improve the global supply chain.

After the initial definition of PortCDM within MONALISA 2.0 project (2013-2015), PortCDM was implemented at the ports of Gothenburg and Valencia. This paved the way for a larger demonstration effort within the STM Validation project (2015-2018), which has possibly been the largest ever "e-navigation" project. During this project, PortCDM has been validated and further refined to meet the desires and demands identified by the shipping and port communities.

In this report, the results of the validation of the PortCDM concept are brought forward including the latest iteration of the concept as such.
1.2 The nature of the maritime ecosystem

Maritime transport is a highly distributed ecosystem with many independent and, in many operations, competing operators. In some cases, up to 40 different and economically independent actors might be involved in one supply chain in the transport network. As a result, the level of coordination often disappoints charterers and other customers, because they experience uncertainty delays, especially when compared to other options such as air transport. The reliability of container ships arriving within one day of the original estimate is below 70%, and far too often, multiple days of delay are experienced. One of the main reasons for the delays (other than weather conditions) is missing or error prone information; for example, errors in the packing list attached to the certificate of origin. It is also not uncommon for up to 15% of the containers on a ship to be placed other than on the cargo plan, and as a result, off-loading cannot be accomplished in a timely manner.

From a logistics perspective, the shipping industry is primarily a self-organising ecosystem with a huge number of sometimes competing individual actors without one overarching governing authority. No public or commercial entity has complete control over all the resources from exporter to importer. In this ecosystem, it is also extremely difficult to effectively manage the utilisation of a wide span of resources - often located in different countries. So, a distributed ownership of the ecosystem has prevailed. If there were a better solution, market forces would likely have fashioned it over time. The most effective way so far, seems to have been to base operations on a large number of independent actors, each one responsible for managing its operations.

However, a self-organising ecosystem, such as the shipping industry, still has to coordinate, particularly when there is tight coupling between the activities of two or more actors. On the highest level, the captain of a ship and a terminal operator for cargo handling need to coordinate. Interestingly, the tighter the coupling, the higher is the potential for a speedy turnaround and optimisation of resources for ships, such as when a terminal is owned or controlled by the shipping company that it serves. The general principle is that tighter coupling improves efficiency because it requires cooperation between two entities. We have used the term episodic tight coupling to describe the tight couplings that occur in the maritime transportation chain for only short periods of time before the parties once again continue as independent entities. However, in this scenario, what cannot be achieved as a result of the brief joint ownership of tight coupling, must be realised by coordination and synchronisation through data sharing.

The maritime sector also competes with other transport options such as trucking and railways. However, because it is a self-organising ecosystem of many independent yet inter-dependent players - unlike trucking or rail, the maritime sector lacks the overall ability to optimise its operations. The risk of detrimental system sub-optimisation is ever present in the maritime sector when each independent player acts opportunistically in its own self-interest. To achieve overall improvement there needs to be acceptance that some actors might, in certain circumstances, have to accept less than optimal operations in their domain in order to ensure that the port ecosystem as an entity can operate optimally. This is a particular challenge.

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In most ports, the principle of first come - first served is standard practice. However, this encourages ships and ship operators to ‘hurry up and wait’, causing unnecessary inefficiencies and higher levels of pollution and greenhouse gas emissions. Contractual issues, legal constraints, and local practices, which have been established over decades of legacy customs, work arrangements, trade union agreements and non-optimal business cultures exacerbate this situation in many ports. However, digitalisation of the maritime sector, e-navigation efforts, and integration of sea transport into a holistic transport system, can enable an enhanced harmonisation on a global scale so that many of the existing challenges and inefficiencies of a self-organising maritime ecosystem are ameliorated or even eliminated.

1.3 Current problems to solve

The transport of goods from producer to consumer requires the integration of the logistic and information supply chains across multiple service providers and transport modes. Ideally, this should be an integrated, efficient, and predictable door-to-door process. To achieve this goal, all actors in the full supply chain need to synchronise their activities through timely and appropriate standardised communication. Unfortunately, this is not the case today, where a huge proportion of communication is either manual or based on non-integrated, non-automated and non-documentated digital systems like e-mails, phone and SMS. These diverse and incompatible communication capabilities among the transport providers severely limit efficiency and predictability.

Maritime transportation typically involves multiple actors, such as agents, terminal operators and other port services, as well as ships and ship owners / ship operators, all providing different types of infrastructure for their immediate collaboration partners. However, these interactions are typically not standardised and only electronically integrated to a limited degree. To enable higher predictability of when and where events will occur requires awareness in the transport chain of the intentions of the different actors and their current status. This includes knowing the client’s needs for co-utilising infrastructure. Digitalisation of all key assets across the common infrastructure creates the foundation for higher predictability.

However, some actors are competing and may be reluctant to share information, especially detailed information. Accordingly, to facilitate an acceptable level of information sharing a balance needs to be found between sharing a sufficient amount of decision-relevant information such as status information for the transport unit to facilitate the flow in the supply chain without the need to share detailed information such as packing lists at the source.

Significantly improving standardised digital data exchange is an opportunity to create a higher level of coordination while at the same time preserving the necessary independence of the various actors. As in other transport and delivery chains, digitalisation and standardisation are key to ensuring tighter, timely, and more efficient operations. This will lead to improved predictability in the maritime supply chain and the consequent reduction in variation will have the potential to unlock entire new levels of efficiency (similar to what could be witnessed with just-in-time or the Six Sigma approaches in other industries). For this purpose, there is a need for concepts that utilise the opportunities that digital collaboration brings to the maritime sector.

1.4 The problem detailed

There are several obstacles preventing just-in-time coordination of actors and services, such as the lack of standardised communications and the fact that many of the actors are competitors. There are also some practical problems making it difficult to accomplish just-in-
time operations without collaboration and data sharing. One problem is that time spent at berth differs greatly for the same ship, even in a port that it visits frequently (examples are shown below). This makes it difficult to predict when the ship will depart. The variability could stem from a number of reasons including differences in the purpose of the call, the number of actors involved in the visit, competing assignments in relation to a particular port call, differences in the quantity of cargo to load and/or discharge, as well as background factors such as traffic density or weather.

From a supply chain point of view this variability makes the process inefficient, resulting in actors having to stand-by on short notice, and, when a ship requests a service, the relevant actors might be busy with other tasks due to their inability to plan.

In figure 1, three examples of this variability are captured. We see how time spent at berth differs for different types of ships - container, ro-ro and tanker. In each case several visits by the same ship to the same port are shown. The time spent at berth has been calculated from AIS data, from when the ships come to a complete stop until they leave.

The container ships have about the same average berth time, approximately 15 hours in both ports. There is a somewhat larger deviation from the mean in the Mediterranean port, but still the variations are very similar. The mean absolute error is 3.6 and 3.9, or 24% and 28% respectively. For both ports, the berth time normally ranges between 11.5 to 18.5 hours for ships visiting frequently. However, this range is large in relation to the mean value. Because the range is so large, no actor in the port can predict how much time the next visit will take, based on previous visits of a particular ship.

The ro-ro and tanker ships have even larger deviations than container ships, so the level of predictability based on time spent at berth during previous visits is even worse.

AIS data does not provide any detail on what activities are performed while at berth. It could be that cargo operations are very regular and that each ship is simply alongside waiting for orders. However, even if that is the case, the problem persists. The fact that a previous visit to a port, by a particular ship, took a certain amount of time does not provide a reliable indication of how much time the next visit will take.

Predictability, based on stability, robustness and standards\(^4\), is key in a lean, just-in-time process. However, since it is difficult to predict and plan based on historical data it becomes important that all actors collaborate and share data in real time. Every actor needs to provide relevant progress and intentions data into the PortCDM process as soon as information becomes available, in order that all other actors providing services later on in the port call process will have a better chance of coordinating and synchronising the use of their resources.

\(^4\) Toyota Production System „House“, https://www.lean.org/lexicon/toyota-production-system
1.5 Collaboration and data sharing – a major key to enhanced performance

As has been described above, collaboration and data sharing in the maritime transportation chain has its challenges. It is fragmented, quite unlike, for example, the ecosystems of the Japanese automakers. Toyota and Honda are renowned for their relentless focus on cost reduction through first class optimisation of their supply chains - much of which they purposely control or influence directly. In August 2018, both companies were reporting improving profits, while US automakers were issuing profit warnings. Toyota and Honda have successfully connected operational databases from their supporting business ecosystems in such a way that databases can be analysed intensively (AI, business analytics, and so on) to identify cost saving opportunities utilising the Japanese kaizen philosophy for continuous improvement. They have experienced that data-driven enterprises are more successful.

By contrast and unlike organisations such as Toyota or Honda, the self-organising and fragmented nature of the maritime industry has traditionally deprived all actors of the data...
needed to achieve high levels of efficiency. Fragmentation is toxic to efficiency, but now there is a solution - digital data sharing.

However, successful collaboration requires among other things, the removal of legal/contractual constraints, and a willingness to share data. As has been outlined already, maritime transport has a strong legacy based on autonomous, often competing, actors in a self-organising ecosystem. This has meant that shipping’s actors are often oriented towards keeping data within their organisation. Thus, outsiders are forced to make less informed operational and strategic decisions. This is an inefficient characteristic for the ecosystem, because low coordinative behaviour leads to less than optimal overall performance.

Current best practices in other markets have long moved away from a data protection bias. As described earlier, in the aviation industry, airlines have for years realised that they need data sharing to survive. Airline alliances and code-share flights are good examples. Connectivity of code-share flights is guaranteed, but it only works if airlines share the necessary data. Even those that have been very outspoken in the past, such as Emirates and Etihad, saying that they did not need or want alliances as they wanted their flights to always be full, have now moved away from this and offer code-share flights. They have realised that they can survive only when they coordinate. The gains from collaboration bias actors to prefer dealing with those who share data.

Walmart is another example. It has a business strategy of efficiency that enables everyday low prices for its customers. In line with this goal, it pioneered bar code scanning and analyses point of sale data. In the mid-1980s, Walmart launched a network, which enhanced its supply chain management process by facilitating data sharing with its suppliers. This then enabled the introduction of a vendor managed inventory, whereby vendors received regular, such as hourly, status reports on their inventory by stock keeping unit (SKU) in each Walmart store. Suppliers could then plan their production and distribution more precisely, lowering their costs and the costs of Walmart for the ultimate benefit of the Walmart shopper. Competitors such as Sears and Kmart failed to match Walmart’s data sharing strategy. This was a substantial contributor to their loss of market share.

Key players in the maritime field are waking up to the data sharing business need - notice the term business need, not business desire. A look at the 2M Alliance (Maersk Line and Mediterranean Shipping Co) shows that key players in the maritime domain know they need to collaborate to serve their customers. The same is true for other trades as well, such as wet and dry bulk, general cargo, and passenger transport. Transparency, data sharing, and collaboration are now essential assets in the competitive game. Old fashioned, protective ways of working will reduce, not protect competitiveness.

While taking in to account what Toyota and Honda did with their suppliers, consideration must also be given to how the different maritime supply chains are competing. The scenario of sharing data with collaborating members within a particular supply chain (in the automotive industry, for example) cannot be extrapolated to sharing data with competitors in a different supply chain, such as between different shipping and terminal alliances. However, different supply chains still share resources in parts of their value chain; for example, port infrastructure and

![Figure 2 Competing (maritime) supply chains utilising the same port](image-url)
services. This is the reason why data sharing between otherwise competing clusters of actors still needs to take place for overall system efficiency (see figure 2) by enabling high levels of resource utilisation, efficiency, and environmental sustainability for maritime transport. Digitalisation provides a contemporary opportunity to re-think, re-configure, and optimise current business processes. This includes inter-organisational re-engineering by spreading some operations and decision-making between actors.

In an ecosystem of autonomous actors serving the needs of different clients, digital access to relevant information allows individual actors to be more efficient, particularly if they are able to access the intentions and the progress of the other actors in real-time. This can also enable the analysis and querying of existing patterns of activity to avoid perpetuating inherently inefficient processes and habits.

Enhanced connectivity using an agreed digital data infrastructure and a standardised data dictionary for sea transport can enhance operational services, facilitate the creation of entire new (data-intensive) maritime services (such as, third-party recommender services) and ultimately raise capital productivity. Two significant benefits that can be achieved through enhanced connectivity and appropriate data exchange are:

- Increased situational awareness for all the actors thereby enabling improved and accelerated decision-making at sea and in port, and
- Seamless track and trace of goods in the sea transport chain for all customers.

Both of these benefits offer substantial savings in operating costs and provide improved customer satisfaction. They also enhance the possibility of green steaming for just-in-time arrivals and optimised port call operations as well as enhanced coordination in relation to the other means of forwarding and onward transport.

A recent master’s thesis study of port call operations concerning conventional cargo in Rogaland in Norway indicates that, if applicable worldwide, there is a substantial savings potential of at least 12 billion USD in port cargo handling operations brought about by avoiding late or early arriving ships, services and cargo, at ports and terminals. A conservative saving of 10% has been identified.

Having the right real-time knowledge about critical operational states has a positive impact on sequential and consequential effects - to the terminals, the ships, and to the hinterland operations. The ship, terminal and other stakeholders will all save money if information is received early enough, and is reliable, safe, accurate and sufficient. All actors can then know if all the stakeholders in the port are ready, or when things change to operations in the value chain where they are involved. The actors in the hinterland, who are also dependent on the same data, can access accurate knowledge and develop a better situational awareness. In turn the goods owner will get a better quality of service on their shipment of goods.

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7 These savings are based on an analysis of making cargo handling more efficient. Taking operations associated to the whole port call into consideration would most likely mean even more savings associated to making port calls more efficient enabled by timely sharing of information.
The Master’s thesis notes that weather is often a significant factor causing delays. Nevertheless, these can still be treated as just another reportable delaying event and be mitigated by better data sharing, planning of voyages routes, by using alternate sailing routes or reschedule the port calls, berth visits and terminal operations. PortCDM supports the sharing of information such as delays due to weather. This, in turn, is used to optimize all just-in-time operations.

For example, if a ship coming to a port can immediately report a breakdown or say, encounters a storm, the planned operations four days later on arrival at the terminal can be rearranged. The stakeholders should, with timely knowledge, be able to better change their sequences of their own services (for example, another ship can be served in the time caused by the delay to the originally planned ship). The delay as such may have an impact but can be mitigated and managed if the ship declares a “delay status” that it available to other actors early enough.

It is important for all actors in the transportation chain to get information about any disruptions causing delays further up the chain as soon as possible. Once this information is available, it needs to be combined with other relevant data sources from the actors, such as:

- downstream ports being informed by upstream ports of the progress of operations related to the port calls that involve them;
- downstream ports being informed when a ship will arrive;
- hinterland operators informing ports of their intentions and capabilities;
- shore centres or Port Control / coordination centres informing affected parties of possible disruptions in planned arrival or departure times;
- the Ports/Terminals have enough information to act professionally and be able to give the best advice and recommendations possible for the ships;
- upstream ports being aware of the capabilities of downstream ports;
- ships informing shore centres of their intentions and progress at all stages; and
- stakeholders informed of contextual information (e.g., weather, traffic).

1.6 Scope and structure of the report

This report is the PortCDM Validation Report. It constitutes delivery M1.3.1 - part of Activity 1 of the STM Validation Project. The report covers the results of the validation of the PortCDM concept, as one of the enablers of the STM concept. The validation itself took the form of a complex innovation project that involved discovering and understanding the needs and in some cases the limitations of the diverse actors involved in the port call process and the limits and opportunities of available information technology to developing and refining the underpinning PortCDM doctrine and an incremental implementation process.

This report captures mainly the results of sub-activity 1.3 (Refinement of the PortCDM concept) based on the efforts pursued in sub-activity 1.2 (Demonstration of the PortCDM concept). Sub-activity 1.2 was arranged in three phases (rounds) of usage and evaluation. The tasks within each phase and comments related to fulfilment of the tasks are captured in Annex L to this report.

The concept of PortCDM is elaborated in chapter 2. This is followed by an elaboration of the validation hypotheses in chapter 3 and related design principles corresponding to the goals of what PortCDM is aimed to achieve. The validation methodology is discussed in chapter 4. The testbed and demonstrator setup is described in chapter 5 together with the process of developing a collaborative culture and the role of supporting technologies. Chapter 6 contains
the validation results on qualitative foundations derived from the PortCDM testbeds and the use of the demonstrator that have been generating data during the last 2½ years. This is followed by chapter 7 covering quantitative analysis of the data generated in the testbeds. Chapter 8 provides the results by revisiting the hypotheses and design principles described in chapter 4. A discussion on the strategy for disseminating the results of the report and encouraging the global adoption of PortCDM is included in chapter 9, followed by a concluding chapter 10.

1.7 Other deliverables from PortCDM testbed during the STM Validation project

Activity 1 - PortCDM testbeds, has been arranged in four sub activities:

- **Sub activity 1.1**: Establishment and maintenance of developers’ zone, which was reported upon in Lind M., Haraldson S., Karlsson M., Mellegård N., Eriksson G., Olsson E., Zerem A., Giménez J., Ferrús G., Deehan S., Watson R. T. (2015) Enabling port optimization by a digital collaborative platform – a first step towards a STM Developer Zone, STMVal_D1.1, as deliveries for M1.1.1 and M1.1.2

- **Sub activity 1.2**: Demonstration of the Port CDM concept which was reported upon in Viktoria Swedish ICT, Valenciaport Foundation (2015) Demonstration plan for PortCDM Test Beds in STM validation project 2015-2018, STMVal_D1.2, as a delivery for M1.2.1 – M1.2.13

- **Sub-Activity 1.3**: Refinement of the Port CDM concept which is reported upon through this report: 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) Improving port operations using PortCDM (Final PortCDM concept description incl. generic specification of identified services), STMVal_D1.3, as a delivery for M1.3.1

- **Sub-Activity 1.4**: Collaboration for definition and sharing of Port CDM commonalities which was reported upon in Lind M., Haraldson S., Watson R.T., Ludvigsen P., Bergmann M., Andersen N-B. (2016) Role and routine of the PortCDM Council, STMVal_D1.4, as a delivery for M1.4.1

Further, Annex E to this report contains a list of the numerous publications that have been generated during the conduct of the project.
2 The conceptual basis for PortCDM

This chapter identifies various factors and their relationships that led to the development of the PortCDM concept. It goes on to provide an outline description of PortCDM as the solution to improving the efficiency of the maritime transportation chain, particularly in relation to the port call planning process and green as well as optimal steaming, and the expected beneficial impacts of implementing PortCDM.

2.1 Introduction

In a competitive global world, business organisations continually strive to improve their capital productivity and that of their suppliers and customers/clients so that their ecosystem thrives. They continually seek new means to improve the efficiency of resource utilisation in their internal operations and those with whom they episodically or regularly interact. This is nowhere more relevant than in the maritime transportation chain and in port call operations in particular.

The predictability of a number of essential operations in the port call process is currently inadequate in most ports. This results in unnecessary waiting times in port visits. Some of the main reasons for this unacceptable outcome are:

- the planning horizon for forthcoming operations is generally too short for the efficient use of resources,
- actors have different conceptions of when and where different operations are about to take place,
- actors have not coordinated their operations in relation to others due to a lack of data of others’ intentions and achievements,
- actors do not make precise and predictable estimations and do not update these,
- data essential to coordinate port call operations are not shared in real-time, and
- plans for operations are changed frequently without informing all the relevant actors.

2.1.1 Improving efficiency in the maritime sector through just-in-time operations enabled by PortCDM

In an ideal world, ships would be served just-in-time for all the different events and episodic tight couplings that constitute a port visit. Just-in-time operations mean zero or minimised waiting times for all the actors involved - the ship, the shore facilities and the providers. Each actor would have enough information to be able to plan and perform their actions/operations just-in-time. Reports from the shipping sector indicate there is potential for a 25% reduction in waiting time in port calls. In 2017, a total of 71,202 hours of idle time waiting to enter ports was recorded from 38,425 container ship calls at Europe’s so-called Tier 1 and Tier 2 ports. Depending upon the value of an hour, this might represent a cost reduction opportunity in excess of USD100 million per year. This study only looks upon container traffic. The same type of investigations has not been made for other segments of shipping, but it is expected to show substantial improvement potential for those segments as well.

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Just-in-time operations also mean assisting ships to reach port at the optimum time using the minimum of fuel and other costly resources - so-called green steaming. Based on AIS data for August 2014 for ships arriving at the Port of Gothenburg, it is estimated that there is a potential energy and emissions saving of 34% if ships can travel to port at their optimal safe speed and minimise anchoring time. Across all commercial ships entering the Port of Gothenburg in August 2014, the emissions and fuel savings were estimated to be 4.1%. Other studies have consistently shown similar positive benefits.

While ports serve as departure and arrival hubs for ships, they also serve as hubs for other means of connecting transportation. It follows that a coordinated transportation system that addresses the goals of the overall transport system for smooth and seamless operations at sea, in port (reaching the port, departing from port, performing loading and unloading operations including ship maintenance and extra administrative tasks) as well as connections to hinterland transportation before and after the port call process is highly desirable. The sharing of standardised digital data of particular types is key to achieving this through just-in-time operations and advancing coordination and synchronisation in the maritime industry. It can generate both individual and ecosystem gains. Accordingly, it should be pursued with vigour and alacrity to maintain the competitiveness of sea transport in the global economy. Port Collaborative Decision Making has been developed to achieve these gains.

PortCDM, which has used the aviation sector (AirportCDM) as its source of inspiration, is the concept that enables enhanced coordination among stakeholders in a port and beyond in relation to approaching and departing ships. Higher predictability in port operations provides substantial benefits for all the actors involved in the maritime ecosystem, particularly shipping companies and port operators, as well as hinterland operators concerned with optimising their operations and the utilisation of the infrastructure. Interestingly, Airport and PortCDM are now being used as models for gaining improvements in the global railway sector.

Put simply, PortCDM enables actors to share intentions and outcomes that, in turn, provide them with a common situational awareness that enables them to align their individual plans based on awareness of the progress of the up-stream and down-stream plans and activities of others in the maritime transportation chain.

The PortCDM concept provides the possibility to synchronise activities, from port of origin via the sea voyage to the port of destination. Accordingly, the goals of the PortCDM concept are to contribute to synchronised approaches and fast turn-around times for visiting ships by providing standardised, safe, and secure communication in real-time that enables the sharing of data regarding intentions as well as information about completed actions.

PortCDM aims to provide significant benefits in four important areas of improvement required in the maritime transportation chain:

- port call synchronisation, coordinating the vessels approach with port of readiness,

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• port call coordination, coordinating and adjusting actions related to other actors shared intentions and performances, based on the set of states for a particular port call,
• port call monitoring, providing a basis for common situational awareness for upcoming and on-going port calls and actors performance, and
• port call improvement, evaluating and proposing means for optimizing future port calls.

In summary, PortCDM is a way for all involved actors to better coordinate and synchronise their activities. Notably, it is a decision support procedure for the actors involved - it does not make decisions for them; it provides the actors with access to a common, reliable and up-to-date status of plans and activities, leaving them to decide what actions to take in each and every situation.

2.1.2 Digital collaboration as a means for enhanced collaboration

In order for all those involved in a port call to improve the productivity of overall operations, it is essential to access real-time information on the status of planned and actual events that affect the port call. This information functions both as a coordination mechanism for improving port operations (and creating readiness for managing necessary loading/unloading operations) and as input for other actors outside the port to increase their efficiency and effectiveness.

Among the various status data required, two fundamental elements are up-to-date estimates and actual Time of Berth and Time of Departure.

2.2 The port call process revisited

A port call can be divided into three process steps; arrival, port visit, and departure, and two linking process steps; pre-arrival and post-departure. Each process step may have different sub-processes and each sub-process may cover a number of events (see figure 3 below). Depending on the purpose of a port call, there will be different combinations of sub-processes and events. Sub-processes and events are typically conducted sequentially, but some could be in parallel, such as pilotage and towage/tug operations. During a port visit there will always be an arrival and a departure process. The combination of sub-processes and events are dependent on the purpose of the port call.

As indicated in Figure 3, the overall port call is composed of the arrival, port visit, and departure processes. The arrival process consists of a port arrival sub process. A port visit consists of the three sub-processes: port manoeuvring, berth visit, and sometimes - anchoring. A port visit can consist of multiple port manoeuvring, berth visit, and anchoring events, such as occurs when shifting berth in the same port. The departure process consists of the port departure as a sub-process.

Figure 3 The conceptual elements of the port call process
From a port perspective, the arrival process is preceded by the pre-arrival process which relates to the ship on its journey from its previous port. Similarly, the departure process is succeeded by actions related to the onward journey of a ship and its arrival at its next port.

In Figure 4 overleaf, a metro map is being used as a metaphor to illustrate the complexity and convergence of events and the interdependencies in a port call and why collaboration between multiple actors is necessary. The metro map shows the port call process and its actors on a generic level, from the arrival of a ship to its departure. Each metro line represents an actor and each metro station (the small white lines on each metro line) an event - such as a location state or a service state, which is important to the successful coordination of the port call process. The bigger circles on the lines represent moments in a port call where different actors need to coordinate and synchronise for a particular port call operation. This is like a junction on a traditional metro map, where several metro lines meet, and people can “change trains”.

There are several states, or coordination points, that indicate where a high degree of coordination and synchronisation is required by several actors. The status of events prior to the coordination points are equally important to the efficient realisation of a port call but are more actor specific in their nature. These are therefore considered as actor specific milestones.

The inherent complexity shown by the port call metro map highlights the need for collaboration between the multiple actors participating in a port call.

The formulation of status related to a particular event can comprise reports of the status of several stages of progress for an event. For instance, the result of the event *towage requested* is an indication of the progress of the overarching event of *towage*.

When status reports relating to a ship’s departure from a previous port to its arrival at the next port are included, the port visit at the focal port then becomes part of a chain of port visits, which, in turn, enables port-to-port collaboration as well as intra-port collaboration.
STM VALIDATION 1.3 – Improving port operations using PortCDM

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Figure 4 Status and coordination points in the port call process
2.3 The PortCDM concept

2.3.1 Purpose of the concept

The overall goal of PortCDM is to improve the predictability of the core operations in the port call process, providing efficiency, and sustainability benefits for all the stakeholders involved. This is driven from two points of view:

- the demands of shipping companies as the prime customers of a port and the terminal, to shorten total turnaround time (TTT) through just-in-time operations, and
- demands from all port actors for more efficient operational port visits by ships.

To satisfy these demands, the different port call actors need to perform operations just-in-time in order to ensure a well-synchronised port visit. To do this, the sharing of relevant planning and progress data is fundamental to achieving more efficient port calls. This is done using standardised reports on the planning, the estimated, and the actual progress of key events. The reports include timestamps and are intended to be updated and made available to all relevant actors as soon as things change.

PortCDM is designed to monitor port calls from the moment that they are declared and to record the status of events that are planned for or completed. This enables port operators to collaborate and synchronise their activities in a proactive as opposed to a reactive way. The foundation of PortCDM is based on enabling enhanced coordination to achieve increased predictability, berth productivity, capacity utilisation, punctuality, as well as reducing waiting times. Enhanced situational awareness would also provide means for enhanced safety since such basis also provides an overview of the situation as-is (by capturing actuals) and to-be (by capturing intentions of different stakeholders).

PortCDM is an interoperable data sharing mechanism that allows involved port call actors, including the ship as a key port call actor, to share data among each other. Optimally, this will be done by machine-to-machine connectors to/from different systems, such as Port Community Systems, Single Window, private actors’ systems, shipping ERP’s (Enterprise Resource Planning), VTS, terminal systems, and so on. Additional manual input connectors are also possible in order to enable non-connected, or semi-connected actors to share data, thereby ensuring the best coordination possible in a port call. Both machine-to-machine and manual connectors are based on the use of standardised formats and protocols, which are now being approved as the internationally recognised port call message format standard S-211.

PortCDM also enables data sharing between the actors involved in the voyage at sea, those in the previous and the next port of call, and hinterland operators, thereby encouraging a transparent door-to-door transportation chain.

The PortCDM concept, including the S-211 data standard, enables a modularised architecture of maritime systems that encourages service innovation in a distributed manner, including:

- PortCDM connectors (adopting the principles of SeaSWIM),
- PortCDM data management platforms / back-end services,
- front-end service for enhanced coordination in the planning and realisation of port calls, and
- analytical services.
2.3.2 Fundamental principles of PortCDM

PortCDM is based on three fundamental enablers:

- the combination of multiple data sources,
- aligning all actors’ conception of different events, and
- evaluating that each event is occurring according to the plan.

The core principles for establishing enhanced and trusted interoperability in PortCDM are to:

- share data,
- align data streams,
- allow for the distribution of all relevant data,
- enable discovery of information and application services,
- ensure credible authentication and data protection, and
- utilise and/or develop internationally agreed standards for message formats, interfaces, authorisation principles, and methods for deriving situational awareness.

If processes and systems are built on these principles, it is possible to obtain:

- enhanced just-in-time operations and efficient capacity utilisation in a port;
- just-in-time arrivals and just-in-time departures for ship movements as the basis for planning inbound and outbound sea voyages. This is enabled by matching external progress with internal capabilities; and
- port-to-port collaboration, independent of any particular shipping operator or terminal operator.

However, in order to obtain these results using PortCDM, the following basic requirements must be fulfilled:

- accurate standardised data for ship arrival and departure status is captured and shared using standardised formats;
- all port call actors agree on a set of events and related data that they will share to optimise the port operations for each port call;
- all port call actors share their revised event status (in real time, wherever possible) as soon there is an event change. This requires machine-to-machine communication from their data systems to those of others;
- data sharing is controlled by the originating source owner. This should take place according to the agreed maturity level implementation (see later for a description of maturity levels);
- data about critical states (see Annex I for definitions) must be captured (ideally automatically, but manually in cases where machine-to-machine capture or transmission is not possible);
- data accuracy is validated by multiple data sources wherever possible;
- port call actors share the same data among each other, unless there is an explicit instruction from a data owner not to disseminate data to specific actors; and
- third-party service providers are offered possibilities to provide services based approved access to PortCDM data.
2.3.3 Example operational scenarios

PortCDM aims to provide the shortest turn-around times for a port visit. This includes green steaming, just-in-time arrivals and just-in-time performance of operations. This is useful both for achieving efficient operations and for handling possible disruptions.

Dynamic adjustment of plans

For example, when planning a new port arrival, or where an existing plan is no longer achievable, and assuming that this is due to delays at the current (upstream) terminal, the flow chart in figure 5 illustrates how the main actors in the current port and the next port are assisted by receiving the crucial timestamps on all key events from the PortCDM processes. It is clear that these more accurate data streams will assist decision-makers making better informed decisions downstream.

![Figure 5 Example flow chart of the port call plan revision process](image)

Green steaming

Successful green steaming and the determination of green steaming starting points and speeds relies on information from the three key components of STM, namely, Voyage Management, Flow Management and PortCDM. An important element in this is to minimise resource queuing in ports so that high value investments, such as a terminal, are maximally deployed. This is where PortCDM comes into play by focussing on optimising port resource utilisation. By taking information from the STM information domain regarding forecast arrivals and voyage progress, PortCDM can help optimise available port resources and thereby enable the identification of optimal arrival times for incoming ships. This can then provide feedback to STM to determine which ships should be targeted for green steaming. As a ship approaches a port, there is a continual exchange of data between the PortCDM and the STM information...
domains to help to fine-tune arrival times and the allocation of supporting resources. This is illustrated in Figure 6 overleaf.

![Diagram](image)

**Figure 6 The process for integrating sea traffic and port activities**

**Enhanced collaboration**

In addition to the significant role that PortCDM plays in supporting enhanced collaboration in port call operations, PortCDM can also play a role in supporting collaboration between actors from one end of a voyage to the other. Figure 7 overleaf indicates four primary areas of collaboration: port operations (collaboration arena #1), pre-sailing and pre-arrival planning and timing (collaboration arena #2), port and hinterland transport planning (collaboration arena #3), and port-to-port information exchange (collaboration arena #4). The latter collaboration arena is of particular importance in short-sea shipping. Each arena represents the forum and the discussion themes that engage particular actors that are obliged to collaborate to reach particular outcomes. This collaboration can be both physical and/or digital. PortCDM stresses the need for establishing physical collaboration as a mean for establishing trust in digital collaboration. Physical collaboration among the participating actors was achieved using a living lab approach.

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2.3.4 Data sharing

Data sharing in PortCDM is achieved through the dynamic and transparent use of simple, common user software applications and message standards, which trigger and prompt the various different stakeholders to review exception alerts and take appropriate action (make amendments to their plans) based upon their physical capabilities, preferences, and requirements.

The use of digital technologies for instant and efficient interaction between actors involved as well as for capturing the status of agreements, planned operations, and operations conducted is key.

As individual plans in ships and within ports are amended, automatic planning revision alerts are triggered. In this way, there could be several or multiple iterative revisions made during a single port call. In addition to the concept of data sharing between ships and ports and between

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the different actors within a port, once a port obtains a certain level of maturity in its use of PortCDM, it is possible and desirable to include also the exchange of data between ports.

With such additional data sharing, not only will the next port for a ship get an actual time of departure of the incoming ship from the previous port, this information will also come from a complementary source independent of the ship or the ship’s agent. This helps to improve the reliability of data by validating important information through independent sources.

2.3.5 The data sharing dilemma

Within the STM validation project, a major challenge has been to determine what data shipping terminals and other commercial actors should and would be willing to share with others in the maritime transportation chain. While one of the most important cornerstones of STM is that a data provider decides who should have access to what data is shared and when; this can conflict with enabling all actors to maintain an appropriate situational awareness necessary for them to make informed decisions in the planning of different tasks related to their contributions to port call operations if relevant data is withheld.

PortCDM faces the same challenge in ensuring that everyone has, for those data aspects necessary for their operations, reliable, relevant and up-to-date data so that they can align their actions in relation to other upstream and downstream plans and activities. The greater the precision of these data, the higher the level of alignment of actions among involved port call actors and a resulting total increase in efficiency.

The PortCDM approach takes a holistic view of the port call process by enabling all actors to share data about significant events or milestones (such as the ship’s arrival to the port, pilotage commenced and completed, berth arrival, cargo operations commenced and completed, and berth departure) in real-time and in a standardised way. For example, from a terminal’s point of view, it is important to have accurate times for when terminal operations for a ship can commence and when a berth can be cleared for the next incoming ship.

While, in the previous example, a terminal is relying on data provided by others, it, in turn, also needs to provide data for operations by others. The same goes for the approaching ships, as well as for nearly all other port-call actors. The importance of data sharing and collaboration cannot be overstressed in its importance for the goal of enhancing integrated performance in the ecosystem. This means moving beyond just sharing straightforward data, such as the status of a wharf being occupied or vacant, or a ship’s movements communicated via AIS.

The maritime sector needs to apply “ecosystem logic”, which means that each actor in the maritime value chain recognises those situations where cooperation is more effective than competition. For example, cooperation in a port can speed ship turnaround and as a result a port can gain a reputation for efficiency that should attract more business for all actors. There needs to be acceptance within the industry that from time to time, depending on the particular circumstances, some actors may be obliged to experience less than optimal operations in order to ensure that the ecosystem as a whole is operating efficiently. As an example, a pilot may have to accept some idle time between servicing several ships, because a ship’s arrival is being optimised for berth readiness. However, in the long run the pilots could still have more business because of the port’s higher competitiveness due to its reputation for overall efficiency.
2.3.6 Data access principles

As stated earlier, and following the STM principles, PortCDM promotes a distributed service ecosystem where each actor owns their data and the owner determines and provides access to the data recipients.

PortCDM encourages that each actor uses shared data for coordination mechanisms for planning their operations in the port call process. Essential data elements are captured in a system of records that can then be shared, but always in accordance with the desires of the data provider.

As indicated in Figure 8 below, PortCDM enabled collaborative capabilities rely on the following principles of access management:

- in internal collaboration, all data are shared among all port call actors to allow for a common situational awareness. Both sources derived from internal as well as external collaboration are used. Data shared with a port by an external actor is made available to anyone who is qualified as an internal collaborator or is part of the port call;
- episodic tightly coupled actors, such as ships / shipping companies intending and/or paying a visit to a port, can only access port call information from the port to be visited;
- ports can access a ship’s port call information from previous ports visited and those to be visited next;
- ports can access hinterland operators’ information related to actors intending to visit the port;
- hinterland operators can access port call information related to port call transhipment of goods to or from the hinterland operator; and
- information service providers desiring to access port call information need to establish collaboration agreements with local port governance or the data owner.
The over-arching principle of access management in PortCDM allows the data provider to choose how much and what data is shared and to whom. This could result in a minimum to a full set of data being made available to some or all actors. The following table depicts the four extremes of variation in data access.

<table>
<thead>
<tr>
<th>Data shared with all in the port call</th>
<th>Minimal set of data elements</th>
<th>Full set of data elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>A minimal set of data is shared with all actors about all port calls</td>
<td>Data regarding all critical states of a port call are shared with all actors about all port calls</td>
<td></td>
</tr>
</tbody>
</table>

| Only shared with specific actors involved | A minimal set of data only is shared among those actors associated with that particular port call | Only data regarding critical states associated with a port call is shared among those actors associated with the port call |

This could mean, for example, maximum coordination at a port call level; combined with more limited coordination opportunities at the terminal level because ETA and ETD details are shared among all actors within the port, while terminal data on cargo operations...
Access management also requires considering regional versus global concerns in providing access to data. This means, among other things, that a port’s local governance must decide which data can be shared outside the port, but possibly within a regional context. On the global level, the country, via its maritime authority, would decide which data is shared between ports in different countries.

### 2.3.7 Data security

Data security is an integral part of the PortCDM concept and an obvious prerequisite for trusted collaboration. Data security is an important concern for all would-be suppliers of data. As such it is addressed at all stages and levels of the implementation of PortCDM. Security of data includes confidentiality, integrity and availability. This includes data generated, processed, transferred and stored in the operation of computer-based systems on board ships and on shore as well as the data exchanged between the different actors in accordance to the relevant data privacy agreements and regulations.

### 2.3.8 Data reliability and validation

Since event changes are instantly captured and shared in PortCDM, it is possible for an individual authorised actor to be notified of event changes that affect them, such as a ship’s arrival at the pilot boarding area, and also be informed of possible deficiencies in the overall plan of the port call process. In order to provide confidence in the reliability of the information being presented, an indicator system has been defined, from which actors receive warnings or alerts:

- *missing data*, which directs attention towards possible missing data in the PortCDM system of records based on when another associated event should have occurred. An example is an alert for a pilotage request triggered a pre-defined number of hours before an ETA that is already in the PortCDM system of records;
- *conflicting data*, which directs attention towards an actor when there are different times associated with an activity. For example, when the port authority, the terminal operator, and the captain report different estimated times of arrival to berth; and
- *unreasonable relationships*, which directs attention towards the relationships between different data elements, such as when the time between estimated times of pilotage commenced and ship arrival at berth differ outside a defined range.

### 2.3.9 Time Stamps and Data Elements in PortCDM

PortCDM provides information in the form of data to enable actors involved in port calls to access and submit relevant data from different information sources, as close to real-time as possible, for the purpose of enhanced coordination. The data concerns time-related port information about different actors’ estimates of when a particular event is about to occur and the actual occurrence of that event, distributed in a standardised way. The status data about a particular event is known as a timestamp.

Timestamp and event information about key events includes the location, the type of event, the timing and its status: i.e. *recommended, targeted, estimated, actual, or cancelled.* Times and event status are then updated as circumstances change or progress.
In this way, shared data indicates the state of a particular asset or event, such as the time an asset has arrived at, or departed from a particular geographical spot (location state), such as the ship is at berth (all fast), and the certain time a particular service commenced or completed (service state), such as cargo operations have commenced. Commencing and completing a service can also be preceded by sequences of bilateral or multi-lateral digital communication between the involved actors, qualified as requested, request received, denied, or confirmed, as appropriate.

A unique port call id is established for each port call. This means that PortCDM internally adopts the maritime resource naming (MRN) standard to ensure uniqueness of the time statements associated with a particular port call.

A unique combination of time and status data constitutes a data element (see figure 10). For example, Estimated Time of Arrival of Ship at Pilot Boarding Area is the specification of what is often referred to simply as ETA. This level of granularity that specifies more precisely what it concerns and to which location, decreases the probability for misunderstanding.

All relevant data is aggregated to provide a common situational awareness that enables the different actors to optimally plan forthcoming operations based on sharing intentions and process status in real-time. As data are updated, existing port call plans can be re-evaluated continually and modified where necessary.

In order to specify the duration time for the various predicted/planned or actual events several different time types are used:

- **Port visit time**, which covers the time from a ship’s arrival until it departs,
- **Movement time**, which covers the time when a ship is moving within the port area,
- **Anchoring time**, which covers the time when a ship is at anchor,
- **Nautical service time**, which covers the time when a ship consumes nautical (such as pilotage and tug operations supporting the ship to move from one location to another) services,
- **Berth visit time**, which covers the time when a ship is at a berth(s),
- **Stationary service time**, which covers the time when a ship consumes stationary services (such as cargo operations, bunkering etc. providing services at the same location), and
- **Waiting time**, which covers the time when a ship is idle, waiting to be served or to move.

The various duration times form the basis for the different actors to make or revise their plans.
2.3.10 Measuring the success of PortCDM

The concept of PortCDM includes six key performance indicators (KPIs): *duration time*, *waiting time*, *berth productivity*, *capacity utilisation*, *predictability*, and *punctuality*.

*duration time* - the elapsed time from arrival to departure. Duration time can be sub-divided into *movement time*, *berth time*, *waiting time*, and so on. Duration time is calculated as the difference in time between arrival to the port / traffic area and departure from the port / traffic area.

*waiting time* - the elapsed time when a vessel is waiting to be served or a particular resource or infrastructure is idle. Waiting times are calculated based on when one party (actor) is waiting for other(s) to serve / being served.

*berth productivity* - a measure for the efficiency of a berth visit in relation to the purpose of a port call. Berth productivity is calculated as the relationship between the time of the ship being served divided by the time being at berth.

*capacity utilisation* - a measure of how much a particular resource/ infrastructure is used. Capacity utilization is calculated based on the relationship between the time of when a particular capacity/resource is utilized divided by the total available (times) of the same capacity / resource.

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16 Lind M. et al (2018) Towards Unified Port Communications – from a project format to a global standard, Concept Note #9, STM Validation Project adjusted with the time type ‘required’ as part of the latest revision of the port call message format.
**predictability** - the degree to which a correct prediction or forecast of a state can be made. Predictability is the expression for the capability to forecast the when a particular event occurs in spatial and timely dimension.

**punctuality** - the deviation between when a particular state eventually occurs and the agreed time of its occurrence. Punctuality is the expression for the deviation between when something was expected to happen (such as the original planned / estimated time of arrival and when it actually happened).

Wherever possible, data to evaluate these KPIs is shared by machine-to-machine interaction between different systems using a standard data format such as the port call message standard, which builds on the proposed international definition of a port call event. Other examples include estimated time of arrival of the ship to the berth (ETA Ship Berth) or estimated time of cargo operations commenced (ET_cargo operations commenced).

The difference between the timing of planned and estimated events and the actual event is an indication of the predictability or reliability of the port-call process. Any deviation between planned/estimated and actual events represents the predictability of the port as such (as a representation of an ecosystems of actors) and represents a measure of how well a port is performing in a synchronised transport chain (enabled by STM).

![Diagram showing planning phases and acceptable deviations](image)

**Figure 11 Acceptable deviation between estimate and actual occurrence during the different phases of planning**

Different planning horizons are associated with different levels of tolerance for deviation between the estimated and the actually reached state (the outcome) as shown in figure 11. Deviations ought to 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 acknowledges the planning processes, performed by the different actors, with different time horizons (long-term, mid-term, and short-term planning) to be performed efficiently, based on information about the interval of the outcome; for example, a time span of when a certain state is reached.

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Monitoring performance through the KPI’s and associated analysis enables the different actors to improve their operations and utilisation of physical infrastructure and variable resources.

**2.3.11 Incremental implementation of PortCDM**

It is intended that PortCDM is implemented locally in each port so as to provide optimal information related to port specifics, such as the designation of locations and relevant services.

During the implementation of PortCDM, every port has to consider its specific conditions and how PortCDM can best be implemented. Dependent upon a port’s characteristics and the attitudes and abilities of each of its actors, implementations will 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. For this reason, seven levels of PortCDM maturity have been defined to characterise the maturity of a port’s CDM implementation. These levels cater for different models of port governance, individual port call actors, and systems/service/tool providers. The PortCDM maturity levels have specific requirements related to the achievement of each level. Not all ports, particularly smaller ones, will need or wish to rise to the highest maturity level, but most should be aiming towards the higher levels.

Each of the seven levels includes all the requirements set out for the lower levels; in other words, achieving level 7 means that the criteria for levels 1 to 6 have already been attained. Levels 1 and 2 aims at establishing capabilities for information sharing, while levels 3 to 6 aims to ensure that designated actors really use the PortCDM capabilities established in levels 1 and 2 in their operations, while the 7th level of maturity, uses the experiences of activity under levels 3 to 6 to improve future port call operations.

At level 1, the standardised Port Call Message Format (PCMF) - S-211, is being used as the mechanism for the submission and consumption of time stamps for port call coordination using standardised interfaces. At this level capabilities for exchanging data with external actors, such as ships, shipping companies, and fleet operation centres, 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.

At 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.

At level 3, core port call actors 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.

At level 4, all actors within the port are using the data-sharing platform for sharing and consuming all states according to the locally adopted principle of access management.

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

20 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.

21 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.
are shared through machine-to-machine or EDI connectivity. Such connectivity builds upon the use of the PCMF.

At level 522, communications with actors outside the port (ship-to-port and port-to-port) are passed via the platform for real-time communication with all port call actors. PCMF compliant standards are used throughout.

At 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 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.

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

The seven layers of maturity may be visualised as shown below:

![Figure 12](image)

**Figure 12 Summary of the PortCDM implementation maturity levels23**

### 2.4 Design principles for PortCDM

In the development of the PortCDM concept, the major design decisions were:

- a reliance on:
  - the port call message standard, based on the contextual understanding of the port call process,
  - the port call process model depicting possible relationships between key events in a port call, and
  - relationships between different states depicting essential coordination points as well as state dependencies in the port call process;

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22 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.

• sharing of data related to agreed location and service states as the basis for coordinating all collaboration in the different arenas;
• situational awareness for coordination will continually emerge based on shared data;
• situational awareness for coordination is derived from shared data complemented by additional contextual data (static and dynamic). This additional data could concern:
  • available resources (e.g., availability of berths),
  • dynamic information of restricting conditions (e.g., divers in the water, tides, weather), and
  • static data of restricting conditions (e.g., maximum depth, possible routes within the port);
• one data element could concern multiple ships or assets (for example, an ice breaker reporting an estimated time of arrival for a convoy of ships, divers in the water);
• KPIs for punctuality, duration time, waiting time, capacity utilisation, and berth productivity are calculated based on shared data, both providing a basis for pre- and post-analytics;
• KPIs for predictability are calculated based on shared data for post-analytics;
• KPIs for duration time are defined based on the understanding of the port call process;
• KPIs for capacity utilisation require that data about available resources are available; and
• the physical port call process as a way to position data elements.

PortCDM is built around a digital, generally web-based, data sharing environment allowing distribution of data by different actors and allowing the subscription to port call messages related to selected port calls. As such, PortCDM is intended to be interoperable with other STM processes, such as

• voyage management, in which voyage information services (VIS) and the ship-port-information service (SPIS) enable interoperability. However, it is essential that PortCDM information is available to ships that are not STM-connected (via the ECDIS equipment), so that they also get access to an appropriate level of situational awareness about their port calls which would be enabled through standardized message formats and interfaces for sharing port call data between applications; and
• the proposed shore centre as a PortCDM actor, allowing that flow management consideration of the port call synchronisation can be considered.

The PortCDM concept covers enhanced coordination based on the port call as its unit of analysis, the resource as a second unit of analysis, and throughput capabilities (flow management within the port area) as a third unit of analysis. The resource view covers physical locations as finite resources (for example; berths, anchoring areas), and variable resources such as workboats (pilot boats, tug boats etc.) and personnel (moorers, stevedores etc.)

2.5 Port call coordination and port call synchronisation - the basis for port call optimisation

2.5.1 Internal and external collaboration as the basis for port call optimisation

Ports are complex organisations as they are hubs, and even though they may look like a single actor serving sea and land transport, they actually consist of multiple actors that must act cooperatively to be an effective hub.
When visiting a port, shipping companies and hinterland operators are episodically tightly coupled with a range of port facilities. They must cooperate by closely coordinating both external and internal processes.

Figure 13 overleaf illustrates both the internal and external collaborative processes associated with the various episodes of tight coupling of port call optimisation.

The efficient accomplishment of port visits needs the currently minimal data exchange and sharing practices of sea operations (e-navigation) and port operations (e-logistics) to become more integrated than they are today. This means better data sharing within and between the two regimes by pursuing the following four activities:

- **Port call coordination.** The sum of each port call actor’s actions to align their operations in relation to other actors’ for a holistic coordination of the port call process as the common object of interest. This concerns internal coordination among involved port call actors.
- **Port call synchronisation.** The continuous process of coordinating a ship’s approach, its previous and next ports’ operations, hinterland transport operators plans, and the progress of a port call. This concerns external coordination among actors involved in the sea transport chain berth-to-berth. As there are significant differences between ship-to-terminal (port) synchronisation, port-to-port synchronisation, and port-to-hinterland synchronisation, driven by different logics, similarities and differences need to be considered.
- **Port call productivity.** The process of making the port call process as efficient as possible according to the needs of the involved actors in the sea transport value chain as part of the larger transportation system. The availability of the proper resources at the appropriate place and time avoids resource oversizing and overtime.
- **Port Collaborative Decision Making (PortCDM).** The concept for facilitating the ecosystem logic for port call coordination (internal collaboration) and port call synchronisation (external collaboration).
2.5.2 Coordination and synchronisation

A core goal of STM is to minimise the resources required to steam between two ports, while maximising the utilisation of resources within a port, with increased safety. For shipping companies, the turnaround process at a port should be as expeditious as possible, as it is in most cases when there is an assignment to continue the voyage or having capabilities to undertaking a new assignment, to enable high utilisation of the ships in their fleets. The PortCDM concept builds upon two principles of coordination to provide a basis for enabling just-in-time operations and optimal resource utilisation:

- **Minimal status-driven coordination** in which involved actors share critical spatial temporal data and status data about the time and location of a status change to allow others to coordinate their actions in relation to these plans. As only critical data are shared, a majority of the status reports in the port call process are not revealed, and just a few of them are shared among actors.

- **Full status-driven coordination** in which the actors share spatial-temporal and process data about the duration and location of all substantive port visit processes. All status reports, except the most minor, of a port call process are shared among involved actors.

However, the maritime ecosystem as a network, is a self-organised ecosystem, where a range of more or less autonomous/independent actors provide different kinds of services for other actors. As described earlier, all the actors have until now been driven primarily by self-interest as they pursue their goals of providing services that the other actors need. Paradoxically, the efficiency of the entire ecosystem is determined by the extent to which the actors effectively collaborate in order to achieve the overall purpose of the ecosystem.

At the core of any collaboration is the involved actors’ capability to coordinate and synchronise their efforts in relation to each other. Effective collaboration is essential to the long-term
success of the entire ecosystem. The better the actors collaborate, the more efficient and synchronised their common ecosystem will be.

The Oxford English Dictionary helps to clarify the difference between coordination and synchronisation:

Coordination is ... *the organisation of the different elements of a complex body or activity to enable them to work together effectively*. Coordination involves one or more linear dependencies - such as customs clearance must be organised before a ship can be unloaded.

Synchronisation is ... *the operation or activity of two or more things at the same time or rate*. Synchronisation deals with one or more joint dependencies - a large ship usually needs tugs in order to come alongside safely. Both the tug and the ship need to meet at the same place at the same time in order to complete their tasks effectively.

Minimal status driven coordination is a first step towards enabling port call actors to align their actions in relation to their common goals of efficiency and effectiveness. It provides an entry point for improving coordination but will not ensure the highest levels of synchronisation. However, any level of effective coordination through data sharing opens the door and provides examples that should motivate a move towards full status coordination because of the benefits that begin to accrue. This is an important reason why the PortCDM concept follows its incremental implementation process.
3 PortCDM Validation Hypotheses

The purpose of the PortCDM concept is to improve the port call process as part of the overall maritime transportation chain. PortCDM enables a port’s different actors to make better-informed decisions based on access to up-to-date data on the status of significant events in the upstream and downstream elements of the maritime transportation chain. These data contain status, plans and intentions, including actual occurrence of events, changes to plans or status etc.

Better informed decision-making leads to multiple benefits for all actors involved. During MONALISA 2.0, the following diagrams were developed showing the principle benefits expected from PortCDM and how they are related to each other.

![Benefit hypotheses diagram](image)

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The scope of PortCDM and its intended objectives is depicted in the following figure.

**Figure 15 Objectives of PortCDM**

Figure 15 shows the physical flow from port to port in the bottom of figure. The top half shows the ‘means-end hierarchy’ of the objectives. Note the three ultimate objectives: efficient resource utilisation, green steaming, and a fast-turn-around of ships.

The figure shows how precision in timestamps can lead to a high precision in time of departure (ETD) and a high degree of predictability in ETA in the next ports.

For the port of departure, high predictability and precision in time of departure will lead to minimising the need to catch-up or chase an existing schedule in order to make the next port of destination. This will have two important implications, better just-in-time-operations, and efficient resource utilisation (ships and port facilities).

For the port of arrival, high predictability and precision in the time of arrival will lead to minimal waiting times, which, in turn, will influence a fast turn-around.

As shown in figure 15, the three main benefits of implementing PortCDM are:

- Efficient port resources utilisation
- Efficient shipping fleet utilisation (the payoff of fast turnaround)
- Reduction in energy for steaming between ports

The following hypotheses were identified and then used as the basis for the validation of the PortCDM benefits:

- H1: Standardised data sharing improves the capital productivity of a port and the shipping companies using it by facilitating efficient resource utilisation
- H2: Standardised reporting by key port actors of intended and completed actions improves coordination of the port call process
- H3: Establishing among key actors their self-interest benefits of data sharing will improve collaboration
• H4: The success of PortCDM is dependent on each actor sending and receiving relevant and timely data to enable all actors to coordinate their actions
• H5: A well-coordinated port call increases resource utilisation and reduces ship turnaround time by requiring timely and accurate standardised data sharing by key stakeholders of their intended and completed actions
• H6: The application of mechanisms for trust building among key actors within a port and across ports will increase the range of data shared and the speed with which it is shared

Building upon the knowledge gained during the project and industry best practices, the following design principles were also identified for consideration:

• P1: Errors in predicting the timing of intended actions disrupt the planning of subsequent events of current port visits or future visits to other ports
• P2: PortCDM must be configurable to fit the local circumstances and resources of each adopting port.
• P3: Port performance can be continuously improved by collecting and analysing operational data for each port visit and acting upon such analyses.
• P4: A sustained success of PortCDM is dependent on a governance infrastructure that maintains the standard for data sharing within a port and identifies improved processes for enhancing port call productivity.

These hypotheses and design principles are evaluated in chapters 6 and 7.
4 Validation Model

4.1 Validation model based on PortCDM benefit hypotheses

The determination of how best to validate the benefit hypotheses for PortCDM identified in chapter 4 was influenced by a range of factors. These included the nature of the PortCDM concept itself, the benefits of using a testbed scenario, the need to test in a range of typical scenarios, the need to obtain factual data as well as user-based opinion. This meant that both qualitative and quantitative methods for collecting data would be required.

These comprised data analysis, interviews, questionnaires and observations, based on the use of PortCDM under operational conditions and the evaluation of the PortCDM KPI’s.

The diagrams at figure 16 below and figure 17 overleaf indicate the logic used to draw together the various factors and determine what sort of data was required and how best to obtain it to validate the PortCDM concept.

This led to the development and use of two regional PortCDM demonstrators as the mechanisms whereby port call actors could put the PortCDM concept into practice in real-time by sharing data using live shipping operations. Details of the PortCDM demonstrators are contained in chapter 5 of this report.

![Figure 16 Methods of data collection](image-url)
4.2 PortCDM Concept KPIs

The PortCDM concept and the principal benefit hypotheses provided the basis for the development of Key Performance Indicators (KPIs). These KPIs enable the monitoring and measurement of the practical implementation of PortCDM. The PortCDM specific KPIs cover:

- Punctuality
- Duration time reflecting the total turnaround time (TTT)
- Waiting time
- Predictability
- Capacity Utilisation
- Berth Productivity

The Predictability KPI is examined in chapter 7 of this report, together with the method for its calculation.
5 PortCDM validation methodology

As discussed in earlier chapters of this report, PortCDM is not a system, it is a concept enabling a holistic approach based on principles of how to share information among different stakeholders so as to optimise and synchronise the activities comprising a successful port call. In order to accomplish the information-sharing goal, it is necessary to establish an effective collaborative culture among all those actors involved in port call processes, from technical-nautical service providers to ports, terminals, maritime authorities and other port actors providing services to the port and to the ships.

5.1 Validation Aspects

The validation methodology described in this chapter considers a set of initial aspects as the basis for collaboration and provision of common situational awareness at and between ports. These aspects are listed below (the full demonstration plan is described in Annex K):

- In-Port data Integration
- Authentication
- Restricted Info Sharing (access management)
- Port Specific Info (information that concerns multiple port calls and/or reflecting the conditions in the port)
- Multiple Views (looking upon multiple aspects of the port at the same time)
- Port Call timeline (with all standard states
- Resource View (as e.g. the quay view)
- Integration with Terminal operations
- Integration with Nautical Services (Pilots, Tugs, Ice-breakers, Linesmen, etc.)
- Port-to-Port Integration
- Port-to-Port information sharing
- Ship-2-Port Integration
- Ship-to-Port information sharing
- Route tracking
- PortCallSynch (allowing for green steaming)

Also, a set of key performance indicators (KPIs) was used for the monitoring and measurement of the practical implementation of PortCDM. These involved calculations of the following parameters:

- Duration time
- Waiting time
- Predictability
- Berth Productivity (expressed as berth utilization)

5.2 PortCDM Concept demonstrators

A specific IT platform in the form of a concept demonstrator, was developed so that PortCDM could be validated by ports in a region through enabling personnel in participating ports to use, evaluate and report on the PortCDM concept.

The PortCDM demonstrator platform is able to receive and share standardised port call messages based on the PCMF in real time among connected stakeholders. The platform has
two components, a back-end that composes, processes or communicates status messages, among other functionalities; and a web-based front-end tool (used jointly with several mobile applications) for visualising the information received by and stored in the back-end system. The front-end Portcall Actor Coordination Tool (PACT) provides a common shared situational awareness for the users in the validation project. The data being shared can be originated in automated connectors using the port call message format that communicate directly with the back-end, or in the front-end through manual insertion.

5.2.1 The Port Call Message Format (PCMF)
To be successful, the messages used to share data in PortCDM about events during a port call must have a unified format, so every actor can produce and access them. Moreover, the format should not only be uniform for messages within a port, but also shared among the port and incoming ships and among different ports. These requirements constituted the foundations of the PCMF.

The PCMF was devised to cover all the key events that may occur during a port call, regardless of the type of port or ship. Moreover, it has developed in a way that it can be easily extended to include more events, or states in future. The development of the PCMF has been led by IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) for recognition as an international standard to be designated as S-211.

As a result of feedback during the PortCDM validation period, additional features were added into the demonstrator and, when required, to the developing PCMF S-211 standard. This process brought the PortCDM demonstrator to an appropriate level of maturity suitable for industry uptake during the anticipated PortCDM implementation phase.

5.2.2 Development of port call Metro maps for each port
As presented in chapter 2 of this report, the progress of a port call can be visualised as a metro map that presents the achievement of a set of desired states throughout the port call process (see paragraph 2.2 - Figure 3). The port call metro map is a metaphor that illustrates the complexity of coordinating a port call in a distributed setting, showing the need for collaboration between multiple actors in staging a port call.

During the living labs, each port defined its own metro map containing the events to be shared and showing the relationships among the different stakeholders involved. The metro maps were not static and were updated during the development of the tests in each port. The aggregation of all the metro maps resulted in the list of states now defined in the PCMF standard.

Appendix G contains the metro maps developed and used at each participating port.

5.2.3 Infrastructural considerations for the testbed setup
The idea of sharing almost real-time digital data across organisational and other boundaries in order to give better support to the business and operational processes is not new. In different forms it has been around for several decades. Technologies used for this purpose have developed from proprietary platforms, many different “of-the-shelf” on-premises solutions and PaaS (Platform as a Service) enabling customers to exclusively focus on the value-adding aspects of their business while everything else (communication, storage, processing, and so on.) is offered as simple-to-use on-demand services.
For a functional PortCDM infrastructure, seen strictly from the data sharing aspect, three important areas were considered for making the testbed setup:

- standardised data format for data exchange, the S-211 PCMF,
- standardised APIs for provision and consumption, as it is essential that common APIs work for everyone, especially from a software ecosystem perspective, and
- standardised ways of discovering services to be consumed for the provision and consumption of PortCDM data.

This results in new ways for providers of new digital services, and/or providers of existing systems to build functionalities using PortCDM services. There are, however, a number of other requirements that need to be fulfilled for a PortCDM infrastructure to present a significant value for the execution of port calls as was used in the testbed setup:

- data submitted from multiple data sources in arbitrary sequence, using local port call identifiers, or none at all, requires the use of a component that correctly clusters data associated with the same port call together;
- aggregation of port call structures representing distinct port calls in such a way as is required for building a common situational awareness;
- codification of knowledge about the port call processes in specific ports to support the use of indicators and warnings as part of the visualisation used to create situational awareness;
- authentication and identification systems and procedures. This is easy within and between local port actors, but to include authentication of ships as well as other ports and hinterland operators, a more generic approach to, especially identification, is required;
- a trusted environment enabling time stamp providers should assure that data is shared only with the intended consumers and that consumers can trust accessed data;
- adoption of the agreed principles for access management on different levels of granularity\textsuperscript{27}; and
- resource, location and vessel registries, which in turn puts requirements on common methods of identification.

From a work flow perspective, PortCDM has three essential properties that are only partially covered by any existing technologies for data sharing:

- PortCDM supports real-time sharing of data, instantly to all authorised connected parties,
- It does so asynchronously, in the sense that a sender of data and a recipient of data do not have to be engaged in the exchange for it to be valuable, and
- data exchange is structured to make it suitable both for visualisation and machine interpretation

This is only partially fulfilled by any currently used technologies. Two examples are:

- VHF or telephone - fulfils the real-time aspect, but requires direct contact between sender and recipient and is very hard to make machine readable. Instant sharing of

\textsuperscript{27} Lind M., Bergmann M., Haraldson S., Watson R.T., Park J., Gimenez J., Andersen T. (2018) Creating a mature data sharing regime – Thriving in the connected ecosystem, Concept Note #4, STM Validation Project
messages among a multitude of stakeholders also becomes a challenge since this requires that all concerned need to be listening in at the same time.

- E-mail - is asynchronous in nature, and may be as real-time capable as PortCDM, but puts all the responsibility of machine readability on the, presumably human, sender.

5.3 PortCDM Evaluation Process

The validation of the PortCDM concept, required the participation of different ports in a practical coordinated demonstration. To facilitate and coordinate the PortCDM testbeds in a more efficient way, participating ports were organised in two different regions as shown in the following table:

<table>
<thead>
<tr>
<th>The Nordic Testbed</th>
<th>The Mediterranean Testbed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port of Gothenburg (Sweden)</td>
<td>Port of Barcelona (Spain)</td>
</tr>
<tr>
<td>Port of Umeå (Kvarken ports) (Sweden)</td>
<td>Port of Valencia (Spain)</td>
</tr>
<tr>
<td>Port of Vaasa (Kvarken ports) (Finland)</td>
<td>Port of Sagunto (Spain)</td>
</tr>
<tr>
<td>Port of Stavanger (Norway)</td>
<td>Port of Limassol (Cyprus)</td>
</tr>
</tbody>
</table>

Figure 18 Participating ports in the two testbeds

Locally, the implementation of the PortCDM evaluation process had two components - the use of living labs as a precursor activity to familiarise participants with what was required and the designation of focus months in which PortCDM was used as practically as possible during real port call events.

Living labs brought together ideas and insights, which also resulted in a first phase of the definition of state metro maps for each port. Afterwards, they provided the forum in which to discuss experiences and feedback from the actors and stakeholders involved in the focus months.

Focus Months were the periods when the PortCDM validation participants could evaluate, by using the PortCDM demonstrators, whether their requirements had been captured and addressed correctly in order to build their feedback for the next living lab.

Each participating Port organised, at least, two focus month rounds according to their local requirements and collaborating actors. The following table presents an overview of the different participating actors based on all eight ports, demonstrating a diverse cross-section of the port community:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Authority</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>VTS</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

28 At a later stage the Port of Brofjorden was brought in as well to serve as a mean for validating the port-to-port aspects of PortCDM
5.3.1 Use of living labs to aid collaboration and understanding

Since the realisation of the PortCDM concept is based on collaboration between involved actors in a port, a collaborative approach to the implementation of the PortCDM testbeds was adopted from the outset. The living lab\(^{29}\) methodology was used to help to achieve this.

Following the living lab methodology, the key actors involved in port calls were brought together for collaborative meetings. The goal of these meetings was to develop a common understanding on how the actors currently collaborate, how they exchange information (now) and how the port call process is affected by this collaboration. Every actor has their own view on how they collaborate, which information they need to share, and to whom they need to share it. These partial points of view must be captured and analysed in order to enhance collaborative decision making in ports.

Getting the key actors involved is important to establish relations of trust and identify potential incentives for the agents to share information among themselves. The living lab approach was aimed at encouraging the different stakeholders engaged in port calls to participate in the use, refinement and evaluation of the concept in each testbed. The purpose of the living lab

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\(^{29}\) Pallot M. (2009). Engaging Users into Research and Innovation: The Living Lab Approach as a User Centred Open Innovation Ecosystem

---

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Agent</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Pilot org</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Towage Operator</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Mooring Org</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Bunkering Operator</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Waste Operator</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sludge Operator</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Fresh Water Operator</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Surveyor</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Slop Operator</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Tour Operators</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stevedores</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ice-Breaking Org</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Customs</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Marine Police</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Diving org</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SUM</td>
<td><strong>93</strong></td>
<td><strong>99</strong></td>
</tr>
</tbody>
</table>

Figure 19 Participating actors in the testbeds
meetings was to integrate and engage the participating actors into the developing process as users and co-creators. It allowed them to explore, test and evaluate information sharing through the approach and principles of the PortCDM concept.

Additionally, this arena of physical collaboration provided the opportunity for actors with different agendas to sit together, reach a better understanding on what each of them does and how they might best share information to enhance their collaboration and coordination.

Based on the ideas in the Living Labs handbooks, the living labs were organised in three different collaborating teams that worked together to develop and adopt a local PortCDM implementation. These teams were:

- The business team consisting of actor representatives from key organisations in the port call process with the role of providing basic operational business knowledge and to formulate requirements and thereby evaluate the PortCDM implementation.
- The technical team consisting of system developers with the main role to implement and change the solutions based on users’ feedback (business actors) and new or changed directions provided from the concept group.
- The concept group consisting of actors from STM, activity 1, coordinating the living labs and ensuring that the PortCDM implementations are within the range of the concept scope for the concept hypotheses to be validated.

![Figure 20 Three teams collaborating in the living lab approach](image)

While separate living labs were organised for each port, an overarching organisation comprising the Activity 1 Management Team coordinated the PortCDM application used across all the participating ports.

### 5.3.2 Focus Months

Focus months were dedicated periods in which specific attention was paid to validating key aspects and services of the implemented PortCDM concept at each participating port. Each participating port ran its Focus Months as follows:

<table>
<thead>
<tr>
<th>PORTS</th>
<th>Start FM1</th>
<th>End FM1</th>
<th>Start FM2</th>
<th>End FM2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARCELONA</td>
<td>15/01/2018</td>
<td>11/02/2018</td>
<td>22/10/2018</td>
<td>22/11/2018</td>
</tr>
</tbody>
</table>

---

Although most data and messages were continuously exchanged through automated connectors, during the focus months, those participating actors without automated connectors were asked to provide data by submitting it manually through the demonstrator and then to validate the PortCDM concept by using its front-end to access the data shared by other involved stakeholders using the PortCDM services. The table below shows the overall proportion of automatic vs manual data supply connectors used during the focus months.

<table>
<thead>
<tr>
<th>User / System</th>
<th>Automatic Connectors</th>
<th>Manual Data Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal System</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>PCS</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Government System</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pilot Systems</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Agent System</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Towage Systems</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mooring Systems</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PortCDM AIS/AIS Connector</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Ice-Breaking System</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Traffic Control System</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bunkering Operator</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Waste Operator</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The realisation of a successful focus month required:

- properly preparing and training the involved actors in their specific roles and in the needs of the project regarding the use of services and applications to report events;
- reliable automatic connectors, where reliable implies an ability to recover from any downtime periods and use of the proper version of the standard;
- correct demonstrator setup, paying special attention to correct port specific configurations (for example, polygons for the AIS connector, location registry, service ship registry, indicator configurations);
- in the case of the mobile Apps, confirmation that any tablets or cell phones used to run the Apps them were compatible with the current version of the software;
- pre-define and agreed test plans, pre-defined roles and scope for each focus month; and
- establishing a plan for the evaluation of the focus months.

The last two points were especially important, given that the focus months involved an additional effort from the stakeholders (manual reporting and consumption of states through the front-end). Similarly, it was important to define how the months were going to be evaluated. Some important aspects, among others, to consider were:

- quantifying the amount of port calls covered during the focus month,
- quantifying the amount of states reported per port call,
- evaluating the completeness of a port call in terms of states covered in the port Metro Map, and
- evaluating the correction of the reported states according to the Metro Map.

After every focus month, an evaluation process was conducted to analyse all these aspects, as well as all the data gathered in the specific period and study its evolution compared with previous focus months.

The experiences from the participating stakeholders were considered equally important. It was therefore important to capture aspects like the user-friendliness of the demonstrator, the completeness of the PCMF standard and any other issues encountered by end users. For this reason, it was especially important to define quantitative and qualitative tools to capture their feedback, as well as arranging living labs after the focus months, whenever this was possible.
5.4 Challenges faced in running the validation testbeds

Several issues were raised in the living labs, during discussions between the different participants, when sharing data, within the Activity 1 work group, and in the information collected in the different ports.

5.4.1 Inconsistent definitions across ports

In the process of defining the PCMF format and its state catalogue, it became apparent that there was inconsistency in how the same operations were defined in different ports. This inconsistency ranged from simple aspects like the definition of port zones and how particular services were understood, to the definition of key performance indicators. Some examples were as follows:

- Definitions of what constitute the traffic area of a port. The measures of the distance from port varied substantially.
- Pilotage service. In some ports the service starts when the pilots leaves base, in others when it arrives at the ship requiring pilotage, and in other ports it starts when the pilot is with the captain.
- Estimated time of arrival. In different ports ETA can refer to the arrival at the berth, at the traffic area or at the port entrance.
- Port efficiency is measured differently in different ports.
- Different ports have different processes. For example, some ports require ships to request a service, it will then immediately confirm the receipt of the request, and when proper investigations are carried out and after a while, it will reply, accepting or denying the service. Other ports will provide a reply immediately on the fly.

Through the living labs these differences were clarified, which meant that the final definitions used in the PCMF were agreed and standardised.

5.4.2 Contractual and legal considerations

The design principles of PortCDM means that the concept should work independently of the management model, contractual relationships, or actor relationships established within a port. It builds upon data being shared instantly as time stamps related to administrative states, location changes, and service states.

This means that PortCDM works independently of the systems environment as well as the contractual relationships, such as charter parties, cargo contracts, as well as tender contracts with local service provider and systems providers. However, the local situation needs to be taken into consideration.

For example, PortCDM supports the newly formed virtual arrival clause that has been incorporated into the BIMCO standardised contractual clauses, as well as other approaches to different incentives (such as the fuel incentive by Equinor and Preem's approach to virtual arrival) in the following way:

- PortCDM provides the situational awareness that allows a port to move from a principle of organising its planning from “first come, first served” to a “slot management system”;
- PortCDM enables each system and thereby each actor to be well informed about other’s capabilities involved in the port call process; and
- PortCDM provides a solid foundation for recommending ships on their arrival times as soon as the collaborative culture is mature enough.
5.4.3 Sharing data

Some participants expressed reluctance to share all the information that was available. The main reason for this was due to potential competitiveness issues. The competitiveness concerns were raised by some terminals operating in ports with more than one terminal devoted to the same purpose, such as, container terminals. However, it was raised also as an issue in some ports where different companies were offering the same technical-nautical services, for example, mooring, pilotage. Some examples were:

- By sharing the real estimated time of arrival of a ship, two terminals may publish that they both have ships arriving at the same time. In that case, one of them may then instruct their ship to increase speed, thereby arriving earlier and causing the other ship to wait at the port entrance, delaying its arrival at its terminal.
- By sharing estimated times of cargo operations, other terminals can infer business aspects like the time it takes to operate a ship, or the time taken per container.
- Sharing estimated commencement and completion times for cargo operations could highlight a poorly operated terminal's productivity or planning that may lead to delays and an increase of anchoring times for incoming ships.
- By studying the estimated and actual times of service of a company, other companies providing the same service could then present themselves to key consumers by offering faster or better services.

Additionally, some participants expressed concerns that, by sharing their information, they could be exposed to "disruption" by having some actors taking advantage of the shared knowledge. One example was that, knowing the estimated time of completion of cargo operations stevedores might require, in advance, that more hands (even if they are not apparently needed) are hired in order to complete the cargo operations in time, threatening a delayed departure if additional workforce was not hired.

It is worth noting that, in most cases, these fears are a lack of trust and unfamiliarity with or distrust of the potential benefits that sharing data will certainly bring. Most of these issues can be addressed by carefully designing access management policies so actors only access information related to those port calls in which they are involved and only to the kind of information that is really needed and agreed upon. This was shown to be the case during the living labs process.

The matter of reluctance to share data is also raised and discussed in chapter 6.

5.5 Some final comments on the approach to validate PortCDM

Collaboration in multi-organizational settings must bridge the boundaries of peer-to-peer interaction if it is to empower self-organized ecosystems. One of the basic foundations for PortCDM is that port call actors share intentions using a data exchange standard so as to empower each other's actions and thereby the performance of the maritime transportation ecosystem in which they operate.

One way to validate the effects of an innovation is to identify a base line against which its outcomes can be compared. However, in the case of PortCDM, this was difficult because of the lack of comparable historical data and difficulty in getting access to paper files in diverse locations. This is not unexpected with proposals that seek to introduce innovative and novel revisions to long standing but inherently uncoordinated processes, such as is seen in the maritime transportation chain.
The quantitative analysis of the statistics from the validation project proved to be problematic. As already described, it was very difficult to establish a comparison baseline in a currently fragmented system that collectively maintains very limited standardised or accessible records regarding the progress of activities involved in a port call - which lies at the heart of PortCDM.

As a result, it was not possible to statistically prove whether, for example, turn-around time is reduced, or berth productivity is increased. This validation report is therefore based mainly on qualitative rather than quantitative analyses.

However, the PortCDM KPI's established as part of the validation project do provide a sound basis for more rigorous quantitative analysis in the future. For instance, we have provided examples of how the KPI's could be derived from shared data using the port call message format, the foundation of the S-211 internationally recognized port call message format standard.

In each of the ports that participated in the PortCDM validation, PortCDM platforms and mechanisms for data sharing and for structured digital collaboration did not exist before the validation project. This is highlighted by the numerous statements from port call actors who reported that it was not until the living lab setup, instigated as part of the validation, that they had met many of the other actors they interacted with as part of their operations. This PortCDM project introduced such a collaboration arena, both physically and digitally, with the purpose of enhancing the collaboration within the port sub-ecosystem.

The PortCDM demonstrator, which is a software-based solution for sharing data, was used to support new collaborative meetings in the participating ports. These collaborative meetings were also used in order to obtain information on the impact of the PortCDM concept for users.

Essentially, the PortCDM validation project highlighted the absence of a collaboration port call process and the impact of introducing one. The validation project examined what it means to introduce such a collaborative environment.

The qualitative analysis reported in chapter 6 provides statements and observations on the impact of the PortCDM concept on day-to-day operations, based on the practical experience and operations of the participants. Specific feedback was obtained from the actors through a series of questionnaires and interviews. The questionnaires are shown in Annexes A and B. A summary of the questionnaire and interview results and an analysis is discussed in chapter 6. This analysis is the prime basis for our conclusions.

The quantitative analysis reported in chapter 7 examines the millions of data points that were shared for enhanced situational awareness among the actors. The quantitative analysis shows trends by comparing the effects of PortCDM in the focus months of the testbed compared with the situation before.

5.5.1 Summary of the validation approach

In summary, the approach taken in the validation of the PortCDM concept has been to evaluate several validation hypotheses and design principles. These hypotheses and principles have all been derived from the fundamental objectives of the PortCDM concept, and they have been used in the collection and analysis of qualitative and quantitative data in order to provide positive and confirming statements on the value of Port Collaborative Decision Making.
6 Validation results from qualitative survey

6.1 Introduction

The purpose of this chapter is to present and analyse the results of a survey of the different PortCDM implementations at the various ports that participated in the PortCDM testbeds from a qualitative perspective. The results of a quantitative analysis based on AIS data are reported in chapter 7.

Results are drawn from feedback covering the first focus month, the second focus month, and finally for the overall time period that the PortCDM demonstrators were running in each participating port. The questions used to obtain the feedback are shown in Annexes A and B.

In addition, this account reports on opinions expressed by the various participants during the living lab sessions regarding the overall operation of PortCDM in their ports as well as their feedback regarding such things as the PortCDM concept itself, their experience with the service and their opinions on the potential benefits, possible improvements, and obstacles for using the service.

The PortCDM validation participants were also asked to submit user stories that illustrated their interaction and experience with the PortCDM concept. These are shown in Annex C.

6.2 Methodology used in the qualitative surveys

Qualitative feedback from stakeholders was collected through an online questionnaire and through personal face-to-face interviews during the final months of the project in late 2018.

The people selected to provide feedback were all participants in the PortCDM validation project directly involved in the port call arrival and departure process at the various PortCDM testbed ports. This means that the respondents had a clear understanding of the problems that currently exist in ports as well as the possible opportunities that lay ahead through the use of PortCDM.

6.2.1 On-line questionnaire and interviews

Two surveys were conducted. The first was a questionnaire (see Annex A) administered on-line using the SurveyMonkey tool. In total 37 responses to the on-line questionnaire were received as follows:

- Nordic testbed 15 responses
- Mediterranean testbed 22 responses

A second questionnaire using open-ended questions, was used during personal semi-structured interviews. The main objective was for these interviews to provide an opportunity for an open discussion where the interviewees could express their opinions regarding all the important issues that had been encountered during the 2½ years of the validation project. The questionnaire (see Annex B) was used as a guide only, enabling participants to focus more on specific issues that were relevant to them given their role in the port call process. A total of 33 personal interviews took place as follows:
Figure 23 shows the number of respondents in interviews. Figure 24 shows the location of the interviewees.

6.2.2 Respondent groups

Interviewees were selected so that all the major stakeholders/key actors that were engaged in the various individual ports’ operations during the focus months and living labs sessions were represented, including:

- Universities and research organisations (Cyprus University of Technology)
- Port Authorities (Cyprus Port Authority (CPA), Norwegian Coastal Administration (NCA), Swedish Maritime Administration (SMA))
- Port Control (Limassol VTS, Kvitsøy VTS, Kvarken ports - Vaasa VTS)
- Terminal Operators (DP World Limassol, Eurogate, Preem, APM terminals, Circle, ST1)
• Marine services (P&O Maritime, Rexor Marine, Buksér og Berging, Amarradores del puerto de Sagunto, Boluda rRemolcadores, Blomberberg stevedoring, Port of Umeå Mooring, Pilot planner for Port of Umeå, Port of Umea berth planners)
• Security companies (Securitas)
• Associations (Asociación de Consignatarios de Barcelona (ACB))

40% of those interviewed represented marine services companies (pilots, tugboat operators, mooring men, berth planners, stevedores) and 27% represented shipping agents. 18% of the interviewees worked for terminals, and 12% worked as traffic managers, VTS operators or in other security related roles. One participant working in the Port of Stavanger was categorised as a port officer.

![Figure 25 Occupations of interviewees](image)

**Figure 25 Occupations of interviewees**

The age range of the respondents to the questionnaires and the interviews was as follows:

![Figure 26 Age range of interviewees and questionnaire respondents](image)
6.3 General background for the PortCDM testbeds

6.3.1 What is an ideal port call?

In order to understand the ideal to strive for with a PortCDM system, the participants in the validation testbeds were asked to describe the optimal, ideal port call. Collectively, they defined an ideal port call as one that is well coordinated with good levels of transparency and real-time information sharing of actions and intentions among all involved actors. Precise information about linesmen, tug boat, pilots and berthing availability as well as the readiness of a terminal/marine services company to receive and serve a ship, is essential for conducting an ideal port call. Better communication among the various actors is important as well, requiring regular exchanges of information in order to plan as accurately and fast as possible and moreover to have adequate time to re-adjust these arrangements in case of changes. Availability, berthing and departure schedules should be communicated as early as possible, with any proposed changes highlighted to all the involved actors.

In summary, an ideal port call would have the following characteristics:

- It is well-coordinated between the different parties/service providers taking part in the port call and moreover it is a port call where all involved actors have a common situational awareness picture in order to plan their operations better.
- There is accurate information (estimates and actuals) from the different stakeholders involved.
- Smooth cooperation amongst the different operators on quay.
- Good information flow and access to relevant information/updates regarding operations on quay, both planned and actual times.
- All parties involved in the port operation share all available information among them in order to be in place to plan more accurately and make better use both of berthing places and available resources.
- Berth planners have accurate information from everyone that is being involved in the call (information regarding ETAs and ETDs, updates from the terminals, communication with the VTS, and suchlike).
- Terminals berth planners/operations managers have accurate information both from the ship agents and the marine services planners in order to be able to make their own planning.
- VTS operators are provided with all the correct information (especially ETAs and ETDs) about the daily movements. The VTS must be aware that all the necessary ship documentation/certificates are in order so as to allow a ship to enter a port.
- The ship agents upload on time all the necessary certificates in order to avoid delays when reaching the destination. For example, information regarding the cargo each ship is carrying, health certificate, waste declaration, crew members as well as all the correct information about the ship (length, beam, call sign, MMSI, and suchlike) must be entered in the PCS in order that the terminal planners are aware of ship size and requirements, what berthing place can be used, what quays are suitable, if the ship can go to another terminal or berth for some hours, if there is a necessity for shifting ships, and suchlike.
- Good visibility of the berth availability of the terminals by the stakeholders.
- There are no delays in cargo operations and submitting documents.
- Pilot and tugs are ready upon arrival.
- Reliable and prompt updates from the terminal/ship are provided during the port call.
- Administrative requirements such as customs cargo clearance is managed and notified in advance once the ship entry to the port has been granted so that clearance can be granted by the time the ship arrives to berth and operations are not delayed.

One participant in the PortCDM validation simply said that an optimal port call is the one where “Everyone is where they need to be when they need to be”.

Another participant working for a terminal in Gothenburg described the procedure for performing a perfect port call as the following:

1. The ship reports its ETA to the terminal, pilots, lines men, tug boat(s) and any other potential actors as soon as possible.
2. The terminal checks if cargo will be ready to be loaded and that there will be a free berth upon arrival.
3. The terminal sends a new recommended time of arrival or accepts the ETA from the ship.
4. The pilots, port control, tug boat(s) and linesmen accept or reject the ETA depending on the situation in the harbour.
5. The terminal sends updates based on other operations going on and the ship sends updates based on weather, speed and break downs. All other actors accept or reject updates.

6.3.2 Biggest challenges in realising an optimal port call today

However, at present the ideal port call is just that - it remains more an ideal then a reality. The respondents identified their biggest challenges for achieving their ideal port call (see figure 27). According to the answers from the interviews and the online questionnaires covering all the ports, the biggest challenge for planning and realising an optimal port call is changes not being communicated among relevant participants (77%), while a lack of information ranked second (66%). Low reliability of shared information (37%), low credibility of information (37%), departure delays caused by cargo operations (34%) and information not shared to all actors (31%), were also notable challenges highlighted by the interviewees and respondents.

Lesser challenges were resource planning (8.5%), pilot not available (8.5%) and flexibility to changes (8.57%).
Interviewees operating in small ports such as Limassol reported that sudden changes to a ship’s route and timetable presents them with the huge challenge of re-planning within a small time frame. This relates directly to the small windows for change created by the short transit times from all the nearby ports. These changes happen often - almost daily - without further notice and as a result a planner may have to re-plan berth, shifting, resource and cargo storage arrangements.

Participants from the Nordic testbed (Gothenburg, Stavanger, Umeå, Vaasa) noted difficulties in ensuring the readiness of a berth to accept a ship because of the need for all the involved port actors to be in place in order to adapt to possible delays.

In ports such as the port of Barcelona, getting all the actors to have a common situational awareness was seen as the key challenge. There are many factors affecting this goal, such as data reliability caused by the lack of trust among competitors or the lack of automation in the coordination process. Terminals cannot share information on their customers’ operations, if the customers are not willing to share it with competitors in a berth assignment scenario managed on a first-in first-out (FIFO) basis. Furthermore, coordination among different actors is frequently performed via telephone or email, making the process very slow and inefficient.

Interviewees raised many points based on their experiences and the special characteristics of their port. For example regarding the Port of Limassol all the stakeholders from their perspective, considered that more accurate and real-time ETAs and ETDs are needed in order to carry out an ideal port call, especially from the nearby ports of the Middle East that are currently being entered in the Port Community System (PCS) from the agents. The problem increases when a ship is coming from a nearby port because the port then has limited reaction time if something changes. With the term “nearby port” actors in the port of Limassol were referring to all the ports that are within a distance /radius of about 150 miles from Cyprus.
means mainly ports such as Beirut, Tel Aviv, Alexandria, Port Said, Rhodes, Ashdod, Haifa, and Aqaba. The basic problem is that the ETAs are not accurate and trustworthy (as many times they are not being updated by the shipping agents) and this means that the private actors and the VTS station must readjust their plans within a short time frame when changes are delivered at short notice or not at all.

6.3.3 Challenges experienced in resource planning for port calls?

The most frequent response regarding challenges relating to resource planning among all the ports are shown in figure 28. These were the lack of real-time information (72%); while the lack of information from external actors ranked second (68 %). Low information transparency ranked third (40%) and low quality of information followed with 34%. This was followed by too many systems to keep updated (17%) and too many emails (17%), then too much administrative work (8.6%).

![Figure 28 Challenges to resource planning](image)

Based on the responses, it seems that the challenges to resource planning relate mainly to the lack of quality, real-time information and less on the administrative side of the port call.

Studying the interview results and the issue of the information necessary for better planning, the port actors referred firstly to the ETAs (especially from nearby ports) as the most essential information required for good planning. Accurate information was required from the ship agents and other involved parties in the process, for example terminals, marine services, port control, and suchlike. Having the information as soon as possible is desired so as to have enough time for planning operations such as maintenance, bunkering and organising resources appropriately. It was agreed that other progress information is useful to improve port call planning, and in particular the following timestamps and data:

- Arrival Traffic Area timestamp
- Arrival Port Area timestamp
- Pilot OnBoard / Pilot Disembarked timestamp
- Arrival Ship at Berth
- Cargo Operations Initiated / Completed
- Cargo Operations Completed (Estimated)
- Barge Alongside Ship
- Barge Departed Ship (Estimated)
- No. of Tugs / Name of Tugs
- Pilot Requested timestamp
- No. of tows in ship movement
- List of next planned port calls
- Berth occupation timeline
- Stevedoring resource availability
- Pilot Time Estimates
- Customs clearance status + Estimates to finish
- Train Arrival + Departure Estimates

### 6.3.4 Business values/benefits from increased reliability of time stamp information

Increased reliability of timestamp information is one of the most crucial issues, and there were various opinions expressed about this in the online questionnaires and the interviews. Business benefits are connected with the individual characteristics of each port. For instance, respondents from Limassol referred to the possibility of offering faster services to the ships; something that can eventually lead to an increase in the domestic competitiveness of the port of Limassol especially in relation to the nearby ports. Another PortCDM validation participant working for a Limassol port terminal answered that consumption of better timestamp information can enable optimisation of arrival planning and better berth utilisation leading to increased efficiency in handling port operations.

Meanwhile, another participant coming from Gothenburg said that increased timestamp reliability will make a port call easier and will help to avoid penalty fees for changing pilot/tugs and providing correct information to the customers. Furthermore, another participant from Gothenburg expressed that it will be easier for the terminals/ships to plan ahead and therefore have smoother port calls with more shared information.

Regarding this issue, a PortCDM validation participant working for a security company that operates in the port of Stavanger reported that “This makes many operations more accurate, which in turn generate time-savings. If operators get more accurate information regarding the time aspect of different operations, more effective planning may be an outcome from that. Effective planning is cost-saving in terms of more effective use of personnel”.

An IT officer in the Stavanger port stated: “This way the ports and actors can plan better and save money, and in turn this will enable Just-in-Time operations and more environmental and sustainable operations. The goods owners can see what happens to their cargo. This transparency will change the legal contracts and the business deals, which are needed to enable a sustainable maritime future”.

In summary, respondents felt that increased reliability of timestamp information could bring benefits including:

- faster service time, faster turnaround time,
- better berth productivity and reduced expenses
- better planning and just in time operations
• more environmental friendly and sustainable operations
• less waiting times, less idle time for a ship off port
• less anchoring time for ships waiting to get into port
• better transparency among the actors
• better communication
• optimizing of average time for providing service to ships
• better utilisation of berths
• enable a port, terminal and operator to become more competitive through the increase of efficiency in the time taken to serve a ship
• provide access to a real-time, live, updated berthing plans which could help in many ways; for example, to improve coordination

6.3.5 Extent of adoption of PortCDM in the testbeds

As shown in figure 29, 62.3% of the interviewees and online questionnaire respondents indicated that they had used the PortCDM system during their daily work.

![Figure 29 Use of PortCDM validation system for daily work](image)

The PORTABLECDM application on a smartphone was the most popular option used by 49% of those accessing the system, access via computer was used by 44% of the PortCDM validation trial participants and a smartphone was used by 7%.

![Figure 30 Access to PortCDM validation system](image)

Notable observations on the reasons and the way of using the system were:

Terminal operators
66% of the people that work for terminals indicated that they used the PortCDM system. Some said that they had used it for entering timestamps such as cargo operations commenced and completed, while others for comparing information such as the Actual Time of Berthing / Unberthing (ATB / ATUB) with their own company system, and suchlike. Some of the others that did not use the system said that in their view PortCDM is a complex system that probably works well in a port with different characteristics than their own ports. Others just said that they operate with their own systems at the moment.

**Marine Services**

92% of the participants that work for a marine services companies or perform this role in their organisations (pilot, tugboat operator, linesmen, berth planners, and suchlike) used the system.

- Personnel working for a mooring company in the port of Sagunto responded that they used PortableCDM and tablets and the PortableCDM mobile app to report the following four states:
  - service requests received
  - arrival to the defined berth
  - service commenced, and
  - Service completed.
- Tugboat operators that work in the ports of Valencia and Sagunto answered that they had established a connector between their system and the Port CDM instance at their port and that all the tugboats were equipped with tablets to report information in real-time.
- A berth planner working in Limassol port used the system for cross checking with their system’s timestamps.
- Pilots working in Umeå used PortableCDM to coordinate better with other colleagues.
- Stevedores working in Vaasa used PortableCDM as a complement to marine traffic and email.

The main adverse issue reported by the PortCDM validation participants concerned the PortableCDM app that according to the actors failed regularly by closing down, reverting to a blank-screen or required restarting.

**VTS / Security services**

People that work as traffic managers, VTS operators or security officers answered that they had all used the system in some way or other.

- Two VTS operators (one working in Limassol and one in Stavanger) used the system for checking the timelines of ships and cross checking with their own system data. They both used it through PACT and a computer and they considered it as a helpful support tool.
- A PortCDM validation participant working for a security company in Stavanger used it for entering port security events such as security commenced, and security completed timestamps. They said also that they had used it to create reports, provide comments on events that can cause delays, report their presence and see what was planned for the call in question.
- A person working as traffic manager in a control station in Vaasa said that they mostly just looked and received the information from there and created some tests regarding
some port calls. They added that they used only PACT on a computer, since the PortableCDM app did not work with its preferred language on iPhones or iPad.

**Shipping agents**

55% of the shipping agents that participated in this research used the PortCDM system. Some of their feedback is provided below:

- A ship agent working at the port of Gothenburg reported: "I have used it for receiving information in order to coordinate berthing, to check berth availability as well as cargo operations start and cargo operations completed times".
- Another ship agent operating at the port of Gothenburg used the web version PACT through Chrome in order to look at port calls of their concern and on other related port calls in order to make prospects that they can send out. Moreover the same person used it to check what the terminals are saying about their port calls, information that was followed up afterwards with a phone call.
- A ship agent in Vaasa port said that they used the mobile version saying that “I used it only via the PortableCDM app which I thought was easier to use then the Web application. You have it with you all the time and can update it from anywhere which I appreciate”.
- Some of the shipping agents working in Stavanger and Gothenburg answered that they have shared their own information to the PortCDM (through a connector) but that they had not interacted directly with the system due to the fact that they already had many systems to update and a high working pace to follow and therefore they did not have the time to use the service. Some of them added that to some extent, they checked that the correct data was entered into PortCDM, for example, that ships had sent updated ETA information.

**Port officer**

- The only port officer in the sample that was interviewed, has a primary role of planning ships’ arrivals to berths, to order and book services and to update the respective information to the PCS for invoicing purposes and said that they used PortCDM through PortableCDM for port calls that were related with cruise ships.

**Actors that did not use the system**

For those actors who did not use the system, the following reasons were provided:

One actor that worked in Barcelona (representing consignees’ interests upon the port community) said that the system is not needed for their job as they are not involved with operations. Nonetheless, the same actor stated that their clients will be interested to see tools such as PortCDM / PACT operating at the port of Barcelona due to the value that a unified platform can provide as a single point for operational port call data management, having all the necessary information in a single platform.

- A shipping agent in Barcelona referred to the fact that the system according to their opinion is still incomplete but they added that they consider it a very good tool if everybody can use it and populate it with data.
- A PortCDM validation participant working for a terminal in Barcelona stated that they already have all the information required for their operations using a company tool (visual interface) but they added that PortCDM will be very useful for them if it could be
as user friendly as their own system and include all the information they lack at the moment for coordination with other actors, such as details of bunkering, watering, and consignees.

- Actors working for a terminal in Limassol answered that they did not use the system having because they had to deal with problems regarding their own system. Nonetheless, these actors said that they would like to use the system if at some point timestamps of their concern, for example, ATDs from nearby ports was included in the service (mainly they referred to the actual departure time from the previous ports and operations completed). According to them, this kind of information will enable the port operators to have better port-to-port communication and as a result, they would become less dependent of the agents’ input.

- An IT manager with access to the Stavanger testbed said that they had not used the system by explaining: “In our daily work we use telephones, e-mails, PMS (Port Management System (PortIT)). The maturity of PortCDM is not there yet, we need a national or international actor to provide connectors to all maritime stakeholders. In addition the VIS (Voyage Information Service) connector has not been available for neither testing nor regular use. Thus the information sharing with the ships and other ports and third parties actors have not been available. The PortCDM is as it is now a second system not Integrated into the PMS which is only used in the testbed and focus testbed months”.

- Another actor working for the port of Stavanger said (through the online questionnaire) that in their new position as a maritime coordinator they had not received training for the system.

- A person working in Stavanger as a tug operator commented: “Our work is based on contracts with our clients. The contracts are not dependent on timestamps but on target time or delivery time agreed according to the contracts”.

- A fleet manager working for an international company based in Cyprus commented the following: “I haven’t used it due to the nature of my work. We as ship managers deal with ship technical and crew management - my role during the project is to provide independent advice on how different functionalities would benefit shipping as a whole. Should any of our managed ships call to ports using PortCDM, our charterers will be using the functionality”.

- A ship agent in Gothenburg answered negatively to the question and provided their reason as: “We have so many systems to update and a high working pace and therefore we haven’t had the time to implement PortCDM”.

6.4 Empirical findings from the PortCDM testbeds

This sub-section of chapter 6 presents the empirical findings from the standardised questionnaires regarding the impact of the PortCDM implementation in the Nordic and the Mediterranean testbeds. Respondents provided feedback on the use of PortCDM in the testbed scenario as well as their expectations of what a full-scale implementation in their port would mean.

6.4.1 Contributions of PortCDM to a shared situational awareness of port calls

The PortCDM validation participants were asked their opinion on whether the PortCDM process contributed to a shared situational awareness of port calls (meaning that involved actors get an overview of different events in a port call, with time stamps for the different actors’ intentions).
Figure 31 indicates that 92% of respondents from all the ports agreed (either fully or to a great extent) with the statement that PortCDM contributed to a shared situational awareness of port calls. None disagreed. This indicates particularly strong support for PortCDM.

![Figure 31 Contribution of PortCDM demonstrator to shared situational awareness](image)

When respondents were asked if they believed that a future full-scale implementation of PortCDM would enable a shared situational awareness of port calls in their ports, the evaluation was equally positive.

As can be seen in figure 32, 84% of respondents from all the ports agreed (either fully or to a great extent), that PortCDM would enable a shared situational awareness of port calls in the case of a full scale implementation in their ports. None disagreed.

![Figure 32 Full-scale implementation of PortCDM will contribute to shared situational awareness](image)

6.4.2 Contribution of PortCDM to providing making better estimates

The PortCDM validation participants were asked to provide their opinion on whether PortCDM provided an enhanced basis for making better estimates. The responses are reflected in figure 11. 72% of all respondents in the ports agreed (either fully or to a great extent) that PortCDM provided an enhanced basis for making better estimates. 28% agreed “to some extent” with the statement, and none disagreed. This was another very positive response to PortCDM.
Figure 33 PortCDM validation trial provided an enhanced basis for making better estimates

When asked whether a full-scale implementation of PortCDM would enable an enhanced basis for making better estimates in a situation where PortCDM was fully implemented in their port, positive support for PortCDM continued; 77.5% agreed (either fully or to a great extent), none disagreed.

Figure 34 Full-scale PortCDM implementation will enhance the basis for making better estimates

6.4.3 Contributions of PortCDM to enable better access to reliable information

The PortCDM validation participants were asked to provide their opinion on whether PortCDM, as used in the testbeds, enabled better access to reliable information.

Here the response, as shown in figure 35, was not quite as clear as in the previous questions. However, 48% of the respondents fully agreed with the statement that PortCDM enabled better access to reliable information. Another 20% agreed at a great extent, while 24% of the participants agreed to some extent. Only 8% agreed to a small extent. None disagreed.
In case of a full-scale implementation of PortCDM, the validation participants were also fairly unanimous in their estimate that a full-scale implementation of PortCDM in their port would enable better access to reliable information as can be seen in figure 36. 56% fully agreed that PortCDM would enable better access to reliable information in a situation where PortCDM was fully implemented in their port, 20% agreed to a great extent, 12% agreed to some extent, and 12% agreed to a small extent. None disagreed.

6.4.4 Contribution of PortCDM to greater awareness of different actors' intentions

The PortCDM validation participants were asked to provide their opinion on whether PortCDM had created a greater awareness of different actors' intentions. 24% fully agreed that PortCDM had created a greater awareness of different actors' intentions. 48% agreed at a great extent while 28% agreed to some extent. None disagreed. This is shown in figure 37 overleaf.
In case of a full-scale implementation of PortCDM, the validation participants also showed a high level of consensus regarding whether greater awareness of different actors’ intentions could be achieved. In line with the previous results, 48% fully agreed that in a situation where PortCDM was fully implemented in their port, the system would create a greater awareness of the intentions of different actors. 36% agreed at a great extent while 12% agreed at some extent. 4% agreed to a small extent. None disagreed. These results are shown in figure 38.

6.4.5 Contributions of PortCDM to improve work procedures

The PortCDM validation participants were asked about the extent to which PortCDM had improved their work procedures.

As shown in figure 39 overleaf, 16% fully agreed that PortCDM had improved their work procedures, 20% agreed to a great extent, 28% agreed to some extent and 24% agreed to a small extent. 12% did not agree that PortCDM had improved their work procedures as it stood during the focus month.
In case of a full-scale implementation of PortCDM, the respondents were slightly more optimistic about the extent to which this would improve work procedures in the future.

As shown in figure 40, 19% fully agreed that PortCDM would improve their work procedures, 26% agreed to a great extent, 33% agreed to some extent and 15% agreed to a small extent. 7% did not agree.

6.4.6 Contribution of PortCDM to reduce the time spent information gathering from multiple applications/actors

The PortCDM validation participants were asked to provide their opinion on whether PortCDM had reduced the time spent information gathering from multiple applications/actors. The results are shown in figure 41 overleaf.

Here we see a much more diverse situation. Only 28% fully agreed that PortCDM had reduced the time spent information gathering from multiple applications/actors, 20% agreed to a great extent, 32% agreed to some extent and 8% agreed to a small extent. 12% did not agree that PortCDM had reduced the time spent information gathering from multiple applications/actors as it stood during the focus months. It should be noted that many, if not most of the participants had to continue to deal with some actors that were not participating in the validation, which in some cases resulted in the need to use additional or duplicate communication channels to obtain information.
In the case of a full-scale implementation of PortCDM, the respondents were more optimistic about the extent to which PortCDM would reduce the time spent information gathering from multiple applications/actors in a situation where PortCDM was fully implemented in their port. 80% agreed (either fully, to a great extent) that PortCDM would reduce the time spent information gathering from multiple applications/actors in a situation where PortCDM was fully implemented in their port. 8% agreed to some extent and 12% agreed to a small extent. None disagreed.

The PortCDM validation participants were asked to provide their opinion on whether PortCDM had reduced their administrative workload per port call. The results are shown in figure 43 overleaf. 32% fully agreed or agreed at a great extent that PortCDM had reduced their administrative workload per port call. A further 32% agree to some extent. However, 36% did not agree or only agreed to a small extent that PortCDM had reduced their administrative workload per port call. As with the previous question on information gathering, many, if not most of the participants had to continue to deal with some actors that were not participating in the validation, which in some cases resulted in the need to use additional or duplicate communication channels to obtain information.
In case of a full-scale implementation of PortCDM, the respondents were much more positive about the extent to which PortCDM would reduce their administrative work load per port call. The results are shown in figure 44 below. Here we see that 68 % fully agreed or agreed at a great extent PortCDM would reduce their administrative work load per port call in a situation where PortCDM was fully implemented in their port, while 12% agreed to a small extent. None disagreed.

6.5 Reflections of respondents on impacts of PortCDM testbeds

6.5.1 Opinions on PortCDM enabling how to plan/make estimates

The interviewees were asked to elaborate on how their ability to plan and make estimates had been affected by using the PortCDM concept.

90% considered that their ability to plan or estimate remained the same but they believed that PortCDM has the potential to enable them to make better planning in the future. Regarding the reasons why this happened some referred to problems relating to the usability of the testbed service (crashes and suchlike) that prevented them from using it, while others did not use the service due to the specific nature of their work.

A shipping agent from Gothenburg referred to the fact that they continued to use the traditional communication mechanisms like phone calls and emails and that they used PortCDM as a
backup system for the port calls where they already had sufficient information. Another respondent, working for an oil terminal in the same port, referred to the fact that currently there was no automatic connector from their own systems so it was difficult to use the system by someone who has to do berth planning.

Another basic problem according to the responses was that the system sometimes displayed incorrect information.

10% indicated that their planning ability had been enhanced; for example, a ship agent in Gothenburg reported that this happened for them after the focus month and referred to the fact that through the PortCDM demonstrator they could follow the updates in the port berth planning which is something they could not do before.

Similarly a traffic manager working for the port of Vaasa port reported that “Maybe it helped a bit. We have mostly used the old ways of doing things in the same time but it has helped a bit.” Also a person working for a mooring company in Stavanger answered positively as well commenting that “I would like to say that is has had a small effect for my planning of estimates since I don’t know when the ship is coming until an hour before. But when you get the information it’s very good. Sometimes it shows the wrong time but that depends on the automatic connector that hasn’t worked properly.”

A person working for a mooring company in Umeå was particularly optimistic: “Maybe not really so much in the near future. In the longer run, it's when I see the vessels earlier. E.g. a tanker vessel that was bound for the port and had an ETA to berth, that we planned from. Then increased the speed and arrived earlier, I saw the change in PortCDM so I had the time to adjust to it. Being able to see the changes is good and to find it out as soon as possible.”

The remainder of the interviewees who reported that PortCDM had had a limited impact on them so far, still believed that PortCDM would help towards a better situational awareness regarding port call status and better coordination of services in the future. It will enable them to plan better, optimise operations, reduce port call time at berth and have a clearer situational awareness in their port. According to one interviewee, getting estimates from stevedoring and trains would help them to improve.

6.5.2 Opinions on PortCDM enabling information transparency

The interviewees were asked to elaborate on why, in their opinion, information transparency is important. According to the collected feedback, information transparency is important because:

- It will allow trust among port actors and can prevent some actors to take advantage over the rest.
- It will allow better resource sharing within the ports. However, according to a PortCDM validation participant working for a terminal, actors must learn to change their work culture and collaborate instead of competing.
- Hiding information creates reduced visibility within the port and can result in uncertainty of what is happening at a specific time. For example, whether an agent has arranged the mooring personnel or not, what is happening at a specific berth place and suchlike.
- It makes it easier to recognise potentially dangerous situations within the port.
- It means better collaboration among various different parties; something that happens constantly within a port.
- It is important to know at any time what is happening. For example, whether ships are to load or unload at several terminals and for creating trust for involved actors.
- Transparency is essential for making good planning. If transparency is limited, planning for the next step is impossible.

A terminal actor from Gothenburg pointed out that while transparency is important; for example, timestamps are acceptable to be shared; but sharing some data, such as the type of cargo, and suchlike might be useful for some but could deter others from sharing. People that work for terminals in other ports might prefer that specific information such as cargo operations commenced and cargo operations completed timestamps be kept confidential due to legal, competitive or privacy reasons.

Some actors that work as tugboat operators commented that the information shared in the PortCDM system has to be neither confidential nor sensitive. A berth planner working for a marine service company in the Port of Limassol said that transparency is needed in order to know what is happening in the port, and that this will enable them to plan better the work operations of the day, assign tugs, pilots and mooring men according to ship priority, and suchlike.

Interviewees that worked in a port where there were two terminals said that information transparency must be in place to enable them to know the daily movements. If there are any delays this would affect their own planning (stowage planning, operation planning, shift planning, berth planning, and suchlike).

A tugboat operator in Stavanger commented that “there is information that is good to have but there is a risk that there might be information overflow. Not always the information that is needed comes.”

According to a shipping agent from Barcelona, information transparency is important because it will allow trust among port actors and can prevent some actors taking advantage over the rest. However, in order for information transparency to work, there is a pre-requisite to establish clear open operating rules on shared resources, so that everyone’s behaviour is exposed and there is no room for some companies to take advantage of others or use their bargaining power to get special treatment.

6.5.3 Opinions on PortCDM in relation to the administrative part of daily work

The interviewees were asked to comment on PortCDM in relation to the administrative part of their daily work. The majority of the interviewees reported that PortCDM had not reduced the administrative part of their work stating as the main reason that the validation tool is just a test version. Nevertheless, most of them were optimistic and believed that PortCDM has the potential to improve their administrative tasks when it is implemented in a full scale scenario that includes all the necessary information from all relevant actors.

Interviewees working for the terminals in Limassol referred to the fact that they could avoid, through the service, the daily manual data entry from Excel files, but that adequate training will be needed for the correct use of the system in order to avoid errors in its use. Tugboat operators from Valencia/Sagunto agreed with this statement as they believed that PortCDM helps to avoid human errors related to manual data entry. Through the elimination of manual data entry, one working hour per day could be saved according to the same actors. This is the current time spent daily on average to input data to the local Port Authority related to service provision.

Shipping agents from the Mediterranean testbed agreed that PortCDM had not reduced the administrative part of their work but that they expect it to happen once it is fully implemented
as they will be able to retrieve the information needed from a simple centralised platform instead of using multiple systems and making unnecessary phone calls.

A shipping agent from Gothenburg referred to the fact that it will be essential to know if the updates coming from PortCDM are accurate as this will bring benefits such as less time for communicating with other actors and for chasing information. For example, it should not be necessary to call five different actors to obtain the information for one time stamp, as is currently the case.

A pilot working in Umeå began by saying that PortCDM did not have an effect for the administrative part of the work for the pilot, but then went on to say “No, I cannot say that. Okay, I do not need to call marine traffic - this (PortCDM) is much faster. Then, there may also be ships called the same name on marine traffic and then you might look at the wrong ship. The app removes the part when the ship is in the system. A full scale development would save a lot of conversation and such. Now you ask your boatmen if they have talked to the port. Then they have to call and then they have to call another person and later they'll call me.”

An interviewee from a Nordic port said that they believed that this part of the work may not change but there will be better predictability through PortCDM while another one referred to the fact that they are not involved with administrative work so this issue is of no concern for them.

One tugboat operator from Stavanger said that in their opinion PortCDM rather increased the administrative part of their work. This happened because they already deal daily with many emails and phone calls (and contact actors such as shipping agents, based on contractual obligations) thus in their opinion PortCDM was, in effect, an extra system. Similarly a shipping agent from Gothenburg commented that the administrative part of their work was increased during the test period but in real use, it would decrease.

6.5.4 Opinions on whether PortCDM reduced interaction (number of phone calls/emails, and so on) related to searching information about a port call

The interviewees were asked for their opinions on whether PortCDM reduced interaction (number of phone calls/emails, and so on) related to searching information about a port call.

The dominant opinion was that PortCDM did not reduce the interactions among them, but it has the potential to do so when it is deployed within a real operational environment and the data is more quality assured. A minority said that PortCDM had already succeeded in reducing the interactions among them, as it provided a lot of information. There was general agreement that in order for PortCDM to succeed a local port community must be committed to provide quality data.

According to a PortCDM validation participant, in a full scale scenario direct reporting could be reduced and maybe some reporting would become completely unnecessary when the information is available to the interested parties via PortCDM. Interesting opinions were provided from the participants from Gothenburg on this point. A respondent referred to the fact that there were instances where PortCDM had reduced the number of phone calls from ten to three and that they are therefore convinced that a full scale implementation will reduce the number of phone calls among all the actors. They provided as a reason that this has not happened yet as being due to the fact that they did not have an automatic connector - thus actors could not rely fully on the system and needed to make some calls to confirm the information. A shipping agent from the same port, added that “Maybe we have avoided some
phone calls, but it may be that I called to check that the time they updated was correct. But that's because it's a test."

A port services worker from Umeå was particularly enthusiastic, indicating that their administrative workload had already been reduced by PortCDM: "Yes, at least there is a place to safely see information. Closer to the truth than, for example, watching Marine Traffic. You get a name on a ship, so you know which ship it is instead of starting to look for which ship it is. Sometimes they are late with sharing the information of the port call and which ship."

6.5.5 Opinions on information quality in relation to PortCDM

The interviewees were asked for their opinions on information quality in relation to PortCDM. The predominant view was that information quality is essential since bad information quality has huge implications in the port call operational chain. Information, especially from official sources, was considered as very important and it was acknowledged that PortCDM can provide the functionality to make it available.

A participant from a Gothenburg oil terminal cautioned that it is not certain that just because something is updated it is correct. When there are multiple sources being used, a quality check is needed in order to identify which is the more accurate information. More specifically the participant said “Several sources that show different times show that you have different perceptions and who knows best then? Should the ship itself update the time to berth, you would trust that time more. It’s a quality-check of data when multiple actors add the times they know. Either I am going on the information when everyone is reporting the same times or if the times are different then I know that the shipping agent most often are more right or that a pilot is booked and that you are informed that there are different times. It highlights that problem as well.”

The opinion of “information filtering” just described, was also expressed by participants working for the two terminals in Limassol. According to those participants, PortCM can be useful for many reasons but with regard to the issue of information quality, multiple data sources do not necessarily lead to increased data quality. Additionally, they commented that information accuracy is still an issue when having access to multiple data sources due to the fact that “if any actor is putting wrong information in the system it can jeopardise the data quality of the system as the rest of the actors can be confused. Also there might be multiple data duplication. So the PortCDM team needs to ensure that there will be adequate information flow control, filtering and error checking in order to avoid such problems.”

One shipping agent from Gothenburg appeared to agree with the above opinion when they commented that in a case of many sources of information they choose the source they trust the most, while another ship agent working also in Gothenburg commented that they already have access to the first-hand information through their company system; for example, when a ship is coming to berth and when it is going to load. Many other participants said that in their opinion they already have access to good quality information through their own systems.

Another shipping agent working in Gothenburg said “It’s good that many people can share and tell what their opinion is, to consider who is responsible for the task that’s being delivered. It is a built-in review. For example, for a ship that is on a voyage between points A and B, it is the captain who is responsible for the ETA. I see PortCDM like a toolbox that the actors in a port can use to determine who is responsible for which time. Who will be the one to decide?”

Regarding this point, another shipping agent from Gothenburg commented that “Some actors are more important than other actors. I would not listen to tug boats or pilots or mooring
personnel or the port when it comes to an arrival, it is me that gets that information. The same goes for a departure, then I would listen more to the surveyor and the terminal that will say that this is going to happen. Different part of the information flow where different actors are important and in some cases a couple of them are important for the times. I guess that the port wants to be the link between that information and they need then to be served with this information, that's the interesting part.”

Stavanger pilots referred to the fact that AIS is not always that exact when a ship is moored so it is good to have access to other sources as well. A tug boat operator from Stavanger said that increased information quality is not that important for them in comparison with the people that are operating at the berth (mooring personnel, ship agents, and suchlike).

6.5.6 Opinions on which information is most valuable to share in PortCDM?

The interviewees were asked their opinions on which information is most valuable to share in PortCDM. The information that according to the PortCDM validation trial participants is most valuable to be shared through the PortCDM is summarised in the following points:

- Actual time to berth and actual time to unberth /ATB and ATUB
- Accurate ETAs and ETDs
- Timestamps such as pilot on board, mooring men at berth, ship agents at berth, tugboat alongside the ship is essential also
- Information that refers to the readiness of a berth to accept a ship and readiness of all the involved port actors in order to recognise possible delays
- Mooring personnel progress, readiness and status
- Berth and tug boats availability
- Cargo operations timestamps
- Name of the ships that are problematic - for instance those who have machinery problems.
- Estimations referring to the different services from all the actors that are involved in the respective port call, for example, pilotage, mooring, towage, bunkering, sludges, and suchlike.

6.5.7 Opinions on whether any information should be excluded when a ship arrives and when it departs

The interviewees were asked their opinions on whether any information should be excluded when a ship arrives and when it departs. The majority of PortCDM validation trial participants did not see any significant obstacle to sharing information such as timestamps and especially ETA/ATA, ETD/ATD, and ETB/ATB. Most of them did not see obstacles in sharing information at a technical level and were only sceptical regarding information connected with business competition.

Participants working for terminals expressed concerns about sharing information on when cargo operations commenced and cargo operations completed due to legal requirements set by the companies themselves and the international rules that govern shipping. Some believed that data such as these two specific timestamps could be used directly or indirectly to evaluate performance (such as berth productivity, time for serving a ship, waiting times, turnaround time, and suchlike) and they would like to avoid situations where such information could be used by potential competitors of the nearby ports.
An operations manager working for a terminal in Limassol cautioned: “If we declare how much time it takes for us to serve a ship and a ship-owner learns about it and compares it with another terminal in a nearby port they may then prefer to go there as the service might be faster. So, any data connected especially with our productivity should not be available to a direct competitor (referring exclusively to terminals operating in the nearby ports) that might use it in any way.”

A process improvement manager for a terminal in Barcelona commented that competitors are very reluctant to share information about their operations since many ports operate on a FIFO basis, thus they are always concerned to secure the next vacant berth ahead of others.

In addition to company policies and competition laws that govern the shipping market and set various restrictions, the shipping agencies /agents expressed concerns on sharing timestamps and other data relating to their ships due to privacy and competition reasons. A shipping agent from Umeå referred specifically to the Personal Data Act that they considered was a barrier to full data sharing.

In addition to the issues described above, some participants considered that it could be a problem in sharing information relating to security.

A tugboat operator at Stavanger said that in their opinion if it is a general port call, there should be no problem with sharing any type of timestamp information, but they pointed out that especially in the case of military ships, the applicable information would most likely be restricted.

One shipping agent working in Barcelona saw no technical obstacles in sharing their information, arguing that the reasons of some actors for not sharing are based on keeping their privileges in a black data environment.

Another participant added that the only concerns regarding data sharing are how to achieve commitment among all the actors for sharing quality data, and data confidentiality and privacy - who will have the responsibility of the data that will be published on the platform and how to establish the appropriate mechanism to monitor adequately this?

6.5.8 Opinions on whether any additional information should be shared through PortCDM

The interviewees were asked whether PortCDM enables common situational awareness by actors sharing port call related time stamps that are not business critical. Do they currently lack any information that should be shared?

Most of the participants said that they did not think that they lacked any information that should be shared through PortCDM. Most of them believed that timestamps relating to arrival, expected berthing time, departure time, ETAs and cargo operations commenced/completed are more than enough. Despite this, some of the actors believed it would be better if they could access additional information.

Moorers from Sagunto proposed additional information such as the size and particulars of ships (length, docking side (port or starboard) and berthing place (bollards), while tugboat operators from the same port proposed that the Port Call Authorisation be included. A port officer in Stavanger commented that despite the fact that they did not lack any information, desirable information for their job is ships’ related data or information regarding the port gates daily movements.
An operations coordinator in a security company in Stavanger suggested that it would be highly desirable if the tour operators could share information regarding their operations while a moorers working for the same port said that they would like to know the name of the responsible ship agent for a specific ship and moreover to be in a position to be able to get this information to the bridge of the ship as sometimes communicating such information is an issue.

Additional information needs are also related to the nature and the characteristics of each port. For example, a pilot working in Umeå referred to tugboat and icebreaking related information saying that “It would have been very good if I could see if the tugboat has been removing ice or not in the port. I would like that. Then I do not know how it is with the icebreakers. If a ship that is planned in or out has assistance or not. He will not get in or out without assistance.”

Meanwhile, for a port like Limassol, PortCDM validation trial participants such as VTS operators, terminal operators and berth planners of the marine services company said that they currently lack accurate information such as ETAs, ETDs, ATDs / cargo operations completed for ships coming from nearby ports in the Middle East to their own port. This is essential for them as in the case of Limassol narrow time windows can create difficult situations.

A shipping agent working in Gothenburg commented “The things we are interested in when the ships arrives since it is mostly first come - first served, is Notice of Readiness, when the ship will be at berth and when it will departure. Cargo operations commenced and completed is more interesting for the actors having the ship. For the actors that do not have the ship a good ETD is more important.”

Another shipping agent working in Barcelona said that they are currently missing a number of fields, where some of these are relevant for PortCDM and some are outside the scope of PortCDM, such as:

- Pilot Requested timestamp
- Number of tows operating in a port call in movement
- List of next planned port calls (ordered by port entry time)
- Berth occupation timeline
- Accurate and updated ETAs
- Destination berths / Alternative destination berths
- Barge Alongside Ship
- Barge Departed Ship (Estimated)
- Number of Tugs / Name of Tugs
- Cargo Operations Initiated / Completed
- Cargo Operations Completed (Estimated)
- Pilot OnBoard / Disembarked
- Bunkering Ops Commenced / Completed
- Sludge Ops Commenced / Completed
- Watering Ops Commenced / Completed
- Stevedoring resource availability
- Pilot Time Estimates
- Customs clearance status + Estimates to finish
- Train Arrival + Departure Estimates
Note that many of the fields reported as “missing” in the previous list were subsequently included in the PCMF standard. These include timestamps regarding pilot request, pilot on-board, pilot time estimates, ETAs, destination berth and commence and completion for various operations including cargo, bunkering, sludge and watering.

6.5.9 What is the most revolutionary feature/effect in PortCDM?

The interviewees were asked to rank what they considered the most revolutionary features/effects in PortCDM. The responses are shown below.

![Bar chart showing the most revolutionary effects of PortCDM](chart.png)

**Figure 45 Most revolutionary effect of PortCDM**

Common situational awareness was selected by 55% of the shipping agents that participated in this research. Information transparency, digital collaboration and increased information quality and port call synchronisation were selected by 22% of the PortCDM validation trial participants.
Among the terminal operators, common situational awareness and port-to-port collaboration were nominated by 50%, while increased predictability and information transparency were nominated by 33%.
Digital collaboration was selected by all those working as VTS operators, traffic managers, or security officers, while common situational awareness was selected by 75% of the actors and port-to-port collaboration along information transparency and increased information quality by 50% of them.

The only port officer that participated in the interviews said that for them the most revolutionary feature/effect of PORTCDM is digital collaboration.

Overall, 23% of the interviewees considered that common situational awareness for enhanced coordination was the most revolutionary feature, closely followed by 21% that thought digital collaboration was the most revolutionary. This was followed by port-to-port collaboration and information transparency at 14% each, then increased predictability for extended planning horizons at 13%. Increased information quality (9%), port call synchronisation (4%) and physical collaboration (2%) were the least favoured.
6.6 PortCDM users’ feedback and comments

6.6.1 Overall impression of PortCDM based on using the test bed tools

Actors from all the ports considered the PortCDM testbed tool as very useful that enables everyone that operates in a port to have access to the same information and have the same ability to react accordingly to a specific situation. Several participants characterised PortCDM as a collaboration arena among the various parties where a number of different actors are grouping themselves in order to share and consume timestamps.

Limassol actors working for the terminals believed that PortCDM is a good information aggregator while mooring men from Sagunto port felt that through PortCDM they were able to overcome resistance to change and start using digital devices in their daily activities which was positive for them.

A representative of shipping companies in the port of Barcelona referred positively to the centralised data approach of PortCDM which allows easily accessible information gathering in a single application, and that the PortCDM tool will be very good if everybody can use it and populate it with data, but at the moment the working culture maybe is not at the level required.

A shipping agent from a Nordic port testbed referred to the fact that PortCDM is more user friendly than the European maritime single window environment. Along the same lines, a person working as a stevedore in Vaasa port said that they liked the fact that “Anytime and anywhere you can view and update the information”, and added that “the app is very useful in the field, as it is easier to use and a good complement to marine traffic and email”.

A person working for a mooring company in Stavanger said that “I have been positive to it (PortCDM), and I think it comes at the right time. Everyone has to start using it I think. It has been interesting to be a part of it”. While a pilot in the same port explained: “I think it is good. I
don’t know that much how it worked for the others. But it is good that you can go in on the mobile application to see if, for example, the mooring personnel have finished their work or not”.

Another actor working as operations coordinator in a security company in Stavanger said that they liked the fact that PortCDM includes estimates of deliveries, for example, sludge deliveries - something that they considered to be very useful.

At the same time, some of the actors expressed concerns, for example, a tugboat operator in Stavanger believed that the tool can be useful but had doubts if PortCDM can reduce the lay time since there are a lot of other factors that have an effect. Some actors believed that the system may not be fit for their needs; for example, some commented on the complexity of the system in relation to their specific port characteristics.

A shipping agent from Gothenburg that expressed a positive opinion for the tool, added that they consider it useful, but always followed up with a phone call as there are some underlying factors that currently are not displayed in the system such as shift changes in the terminal which have an effect on the estimates provided from the personnel in the terminal.

Another shipping agent in Gothenburg port believed that it is a prerequisite for information sharing that everyone that has a need of information gets the information. The same actor said that the advantage of PortCDM is that you get closer integration with the port on the digital arena. More specifically they referred to the fact that “When we talked digitally with authorities, we do not get feedback on it. It may be incorrect or correct but we will not get feedback from them, so you don’t know if it’s correct or not. A larger accuracy is one of the offered benefits if many people can see the information and validate it when many people notice it”.

6.6.2 Benefits of a full-scale PortCDM implementation in the two testbeds

Very positive support was received for a future full-scale implementation of PortCDM by participants. Overwhelmingly positive benefits were identified by respondents to the questionnaires, interviews and in other elaborating comments that were received during the validation, including that PortCDM will:

- increase the efficiency, decrease costs and save emissions through just-in-time arrivals;
- provide better knowledge and broader image on what is happening within the port and to avoid delays;
- provide better access to information;
- provide an extra source of records - PortCDM can act as a log book of information, for example, for comparison purposes with the PCS system especially when you are doing work such as preparing invoices;
- gather all the information in one place. Information such as berth availability, mooring personnel progress, tug availability, and suchlike;
- avoid duplicated information and create a better communication basis for all actors involved in a port call in order that everyone involved has the same information to plan on;
- reduce volume of emails and daily telephone communication, to allocate less time in chasing information and to minimise administrative burden;
- facilitate real-time reporting;
- enable real-time situational awareness with reliable data in order to plan operations;
- reduce interaction among the actors, for example, unnecessary phone calls to other actors (for example, pilots, traffic control, and suchlike) for requesting update on port call status;
- provide the basis for data transparency, which is essential for fair play among the port actors;
- reduce delays for the terminals; and
- allow the use of contemporary and readily available data devices such as smartphones and tablets.

In relation to quantifiable benefits that could be achieved by enabling timestamp consumption within a port (in a future PortCDM full scale scenario), PortCDM validation participants from all ports referred mainly to the following benefits:

- Faster ship turnaround
- Better utilisation of berth
- Increased berth productivity
- Improvement of waiting times
- Less number of ships that wait /are idle off port
- Days saved for a ship waiting in the anchorage area
- Scheduling optimisation
- Improvement of berth capacity
- Optimisation of average time for providing service to a ship
- Improvement of predictability and resource planning
- Improvement of scheduling capacity

6.6.3 Quantifiable benefits

In the Nordic testbed, port participants declared that they see various possible benefits when a full scale scenario of PortCDM takes place in their port. A VTS operator in Stavanger said that the main benefit from such a scenario will be that they could see easily to which berth a ship is heading - something that means time optimisation, automation of the processes, better coordination among the actors and better visibility of other actors readiness for accepting a ship especially in confined areas with increased traffic events. Thus, through PortCDM the risk of ships blocking the port area (due to the fact of not having an available berth to go) could be minimised.

A port officer working in Stavanger referred to the fact that in such a scenario you could be running your operations more efficiently as people will not have to wait for the information that is going to be in one place. It would be more cost effective for the port and its actors.

According to another actor working for a security company in Stavanger, the potential benefits from a full scale PortCDM deployment can be better access to accurate information - something that is essential for better planning as well as more efficient operations. They provided the following example: *For instance today you have information that a sludge truck will arrive so we need to have one dedicated person waiting for the truck to arrive. With the service you can have an estimate of when the truck will arrive and send a person to meet them at that time*.

A shipping agent said that *“Now in shipping there are many statistics services easily available. Loading and discharging operations, that’s where the problems come, at the berth, thus there is bigger need for this”*. 
A PortCDM validation participant working for an oil terminal in Gothenburg commented: “I would be in a position to see if we have a ship bound for our terminal that goes to another terminal before, this way we can keep up to date in a better way when they come to us afterwards. I see that as the biggest advantage in Gothenburg. At our port in Brofjorden I would say Port-to-Port, to get much better updates and a more holistic view of the ships and the port calls, both way, as there is short notice and travel distance between the ports”.

A berth planner working in Umea said that if such a scenario takes place in the future “The number of phone calls between me and the ship agent, and me and the ship [would be reduced]. I would be able to remove basically all phone calls and [still have] a real-time overview of the status of the ships and also the ships would get a better overview when they ordered services and when they are planned. Also our moorers [would] get a better overview of the other actors”.

Additional statements of the potential benefits provided through the interviews were:

“Better and more transparent port call planning and everything that relates with this kind of planning, such as bunkering, crew exchanges, deliveries and coordination before ship arrival”

“Better predictability as the PortCDM use has also an effect on future voyages, for example, next destination port”

“Reduction of the administrative burden. For example, you would not have to call about everything, such as five different actors to find out one time stamp”

“Shorten the lay time to make it more efficient. If all actors understood why it is important with updates then money could be saved in many steps”

In the Mediterranean testbed participants’ responded that a PortCDM full scale development can bring the following benefits:

“It can reduce administrative burden and interaction among the actors, for example, unnecessary phone calls to other actors (pilots, traffic control, and suchlike) for requesting update on port call status”.

“It can provide the basis for data transparency, which is essential for fair play among the port actors. Currently some actors are sheltered on the lack of data transparency to cheat and get priority over others (normally big players which can influence decisions on terminals because of their high turnaround)”. According to a PortCDM validation participant, this is eventually translated into a higher ship fuel consumption (a kind of ‘black steaming’) since ships compete to get first to the port and go to the berth

“Improved and more efficient planning can be succeeded as port actors such as berth planners, operations planners will have a priori the information through the system and they will be in place to make the appropriate changes on their planning due to the fact that the delays can be recognised more easily”.

“It can simplify the procedures since there is a single data access point for everyone”.

“It can enable real-time situational awareness with reliable data in order to plan operations”.

“The use of the service it can enable them to minimise their costs”.

“The ship owners can have multiple benefits such as cost savings due to less fuel consumption as a ship could avoid being idle off port but instead will be served and depart as soon as possible”.

“In the long run, PortCDM could even create more jobs in the shipping industry”.
“PortCDM can offer the actors better predictability of a shipping arrival time”.
“Better berth productivity can be succeeded”.
“Less service time and waiting times for a ship can be succeeded as well”.
“Improvement of staff organisation”.
“Better situational awareness”.
“Better real-time reporting”.
“Easier access to the information”.

An operations officer working for a terminal in Limassol submitted that: “optimisation of waiting times is essential in the shipping industry. As you may know, contracts – bilateral agreements are being signed among the ship-owners and the shippers/charterers where the ship-owner receives a fare for providing the shipper with a ship. On the other side, the shipper undertakes the mission of carrying / transporting safely and on time passengers, cargo or goods to their destination. Thus, as you understand, the accurate time of delivery is an essential part not only for us the terminal operators but also for the shipping companies in order to avoid braking agreements / and paying fines to the ship-owners. Thus any tool that can help towards this direction is more than welcome.”

Additional comments were provided relating specifically to particular port characteristics or location, such as in the case of Limassol, where it was commented that PortCDM is needed in order to enable port to port communication and collaboration with all the nearby ports of the Middle East. This way you will get informed immediately when something goes wrong, for example, strike, accidents, bad weather conditions, delays in serving the ship, and suchlike.

Despite the overwhelming majority of positive support for PortCDM, there were a few different views. For example, a tugboat operator working for a marine services company in Stavanger said that PortCDM is not needed in their port. According to this actor “PortCDM is better in a port where the port itself operates the towage and in my opinion is not needed in the our port since we have that kind of changes that we need to have direct contact via phone or email in order to coordinate. Where the terminal governs and determines which ship that needs a tug boat it would be easier.”

As indicated earlier in this report (see paragraph 5.4.3), a small number of participants were hesitant to share some data on the basis that it might provide a commercial advantage.

6.6.4 Shortcomings and areas of improvement for the PortCDM testbed

According to the feedback received, several improvements to the PORTCDM validation testbed would be beneficial, such as a user-friendlier interface. Several comments and suggestions were made:

“It is a bit complex system that probably works well in ports where there is no such complexity. A port that, for example, there are not some many changes as there are in the big ports such as for example the Gothenburg port.”

“If you have not a connector to it you have an extra system to update.”

“The mobile application needs to be customised in different languages in order to be functional.”
“That it was very open which is fine during the test period, but should everyone use this, the market will certainly want to get a closer look at what is being shared.”

“Interface could be improved in terms of better user friendliness, for example, the important points could be trimmed so that they leave relevant times for arrivals, lay times and departures. Regarding this point additionally some actors referred to the comment fields in the app that could be more visible in order to increase the trust in the app. Also the sorting of the dates could be shown differently and the time notifications could be a bit clearer.”

“The way of searching and finding ships must be improved. For example, a PortCDM validation participant reported that he had problems - difficulties of finding the correct ship or the availability of a specific berth and that he experienced problems also with the overall usability of the system. Regarding the ship timeline visibility, a PortCDM validation participant asked for timestamps to be displayed on the timeline.”

“Another interesting point provided from the answers, is the better grouping and dividing of berths meaning the possibility to group/sort the berths based on the area or type. Similarly to this, another actor asked for a functionality that will display to the users the time of when a berth becomes available in order to avoid calling the terminals.”

“Improve stability and usability. According to some actors the service was not stable, for example, mobile app crashes and furthermore that it needs further development in order to facilitate the data reporting.”

“It works well only if every actor involved in the process provides input to the platform otherwise its value gets limited and moreover estimations are needed and must be included (except from the real-time information).”

“The reliability of the platform should be improved and moreover it must provide the functionality to the users to customise locally notifications.”

“Better information control of the system is needed as some of the actors believe that if someone that has access to the system enters a wrong timestamp it can create confusion to the rest that will access this information.”

“To provide the users with the functionality to customise notifications locally.”

“To include information such as preferred destination berth and alternative destination berths for port calls, so that this data provides basis for better berth optimisation by the port managers, terminals, and suchlike.”

An IT manager in the Stavanger port suggested that PortCDM should be enabled in a "live" situational picture through a single window "hub", which will have all the port call stakeholders integrated (preferably machine-to-machine). Such a "hub" should be able to provide a green, yellow and red light to the stakeholders own systems or produce alarms. If a state is red or yellow, actions may have to be taken depending upon upper/lower control limits set for each actor/state (matrix).

### 6.7 Questions related to the living labs process

The questionnaires and interviews contained several questions related to the living labs process that was used during the validation. This sub-section includes the results.
In addition to the results shown here, Annex D contains a synopsis of the feedback and opinions on the living labs process.

### 6.7.1 Living lab participation rate
95% of those that provided feedback (either through the interviews or through the online questionnaire) participated at least once in the living labs meeting that were organised in their respective ports. This was broken down into:

- 97% of those interviewed participated in the living labs meetings
- 81% of the respondents to the online questionnaire participated in the living labs meetings

### 6.7.2 Importance of the living lab meetings
73% of those that participated in the living labs meetings answered that they were more than satisfied (score 4 out of 5); while 13% of the respondents that participated answered that they were very satisfied (score 5 out of 5) and an equal percentage of 13% said that are satisfied (score 3 out of 5).

![Figure 50 Value of the living lab meetings](image)

### 6.7.3 Living labs meetings encouraged first contact with other port actors
70% of those that participated in the living labs meetings answered that they had started talking to actors that they did not know before, while 20% answered no and 10% responded that were not sure about this issue.

![Figure 51 Working with actors previously not contacted](image)

### 6.7.4 Collaboration with previously uncontacted actors
40% of the participants answered that, as a result of the living labs meetings, they had started collaborating with actors previously not contacted, while 46% answered that they did not. 13% were not sure on this issue.
The key areas of collaboration for those that did collaborate, were:

- Related to the PortCDM concept
- Better communication and better understanding of other actors’ work
- Started using some of other actors techniques
- Getting a better understanding of each actor’s needs and their possibility to contribute with time-stamp information
- Disclosing the need of more machine-to-machine integrations, that are still not in place

### 6.7.5 Collaboration enhancing operations

Of those that answered the question on whether the collaboration achieved through the living labs meetings enhanced their own operations, 66% answered Yes, 33% answered negatively. One of the actors that answered positively provided the reason as being that they and their company got a better view and focus on bottlenecks and discovered causes of delay to different operations in a port call. However, many participants choose to skip the question on whether the collaboration achieved through PortCDM enhanced their own operations.

### 6.7.6 New knowledge of other actors’ operations gained by participating in the living labs meetings

Most of the participants choose to skip the question on whether they gained new knowledge/information of other actors’ operations through participation in the living labs meetings. However, all those that answered the question answered it affirmatively.

### 6.7.7 Importance of new knowledge/information gained through living labs meetings on existing port operations?

Everyone that answered the question on whether any new knowledge and information gained as a result of the living labs process was important for their port operations answered affirmatively. A PortCDM validation participant from Stavanger commented in this question. “As an IT manager I have seen that the engagement in both our own and outside organisations have increased, mainly from the actors who have participated in the living labs. There is still a
need to convince the management of the companies as they may not see the benefits, which is crucial if PortCDM and STM is going to have a future in the Port of Stavanger and the region.” However, similarly to the previous two questions, many of the participants choose not to provide an answer.

6.8 Challenges in providing Recommended Time of Arrival to ships that have shared their planned time of arrival to a port

Within the scope of the project, trials to encourage the declaration by ports of a recommended time of arrival (RTA) were attempted. This was found to be difficult to achieve because many of the ports involved seemed reluctant to commit to when they would serve a particular ship, given that most ports currently follow the practice characterised by “first come – first served”.

The following five use cases describe different situations related to ETA and RTA that occurred during the PortCDM validation. They are based on examples of the collaborative decision making process that was operating during the PortCDM validation in which Port Control (as facilitator), involved ship agents, involved terminal operators, the local living lab facilitator, and the STM Shore centre, (involved people from Shore Centre) gathered. It provides some insights in to the challenges of issuing RTA’s. The process that was followed is captured in the figure below.

Figure 54 Collaborative process adopted for providing recommended time of arrival to the ship

6.8.1 Use Case 1 – congestions at berth and change of berth

A motor tanker shared its route to the PortCDM instance in Gothenburg via its ECDIS by sending a Planned Time of Arrival (PTA) to Traffic Area as 2053 on 20 August. This was done on 19 August at 0819.

The living lab coordinator was informed on 20 August at 1253 from the STM shore centre that the ship had shared its route.
The ship was first planned to berth at berth 511, which is one of several berths in Gothenburg that are operated by different competing terminals using the same infrastructure, and where a first come - first served rule is applied. The ship had a first ETA to berth 511 on 21 August at 1200, and the Estimate of Arrival to the Traffic Area was 21 August at 1030.

Following the process, brought forward in figure 20 and jointly agreed during living lab meetings, the living lab coordinator informed Port Control, the ship agent responsible for the port call and the terminal to discuss if an RTA could be sent to the ship.

In this case the actors involved concluded that it was not possible to send an RTA to the ship since the berth the ship was bound for was one of the berths where several competing resources share the same infrastructure, the berth was already occupied by another ship, other ships were waiting at anchorage for the same berth and other ships bound for that berth were also on their way with similar arrival times as the ship. The actors also advised that the berth plan was not confirmed yet and there might be changes concerning which berth it would eventually use. Furthermore, the actors were not sure what would happen if an RTA was announced to Traffic Area and the ship accepted that time but then arrived later than the other ships with similar ETAs to Traffic Area.

After it was determined that an RTA could not be sent to the ship the actors involved sent an email with feedback to the ship indicating that its PTA had been received and provided some explanation of why that did not result in it receiving an RTA. The following email was sent to the ship via the ship agent:

Good day Captain,

Thank you for sharing your Planned Time of Arrival (PTA) through your ECDIS system with Port of Gothenburg and its actors which was well received.

In this case the involved actors in the port couldn’t respond with a Recommended Time of Arrival (RTA) due to congestions at berth and change of berth after your arrival to Gothenburg Anchorage Area

Best Regards

STM testbed Gothenburg

It also turned out that after the ship arrived at the Traffic Area on 21 August at 0320 and then arrived at Anchorage Area B at 0400 on the same day an update was made at 0944 that morning providing a new ETA, now for berth 521 at 00.01 on 23 August instead of berth 511.

6.8.2 Use Case 2 – competing terminals sharing the same infrastructure

A motor tanker shared its route to the PortCDM instance in Port of Gothenburg via its ECDIS by sending a PTA to Traffic Area for 0517 on 22 August. This was made on 20 August at 1441. The living lab coordinator was informed on 20 August at 1426 from STM shore centre that the ship had shared its route.

The ship was first planned to berth at berth 511, which is one of several berths in Port of Gothenburg that are operated by different competing terminals using the same infrastructure, and where a first come first served rule is applied. The ship had a first ETA to berth 511 on 21 August at 1801, and the ETA to the Traffic Area was 21 August at 1631.

At 1543 on 20 August a new estimate for Arrival Ship Berth was shared with an updated time on 22 at 0500 and a new estimate to Arrival Ship Traffic Area was also declared for 22 August
at 0330. At the same time as those times were updated a new updated PTA was sent from the ship with a new time for Arrival Ship Traffic Area as 22 August at 0701.

Later that afternoon the ship shared a new PTA for Arrival Ship Traffic Area as 22 August at 0619. After that a new estimate for Arrival Ship Traffic Area was updated by the port as 21 August at 1631 and also the port updated a new estimate for Arrival Ship Berth, berth 511 as being 21 August at 1801.

At 1845 on 20 August an ETA at Ship Anchorage Area was also added for Anchorage Area B as 21 August at 1800 and the estimate for Arrival Ship Berth for berth 511 was updated to 24 August at 0600 by the Port.

On 21 August at 1110 the estimate for Arrival Ship Traffic Area was updated to 22 August at 0430 by the Port and the estimate for Arrival Ship Anchorage Area for Anchorage Area B was updated to 22 August at 0600 at the same time.

The berth was also changed on 21 August at 1228 to Berth 510 instead of berth 511 and the new estimate was given for berth 510 as 25 August at 0100.

Following the process, shown in figure 53 and jointly agreed during living lab meetings, the living lab coordinator informed port control, the ship agent responsible for the port call and the terminal to discuss if an RTA could be sent to the ship.

In this case there had been several changes in the PTA, ETA to Traffic Area and berth and Anchorage area and changes of berths. Both berths 511 and 510 are berths where several competing terminals sharing the same infrastructure. In the circumstances it was hard to provide an RTA to the ship. There were other ships already at berth, ships at anchor waiting for available berths and ships on their way also bound for the berths. The planned berth 511 was also changed to berth 510 but that was also a berth with shared infrastructure. Since the berth planning was not confirmed yet from the production planners in the port the actors thought it was too uncertain to send an RTA to the ship. Nevertheless, they wanted to inform the ship that they had received the times from the ship, so the actors involved agreed to send an email to the ship via the Ship Agent. The following email was sent:

Good day Captain,

Thank you for sharing your Planned Time of Arrival (PTA) through your ECDIS system with Port of Gothenburg and its actors which was well received.

In this case the involved actors in the port couldn’t respond with a Recommended Time of Arrival (RTA) due to congestions at berth and due to planning not confirmed yet?

Best Regards

STM testbed Gothenburg

6.8.3 Use Case 3 – late sharing of planned time of arrival

A motor ship shared her route to the PortCDM instance in the Port of Gothenburg via its ECDIS by sending a PTA to Traffic Area as 1200 on 27 August. This was done on 27 August at 1011.

The living lab coordinator was informed on 27 August at 0925 from STM shore centre that the ship had shared its route with them. It then took 46 minutes before the ship shared its PTA with the Port by which time the ship was only 1 hour and 49 minutes away from the Traffic Area, which was too short time period to send an RTA to the ship.
The living lab coordinator asked STM Shore Centre to respond back to the ship with the following message:

*Good Morning Captain,*  
*Thank you for sharing your Planned Time of Arrival (PTA) through your ECDIS system with Port of Gothenburg and its actors which was well received.*  
*Best Regards*  
*STM testbed Gothenburg*

**6.8.4 Use Case 4 – An RTA was sent from the port but in the end the port could not meet the expectations**

A motor tanker shared its route to the PortCDM instance in Port of Gothenburg via its ECDIS by sending a PTA to Traffic Area for 17.09 on 20 October.

The living lab coordinator was informed on 18 October at 0856 from STM shore centre that the ship had shared its route. According to the port the PTA was shared at 1607 on 18 October.

The Estimated time of Arrival to berth for berth 519 was 19 October at 1200 and it was shared from the port on 16 October at 1326. At 1348 on the same day an Estimate for Arrival Ship Traffic Area of 19 October at 1030 was also shared.

The ship continued to update PortCDM with PTA to Traffic Area as 1709 on 20 October during the evening of 16 until the morning of 17 October. At 1012 on 17 October an updated Estimate of Arrival Ship Berth 519 for 20 October at 2100 was received from the port and one hour and 40 minutes later the Arrival Ship Traffic Area was also updated by the port as 1930 on 20 October.

On 18 October at 0256 a new PTA was sent from the ship with Arrival Ship Traffic Area as 1709 on 20 October, which it continued to send during 18 October.

An Estimate of Arrival Ship Berth 519 for 20 October at 1700 was shared from the port at 1509 on 18 October and at 1854 later that day the estimate was once again updated by the port to 20 October at 0930 for Arrival Ship Berth, which in the morning the 19 October at 0906 was updated to 20 October at 1500.

Port Control requested a teleconference meeting in accordance with the process brought forward and jointly agreed during living lab meetings which can be seen in figure 53. When no response was received regarding the meeting times Port Control called each actor individually to check if an RTA could be sent and if everything was well coordinated.

Port Control decided together with the involved actors to reply to the ship with an RTA. According to the planning the ship would have the possibility to berth on arrival, but since two other ships were already in a queue waiting for the berth and it was undesirable to require the ship to increase its speed too much and waste fuel, it was decided to send an RTA for Arrival Ship Traffic Area as 20 October at 1500. This was sent from port control at 1406 on 19 October. The RTA was also communicated via an Email to the ship.

On 20 October at 0324 a new PTA was received from the ship with Arrival Ship Traffic Area as 20 October at 1709 and at 1446 on 20 October an Actual Arrival Ship Traffic Area was received from the PortCDM AIS and at 1904 the same day an Actual Arrival Ship Berth 519 of 20 October at 1900 was received from the PortCDM AIS connector.
In this case the ship was bound for a berth which is only operated by two terminals and the berth planning was confirmed from the terminals. The port actors agreed that it would be suitable to send out an RTA to the ship. The ship did not accept the RTA but it seems likely that it adjusted its speed to make the RTA and arrived 14 minutes before the RTA time. Unluckily the ship still had to wait for the berth for a couple of hours due to another ship that had not yet departure.

6.9 A use case on possibilities with port-to-port collaboration

During the autumn of 2017, a PortCDM instance was set up for the Port of Brofjorden using three automatic connectors that had been developed within the project - the Maritime Single Window connector, the Swedish Pilotage connector and the PortCDM AIS connector. This was done without any living lab meetings or other meetings with the actors in Brofjorden. Several of the living lab actors in Gothenburg had been talking about Gothenburg and Brofjorden as ports where there is quite a lot of traffic between them and the voyage is only about 4.5 hours pilot to pilot. This means that even a short delay in one of the ports will have an effect on the arrival time in the other port.

During October 13 2017, while the PortCDM instance and port-to-port service was being tested a tanker ship that was bound both for Brofjorden and Gothenburg received an Actual Arrival Ship Berth notification from Brofjorden for December 12 at 1122 and the departure time was estimated 13 October at 0400. The relevant statement log and time line from one of the PortCDM front end applications is shown below.

Meanwhile on 12 October the Gothenburg the terminal that was going to handle the port call was waiting for the ship. The information held by Gothenburg was that the ship had an estimate of arriving to berth as 12 October at 1200. That information was three days old, as indicated in
the screenshot shown below. In the absence of any updated information Gothenburg looked at Marine Traffic to see where the ship was and discovered that it was in Brofjorden.

Figure 57 Statement log for arrival and departure vessel berth in Port of Gothenburg

Figure 58 Port call timeline for the port call in Port of Gothenburg

Given that the terminal in Gothenburg has good relationships with the terminal in Brofjorden it was simplest to call and ask when the ship was expected to leave, which was given as 0400 the 13 October.

Because Gothenburg was unaware of the latest information regarding the timetable for the ship, original plans remained in place. In the circumstances it may have been possible to take another ship in before. Preparations at the wharf could also be affected if another ship takes up the planned berth but with a different cargo.

This situation could have been avoided using the Port to Port module, since the PortCDM in Brofjorden would have been sent information to PortCDM Gothenburg that they had a ship bound for Gothenburg that had an ETD from Brofjorden of 13 October at 0400.

PortCDM in Gothenburg would then have monitored the information on PortCDM regarding the departure time from Brofjorden, both estimates and actuals and would have subsequently received information that the ship was not going to leave Brofjorden until 16 hours later then the originally promulgated ETA to berth in Gothenburg. This information would have been receiving as soon as the port call was created in PortCDM Brofjorden and in Gothenburg, thereby creating better situational awareness for planning the port calls.
Validation results from the Quantitative Analysis

7.1 Introduction

The purpose of this chapter is to present and analyse in an aggregated fashion the validation results from the different PortCDM implementations at the various ports that participated in the PortCDM testbeds from a quantitative perspective. The total number of port calls and port call messages captured during the validation period are as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of port calls</td>
<td>43976</td>
</tr>
<tr>
<td>Total number of port call messages</td>
<td>1 696 115</td>
</tr>
</tbody>
</table>

A port call includes the arrival/departure process of a specific vessel to/from the port, while a port call message is the piece of information sent concerning this process. So a port call can have tens or even hundreds of port call messages associated with it depending on how much information is actually exchanged during a particular port call. Also, PortCDM demonstrators did not differentiate between different vessel types, so a port call can be about any type of vessel that visited the particular ports. Finally, all reported statistics come from the log of messages recorded at the various PortCDM demonstrators and refer to the whole period when the PortCDM demonstrators have been active at the various ports, not just the focus month periods. It is also worth pointing out that the reported data are not compared against a baseline, because no such data existed before implementing the PortCDM demonstrators (see paragraph 5.5 for a relevant discussion).

In what follows, the port calls are first analysed with respect to the vessel type and the port of origin. Next, the port call messages are analysed with respect to the port of origin, the state type, and the time type (AT or ET). Following the statistical analysis, we then present the results from KPI calculations on turnaround time (duration time) and predictability. More specifically, we first calculate the average duration time at berth and inside the port area for different types of vessels. Next, we present some results on predictability concerning the four most important states of a port call: Arrival/Departure Traffic Area and Arrival/Departure Berth. Finally, we also present the results of the predictability analysis on STM Routes and Targeted Time of Arrival.

7.2 Statistical analysis of Port Calls

7.2.1 Port Calls by port

![Figure 59: The distribution of port calls per port participating in the PortCDM testbeds](image-url)
Figure 59 on the previous page shows the number of port calls captured at each port during the validation period. Most of them, as expected, were captured in Gothenburg (16,581) followed by Stavanger (12,009), Valencia (6,378), Barcelona (3,741) and Limassol (2,011). Smaller numbers were captured in the remaining ports as shown in the figure.

7.2.2 Port calls by vessel type

Figure 60 The distribution of port calls among different types of vessels

Figure 60 shows the number of port calls captured during the validation period with respect to the vessel type. Most of them involve ro-ro (13,407), followed by bulk carriers (9,206), tankers (7,943), container (13,407), offshore (2,829) and passenger (1,756). The remaining 2,334 port calls can be attributed to other types of vessels.

7.2.3 Analysis of port calls by port and vessel type

The following table shows the analysis of the number of port calls per port and ship type, highlighting the differences in implementation between the various port instances.

<table>
<thead>
<tr>
<th></th>
<th>BULK CARRIER</th>
<th>CONTAINER</th>
<th>OFFSHORE</th>
<th>OTHER</th>
<th>PASSENGER</th>
<th>RO-RO</th>
<th>TANKER</th>
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</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>268</td>
<td>754</td>
<td>5</td>
<td>173</td>
<td>406</td>
<td>1379</td>
<td>279</td>
</tr>
<tr>
<td>Brofjorden</td>
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<td></td>
<td>19</td>
<td>4</td>
<td>94</td>
<td>7394</td>
<td>5546</td>
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<tr>
<td>Gothenburg</td>
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<td>1353</td>
<td>6</td>
<td>265</td>
<td>94</td>
<td>7394</td>
<td>5546</td>
</tr>
<tr>
<td>Limassol</td>
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<td>314</td>
<td>281</td>
<td>72</td>
<td>190</td>
<td>279</td>
</tr>
<tr>
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<td>13</td>
<td></td>
<td>356</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Stavanger</td>
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<td>2304</td>
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<td>377</td>
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<td>526</td>
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<td>7</td>
<td>219</td>
<td>107</td>
<td></td>
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<td></td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Valencia</td>
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<td>2946</td>
<td>157</td>
<td>62</td>
<td>269</td>
<td>2116</td>
<td>220</td>
</tr>
</tbody>
</table>

Figure 61 The distribution of amount of port calls in the PortCDM testbeds
7.3 Statistical analysis of Port Call Messages (PCMs)

7.3.1 PCMs by port

Figure 62 shows the number of port call messages captured at each port during the validation period. Most of them, as expected, were captured in Gothenburg (704204) and Valencia (449025), followed by Stavanger (178083), Barcelona (134831), Brofjorden (74324), Limassol (66788) and Sagunto (65456). Smaller numbers were captured in the remaining ports as shown in the figure.

7.3.2 Analysis of PCMs by time type

The following pie chart provides an analysis of port call messages (PCMs) by time type. As seen on the chart, 53% of the received PCMs were Actual Times (AT), 42% were Estimated Times (ET) and the remaining 5% were Target Times (TT).
### 7.3.3 Analysis of PCMs by state and time type

The bar graph below shows the analysis of the number of port calls for all ports by state and time type. As expected, the predominant states captured by the Port Call Messages are Arrival_Vessel_Berth, Departure_Vessel_Berth, Arrival_Vessel_TrafficArea and Departure_Vessel_Traffic_Area.

![Bar Graph](image)

**Figure 64 The distribution of port call message over states and time types**
### 7.3.4 Analysis of PCMs by state, time type and port

The table below shows the analysis of the number of ATs per state and port. The number of ETs is also provided inside a parenthesis for each entry.

<table>
<thead>
<tr>
<th>State</th>
<th>Limassol</th>
<th>Barcelona</th>
<th>Sagunto</th>
<th>Valencia</th>
<th>Vasa</th>
<th>Stavanger</th>
<th>Brofjorden</th>
<th>Gothenburg</th>
<th>Umeå</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival_Agent_Berth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_EscortTug_Vessel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Moorers_Berth</td>
<td>76 (19)</td>
<td>21492 (0)</td>
<td></td>
<td>84 (27)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Pilot_Berth</td>
<td>1 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Pilot_Vessel</td>
<td>96 (2)</td>
<td>4293 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_PilotBoat_PilotBA</td>
<td>11 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_PilotBoat_Vessel</td>
<td>4148 (0)</td>
<td>4 (0)</td>
<td>44 (0)</td>
<td>11730 (0)</td>
<td>271 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Pontoon_and_Fenders_Berth</td>
<td>20 (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Security_Berth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Tug_Berth</td>
<td>6 (0)</td>
<td>2886 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Tug_HomeBase</td>
<td>12 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Tug_LOC</td>
<td>9302 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Tug_TugZone</td>
<td>0 (1)</td>
<td>4470 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Tug_Vessel</td>
<td>6 (0)</td>
<td>4604 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Vessel_AnchorageArea</td>
<td>6366 (246)</td>
<td>2170 (0)</td>
<td>19 (9)</td>
<td>77 (6)</td>
<td>6 (0)</td>
<td>2673 (439)</td>
<td>1261 (485)</td>
<td>10480 (5145)</td>
<td>6 (11)</td>
</tr>
<tr>
<td>Arrival_Vessel_Berth</td>
<td>2170 (499)</td>
<td>12330 (0)</td>
<td>4579 (3)</td>
<td>21213 (6179)</td>
<td>449 (84)</td>
<td>53712 (3562)</td>
<td>4327 (4928)</td>
<td>80566 (89114)</td>
<td>2810 (1530)</td>
</tr>
<tr>
<td>Arrival_Vessel_LOC</td>
<td>1924 (0)</td>
<td>2896 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Vessel_PilotBA</td>
<td>1934 (921)</td>
<td>14 (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Vessel_PortArea</td>
<td>685 (309)</td>
<td>2899 (0)</td>
<td>3736 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrival_Vessel_TrafficArea</td>
<td>6026 (8103)</td>
<td>5340 (0)</td>
<td>52 (6571)</td>
<td>4698 (2878)</td>
<td>615 (16)</td>
<td>23752 (1129)</td>
<td>2056 (0)</td>
<td>30953 (2761)</td>
<td>853 (0)</td>
</tr>
<tr>
<td>Arrival_Vessel_TugZone</td>
<td>0 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure_Agent_Berth</td>
<td>42 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure_EscortTug_Vessel</td>
<td>3 (2)</td>
<td>911 (0)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure_Moorers_Berth</td>
<td>48 (23)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.3.5 State/Coverage Analysis: Number of critical states reported

The results show that a set of 31 out of 36 different critical states were reported overall during both focus months. The figure below discriminates the number of critical states used by each port at each focus month.

Figure 66 State/coverage analysis: Number of critical states reported
In general, there are no big differences in terms of the number of states reported between each focus month. The big differences are more qualitative than quantitative and correspond to new automatic connectors providing a higher degree of report automation, different degrees of port actors’ collaboration (maybe reducing/increasing the reporting of some estates manually) or some misreporting due to data quality issues.

The specific states reported at each port are shown in the table below.

![Table of states reported at each port]

<table>
<thead>
<tr>
<th>Time Type</th>
<th>Estate Name</th>
<th>Gothenburg</th>
<th>Stavanger</th>
<th>Umeå</th>
<th>Vasa</th>
<th>Limassol</th>
<th>Valencia</th>
<th>Sagunto</th>
<th>Barcelona</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Anchoing_Completed</td>
<td>1 1 1 1 1</td>
<td>1 1 1</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Anchoing_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td>0 1</td>
<td>1 1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Arrival_Pilot_Vessel</td>
<td>1 1 1 1 1 1 1 1</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Arrival_Vessel_Berth</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Arrival_Vessel_Berth</td>
<td>1 1 1 1 1 1 1</td>
<td>1 1</td>
<td>1 1</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Arrival_Vessel_TrafficArea</td>
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<td>1 1 1 1 1</td>
<td>0 1 1 1</td>
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<td></td>
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<td></td>
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<td>1 1 1 1 1</td>
<td>1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>CargoOp_Completed</td>
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<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1</td>
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<td></td>
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</tr>
<tr>
<td>AT</td>
<td>CargoOp_Completed</td>
<td>1 1</td>
<td>1 1 1</td>
<td>1 1 1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>CargoOp_Completed</td>
<td>1 1</td>
<td>1 1 1</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Departure_Pilot_Vessel</td>
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<td>1 1 1 1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>1 1 1 1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Departure_Vessel_Berth</td>
<td>1 1 1 1</td>
<td>1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Departure_Vessel_TrafficArea</td>
<td>1 1 1 1 1 1 1</td>
<td>1 1 1 1</td>
<td>0 1 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Departure_Vessel_TrafficArea</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>MooringOp_Completed</td>
<td>1 1 1 1 1</td>
<td>1 1 0 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>MooringOp_Completed</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 0 1</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Pilotage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1 1 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Pilotage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AT</td>
<td>Pilotage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1 1 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Pilotage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>Towage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>Towage_Completed</td>
<td>1 1</td>
<td>1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>UnmooringOp_Completed</td>
<td>1 1 1 1 1</td>
<td>1 1 0 1</td>
<td>1</td>
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<tr>
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<td>1 1 1 1 1 1 1 1</td>
<td>1 1 0 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| TOTAL      | 27 | 23 | 15 | 21 | 17 | 20 | 20 | 10 | 18 | 22 | 20 |

Figure 67 The distribution each particular critical state in relation to participating ports

7.4 Turnaround, Time at Berth and Operating Time by ship type

The graph and table overleaf include the average duration times for the different ship types. Three different duration times have been calculated: (i) Total turnaround time (TTT), (ii) Time at berth and (iii) Time doing cargo operations. Note that % at Berth = Time at Berth / TTT x 100, while % Operating = Time doing cargo operations / TTT x 100.
Figure 68 Distribution of % time at Berth and % time doing operations by ship type

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number of Port Calls</th>
<th>Average Turnaround Time</th>
<th>Total Port Calls for Turnaround</th>
<th>Average Time at Berth</th>
<th>Total Port Calls at Berth</th>
<th>Average Operating Time</th>
<th>Total Port Calls for Operating</th>
<th>Percentage (%) at Berth</th>
<th>Total Port Calls for % at Berth</th>
<th>Percentage (%) Operating</th>
<th>Total Port Calls for % Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTAINER</td>
<td>6501</td>
<td>23:20</td>
<td>3621</td>
<td>21:36</td>
<td>4303</td>
<td>12:55</td>
<td>2484</td>
<td>69.93%</td>
<td>2661</td>
<td>80.55%</td>
<td>80.23%</td>
</tr>
<tr>
<td>PASSENGER</td>
<td>1756</td>
<td>140:31</td>
<td>634</td>
<td>118:06</td>
<td>836</td>
<td>11:24</td>
<td>169</td>
<td>80.55%</td>
<td>603</td>
<td>57.60%</td>
<td>1056</td>
</tr>
<tr>
<td>BULK CARRIER</td>
<td>9206</td>
<td>80:38</td>
<td>1236</td>
<td>27:32</td>
<td>1940</td>
<td>14:35</td>
<td>755</td>
<td>71.07%</td>
<td>1064</td>
<td>50.05%</td>
<td>111</td>
</tr>
<tr>
<td>OFFSHORE</td>
<td>2829</td>
<td>101:45</td>
<td>1504</td>
<td>39:45</td>
<td>1617</td>
<td>15:05</td>
<td>166</td>
<td>64.71%</td>
<td>1455</td>
<td>41.90%</td>
<td>94</td>
</tr>
<tr>
<td>RO-RO</td>
<td>13407</td>
<td>22:09</td>
<td>8776</td>
<td>12:05</td>
<td>11487</td>
<td>8:49</td>
<td>2271</td>
<td>69.04%</td>
<td>8627</td>
<td>65.73%</td>
<td>958</td>
</tr>
<tr>
<td>TANKER</td>
<td>7843</td>
<td>58:30</td>
<td>4817</td>
<td>24:21</td>
<td>5421</td>
<td>17:32</td>
<td>126</td>
<td>60.78%</td>
<td>4534</td>
<td>52.74%</td>
<td>58</td>
</tr>
<tr>
<td>OTHER</td>
<td>2334</td>
<td>95:18</td>
<td>782</td>
<td>45:14</td>
<td>877</td>
<td>12:10</td>
<td>10</td>
<td>60.74%</td>
<td>695</td>
<td>50.86%</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>43976</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Figure 69 Distribution of turnaround time, time at berth, and operating time by ship type. For each calculated statistic, the number of port calls for which this calculation was possible is also provided in the next column.
For example, on average container ships in a harbour spent only 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. As shown in figures 68 and 69, turn around times for passenger ships and RoRo vessels were the most effective, with larger inefficiencies observed for bulk, offshore, tanker, container and other vessel types. For example, on average container ships in a harbour spent only 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.

7.5 Predictability

Predictability is the degree to which a correct prediction or forecast of a state can be made. In PortCDM, predictability is calculated based on the amount of minutes (date and time reported) that each estimate (target date and time) is made. The formula for a single estimate is as follows: $\text{PRED}_{\text{RAPP}} = 1 - \frac{\text{Deviation from actual}}{\text{Time before actual}}$

This allows for a higher deviation the longer (in time) the actual state change is; in other words, the longer from the actual state change that the report is made, the higher the deviation that is allowed for keeping a high rate of predictability. For a certain state the average was taken based on all reported estimates:

$$\text{PRED}_{\text{STATE}} = \text{AVERAGE}(\text{PRED}_{\text{RAPP}(1..n)})$$

For a port call the averages are taken based on the predictability of all states:

$$\text{PRED}_{\text{PORTCALL}} = \text{AVERAGE}(\text{PRED}_{\text{STATE}(1..n)})$$

For a particular time period the average of either states of port call is used to determine a port’s predictability. Figure 69 shows an example of calculating state predictability and overall predictability:

**State #1**

<table>
<thead>
<tr>
<th>Date reported</th>
<th>Time reported</th>
<th>Minutes before actual</th>
<th>Target date</th>
<th>Target Time</th>
<th>Deviation from actual</th>
<th>Type</th>
<th>Predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-12-15</td>
<td>10:00</td>
<td>1,680,00</td>
<td>15-12-16</td>
<td>13:50</td>
<td>10,00</td>
<td>Estimate</td>
<td>99,40%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>10:00</td>
<td>240,00</td>
<td>15-12-16</td>
<td>13:58</td>
<td>2,00</td>
<td>Estimate</td>
<td>99,17%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>12:00</td>
<td>120,00</td>
<td>15-12-16</td>
<td>13:55</td>
<td>5,00</td>
<td>Estimate</td>
<td>95,83%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>13:00</td>
<td>60,00</td>
<td>15-12-16</td>
<td>14:00</td>
<td>0,00</td>
<td>Estimate</td>
<td>100,00%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>14:00</td>
<td>0,00</td>
<td>15-12-16</td>
<td>14:00</td>
<td></td>
<td>Actual</td>
<td></td>
</tr>
</tbody>
</table>

State predictability: 98,60%

**State #2**

<table>
<thead>
<tr>
<th>Date reported</th>
<th>Time reported</th>
<th>Minutes before actual</th>
<th>Target date</th>
<th>Target Time</th>
<th>Deviation from actual</th>
<th>Type</th>
<th>Predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-12-15</td>
<td>12:00</td>
<td>1,740,00</td>
<td>15-12-16</td>
<td>15:25</td>
<td>95,00</td>
<td>Estimate</td>
<td>94,54%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>12:00</td>
<td>300,00</td>
<td>15-12-16</td>
<td>16:00</td>
<td>60,00</td>
<td>Estimate</td>
<td>80,00%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>13:00</td>
<td>240,00</td>
<td>15-12-16</td>
<td>16:30</td>
<td>30,00</td>
<td>Estimate</td>
<td>87,50%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>15:00</td>
<td>120,00</td>
<td>15-12-16</td>
<td>16:45</td>
<td>15,00</td>
<td>Estimate</td>
<td>87,50%</td>
</tr>
<tr>
<td>15-12-16</td>
<td>17:00</td>
<td>0,00</td>
<td></td>
<td></td>
<td></td>
<td>Actual</td>
<td></td>
</tr>
</tbody>
</table>

State predictability: 98,60%

Overall predictability: 87,39%

92,99%

Figure 70 Examples of Predictability Calculations

By calculating the predictability based on all the port call data it can be revealed that the predictability is getting lower further into the port call process. The predictability of the different states are detailed in the two diagrams below.
7.5.1 Arrival Traffic Area Predictability

This is a measure of how accurate are the Estimated Times in the system in predicting the actual arrival to the traffic area by a ship.

Formula used: 1 - [abs(ATA – ETA) / (ATA – Time ETA was Reported)]
The chart below displays the number of port calls in each predictability range.

**Figure 73 Arrival Traffic Area Predictability**

For port calls for which multiple ETAs were provided, the predictability was calculated for each ETA and then the average was taken for the whole port call. There were cases where more than ten ETAs were provided. As can be seen in the chart above most of the port calls for which calculation was possible had quite accurate predictions on the ETA.

### 7.5.2 Arrival Berth Predictability

This is how accurate are the Estimated Times in the system in predicting the actual arrival to berth for a ship.

Formula used: $1 - \frac{\text{abs(ATB – ETB)}}{\text{ATB – Time ETB was Reported}}$

The chart overleaf displays the number of port calls in each predictability range.
For port calls for which multiple ETBs were provided, the predictability was calculated for each ETB and then the average was taken for the whole port call. As seen in the chart above, three-quarters of the port calls for which calculation was possible had accurate predictions for the ETB.

Even though one might expect that a berthing time would be very accurate it seems that there were several cases of estimates being overrun. This most likely has to do with port congestion and organisation / resource issues at the port which make it hard to predict accurate berthing times.

### 7.5.3 Departure Berth Predictability

This is how accurate are the Estimated Times in the system in predicting the actual arrival to berth for a ship.

Formula used: $1 - \frac{\text{abs}(\text{ATUB} - \text{ETUB})}{\text{ATUB} - \text{Reported ETUB}}$

The chart below displays the number of port calls in each predictability range.
Figure 75 Departure Berth Predictability

For port calls for which multiple ETUBs where provided the predictability was calculated for each ETUB and then the average was taken for the whole port call. As can be seen in the chart above a little more than half of the port calls for which calculation was possible had accurate predictions for the ETUB.

The estimates for unberthing time seem less accurate than the estimates for berthing times. This most likely has to do with the difficulties of estimating with accuracy the time needed for completing all operations before departing from the berth.

7.5.4 Departure Traffic Area Predictability

This is how accurate are the estimated times in the system in predicting the actual departure from the traffic area by a ship.

Formula used: 1 - \( \frac{\text{abs(ATD – ETD)}}{\text{ATD – Time ETD was Reported}} \)

The chart below displays the number of port calls in each predictability range.

Figure 76 Departure Traffic Area Predictability
For port calls for which multiple ETDs were provided the predictability was calculated for each ETD and then the average was taken for the whole port call. As seen in the chart above, a little more than half of the port calls for which calculation was possible had accurate predictions for the ETD.

Not as many multiple ETDs were provided as was the case for ETAs. In most cases a single ETD was provided. Predicting the time of departure of a ship appeared to be of less importance for most actors, hence the lower reporting and consequential accuracy in predictability.

7.5.5 STM Routes Predictability

The histogram below shows how accurate the ETA is compared to the ATA in predicting the arrival time to the Traffic Area. The histogram shows the number of STM routes for each predictability range. Range is values rounded up to 1/10th. The analysis is based on 1,008 RTZ routes, sent between August and October 2018.

Formula used: 1 - [abs(ATA – ETA) / (ATA – Time ETA was Reported)]

Almost all STM routes were sent from cruise ships. This explains the very good predictability seen in the histogram. It is due to two separate factors, which together gives very good results. First, the fact that cruise ships are most often on time. Secondly, that they plan their routes and schedules well in advance. Both of which adds to the positive result shown in the analysis.

![Figure 77 STM Routes Predictability](image)

7.5.6 Predictability on targeted time of arrival derived from STM routes

The histogram below shows how accurate the targeted time of arrival (TTA) was compared to the actual time of arrival (ATA). The TTA has its origin in the STM routes that have been shared between the ship and the port.

Formula used: 1 - [abs(ATA – TTA) / (ATA – Time TTA was Reported)].

Analysis is based on 72 port calls with data for targeted time of arrival from ship to port route exchange between August and October 2018.
Targeted time of arrival predictability

Derived from STM Routes

Figure 78 Targeted Time of Arrival Predictability
### 8 Consideration of results and initial conclusions

#### 8.1 Validation of benefit hypotheses

In the table below, the benefit hypotheses identified in chapter 4 are considered in relation to whether they have been validated or not.

<table>
<thead>
<tr>
<th>Benefit hypotheses</th>
<th>Methods of validation / testing used</th>
<th>Conclusion</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Standardised data sharing improves the capital productivity of a port and the shipping companies using it by facilitating efficient resource utilisation</td>
<td>Qualitative Analysis</td>
<td>Supported</td>
</tr>
<tr>
<td>H2</td>
<td>Standardised reporting by key port actors of intended and completed actions improves coordination of the port call process</td>
<td>Qualitative and quantitative Analysis</td>
<td>Supported</td>
</tr>
<tr>
<td>H3</td>
<td>Establishing among key actors their self-interest benefits of data sharing will improve collaboration</td>
<td>Qualitative Analysis</td>
<td>Supported</td>
</tr>
<tr>
<td>Benefit hypotheses</td>
<td>Methods of validation / testing used</td>
<td>Conclusion</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>H4 The success of PortCDM is dependent on each actor sending and receiving relevant and timely data to enable all actors to coordinate their actions</td>
<td>Qualitative and quantitative Analysis</td>
<td>Supported</td>
<td>Key positive supporting results are those reported in chapter 6. It was that certain actors were share data, which reduces the intended effect. (see paragraphs 5.4.3, 6.5.7 and 6.6.3) See also comments for H2.</td>
</tr>
<tr>
<td>H5 A well-coordinated port call increases resource utilisation and reduces ship turnaround time by requiring timely and accurate standardised data sharing by key stakeholders of their intended and completed actions</td>
<td>Qualitative and quantitative Analysis</td>
<td>Supported</td>
<td>While the qualitative analysis shown in chapter 6 suggests that this hypothesis is proven to a large degree, the quantitative analysis is missing data of pre-PortCDM to be able to fully justify the support of it. However, due to that we have had several focus months in the test beds the analysis shows positive trends.</td>
</tr>
<tr>
<td>H6 The application of mechanisms for trust building among key actors within a port and across ports will increase the range of data shared and the speed with which it is shared</td>
<td>Qualitative Analysis</td>
<td>Partially supported</td>
<td>Besides direct comments in the qualitative analysis, comparing ports with less or more reluctant actors indicates this hypothesis to be supported, but a longer observation time with more quantitative data will be needed for full justification.</td>
</tr>
</tbody>
</table>
## 8.2 Validation of design principles

In the table below, the different design principles identified in chapter 4 are considered.

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Methods of validation / testing used</th>
<th>Result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P1</strong> Errors in predicting the timing of intended actions disrupts the planning of subsequent events of current port visits or future visits to other ports</td>
<td>Qualitative Analysis</td>
<td>Supported</td>
<td>This design principle was proven to be beneficial. Key positive conclusions are those reported in chapter 6.</td>
</tr>
<tr>
<td><strong>P2</strong> PortCDM must be configurable to fit the local circumstances and resources of each adopting port</td>
<td>Qualitative and quantitative Analysis</td>
<td>Supported</td>
<td>This design principle was supported both by remarks within given ports as well as comparing the qualitative results of the different ports. Comparing the quantitative analysis further supports the conclusion derived.</td>
</tr>
<tr>
<td><strong>P3</strong> Port performance can be continuously improved by collecting and analysing operational data for each port visit and acting upon such analyses</td>
<td>Quantitative Analysis</td>
<td>Not conclusively supported</td>
<td>Not enough data is available in the quantitative analysis to justify support for this design principle. Especially the lack of historical, pre-PortCDM, data doesn’t allow proper conclusion.</td>
</tr>
<tr>
<td><strong>P4</strong> A sustained success of PortCDM is dependent on a governance infrastructure that maintains the standard for data sharing within a port and identifies improved processes for enhancing port call productivity</td>
<td>Qualitative and quantitative Analysis</td>
<td>Not conclusively supported</td>
<td>Not enough data, both project data as well as baseline data is available to support this design principle. In fact, the project was not set up to support it, but rather the lessons learned through implementation of other concepts need to be used as well.</td>
</tr>
</tbody>
</table>

As can be seen from the table above, there is a solid indication that the design principles of PortCDM are rational, however, two of the design principles require more data and study in order to provide a more conclusive result.

## 8.3 Other findings

### 8.3.1 Efficiency improvement potential – conclusions from the quantitative analysis

The results presented in chapter 7 indicate the potential for improvement in port call operations through the use of digital data sharing complying with the design principles of PortCDM.
More specifically, according to the statistics shown in paragraph 7.4, there are various inefficiencies observed with respect to the amount of time that ships spend at a particular port area waiting to be served. This is reflected in the presented table for various types of ships. For example, container ships spend on average only about 70% of their time at berth, while the remaining time is utilised for various operations related to arriving and departing from the particular port including pilotage, towage and linesmen operations. This remaining time, however, also includes unnecessary waiting times spent at anchorage or idle times while waiting to be served. The latter can be significantly reduced by implementing PortCDM principles. Note that for other types of ships (tankers, ro-ro and general cargo) it seems likely that the percentage of time at berth can be significantly lowered by between 50-70%, showing an even greater potential for improvement.

The test bed results on predictability reflected in paragraph 7.5 also indicate a potential for gaining significant benefits. The analysis shows that predictability of the four critical states (Arrival Traffic Area, Departure Traffic Area, Arrival Berth and Departure Berth), as they have been analysed for the various testbeds, identifies an improvement potential for a large number of port calls, reaching up to 90% in some cases. For example, for the Arrival Traffic Area predictability shown in paragraph 7.5.1, the results indicate that predictability could be improved by at least 25% for 2,683 port calls, 50% for 678 calls and 75% for 229 calls.

An area for further investigation would be to compare what it would mean to introduce slot management systems rather than the current practice which is more of a first come first served basis. Data sharing and collaborative decision making would, of course, be essential in such a transformation, but it would also require some changes in the legal and contractual domains. It is however expected that such a transformation to slot management would enable actors to plan better and thereby gain even more efficiency.31

Similar improvement potential was also observed for the remaining reported states.

Note, that the reported results only included situations for which predictability calculations were possible. There were many instances where predictability could not be calculated because of the absence of any valid estimates. This could mean that the improvement potential by implementing PortCDM principles is even greater than shown in the results provided here.

8.3.2 Port call synchronisation improvement potential

The results presented in paragraph 6.5 clearly indicate a strong potential for improvement in port call synchronisation through the use of digital data sharing between a ship and the intended port of arrival complying with the design principles of PortCDM.

More specifically, the presented use cases clearly illustrate 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 the port call synchronisation procedure has only been 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.

8.3.3 Collaboration improvement potential – the living labs approach

Besides putting requirements on digital collaboration, an important ingredient of the PortCDM concept is the introduction of physical collaboration to enhance the collaborative culture within ports. The results presented in paragraph 6.4 and Annex D clearly indicate the successful creation of a collaborative culture within the ports of the various testbeds through the living labs process. All the actors that participated in the living labs were satisfied with the meetings, 70% of them stated that through the living labs they started talking to some port actors for the first time, 40% started to collaborate with these new actors and for 67% of them this collaboration enhanced their own operations.

All believed that the living labs contributed positively towards port collaboration and that it was interesting to hear other people’s views and understand their situation. It was very positive that all the participants supported the concept of the sharing of information through the living labs process, enabling them to improve their ways of solving problems and through the discussion and the exchange of opinions many questions were answered. Also, participants referred positively to the fact that everyone that was involved was allowed to freely express their opinions. A majority of the respondents confirmed that this situation enabled a better understanding for the other actors’ roles in the port call and that as a result they now have a broader understanding of the full port call process.

Developing a collaborative culture within the port is at the very heart of the PortCDM concept, and through the living labs process this project has demonstrated how to create and maintain such a culture.

8.4 Overall impact of PortCDM – conclusions from the qualitative analysis

The feedback from those involved in the validation of PortCDM as part of the STM validation project clearly indicated that PortCDM is viewed as a beneficial concept for improving the performance of the port call process.

The use of the living labs approach to bring the various port call actors together was popular and was acknowledged as a successful mechanism for bringing the actors together and fostering the open, information sharing environment upon which PortCDM depends.

Some of the most sought after benefits, which were highlighted during the validations were:

• Better coordination among port call actors
• Improvement of port-to-port collaboration and communication, to get much better updates and a more holistic view of the ships and the port calls
• Reduction of demurrage costs for terminals
• Better basis for communication for all actors involved in a port call that everyone involved has the same information to plan on
• More efficient distribution and sharing of resources
• Data transparency, fair play among port actors
• Better visibility regarding plans of other operators
• Better understanding of the daily situation in a port
• Better situational awareness regarding port call operations

The level of sharing of commercially or security sensitive data was considered by the participants. There was general agreement that sharing timestamps covering ships’ movements was uncontested, however, including cargo and cargo operations will require further consideration for some.

Port call stakeholders were most supportive that PortCDM can provide accurate, reliable, and real-time ETAs and ETDs, and particularly importantly, for those ships arriving from nearby ports.

Many of the participants that provided feedback made suggestions on how the system used for the validation could be improved. There was no significant or notable adverse criticism of any aspects of the validation project. On the contrary, the majority of participants were enthusiastic and looked forward to a full implementation of PortCDM in the future.

8.4.1 Impact on terminal operators

Terminal operators exist within a complex competitive and unpredictable environment. Their primary concern is to provide competitive tariffs to their customers - the shipping companies, especially in relation to other terminals in nearby ports.

Based on the responses from those that work in terminal operations, everyone considered PortCDM as a good and useful mechanism. Only one single individual passed the judgement that it was complex and better suited to more complicated environments than the one they were currently operating in.

As regards the validation feedback, many benefits could be realised for terminal operators through implementing PortCDM and enabling real-time data sharing among port actors and especially terminal operators. Quantifiable benefits identified by the terminal operators included:

• Faster ship turnaround
• Just-in-time operations and faster service time
• Decrease in time ships spend alongside quay
• Better utilisation of berths
• Reduction of waiting times
• Improvements in predictability and resource planning
• Increased berth productivity
• Improved schedule reliability
• Reduction of administrative burden - less hours dedicated for emails, phone calls
• Improvement of berth capacity
• Improvement of the terminal’s ability to avoid berth congestion
Reducing ship idle time is an important factor in the business case for terminal operators. By contributing to a common data sharing platform that lies at the heart of the PortCDM concept, terminal operators can support each other. They can learn of progress in the upstream port and inform the downstream port of their progress. It is in their mutual interest to cooperate to all reap efficiency gains from better planning through better data. Terminal operators can improve their resource efficiency and utilisation through working with more dynamic and accurate input information. Efficient terminals could attract more maritime traffic that will prefer to visit their ports instead of going in a nearby port and this could bring profits to the owner companies.

8.4.2 Impact on marine services operators

If a port facility does not have sufficient capability to serve a visiting ship (through its operating companies) and to efficiently handle cargo flows, ships may be chosen to go/be directed elsewhere dependent on the assignment - in nearby ports, in order to get adequate service. Ports and marine services companies competing to serve the largest shipping companies in the world should understand that those with the lowest total idle time will be most attractive.

Feedback from the marine services workers in the ports used in the validation revealed the following main challenges:

- In many cases there is reduced availability of human resources
- In many cases there are limits in the availability of equipment, such as a limited numbers of tug boats
- Readiness to serve a ship is an issue while operating in an environment where things change constantly, for example, when a ship arrives sooner than its expected time or is delayed due to unforeseen situations (strikes, weather conditions, and suchlike). Moreover short-notice changes can cause big problems
- Many information and communications systems to be kept updated
- Resources allocation depends on the size of the ships
- Reduced or excess berth availability creates scheduling difficulties for berth/ operation planners
- Reduced transparency or visibility of important planning data among key stakeholders
- Lack of coordination with other port call actors, for example, with terminals, shipping agents, and suchlike.
- Cancellations create extra fees
- Onerous administrative burdens in many cases, over reporting and duplicated reporting
- Imprecise planning based on unreliable data- wrong data coming from other actors creates inefficiencies not only in planning but also in the way of preparing and coordinating to serve a ship

Based on the responses from those that work in a marine services organisation the following benefits could accrue through adopting the PortCDM concept:

- Better coordination among the various port call actors - pilots, tugboat operators, linesmen, berth planners, terminals, and suchlike
- Digitally accessible information available in one place thereby saving time in searching for information
- Better planning and predictability of capacity
- Improved personnel and equipment planning and deployment
• Easier reporting and time saving on daily administration work
• Reduction in phone calls because, for example, a pilot could look in the PortCDM data interface to see when a berth is going to be available instead of calling the terminal
• Provision of useful statistics through a user-friendly interface
• Saving in working hours and money through reduction in administration
• Greater flexibility for every actor involved in the port call process
• Better coordination among the port call actors
• Access to better information due to improved port-to-port collaboration, that will provide the actors the opportunity to get better updates and a more holistic view of the ships and the port calls
• Improved and up-to-date situational awareness
• More stable basis for communication for all actors involved in a port call in order that everyone involved has access to the same information for planning
• Just-in-time actions that will better satisfy customers
• Saving of resources through more effective planning

A system such as PortCDM with real-time information on the evolution of port calls and accurate estimations about next events will allow an operator such as, for example, a tugboat operator to optimise the use of their tugs and will help them to carry out optimal maintenance. Similarly, it could help a pilot operator to save working hours and pilot boat transport along with bunker fuel (and money) through the provision of information of accurate ETAs and instant communication of changes to the companies planners. When a planner observes a change via PortCDM they will have the time to adjust to it and distribute the required resources accordingly.

PortCDM offers marine service operators benefits such as:
• faster service time to the ships (optimisation of average time of service provision to a ship)
• faster average ship turnaround
• increased berth productivity
• improvement of waiting times
• improvement of predictability
• efficient resource planning

8.4.3 Impact on shipping agents and shipping companies

From a shipping company’s point of view, especially for those en-route between different regions in the world, it would be highly beneficial to have up-to-date situational awareness in relation to planning at all destination ports. Plans can then be adjusted progressively and dynamically by providing updated times of arrival well in advance of reaching down-stream ports. This would allow for just-in-time arrival and just-in-time operations upon the arrival of the ship. Consequently, idle time would be reduced, and profits should increase.

Feedback from the shipping agents participating in the PortCDM validation revealed the following main challenges:
• Reduced visibility of other actors’ planning; for example, terminals planning due to lack of transparency.
• Lack of coordination and synchronisation with other port call actors. One main reason for this is that communication between ship’s agents and other port call actors (agents,
service providers, traffic control, pilots, and suchlike) is often still performed in a very basic way by point-to-point communication using telephone or email, and spreadsheet file exchange due to the lack of better tools and/or common operating procedures.

- Refusal to change attitudes, in many cases.
- Missing data or access to insufficient sources of data.
- Missing documents, for example, important certificates, and suchlike create various problems - if important documents are missing from the Single Window delays in serving a ship should be expected.
- Unexpected and unanticipated changes such as strikes - from anyone involved in the process (stevedores, truckers, port workers) or other unforeseen problems such as bad weather conditions, cranes malfunctions, and suchlike create delays in the process and bring enormous costs for the shipping companies.

The implementation of the PortCDM concept could assist ship agents and shipping companies as follows:

- It can help to optimise communications as the ship agent will be in place to receive live updates without the need of sending emails or make unnecessary phone calls to the terminal operators, marine service providers for requesting a port call status, and suchlike.
- It can reduce administrative work as the ship agent will not have to call about everything, for example, five different actors to find out one specific time stamp
- It can shorten the time spent in port for cargo operations by improved planning which can save money for both the shipping company that can plan their voyages better and the terminals that can serve more ships. It might also decrease the demurrage cost for terminals and despatch cost for shipping companies.
- It can help to improve the coordination between them and other actors, for example, through a real-time live updated berth plan.
- It can provide quick updates via the app without the need of being at office in order to access this information.
- It can provide better planning of port calls and things around it, like bunkering, crew exchanges, and deliveries with enough time to readjust if needed. Better planning means better fuel efficiency for a ship and money saving.
- It can offer graphical representation of a ship time plan which makes it more visible and easier to understand than having to deal with a spreadsheet file with times coming, for example, from a terminal.
- It can offer better accuracy (if many people can see the information, it will be easier to validate).
- It will provide the basis for data transparency, which is essential for fair play among the port actors.
- It can offer better coordination of the different services.
- Just-in-time operations, minimal waiting times, fast turn around and less ships idle off port (anchorage) translate in money saving and increased profits for the shipping company and the agency.

8.4.4 Impact on VTS operators and traffic managers

Feedback from the VTS operators and traffic managers participating in the PortCDM validation revealed the following main challenges:
• Access to insufficient sources of data and reduced visibility of other port call actors’ data, for example, terminals or marine services timestamps.
• Significant time consumed for administrative work such as email exchange, telephone calls, faxes, and suchlike. Moreover they have to dedicate also a significant amount of their time on cross checking ship data such as certificates, crew members lists, and suchlike (that many times are missing) and usually have to deal with large amounts of emails.
• They have to possess extensive knowledge of all the maritime regulations and international maritime standards.
• Increased readiness is always necessary in order to be in place to take immediate measures and avoid difficult situations such as ship collisions, and suchlike.
• Unforeseen events (for example, strikes in nearby ports) can affect them.
• Lack of coordination and synchronisation with other actors. Communication and information exchange performed in a very basic way by point-to-point communication using telephone or email, and spreadsheet file exchange.
• Refusal to change attitude and use of old fashioned technologies.
• Reliance on out-dated information, for example, inaccurate ETAs from the shipping agents.
• Imprecise planning based on unreliable data- wrong data coming from other actors creates inefficiencies in their operations planning.
• The implementation of the PortCDM concept could assist VTS operators and traffic managers as follows:
  • It will help them to reduce administrative burdens and optimise their work efficiency without the need for inefficient communications with other actors, for example, making unnecessary phone calls to terminal operators, agents, and suchlike seeking a clarification, and suchlike;
  • It will help manage the traffic in a safer and more efficient way;
  • It will provide access to more reliable information and reduce the need to chase for information;
  • It will enhance predictability, especially important in areas with a lot of traffic or where there is increased possibility of ships blocking the port if they enter when a berth is not ready;
  • Planning will not be dependent exclusively on other people’s data but they will have a priori the integrated information provided through PortCDM so as to be able to make the appropriate changes to their planning; and
  • Information transparency will enable delays to be recognised more easily.
9 Strategy for advocating and promoting PortCDM

In both the aviation and the maritime sector, the collaborative decision making concept aims to enhance operations through better coordination and synchronisation of close-coupled events, particularly when they are being delivered by otherwise independent or separate providers or actors in the transportation chain.

The PortCDM concept owes its origins to the aviation sector, where the AirportCDM concept is now being implemented in various airports - beginning in the European region, but set to become a worldwide adoption in due course, as more and more airlines and users of airports become aware of the financial, organisational and environmental benefits. Given these very attractive benefits, a similar incremental adoption for PortCDM can be foreseen in the maritime sector. This can only be accelerated by an appropriate education and awareness raising campaign.

Figure 79 Progress of A-CDM implementation

9.1 Strategy for diffusion of PortCDM

PortCDM is mainly looking at safe, efficient and environmentally friendly sea transport. To achieve this, all actors in the maritime domain need to be made aware of the concept so that they can embrace it in a way that ensures the necessary critical mass of ports and actors is achieved.

In order to create awareness of PortCDM in the maritime domain a number of strategies have been developed and executed.

9.1.1 Conference Contributions

The PortCDM concept has been presented regularly at various international conferences and workshops. These conferences have been mainly in Europe, but more recently have included other parts of the world - prompted by the interest already being shown in Europe and reflecting the fact that those actors exposed to PortCDM that are based in Europe are also engaged in a global trans-continental maritime transportation chain.

Speeches and exhibitions have been delivered at the e-Navigation Underway conferences organised by IALA, in commercial conferences and industry events, where participants have attended dedicated PortCDM workshops; for example, in collaboration with the Port Development Middle East 2018 Conference in Muscat, Oman.

![PortCDM Workshop - Oman](image)

Figure 80 PortCDM Workshop - Oman

9.1.2 Presenting PortCDM in international organisations

Important communication, governance and standardisation instruments in the maritime domain are the various international organisations. For this reason, regular presentations and briefings have been delivered to the following international organisations:

- The International Maritime Organization (IMO), the United Nations specialised body dealing with regulating international maritime shipping, with its headquarters in London, UK
- The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), a non-governmental international organisation ensuring the standardisation of marine aids to navigation and aspects of traffic management, with headquarters in Saint Germain en Laye, France
- The International Harbour Masters’ Association (IHMA), the professional body for those with responsibility for the safe, secure, efficient and environmentally sound conduct of marine operations in port waters with members in more than 50 countries, bringing
together Harbour Masters and all those who hold a managerial position in aspects of the control of marine operations within a port.

This included reaching out to the leaders of those organisations and gaining their personal support. As a result, the PortCDM concept has then been discussed regularly by the members and observers in those organisations in terms of the concept and the benefits of PortCDM.

The concept of PortCDM supported by an exhibition has been elaborated at IMO headquarters during the sessions of several high level committees. At IALA the PortCDM concept has been introduced during the meetings of the three main committees: VTS Committee, ENav Committee and ARM Committee. At IHMA an invitation to present at the IHMA Congress - Global Port and Marine Operations.

Notably, IALA and IHMA are actively supporting the development of the relevant underpinning data exchange standards (S-211 and the port call standard message format (PCMF)) for PortCDM, while the IMO has encouraged PortCDM initiatives be presented at the earliest opportunity to the IMO for consideration under the overall umbrella of STM.

In addition, PortCDM has been presented to other groups, including shipping organisations, ship owners associations, port actor groups and other relevant organisations.

9.1.3 Publishing articles and social media

One key strategy to increase visibility and awareness of maritime actors on PortCDM has been the utilisation of press and social media.

The authors of this report have, so far, published twenty “concept notes” (see Table below). These notes, each between eight and ten pages in length, have explained different aspects of PortCDM and STM from different viewpoints; each with a focus of different market segments and actors.

The concept notes have been published on and promoted through social media as well as in technical and industry journals and publications - both printed versions and online. This has regularly gathered five-digit readership numbers, high volume of likes and re-sharing. Additionally, publishing on Facebook reached yet another level of readers.

The various postings and publications have resulted in substantial feedback, new connections and interest from other market sectors, such as logistics.

Other articles on PortCDM have been published in various journals. Examples include the journal of The United Nations Conference on Trade and Development (UNCTAD) and a cover story in Seaways, the journal of The Nautical Institute.
9.1.4 Enabling digital innovation based on the PortCDM digital infrastructure

One of the purposes behind the STM validation project has been to lower the thresholds for inviting new digital innovators to provide supporting digital applications. To explore how the PortCDM validation project could support the development of digital innovations, activity 1 included participation in two Masters courses for students at the Chalmers University of Technology (during the spring 2017 and the spring 2018). During these courses the students were invited to elicit requirements from port call actors, develop digital applications connected to the PortCDM demonstrator backend, and to elaborate on business opportunities for relevant

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33 Concept notes overview, [www.ipcdm.org](http://www.ipcdm.org), 2018
port call actors. In total 140 students were engaged and jointly developed the following mobile applications during a five week course (on 50 % of their time) (see also appendix H for more details of the Apps):

- **PortableCDM**, with the purpose of providing any port call actor with situational awareness of the port calls that the port call actor is involved in
- **Portable Captain**, with the purpose of providing a ship’s captain with situational awareness of port calls about to be conducted
- **Portable Agent**, with the purpose of providing the agent with situational awareness for the port call that the agent is involved in
- **Portable Services**, with the purpose of providing the service provider with situational awareness for the port call that the service provider is involved in
- **Portable Berths**, with the purpose of providing the terminal operator with situational awareness for the port call that the terminal is affected by

All the apps provided the user with capabilities to provide manual input of time stamps that the port call actor / user was authorised to provide. During the testbed periods, the apps enabled the port call actors to access information to provide them with better situational awareness, manually provide time stamps, and to engage in the focus months. The students capabilities of bringing forward these digital innovations in a very rapid way shows that the PortCDM environment, using standardised interfaces for the provision and consumption of time stamps is an easy way to provide new digital innovation to the maritime community.

### 9.2 Governance of PortCDM

It is important that PortCDM is implemented in such a way that shipping and all the involved actors in the maritime transportation chain can easily participate. This means that there must be an underlying adherence to basic standards and principles of operation. At the same time, each region and each port will have its own processes, procedures, natural advantages and constraints that will need to be taken in to account. For this reason, PortCDM is seen very much as a concept, rather than a fixed set of rules or procedures. In fact, the PortCDM concept seeks to maintain as much flexibility as possible, while ensuring the minimum level of standardisation is in place to enable it to be implemented on a truly global basis.

The governance and coordination of PortCDM implementation is envisaged to be multi-level, with broad overall global guidance, then increasing levels of detailed coordination and harmonisation at the regional, then port area level. The International PortCDM Council (IPCDMC) has already been established to provide the global governance and coordination.

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34 Lind M., Bergmann M., Ward R. Carson-Jackson J. (2018) Port Collaborative Decision Making – Making port calls more predictable can improve the experience for ships’ Masters and ship operations calls, Seaways, December 2018 (www.nautinst.org/seaways)
Figure 82 PortCDM governance - from global reach to local port implementation

The hierarchy of global, regional and local governance and coordination structures shown in figure 82 has the purpose of ensuring that ships can travel from port-to-port across the world and provide and utilise time stamps and PortCDM services in the same way wherever they berth. This, in turn, provides confidence to ports that any investments that are made are universally applicable to all ships seeking their services, regardless of their origin. The same principle applies to all port service providers.

9.2.1 Global Governance

In order to establish PortCDM as a sustainable concept, as defined in the STM Validation Project details, the authors of this report established the International PortCDM Council. Intentionally the Council was decoupled from the PortCDM validation project after it reached a critical mass and it is now a standalone, established organisation.

The International PortCDM Council (IPCDMC) develops and agrees common procedures, standards, data formats, guidelines and guiding principles for the successful implementation of PortCDM at the regional and local level.

While the Council does not seek to define how PortCDM should be implemented in any given port or in a region, it provides the necessary over-arching guidance that ensures that any of the implementations meet the overall aims of PortCDM and therefore serve the needs of sea traffic that moves from port-to-port, country and continent.

The IPCDMC defines procedural, operational, and technical guidelines and it makes recommendations related to the implementation of those guidelines.

To establish PortCDM in any port community the implementation requires appropriate digital data tools to enable and manage collaborative data exchange and the tracking of decision-making and event progress. The IPCDMC is not developing those tools, but rather provides advice and guidance on appropriate digital data tools to enable and support PortCDM activities and is developing the certification criteria to ensure that the tools are compliant with the guiding principles of PortCDM and are suitable for use in PortCDM.

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35 Guideline on PortCDM Governance, IPCDMC, 2018
The role and the task of the IPCDMC is summarised in the figure below.

![Figure 83 The Role of the IPCDMC](image)

The IPCDMC is currently working on the following tasks:

- Agree on a harmonised terminology for PortCDM and maintain / facilitate the continual development of the PortCDM concept definition
- Developing guiding principles for PortCDM
- Defining Key Performance Indicators for PortCDM stakeholders
- Defining criteria for PortCDM compliance on all aspects of PortCDM, including implementation guidelines, processes, procedures and criteria for tools (including applications and services)
- Work with and support standardisation organisations to establish necessary standards for international harmonisation of PortCDM
- Accredit the Port-Call Message Standard and other standards (including the appurtenant Port Call Process Ontology (c.f. appendix J)) seen as necessary to achieving the goals of PortCDM
- Develop and promote PortCDM related Best-Practices
- Manage PortCDM Council Stakeholders Membership;
- Develop concepts for PortCDM Quality Assurance
- Support regional coordination and port-level implementations

The constitution of the IPCDMC ensures that its members are representative of all those actors involved in PortCDM across the world. They are drawn from international organisations (such as IMO, IALA etc.), flag states (such as, Cyprus Chamber of Shipping, Bahamas Shipowners Association etc.), maritime authorities (SMA, NCA etc.), some major ports in the world, some major shipping companies, and some major terminal operators. For a complete list of members (confirmed / to be confirmed), which have been approached as of today, see [www.ipcdmc.org](http://www.ipcdmc.org).

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36 Guideline on PortCDM Governance, IPCDMC, 2018
The work of the Council is primarily conducted on a voluntary and distributed basis. The Council strives to arrange meetings in conjunction with other larger events pursued in the maritime industry.

9.2.2 Regional Coordination

It is envisaged that stakeholders will set up regional coordination organisations to handle coordination with a region of one country or across a region spanning several countries. This will be beneficial if regions already have collaborative agreements in place between different ports or port clusters. Regional legislation may already encourage such cooperation between countries or other regional bodies. Examples would be the existing cooperative arrangements covering maritime activities within the Baltic Sea area, other EU regions, in the Straits of Malacca and Singapore and between the USA and Canada.

Any PortCDM Regional Coordination Body (PRCB) should be guided by the general guidelines and standards set by the IPCDMC. It would define more specific implementations within its area of influence. In essence it would define sub-guidelines and specific implementation guidelines of the principles agreed in the IPCDMC as required for effective and efficient collaboration of the different stakeholders in the region.

A PRCB would set its Terms of Reference and organisational model to best fit the conditions of its region. Regional implementations of PortCDM might include additional procedures, which all stakeholders in the region agree to, above and beyond any global definitions provided by the IPCDMC. Depending on the agreement of the stakeholders, the guidelines and standards of the PRCB might be defined on a very high level or a more detailed level. Within a region visiting ships would be assured of common port call handling and procedures according to the definitions set by the PRCB. In some areas different PRCBs might wish to create harmonisation bodies to improve collaboration over a larger regional area. For example, PRCBs for the Baltic, the Northern and the Mediterranean Sea might see a value in coordinating and harmonising certain aspects of PortCDM on an EU level.

9.2.3 Port Implementation

The detailed implementation of the PortCDM concept should always be left to individual ports. Given that port operations may vary substantially from port-to-port, the focus of PortCDM must be locally driven. It should be developed by local stakeholders. The fundamental idea is to gather the port call actors, as stakeholders, involved in the port call process to agree collaboration procedures and common goals. These stakeholders will most often be a mixture of both governmental and commercial actors. Furthermore, some stakeholders, such as terminal operators and shipping companies are typically active in multiple ports and may bring ideas and concepts from operations in their other ports of interest. What remains of utmost importance is that the principle of PortCDM supporting every actor in their processes and not being biased towards any stakeholder - neither the shipping operator, the port authority, the service provider nor the terminal operator, is upheld. PortCDM should be neutral to existing power structures or business models.

Each participating port community should establish its coordination body/governance structure, procedures and guidelines on how best to collaborate based on the specific conditions and stakeholders at a given port. Those guidelines and procedures, as well as the criteria for tools used, should nevertheless be in compliance with the governing guidelines and standards set by the IPCDMC and, if they exist, comply with those of the PRCB.
In this way, overall compliancy with the IPCDMC guidelines and standards ensures that ships and their stakeholders trading regionally or internationally can participate fully in any local implemented PortCDM.

### 9.2.4 Multi-level governance summary for PortCDM

The following table sets out examples of the different levels of governance and coordination to be exercised at the global, regional and port area level:

<table>
<thead>
<tr>
<th>Global governance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong></td>
</tr>
<tr>
<td>Align with other standards</td>
</tr>
<tr>
<td>Developing guiding principles for PortCDM</td>
</tr>
<tr>
<td>Agreeing on and disseminating Best Practices</td>
</tr>
<tr>
<td>Agree on a harmonised terminology for PortCDM</td>
</tr>
<tr>
<td>Facilitate the continual development of the PortCDM concept definition</td>
</tr>
<tr>
<td>Defining KPIs for PortCDM stakeholders</td>
</tr>
<tr>
<td>Defining compliance criteria for PortCDM</td>
</tr>
<tr>
<td>Support the establishment of necessary standards for PortCDM</td>
</tr>
<tr>
<td>Manage PortCDM Council Stakeholders Membership</td>
</tr>
<tr>
<td>Develop concepts for PortCDM Quality Assurance</td>
</tr>
<tr>
<td>Supports regional coordination and port-level implementations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regional coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong></td>
</tr>
<tr>
<td>Define regional details</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Port implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong></td>
</tr>
<tr>
<td>Collaborative governance of procurement and port implementation, including detail roles and responsibilities of all actors</td>
</tr>
</tbody>
</table>

Figure 84 Multi-level governance for PortCDM
9.3 Globalisation of PortCDM

The level of awareness of the advantages of PortCDM among all actors in the maritime transportation chain is continually increasing. Many are keen to participate in PortCDM but are not sure on what to do next. The following table provides some guidance to the various actors on what measures they might take to advance the uptake of PortCDM in their area of operations.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>shore centres</td>
<td>• Evaluate S-211 and incorporate capabilities to receive S-211 data</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>the Ports/Terminals</td>
<td>• If PCS exists, update their capability to receive and send S-211 data</td>
</tr>
<tr>
<td></td>
<td>• Implement digital data exchange with internal and external actors as seen fit.</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>Ships</td>
<td>• Update ship system to be able send and receive S-211 data</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>Service providers (e.g., weather, traffic)</td>
<td>• Update services to enable data integration with S-211 as seen appropriate</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>hinterland operators</td>
<td>• Review own system and implement changes so relevant data from S-211 data streams can be received ad, if appropriate, send with updates.</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>upstream ports</td>
<td>• Update services to enable data integration with S-211 as seen appropriate</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
<tr>
<td>downstream ports</td>
<td>• Update services to enable data integration with S-211 as seen appropriate</td>
</tr>
<tr>
<td></td>
<td>• Review PortCDM procedures and update own procedures accordingly where appropriate</td>
</tr>
</tbody>
</table>
10 Conclusions and the way ahead

10.1 Overall findings

The validation project examined the current situation, the shortcomings, and the needs and desires for the future; and from this, identified that PortCDM could provide the mechanisms and processes to achieve significant improvement. Each element of PortCDM was iteratively validated by using PortCDM in operational scenarios in nine different ports on several occasions over a 2½ year period.

The principal actors involved in the validation project were brought together in living labs as a very successful means of fostering understanding, collaboration and data sharing.

Each port developed a “metro map” of their current operations to illustrate the complexity and convergence of events and the interdependencies in a port call and why collaboration between multiple actors using a concept such as PortCDM is necessary.

A PortCDM Council was established to assist in refining the PortCDM concept, develop doctrine, and to provide valuable input to the development of S-211 - a robust, extensible, internationally recognised data exchange standard for the port call messages upon which PortCDM relies.

The concept of PortCDM was continuously refined as a result of the experiences and feedback during the 2½ years of the project.

About 1.7M port call messages were shared successfully in the ports utilizing the demonstrator based on the design principles of the PortCDM concept. The principles of PortCDM were implemented successfully in the participating ports.

The qualitative analysis of the results of the PortCDM validation project, comprising 33 face-to-face interviews and 37 written responses to questionnaires, shows that enhanced situational awareness, provided by the data sharing enabled by PortCDM is of value to participants. The participants pointed out that an increased reliability of ETAs and ETDs for port actions has substantial benefits.

Enhanced situational awareness as facilitated by PortCDM provided port call actors with access to more reliable data and a greater awareness of other actors’ intentions. Enhanced situational awareness was shown to provide positive effects for operations, including:

- Making better estimates for ETAs and ETDs (100% of respondents agreed ‘to some extent’ or ‘more’ with this conclusion)
- Improved work procedures (> 50 % agreed to some extent or more)
- Reduced time spent on information gathering (> 80 % agreed to some extent or more)
- Reduction of administrative workload (> 80 % agreed to some extent or more)

The participants also reported that the culture of collaboration embedded in the PortCDM concept was of particular value and that establishing the four collaboration arenas for data sharing resulted in enhanced collaboration and more effective operations.

Analysis of the quantitative results indicated that the predictability of berth arrival and berth departure was enhanced when port call actors collaborated through data sharing using the PortCDM demonstrator.
The introduction of PortCDM, and its associated design principles for enhanced collaboration empowered by digital technologies, had positive effects on the ports and actors that participated in the validation project. This provides confidence in recommending the establishment of standardised data sharing environments within and between ports as an essential step on the path towards increased efficiency and sustainability.

In summary, the validation project has demonstrated that PortCDM enables transformation as follows:

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmented situational awareness</td>
<td>Common situational awareness</td>
</tr>
<tr>
<td>Low information quality</td>
<td>Reliable information quality</td>
</tr>
<tr>
<td>Limited planning horizon</td>
<td>Predictable planning and operations</td>
</tr>
<tr>
<td>Unstructured information exchange</td>
<td>Standardised data exchange</td>
</tr>
<tr>
<td>Sub-optimisation</td>
<td>Collaborative culture</td>
</tr>
<tr>
<td>Unnecessary waiting times</td>
<td>Just-in-time operations</td>
</tr>
<tr>
<td>Low IT maturity</td>
<td>Enhanced IT systems and third-party innovation opportunities</td>
</tr>
</tbody>
</table>

Figure 85 Transitions enabled by PortCDM

10.2 Summary Conclusions

Based on a combination of the results of the use of the validation testbeds in nine ports on three separate occasions over a period of two and a half years and the qualitative and quantitative analysis of the resultant feedback it can be concluded that:

- the Port CDM concept and digital data sharing provides significant positive benefits by enabling port call actors to plan, coordinate and synchronise activities more efficiently giving rise to enhanced and more efficient overall port call performance; and
- the basic doctrine, procedures and standards for PortCDM have reached such a level of maturity that they can now be used as the foundation for a global implementation of PortCDM.

10.3 Achievements

10.3.1 Conceptual Level

During the project, activity 1 team further developed the PortCDM concept by building on the STM principles established in the MONALISA 2.0 project. The team not only elaborated the fundamental principles of the PortCDM concept and how it fits in and supports the overall STM concept, it also characterised the purpose and goals of PortCDM.

Port call coordination and port call synchronisation have been further developed as the underpinning basis for port call optimisation. With this level of development, PortCDM has
reached a level of granularity which allows it to be adopted operationally as a modular concept with various maturity levels, according to the specific needs of each port, be it a smaller local port, a large international port or a port which functions as regional hub. This is an essential requirement given the nature of the maritime transportation chain and its actors.

The validation process has highlighted that PortCDM is well received by the actors. While several implementation hurdles were identified, particularly the challenges of convincing competing actors to share and collaborate, the overall concept was overwhelmingly validated and the granularity and maturity levels supported by those involved in the validation trials.

10.3.2 Technical Level

A major achievement at the technical level has been the definition of an internationally recognised, standardised Port Call Message Format (PCMF). The activity 1 project team, primarily through the International PortCDM Council (see 10.3.4), continuously fed the validation results in to the development of the PCMF. As a result, the PCMF will be recognised shortly by IALA as international standard S-211. S-211 will then become an important element of the IMO Common Maritime Data Structure (CMDS).

Based on the S-211 standard the activity team created a series of software tools, both on PCs and as apps for mobile devices, in order to allow the participants of the validation project to share data, update status and gain situational awareness as well as enable the collaborative decision making process. While those tools were created as validation tools and are not yet product-ready, they provide a sound basis for the development of the commercially available products that will be required during the envisioned operational implementation of PortCDM in the near future.

Besides working directly on the validation project, the activity 1 team reached out to other relevant international activities to ensure that PortCDM was recognised and integrated in other developments; for example with the Port Call Optimisation Task Force, the International Harbour Masters Association (IHMA) and in the logistics arena, such as the GS1 standards.

10.3.3 Promotional Level

The activity 1 team worked on promotional aspects in close collaboration with the relevant lead of Swedish Maritime Administration.

Besides participation in project internal meetings and conferences, the activity team participated in numerous national and international conferences, promoting PortCDM and STM at various levels. The team gained access to important stakeholders and whenever possible promoted PortCDM and STM, for example at IMO, IALA, IHMA, BIMCO, ICS and other relevant international organisations.

A key component of the promotional activities was the development of “Concept Notes” as well as other publications. Not only did the team reach a very broad audience - more than 200,000 readers of the concept notes were recorded on LinkedIn alone; but it also attracted close to 50 co-authors from within and outside the project to help draft the concept notes themselves for various audiences and target sections of the maritime domain and beyond (see figure 80).

10.3.4 Sustainability Level

The goal of activity 1 was not simply to validate the PortCDM concept, but also to establish mechanisms that will ensure that the concept can be implemented globally. In order to achieve this the activity team has pursued two main initiatives:
• The development of the S-211 standard PCMF through international support. S-211 has been established and will become an internationally recognised standard shortly. This standard is within the internationally recognised and IMO endorsed CMDS, is based on the ISO 19100 series of geographic standards and is compatible with logistical standards such as EPCIS.

• The creation of the International PortCDM Council (IPCDMC) - now an organisation with more than 30 active participating organisations and 30 observer organisations. This standalone organisation now works internationally to oversee the operational and governance aspects of the implementation of PortCDM and provides input to ensure the maintenance and future development of S-211.

These two key initiatives, together with the doctrine established as part of the validation project provide a basis upon which PortCDM can now be established internationally as a recognised concept with its own governance and with the necessary assets for further development and sustainability above and beyond the STM Validation project live cycle.

10.4 Collaboration arenas

During the course of the project all the collaboration arenas were reviewed and considered.

As can be seen in chapter 7, data was collected to enable a quantitative analysis for the intra-port collaboration arena. In addition substantial qualitative data was collected and is reported in chapter 6.

For the port-to-port collaboration arena as well as for the ship-to-port collaboration arena the focus of the analysis was on qualitative analysis that is reported in chapter 6. Limited availability of quantitative data made this focus necessary.

While not considered in the project application, an additional collaboration arena was encountered and considered during the course of the project: the port-to-hinterland collaboration arena. This arena was highlighted through discussion when finalizing the Port Call Message Standard S-211. In those discussions, especially in the working sessions of the International PortCDM Council (IPCDMC) and when reaching out to other initiatives, like the Port Call Optimization Task Force, mainly supported by Port of Rotterdam, the logistical standard EPCIS was raised and discussed.

EPCIS is a key standard for data sharing in the logistics domain and initiated by the standardization group GS1. The ensuing discussions highlighted that the inclusion of the port-to-hinterland collaboration arena could generate a substantial benefit for the actors implementing PortCDM. To assist this, S-211 was enhanced to be compatible with EPCIS and GS1 standards. In fact, after the discussions GS1 requested and was assigned a Maritime Resource Name (MRN) domain and GS1 will implement MRN in EPCIS to reach interoperability with S-211 and PortCDM. Further review and validation of this arena has not been performed, as it was outside the scope of the project. But it is on the agenda for the IPCDMC.
### 10.5 Business benefits and effects

Significant business benefits have been identified for the different types of stakeholders. They are identified in the following table.

<table>
<thead>
<tr>
<th>For shipping companies /ships</th>
<th>For ships’ agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>saved bunker due to just-in-time arrivals</td>
<td>enhanced basis for planning and easier coordination of port call operations</td>
</tr>
<tr>
<td>saved bunker due to just-in-time departures that avoid chasing the time window for the next leg</td>
<td>less time spent on chasing different actors, more time for other services to the ships</td>
</tr>
<tr>
<td>fleet optimisation and saved bunker due to shorten TTT</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For terminals operators</th>
<th>For VTS operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>enhanced possibilities for berth management</td>
<td>possibilities to digitally log arrivals and departures</td>
</tr>
<tr>
<td>enhanced capacity utilisation (resources and infrastructure)</td>
<td>better coordination of ship movements</td>
</tr>
<tr>
<td>better planning horizons for arrivals</td>
<td>increased capability to synchronise the traffic dependent on the status in the port</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For port authorities</th>
<th>For port control / pilot planning, tug operators, mooring companies, and service providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>safe and efficient port approaches</td>
<td>enhanced basis for planning</td>
</tr>
<tr>
<td>long- and short-term overview of port visits</td>
<td>optimised capacity utilisation</td>
</tr>
<tr>
<td></td>
<td>enhanced capacity utilisation (resources and infrastructure)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For hinterland operators</th>
<th>For digital service providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>enhanced capacity utilisation (resources and infrastructure)</td>
<td>low entry barriers to provide digital innovations</td>
</tr>
<tr>
<td>better planning horizons for loading / offloading at ports</td>
<td>enhanced capabilities in existing systems</td>
</tr>
<tr>
<td>enhanced predictability</td>
<td>by be connected to the “outside”</td>
</tr>
</tbody>
</table>

The full effects of PortCDM will not be realized until all parts of the maritime transport chain become inter-connected. This is an important task for the Sea Traffic Management concept as a whole.

Interconnectivity is a long-term goal and most active ports in the world are showing a desire to become better connected to their “outside world”; shipping companies wish to be better updated on port situations before reaching the port limit and service providers see substantial benefits of enhanced situational awareness.
A number of the concept notes, mentioned several times in this report, have explained the model of Port Collaborative Decision Making (PortCDM) as one of the main enablers of Sea Traffic Management (STM)\(^{37}\).

The concept notes have focused on elaborating on the key constructs of PortCDM as well as on their application in different operational domains, such as resource management,\(^{38}\) short-sea shipping,\(^{39}\) eBerthing,\(^{40}\) and financial validation\(^{41}\) (see figure 86). Fundamentally, the development of PortCDM has been driven by the vision of enhanced data sharing among all the involved stakeholders. This will lead to enhanced digital collaboration, and more reliable operational outcomes in the maritime transportation chain. It is all about coming together and support each other for the benefit of the maritime ecosystem. The technical means are there, now it is all about facilitating a cultural change for the practices involved and connected to sea transports.

### 10.6 Generic service specifications of identified services

Besides developing and maturing the concept of PortCDM, associated services have been identified and generic service specifications have been developed.

Key aspects of services and their specifications have been developed in a document initiated in activity 1 and further developed as part of the technical work of the IPCDMC: Criteria for PortCDM Compliancy.\(^{42}\) Both technical as well as procedural services and associated compliancy criteria have been defined and are available to evaluate the compliancy of ports, ships, service providers or other actors with PortCDM.

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\(^{39}\) 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 East Mediterranean, Concept Note #5, STM Validation Project

\(^{40}\) Forthcoming note


\(^{42}\) IPCDMC (2018) Criteria for PortCDM Compliancy
Figure 87 below is an example of an overview of how the document - *Criteria for PortCDM Compliancy*, shows aspects of generic service specifications.

Figure 87 Different technical dimensions for positioning technical compliance

10.6.1 PortCDM maturity levels

Of particular note is the development and documentation of a maturity level concept on service specification compliancy. This concept allows incremental compliancy with the generic service specifications depending on individual needs and desires of the ports implementing PortCDM. It also indicates to outside actors the level of PortCDM services that are available.

<table>
<thead>
<tr>
<th>Level</th>
<th>Short description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic foundation</td>
<td>Capabilities to share of timestamps (PCMF)</td>
</tr>
<tr>
<td>2</td>
<td>Real-time data sharing</td>
<td>PCMF sharing platform established</td>
</tr>
<tr>
<td>3</td>
<td>Core port call actors included</td>
<td>Core port call actors share PCMF data</td>
</tr>
<tr>
<td>4</td>
<td>All port call actors included</td>
<td>All actors are using real-time PCMF data sharing</td>
</tr>
<tr>
<td>5</td>
<td>Outside actors included</td>
<td>PCMF sharing with outside actors established</td>
</tr>
<tr>
<td>6</td>
<td>Actors use CDM</td>
<td>Actors use full Collaborative Decision Making</td>
</tr>
<tr>
<td>7</td>
<td>Continuous Improvement</td>
<td>Actors use continuous improvement processes</td>
</tr>
</tbody>
</table>

Figure 88 PortCDM Maturity Level Descriptions

10.7 Next steps

The PortCDM concept has been validated. At the core of the PortCDM concept is the sharing of time stamps enabling each actor to optimise their planning. The standard for time stamp
data sharing (S-211) as well as the guidelines governed by the IPCDMC is now coming into use. Implementation can now begin.

The sharing of best practices, the emergence of a PortCDM community, as well as the accreditation of ports reaching different levels of PortCDM maturity and certification of digital services that could be claimed as PortCDM compliant will all be important aspects of implementation.

The validation effort pursued within the STM validation project has provided insights on the need for richer empirical data to gain even more insights of the value of PortCDM. Naturally this would be something that could be done in parallel as the concept is being implemented by different stakeholders throughout the world empowered by the S-211 standard as well as the work pursued by the International PortCDM Council. These aspects are:

- the exchange of planned arrival time for a ship and the readiness of a port to serve the ship
- the port-to-port collaboration, especially related to short-sea shipping
- the role of PortCDM in port visits during ice conditions
- identification of potential barriers related to share data on cargo operations
- further expansion of PortCDM into hinterland operations and thereby empowering the global supply chain

As implementation proceeds, there will be a need to capture inevitable concerns as they are raised during the uptake by industry and government actors. However, it is considered that the most significant concerns have already been flagged during the validation project and taken into account in the latest version of the PortCDM Governance documentation, currently under development by IPCDMC.

The key building blocks for the global implementation of PortCDM have been developed during the validation project and are now available; in particular:

- The S-211 Port Call Message Format
- The proven use of living labs to ensure that all involved actors are informed and engaged in the PortCDM process
- The proven use of a metro map for each port to identify the key areas and actors where data sharing is essential to overall improvement
- A PortCDM maturity model that provides the flexible pathway for incremental implementation of PortCDM, according to each port, its scope and its circumstances
- An International PortCDM Council that stands ready to provide governance and coordination for the implementation of PortCDM at the local, regional and global level

Besides the implementation of the S-211 data standard the definition of a technical service specification has been worked on. As the template for the technical service specification, in order to be sustainable, has been promoted to be included in the IMO Maritime Service documentation of MS 4 (Port Support Service). IHMA (International Harbour Master Association) has included S-211 in their submission to IMO\(^{43}\), meanwhile adopted by NCSR6.

\(^{43}\) NCSR 6/8/2 „Input from IHMA on Maritime Service 4“, IMO NCSR6, 13 November 2018
This submission further defines IPCDMC as the standardization body on the technical service specification "PortCallMessageExchangeService".

10.8 Actions now required for the global implementation of PortCDM

The following activities will assist in promoting and encouraging the implementation of PortCDM on a global scale:

<table>
<thead>
<tr>
<th>Key activity</th>
<th>Supporting actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage / support industry to put the PortCDM principles and the S-211 format into operational use</td>
<td>• Present PortCDM and S-211 in industry events like conferences, workshops, and the like&lt;br&gt;• Write articles in relevant industry publications&lt;br&gt;• Collaborate with industry actors intending to create PortCDM/S-211 compliant products or services&lt;br&gt;• Keep open dialog with implementers and adopt changes as seen fit</td>
</tr>
<tr>
<td>Promote the emergence of projects that are implementing PortCDM, such as in short-sea shipping</td>
<td>• Promote and support relevant projects&lt;br&gt;• Encourage actors and project consortia to include PortCDM functions in projects of relevance&lt;br&gt;• Support development of new project ideas which include PortCDM or aspects of it</td>
</tr>
<tr>
<td>Encourage further research on port operations</td>
<td>• Support activities executing further research&lt;br&gt;• Review new research on port operations to improve PortCDM concept</td>
</tr>
<tr>
<td>Invite service providers to bring new service opportunities building upon the capabilities the third-parties can provide to the maritime industry (and by that lowering the thresholds for new service providers to come into the maritime sector)</td>
<td>• Identify relevant service providers&lt;br&gt;• Start discussions to promote the development of services compliant and in support of PortCDM</td>
</tr>
<tr>
<td>Strengthen the role of the PortCDM Council by encouraging the Council to report upon best practices identified in existing PortCDM implementations</td>
<td>• Participate actively in PortCDM and its working group&lt;br&gt;• Suggest initiation of activities on defining best practices on PortCDM in the Operational Working Group of IPCDMC</td>
</tr>
<tr>
<td>Encourage the establishment of a PortCDM community of users and providers</td>
<td>• Analyse options and potential sponsors for a “PortCDM community”&lt;br&gt;• Define details of this idea&lt;br&gt;• Recruit actors and support the establishment</td>
</tr>
</tbody>
</table>
10.8.1 Practical next steps for the implementation of PortCDM

The time is now ready for PortCDM to be progressively implemented worldwide. Indeed, several ports involved in the PortCDM validation are continuing to use PortCDM and developing it further as part of their operating practice.

For those actors that now wish to adopt PortCDM, the next practical steps are:

- ensure that the digital data reporting mechanisms being used in their business are interoperable with the S-211 data exchange format
- discuss the mutual benefits of PortCDM with their direct collaboration partners and other actors in their locality
- discuss the mutual benefits of PortCDM with the other actors in their profession and business
- help to establish a local “PortCDM community” to bring all the interested actors together
- participate in the IPCDMC either as a participant or an observer

As one of the defined deliverables (STMVal_D1.4) described in the project definition document, it is expected that the International PortCDM Council (IPCDMC) will now continue in its role of providing international governance and practical guidelines for the different stakeholders that wish to engage in an emerging PortCDM community of users and providers.

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44 Lind M., Haraldson S., Watson R.T., Ludvigsen P., Bergmann M., Andersen N-B. (2016) Role and routine of the PortCDM Council, STMVal_D1.4

45 APPLICATION FORM PART D, STM Validation Project (project no. 26169266), Connecting Europe Facility 2014-2020, TRANSPORT CALLS FOR PROPOSALS 2014
## Acknowledgements

We gratefully acknowledge the following organisations for their active participation and contribution to the validation of the PortCDM concept and to this report.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Contribution</th>
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<tbody>
<tr>
<td>AB Klippans Båtmansstation (Gothenburg)</td>
<td>Hutchison Ports BEST (Barcelona)</td>
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<td>AF Shipping AB (Umeå)</td>
<td>Inter Terminals Sweden AB (Gothenburg)</td>
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<td>Kvarken Ports Ltd (Umeå)</td>
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<td>Kvitsøy VTS (NCA)</td>
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<td>Maritima del Mediterráneo SA</td>
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<td>Mooring &amp; Port Services S.L. (Barcelona)</td>
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<td>Noatum Multipurpose Terminal (Sagunto)</td>
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<td>Bugser og Berging (Stavanger)</td>
<td>Noatum Terminal Valencia</td>
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<td>Northern Energy &amp; Supply AB (Gothenburg)</td>
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<td>Oy Backman-Trummer Ab (Vaasa)</td>
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<td>Oy Blomberg Stevedoring Ab (Vaasa)</td>
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<td>EUROGATE Limassol Container Terminal</td>
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<td>Securitas (Stavanger)</td>
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<td>Noatum Terminal Valencia</td>
<td>ST1 Refinery AB (Marine Terminal) (Gotenburg)</td>
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<td>Northern Energy &amp; Supply AB (Gothenburg)</td>
<td>SVITZER Sverige AB</td>
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<td>Oy Backman-Trummer Ab (Vaasa)</td>
<td>Swedish Maritime Administration (Gothenburg)</td>
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<tr>
<td>Oy Blomberg Stevedoring Ab (Vaasa)</td>
<td>Swedish Maritime Administration (Icebreaking management)</td>
</tr>
<tr>
<td>Oy Vaasan Hinaus - Vasa Bogsering Ab</td>
<td>Swedish Maritime Administration (Pilot organization Umeå and Gävle)</td>
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<tr>
<td>P&amp;O Maritime (Limassol)</td>
<td>Swedmar Shipping Services AB (Gothenburg)</td>
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<td>Tananger Pilot Station (NCA)</td>
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<td>Pilots’ Corporation of Valencia</td>
<td>TEMAGRA (Valencia)</td>
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<td>TSA AGENCY SWEDEN AB</td>
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<td>Port of Gothenburg</td>
<td>Vald. Andersons Shipagency AB (Gothenburg)</td>
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<td>Port of Stavanger</td>
<td>Vopak Agencies Sweden AB</td>
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</tbody>
</table>
Annex A: Online Questionnaire

Introduction

*PortCDM, joint survey*

This survey that you are kindly asked to complete, regarding (a) your daily work and (b) how you experience the port calls during the PortCDM focus month, is part of the evaluation process for PortCDM in the EU “STM Validation” project.

Your contribution is very important because you or your organisation participates in the living lab and the *PortCDM testbed* for which we thank you once more.

*Thank you! PortCDM Team*

**Questions in PortCDM concept validation questionnaire**

1. Which testbed (port) did you participate in?
2. Please check the box that best matches the description of your work
   - Port Authority
   - Pilotage
   - Towage
   - Mooring
   - Terminal
   - Security
   - Ship Agent
   - Customs
   - National Maritime Authority
   - Coastguard
   - Other (please specify)
3. What kind of information do you require regarding port calls to plan and execute your work?
   Information about...(multiple options available):
   - Anchoring Operations
Pilotage Operations
Ship Agent at Berth
Mooring Operations
Pilot Boat Operations
Pontoons & Fenders
Arrival Berth
Provision Operation
Ship Entering VTS
Departure Berth
Ready-to-Sail Operations
Security Operations
Bunkering Operations
Customs Clearance
Passengers Onboard
Cargo Operations
Slop Operations
Forklift Operations
Garbage Operations
Sludge Operations
Tour Operations
Gangway Operations
Towage Operations
Customs Clearance
Lube Oil Operations
Water Operations
Icebreaking Operations
Other (please specify)

4. What of the following options do you see as the biggest challenges to plan and realise an optimal port call?

Occupied berth
Low credibility of the information
Lack of updates from other actors
Pilot not available
Arrival/departure time
Lack of information transparency
Tugs not available
Weather conditions
Resource planning
Lack of information
Departure delays caused by cargo operations
Flexibility to changes
Changes not communicated
Changes in according to plan
Low reliability of shared information
Information not gathered in one place
Information not shared to all involved actors
Please comment on your answers

5. How would an ideal port call be carried out from your point of view?

6. What challenges do you experience when it comes to resource planning?

Lack of information from external actors
Lack of real-time information
Challenges to create situational awareness of the Port call
Too much administrative work
Too many phone calls
Low quality of shared information
Low quality of information
Too many emails
No standardised way to communicate changes
Too many systems to keep updated
Too much information to process
Low information transparency (not all relevant actors get the information)

Comments

7. What new business values/benefits do you see is being enabled by increased reliability of time stamp information?

8. Give an estimate of when you usually start planning your work regarding a port call (Several options can be relevant)?

   Two years before
   One year before
   Six months before
   Three months before
   Two months before
   One month before
   Two weeks before
   One week before
   12 hours before
   120 hours before
   6 hours before
   96 hours before
   5 hours before
   72 hours before
   4 hours before
   48 hours before
   3 hours before
   36 hours before
   2 hours before
   24 hours before
   1 hour before
   Other (please specify)

Focus Month PortCDM, PACT and PortableCDM

This part of the questionnaire focuses on how you interacted with PortCDM via PACT and PortableCDM during the focus month.

9. Have you used PortCDM in your daily work?
   Yes
   No

10. How did you use PortCDM in your daily work and could you please describe your daily work?

Focus Month PortCDM, PACT and PortableCDM

11. How did you interact with PortCDM
I used PACT on a computer
I used PACT on a smartphone
I used PACT on a tablet
I used PortableCDM on a smartphone
I used PortableCDM on a tablet

12. Could you please describe your daily work and why you did not use PortCDM?

The purpose with this part is to capture your perception of PortCDM as is in the test bed and in a full-scale implementation in the future.

13. PortCDM contributes to a shared situational awareness of port calls (meaning that involved actors get an overview of different events in a port call, with time stamps for the different actors intentions)

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<thead>
<tr>
<th>1</th>
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<td>I don't agree</td>
<td>I agree to some extent</td>
<td>I totally agree</td>
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Comments

14. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM contributes to a shared situational awareness of port calls (meaning that involved actors get an overview of different events in a port call, with time stamps for the different actors intentions)

<table>
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Comments

15. PortCDM enables an enhanced basis for making better estimates.

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Comments

16. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM enables an enhanced basis for making better estimates.

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Comments

17. PortCDM enables better access to reliable information.

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Comments

18. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM enables better access to reliable information.

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Comments

19. PortCDM has created a greater awareness of different actors’ intentions

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</table>
Comments
20. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM has created a greater awareness of different actors’ intentions

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Comments
21. PortCDM has improved my work procedures

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Comments
22. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM has improved my work procedures

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Comments
23. PortCDM has reduced the time spent information gathering from multiple applications/actors

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Comments
24. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM has reduced the time spent information gathering from multiple applications/actors

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Comments
25. PortCDM has reduced my administrative work load per port call

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26. In a situation where PortCDM is full-scale implemented in your port, rate the likelihood in the following statement: PortCDM has reduced my administrative work load per port call

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</tbody>
</table>

Comments
27. Do you have to wait for other actors (including the ship) in the port call?
   Yes
   No

28. How much time would you estimate you spend on waiting for other actors (including the ship) per port calls?
   Less than 20 minutes
   20-40 minutes
   40-60 minutes
PortCDM in STM

PortCDM is not just a technical solution, but also has a collaborative model/concept that has been promoted by living labs and port actors and other stakeholder meetings. The following questions are themes of discussion that is to be discussed around based on the experience from running the living lab meetings.

The following questions will ask you about your experience from participating in these LL.

29. Have you participated in a living lab meeting or other meetings during the last 2½ years?
   Yes
   No

30. On a scale from 1 to 5 how would you rate the importance of the living lab meetings?
   Not at all Satisfied
   Partly Satisfied
   Satisfied
   More than Satisfied
   Very Satisfied

31. As an outcome from participating in one or more LL meetings, did you start to talk to port actors that you have not spoken to before?
   Yes
   No
   Not sure

32. Did you as a result of the project start to collaborate with the new actors?
   Yes
   No
   Not sure

33. In what way did you start collaborating with new actors?
   Please describe

34. Did this collaboration enhance your own operations?
   Yes
   No

35. How did it enhance your operation?
   Please describe

36. Did you gain any new knowledge/information of other actors operations by participating in the meetings arranged within the project?
   Yes
   No

37. Will this new knowledge/information have an importance for your port operations?
   Yes
   No
38. Do you have any example of such new knowledge/information? We would appreciate if you could give us a short user story or examples of where such knowledge/information could or have been of help in your daily work.

39. Please indicate which of the following age range you belong to:
   >20
   20-25
   25-30
   30-35
   35-40
   40-45
   45-50
   50-55
   55-60
   60-65
   >65
Annex B: Open questionnaire for personal interviews

Introduction
Dear PortCDM user,
You have been one of several in your organisation that have used PortCDM to create a shared common situational awareness of the port calls. The purpose of this interview, is to reflect upon the PortCDM concept, the intended effects and benefits and identify potential shortcomings and areas of improvement for further development.

Interview questions for PortCDM concept validation

Background questions
1. Where do you work and what is your exact role in your organisation?
2. With how many calls do you approximately deal with every month?
3. How many years have you been working for your organisation?
4. What is your primary role during the port call process?
5. What are the biggest challenges you face in your kind of work?
6. How would an ideal port call be carried out from your point of view?
7. What kind of information would you require to do better planning (resource / stowage / equipment / berth)?
8. What type of real-time information do you currently lack?
9. During your daily work have you been calculating any KPIs and especially:
   - Predictability
   - Waiting times
   - Berth productivity
   - Port productivity (time at berth / time in port or traffic area)

Questions on the use and benefits of PortCDM:
10. Have you used PortCDM as a part of your daily work? If not, why?
11. If you used PortCDM in your daily work, in what way did you use it? Would you like to continue using the tool in your daily work? What problems did you identify?
12. If you didn’t use PortCDM, could you state the reasons why you did not use the tool? Would you like at some point to start using the service?
13. What new features would you like to see in our tool? Why? How do you envision this new feature implemented? What problems do you expect it to solve?
14. What is your overall impression of PortCDM (as-is) in the test bed?
   - Benefits/Values? Elaborate
   - Shortcomings/ Areas of improvement? Elaborate
1. In a situation where PortCDM is implemented in a full-scale in the Port, what benefits do you see?
2. Elaborate on how your ability to plan/make estimates has been affected by PortCDM?
3. Why is PortCDM needed in your opinion?
4. PortCDM enables information transparency. Why is that important in your opinion?
5. PortCDM enables increased information quality through the use of multiple data sources. What is your opinion on this?
6. The basic idea behind PortCDM is actors sharing of information. Do you see any obstacles in sharing information? If yes, which?
7. PortCDM enables common situational awareness by actors sharing port call related time stamps that are not business critical. Do you lack any information that in your opinion should be shared?
8. Which information do you believe is most valuable to share In PortCDM?
9. Which benefits could be achieved by consuming time stamp information from other actors within the port, related to ship movements, and between ports and terminals (outside their own port)? Is it possible to quantify these benefits?
10. Would you say that PortCDM has reduced the administrative part of your work? If yes, how?
11. Would you say that PortCDM has reduced the interactions (number of phone calls, e-mails, and suchlike) related to searching information about a port call?
12. What is in your opinion the most revolutionary feature/ effect in PortCDM?
   a. Common situational awareness for Enhanced Coordination
   b. Increased Predictability for Extended Planning Horizons
   c. Port-to-Port Collaboration
   d. Information Transparency
   e. Digital Collaboration
   f. Physical Collaboration
   g. Increased information quality
   h. Port Call Synchronisation
   i. Anything else?
13. Can you tell us a story where PortCDM has helped you during your daily work?

Questions on collaboration and information sharing

14. Have you participated in living labs and other PortCDM related meetings during the last 2 years? How often?
15. Have the living labs or other meetings related to PortCDM during the last 2 years, been of value?
16. Have these meetings facilitated an enhanced interaction among the port actors?
17. During the last 2 years, have you increased the collaboration in port call operations among you as a community?
18. Have things changed for you during the last 2 years due to enhanced collaboration?
19. Did you gain new knowledge of the other actors operations by participating in such meetings?
20. Has data sharing increased your (as a single port call actor/ as a port as a whole) competitive advantage?
21. How has your attitude to share data with others changed during the last 2 years?
22. Do you have any example of when increased collaboration has been of value? We would appreciate if you could give us a user story or examples of where such information could or has been of help in your daily work.
Annex C: Stories

PortCDM validation trial participants were invited to provide a short user story or examples of where PortCDM could or has been of help in their daily work.

DP World - Limassol

“As it is among my duties to deal with berth, operations, stowage and shifting planning I was aware from the morning that a specific ship was scheduled from the service provider P&O MARITIME to depart from our terminal at 15:00 hours (ACTUAL TIME TO UNBERTH).

I received this information – as always through an email from P&O MARITIME.

Having this knowledge in mind, I had made all the necessary arrangements, prepared the respective plan and notified the appropriate people within the terminal.

Nonetheless at some point in the morning and while I was updating the PORTCM system (which I usually use to enter three specific timestamps: all fast, unberthing and ATA; I saw a last minute update coming from P&O MARITIME regarding this ship, that it was rescheduled for leaving the port at 20:00 instead of 15:00 that -as I said before, was stated previously in the respective email. When I saw in the PortCDM system that the specific ship (probably due to priority reasons) was rescheduled to unberth from our terminal five hours later than the expected time, I took immediately the appropriate measures and changed all the related planning. After about 40 minutes I received in my email an update from P&O MARITIME that informed me of this change in the schedule of the ship. Thus, using the PortCDM system I was able to receive this information before the email and as a result I made all the appropriate changes on time without delay!” - Participant from DP World, Limassol

P&O Maritime - Limassol

“Every day early in the morning I prepare my daily planning. During this time, I have to prepare the ship priority list, and make the necessary arrangements for pilotage, towage and mooring as well as to find an appropriate berthing place for the ship in collaboration with the two terminals DP WORLD and EUROGATE. All these are being updated in my company’s system called WAVEZ - HMS.

Also I regularly use the PCS system and the PortCDM desktop application, for cross checking the data in my system. Doing this, and checking a specific ship’s port call timeline in the PortCDM system I came to the conclusion that a ship coming from Lebanon had been delayed without the respective agent notifying on this either through the PCS system or via email / telephone communication.

I had previously noticed this on my own system, but upon checking more carefully and in depth the ship’s graphic timeline through the PortCDM desktop application helped me to extract safer conclusions. Using this knowledge I was able to reschedule my berthing planning on my system and make the necessary adjustments regarding tugs, pilots and linesmen reservations. Having done this, I sent the necessary work orders to the people required for serving the ship and informed the rest stakeholders, for example, the two terminals, and suchlike through an email update” - Participant from P&O Maritime, Limassol

Eurogate - Limassol
“Despite the fact that I don’t use regularly PORCDM for my work as I deal with my own systems - TopX and COIN, for organising the processes, I saw that the system has the potential to offer us the capability of minimising the time allocated for communicating with P&O Maritime and the agents and provide us with better port overview and a cleared image of incoming ships. Moreover through the provision of real-time information and especially ETS (estimated time to sail) and ETAs from nearby ports, the service can help us improve berth and resource planning. I hope to see these improvements in the near future and I am very happy that I was able to contribute in the project.” - Participant from Eurogate, Limassol

Limassol VTS

“As discussed in many face to face meetings and living labs the basic problem here is that nearby ports are very close, so if something goes wrong there is little time for reaction. For instance, you can wait for a ship from Alexandria to the Limassol port, at a specific time, you make the necessary arrangements and at some point of the day you find out that it is arriving in Limassol many hours after its expected ETA (that had previously been entered in the PCS by the agent of the ship). This delay may have been caused by unforeseen weather conditions that delayed the ship but nobody notified the Limassol VTS station or any other company operating in the Limassol port about this. Having used the PortCDM and knowing its capabilities I am convinced that it can offer us the functionality of having all the ATD timestamps of ships coming to Limassol from the nearby ports of Israel, Egypt, Greece, Lebanon, and so on. This will enable us to have a wider picture of the situation, to update accurately the ship ETAs without the need of communicating with the specific ship’s agents. Having immediate access to the necessary information will enable us to become more efficient and proactive.” - Participant from Limassol VTS

Cyprus University of Technology (CUT)

“As discussed in many face to face meetings and living labs the basic problem here is that nearby ports are very close, so if something goes wrong there is little time for reaction. For instance, you can wait for a ship from Alexandria to the Limassol port, at a specific time, you make the necessary arrangements and at some point of the day you find out that it is arriving in Limassol many hours after its expected ETA (that had previously been entered in the PCS by the agent of the ship). This delay may have been caused by unforeseen weather conditions that delayed the ship but nobody notified the Limassol VTS station or any other company operating in the Limassol port about this. Having used the PortCDM and knowing its capabilities I am convinced that it can offer us the functionality of having all the ATD timestamps of ships coming to Limassol from the nearby ports of Israel, Egypt, Greece, Lebanon, and so on. This will enable us to have a wider picture of the situation, to update accurately the ship ETAs without the need of communicating with the specific ship’s agents. Having immediate access to the necessary information will enable us to become more efficient and proactive.” - Participant from Limassol VTS

“From our side as living lab coordinators we experienced the transfer of commercial operations at Limassol port to private operators. The concession deal completed in 2016 and as we mentioned on previous documents in January 2017 three consortiums took over the port operations:

- DP World Limassol received a 25-year concession for the exclusive right to operate the multipurpose terminal, whose activities include break-bulk, general cargo, ro-ro and the operation of the passenger terminal,
- P&O Maritime Cyprus, a subsidiary of DP World Limited, won a 15-year concession to provide a full range of port marine services including tugs and pilotage at the port; and
- a consortium comprising EuroGate International GmbH, which has the majority holding, Interorient Navigation Company Ltd, and East Med Holdings S.A, has taken control at the port’s container terminal.

CUT coordinated the living lab before the privatisation for one year (January 2016 to December 2016) having as basic participants only people coming from CPA (tug operators, pilots, VTS operators, IT officers, quay inspectors, mooring men) and continue the living lab coordination for another two years after the privatisation (January 2017 to December 2018).

This change on the operational and managerial status of the port was also a challenge for us as we had to start the living lab process from the beginning, to bring people together from different organisations (that as someone can understand might be competitors) which until
then didn’t know anything about the project and moreover to convince them to actively participate and contribute.

Also we had to record again all the procedures/ processes regarding arrival and departure, for example, the metro maps, the information exchange among the actors, ways of communication, and suchlike as we had to do now with 4 different organisations (CPA, P&O Maritime, Eurogate and DP World).

In order to bring in the new actors in the living labs we organised several face-to-face meetings where the project objectives and aims were explained thoroughly and of course from their side provided an opportunity to provide information about their organisations.

We are happy now to report that all the private operators are active participants in the living labs having been involved in both focus months through the provision of data input. A connector to P&O’s system is nearly completed something that will help in the further future development of the service in the port of Limassol.

Thus we are convinced that these participants will continue to be committed with the PortCDM concept after the project ending and will be involved also in future projects such as STEAM, and suchlike.” - Participant from Cyprus University of Technology

Boluda Remolcadores - Valencia

STORY 1

“Before starting to use the PortCDM system and the necessary connectors we had to update electronically the information regarding our service provision twice per day, both in our own system and in the Port Authority system as well, because these two systems were not interconnected. We believe that the automatic connector established during the PortCDM testing period will help us to avoid the necessity of human intervention for this daily reporting to the Port Authority that was highly time consuming.” - Participant from Boluda Remolcadores - Valencia

STORY 2

“For our work we have limited resources available (five tugboats are being used in the Port of Valencia) and one tugboat can be used in Sagunto too. A system such as PortCDM that can provide us with real-time information regarding port calls and accurate estimations about future events will allow us to optimise the use of our tugs and it will help us to carry out an optimal maintenance (and better scheduling when to perform the downtimes).” - Participant from Boluda Remolcadores - Valencia

Amarradores del Puerto de Sagunto

“Our involvement with the PortCDM system was positive for our organisation as it helped us to overcome resistance to change (“attitude refuse to change”) and start using digital devices on a daily basis.” - Participant from Amarradores del Puerto de Sagunto

Marmedsa - Ship agent - Barcelona

“Just to mention that we currently operate in private and public berths. In public shared berths, we lack a common situational awareness to plan our port calls. The procedure we follow involves:
1. Check the PORTIC systems to review other scheduled port calls on these dates (web interface)
2. Check port calls going to adjacent berths (web interface)
3. Check with Berth Planning (Phone call)
4. Check with all Terminals sharing the berth (Phone call)
5. Check with Agents from other concurrent Port calls

All this hassle just to know if there could potentially be any port call overlaps. This could be saved with a Full scale PortCDM implementation.

Port officer Stavanger

“In my work I also do some of the invoicing for services that has been provided for a ship during its port call and normally I have to wait for the papers to come in where I can see the times so I can start the process with the invoices. In PortCDM I can sometimes find the information about those services if they have been started or completed and then I can start making the invoices directly if want to”.

VTS Stavanger

“I use PortCDM on a daily basis since it is a good tool for me to use to check which berth the ship is going to. I don’t have to investigate where the ship is going and that’s useful and I can see if the actors in the port is ready to receive the ship at berth which is good for the coordination. Ships over a certain length will block the entrance to some of the areas in the port for other ships if they go in and the berth is not ready, which makes it important to be able to see if the berth is free and ready in dens areas with a lot of traffic.”

Pilot Stavanger

“When I go onboard a ship to take it in to the berth, I can see if the berth are free and they are ready to receive the ship. Then I don’t have to start making phone calls if the captain asks me questions which doesn’t looks professional and I can focus on the my job.”

Moorer Umeå

“We had a tanker ship bound for the port that had an ETA to berth. When I looked in PortableCDM after office hours I could see that ETA had just been updated to an earlier time than it was planned from the beginning. Since I saw that change in the ETA I could replane my work and adjust to the new time and be at the berth ready to serve the ship when it arrived.”

Pilot Umeå

“When the ship is in PortCDM I don’t have to start Marine traffic to check where the ship is sin PortCDM is much faster. Also if you look on Marine Traffic there might be ships with the same name so if you are unlucky you look on the wrong ship and since PortableCDM also now have the length and the breadth of the ship I can find those details also without starting my organisations own system to find that information since I have it in PortableCDM on my phone.”

Ship Agent Gothenburg

“Finally, a step forward for the shipping industry since now I can finally see real-time data from other actors. Me as quite new on the job as a ship agent I haven’t understood why we have to send all the emails and make all the phone calls when we can share the information in real-
time to everyone at the same time and we don’t have to call and search for information since we can see real-time information from other actors once it is updated."

Terminal Gothenburg

“For us as a terminal having some ships going to another terminal in our port to load or discharge some cargo before coming to our berth for operations PortCDM is a good tool to get information when the ship is ready to come over, when the pilot is booked etc. Then I can make my plans for our operations when I have those times."

Ship Agent Vaasa

“PortCDM and the APP PortableCDM gives me the advantage that I don’t have to sit down in front of the computer as often as before. I can update times for the port call via the app quickly. This is also especially good during the weekends and we have ships arriving in the beginning of the week after, when you just update the times in PortCDM and avoiding making phone calls and send Emails. It is also good that you get real-time information when the ship is coming into the port area, so you know better when it will be at berth. To get the times for cargo operations commenced and completed is good even if it isn’t updated all the time but when it is updated you don’t have to call for those times since the information was shared in PortCDM.”
Annex D: PortCDM validation trial participants opinions on the living lab process

A percentage of 95% of those that provided feedback for this report (either through the interviews or through the online questionnaires) had participated at least once in the living labs that were organised in their respective ports. Some of them participated from the beginning of the project while others participated only in a few meetings. All the participants found the living lab meetings very interesting and they believed that this offered them multiple benefits. One of them working as a VTS operator (Limassol port) said that they considered the living lab meetings as “think tanks” while another participant (berth planner) working for a marine service company also in Limassol said that they believed that they were “valuable brainstorming sessions”.

All believed that the living labs contributed positively towards port collaboration and that it was interesting to hear other people’s views. Participants think that it is important that these living lab meetings are being attended from the most important people that participate in a port call. Some of the opinions expressed referred to better and closer collaboration and understanding of other stakeholders insights, what they are doing and what is their exact role in a port call process. Some respondents said that they met people face-to-face for the first time despite the fact that they had been communicating previously for some time through email exchange, telephones, and suchlike.

Others said that they understood better the necessity of having a common platform and information at one place. Some of the interviewees said that in their opinion the living lab concept taught them that they can work and behave as a team targeting on the solution of common problems and ways to improve as organisations individually but also as a local port community at a whole.

It was quite positive that all the participants supported the concept of sharing of information through PortCDM as enabling them to improve the way of solving problems and through the discussion and the exchange of opinions in the living labs many questions were answered. Also people referred positively to the fact that everyone that participated was allowed to freely express their opinions. A majority of the respondents confirmed that this situation enabled a better understanding for the other actors’ roles in the port call and they now have a broader understanding of the full port call process.

A pilot in Stavanger said that they liked the fact that the living lab meetings took place at the different actors’ offices so they had the chance to observe in more detail what other people were doing in their work. Moreover all those that participated in the interviews seemed to have a positive attitude and to understand the importance of sharing real-time information. It is interesting to quote what some people said regarding the living labs process:

- An operations manager at Limassol terminal said “I am grateful for having the chance of meeting people I collaborated for some time without knowing them in person till then, and that through this process I became more open to suggestions and tips from other actors. During one lab I heard the participant working from the other terminal of the port describing a technique that they were using in their work, something that I found very useful and I am now applying to my job as well”.
A person coming also from a terminal in Limassol said “Through my participation on the living labs my daily communication and collaboration with persons working for the other port terminal were improved because of the friendlier relationships we developed, (we had never met face-to-face before the living labs).”

A tugboat operator in Stavanger said that “I think it has been great that I’ve been able to meet the others and see what’s going on in other ports in Norway that we would know. I might have been sounding a bit negative on the meetings but that’s just because I need to say something if I have another opinion in some questions.”

A traffic manager in Vaasa said “I think it’s been good. This was the first time I met our new agent at such a meeting, I had a pretty good picture of what the actors were doing but I have received new information about the Stevedoring company and the Ship agent/logistic company.”

A participant working also for a terminal in Limassol said “I think the most important was that people from different backgrounds sit together and were able to see the whole picture and think beyond our organisation’s point of view.”

A pilot in Umeå believed that “Yes, it's great that you get involved and can influence opinions. Get an insight into it all and share that with colleagues so they know when it comes out.”

A shipping agent working in Vaasa said “That is of course interesting. I do not meet those I've met at meetings at work so it is interesting to hear what they say and think about their situation. They also seem positive to get a transparent sharing of times.”

A person working for Umeå terminal said “Interesting to know others' point of view, what they think and think about things. Usually you are in your own bubble and interesting to know the other views on things”

A shipping agent from Gothenburg referred to the fact that “There was open discussion among actors that have different interests and information needs and when they need it.”

A berth planner working for a marine company in Limassol said “Until I started participating in these meetings I was not aware that person X coming from the one of the two terminals of the port makes also the logistics. We collaborated for over a year and I learned it when we participated in the living labs organised at Port Authority premises.”

A participant working for a terminal in Gothenburg said that “Challenges wouldn’t have been put on the table if we didn’t have these meetings and talked about it.”

A representative of consignees’ interests in the port community in Barcelona said “It has been interesting to see that there are initiatives that can fulfil our needs if implemented fully.”

A point of concern raised by some participants was the level of commitment that would remain after the project was completed.
Annex E: Publications related to the PortCDM concept


Lind M. (2016) Port Call Message Standard, version 0.5, ENAV19-6.6, IALA


Lind M. et al. (2014) Identifying the Scope of Sea Traffic Management: The Interface to Ports Operations, position paper with preliminary findings, MONALISA 2.0

Lind M. et al. (2014) Sea Traffic Management in MONALISA 2.0, position paper with preliminary findings, MONALISA 2.0


Lind M., Bergmann M. (2018) Functional Definitions of Port Call Message – The Ability of the Port Call Message Format to address functional definitions for nautical port call information, STM Validation project


Lind M., Haraldson S. (2016) New KPIs will show how ports become more efficient with PortCDM, Newsletter December 2016, STM validation project


Lind M., Haraldson S., Watson R.T., Ludvigsen P., Bergmann M., Andersen N-B. (2016) Role and routine of the PortCDM Council, STM validation project


industry more profitable through PortCDM, Concept Note #17, STM Validation Project (https://www.ipcdmc.org/galerie)


Annex F: Criteria for PortCDM compliance. Enabling enhanced collaborative capabilities of ports

Standardised and Transparent Data Exchange

Maritime transport is global, involving multiple ports with multiple stakeholders. 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 shipping companies, and between ports and hinterland operators. The PortCDM port call message format for event-based data has recently been agreed by IALA to be finalised as the S-211 standard. Furthermore, by design, the S-211 message format will also be fully compatible with the functional definitions for nautical port information, as proposed by UKHO and IHMA. As a result, this development will enable all actors (including the ships) involved to communicate and coordinate plans, outcomes, and changes related to events in port call operations.

Having a standardised and transparent exchange of all time stamps for the planned and actual time of events will enable the actors to achieve enhanced situational awareness. This improved situational awareness will in turn provide the port call actors with improved capabilities for coordinating and executing their operations just-in-time, thereby raising the efficiency and effectiveness not only their own, but also of the port’s overall operations.

Harmonisation of Operations

To achieve this, two levels of harmonisation are proposed: the local level, emphasizing necessary alignments between port call actors within a specific port; and the global level, emphasising necessary alignment between ports and their external stakeholders in the global maritime transport chain.

PortCDM, which has been developed and tested/piloted as part of the MONALISA and STM Validation projects, is a key enabler of STM. PortCDM covers the following aspects of port operations harmonisation:

- Time stamp data from multiple sources associated to the same port call as well as voyage identifiers so as to enable a holistic view, higher transparency, and enhanced situational awareness
- A unified format for port call messages (the port call message format(S-211))
- 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)
- A governance structure at the global, regional, and local (port) level:

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47 UKHO, IHMA (2018) Functional Definitions of Nautical Port Information
48 The KPI’s of PortCDM are: Duration time, waiting times/anchoring times, predictability, punctuality, berth productivity, and capacity utilization (c.f. Lind M., Haraldson S. (2016). New KPIs will show how ports become more efficient with PortCDM, STM Validation project)
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

- Compliance of port actors meeting levels of maturity

To ensure that the expectations of all PortCDM participants can be properly met, criteria for different maturity levels have been developed. The criteria reflect the different stages of PortCDM maturity that are either desired or expected of a particular actor in the maritime transport chain. This is based on the operational capabilities that others would expect of a port and the reliability of keeping operations “just-in-time”. The different maturity levels for PortCDM should not be confused with the capabilities or professionalism at a given port; it simply identifies with defined specifications, which level of implementation of PortCDM a given port has established. A given level may be seen as an implementation phase of PortCDM with the aim of achieving a higher level later in the implementation, or, for another port, it may be seen as the current end state in implementing PortCDM given the local circumstances.

Accreditation of these different levels is defined in conjunction with three types of capability dimension giving rise to necessary criteria for ports, applications, and collaboration principles to be adopted for local and global integration; (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 timestamps based on the port call message format (PCMF) according to the S-211 standard. This foundational capability is key to being PortCDM compliant, and is the basis for developing the various incremental maturity levels of PortCDM. Even the basic level of capability will enable both internal (local) and external (global) port collaboration, thereby expanding the planning horizons and enabling each actor to inform down-stream actors about progress and possible disruptions using a standardised format.\(^5\)

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Annex G: Examples of metromaps developed by the different testbed ports

Nordic testbeds

Port of Gothenburg (Sweden)
Port of Stavanger (Norway)

Port of Umeå (Kvarken ports) (Sweden)
Port of Vaasa (Kvarken ports) (Finland)

Mediterranean testbeds
Port of Barcelona (Spain)
Port of Valencia (Spain)

Port of Sagunto (Spain)
Annex H: Details about digital apps developed by third parties

The following information sheets describe the digital apps developed for use as part of the PortCDM validation testbeds.

- PortableCDM
- Portable Captain
- Portable Agent
- Portable services
- Portable Berths
PortableCDM

PortableCDM

PortableCDM is a general-purpose, fully featured PortCDM interaction tool for mobile devices. PortableCDM provides users with an easy way to access, monitor and update forthcoming, present and completed port calls at a given port. Users can report new timestamps for selected port calls. PortableCDM accesses timestamp information according to the Port Call Message Format (c.f. IALA S 211) and adopts the principles of data sharing and situational awareness according to the Port Collaborative Decision Making (PortCDM) concept, as part of the Sea Traffic Management (STM) project. Users are authenticated through the Maritime Connectivity Platform (MCP). The application connects to APIs for consumption and submission of timestamps provided by PortCDM compliant data sharing platforms. The application was created as a mobile complement to the web-based PORTACT system. It is designed to cover almost all features that are available from PortCDM and can be used by users wishing to share and view real-time information about a port’s activities.

Features

1. Active port calls
   To get a quick overview of port activities at the given port. Users are presented with a list of past, present, and upcoming port calls, which includes relevant details such as current stage and vessel name. The port calls can be searched, filtered, and added to a list of favorites, enabling quick and easy customizable access to relevant information.

2. Port call timeline
   A sequential timeline of all port call events at the given port is provided, giving the user a more detailed overview of the port calls. Individual timestamps and potential warnings can also be accessed, allowing users to quickly identify and address potential issues. This allows increased informational awareness of the port through more efficient communication. The user can submit new timestamps from the timeline, thus enabling rapid information sharing on the fly. The app is dynamically updated when new information becomes available through the PortCDM platform.

3. Berth timeline
   The berth timeline presents the user with a GANTT scheme that provides the user with a graphical overview of past, present, and upcoming port calls at the given berth place. The timeline can be customized with advanced filters and berths can be added as favorites, giving the user detailed control of the information they are presented with.

4. Port call submission and creation
   Users can effortlessly submit timestamps for all states and timetypes, according to the Port Call Message Format (c.f. IALA S 211) for their port call. Users can also easily create new port calls for any vessel. This facilitates the communication process and reduces the technical and practical obstacles associated with information sharing. When creating a new port call the app helps the user to fill in the fields with appropriate information.

5. Notifications
   PortableCDM can deliver push notifications to all mobile devices, allowing users to effortlessly be notified regarding real-time port events without having to manually interact with any of the PortCDM tools. The notification system can be configured using advanced filters, and thereby tailored for very specific use cases. Configurations can be configured for combinations of states, vessels, locations, timetypes, warnings, and port calls. Users can also choose when they want to be notified in relation to events of interest.

6. Vessel information and position
   PortableCDM also exposes real-time vessel information for vessels selected by the user, including vessel position, status, speed, draught, and more. This is displayed on a live map where other vessels can also be seen. Additional vessel information can also be accessed.

Why is there a need for PortableCDM?

PortableCDM delivers all the features associated with the PortCDM platform in an easy accessible format. By enabling mobile access to shared real-time operational information, PortableCDM saves time and reduces the administrative burden for users in the port - captains, agents, moorers, administrators, and other port actors. PortableCDM also encourages users to share information concerning their own operations, thereby contributing to a more collaborative environment where decisions can be more informed, and the efficiency of the port can be increased.

PortableCDM as part of STM and PortCDM

STM connects and updates the maritime world in real time with efficient information exchange. In the IALA the standardized container revolutionized shipping. The next evolution is the containerization of information – creating a safer, more efficient and environmentally friendly maritime sector. PortableCDM has been developed within the STM validation project, as part of activity 1 (PortCDM testbeds), and aims at being used for validation of the PortCDM concept.

For more information please contact:
Mikael Lind, Activity Leader PortCDM testbeds, RISE Viktoria, Mikael.Lind@ri.se
Sandra Haraldson, Activity Leader PortCDM testbeds, RISE Viktoria, Sandra.Haraldson@ri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@ri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se
Portable Captain

Portable Captain is a mobile application designed with the needs of connectivity between sea captains and ports. Utilizing PortCDM functionality and real-time information, the captain would be able to monitor the progress in the port related to his/her upcoming, ongoing, and conducted port calls. By combining all the reported port calls of a route in one view, the information is presented in a more efficient manner and gives a better perspective of the whole route. Timestamps for the ongoing port call are displayed segmented in different views best suited for the current stage. Portable Captain accesses timestamps information according to the port call message format (e.g., MAA L2 L1) and adapts the principles of data sharing and situational awareness according to the Port Collaborative Decision Making (PortCDM) concept, one of the enablers of Sea Traffic Management (STM). Users are authenticated through the maritime connectivity platform (MCP). The application connects to APIs for consumption and submission of timestamps provided by PortCDM compliant data sharing platforms. The application was created as a complement to the more general PortableCDM application for the purpose of providing sea captains with their tasks in fulfilling needs in multiple port calls.

Features

1. Timeline
   In a sea transport, ships visit multiple ports during each route. To make it easier to stay up-to-date, Portable Captain has combined multiple port visits into a single view where the user can, in a glance, get real-time timestamps via PortCDM. This is possible for the ports that are equipped with PortCDM capabilities. This gives a more cohesive overall picture of the planned route rather than having to find these records separately.

   The view is comprised of Port Calls in a descending order with adherent collapsed operations underneath. Making for an information dense and complete yet manageable overview.

2. Before-During-After Port Call
   Timestamps for operations in the ongoing port call have been segmented into three parts, best suited to the nature of the different stages. By this, the user is presented with Port Calls reporting references.

3. Services
   An important part of any port call is the utilization of port services and the planning and booking thereof. Portable Captain offers a view listing the most common services at the port of the ongoing port call and a quick way of sending a PortCDM statement making a request for these services.

4. Vessel Information
   Portable Captain has plans to add the ability for a captain to update data about the current vessel and relay them to PortCDM, to keep all involved parties up-to-date on vessel data. Keeping records regarding a specific vessel is important in both an efficiency aspect in order to negate unnecessary communications. It is also important from a safety aspect that all weights and measurements are accurate.

Why is there a need for Portable Captain?
Due to an increasing port-to-port connectivity, the need for captains to be more involved by sharing real-time information to the PortCDM ecosystem via the use of the mobile application, Portable Captain, lets captains participate in a more collaborative information environment that increases port efficiency and reduces unnecessary administrative burdens, delays and the environmental impact.

Portable Captain as part of STM and PortCDM
STM connects and updates the maritime world in real-time with efficient information exchange. In the 60s, the standardization of containerized shipping was the next revolution in the containerization of information — creating a safer, more efficient and environmentally friendly maritime sector. Portable Captain has been developed within the STM validation project as part of activity 2 (PortCDM testbeds), and aims at being used for validation of the PortCDM concept.

For more information please contact:
Mikael Lund, Activity Leader PortCDM testbeds, RISE Viktoria, mikael.lund@fri.se
Sandia Harahbous, Activity Leader PortCDM testbeds, RISE Viktoria, sandia.harahbous@fri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@fri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se

For more information please contact:
Mikael Lund, Activity Leader PortCDM testbeds, RISE Viktoria, mikael.lund@fri.se
Sandia Harahbous, Activity Leader PortCDM testbeds, RISE Viktoria, sandia.harahbous@fri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@fri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se
Portable Agent

PortableAgent is a mobile application designed for ship agents to streamline and enhance their daily work which often requires being on the move. By providing agents with an easy way to access and store relevant information, it gives them valuable tools needed both inside and outside the office. PortableAgent accesses time stamp information according to the port call message format (i.e. MAKAS-212) and utilizes the principles of data sharing and situational awareness according to the Port Collaborative Decision Making (PortCDM) concept, one of the elements of Sea Traffic Management (STM). Users are authenticated through the maritime connectivity platform (MCP). The application connects to APIs for consumption and submission of time stamps provided by PortCDM compliant data sharing platforms. In the ecosystem of PortCDM it serves to extract the most important features of the generic mobile application. PortableCDM, in order to provide agents with an efficient and digitized workflow. By transitioning towards a deeper integration of digitalization, ship agents will be able to take advantage of new technologies and successfully adapt to change in their environment. In a field that is currently seeing rapid progression towards new methods of efficiency and cost reduction, this is crucial in order to stay competitive and relevant not only today, but also tomorrow.

Features

1. Port call List
    Agents are responsible for many port calls each week and have a lot of tasks to keep track of. PortableAgent provides the user with a list of all port calls at the current port, which is selected upon login. Port calls that are assigned to the agent can be marked as favorites in order to filter the list and simplify navigation. When a port call is favored, it becomes accessible through the top right corner and is always just a tap away. This is useful when

2. To-Do checklist
    When a port call has been selected in the Port call list, the agent gets access to several other tools to manage it. One is the ability to list specific requests that can be made and sent from the PortableAgent and the other applications of the ecosystem to the specific agent. When entering the To-Do page with a new port call selected, a pop-up will ask what particular events to scan for. If needed, this can be changed later, as well as customized in the settings as to which events should be pre-selected for future port calls. PortableAgent also allows the agent to create individual checklists with tasks specific to each port call, which simplifies managing and planning what needs to be done. These tasks can later be attached to a service provider in order to keep track of who is doing what. Since agents sometimes have to board the vessel, it is also useful for taking notes and remembering important details. In short, the checklist gives the agent an overview of what needs to be done, what is being done, and what has been done—but also who is responsible for it.

3. View Requests
    In the Requests view, an overview is shown of all requests that have been made on the port call that are currently marked as favorites. The page consists of two views, where one shows Requested events and the other shows Completed events. The requested events that

4. Service Providers
    The Service Providers page is essentially an enhanced address book, letting the agent keep valuable contacts easily available and more importantly, keep track of what they are doing. Each service provider can be attached to a specific task created in the checklist for a port call. The service provider page, there is an overview of all currently assigned jobs that the service provider is responsible for, as well as their status. This page also contains a business card with details such as contact information, as well as the possibility to add any other information that may be of importance. Ship agents have a lot of contracted partnerships with service providers. Some are used frequently while others are used less often. Partners that are used often can be marked as favorites to quickly find them. Whether a service provider is in advance, or by short notice, having quick and easy access to all partnered service providers is essential in order to ensure accommodation of a vessel’s needs to enable an efficient port visit.

5. Settings
    The Settings view lets the user define pre-selected templates for default tracked events, as well as make custom queries for these tracked events. As an example, the user could make a query so that Timezone operations always have the following parameters: “Number of tugboats needed into the port” and “Number of tugboats needed out of the port”. These queries can then be added to the checklist, so the user remembers them when calling the service provider. Settings also allows the user to turn on notifications. Notifications are a big part of PortableAgent as they notify the agent as soon as a specific event has been created, updated or completed. Since an agent’s work relies heavily upon information, it is important that the information is valid. Therefore, notifications are crucial to ensure that the agent is always up to date, which is enabled by being connected to the information sharing environment in the port.

Why is there a need for PortableAgent?

Ship agents are an important part of each port. They are distributors and coordinators of services and ensure that the vessels they manage have smooth and efficient port calls. Much of their daily work requires them leaving the office, and as of such it is important that they always have access to the tools they need. When on the move, their most valuable tool is their mobile device. By gathering all different sources of information and putting them in the same place, we ensure that agents have a quick and easy access to everything they need, effectively letting them provide an even better service to their customers.

PortableAgent as a part of STM

STM connects and updates the maritime world in real time with efficient information exchange. In the 60s the standardized container revolutionized shipping. The next revolution is the commercialization of information – creating safer, more efficient and environmentally friendly maritime sector. PortableAgent has been developed within the STM validation project, as part of activity 2 (PortCDM testbeds), and aims at being used for validation of the PortCDM concept.

For more information, please contact:
Mikael Lind, Activity Leader PortCDM testbeds, RISE Viktoria, Mikael.Lind@ri.se
Sandrine Haraldson, Activity Leader PortCDM testbeds, RISE Viktoria, Sandrine.Haraldson@ri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@ri.se
Sandra Haraldson, Activity Leader PortCDM testbeds, RISE Viktoria, Sandra.Haraldson@ri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se

STM VALIDATION 1.3 – Improving port operations using PortCDM
Improving port operations using PortCDM


PORTABLESERVICES IS A MOBILE APPLICATION TAILOR-MADE SPECIFICALLY FOR PORTCalls SERVICE PROVIDERS ENGAGED IN PORT CALL OPERATIONS. IT IS TAILORED BOTH FOR WORKERS ON THE MOVE WITHIN THE PORT AND FOR OFFICE ADMINISTRATORS OF SERVICE PROVIDING COMPANIES. PORTABLESERVICES ACQUIRES TIMESTAMP INFORMATION ACCORDING TO THE PORT CALL MESSAGE FORMATTED (I.E. STM 3.211) AND ADAPTS THE PRINCIPLES OF DATA SHARING AND INFORMED DECISION MAKING (PORTCDM) CONCEPT, ONE OF THE ENDORSERS OF SEA TRAFFIC MANAGEMENT (STM). USERs ARE AUTHENTICATED THROUGH THE MarITime CONSISTENT PLATFORM (MCP). THE APPLICATION CONSTRUCTS TO APIs FOR CONSUMPTION AND SUBMISSION OF TIMESTAMPs PROVIDED BY PORTCDM CONFORMING DATA SHARING PLATFORMS. THE APPLICATION WAS CREATED AS A COMPLEMENT TO THE MORE GENERAL PORTABLESERVICES APPLICATION FOR THE PURPOSE OF PROVIDING SERVICE PROVIDERS ESSENTIAL TOOLS FOR THEIR TASKS IN FOLLOWING NEEDS IN MULTIPLE PORTS. IT IS DESIGNED TO BE SIMPLE AND STRAIGHTFORWARD SO THAT IT CAN BE USED AND UPDATED USING TIMESTAMPS EFFECTIVELY BY ANYONE, ANYWHERE.

FEATURES

1. Timelines of the daily workflow
With an intuitive and graphical user interface, the timeline paints a picture of the daily workflow. It allows users to navigate in the past and future, displaying events and operations. Each operation is considered a "card," containing the most relevant information such as vessel name, duration of the operation, and the latest reported state.

2. Timeline Settings
PortableServices strives to make it as easy as possible for the user to find, update, and add information that is of interest. In the settings, the user can define all of the parameters that determine what type of information that will be shown to the user, i.e.,
- toggling whether administrative states (e.g., Requested and Cancelled) are of interest.
- specifying intervals of displayed operations for determining the time scope that the timeline will show port calls for.
- selecting services that are of interest. This determines that only port calls with operations regarding these services will be displayed.
- choosing how many days ahead that incoming vessels are fetched. This makes the most relevant vessels will be selectable when initiating operations.
- enabling/DIshough push notifications. The notifications are based on what type of services that are of interest, which enables the user to be notified when any timestamps related to any of these services are submitted/updated.

Why is there a need for PortableServices?
PortableServices makes the service information related to port calls from PortCDM accessible and easily manageable. It only displays timestamps and functionalities related to the service provider that is using the application. The user saves time by not having to navigate through large amounts of information but will rather be served relevant information. Furthermore, the application encourages information sharing through effortless suggestion-based updating of timestamps.

Target group
PortableServices is currently supporting service providers who provide the following services:
- Anchoring
- Bunkering
- Cargo
- Garbage
- Lashing
- Mooring
- Pilotage
- Repair
- Stop
- Shovel
- Traneage
- Water

The application includes two different user modes, office mode and field mode. Office mode gives administrative personnel access to extended information, regardless of e.g., cancelled or requested services. Since field workers usually aren't interested in this type of information, the field mode hides this information in favor of a simpler interface and a more efficient navigation.

For more information please contact:
Mikael Lind, Activity Leader PortCDM testbeds, RISE Viktoria, Mikael.Lind@ri.se
Sandra Hindmarsh, Activity Leader PortCDM testbeds, RISE Viktoria, Sandra.Hindmarsh@ri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@ri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se

STM VALIDATION 1.3 – Improving port operations using PortCDM
Portable Berths

PortableBerths is a mobile application tailored specifically for terminal operators. It acquires timestamp information according to the port call message format (cf. IALA S-212) and adapts the principles of data sharing and situational awareness according to the Port Collaborative Decision Making (PortCDM) concept, one of the enablers of Sea Traffic Management (STM).

Users are authenticated through maritime connectivity platform (MCP). For consumption and submission of time stamps the application connects to API’s provided by PortCDM compliant data sharing platforms. PortableBerths was created as a complement to the more general PortableCDM application for the purpose of providing terminal operators and berth planners essential information for their tasks of planning one or several berths. It is designed to be easy and intuitive so that it can be used to get an overview of the relevant berths effortlessly and allow for quick navigation to the other important features.

Features

1. Berth View / Favorite Berth View

Terminal and berth operators have a need to get an easy overview of what is happening and planned at their user-selected favorite berths. To help with this, PortableBerths gives a minimalistic overview of said berths, where events are highlighted with an image preview of the associated vessel as well as the reported time of arrival or departure using the time-type: Actual or Estimated. The events are sorted by the most recent first. The user will also be able to see any errors or conflicting data for each port call that is associated with. Another feature is that all other views are easily navigable from here. For example: With only a swipe, a more visual representation is shown. It consists of timelines similar to Gantt schemes where every upcoming event at a specific berth is drawn up. It provides the user with a complementing graphical representation with additional information, such as start and end times for cargo operations, drawn up if timestamps are available.

2. Port call Timeline

A sequential timeline of all port call events for a selected ship is provided, giving the user a more detailed overview of the port call, and where individual timestamps and potential warnings can also be accessed. The latter allows users to quickly identify and address potential issues, increasing the informational awareness of the port through more efficient communication. The user can also submit new timestamps from the timeline, thus enabling rapid information sharing on the fly.

3. Send Portcall

With ease of use in mind, the Send Portcall View uses cached in-app data to automatically fill out forms, letting the user quickly communicate information about their port operations. The information is submitted to the PortCDM platform, and contributes to a better collaborative informational overview, which in turn contributes to a more efficient port where administrative burden, delays, and the environmental impact can be reduced.

4. Settings

The Settings View offers two main features, aside from displaying the current host and active user. One is the possibility of turning on or off the other is the ability to select the time span for occurred and upcoming events at the specific berths which the user has chosen as favorites. The notifications are configured to notify the user when estimated or actual timestamps for either arrival or departure are updated, so appropriate planning actions can be taken.

Why is there a need for PortableBerths?

PortableBerths takes the original PortableCDM app and revamps it to accommodate the needs of the berth planner. By revamping the main view to only show information about the berths which the terminal has selected as favorites it reduces the amount of redundant information while maximizing relevant content for the user. From the first log in it is apparent what the main functionality of the app is, to present information about the terminal’s favorite berths. There are no side-out menus, everything that can be done in the app is accessible straight from the two main screens. Thus, increasing the chance of users sticking with the app and updating timestamps.

PortableBerths as part of STM and PortCDM

STM connects and updates the maritime world in real-time with efficient information exchange. In the 60s the standardized container revolutionized shipping. The next evolution is the containerization of information – creating a safer, more efficient and environmentally friendly maritime sector. PortableBerths has been developed within the STM validation project, as part of activity 1 (PortCDM testbeds), and aims at being used for validation of the PortCDM concept.

For more information, please contact:

Mikael Lind, Activity Leader PortCDM testbeds, RISE Viktoria, Mikael.Lind@ri.se
Sandra Haraldson, Activity Leader PortCDM testbeds, RISE Viktoria, Sandra.Haraldson@ri.se
Mathias Karlsson, RISE Viktoria, Mathias.Karlsson@ri.se
Eddie Olsson, RISE Viktoria, Eddie.Olsson@ri.se
Annex I: Critical states\textsuperscript{51}

<table>
<thead>
<tr>
<th>ET Vessel Traffic Area</th>
<th>AT Vessel Traffic Area</th>
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<tr>
<td>ET Departure Vessel Traffic Area</td>
<td>AT Departure Vessel Traffic Area</td>
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<tr>
<td>ET Arrival Vessel Berth</td>
<td>AT Arrival Vessel Berth</td>
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<tr>
<td>ET Departure Vessel Berth</td>
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<tr>
<td>AT Arrival Pilot Vessel</td>
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<td>AT Pilotage Commenced</td>
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<td>AT Pilotage Completed</td>
<td>AT Departure Pilot Vessel</td>
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<td>AT Towage Commenced</td>
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<td>AT Towage Completed</td>
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<td>ET Anchoring Completed</td>
<td>AT Anchoring Completed</td>
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</tbody>
</table>

**Table 1 Critical States**

Pilotage and tug is based on whether the ship needs tug and pilotage services

AT = Actual time, ET = Estimated time

\textsuperscript{51} When reporting an ET or AT, there will be requirements in terms of anticipation of the estimation, accuracy, etc. which will be defined elsewhere
Annex J: Port call process ontology

A port call is composed of different events. Informed by the validation efforts pursued in the MONALISA 2.0 and the STM validation projects, a port call process ontology capturing different events associated with a port call performed by different actors within the port has been developed (see figure 88 below).

The port call process ontology is structured around ships making port visits. In the port call process, there are a number of events preceding and succeeding the actual purpose of a call that could occur at a berth and/or at an anchorage area; towage operations, escort towage operations, ice breaking operations, and pilotage operations. Being at anchor or at berth enables different stationary services, such as cargo operations, sludge operations, slop operations, water operations, provisioning operations, lube oil operations, and bunkering operations. As indicated in the figure, a departure is always associated with an arrival.

![Port Call Process Ontology](image)

Figure 89 Port Call Process Ontology
Annex K: Demonstration plan

Each of the participating ports performed three iterations. The Port of Gothenburg and Port of Valencia have gone on to use their installed PortCDM solution as a basis for the further application of PortCDM in their ports. The table below provides a summary of the focus for each of the three iterations.

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<tbody>
<tr>
<td><strong>The Nordic Test bed</strong></td>
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<tr>
<td>Port of Gothenburg</td>
<td>Involvement of more actors</td>
<td>Enhanced synchronization with VM</td>
<td>Continuous improvement of the PortCDM implementation</td>
</tr>
<tr>
<td></td>
<td>Expansion towards full coverage of port calls</td>
<td>Focus on port-to-port collaboration (short-sea-shipping) with Port of Brofjorden, Port of Halmstad?, Port of Helsingborg?, Port of Rotterdam?</td>
<td>Hinterland integration</td>
</tr>
<tr>
<td></td>
<td>More process steps (bunkering, sludge disposal, berth shifting)</td>
<td>Transformation of the PortCDM implementation to enhance collaboration</td>
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<td></td>
<td>More automatic connections</td>
<td>More automatic connections</td>
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<tr>
<td></td>
<td>Eliciting requirements for integration with VM</td>
<td>Continuous improvement of the PortCDM implementation</td>
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<td></td>
<td></td>
<td>Establish technical solution for the “small port”</td>
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<tr>
<td><strong>Kvarken Ports (Umeå and Vaasa)</strong></td>
<td>Set up PortCDM implementation in Umeå as a basis for enhanced coordination within the port (incl. connection to Single Window)</td>
<td>Continuous improvement in Umeå and Vaasa</td>
<td>Continuous improvement in Umeå and Vaasa</td>
</tr>
<tr>
<td></td>
<td>Establish technical solution for the “small port”</td>
<td>Develop interfaces to existing systems</td>
<td>Explore integration with VM and ice planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Set up PortCDM implementation in Vaasa as a basis for enhanced coordination within the port</td>
<td>Port-to-port collaboration between Vaasa and Umeå</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collaboration with NLC-ferries (Vasaline) with VM integration</td>
<td></td>
</tr>
<tr>
<td><strong>Port of Stavanger</strong></td>
<td>Set up PortCDM for cruise vessel approaches as a basis for enhanced coordination within the port</td>
<td>Expansion of the types of vessel approaches Common use of berth infrastructure</td>
<td>Port-to-port collaboration (ports not yet defined)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TBD based on the outcomes from iteration #1</td>
<td>Established collaboration with third-party actors (e.g. tour companies)</td>
</tr>
<tr>
<td><strong>Port of Oslo</strong></td>
<td>Terminal-driven setup of PortCDM as a basis for enhanced coordination within the port</td>
<td>TBD based on the outcomes from iteration #1</td>
<td>TBD based on the outcomes from iteration #2</td>
</tr>
<tr>
<td></td>
<td>Exploration of market-driven incentives for PortCDM</td>
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<tr>
<td><strong>A Norwegian Port (TBD)</strong></td>
<td>TBD</td>
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<tr>
<td><strong>The Mediterranean Test bed</strong></td>
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</tr>
<tr>
<td>Port of Limassol</td>
<td>Set up PortCDM implementation as a basis for enhanced collaboration</td>
<td>Transform the PortCDM implementation to enhance collaboration</td>
<td>Port-to-port collaboration with Mediterranean ports</td>
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</tr>
<tr>
<td>Port of Barcelona</td>
<td>coordination within the port Integration with a new forthcoming port community system and possibly integrate PortCDM SIP as part of that</td>
<td>in the Limassol privatization process</td>
<td>participating in the STM validation project Port-to-port collaboration with ports in Greece, Israel, Egypt, and Lebanon</td>
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<tr>
<td></td>
<td></td>
<td>Expand with port calls related to container traffic Port-to-port collaboration with port of Civitavecchia</td>
<td>Expand with port calls related to liquid traffic Enhanced port-to-port collaboration with Mediterranean ports participating in the STM validation project</td>
</tr>
<tr>
<td>Port of Valencia</td>
<td>Set up PortCDM for cruise vessel approaches as a basis for enhanced coordination within the port</td>
<td>Establish collaboration with PortCDM on daily basis</td>
<td>Port-to-port collaboration with the port of Sagunto and Gandia Port-to-port collaboration with Mediterranean ports participating in the STM validation project Hinterland integration enabled by parallel projects</td>
</tr>
<tr>
<td></td>
<td>Cont. impr. of the established PortCDM implementation by developing new automatic connectors Explode the use and maintenance of PortCDM SIP Encourage terminals and shipping agents to use PortCDM on daily basis</td>
<td>Expansion to include smaller operations Include actors without digital infrastructure (e.g. linesmen)</td>
<td></td>
</tr>
<tr>
<td>Port of Civitavecchia</td>
<td>Integration between PortCDM and PIL Set up PortCDM for cruise vessel approaches as a basis for enhanced coordination within the port Establish integration with voyage management for approaches made by Costa Crociere</td>
<td>Port-to-port collaboration with Mediterranean ports participating in the STM validation project</td>
<td>Port-to-port collaboration with ports that Costa Crociere make port approaches to</td>
</tr>
<tr>
<td>Port of Venice</td>
<td>Integration between PortCDM and PIL Set up PortCDM for different types of vessel approaches as a basis for enhanced coordination within the port</td>
<td>Continuous improvement of the portCDM implementation Expansion to include slot-times for opening/closing the lock Expansion to include slot-times for canal passages</td>
<td>Establish integration with voyage management</td>
</tr>
<tr>
<td>Port of Naples</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port of Genoa</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To summarize, the focuses in the different iterations for the different ports are depicted in the figure below.
Annex L: Phases of demonstration of the PortCDM concept

The demonstrations of the PortCDM concept were conducted in three phases as shown in the table below. Comments on the fulfilment of the tasks have been included.

<table>
<thead>
<tr>
<th>Expected task</th>
<th>Comments related to fulfilment of the task</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1 (First round of usage and evaluation)</strong></td>
<td></td>
</tr>
<tr>
<td>Identification of key challenges</td>
<td>The series of living lab meetings throughout the project enabled the activity to get a thorough understanding of the key challenges reflecting be addressed in the design principles of the PortCDM concept.</td>
</tr>
<tr>
<td>Processes and base line</td>
<td>The metromap was used with particular success to show the as-is process.</td>
</tr>
<tr>
<td>Adaptation of services to local conditions</td>
<td>Standardised interfaces and payload formats were used to enable different actors and systems to provide time stamps.</td>
</tr>
<tr>
<td><strong>Phase 2 (Second round of usage and evaluation)</strong></td>
<td></td>
</tr>
<tr>
<td>Process refinement</td>
<td>Discussion in the living lab meetings and each port’s metro map were used to improve and adjust the PortCDM processes.</td>
</tr>
<tr>
<td>Root cause analysis</td>
<td>Root causes were identified to assist in improving the PortCDM concept.</td>
</tr>
<tr>
<td>Optimization of port approaches governed by selected KPI:s</td>
<td>In the analysis, some of the KPI results showed the potential for improvement performance; especially total turn-around time, berth productivity, and predictability for selected states.</td>
</tr>
<tr>
<td>Service refinement and introduction of additional service</td>
<td>A number of front-end services were identified based on discussions and outcomes of the living lab meetings.</td>
</tr>
<tr>
<td>First engagement of commercial service developers</td>
<td>Engagement of commercial service providers was achieved by both engaging service providers as well as initiating collaboration with prime movers.</td>
</tr>
<tr>
<td><strong>Phase 3 (Third round of usage and evaluation)</strong></td>
<td></td>
</tr>
<tr>
<td>Deeper engagement of commercial service developers</td>
<td>The greater engagement of commercial service providers was achieved through two rounds of working with third-party developers in using standardised interfaces and payload formats for the provision and consumption of PortCDM services.</td>
</tr>
<tr>
<td>Active sharing of experiences / services between ports</td>
<td>Experiences were shared between participating ports in biweekly meetings and through the concept notes that resulted in wider discussion and feedback from other interested parties.</td>
</tr>
<tr>
<td>Introduction of services for port-to-port collaboration</td>
<td>Within the PortCDM infrastructure, services for sharing timestamps between ports was implemented and provided the ability for downstream ports to consume time stamps (estimates and actuals) of departure related to the port calls for expected ships in the upstream port.</td>
</tr>
</tbody>
</table>
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