Activity 2 – Defining Sea Traffic Management

PortCDM Validation Report

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Document Status

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1 General Information

MONALISA 2.0 is a project with 39 private, public and academic partners from 10 different countries. Its overall objective is to strengthen efficiency, safety and environmental performance in maritime transportation. Coordinated by the Swedish Maritime Administration, the project is co-financed by TEN-T under the Motorways of the Sea Programme and is part of the EU’s e-Maritime initiative. MONALISA 2.0 follows on from the MONALISA project (2010-EU-21109-S) and also incorporates results and experiences from the SESAR (Single European Sky Air Traffic Management Research) programme in the aviation sector. MONALISA 2.0 is divided into four Activities: Activity 1, STM Operations and Tools; Activity 2, STM Definition; Activity 3, Safer Ships; and Activity 4, Operational Safety.

This report is a deliverable from Activity 2 of the MONALISA 2.0 project. The objective of Activity 2 is to outline a framework for Sea Traffic Management (STM), elaborate its target concept, and develop a plan for further development and deployment. Activity 2 is divided into 7 sub-activities:

- **SA2.1 Current Situation Analysis** describes today’s maritime transport industry, focusing on information sharing. It highlights its strengths, weaknesses, and current development, as well its needs. The results of this analysis are presented in report D2.1.1 STM The Current Situation.

- **SA2.2 STM Performance Target Development** is an analysis and elaboration of a performance framework including: performance targets, key performance areas, vision and goals. Its results are presented in report D2.2.1 STM Performance Framework.

- **SA2.3 STM Target Analysis** develops the target concept(s) of Sea Traffic Management based on the current situation analysis and performance targets. The results of this work are summarised in the report, D2.3.1 STM - The Target Concept.

- **SA2.4, 2.5 & 2.6 STM Strategic Roadmap and Master Plan Development and Work Programme for Development Phase** is a combination of three sub-activities that together establish a shared vision of the overall transition sequence for implementing the STM Target Concept. Results are described in report D2.4.2/D2.5.1/2.6.1 STM Master Plan.

- **SA2.7 PortCDM Demonstrator** developed and demonstrated initial versions of some information sharing services used in the Port CDM concept. Results are presented in this report D2.7.1 Port CDM report.

This is the PortCDM validation report.
2 Executive summary

PortCDM as a Sea Traffic Management concept in MonaLisa 2.0 was founded in March 2014. In order to prove PortCDM as an enabling concept for STM and sustainable sea transports, the decision to conduct two mini-demonstrators, by running PortCDM as real-life tests involving multiple users, was taken in June 2014. Based on that decision, a development team was formed at Viktoria Swedish ICT after the summer and a couple of month later the Living Lab Approach was selected as methodology. Based on the scope and the design vision of PortCDM, a number of actors involved in Port Calls in Gothenburg were invited and formed, together with the concept group and the technical team, the Living Lab GOT. In the beginning of 2015 the same setup was made for Port of Valencia facilitated by Valenciaport Foundation.

For being able to validate the demonstrators in Gothenburg and Valencia a set of hypotheses were derived based on the objectives and design vision of the PortCDM concept. The purpose with the demonstrators has been to validate (in small scale), through processes of verification, falsification or identification of trends, confirm whether the concept in use give rise to intended effects. The validation clearly indicates that actors involved in Port Calls experience benefits form the PortCDM implementation. The major benefits derived from the validation are:

- enhanced situational awareness based on actors shared intentions and performances.
- enhanced possibility to plan operations based on actors shared intentions and performances.
- enhanced possibility to predict occurrences based on actors shared intentions and performances.
- enhanced possibility to parry to avoid waiting and dwell times based on the increased ability to predict.
- enhanced data quality based on automatic and/or several data sources for the same time stamp.
- less administrative burden based on the reduced number of non-digital interaction.
3 Introduction

In MonaLisa 2.0 (ML2) activity 2 (Act2), work packages 3 and 7 defined and initially demonstrated the concept of PortCDM (Port Collaborative Decision Making).

Work package 3 (WP3) documented the purpose and goals with the PortCDM concept, as well as the functionality an implementation needs to comprise to be useful in practice. In work package 7 (WP7), an initial demonstrator, technically implemented as a subset of the concepts defined in WP3, was developed and tested in real-life in two ports. The purpose with the demonstrators has been to validate in a smaller scale, through processes of verification, falsification or identification of trends, confirm whether the concept in use give rise to intended effects. The role of the demonstrators was to show, and to enable initial evaluation of, the practical effects of the PortCDM concept by a limited deployment in its target environment.

The role of the demonstrator is depicted in figure 1 below. Founded in the design principles of PortCDM, a set of hypothesis was developed. The demonstrator used these initial hypotheses as a basis for what to direct attention towards during the requirement elicitation, for the definition of the concept, and for the emergence of a refined list of hypotheses (see section 6.4). The use of the demonstrator provided with user experiences, data from use, and performance outcomes.

![Diagram](image)

**Figure 1: The role of the demonstrator in the initial validation of the PortCDM concept**

The purpose with this report is to present the validation of the PortCDM concept, an overview of the ML2 PortCDM demonstrator (WP7), and to suggest future development by providing:
- A description of the scope and purpose of the demonstrator with respect to the PortCDM concept (WP3);

- An technical overview of the demonstrator implementation (WP7);

- Conclusions of the validation based on the identified hypotheses founded in the PortCDM concept (WP3);

- An overview of suggested future development of the PortCDM demonstrators to be useful as an evaluation platform for the STM Validation project.

### 3.1 PortCDM Concept Overview (WP3)

The PortCDM metro map, shown in figure 2, provides a metaphor illustrating the complexity, and the need for collaboration between multiple actors, in staging a port call. In figure 2, an example port call is illustrated as a metro map, where each metro line represents an actor and each metro station represents a State—such as occurrence of events or performance of actions—that is important in the port call process. The metaphor illustrates a flow of actions and events that occur in a port call, from the arrival of a vessel (left part of figure 2) to its departure (right part of figure 2), with terminal operations in between (shown in the dotted ellipsis in the same figure).

![Figure 2: States and milestones for the port call process - a generic state chart used for port specific adaptation of the PortCDM concept](image)

As can be seen in figure 2, there are many states in which the actions of several actors need to be synchronized. States associated with the vessel’s turn around process is

---

also considered as the common object of interest among participating actors. Efficient resource allocation and port call execution require predictable state changes and would therefore benefit from improved communication and collaboration among participating actors. PortCDM aims at being a platform enabling such support. The overall goal with PortCDM is to enable the sharing of intentions and actual state updates among involved actors to enable enhanced informed decisions concerning each actor's coordination of upcoming operations to perform.

PortCDM builds upon, a SeaSWIM compliant service-oriented architecture in which different information services are being made available for the purpose of discovery and consumption.

WP3 in ML2 defined a number of information services that PortCDM shall provide to be useful. These services each belong to one of the four categories planning, execution, evaluation, and other, as shown in figure 3.

![PortCDM service catalogue](image)

Figure 3 PortCDM service catalogue as defined by ML 2.0, Act 2, WP3.

3.2 The purpose and scope of PortCDM demonstrators

3.2.1 Concept Service Coverage

The purpose of the ML2 demonstrator (WP7) was to validate PortCDM as an enabling concept for STM and sustainable sea transports giving just-in-time operations. In these initial implementations, the PortCDM demonstrators focused on a subset of the services defined in WP3 that would enable support for shared situational awareness for sea and shore based operations, i.e. information / data services that aggregate port call data
from a variety of sources and provide access to that data in a coherent manner giving rise to enhanced situational awareness:

- **ETx Manager**
  To establish/update a network/tree of related desires/intentions/outcomes/capacities for a certain port approach, where involved actors inform each other about status.

- **State Indicator**
  To provide service consumers with the current state, and planned state changes, of a certain object.

- **Approach Status**
  To provide service consumers with a status report of how the port approach is planned for/is realized.

- **State Updates**
  To provide information about changed states related to the ETx_Manager and ETA_Planner for one voyage or SUM(Voyage).

- **Berth Productivity**
  To provide a number on the berth productivity for a certain time period for a certain terminal.

The demonstrator, realizing parts of these services, was implemented as a service integration platform (PortCDM SIP). The PortCDM SIP is a back-end component, to which applications can connect in order to access the services.

The PortCDM SIP was implemented with 6 main information services, as can be seen in the centre of figure 4, illustrating the high-level logical view of the architecture in the ML2 PortCDM demonstrator. The implementation was made SeaSWIM compliant building on the core principles of the Maritime Cloud.
The 6 main information services are:

- **DataDictionary**
  DataDictionary is a support service that provides access to the state and information types available in the PortCDM SIP (see data model description below).

- **ProcessManager**
  ProcessManager provides functionality to manage information about a port call process, i.e. which states that are included in staging a port call, and in which order they are expected to be achieved.

- **PortCallManager**
  PortCallManager provides functionality to access the data about a specific port call, i.e. estimates and actual times reported for states and other port call related information.

- **PortCallStatus**
  PortCallStatus provides functionality to evaluate the status of a port call. The status of a port call can be evaluated by combining port call data (from PortCallManager) with a specific process (from ProcessManager).

- **UpdatePortCall**
  UpdatePortCall provides functionality to submit port call data updates to PortCDM SIP (i.e. estimates and actual times for states, and other port call related information).
- **PortStatistics**
  PortStatistics provides functionality to calculate statistics for the port as whole, for instance estimated workload in terms of the number of on-going port calls per day over the next 7 days.

In order to evaluate the concepts defined in WP3, the demonstrator needed in addition to the PortCDM SIP (further elaborated on below):

- **Data connectors**, shown at the bottom of figure 4 providing the PortCDM SIP with data (such as estimated and actual time of arrival, booking of tug boats, estimated and actual time of departure). These connectors need to interact with existing external systems (such as AIS, management systems at the tug operators, pilot operators, terminals, vessel agents, port authority etc.), and transform data into PortCDM updates.

- **End-user applications**, shown at the top of figure 4. In a fully deployed PortCDM, existing systems would integrate with the PortCDM SIP, thus enabling these systems to access real-time information updates and thereby improving their functionality. Within the scope of the ML2 demonstrator, however, this was not considered feasible. Instead, an end-user application for providing a shared port call situational awareness (referred to as front-end) was developed as part of the demonstrator to show the possibilities with integrating with the PortCDM SIP.

### 3.2.2 Concept Scope Coverage

The PortCDM Concept strives towards enabling an enhanced coordination on several areas i.e. collaboration areas in figure 5. The demonstrators have had a primary focus on the collaboration arena #1, which means a focus on the internal coordination between the key actors in a PortCall as important basis to enable efficient port operations. This figure 5 is an expression for enabling collaboration in different areas such as between port and the sea voyage (collaboration arena #2), between the port and hinterland transports (collaboration arena #3), and between ports (collaboration arena #4). The latter collaboration arena is of special concern in short-sea shipping. All these collaboration arenas require standardized message formats and standardized interfaces, carried by information services, between different operational systems.
For this purpose a port call message standard building on efforts on standardizing time stamps has been developed and validated in parallel in this validation endeavour. The port call message standard builds upon the timestamp as a communicative act constituted by the following basic components: sender, recipient, communicative function and propositional content. In the nomenclature (c.f. figure 6 below), the communicative function corresponds to time type (i.e., Arrival, Departure, Start, Complete), the propositional content is translated into the combination of time sequence in relation to location/service/administrative process and reference object, the sender is labelled as the information provider and the recipient as the information consumer.
In the nomenclature, states are expressed using timestamps to combine relevant information categories (Time type, Time sequence, Reference object, Information provider and Information consumer) to a certain Location, Service or administrative Process based on a particular Data Source being reported at a certain time (Time Reported). Therefore “timestamps” are the generic set of combined categories (c.f. figure 6 below) used to express a state based on the nomenclature, and “states” are the actual information communicated.

<table>
<thead>
<tr>
<th>Time Type</th>
<th>Time Sequence</th>
<th>Location/Service/Adm</th>
<th>Ref. obj</th>
<th>Info Provider</th>
<th>Info Consumer</th>
<th>Data Source</th>
<th>Time Reported</th>
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<tr>
<td>CT [Committed]</td>
<td>AA [Anchor Area]</td>
<td>Linesmen</td>
<td>Linesmen</td>
<td>Pilot</td>
<td>Pilot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT [Actual]</td>
<td>TU [Tug Area]</td>
<td>Stevedore</td>
<td>Vessel</td>
<td>Port Authority</td>
<td>Vessel</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PA [Port Area]</td>
<td>Terminal</td>
<td>Tug</td>
<td>Port Authority</td>
<td>Tug operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S [Start]</td>
<td>Service</td>
<td>Service Provider</td>
<td>Terminal</td>
<td>Port Control</td>
<td>Port Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C [Complete]</td>
<td></td>
<td>Quay</td>
<td>Linesmen</td>
<td>Governmental body</td>
<td>Maritime Administration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6 Basis for port call message standards: nomenclature for timestamps**
4 The PortCDM Demonstrators

PortCDM defined as an STM concept in MonaLisa 2.0 was founded in March 2014 on a Workshop in Malmoe, Sweden. In order to prove PortCDM as an enabling concept for STM and sustainable sea transports, the decision to develop two mini-demonstrators were taken in June 2014. Based on that decision a development team was formed at Viktoria Swedish ICT after the summer and a couple of month later the Living Lab Approach was selected as the methodology. Based on the scope and design vision of PortCDM a number of actors involved in Port Calls in Gothenburg were invited and formed, together with the concept group and the technical team the Living Lab GOT. The Living approach was then brought into use in the demonstration performed at Port of Valencia.

Due to the nature of the demonstrators as small-scale implementations there was not enough time to develop solutions for all existing systems to provide situational awareness images. Therefore, a web-based application to function as an image for common situational awareness was developed. The purpose with the application was to visualise some of the potential effects of the concept PortCDM.

The scope in the demonstrators was the Port call process defined as four subprocesses: the approach/arrival, berth, cargo operations and departure (c.f. figure 7).

![Port Call Process](image)

**Figure 7 Scope in PortCDM Demonstrators**

4.1 The Living Lab Approach

Since the realization of the PortCDM concept is based on collaboration between involved actors in a PortCall, a collaborative approach was adopted in the development of the PortCDM demonstrators. The Living Lab Approach implies that actors are gathered in a collaborative manner for the purpose of establishing trust and identifying incentives to share information. Each Living Lab has been organized as three collaborating teams; business team, technical team and concept team working together to develop and adopting a local PortCDM implementation (see figure 8).
The business team consists of actor representatives from key organizations in the PortCall process with the role to provide basic operational business knowledge and to formulate requirements on and use and thereby evaluate the PortCDM implementation. The concept group consists of actors from WP3 coordinating the Living Labs and ensure that the PortCDM implementations are within the range of the concept scope for the concept hypotheses to be validated. The technical team consists 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.

4.2 The PortCDM Demonstrator in Gothenburg

4.2.1 Living Lab in GOT

The kick-off for the Living Lab in GOT was held in February 2015, with Viktoria Swedish ICT as the facilitator. During nine months the Living Lab met for breakfast meetings in average every second week, in total we held 16th Living Lab meetings.

The purpose with the Living Lab meetings was to integrate and engage the participating actors into the developing process as users and co-creators to examine, explore, test and evaluate PortCDM both as a concept and as an application that we together was building (a summery of the different Living Lab meetings can be read in the table below). The meetings were also an arena for actors, with different agendas and requirements regarding a port call, to meet and learned about each other’s intentions and different information needs.

During the nine months period people from the concept group together with people from the development team also made a visit to each participating organisation in order to see how they worked and what kind of systems they used. Furthermore interviews were
conducted to get feedback regarding the first test version of the PortCDM application in order to make necessary changes to the application before the focus month.

In Gothenburg September was chosen as the focus month, where the actors used PortCDM in their daily operations. During this focus month breakfast meetings were held every week in order to capture conclusions from the different actors. The main conclusions from these meetings were then distributed to the user group together with information regarding new features that was implemented. During the focus month some actors had to report PortCDM information manually, since an automatic integration was not possible to include in the solution, which meant some additional administrative burden for them during the focus month. The organisations that had to report information manually were paid a visit and the users were shown how to report information in PortCDM.

**Business actors representatives in the GOT Living Lab**

The Living Lab in GOT included business actors from all key roles involved in a Port Call;

- Port Authority
- Pilot Organization
- Towage Company
- Ship Agent
- Terminals (2 Oil Terminals and 1 Container Terminal)
- Linesmen Organization
Table 1. Living Labs’ dates, participants and key outcomes at GOT.

<table>
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<th>Meeting no</th>
<th>Date</th>
<th>Involved actors</th>
<th>Key outcome</th>
</tr>
</thead>
<tbody>
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<td>#1</td>
<td>3/02/2015</td>
<td>Swedish Maritime Administration as a representative for GOTAPP (Port Control, VTS, Pilot Administration), Ship Agent, Viktoria Swedish ICT, An IT Company</td>
<td>Presenting the PortCDM concept in the framework of the MonaLisa 2.0 project to the involved parties. Presenting a first version of the PortCDM demonstrator, discussed and analysing the potential challenges for involved actors. Open discussions regarding what information is important for each actor</td>
</tr>
<tr>
<td>#2</td>
<td>17/02/2015</td>
<td>Pilot Administration, Towage Operator, Ship Agent, Linesmen, A Professor from The Swedish-Brazilian Research and Innovation Centre, Viktoria Swedish ICT, An IT Company</td>
<td>The main goal was to go through a virtual call to identify what kind of information different actors involved in a port call exchange, how they exchange it and to illustrate the role PortCDM could play. Due to fruitful discussions we only managed to go through arrival phase of the port call and although PortCDM ended up slightly overshadowed it gave us plenty of inspiration and information further development of PortCDM.</td>
</tr>
<tr>
<td>#3</td>
<td>03/03/2015</td>
<td>Port of Gothenburg as a representative for GOTAPP, Towage Operator, Viktoria Swedish ICT, An IT Company</td>
<td>The main goal was to follow up with reflections from the first virtual port call exercise from the previous meeting and to discuss how a port call can be visualized in PortCDM based on current (and prospective) information sources. A Summary of the Valencia visit and the progress happening there was also given to the participating actors</td>
</tr>
<tr>
<td>#4</td>
<td>31/03/2015</td>
<td>Port Control, Pilot Administration, Towage Operator, Ship Agent, Linesmen, Viktoria Swedish ICT, An IT Company, The director of Lighthouse (an organisation focusing on collaboration between maritime stakeholders such as industry, society, academy and institutes for research, development and innovation within the maritime sector), Master Students from Chalmers University of Technology</td>
<td>The main goal was to demonstrate an initial application for shared situational awareness with inspiration from the metro map metaphor, which has been shown many times in PortCDM and MonaLisa presentations. At the meeting the application was discussed and new ideas and opinions on what a useful visualization should include and look like was discussed.</td>
</tr>
<tr>
<td>#5</td>
<td>14/04/2015</td>
<td>Port of Gothenburg as a representative for GOTAPP, Port Control, Towage Operator, Ship Agent, Viktoria Swedish ICT, An IT Company</td>
<td>The main goal was to demonstrate a second iteration of our initial application for shared situational awareness. During this iteration we focused on building a visualization that provided more details about all on-going and planned port</td>
</tr>
<tr>
<td>#</td>
<td>Date</td>
<td>Participants</td>
<td>Event Description</td>
</tr>
<tr>
<td>----</td>
<td>------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>#6</td>
<td>28/04/2015</td>
<td>Port of Gothenburg as a representative for GOTAPP, Port Control, Pilot Administration, Towage Operator, Ship Agent, Container Terminal, Oil Refinery Terminal, Linesmen, Viktoria Swedish ICT, An IT Company, Master Students from Chalmers University of Technology</td>
<td>The main goal was to go through the second part of the virtual port call. In this second part, we started from when the vessel was all fast, and continued with cargo operations and finally departure process. As in the first part of the virtual port call, held in February, we got lots of interesting and valuable information. In addition, we shortly demonstrated the current version of the shared situational awareness application.</td>
</tr>
<tr>
<td>#7</td>
<td>12/05/2015</td>
<td>Pilot Administration, Towage Operator, Ship Agent, Oil Refinery Terminal, Linesmen, Viktoria Swedish ICT, An IT Company, Master Students from Chalmers University of Technology</td>
<td>The main goal was to follow up with reflections from the virtual port call, discuss possible ways to deploy the PortCDM deployment applications and to demonstrate and discuss the new data entry application. The data entry application is a way to manually provide PortCDM with data, where the data is not otherwise available. Valuable opinions and feedback on the application was discussed as well as reflections on the virtual port call.</td>
</tr>
<tr>
<td>#8</td>
<td>26/05/2015</td>
<td>Pilot Administration, Towage Operator, Ship Agent, Container Terminal, two Oil Refinery Terminals, Linesmen, Viktoria Swedish ICT, An IT Company,</td>
<td>The main goal was to plan the summer activities, meetings and when to provide alpha versions of the PortCDM F.E for the users to test. Dates for interviews with the actors to get feedback before the focus test month was also discussed.</td>
</tr>
<tr>
<td>#9</td>
<td>09/06/2015</td>
<td>Port Control, Pilot Administration, Ship Agent, Towage Operator, Oil Refinery Terminal, Viktoria Swedish ICT, An IT Company,</td>
<td>The main goals were to show and discuss the current version of the alpha version of the PortCDM F.E and to set the dates of when the feedback interviews could take place. The current state of PortCDM with the data entry application and situational awareness deployment plan discussed. A presentation of the demonstration event that Viktoria Swedish ICT together with Valenciaport Foundation will arrange the following week in Valencia was presented.</td>
</tr>
<tr>
<td>#10</td>
<td>01/07/2015</td>
<td>Oil Refinery Terminal, Ship Agent, Linesmen, Viktoria Swedish ICT</td>
<td>This meeting took part at one of the Oil Refinery Terminals and the purpose of the meeting was to discuss terminal operations in relation to PortCDM and improving the predictability of berth</td>
</tr>
</tbody>
</table>
availability and departure times.

We also and we also talked about states and times relevant for the Ship Agent and the Linesmen.

A presentation of the demonstration of possibilities with PortCDM to show how a common situational awareness could create benefits for the different organisations, that took part 17th June at Valenciaport Foundation, was also given to the participants.

| #11   | 19/08/2015 | Swedish Maritime Administration as a representative for GOTAPP, Port Control, Pilot Administration, Ship Agent, Two Oil Refinery Terminals, Viktoria Swedish ICT, An IT Company | The main goals were to present the changes done by the developer that was identified from the feed back interviews with the actors during July and August and to prepare the actors for the focus month in September.

New features to implement in the next release before the focus month were also discussed.

We also decided on dates for when some one from Viktoria Swedish ICT was going to visit the different actors to instruct them on how PortCDM works.

| #12   | 09/09/2015 | Port Control, Pilot Administration, Ship Agent, Oil Terminal, Viktoria Swedish ICT | The main goal was to discuss and get the actors first views of the first focus week with PortCDM.

Some issues with the connectors were discussed and fixes for those was identifies. A decision to switch from Windows tablets to iPads for the organisations using tablets was made since the Windows tablets did not interact well with PortCDM.

New features to implement in the next release were also discussed.

| #13   | 16/09/2015 | Port Control, Pilot Administration, Ship Agent, Oil Terminal, Linesmen, Viktoria Swedish ICT | The main goal was to discuss and get the actors views of the second focus week with PortCDM.

Discussions on how the demonstrator goes and the what the people in the different participating organisations think of PortCDM.

A presentation of the new features that is implemented into the new release that was going out the same day was also made and discussed.

| #14   | 23/09/2015 | Port Control, Pilot Administration, Ship Agent, Oil Refinery Terminal, Viktoria Swedish ICT | The main goal was to discuss and get the actors views of the third focus week with PortCDM.

Continued with discussions on how the demonstrator goes and the what the people in the different participating organisations think of PortCDM.

Another release was going to be deployed later the same day and a presentation of the changes was made and discussed.

| #15   | 30/09/2015 | Swedish Maritime | The main goals were to discuss and get the |
Administration as a representative for GOTAPP, Port Control, Towage Operator, Oil Refinery Terminal Viktoria Swedish ICT, actors views of the last focus week with PortCDM and to give presentation of the next phase of PortCDM in the STM Validation project.

We also decided not to close down the PortCDM demonstrator since there will be new features and new information integrated to the F.E and all the participating organisations though it would be a good idea to let it continue.

Port Control, Pilot Administration, Ship Agent, Towage Operator, Viktoria Swedish ICT

The focus of the meeting was to present and evaluate the joint work we have done and what we have accomplished during the year. We also discussed how the work with evaluation will proceed and expected results and how it is going to be used as input into the next project.

We discussed the next steps for the Living Lab and the demonstrator and decided on the date for the upcoming Kick-off for PortCDM in the STM Validation Project.

4.2.2 The metro-map of Gothenburg

The Metro-Map presented in figure 9 below shows the different states used by the different participating actors in the GOT Demonstrator for coordination of a port call. In the Metro-Map each state refers to an event in the port call process, identified as core information to share between involved actors to enable enhanced coordination. The states represented in the Metro-Map can be estimated and reported as actuals when they are reached. Different states have different functions, as coordination points (i.e. important milestones in the port call process where two or more actors performances correlates). These states indicate a higher degree of coordination and synchronization between involved actors. One example of such coordination point is ATA to Pilot Station that requires synchronized efforts from the vessel, the pilot and the tug to be at the same physical place (the pilot station) at a certain time, in order for the state to be reached. States can also be used as waypoints for actors to plan and monitor the status of the process for an increased awareness and ability to predict upcoming events. The sum of states selected for the GOT Demonstrator, 36 states, are all events possible to report in the front-end application and visualized in the image for situational awareness that is shared among the key actors involved in port calls in Gothenburg. The states as represented in the front-end application and its equivalent term in the back-end solution are listed in Appendix 1.
4.2.3 GOT Characteristics

The Port Authority, which is the public body owned by the city of Gothenburg, that owns the land and the infrastructure in Port of Gothenburg, They allow international port operators to run terminals and to deal with freight handling in the port. The Port of Gothenburg with its 400 year history and the largest port in Scandinavia, handling almost 30 per cent of Swedish foreign trade, is located on the west coast of Sweden.
Facilities at the Port of Gothenburg RoRo Terminal

The RoRo Terminal in Gothenburg with the area of 500,000 square meters is operated by Gothenburg Roro Terminal with some 300 employees. At the Terminal a wide range of machines such as terminal tractors and translifter trucks to handle trailers, cassettes and SECUs. There are also electrically powered trucks, straddle carriers and reach stackers. Apart from trailers, large volumes of trucks and containers are handled. The Terminal has around 20 calls per week.

Container Terminal

APM Terminals Gothenburg is operating the container port in Gothenburg, which is the largest container terminal in the Nordic region and it act as a hub for Swedish foreign trade. Over 50% of all containers to and from Sweden pass through the terminal. Around 15 shipping lines use the terminal, with over 20 visits per week. There is also an extensive system of rail shuttle, at present, there are around 25 train shuttles operating to and from large areas of Sweden and into Norway.

Vehicle Terminal

Logent Ports & Terminals in Gothenburg is operating the largest export port for vehicles in Sweden with a significant import volume. Logent Ports & Terminals also offers parking and storage as well as PDI services to its customers. PDI involves adapting car models to the specifications stipulated in different countries.

Energy Port

Gothenburg Energy Port is the largest energy port for open access in Scandinavia and the site of three refineries and five storage companies. Its advantageous geographical location makes the Port of Gothenburg a hub for the whole of the Scandinavian market. About 2,500 tankers visit the Gothenburg Energy Port and its three terminals: Tor Harbour, Skarvik Harbour and Rya Harbour, every year and half of the crude oil that enters Sweden does so via the Port of Gothenburg. The Energy Port is also the site of Sweden's largest depot operations, supplying western Sweden with petrol and diesel and other products. About 50 per cent of all refined products remain in Sweden whilst the other 50 per cent are exported to the rest of the world.

Ferry Terminal

Stena Line that is operating the Ferry Terminal is one of the world's largest ferry operators with about 40 vessels and 23 routes in northern Europe. The head office is in Gothenburg, where the ferries are a familiar sight as they are moored at the inner harbours. Almost 1.5 million passengers travels with the combined passenger and
freight ferries on the two routes: one to Frederikshavn in Denmark and one to Kiel in Germany every year. All ferries shut down their engines when they are berthed in Gothenburg and use environmentally labelled Onshore Power Supply.

**Cruise**

Several different cruise lines visit Gothenburg every year and the number of visits by cruise ships has increased substantially over the last decade. In 2014 over 100 000 cruise travellers visited Gothenburg on 73 vessels.

**Forest port**

In recent years, Port of Gothenburg have made a succession of investments to ensure that they are able to handle all types of forest products. These investments include completely new dedicated forest terminals, new train solutions and a closer collaboration between the Port of Gothenburg, shipping lines and other key businesses operating in the vicinity of the port zone.

**The Port of Gothenburg in figures, 2014**

- 836,631 containers, TEU
- 548, 801 ro/ro units
- 166, 069 new cars
- 1.82 million passengers
- 19.23 million tonnes of oil
- 37.1 million tonnes of freight

**4.3 The PortCDM Demonstrator in Valencia**

**4.3.1 Living Labs in Valencia**

At the end of 2014, the Valenciaport Foundation contacted the Port Authority and Pilots to explain the project scope. Next, some face-to-face meetings were planned for the beginning of the year 2015 in order to explain the scope of the PortCDM pilot test bed at the Port of Valencia to the most representative stakeholders involved in the port calls (including Towage Company, Mooring Corporation, shipping agents, stevedores and terminal operators).

The first Living Lab in the Port of Valencia was held in February 2015, with Valenciaport Foundation and Viktoria Swedish ICT as facilitators. The port community welcomed the initiative and interesting discussions took place during the meeting where challenges and potential improvements arose.

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2 Source: http://www.portofgothenburg.com/About-the-port/About-the-Port-of-Gothenburg/The-Port-of-Gothenburg/
After some individual meetings, the second Living Lab was organised in April (2015). The main purpose at that time was to introduce the technical advances developed at the Port of Gothenburg by Viktoria Swedish ICT to the key Valencian stakeholders as well as the presentation of a simulation of PortCDM services. Furthermore, Valenciaport Foundation showed the first version of the states’ sequence at the Port of Valencia in order to get feedback from the attendants.

In the third Living Lab, the main goal was to validate the relevant states and the role of each stakeholder during the port approach. Moreover, a recap session was included because new potential partners were attending the meeting (the three container terminals at Valenciaport were represented). The fourth Living Lab was a Demonstration Session. In addition, a PortCDM Simulation that considered a hypothetical scenario, was conducted and each stakeholder played its real role in the port call process. Finally, a fifth Living Lab has been scheduled for 17th December.

Table 2. Living Labs’ dates and goals at Valenciaport.

<table>
<thead>
<tr>
<th>Meeting no</th>
<th>Date</th>
<th>Involved actors</th>
<th>Key outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0</td>
<td>29/01/2015</td>
<td>Port Authority and pilots.</td>
<td>Preliminary face-to-face meetings to individually explain the scope of the PortCDM pilot test at the Port of Valencia.</td>
</tr>
<tr>
<td>#1</td>
<td>25/02/2015</td>
<td>Port Authority, pilots, tug-operators, linesmen, stevedores, container terminal operators, an IT company and a shipping agent.</td>
<td>Presenting the PortCDM concept in the framework of the Monalisa 2.0 project to the involved parties. Understanding the current procedures at the port calls and analysing the potential challenges for each involved party. Open discussions regarding what information is important for each actor.</td>
</tr>
<tr>
<td>#2</td>
<td>24/04/2015</td>
<td>Port Authority, pilots, tug-operators, linesmen, stevedores, container terminal operators, an IT company and a shipping agent.</td>
<td>The main goal was to introduce the technical advances developed at the Port of Gothenburg by Viktoria to the Valencian key stakeholders. Additionally, a simulation of Port CDM services was presented. The second part of the meeting focused on assessing the suitability of the status</td>
</tr>
</tbody>
</table>
defined for the Valenciaport characteristics (A Time Line including the states was provided to the participants).

#3 21/05/2015
Port Authority, pilots, tug-operators, linesmen, stevedores, container terminal operators, an IT company and a shipping agent.

The main goal was to validate the relevant states and the role of each stakeholder during the port approach. It was important to define which information is necessary for each agent. Pilots, Linesmen and the Tug Boat entity validated a new section in the timeline identifying the current system used for exchanging information. Moreover, we organised a recap activity as new potential partners were attending the meeting. Finally, we discussed the pilot proposal.

#4 17/06/2015
Port Authority, pilots, tug-operators, linesmen, stevedores, container terminal operators, an IT company and a shipping agent.

We presented a historical data analysis of calls at Valenciaport in April 2015. Then, each agent explained the main potentialities and expected benefits from the PortCDM implementation from its point of view. Finally, we carried out a Port CDM Simulation (Hypothetical scenario). Each stakeholder played its real role in a port call process.

Source: Valenciaport Foundation.

4.3.2 The Metro-Map of Valencia

All ports differ in terms of how they work and operate. For that reason, it is necessary to study the port call process in depth in each port. In the case of Valenciaport, we started to visually represent the process and then the involved agents validated those diagrams.

The process modelling was done using BPMN (Business Process Modelling Notation). More specifically, Bizagi Modeller was the tool used by process analysts for process modelling.

The diagrams for calling request process and calling confirmation are showed below.
Once the processes were analysed, the definition of the relevant states for Valenciaport began.
Figure 14  States at the arrival process in Valenciaport (Source: Valenciaport Foundation).

Figure 15  States at the departure process in Valenciaport (Source: Valenciaport Foundation).

Finally, because of the process of analysis and the definition of the relevant states, the following Metro-Map was produced.
### 4.3.3 Valencia Characteristics

The Port Authority of Valencia (PAV), which trades under the name of Valenciaport, is the public body responsible for running and managing three state-owned ports along an 80 km stretch of the Mediterranean coast of Eastern Spain: Valencia, Sagunto and Gandía. Nevertheless, the MonaLisa 2.0 test bed focused on just one of them: Valencia.

Valenciaport is currently the leader port in the Mediterranean Sea in terms of commercial traffic, mostly containerised cargo (4,441,949 Total TEUs Handled in 2014), due to its dynamic area of influence and an extensive network connecting it to major world ports.

The PAV reached the objectives set out in its Strategic Plan 2015 ahead of time. In recent years, growth at the PAV has surpassed the figures set out in the 2015 Strategic Plan. For instance, in 2010, 4.2 million TEUs were handled, thus exceeding the strategic growth objective for container throughput. Currently, the PAV works with its Strategic Plan for 2020 taking into consideration the new challenges posed by the current economic scenario.

#### Facilities at the Port of Valencia

The Port of Valencia is highly specialised in container traffic, as well as liquid bulk, solid bulk, and Ro-Ro traffic.

It also offers regular passenger and goods services to and from the Balearic Islands, and welcomes large numbers of cruise passengers every year.

There are twelve different terminals operating at the Port of Valencia:

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Figure 16: Valenciaport Metro-Map (August 2015), (Source: Valenciaport foundation)
Three container terminals: TCV, Noatum and MSC.

Two passenger terminals: Balearia and Transmediterrania-Acciona.

One RO-RO terminal: Valencia Terminal Europa.

One solid bulk terminal: Temagra, Holcim and Cemex.

Two chemical and oil terminals: Tepsa and Galp.

Three liquid bulk terminals (Asphalt, oil and molasses): DEMAGRISA, Teva-Tank and Productos Asfálticos.

Foreland

Through its comprehensive network of regular shipping services, Valenciaport ensures exports, imports and transhipments are linked to the world’s main shipping routes, providing access to markets on all five continents.

Hinterland

The Port of Valencia is directly linked to Spanish and international road and rail networks. The V-30 (Valencia bypass) connects the Port of Valencia to the national road network and to all other roads in its hinterland.

In turn, rail connections from Valencia provide access to all the production areas in the Iberian Peninsula and in Europe. Three trains run daily in both directions on the Valencia-Madrid corridor, which is the main rail link for Valenciaport, channelling 25% of land container traffic by train. It also has connections to the Atlantic (Valencia-Saragossa-Bilbao corridor). In line with European transport policies, Valenciaport is also committed to the Mediterranean corridor.

Valenciaport is the main driver of import and export flows in the Iberian Peninsula. In addition to being Madrid’s natural port, its hinterland extends to many other Spanish regions, including Aragon, Castile La Mancha, Castile-Leon, Murcia, and Andalusia.
2014 Traffic Figures

Figure 17 Valenciaport Traffic Figures (2013 - 2014), (Source: Valenciaport Marketing Brochure 2015.)

Figure 18 Kind of Cargo at the Port of Valencia in 2014 (Source: Valenciaport Marketing Brochure 2015).
5 Technical overview - PortCDM demonstrator

In this section the PortCDM SIP demonstrator is described in more technical terms; the data model, the services and architecture, as well as data connectors and the front-end.

5.1 Data Model

The central subset of the data model used in the PortCDM SIP demonstrator is described below. The data model described pertains mainly to the services PortCallManager, ProcessManager and PortCallStatus.

5.1.1 Port Call Data Model

The central entity in PortCDM SIP is the PortCall. The PortCall entity serves as the abstraction that encapsulates the data about a specific port call.

Port call data comprise state data and information data.

In the metro map metaphor (c.f. figure 2), each station represents a coordination point. In the PortCDM SIP, a coordination point is represented as a state, example states types are shown in Table. In a PortCall instance, state data comprise a date and time (estimate or actual time for the achievement of the particular state), who reported it and when it was reported, as well as a comment (free text field).

A state type is identified by a textual identifier as shown in the left column in table 3. The identifiers are descriptive, and are prefixed with an abbreviation of the actor responsible for its achievement (corresponding to the “metro line” on which the station is located, c.f. figure 2).

Table 3: Example state types

<table>
<thead>
<tr>
<th>State type ID</th>
<th>State type description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSL_Notification_Submitted</td>
<td>Vessel notification has been submitted</td>
</tr>
<tr>
<td>VSL_Arrival_TA</td>
<td>The vessel has arrived to the traffic area</td>
</tr>
<tr>
<td>VSL_AllFast</td>
<td>The vessel is ALL FAST</td>
</tr>
<tr>
<td>TUG_Arrival_Order</td>
<td>Tug order for arrival. Estimates represent preliminary booking of tug and an actual represents a confirmed booking. The time refers to when the tug job is to commence</td>
</tr>
<tr>
<td>COP_STARTED</td>
<td>Loading and unloading (discharging) has started</td>
</tr>
<tr>
<td>COP_Completed</td>
<td>Loading and unloading (discharging) has finished</td>
</tr>
</tbody>
</table>

Port call information represents more generic types of port call data. Example information types are shown in table 4. This type of information should most likely be managed by other STM concepts. In the ML2 demonstrator this information was included in the port call data model as it was considered useful for the front-end application (and no other STM concepts were yet implemented).
An information type is identified by a textual identifier, as shown in the left-most column in Table. The identifiers are descriptive, and are prefixed with a string indicating by which STM concept the information probably should be managed (for instance, VSL corresponds to vessel registry and VOY to voyage management).

**Table 4: Example port call information types**

<table>
<thead>
<tr>
<th>Info type ID</th>
<th>Info type description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSL_Name</td>
<td>Vessel name</td>
</tr>
<tr>
<td>VSL_Draught</td>
<td>Vessel draught [m]</td>
</tr>
<tr>
<td>VSL_Callsign</td>
<td>Vessel callsign</td>
</tr>
<tr>
<td>VSL_Type</td>
<td>Type of vessel, e.g. cargo, tanker, bulk, passenger</td>
</tr>
<tr>
<td>VSL_CurrentSpeed</td>
<td>Current vessel speed [kn]</td>
</tr>
<tr>
<td>PCL_ArrivalTugs</td>
<td>The requested number of tugs on arrival</td>
</tr>
<tr>
<td>PCL_Quay</td>
<td>The destination quay(s) for the port call</td>
</tr>
<tr>
<td>VOY_LastPort</td>
<td>The port from which the vessel is arriving</td>
</tr>
<tr>
<td>VOY_NextPort</td>
<td>The port to which the vessel is departing</td>
</tr>
</tbody>
</table>

The PortCall class is shown in figure 19. The port call data is stored in the two sets PortCallState and PortCallInfo, where state type ID and info type ID are identifiers.

Each PortCallState refers to a specific StateType (see table 4 for examples), and may contain any number of estimates and actual times for that state (represented by the TimeStatement class).

Each PortCallInfo refers to a specific InfoType (see table 4 for examples), and may contain any number of reports (represented by the InfoStatement class).

### 5.1.2 Process Data Model

A port call process serves as a template describing how a port call shall (ideally) be performed. The process includes which states shall be achieved and in which order. The choice of process may be dependent on any number of factors, e.g. type of ports, weather, type of vessel and cargo, certificates held by the captain. Each port use a selection of states derived from the generic state chart (c.f. figure 2).

The data model for Process is shown in figure 20.
A Process contains a set of ProcessState instances, where each refers to a specific StateType (state type ID is the identifier in the ProcessState set). A ProcessState may define any number of ProcessState instances as prerequisites (i.e. on which it depends). Furthermore, each ProcessState belongs to a ProcessPhase.

5.1.3 Port Call Status Data Model

The status of a port call is evaluated by combining the port call data with a specific process. The status is evaluated based in part on how well the data corresponds to the order of states as stipulated in the process.
As can be seen in figure 21, PortCallStatus refers to a PortCall instance and a Process instance. The status of a port call is dependent on the status of its states, shown in figure 21 as a set of PortCallStateStatus instances where each instance refers to a PortCallState and a ProcessState. This means that functionality is provided for enabling a particular port call to include a specific set of states used for coordinating the particular port call.

5.2 Service definitions

The full API documentation can be found here:

- REST API (SNAPSHOT_1.1-1546-01): http://brink.viktoria.chalmers.se/x/uwIY

- MSDL (SNAPSHOT_1.1-1546-01):

(Contact PortCDM@viktoria.se to apply for access.)

5.2.1 DataDictionary

The DataDictionary service provides read-only access to the state and port call information types available (see Codelist).

Codelist 1: Msdl specification for the ProcessManager service

```java
endpoint ProcessManagerEndpoint {
    Process create();
    Process update( 1:Process process );
    Process get( 1:text processId );
    list<ProcessIdentity> getAll();
}
```

5.2.2 Process

The Process service provides access (CRU) to port call processes (see Codelist).

Codelist 2: Msdl specification for the ProcessManager service

```java
endpoint ProcessManagerEndpoint {
    Process create();
    Process update( 1:Process process );
    Process get( 1:text processId );
    list<ProcessIdentity> getAll();
}
```

5.2.3 PortCall

The PortCall service provides access (CRU) to port calls (see Codelist).
5.2.4 PortCallStatus

The PortCallStatus service provides read-only access to status evaluations of port calls (see Codelist). Evaluation of a port call is done by implementation-specific rules, such as to indicate if a required state is not achieved within a specific time before a dependant state is estimated to be achieved. Such rules are to be defined by the process against which the port call data is evaluated. In each PortCDM implementation the process configuration contains rules for state dependencies and process durations as a basis to indicate port call status.

In addition, the service provides various filters for convenience, such as retrieving ongoing port calls, or port calls that have been updated within a certain time period.

5.2.5 PortStatistics

The PortStatistics service (Codelist) is intended to provide various (read-only) statistics over port performance and productivity.

Codelist 3: Msdl specification for the PortCallManager service

```plaintext
codelist 3: Msdl specification for the PortCallManager service

eventPortCallManagerEndpoint {
    PortCall call( 1: text processId );
    list<PortCallIdentity> get(1);}

    // Administrate portcall
    void merge( 1: text fromPortCallId, 2: text toPortCallId);
    void delete(1: text portCallId);
    void moveStatement(1: int timeStatementId, 2: text toPortCallId);
    void deleteTimeStatement(1: int timeStatementId);
}
```

Codelist 4: Msdl specification for the PortCallStatus service

```plaintext
codelist 4: Msdl specification for the PortCallStatus service

eventPortCallStatusEndpoint {
    // Get a portcall with annotated status according to the default process
    PortCallStatus getStatus( 1: text portCallId );

    // Get a portcall annotated according to the provided process
    PortCallStatus getStatusForProcess( 1: text portCallId, 2: text processId );

    // Get a portCall state annotated according to the provided process
    PortCallStateStatus getStatusForPortCallState( 1: text portCallStateId );

    // Get a list of the states that have been updated
    // since the provided date for the provided portcall
    list<PortCallStateStatus> getUpdatedSince( 1: text portCallId, 2: timestamp updatedSince );

    // Get a list of the states that were updated between the supplied times
    list<PortCallStateStatus> getUpdatedBetween( 1: timestamp from, 2: timestamp to );

    // Gets a list of the portcalls that have been updated since the provided date
    list<PortCallStatusSummary> getUpdatedPortCallsSince( 1: timestamp updatedSince );

    // Gets a summary list of all currently ongoing portcalls
    // (i.e. that is not in stage 'SAILED' or 'EXPIRED')
    list<PortCallStatusSummary> getOngoing();
}
```
Codelist 5: Msdll specification for the PortStatistics service

```java
endpoint PortWorkloadEndpoint {
    // Get data to calculate port workload
    list<PortCallDuration> getPortCallDurations();
    // Get workload for a set of time periods.
    list<WorkloadPeriod> getWorkload( list<Period> periods);
}
```

5.2.6 UpdatePortCall

The UpdatePortCall service provides APIs for submitting port call data (see Codelist). The submission of port call data requires three parts

1. **Port call identification**
   A port call can be identified by its (internal) port call id available from PortCallManager, or by vessel IMO-number together with an approximate planned arrival date. The planned arrival date is used by the PortCDM SIP to identify the most likely port call, or create a new port call if none are found.

2. **Port call data type**
   The type of data to be submitted, either from StateType or InfoType. StateType updates can be submitted as either an estimate or an actual time.

3. **Statement**
   The statement is the data submitted along with meta data, such as who submitted the data and when. For StateType updates, the statement is a point in time in UTC (see TimeStatement in figure 21). For InfoType, the statement is a string (see InfoStatement in figure 21).
5.3 PortCDM SIP Architecture

The PortCDM SIP architecture is shown in figure 49 (logical view) and figure 22 (development and deployment views).

Figure 22 shows the interface between client- and server-side service modules (APIs). The APIs—the functions and data types by which client interact with the PortCDM SIP—are defined in the language Maritime Service Definition Language (MSDL). MSDL is part of the Maritime Cloud framework (MC). MC provides:

Codelist 6: Msdl specification for the UpdatePortCall service

```c
endpoint UpdatePortCallEndpoint {
    /* StateUpdate */
    PortCallIdentity addEstimate(
        1: text imo,
        2: timestamp plannedArrivalDate,
        3: text stateId,
        4: timestamp newEstimatedTime,
        5: text reportedBy,
        6: timestamp reportedAt,
        7: text comment
    );
    PortCallIdentity addActual(
        1: text imo,
        2: timestamp plannedArrivalDate,
        3: text stateId,
        4: timestamp newActualTime,
        5: text reportedBy,
        6: timestamp reportedAt,
        7: text comment
    );
    PortCallIdentity addEstimateWithPortcallID(
        1: text portCallId,
        2: text stateId,
        3: timestamp newEstimatedTime,
        4: text reportedBy,
        5: timestamp reportedAt,
        6: text comment
    );
    PortCallIdentity addActualWithPortcallID(
        1: text portCallId,
        2: text stateId,
        3: timestamp newActualTime,
        4: text reportedBy,
        5: timestamp reportedAt,
        6: text comment
    );
    /* InfoUpdate */
    PortCallIdentity addInfo(
        1: text imo,
        2: timestamp plannedArrivalDate,
        3: text infoId,
        4: text infoText,
        5: timestamp reportedAt,
        6: text comment
    );
    PortCallIdentity addInfoWithPortcallID(
        1: text portCallId,
        2: text infoId,
        3: text infoText,
        4: timestamp reportedAt,
        5: text comment
    );
}
```
- An API definition language (MSDL);

Generation of client and server side source code (e.g. Java) representations from MSDL;

- A flexible run-time communication framework for client-server connections (MMS). The framework takes client connectivity into consideration and provides services such as authentication and service discovery.

As can be seen in figure 22, the PortCDM SIP APIs are defined in MSDL from which client and server side Java classes are generated. These classes are generated into the lib package, and are kept separate from the reference implementation (shown to the right in figure 22). This ensures compatibility between client and server regardless of implementation.

In the PortCDM SIP, the lib package was extended with a REST API mirroring the APIs defined in MSDL. This was due to the need to support web clients (whereas currently only Java can be generated from MSDL).

The client applications developed in WP7 are shown to the left in figure 22. These, described below, are: data connectors written in Java providing the PortCDM SIP with port call data, and a web application written in JavaScript providing best known information about on-going port calls.

5.4 Data Connectors

Data connectors provide functionality that integrates external systems with PortCDM for the purpose of submitting port call related information.

Several connectors were developed:
- AIS data for vessels in Swedish territorial waters. Delivers data such as:
  
  o *State data:* Estimated and actual time of arrival to traffic area, actual time to berth, actual time of departure from berth, anchor and aweigh times.
  
  o *PortCall info:* Vessel location and speed, and vessel type.

- SafeSeaNet data. Delivers data such as:
  
  o *State data:* Estimated and actual time of arrival to berth, as well as departure from berth.
  
  o *PortCall info:* Vessel type, which port the vessel is arriving from and departing to, number of passengers and crew on arrival and on departure.

- Maritime Single Window currently in development. The connector will deliver a superset of the SafeSeaNet data.

- Gatship Delivers data such as:
  
  o *State data:* Estimated and actual time of arrival to and departure from traffic area and berth, as well as anchor and aweigh times.
  
  o *PortCall info:* Quay(s), number of passengers on arrival, and which port the vessel is departing to.

### 5.4.1 Connector Design

Data connectors extract data from external sources and provide these to the PortCDM SIP using the UpdatePortCall API, as illustrated in figure 23. By relying on the service discovery service in MC, a connector for a specific external system should be able to integrate with any PortCDM SIP implementation or deployment.
In MONALISA 2.0, three types of data connectors have been explored, each described below:

- **System level** connectors built into the external systems;

- **Direct data level** connectors accessing the data storage of an external system, but that does not require integrate with it;

- **Indirect data level** connectors, acquiring in various other ways.

**System Level Connectors**

System level connectors are integrated directly into the external system. Whenever there are relevant updates made in the system, these updates are submitted to the PortCDM SIP using the UpdatePortCall API.

System level connectors are the preferred way of integrating with PortCDM SIP, as the integration is made directly into the code of the system (as illustrated in figure 24) thereby enabling fine grained control over the types of updates that are submitted to PortCDM SIP. Furthermore, in a scenario with a fully deployed PortCDM, external systems would typically also access data available in PortCDM that would require system level integration.

In WP7, no system level connectors were developed.

![Figure 24 PortCDM data connector, integrated on system level](image)

**Direct Data Level Connectors**

Direct data level connectors extract updates from the external system by directly accessing its data store (typically an SQL database). This type of connector does not require integration into the code of the external system; integration can thus be done without the need for modifications, or even access, to the code of the external system. Direct data level connectors are, however, entirely dependent on the type and structure of the database, and how well that structure is documented. The main drawbacks of this type of integration are therefore:

a) Insufficient database documentation requires challenging reverse engineering;
b) Uncertainty in how and when data is updated (this logic is typically hidden in the application code);

c) The external system may, without notice, change how the data is stored and managed.

A typical deployment for direct data level connectors is an external application that regularly performs a database search and identifies relevant updates that have been made since the previous search. The success of the connector is thus highly dependent on the database structure; for instance, in order to identify the relevant updates that has occurred since a previous point in time.

In WP7, a direct data level connector was developed for the ship agent management system Gatship.

**Indirect Data Level Connectors**

Indirect data level connectors (illustrated in figure 26), similar to direct data level connectors, do not require integration into the external systems themselves. Rather, this type of connector relies on an existing integration interface in the external system (for instance, automatic data export functionality).

As can be seen in figure 26, the external system contains some functionality to export data that the connector can read and transform into PortCDM updates.

Compared to direct data level connectors, existing integration interfaces are typically better documented and maintained than the data store is (which, in this respect, serves as the integration interface for direct data level connectors). Integration using indirect data level connectors are typically more straight-forward to implement, and less sensitive to changes made to the external system, than using direct data level connectors.
In WP7, indirect data level connectors were developed for:

- **AIS data**, where Swedish Maritime Authority (SMA) provides streamed AIS data over a web socket in a well-documented format (corresponding to “Exported Data” in Figure). The connector receives AIS messages continuously over the socket and transforms relevant messages into PortCDM updates;

- **SafeSeaNet and Maritime Single Window**, where the SMA exports messages in a well-documented XML format to an FTP-server. The PortCDM connector runs a service at 10 minutes interval, which downloads and transforms these messages into PortCDM updates.

5.5 Front-end application

As earlier mentioned, in addition to the PortCDM SIP demonstrator implementation and the data connectors, a front-end application was developed as part of WP7. While in a fully deployed PortCDM, the existing IT systems deployed at each actor would typically integrate with the PortCDM SIP and thereby serve as custom front-ends for PortCDM, in WP7 this was not feasible. Instead, a generic front-end application was developed to demonstrate the possibilities with integrating with PortCDM SIP.

The main focus for the front-end was to provide a shared situational awareness application with regard to the state of the port calls in a port. For this, the front-end provides:

- List of all on-going port calls (planned, arrived, berthed, and anchored vessels) with filtering and sorting functions;

- Detailed presentation of port calls, including submitted data and an evaluation of their current status (whether estimates are likely to hold etc.);

- Port statistics and workload overview.
- Possibilities for manually entering time stamps related to a certain state (to be used for correcting and/or complement automatic connections with manual data.

All functionality in the front-end is enabled by the (REST) APIs available in the PortCDM SIP.

Figure 27 Front-end application showing the port overview page.

Figure 27 shows the port overview page. The list of all currently on-going port calls is on the left pane in the figure. The circle with the plus sign at the bottom of that pane provides functionality to register a new port call.

The main panel in figure 27 shows aggregated port call data for the entire port. The two pie charts at the top shows the current status and phase of on-going port calls. As can be seen from the left pie chart, there are currently 55 on-going port calls of which 44 is going as planned, 7 have a warning (e.g. an estimated time might not hold), and 4 have a problem (e.g. an estimate was missed thus there is a risk that subsequent states might be delayed). From the right pie chart it can be seen that 40 of the 55 port calls are planned (i.e. the vessel has yet to arrive to the traffic area), 3 has arrived but have still not berthed (possibly en route to the quay, or anchored), 8 vessels are at berth (performing cargo operations), 1 has departed from the berth but has yet to leave the traffic area, and 3 has recently left the traffic area (i.e. have sailed).

The chart at the bottom left in figure 27 shows an estimated workload view for the coming week. The chart shows the estimated number of on-going port calls per day for the coming week. The chart is continuously updated as data is submitted from the data connectors.

Finally, the bottom right in figure 27 shows weather information from a number of observation stations around the Port of Gothenburg. The data is provided by SMA, and includes weather and wind conditions, as well as water level, salinity and density.
Figure 28 shows an overview of a specific port call. The top pane shows a port calls status overview, the middle pane visualize the current best known port call state information, and the bottom pane shows a log with the most recent state updates.

Figure 28 Front-end application showing the port call overview page.

Figure 29 shows a detailed log with the received state updates.

Figure 29 Front-end application showing recent state updates for a port call

Figure 29 shows a detailed log with the received state updates.

Figure 30 shows the list of all submitted port call information. The circle with the plus sign to the right allows manual submission of information.

Figure 30 shows the list of all submitted port call information.
Figure 30 Front-end application showing port call information.
6 Validation of PortCDM Concept

6.1 Validation Model(s)

6.1.1 Validation Hypotheses based on PortCDM Concept Objectives

The PortCDM Concept has been validated guided by a set of hypotheses which has the origins in the objective with the concept for respond to challenges of today leading to desired effects (see figure 31 below). Different methods could be applied for such purpose where different data sources are being used. The validation effort combines qualitative and quantitative methods for collecting data (see figure 31 below).

![Validation Model of PortCDM](image)

**Figure 31 Validation Model of PortCDM**

6.1.2 Evaluation aspects

The validation model used to validate the PortCDM concept through the two demonstrators is directed towards aspects in two dimensions: the concept and the PortCDM SIP, and the Living Lab as the local implementation of PortCDM (see figure...
These dimensions are brought forward for concerns in future validation efforts as well as keeping the PortCDM concept in focus.

6.1.3 PortCDM Concept KPIs

The data collection used in the validation is a combination between quantitative and qualitative data. The quantitative data has been used to calculate PortCDM concept specific KPIs.

The PortCDM concept has been translated into KPIs, to enable PortCDM to be measured. The concept specific KPIs are: Punctuality, Predictability, Waiting Times/Anchoring Times, Berth Productivity and Resource Utilization. These measures are detailed and further described, and the method for the calculations is outlined in the section 6.1.4 below. The measure of the ability to predict has especially been focus in the two demonstrators.

The design vision of PortCDM has also been translated into hypotheses for validation to be verified or falsified in the validation process. The hypotheses include concept specific KPIs but are also, as mentioned above, formulated based on the objectives with PortCDM concept.

Therefore, the hypotheses include both quantitative and qualitative aspects why a combined approach of data analysis with questionnaires and in-depth interviews has been selected.
6.1.4 Method for data generation

Data Analysis (D)

The data analysis has been performed comparing baseline data with data retrieved during the focus month. Due to the fact that the demonstrator is a small-scale implementation with a selection of Port Calls included, the data analysis has provided indication of trends rather than facts for a number of key measures. In the data analysis green steaming analysis has been performed using AIS–data. The analysis was made by calculating waiting times identifying which, and for how long, vessels were anchoring based on AIS–data. The data analysis also included calculations on, and/or the derivation of formulas for, PortCDM Concept KPIs; Predictability, Punctuality, Waiting times/anchoring times, Berth Productivity and Resource Utilization. Another source for validation included in the data analysis was calculations on Usage Statistics.

**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:

- \[ PRED_{RAPP} = 1 - \frac{\text{Deviation from actual}}{\text{Time before actual}} \]

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

- \[ PRED_{STATE} = \text{AVERAGE}(PRED_{RAPP(1..n)}) \]

For a PortCall the averages is taken based on the predictability of all states:

- \[ PRED_{PORTCALL} = \text{AVERAGE}(PRED_{STATE(1..n)}) \]

For a particular time period the average of either states of PortCall is determining the ports ability. Below follows an example of calculating state predictability and overall predictability:
Figure 34 Examples of Predictability Calculations

**Punctuality** is the characteristic of being able to complete a required task or fulfill an obligation at a previously designated time. In PortCDM, punctuality is used for determining whether a state occurs "on time". Punctuality is thus determined by the deviation between when a particular state occurs and the agreed time of its occurrence. In PortCDM, a state is defined as "on time" if it appears within 15 minutes, i.e. within the time span +/- 15 minutes. Punctuality is the percentage of state occurrences “on time” of a selected state divided by the total number of instances of the selected state for a chosen time period. As e.g. the number of berth occurrences that was within a +/- 15 minute time span divided by the total number of berths for a particular quay for a particular time period. +/- 15 minutes have been chosen as a basis for PortCDM, but is configurable for different states based on the characteristics of the port. Agreed time is determined by two or more actors’ agreement of a particular time for an occurrence of a state change. Overall punctuality is determined by the average of the punctuality for chosen states:

- \( \text{PUNCT}_{\text{STATE}} = \text{Number of state changes that are within +/- 15 minutes divided by the total amount of state changes for a certain time period} \)
- \( \text{PUNCT}_{\text{PORTCALL}} = \text{AVERAGE (PUNCT}_{\text{STATE}(1..n)}) \)

**Waiting times** is determined based on when a particular resource/infrastructure is idle. This is calculated based on actual times for related state occurrences of a milestone.

- \( \text{WAITING}_{\text{RESOURCE}(1)}@\text{MILESTONE}(n) = \text{IF ACTUAL}_{\text{TIME}}\text{RESOURCE}(1) < \text{ACTUAL}_{\text{TIME}}\text{RESOURCE}(2...n) \) \( \text{THEN ACTUAL}_{\text{TIME}}\text{RESOURCE}(2...n) - \text{ACTUAL}_{\text{TIME}}\text{RESOURCE}(1) \)
- \( \text{WAITING}_{\text{ RESOURCE}(1)} \text{RESOURCE}(1) = \text{SUM(WAITING}_{\text{RESOURCE}(1)}@\text{MILESTONE}(1..n)) \)
- \( \text{WAITING}_{\text{ RESOURCE}(1)}\text{PERIOD} = \text{SUM(WAITING}_{\text{ ACC PORTCALL}}(1..n)\text{RESOURCE}(1)@\text{MILESTONE}(1..n)) \)

**Berth productivity** is determined based on conventional methods, i.e. the time when cargo operations have been performed (Commenced cargo operations – completed cargo operations) divided by the total time at berth (Departure berth – arrival berth).
- BERTH_PROD_{PORTCALL(1)} = (COP_COMPLETED_{ACTUAL} – COP_STARTED_{ACTUAL}) / (VSL_DEPARTURE_BERTH_{ACTUAL} – VSL_ARRIVAL_BERTH_{ACTUAL})

- BERTH_PROD_{AVERAGE_{PERIOD}} = BERTH_PROD_{PORTCALL(1..N)}

**Resource utilization** is determined based on the use of a particular resource / infrastructure put in relation to the resource’s overall availability. This could concern e.g. a crane or a particular person as the resource.

**Interviews (I)**

The first quantitative validation data consist of interviews, with the purpose to balance the data analysis and enable in-depth interviews with Living Lab participants about the PortCDM Concept, the front-end application, back-end solutions and the Living Lab approach.

**Questionnaires (Q)**

The second quantitative validation data is the online survey. The survey consisted of 33 numbers of questions addressing the same aspects of the demonstrator as the interviews. Each response in the survey required a comment from the respondents. The main purpose with the questionnaires has been to retrieve users feedback on the four main areas of validation.

**Observations (O)**

The third and last quantitative validation data has been observations at different occasions throughout the Living Lab Process. The observation has been conducted at the participating organisations workplace and the main purpose has been to study the use and the reception of the demonstrator in each of the participating organizations.

### 6.2 Validation process GOT

#### 6.2.1 Preparation

Preparations for the validation process in Gothenburg was done in collaboration with the participants in the Living Lab, such as selecting relevant focus month and identifying respondents for interviews and questionnaire. The concept and development team visited the future PortCDM users with the purpose to educate them in the PortCDM application, brief about the purpose with the project, the concept, the impending focus month and the subsequent study. Each PortCDM user received a guide as support in the use of the application.

An email-address was created and we had a support number accessible 24h, for user support and to facilitate for users to submit feedback. It was also decided in the Living Lab to have weekly meetings during the focus month. The interview questions and the questionnaire were then constructed based on the hypotheses and the four main areas; PortCDM concept, Back-end solutions, Front-end application, and the Living Lab Approach. It was decided to have an anonymous questionnaire. September 2015 was selected as focus month and the participants in the Living Lab were chosen as interviewees.
respondents. Further, the actor representatives selected the PortCDM users to respond to the web-based questionnaire after the focus month.

6.2.2 Execution

All participating actors had access to the application during the focus month. The feedback as such, the response to questions and reviews as well as other improvements, were summarized and responded to in weekly newsletter distributed to all PortCDM users and the Living Lab participants.

During the focus month the usage statistics were gathered and distributed to the concept team every day and the basis was then consolidated into a weekly report and distributed to the Living Lab participants. The purpose with the usage statistics was to retrieve trends of users interaction and to identify interaction patterns.

The 10 conducted interviews with Living Lab participants was conducted and PortCDM users got access to the online questionnaire. The usage statistics was collected and summarized continuously on a daily basis.

6.2.3 Evaluation

There was a continuous evaluation during the entire Living Lab process and the evaluation aspects were intensified during the focus month. The focus was expanding from eliciting new requirements to also include validation of the functionality in relation to user needs, usability, reliability, data accuracy and potential effects.

The Concept KPIs was calculated prior and post implementation, using baseline-data for comparison. The data for the same period of time one year before was collected, aggregated and compared with new data post implementation. Since the demonstration in GOT only included a selection of port calls this analysis was done mainly for the purpose of identify indicators and retrieve trends of effects likely to occur due to a large-scale PortCDM implementation. Further, the average process duration times, as in turn around process time and efficient process duration (the sum of operations) were calculated.

The response rate to the questionnaire was consolidated and analysed together with data about the respondents. The interviews were analysed, validated and reviewed to. The data accuracy analysis was conducted by comparing data from all existing data sources for the same state and identifying incomplete port calls, meaning port call data not applicable in the validation.

6.3 Validation process VAL

6.3.1 Preparation

The preparation for the validation process in Valencia began with contacting the stakeholders who would be directly participating in the process. These included the Piloting station, the port authority, the mooring personal and the tug company. Selecting one month of the previous year, April of 2015 we asked each of the actors to provide
the data that they had gathered for this period of time. The data would work on two level, one as a baseline for the different states identified in the living lab but secondly as an insight into the backend systems so we could begin designing the connectors.

The first and primary connector to be established was the link to the port authority via the Port Community System (PCS). This would provide the data required to create a new port call within the platform, all other connectors would then add states to these port calls. The PCS in Valenciaport is advanced and works from a service orientated architecture that is flexible and can easily adapt and integrate with other systems however the system contains a lot of commercially sensitive information which is not relevant to the scope of the PortCDM platform so direct access was not a viable solution. Since the port authority wished to control the data being extracted the solution developed was to set up a web service.

6.3.2 Execution

Each of the connectors for the actors were all established and the database was cleared before the live launch of the platform on the 1st of October at 8am. For the first few hours the information being received by the platform was closely monitored manually to make sure no inaccurate or junk data was being sent. No problems we detected during this monitored time and the stakeholders were then contacted to begin accessing the system to view the data in real-time. As requested by the Swedish partners an automated mail was sent every morning with details statistics on use gathered by parsing the platform logs.

6.3.3 Evaluation

From a technical perspective, the PortCDM was evaluated on aspects of usability, reliability and accuracy.

In terms of usability the platform was very well received among the stakeholders. In face to face meetings we encouraged feedback in regards to the user interface however most of the stakeholders found it to be intuitive and the information was very clearly displayed. Further information was gathered from the interviews and surveys.

Secondly the reliability of the platform was evaluated and during the two month cycle of testing the live system was only offline once for a scheduled maintenance which required a restart of the server. All information during the period of shutdown was retroactively entered into the system to maintain the integrity of the data.

Finally the accuracy of the data was evaluated by comparing the data with the published lists of port calls (published one day after the fact in the local maritime publication). It was possible to find each of the vessels recorded in the publication in the platform verifying that the information received from the port authority was accurate. The pilots data was cross referenced with the data received from the PCS which confirmed its accuracy however the data was not being collected in real-time as there was a delay sometimes of hours between the reporting of the state to when the information was entered into the pilots system. This issue of real-time piloting
information will be something targeted for improvement in the following iterations of the project.

6.4 PortCDM Hypotheses

Based on the data sources these have been related to the different hypotheses formulated as the assumptions for the PortCDM solution. The design vision for PortCDM is:

Structured information sharing by multi-stakeholder collaboration for enhanced situational awareness in port calls

The overall purpose with PortCDM is to enable sustainable sea transports as part of inter-modal transportation processes. PortCDM enables different actors to make informed decisions based on the consequences that a particular information object (intention of, or occurrence of, a state change) have on the port call process in real time, i.e. which consequences a particular state have on other states for the efficient realization of a port call

6.4.1 Goals with, and enablers, for PortCDM

The basis for deriving the validation hypotheses for PortCDM has been the objectives for PortCDM. In the goal diagram below the objectives are depicted and related to each other.
6.4.2 Hypotheses in different categories derived from the goals

In the following section the different hypotheses are presented in different categories.

Table 5: Validation Hypotheses for PortCM

<table>
<thead>
<tr>
<th>Overall</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Structured information sharing by multi-stakeholder collaboration for enhanced situational awareness among involved actors in a port call leads to well-coordinated port approaches enabling sustainable sea transports berth-to-berth.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PortCDM basics</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>A state functions as a coordination mechanism in a port call</td>
</tr>
<tr>
<td>3</td>
<td>A well-coordinated port call is a process depending on multiple actors’ performances</td>
</tr>
<tr>
<td>4</td>
<td>By using state changes as coordination points well-coordinated port approaches is achieved</td>
</tr>
<tr>
<td>5</td>
<td>Related states in a port call process, forming the common object of interest, enhance the ability of coordination performed by involved actors</td>
</tr>
<tr>
<td>6</td>
<td>Distributed coordination, as opposite of centralized coordination, based on enhanced and shared situational awareness is achieved by each actor’s sharing of intentions and occurrences (i.e. actual state changes) to other (involved) actors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The role of estimation</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Multiple estimates, in time and/or from multiple data sources, for the same states leads to an increased degree of precision about the estimates for a particular occurrence</td>
</tr>
<tr>
<td>8</td>
<td>An increased ability to estimate is based on enhanced accuracy in preceding states</td>
</tr>
<tr>
<td>9</td>
<td>Real-time based updates of estimates of, and actual state changes, enables enhanced accuracy in estimates for preceding and succeeding operations leading to state changes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State Dependencies</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Deficiencies in planning and realization of port calls are identified as state relationships based on time dependencies</td>
</tr>
<tr>
<td>11</td>
<td>The process of well-coordinated port calls are situational dependent and must be configurable for each port and different types of port calls based on representation of, and the configuration of, states as well as a time line depicting the dependency between states</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actor Collaboration</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>A common ground for digital collaboration could be established by an actor-network approach (physical collaboration)</td>
</tr>
<tr>
<td>13</td>
<td>The use of a living lab approach establish a common understanding of actor’s incentives and roles in port operations, a common object of interest, and common goals</td>
</tr>
<tr>
<td>14</td>
<td>By common understanding of the role and use of different information objects in each involved actor’s operations establish incentives for sharing information</td>
</tr>
<tr>
<td>15</td>
<td>Sharing of real-time digital information between actor’s decrease stress and increase safety, e.g. reduced number of phone calls reduces stress and decrease the risk to disturb during critical situations such as when an oil terminal and a vessel are on stand by for stopping a cargo operation</td>
</tr>
</tbody>
</table>

**Actor’s performances**

| 16 | Each actor’s optimized operations in port calls is based on that each actor receives information about other actors’ intentions and performances in real-time according to agreed information sharing model, i.e. the adapted state chart as a common object of interest |
| 17 | Different actors involved in a port call needs different basis for their efficient coordination |
| 18 | Different actor’s images of situational awareness have different components dependent on which role the actor has in the process |

**PortCall performance**

| 19 | A well-coordinated port approach leads to: |
|    | • *reduced waiting times*; reduced unnecessary waiting times / anchoring times |
|    | • *increased predictability*; increased ability to predict state changes, i.e. when operations are planned for and/or actually occurs, based on estimates in relation to the outcome |
|    |   o The closer to the realization a lower degree of deviation is allowed and the frequency of updates will be higher |
|    | • *increased punctuality*; increased ability for different actors to perform their actions in time in relation to the timeline defining the dependencies between different states (+/- acceptable deviation) |
|    | • *increased/or kept level of berth productivity*; increased berth productivity due to reduced waiting times for operations between actual time of berth and actual time of departure from berth |
|    | • *increased capacity utilization*; increased utilization of available infrastructure and resources based on an increased degree of just-in-time operations |

<p>| 20 | State changes related to the common object of interest forms the basis for actors to plan for their optimized and just-in-time operations leading to enhanced punctuality |
| 21 | High precision in planning port calls prior realization enables well coordinated port calls |
| 22 | Real-time updates of state updates during realization, i.e. estimates and actuals, enables well coordinated port calls |</p>
<table>
<thead>
<tr>
<th></th>
<th>Administrative burden and the cost of coordination is reduced by real-time based sharing of intentions of, and actual, state changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous improvement</td>
<td>Continuous improvement for reaching well-coordinated port calls is driven from the identification of relevant states as coordination points and the introduction of causal states forming situational awareness</td>
</tr>
<tr>
<td>Optimal patterns of interaction is achieved by structured digital collaboration informed by historical actors’ and port ‘call performances</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>An enhanced ability to visualize information from other actors’ in actor specific systems increases the quality of the information managed in the actor’s systems</td>
</tr>
<tr>
<td>Standardization of data access is an enabler for actors’ participation in PortCDM</td>
<td></td>
</tr>
<tr>
<td>A standardized approach to approval, discovery, and consumption of services increase actor collaboration, degree of innovation, and quality in the interaction</td>
<td></td>
</tr>
<tr>
<td>Common principles of authentication and accessibility increase actors’ willingness to distribute information</td>
<td></td>
</tr>
</tbody>
</table>

### 6.5 Validation of PortCDM in GOT

In this section the result from the analysis based on the data sources used for the validation of the Gothenburg Demonstrator is presented in different categories based on their main impact area. The section includes a summary for all data source for aspects related to the PortCDM Concept, Back-end Solutions, Front-end Application and Living Lab Approach.

In the figure 35 below usage statistics is depicted for the trial periods for Port of Gothenburg. The diagram is both covering the amount of interactions and the amount of estimates and the amount of actual state updates. In table 6 the number of respondents for each data source are summarized.

![Figure 35 Usage statistics of the PortCDM demonstrator in Port of Gothenburg](image)

**Table 6: Summary of data collections in GOT Demonstrator.**
6.5.1 Data Access and Data Quality:

- The analysis shows that actors experience better access to port call data (73.33%) (see diagram 1), at the same time the same actors (25+%) (see diagram 2) do not consider that PortCDM gives access to new data why one conclusion is that PortCDM increase the accessibility to, and thus increases the usability of, existing port call data.

![Figure 36 PortCDM has given better access to PortCall information.](image)

![Figure 37 PortCDM has given access to more PortCall information.](image)
The data analysis clearly indicates the necessity to apply automatic connections between PortCDM and existing systems. The calculations depict that a lot of problems occurs due to manual data input, e.g. estimates reported after the actuals occurs.

The data accuracy was also calculated based on the reasonability in reported data. One important finding during the process concerned interoperability and inconsistency in data models between two of the systems reported data to PortCDM. This meant that a huge amount of data was invalid and unfortunately this effected the calculations due to that the invalid amount of data was to be removed from the analysis. Therefore, certain KPIs have been hard to measure since a critical mass of port calls could not be achieved during the process for analysis.

**Data accuracy** is determined by comparing different data sources for the same state or by a logic derivation (such as that the estimate/actual is mismatched in relation each other or in relation another state.

### 6.5.2 Conditions for planning

The analysis also shows that PortCDM provides an enhanced possibility for planning. From the interviews it is revealed that it happens that the consequences of a change in time of when operations are to be conducted in a certain port call on other port calls is not communicated to involved actors. By the PortCDM implementation such consequences are highlighted instantly enabling involved actors to re-plan.

### 6.5.3 Common Situational Awareness

73,33 % of the respondents verify that PortCDM has increased the common situational awareness. For the remaining 26,6 %, almost 20 % is not applicable since they have not used the system or see a clear potential in the future in PortCDM as a full-scale implementation. This means that less than 7% (1 respondent) consider PortCDM not to increase the common situational awareness with the argument that it is hard to see the overall picture.

This trend is also verified through the conducted interviews and a majority of the respondents in the GOT demonstrator believes that an enhanced common situational awareness can be reality if the application would include more actors and more automatic data sources.
6.5.4 Actor Collaboration

Actor collaboration is a condition for digital collaboration. To adopt a collaborative approach such as the Living Lab Approach was appreciated by all Living Lab participants. Benefits such as shared view of the common process, increased insight and knowledge in other actors operations.

6.5.5 Administrative Burden

The validation indicated both experienced and expected reduced administrative burden such as reduced number of phone calls due to lack of information or uncertainty of data accuracy.

6.5.6 Living Lab Approach

All the participants in the Living Labs found the Living Lab Approach successful. The approach enhanced the actor collaboration among involved actors in the port community. The approach also facilitated a deeper understanding of each other’s conditions and business operations. This has been highlighted as important to avoid sub-optimization among actors in the port. The approach were also seen as a good method to establish common understanding of the port call process as a common object of interest, as well as define common objectives, challenges and the way forward. The Living Lab approach does not only allows the business actors to get closer, but also to facilitate a strong collaboration between the business actors and the technical and the concept teams. This working approach has enabled a direct feedback and close dialogue between the three teams involved, which has been seen as a successful approach for appropriate prioritization of improvements, a greater understanding of business actors needs and a decreased level of acceptance from the future PortCDM users.

6.5.7 Ability to coordinate in figures

The PortCDM builds upon the following KPI:s; Predictability, Punctuality, Waiting Times/Anchoring Times, Berth Productivity, Resource Utilization, and Data Accuracy. Calculations and thoughts of these are commented below.

Comments on predictability

In the table 7 below the predictability for port of Gothenburg is captured. Predictability rates that are way beyond relevance, such as manually entered values that are obvious human errors, like estimates with deviation that significantly exceeds the time passed after the estimate to the actual event, are filtered away. An
estimate for arrival to traffic area reported 24 hours before the actual arrival, that
deviates by more than 40 hours, for instance. Estimates reported after the actual time
have also been excluded since they are, by their very nature, not estimates.

Table 7: Rate of predictability for each state and for port of Gothenburg over the test period

<table>
<thead>
<tr>
<th>State</th>
<th>Percentage</th>
<th># trans valid est (all est)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSL_Arrival_TA</td>
<td>59.91%</td>
<td>1710(2008)</td>
</tr>
<tr>
<td>VSL_Anchoring</td>
<td>100%</td>
<td>2(2)</td>
</tr>
<tr>
<td>PLT_Arrival_Order</td>
<td>80.01%</td>
<td>22(23)</td>
</tr>
<tr>
<td>TUG_Arrival_Order</td>
<td>97.71%</td>
<td>3(3)</td>
</tr>
<tr>
<td>PLT_Berth_Order</td>
<td>90.90%</td>
<td>1(1)</td>
</tr>
<tr>
<td>VSL_Arrival_Berth</td>
<td>73.12%</td>
<td>286(406)</td>
</tr>
<tr>
<td>COP_Started</td>
<td>69.64%</td>
<td>9(11)</td>
</tr>
<tr>
<td>COP_Completed</td>
<td>72.14%</td>
<td>9(10)</td>
</tr>
<tr>
<td>PLT_Departure_Order</td>
<td>70.69%</td>
<td>23(23)</td>
</tr>
<tr>
<td>TUG_Departure_Order</td>
<td>94.42%</td>
<td>3(3)</td>
</tr>
<tr>
<td>VSL_Departure_Berth</td>
<td>69.85%</td>
<td>493(582)</td>
</tr>
<tr>
<td>VSL_Departure_TA</td>
<td>94.15%</td>
<td>1(1)</td>
</tr>
</tbody>
</table>

These estimates has been captured from the different available systems as follows:

Table 8: Amount of State Changes reported from each actor.

<table>
<thead>
<tr>
<th>Gothenburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS PositionReportClassAScheduled</td>
</tr>
<tr>
<td>SSNS</td>
</tr>
<tr>
<td>VAS</td>
</tr>
<tr>
<td>AIS StaticAndVoyageMessage</td>
</tr>
<tr>
<td>LotsOp</td>
</tr>
<tr>
<td>PREEM</td>
</tr>
<tr>
<td>Port authority</td>
</tr>
<tr>
<td>Klippans Linesmen</td>
</tr>
</tbody>
</table>
As can be revealed from the table 8 above different states has been used for Port of Gothenburg and Port of Valencia. From the figure 38 below it can be revealed that Port of Gothenburg has lower rate of predictability from arrival berth, terminal operations, and departure berth. As expected the estimated time to anchor in Port of Gothenburg is high. The states providing zero predictability are based on the fact that the estimates have been reported long time after the estimate.

In Port of Gothenburg just one agent's port calls (VAS) are covered. Data for all port calls has however been captured when it has been possible to capture automatically from different systems. This means that it has been possible to also compare what it means to use PortCDM actively or non-actively. Below a diagram comparing Port of Gothenburg with PortCDM (for VAS port calls) and without (without VAS port calls) is depicted. This figure 39 below shows a higher predictability (for states that has been possible to derive) when PortCDM is being used actively (in Gothenburg).
The results of real-life tests have also been put in relation to baseline data derived from August 2014. The baseline data does however neither consists of any data of when a particular report on an estimate or an actual was made nor the historical sequence of multiple estimates for a particular state. Further there are also very few states captured in the baseline identification. Just to get some kind of understanding of the situation as it was before the introduction of PortCDM the two diagrams below (see figure 40) shows the deviation in minutes (from the latest reported) ETA vs. ATA and ETD vs. ATD. Out of 488 part calls during august 2014, seven are discarded from the diagrams due to deviation of more than 4 000 minutes.

The two diagrams provide an understanding of difficulties in predicting the time of departure.

Another analysis has also been made for all the 77 captured port calls during the demonstration period. In the diagram below (see figure 41) it is clearly indicated that the predictability rate clearly deviates from port call to port call. This is a call for further analysis using the root-cause analyser. The overall port call predictability (during the test period) was 71 %.
This deviation is however also due to the fact that there is an incompleteness of state data reported from the different actors (manually reported and/or automatically withdrawn) (as for example 537 out of 3099 estimates were invalid). Below follows the summary (see figure 42) of used states in Port of Gothenburg during the focus month, i.e. the amount of states that have just estimates, just actuals or both estimates and actuals bound a particular port call. This shows that there are rather few (270 out of 895 states within port calls) that cover both estimates and actuals.
Figure 42 Used states in Port of Gothenburg during the test period

Comments on punctuality

Punctuality has not been calculated based on data from the demonstrations due to that the agreed time for a particular state has not been captured.

Comments on waiting/Anchoring Time

Due to the fact that too few states have been covered in the demonstrator it is a lack of solid basis for deriving the different resources actual times for the relevant milestones. By using AIS-data for approaching vessels to Port of Gothenburg an anchoring time analysis has been made (see table below)³. This shows that 653 approaches during 2014 (out of 3289) anchored waiting for coming to berth. These vessels anchored in total 14306.7 hours. 4140.9 of these anchoring hours were reducible by a green steaming approach (i.e. slowing down the last ~190 nautical miles). The reducibility of

CO2 was limited by the amount of hours the vessel had been observed laying at anchor, or the maximum distance that those hours could be propagated, whichever was the smallest, as well as the lowest speed in the speed profile of each vessel, i.e. the reduced speed used towards the anchoring area. Based on each vessel’s speed profile gave rise to a potential energy saving of 53 % for those last nautical miles (total MGO\(^4\) savings).

<table>
<thead>
<tr>
<th>Month</th>
<th>Straight approaches</th>
<th>Anchoring approaches</th>
<th>Total anchoring hours</th>
<th>Reducable anchoring hours</th>
<th>Total MGO before reduction [Kg]</th>
<th>MGO savings [Kg]</th>
<th>Percent saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>243</td>
<td>68</td>
<td>1070,5</td>
<td>423,8</td>
<td>118169</td>
<td>66271</td>
<td>56</td>
</tr>
<tr>
<td>February</td>
<td>259</td>
<td>44</td>
<td>1206,6</td>
<td>263,9</td>
<td>88877</td>
<td>47903</td>
<td>54</td>
</tr>
<tr>
<td>Mars</td>
<td>293</td>
<td>44</td>
<td>1129,5</td>
<td>308,9</td>
<td>141888</td>
<td>73389</td>
<td>52</td>
</tr>
<tr>
<td>April</td>
<td>271</td>
<td>69</td>
<td>1118,8</td>
<td>406,4</td>
<td>154024</td>
<td>84397</td>
<td>55</td>
</tr>
<tr>
<td>May</td>
<td>278</td>
<td>62</td>
<td>1202,9</td>
<td>449,8</td>
<td>194898</td>
<td>108040</td>
<td>55</td>
</tr>
<tr>
<td>June</td>
<td>272</td>
<td>53</td>
<td>1494,5</td>
<td>306,6</td>
<td>127575</td>
<td>64914</td>
<td>51</td>
</tr>
<tr>
<td>July</td>
<td>274</td>
<td>62</td>
<td>1778,2</td>
<td>441,1</td>
<td>138548</td>
<td>78964</td>
<td>57</td>
</tr>
<tr>
<td>August</td>
<td>275</td>
<td>58</td>
<td>1363,9</td>
<td>387,7</td>
<td>173599</td>
<td>92216</td>
<td>53</td>
</tr>
<tr>
<td>September</td>
<td>291</td>
<td>34</td>
<td>460,7</td>
<td>168,9</td>
<td>63426</td>
<td>31719</td>
<td>50</td>
</tr>
<tr>
<td>October</td>
<td>307</td>
<td>44</td>
<td>892,3</td>
<td>311,1</td>
<td>127102</td>
<td>66490</td>
<td>52</td>
</tr>
<tr>
<td>November</td>
<td>276</td>
<td>66</td>
<td>1312,9</td>
<td>393,9</td>
<td>119214</td>
<td>58689</td>
<td>49</td>
</tr>
<tr>
<td>December</td>
<td>250</td>
<td>49</td>
<td>1275,9</td>
<td>278,8</td>
<td>118668</td>
<td>60051</td>
<td>51</td>
</tr>
<tr>
<td>Yearly</td>
<td>3289</td>
<td>653</td>
<td>14306,7</td>
<td>4140,9</td>
<td>1565988</td>
<td>833043</td>
<td>53</td>
</tr>
</tbody>
</table>

**Figure 43 Green steaming analysis for Port of Gothenburg**

**Berth Productivity**

Berth productivity has been calculated on the port call data making this possible (i.e. when there are actual values on arrival and departure time from berth as well as when cargo operations where started and completed). The table below (see figure 44) shows complete data for 6 (out of 77) port calls to make such calculation.

**Berth Productivity**

<table>
<thead>
<tr>
<th>VSL_Arrival_Berth</th>
<th>VSL_Departure_Berth</th>
<th>Time at quay (min)</th>
<th>COP_Started</th>
<th>COP_Completed</th>
<th>Time at Cargo Ops (min)</th>
<th>Berth productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-09-15 16:00</td>
<td>2015-09-16 20:00</td>
<td>1680</td>
<td>2015-09-15 20:15</td>
<td>2015-09-16 18:42</td>
<td>1347</td>
<td>80,18%</td>
</tr>
<tr>
<td>2015-09-20 03:06</td>
<td>2015-09-20 14:00</td>
<td>654</td>
<td>2015-09-20 04:00</td>
<td>2015-09-20 13:05</td>
<td>545</td>
<td>83,33%</td>
</tr>
<tr>
<td>2015-09-07 01:24</td>
<td>2015-09-07 16:55</td>
<td>930</td>
<td>2015-09-07 03:10</td>
<td>2015-09-07 15:20</td>
<td>730</td>
<td>78,49%</td>
</tr>
<tr>
<td>2015-09-17 07:26</td>
<td>2015-09-18 08:00</td>
<td>1474</td>
<td>2015-09-17 15:30</td>
<td>2015-09-18 05:30</td>
<td>840</td>
<td>56,99%</td>
</tr>
<tr>
<td>2015-09-01 06:42</td>
<td>2015-09-01 14:42</td>
<td>480</td>
<td>2015-09-01 07:10</td>
<td>2015-09-01 14:26</td>
<td>436</td>
<td>90,83%</td>
</tr>
</tbody>
</table>

**Figure 44 Calculation of Berth Productivity**

Since PortCDM also captures estimates for used variables to calculate berth productivity, a forecast for the berth productivity for a particular port call can be brought forward as soon as there are estimates for each used variable. This is potentially to be used as an indicator for when there is a need to further synchronize forthcoming operations in order to reach a higher berth productivity rate.

Resource Utilization

Resource utilization has not been captured for Port of Gothenburg due to that all port calls has not been captured during the time period. Only a selection of port calls has been monitored and used as basis for enhanced coordination.

6.6 Validation of PortCDM in VAL

In the figure 45 below usage statistics is depicted for the trial periods for Port of Valencia. The diagram is both covering the amount of interactions and the amount of estimates and the amount of actual state updates. The reason why the numbers are much higher in the Port of Valencia is due to both that the state updates where done by capturing the status in the system in a certain time interval while the state updates in Port of Gothenburg were triggered from the actual update.

![Figure 45 Usage statistics of the PortCDM demonstrator in Port of Valencia](image)

6.6.1 Conclusions of Interviews VAL

Four interviews were managed after the Demonstration Workshop in June. Feedback was received from the agents that played their own roles during the simulation carried out (Port Authority, Pilots, Tugboat Company and Mooring Corporation).

The tables below summarises their comments and opinions. Table 5 shows the usefulness of the different proposed states for each of the main actors involved in the port call processes.

It highlights that only the public body is interested in having information available regarding the first ETA when the port call is accepted. Instead of this state, service provider companies prefer to use ETA 24 hours before the ship arrival to the port, which is more useful from the operative perspective. They mentioned that it is how it currently works. The PA sends the berthing authorisations to them 24 hours before the ship arrival (every day at 12:30).

There is more dispersion on the others states and it shows that the usefulness is directly related to the importance from the operational point of view.
### Table 9. Usefulness of the different states for each stakeholder.

<table>
<thead>
<tr>
<th>State</th>
<th>Port Authority</th>
<th>Pilots</th>
<th>Tugboat Company</th>
<th>Mooring Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ETA – Port call accepted</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ETA updates</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Vessel contacts Pilot</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Pilot Available</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Tugs Depart</td>
<td>5</td>
<td>2</td>
<td>2,5</td>
<td>3</td>
</tr>
<tr>
<td>Pilot on Board</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Tugs Attached</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Vessel Secured</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Tugs detach</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Pilot disembarks</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Vessel requests pilot</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pilot is available for the vessel</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Tugs Depart</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pilot is on board the vessel</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Tugs Attach</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Vessel released, last line removed</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Tugs Detach</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Pilot disembarked</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Degree of importance (Likert scale): 1. Not relevant. 2. Low. 3. Medium. 4. High. 5. Very important.

Source: Valenciaport Foundation.

Table 6 shows the comments that the stakeholders provided in the face-to-face interviews regarding each proposed state.
Table 10. Comments of the different states.

<table>
<thead>
<tr>
<th>State</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ETA – Port call accepted</td>
<td>(P) Instead of this one, they also need a new state (ETA 24 hours before), which is more useful from the operative perspective. It is how it currently works. The PA sends the berthing authorisations to them 24 hours before the ship arrival (every day at 12:30).&lt;br&gt;&lt;br&gt;(MC) They are only interested in 24 hours period updates (It is more useful from the operative point of view).&lt;br&gt;&lt;br&gt;(TB) He proposes a new state (ETA 24 hours before), which is more useful from the operative perspective. It is how it currently works (it is sent by the PA of Valencia).</td>
</tr>
<tr>
<td>ETA updates</td>
<td>(P) They do not receive any updates in the 24 hours’ time lapse.&lt;br&gt;&lt;br&gt;(MC) They are only interested in 24 hour periodic updates.&lt;br&gt;&lt;br&gt;(TB) The PA sends the berthing authorisation to them 24 hours before the ship arrival. With this outlook, they program the next day activities. They need more information about this lapse time. Manuel considers that the shipping agent should update the ETA in the database.</td>
</tr>
<tr>
<td>Vessel contacts Pilot</td>
<td>(P) Sometimes captains call them 2 or even 3 hours before the arrival.&lt;br&gt;&lt;br&gt;(TB) The captain calls the pilots 1 hour before its arrival.</td>
</tr>
<tr>
<td>Pilot Available</td>
<td>(TB) The captain does a second communication at 3-miles away in order to confirm the berth and nautical services availability.</td>
</tr>
<tr>
<td>Tugs Depart</td>
<td>(TB) It is not so important for other stakeholders. Although it could be (5 instead of 2 or 3) in case of an emergency service.</td>
</tr>
<tr>
<td>Pilot on Board</td>
<td>(P) Real-time information is not available. Currently, pilots are taking notes in the ships and the pilot controller introduces this information into the database when they return to the base.</td>
</tr>
<tr>
<td>Tugs Attached</td>
<td>(TB) It should be renamed as tugs in position. It means when they are next to the ship and ready to provide the service according to the pilot instructions. According to the terms of service, they have 20 minutes for going from the base to the ship. They could provide the number of tugs as an input parameter.</td>
</tr>
<tr>
<td>Vessel Secured</td>
<td>(MC) We should include additional parameters such as the number of vehicles, numbers of linesmen, use of boat, etc. Moreover, they want to include an extra state regarding the last line.&lt;br&gt;&lt;br&gt;(TB) Which times do we need? The first one, the last one or both? The time of the last line attached represents the ATA in Valenciaport.</td>
</tr>
<tr>
<td>Tugs detach</td>
<td>-</td>
</tr>
<tr>
<td>Pilot disembarks</td>
<td>(P) They will need an app to introduce it. 3G connection is only available at 2 miles away from the port.</td>
</tr>
</tbody>
</table>
(TB) If they knew that all the pilots are working they could wait on the base.

<table>
<thead>
<tr>
<th>New State</th>
<th>Comments</th>
<th>Usefulness (0-5)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel requests pilot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot is available for the vessel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tugs Depart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot is on board the vessel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tugs Attach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel released, last line removed</td>
<td>(TB) This state is more important for the pilots than for them.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tugs Detach</td>
<td>(TB) They could provide the number of tugs as input parameter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot disembarked</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Source: Valenciaport Foundation.

Moreover, they suggested new potential states that could be useful for improving the efficiency of the overall port call process.

Table 11. Potential states proposed by Pilots.

<table>
<thead>
<tr>
<th>New State</th>
<th>Comments</th>
<th>Usefulness (0-5)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal availability</td>
<td>They should provide the proposed location and the berthing side (larboard or starboard).</td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Terminal Operations Completed</td>
<td>Loading and unloading</td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Stevedores down</td>
<td></td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Engine ready</td>
<td></td>
<td>5</td>
<td>Vessel</td>
</tr>
<tr>
<td>STS gantries upright</td>
<td></td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Services providers operations completed</td>
<td></td>
<td>5</td>
<td>Terminal</td>
</tr>
</tbody>
</table>

Source: Valenciaport Foundation.
Table 12. Potential states proposed by Mooring Corporation.

<table>
<thead>
<tr>
<th>New State</th>
<th>Comments</th>
<th>Usefulness (0-5)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETA 24 hours before</td>
<td></td>
<td>5</td>
<td>Port Authority</td>
</tr>
<tr>
<td>ETAs updates in the 24 hours period</td>
<td>Pilot is not usually on board until the mooring process is completed. He/she sometimes leaves the vessel before the end of the manoeuvre in order to be able to attend other calls.</td>
<td>5</td>
<td>Linesmen</td>
</tr>
<tr>
<td>Mooring operations completed</td>
<td></td>
<td>5</td>
<td>Linesmen</td>
</tr>
<tr>
<td>Mooring starts</td>
<td></td>
<td>5</td>
<td>Linesmen</td>
</tr>
<tr>
<td>Pilots Call Time</td>
<td>The Port Authority requests it. They have 20 minutes for going to the quay since pilots call them.</td>
<td>5</td>
<td>Linesmen</td>
</tr>
<tr>
<td>Time of arrival to the quay</td>
<td></td>
<td>5</td>
<td>Linesmen</td>
</tr>
<tr>
<td>Number of vehicles, numbers of linesmen, and the use or not of boat.</td>
<td></td>
<td>5</td>
<td>Linesmen</td>
</tr>
</tbody>
</table>

Source: Valenciaport Foundation.

Table 13. Potential states proposed by Tugboat Company.

<table>
<thead>
<tr>
<th>New State</th>
<th>Comments</th>
<th>Usefulness (0-5)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal availability</td>
<td>They should provide the proposed location and the berthing side (larboard or starboard).</td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Terminal Operations Completed</td>
<td>Loading and unloading</td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Stevedores down</td>
<td></td>
<td>5</td>
<td>Terminal</td>
</tr>
<tr>
<td>Engine ready</td>
<td></td>
<td>5</td>
<td>Vessel</td>
</tr>
<tr>
<td>STS gantries upright</td>
<td></td>
<td>5</td>
<td>Terminal</td>
</tr>
</tbody>
</table>

Source: Valenciaport Foundation.
Table 14. Potential states proposed by the Port Authority.

<table>
<thead>
<tr>
<th>New State</th>
<th>Comments</th>
<th>Usefulness (0-5)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Authorization</td>
<td></td>
<td>5</td>
<td>Port Authority</td>
</tr>
<tr>
<td>First ETD communication</td>
<td>They should be provided before the ship departure process starts.</td>
<td>5</td>
<td>Port Authority</td>
</tr>
<tr>
<td>ETD updates</td>
<td></td>
<td>5</td>
<td>Port Authority</td>
</tr>
<tr>
<td>Terminal operations commence</td>
<td></td>
<td>4</td>
<td>Terminal</td>
</tr>
<tr>
<td>Terminal operations complete</td>
<td></td>
<td>4</td>
<td>Terminal</td>
</tr>
<tr>
<td>Services suppliers (water and fuel) commence</td>
<td></td>
<td>4</td>
<td>Service suppliers companies</td>
</tr>
<tr>
<td>Services suppliers operations complete</td>
<td></td>
<td>4</td>
<td>Service suppliers companies</td>
</tr>
</tbody>
</table>

Source: Valenciaport Foundation.

### 6.6.2 VALENCIA in figures

A major difference of the real-life tests performed in Port of Valencia and in Port of Gothenburg was that Port of Valencia covered all port calls realized during the trial period why Port of Gothenburg just focused on the port calls engaging one of the ship agents during the trial period. Data generated from Port of Valencia was 6318 transactions and from Port of Gothenburg 3597 transactions. A transaction is defined as a generated estimate and actual state updates manually or automatically.

**Comments on predictability**

In the table below the predictability for the Port of Valencia is captured. Predictability rates that are way beyond relevance, such as manually entered values that are obvious human errors, like estimates with deviation that significantly exceeds the time passed after the estimate to the actual event, are filtered away. An estimate for arrival to traffic area reported 24 hours before the actual arrival, that deviates by more than 40 hours, for instance. Estimates reported after the actual time have also been excluded since they are, by their very nature, not estimates.
Table 15: Rate of predictability for each state

<table>
<thead>
<tr>
<th>State</th>
<th>Predictability rate</th>
<th>Percentage</th>
<th># trans valid est (all est)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSL_Arrival_TA</td>
<td>74,31%</td>
<td>353(741)</td>
<td></td>
</tr>
<tr>
<td>PLT_Arrival_Start</td>
<td>15,77%</td>
<td>382(1079)</td>
<td></td>
</tr>
<tr>
<td>COP_Load Started</td>
<td>84,99%</td>
<td>3(271)</td>
<td></td>
</tr>
<tr>
<td>COP_Load_Completed</td>
<td>79,89%</td>
<td>493(1288)</td>
<td></td>
</tr>
</tbody>
</table>

As can be revealed from the table above different states has been used for Port of Valencia. In the diagram (see figure 46) it is revealed that the ability to predict is low in different stages of the port call process at the Port of Valencia. From the diagrams below it can be revealed that the Port of Valencia has a low predictability in when to bring the vessel into the port. As expected the arrival to traffic area (VSL_arrival_TA) in Port of Valencia is high. The states providing zero predictability are based on the fact that the estimates have been reported long after the time of the estimate.

An analysis has also been made for all the 495 captured port calls (217 has been filtered away due to inconsistency in the data). In the diagram below (see figure 47) it is clearly indicated that the predictability rate clearly deviates from port call to port call. The overall port call predictability (during the test period) was 78 %.
This deviation is however also due to the fact of that there is an incompleteness of state data reported from the different actors (manually reported and/or automatically withdrawn) (as for example 2576 out of 3807 estimates were invalid). Below follows the summary of used states in the Port of Valencia during the test period, i.e. the amount of states that have just estimates, just actuals or both estimates and actuals bound a particular port call. This shows that there are rather few (1693 states within port calls) that cover both estimates and actuals.

<table>
<thead>
<tr>
<th>State</th>
<th># trans</th>
<th>Just estimates</th>
<th>Just actuals</th>
<th>Both Estimates and actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>COP_Load_Completed</td>
<td>481</td>
<td>223</td>
<td>1</td>
<td>257</td>
</tr>
<tr>
<td>COP_Load_STARTED</td>
<td>485</td>
<td>71</td>
<td>0</td>
<td>414</td>
</tr>
<tr>
<td>PLT_Arrival_Complete</td>
<td>274</td>
<td>0</td>
<td>274</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Arrival_Order</td>
<td>381</td>
<td>0</td>
<td>381</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Arrival_Start</td>
<td>423</td>
<td>145</td>
<td>42</td>
<td>236</td>
</tr>
<tr>
<td>PLT_Berth_Complete</td>
<td>48</td>
<td>0</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Berth_Order</td>
<td>51</td>
<td>0</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Berth_Start</td>
<td>51</td>
<td>2</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>PLT_Departure_Complete</td>
<td>276</td>
<td>0</td>
<td>276</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Departure_Order</td>
<td>388</td>
<td>0</td>
<td>388</td>
<td>0</td>
</tr>
<tr>
<td>PLT_Departure_Start</td>
<td>388</td>
<td>109</td>
<td>0</td>
<td>279</td>
</tr>
<tr>
<td>VSL_Anchoring</td>
<td>31</td>
<td>0</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Anchoring_Aweigh</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Arrival_Berth</td>
<td>418</td>
<td>0</td>
<td>418</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Arrival_TA</td>
<td>533</td>
<td>60</td>
<td>15</td>
<td>458</td>
</tr>
<tr>
<td>VSL_Departure_Berth</td>
<td>515</td>
<td>515</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Departure_TA</td>
<td>250</td>
<td>2</td>
<td>248</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Notification_Approved</td>
<td>399</td>
<td>0</td>
<td>399</td>
<td>0</td>
</tr>
<tr>
<td>VSL_Notification_Submitted</td>
<td>399</td>
<td>0</td>
<td>399</td>
<td>0</td>
</tr>
<tr>
<td>SUM</td>
<td>5821</td>
<td>1127</td>
<td>3001</td>
<td>1693</td>
</tr>
</tbody>
</table>

Figure 47 Predictability rate per port call in Valenciaport

Figure 48 Used states in Valenciaport
Comments on waiting/Anchoring Time

Due to the fact that too few states have been covered in the demonstrator it is a lack of solid basis for deriving the different resources actual times for the relevant milestones. In this round we have neither been able to run an anchoring time analysis for the Port of Valencia due to lack of access to AIS-data.

Comments on Berth Productivity

Berth productivity has not been calculated for the Port of Valencia due to that data has not been captured for the four variables used to calculate the berth productivity.

Comments on Resource Utilization

Resource utilization has not been calculated for the Port of Valencia due to lack of data from different actors related to particular milestones.

6.6.3 Conclusions of Data-Analysis VAL

There are a number of conclusions in regards to the data; the primary conclusion is that there is not a priority put on real-time gathering of information in the area of port operations. This is shown in particular with both the mooring personal and pilots who gather the information only to enter it into their own systems hours after the task has already been complete. This analysis has presented an opportunity for PortCDM to establish itself in Valencia port as a means of which actors can automatically input the data without the manual process by use of a mobile application; this will be a focus of the coming iterations of the project.

Data from the Tug operators system is gathered in real-time as the operators update each of the states while on-board the vessels. A connector was built specifically for the system operators (Neptune Lines) to integrate the backend system to send the information immediately to PortCDM however the link was never established and hence no real-time data points for the port call were established as a baseline to compare and contrast. Completing this connection will be a top priority with the next stage of the project.

6.7 Validation of PortCDM against the hypotheses

6.7.1 Validation Categories

In this section the results from the data sources are validated in relation to the hypotheses presented in section 6.4.2. Each hypothesis is either verified or falsified through one or a combination of data source, the site for the validation is noted and an overall comment are stated with the main arguments. The results are also labelled based on three main categories due to the strength of the statement and/or the level of probability from which the validation of the hypothesis have been valued:

- **Direct Effects** (Measurable/Experienced effects) (DE).
- **Semi-Direct Effects and Trends** (Derived effects based on calculations and statements and identified trends) (SDET).

- **Speculative Conclusions** (Conclusions based on statements with certain conditions, such as future implementation, and/or conclusions derived from ambiguous trend curves or calculations with less clear result) (SC)

In the table below each of the hypotheses are commented followed by an overall conclusion.

<table>
<thead>
<tr>
<th>#</th>
<th>Verified / falsified</th>
<th>Data source(s)</th>
<th>Site (GOT / VAL)</th>
<th>Comments</th>
<th>Value basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V</td>
<td>I, Q, D</td>
<td>GOT/VAL</td>
<td>The responses from the involved actors, and the data analysis argue for a critical mass of port calls, to be further verified.</td>
<td>DE</td>
</tr>
<tr>
<td>2</td>
<td>V</td>
<td>I, D</td>
<td>GOT/VAL</td>
<td>Different states are used as a commonality for sharing information about short-term and/or long-term changes (instead of having to call each involved participant)</td>
<td>DE</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>I, Q, D</td>
<td>GOT/VAL</td>
<td>The data analysis shows the necessity to have data on all states from the different actors. Actors express a need to inform each other about changes</td>
<td>DE</td>
</tr>
<tr>
<td>4</td>
<td>V</td>
<td>I, (D)</td>
<td>GOT/VAL</td>
<td>Real-time state changes enables that involved actors has the latest information about actual occurrences of preceding and estimates of succeeding state changes</td>
<td>DE</td>
</tr>
<tr>
<td>5</td>
<td>V</td>
<td>I, D</td>
<td>GOT/VAL</td>
<td>Insights from other actors planned operations provide a basis for more precision in the own planning. Different statistics paving the way for optimization could be derived</td>
<td>DE</td>
</tr>
<tr>
<td>6</td>
<td>V</td>
<td>I, D</td>
<td>GOT/VAL</td>
<td>Derived from hypotheses 2, 3, 4, and 5, and by different actors stating the value of situational awareness images. The degree of predictability has been increased for port calls using PortCDM</td>
<td>SDET</td>
</tr>
<tr>
<td>7</td>
<td>V</td>
<td>I, D</td>
<td>GOT</td>
<td>Data shows that estimates for the same state have been made using multiple sources. Actors claim that using the same information presented from the multiple sources for the same state can increase the precision in estimates.</td>
<td>SDET</td>
</tr>
<tr>
<td>8</td>
<td>V</td>
<td>I, Q, D</td>
<td>GOT/VAL</td>
<td>It has been brought forward that estimates are better if all estimates were shared. The data analysis does however show that estimates are better when the preceding steps have a higher predictability.</td>
<td>DE</td>
</tr>
<tr>
<td>No.</td>
<td>(V)</td>
<td>Actors</td>
<td>GOT/VAL</td>
<td>Comments</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>--------</td>
<td>---------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>V</td>
<td>I, D</td>
<td>GOT/VAL</td>
<td>Actors claim that improved accuracy in the estimates by using information from multiple sources in real-time. This also strengthens the need for automatic connections to the different systems</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>V</td>
<td>D</td>
<td>GOT/VAL</td>
<td>By having more up-to-date information shared in real-time it has been possible to increase the accuracy in the estimates of other states</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>V</td>
<td>O</td>
<td>GOT/VAL</td>
<td>To few port calls in the analysis, but it is reasonable to believe that different types of port calls require the use of states on a more fine-grained level. The two demonstrators use different states for their coordination.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>V</td>
<td>I</td>
<td>GOT/VAL</td>
<td>Insights of other actors’ processes and intentions has been claimed to be valuable and a willingness to contribute to others have been claimed. The Living Lab approach establishes the foundations for a enhanced digital collaboration.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>V</td>
<td>I</td>
<td>GOT/VAL</td>
<td>(see evaluation of hyp. 12) and also an inspiration for identifying what the constituents of the common object of interest should be.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>V</td>
<td>I</td>
<td>GOT/VAL</td>
<td>(see evaluation of hyp. 12)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td></td>
<td>GOT/VAL</td>
<td>Not commented, but reasonable due to the fact that many actors claim less phone calls due to images of situational awareness as the primary sources of information</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>V</td>
<td>I, Q, D</td>
<td>GOT/VAL</td>
<td>The interviews and the questionnaires’ reveal that different actors express different needs of information. Images of situational awareness building on a common information model are expressed as valuable. Data analysis of the different PortCDM KPI’s has (partly) been possible to conduct. Full-blown analysis of KPI’s does however require that data are captured for all states.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>V</td>
<td>I</td>
<td>GOT/VAL</td>
<td>The interviews reveal that different actors express different needs of information for their own purpose</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>V</td>
<td>I</td>
<td>GOT/VAL</td>
<td>Consequence of hyp. 17</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>V</td>
<td>D</td>
<td>GOT/VAL</td>
<td>Increased predictability has been proven by data analysis. Berth productivity has been possible to express, and the demonstration has enabled us to enhance the precision of how to measure waiting times, punctuality, and capacity utilization. For the latter three has however been too few transactions</td>
<td></td>
</tr>
</tbody>
</table>
V = Verified, (V) = partly verified, - = not enough basis for verifying / falsifying, (F) = partly falsified

Based on the different data sources it is very clear that the legacy in port operations has been challenged and new patterns of collaboration has a potential to be formed.

From the validation effort above the formulated hypothesis are mostly valid. The triangulation of multiple data sources for the validation of the hypotheses has been valuable. It is also to be noted that some hypotheses are validated based on the

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>(V)</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>(F)</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>(V)</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>V</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>-</td>
<td>(D)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>-</td>
<td>(D)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>V</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>(V)</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G0T/VAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actors have expressed an increased ability to synchronize their operations based on the insights of other actors’ plans and performances in prior steps of the port call process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE</td>
</tr>
<tr>
<td>21</td>
<td>(F)</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G0T/VAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This hypothesis is hard to validate due to the fact that if you have a high degree of flexibility in latter stages of the port call then you would have higher precision in those operations. The predictability of starting and completing cargo operations in Valencia is higher than in Gothenburg, but the planning process prior the port call is more intense in Gothenburg. In Valencia the predictability of when the vessel is brought to berth is lower than in Gothenburg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC</td>
</tr>
<tr>
<td>22</td>
<td>(V)</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G0T/VAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actors has expressed an increased ability to synchronize their operations based on real-time updates on estimates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDE6</td>
</tr>
<tr>
<td>23</td>
<td>V</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G0T/VAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A lot of actors express that planning and synchronization became more efficient due to real-time based sharing of information by automatic connections to different systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDE6</td>
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<td>24</td>
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<td>G0T/VAL</td>
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<tr>
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<td>Not enough basis yet for enabling continuous improvement. However the data analysis shows so far the necessity to ensure accurate information for each port call and calculations have been possible to make for a few port calls showing the potential in continuous improvement when having a solid base of data to rely on.</td>
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<td>A desire to see others’ information about states has been expressed</td>
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validation results of other hypotheses. It is also acknowledged that data is missing for fully validating some of the hypotheses.

This validation effort has also shown that there is a need for a hypothesis related to automatic connectivity between systems. Many actors have commented the value of automatic connections (an infrastructural hypothesis). This is formulated as follows (partly validated): Automatic connection between different systems increase actors’ willingness to contribute with information and consequently actors’ use of PortCDM.

An unresolved quest so far is also how much of the states that should be shared, i.e. what should constitute the common object of interest. The problem is not the actors willingness to share information, but rather on how many and how much of the states that are being shared among the involved actors that should be ensured high level of quality (such as that both estimates and actuals is being reported in real-time). An hypothesis is that the states that are directly related to operations performed related to the vessel putting the milestones at the core is important for the efficient (distributed) coordination of the port call. The common object of interest forms the basis for each actor to introduce diverse states for their own coordination.

The overall analysis of the PortCDM validation based on the hypotheses, points in two directions. (1) the objectives for PortCDM can be reached by this solution. There is however a need for further basis for making the validation. Such basis must include more comprehensive data for each state, constituting the common object of interest, for each port call. (2) the hypotheses formulated for the validation forms the basis for planning forthcoming validation efforts of PortCDM.
7 Final remarks

The validation of the PortCDM concept in real-life testing shows that it is valuable to enable enhanced coordination of port calls. By using multiple data collection approaches a number of hypotheses based on the underlying assumptions and the objectives for PortCDM have been verified. PortCDM is a concept that would be used for increasing the ability to forecast when diverse operations are to be performed. The concept does however rely on a distributed approach to coordination in which actors share, based on automatic connections to their own systems, data on estimates and actual state changes. Essential states in the port call process constitute the common object of interest. This means that for each port that apply PortCDM it becomes highly essential that core activities are captured and to which state changes they lead to. The port call process is seen as a series of interrelated states.

The validation efforts reported upon here does however also point at the necessity to increase the data accuracy as being used for capturing relevant data, both for long-term and short-term planning by different actors, and for enabling intermediary and post-evaluations of port call performances. It is therefore proposed that reports are made continuously providing an insight of the use of PortCDM information services as well as the level of quality that the data being generated. This is especially relevant for the states that are core of the common object of interest. Further, the validation process of PortCDM created foundations for the creation of port statistics.

In response to today’s situation, PortCDM enables coordination based on sharing of intentions and estimates as states arranged as s business logic. In this validation effort different KPI’s have been formulated and algorithms have been developed, where this validation has shown the possibility to use these as a basis to enhance the coordination of port calls. Due to the fact that reports on estimates are encouraged it is also possible to provide forecasts on resource utilization, berth productivity and waiting times giving rise to perform actions of optimization. The validation process has also identified new measures to include for increased optimization; Process duration for Vessel Turn around (Arrival to Traffic area to departure from traffic area), Efficient Process Duration (i.e. the sum of process duration for operations in a specific port call).

In the validation effort a LivingLab approach has been used in order to strengthening the relationships between the involved actors providing trust and insights of each other’s role and pre-conditions to act in the port call process. This has also been an important basis for establishing digital collaboration preferably enabled by automatic connections for stimulating the use of PortCDM. The LivingLab approach has been very appreciated; **actor collaboration is a condition for digital collaboration.**

The underlying architecture, building on SeaSWIM and Maritime Cloud, has been tried out and resolved in a situation where the back-end is rebuilt to a standardized service integration platform (see next section). The validation process has derived numerous requirements on such a platform possible for enabling standardized interaction, carried by information services, among involved actors. It is also to be emphasised that a front-end has been used for ensuring effects from the validation but it is encouraged that
each actor use PortCDM information services in the integration in actor's own system. The process of this integration is a task for the forthcoming validation efforts of the PortCDM concept.

During this validation process a number of improvements for how to validate the PortCDM concept using demonstrators has been identified:

- Capture all port calls for a particular time period
- Continuously capture quality in the data
- Carefully retrieve baseline data
- Enhanced number of automatic connections to enable access to data sources (in real-time).

PortCDM allows for single actors performances and intentions to be interrelated as a logical chain of events. This means that PortCDM enables the port call process to be coordinated as a holistic process including co-production of key actors involved in a port call. Thereby PortCDM enables port operations to be the beginning and end of each sea voyage, successfully closing the loop in the transport chain.
8 Future Work – PortCDM SIP for STM

The future work for PortCDM SIP in the STM project relates mainly to:

- Improved architecture to:
  - Achieve better separation of core PortCDM functionality from what can be provided as external services (including mechanisms to publish, discover and consume such services);
  - Enable implementation of mechanisms that were identified as crucial in the PortCDM concept (WP3); for instance, to allow data to be stored at, and access to that data to be controlled by, the data owner.

- **Standardization** of key data structures and APIs to ensure system interoperability.

In the STM Validation project, the PortCDM will be deployed in 13 ports, and will be integrated with a large number of land-, shore-, and sea-based systems. With this deployment, there will be a need to integrate, not only more systems within a port but also PortCDM deployments in multiple ports—such integration will enable communication between ports, and thereby earlier notifications and estimates of vessel arrivals.

In ML2, the PortCDM SIP was initially developed and deployed in the Port of Gothenburg, and later also in the Port of Valencia. With these deployments, a number of areas in need of further development was identified in order for the PortCDM SIP to serve as an efficient evaluation platform in the STM Validation project.

8.1 Improved Architecture

The logical architecture (as shown in figure 4) needs to be improved to accommodate for additional requirements identified in WP3, and to provide a clearer separation (lower coupling) between the services.

8.1.1 Data Providers in Control of Their Data

A key requirement for the PortCDM concept, identified in WP3, is to allow data providers full control of their data. This should ideally mean:

- Data shall be stored at the data provider (or a delegate of their choosing);
- Access to the data shall be controlled by the data provider (or a delegate).

The PortCDM does not yet fulfil this requirement.
8.1.2 Clearer Separation Between Services

The architecture of PortCDM, as implemented in ML2, is monolithic; in addition to shared detailed data models, there is also a shared centralized data storage. This means that modifications and additions to the services need to modify the PortCDM code-base.

This monolithic architecture is inadequate in the STM Validation project, in which variation in characteristics among the ports will require specific customizations in each deployment; still, interoperability between these deployment is required. This calls for a more flexible architecture, where core functionality (i.e. functionality that will be shared among deployment and that will ensure basic interoperability) is isolated in a specific package, and for mechanisms that allow service publication and discovery by system suppliers.

More specifically, the functionality in the current PortCDM SIP implementation overlaps to a large extent with functionality typically found in Port Management Information Systems (PMIS). This means that functionality now implemented as part of the PortCDM SIP is available in existing systems. To make for a more conceptually sound architecture, the PortCDM SIP should instead facilitate publication and discovery of such services.

Parts of the current PortCDM SIP should, as a consequence, be moved outside the PortCDM core and instead be regarded as a reference implementation for a PortCDM-compliant PMIS (further elaborated below).

8.1.3 A Proposed Architecture for PortCDM in the STM Project

Figure 49 illustrates a proposed high-level architecture for PortCDM (as an adaptation of the logical view shown in figure 4). In Figure 49, the responsibility of PortCDM SIP has been entirely redefined, with its current functionality extracted to PortCDM DMP (Data Management Platform), and to PortCDM Back-end.
The DMP shall comprise functionality related to managing port call data and its associated meta-data. This includes the services:

- DataDictionary
- PortCallManager
- UpdatePortCall

The DMP is envisioned to be the component which will be shared among all PortCDM instances. The DMP is responsible for managing all the data known about a port call, where each data point is stored and how to acquire it.

Envisioned procedure for submitting new port call data:

1. A relevant update is identified in an external system (see the data connectors, above);
2. The connector translates the update into the port Call Messaging Format (PCMF, see below);
3. The DMP service UpdatePortCall is called with the PCMF update (except the actual data). The purpose of the call is to notify PortCDM DMP about the availability of the data point (not the data itself);
4. The DMP service stores the update together with information about the source of the data point (i.e. routing information);
5. The DMP service generates a unique identifier for the data point and returns it to the connector;
6. The connector stores in a local database the full data point (in PCMF) identified by the unique identifier received in step 5.

The DMP shall provide services for requesting individual (or aggregations) of port call data from the data providers.

Envisioned procedure for requesting a data point:

1. A data/service consumer requests a data point (identified by the identifier, see step 5 above);
2. The DMP identifies the data provider, using the routing information;
3. The DMP sends a request to the data provider together with the identity of the requester;
4. If the data provider grants the request, the data point is returned. In addition to the core services described above, the DMP may contain convenience functionality, such as requesting all available data points about a port call.

**Data Connectors**

The functionality of the data connectors (deployed at each data provider) will be extended with:

- Storage of the data points reported to PortCDM DMP;
- A service interface by which the DMP can request data points;
- An access control component that determines whether a request for data is granted.

The data connector will thus no longer report the data (i.e. the statement) to PortCDM, but rather the availability of that statement. PortCDM DMP will store that information, and generate a unique identifier for the data point which is returned to the connector. When a data consumer requests the statement, the DMP propagates the request to the data provider, which in turn evaluates access and returns the statement (if granted).

This will increase the complexity of the connectors compared to their implementation in ML2. Furthermore, as the data storage is distributed, this architecture will be sensitive to downtime at the data provider side.

**PortCDM SIP—Service Integration Platform**

The role of the SIP in STM will be refined into providing mechanisms for service publication, discovery and consumption (inspiration taken from http://eur-registry.swim.aero/). The purpose of the SIP is to facilitate a flexible and coherent framework for third-party services.

As a concrete example, among the 6 services implemented in the ML2 PortCDM demonstrator were PortCallStatus and PortStatistics. These services would typically be found in a PMIS. To enable consumption of such services by other applications, the SIP will need to provide a registry in which the provider can register availability of the service.

While the SIP needs to be provided as part of the PortCDM core, the mechanisms should be defined and provided by SeaSWIM.

**PortCDM Backend**

The current PortCDM SIP was implemented as a back-end component to enable a shared situational awareness application (described as the Front-end application above). The monolithic back-end component needs to be re-factored into more conceptually sound components (as described above). The remaining services after factoring out the UpdatePortCall, parts of the PortCallManager, and DataDictionary services into the DMP, can be seen as a PortCDM-compliant PMIS back-end. The
services provided by this back-end can then be registered with the PortCDM SIP and consumed by clients that are granted access.

Presumably, the PortCDM-compliant PMIS will initially be the main demonstrator system in use in STM as it will take some time before existing system suppliers make their systems PortCDM compliant, integrate with DMP, and publish services with the PortCDM SIP.

In addition, smaller ports which currently do not have a full featured PMIS can use the demonstrator as their main system (for evaluation purposes).

8.2 Standardization

In order to ensure interoperability between systems, there is a need for standardization. The following areas of standardization has been identified:

- A standardized **messaging format** for communicating state data;
- A basic standardized **data model** for representing data at a higher level of abstraction (especially regarding states, port call process, and port call data);
- A standard minimum set of **APIs** for PortCDM DMP and data providers, and for PortCDM SIP;
- A standard set of services a PortCDM-compliant PMIS need to provide (as defined by WP3).

8.2.1 Standardized Messaging Format

There is a need for a standard representation of port call data (see section 3.2.2). While interaction with PortCDM compliant systems within a port will most likely use APIs and the data model (i.e. port call data represented at a higher abstraction level), interaction with other STM concepts (via SeaSWIM) will require a generic representation of data points. This data representation format shall ensure unambiguous communication of port call data regardless of sender and receiver, and need to be able to encapsulate the complete data point (this is elaborated below).

There is an on-going initiative to define such a standard messaging format (see section 3.2.2) that need to be evaluated and that the PortCDM demonstrator platform within STM needs to be adapted to support.

8.2.2 Improved Data Model

The data model shall define a minimum viable and generic way to represent port call data and its related information at a higher level of abstraction (relative the standardized messaging format, described above).
8.2.3 States and Port Call Information

In the demonstrator developed in ML2 WP7, each (relevant) state in the metro map (see figure 2) was encoded as a string constant. Data about a state (held in a set of PortCallState instances), either an actual or an estimate, was represented as the two relationships, actuals and estimates, to TimeStatement in the data model. This representation has a number of drawbacks:

- A data point is not self-contained, but rather depends on the context in which it appears (i.e. in which relation in the data model it appears). This makes it difficult to exchange data (for instance, between ports) as some of the semantics of the data point is contained in the data model;

- The type of state data (estimate or actual) will need to be extendible; for instance with requested, confirmed and recommended (with the possibility to further extend these types in the future). Furthermore, the relationships between statements may need to be represented properly (which requested time was confirmed etc);

- In the ML2 representation of states, there were several states that had clear conceptual relationships but was lacking such relationships in the data model. As an example, tug boat order has a direct relationship with tug job commenced (ordering towage is implicitly an estimate of when the towage is to commence). A more useful data model would have such relationships represented explicitly;

- Some states need additional information to be complete. For instance, states that represent a nautical operation need a information about location of origin and destination (such as the destination quay for berth shifting operations). Therefore, there needs to be mechanisms for custom information structures per state type.

State types, and their data will need to be aligned with the port call messaging format (see section 3.2.2). Probably, the semantics of a state statement will be defined in terms of a port call message (see above).

The PortCallInfo class was used as an abstraction for port call data that did not fit into the state abstraction (see Table). This representation needs to be refined (probably will some information types be moved into state representations, such as PCL_Quay, and some will be the responsibility of other STM services to manage, such as VOY_NextPort).

Port Call Data

The representation of port call data (the PortCall class, see figure 19) needs to be refined and adapted to other STM services. The PortCall data model shall be defined as part of the PortCDM DMP, and shall address the issues:
- The single representation of state data (PortCallState) is too simplistic. Some states will need to store specific data; for instance, states concerning approach and departure from berth will need to store information about the relevant quay;

- Due to the Set relationship with PortCallStates, states cannot be repeated. In practice, there are states that repeat, for instance with berth shifting and anchoring. This representation will therefore need to be reworked (see also);

- A clearer and closer relationship with a port call process (see below);

- Integration with voyage management in STM, such that the port call becomes a part of its voyage, e.g. notification (i.e. creation) of a planned port call, to get ETD from the previous port and to supply ETD to the next port;

- Vessel information should be accessed from an STM service. As current vessel registries (e.g. Lloyds) are licensed services provided by private actors, the STM project may need to define shared APIs to allow for third-party STM-compliant vessel registries.

**Port Call Process**

The concept of a port call process needs to be generalized and refined. In ML2, the purpose with a port call process was to stipulate an ideal course of action, and to allow evaluation of port call status by comparing port call data to that process.

In STM, the responsibility of the process shall rather be to:

- Provide the port call data in DMP with a sensible structure;

- Provide a generic high-level base structure for a port call in a way such that external services can extend and refine it.

Probably, the process in DMP shall contain port call phases, such as arrival, anchoring, berth (or cargo) operations, and departure. Furthermore, meta-entities, such as a sub-process (berth shift is a typical sub-process which could comprise tugging, pilotage etc), need to be defined.

**Standard Set of APIs**

An important focus for PortCDM in STM (act 1) is to define standard APIs. The components that need standardized APIs are (see figure 49):

- **PortCDM DMP.** The APIs include how to query availability of data, and to request data (from data/service consumers), and for interaction between the DMP and data providers (i.e. how data providers announce the availability of a data point, and how the DMP propagates a request for that data point from a consumer);

- **PortCDM SIP.** These APIs include how to enable service publication, discovery and consumption, as well as required basic functionality for integrating with the
specifics of each port (e.g. available quays and anchoring areas). The exact responsibilities of this component need to be further explored;

- **PortCDM-compliant PMIS services.** In ML2 WP3, a number of services were defined that are required in order to enable efficient planning, execution and evaluation of port operations. Such services are typically already available in various existing systems (such as port management information systems, PMIS). Therefore, it is envisioned that these services shall be provided by external system suppliers enabled by the components in PortCDM core (DMP and SIP), rather than included in the PortCDM core. In STM, there is a need to explore whether PortCDM need to define standard APIs for these services.
9 Publications


## Appendix A  State catalogue

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<th>State concept in Back-end</th>
<th>State concept equivalence in Front-end</th>
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Appendix B  Interview question, questionnaire

Interviews

ABOUT THE EVALUATION

The Purpose:
- The purpose with the interview is to collect arguments from participants regarding: the Living Lab as a method for innovation, PortCDM Concept (both in terms of possibilities in a full-scale implementation and the impact based on the implementation of PortCDM application and the Image for Situational Awareness (as a tool for enhanced coordination of port calls).

Respondents:
- Participants in the PortCDM Living Lab.
- Users of PortCDM

Interview setup:
- One respondent at the time.
- Record the interview for further analysis.
- Make sure to be able to follow up after the interview.

Important reflections to make:
- Why?
- Please, exemplify…
- Please explain what you mean…?
- Comparison for better understanding…
- Inform/Verify that the respondent understands the question…

INTRODUCTION

Describe the purpose of the validation and the interview for the respondent and what we mean with image for common situational awareness.

- Before we start. Is it OK that I record the interview? The recording will not be shared with others, it will be used for documentation and make it possible for us to go back and listen again and for further analysis of the answers.

1. QUESTIONS ABOUT THE RESPONDENT?

- What's your name?
2. QUESTIONS ABOUT THE LIVING LAB
You’ve been involved in several Living Lab meetings, and in this section we will ask questions about the Living Lab as a method for innovation.

2.1 How do you think the Living Lab has worked as a method to drive the project forward?
   Explain the LL method if it is unclear.

2.2 How do you think the working approach has been?
   Good / bad? Why?

2.3. How do you think about the Living Lab as a collaboration platform?
   Good/ Bad, Why?

2.4 Do you feel that you have been involved and contributed to the development of PortCDM?
   In what way? Is there something we could have done differently (better)?

2.5 What do you think of the content on the Living Lab meetings (e.g. meaningful/not meaningful)?
   What? Why?

2.6 How would you characterize (e.g. ) the dialogue been?
   Between Valenciaport Foundation and the participants?
   Between the participants during the meetings?

2.7 What do you think about the meeting frequency of the Living Lab meetings?
   Too often, good or to few?

2.8 What have been the main lessons learned from the Living Lab meetings?
3. QUESTIONS ABOUT THE PortCDM CONCEPT

3.1 Can you describe from your perspective ______ what PortCDM is to you?

During the focus period (test period) that has been completed:

3.2 How well would you say that the different actors needs have been fulfilled?

3.3 Would you say that PortCDM has enabled involved actors to get an image for common situational awareness?

3.4 Would you say that involved actors have acted based on the information from such common situational awareness? How?
   E.g. Do you experience that e.g. phone calls/ Port Call Administration have been reduced?

3.4 Has the common situational awareness informed the users in a better way? How?
   E.g. have the predictability increased? Waiting times decreases? Etc.

3.5 Has the image for common situational awareness made it easier for you to make estimates? How?
   E.g. Have more information from more actors made it easier to make estimates?

3.6. Has the image for common situational awareness created a better awareness about the Port Call process and of the different actors intentions? How?
   E.g. A better understanding of other actors operational business and their incentives to act in a certain way?

3.7 Do you feel that PortCDM have contributed with a better basis for planning? How?
   How did you do before?
If we imagine PortCDM in a broader perspective, more actors involved, more automatic connections/integrations to existing systems and more access real time data:

3.8 Would you have a different view on PortCDM regarding:

...How well the different actors needs would be fulfilled?

...The possibilities to create an image for common situational awareness?

...The possibilities for users to act up on the image for common situational awareness?

...How the image for common situational awareness could inform the users in a better way?

...How the image for common situational awareness can create better awareness about the different actors processes and their intentions? How?

3.9 How do you think the image for common situational awareness could contribute to create better planning?

4. QUESTIONS ABOUT THE APPLICATION “COMMON SITUATIONAL AWARENESS”

4.1 How have you been working with PortCDM?
   Web browser on the computer, tablet, smarth phone?
   Which web Brower?

4.2 How do you perceive it (e.g.)?

4.3 What do you think about the usability/actability?
4.4 What do you think about the functionality?

4.5 What opportunities do you see with the application you’ve been using?

4.6 What limitations do you see with the application?

4.7 If you could decide, how would you prefer that the application was designed and worked?

4.8 What do you think about the possibility of integrating PortCDM information into other systems?

5. OPEN QUESTIONS

Depends on the interview.
Questionnaire

1. In which of the following organizations are you working in?

2. How did you interact with PortCDM? (You can choose several options)

3. Which browser did you use?

4. Which operating system did the tablet have? (You can choose several options)

5. Which operating system did the smartphone have? (You can choose several options)

6. Have you used PortCDM as a part of your daily work?

7. Please indicate which of the following age range belong to.

8. How have you used PortCDM in your daily work and can you specify what your daily work is?

9. Can you describe your daily work and why you did not use PortCDM?

10. Do you feel that the PortCDM application provides a common shared situational awareness? (With a common shared situational awareness, we are referring on a better overview of the different states that a port call includes from the first information of that a vessel is coming to the port and until it have departed.)

11. Motivate your answer to the above question.

12. PortCDM has given me better access to information?

13. Why do you feel that you do not have access to better information?
14. In the following, I feel that PortCDM has given me better access to information (we think of real-time information and that the information is more complete and more accurate):

15. Please describe the type of information you have got better access to (exemplify):

16. This type of information I would have needed better access to (exemplify):

17. PortCDM has given me access to more information than I had before?

18. In the following ways I feel that PortCDM has given me access to more information:

19. This kind of information I did not have access to before (exemplify):

20. Why do you feel that you have not got access to more information?

21. The shared common situational awareness has given me the basis to do "better" estimates?

22. In the following way, I feel that the shared common situational awareness has given me the basis to make "better" estimate:

23. How has the shared common situational awareness not given you a basis to make "better" estimate?

24. The shared common situational awareness has created a greater awareness of the various operators' intentions?

25. Describe how you feel that the shared common situational awareness has created a greater awareness of the different operators' intentions?

26. How has the shared common situational awareness not contributed to a better awareness of the different operators' intentions?
27. Do you feel that the shared common situational awareness has changed your behavior?

28. How has the shared common situational awareness changed your behavior?

29. How has the shared common situational awareness not changed your behavior?

During the focus months, you have been one of several in your organization that have used PortCDM to create a shared common situational awareness of the port calls. In the section below there are some questions about the Front-End application that you have used, where you have entered estimates and actuals that other involved actors have been able to view.

30. When you log in to PortCDM the first picture you see is "Port Overview", see picture above. The idea with "Port Overview" is to give an overview of all port calls based on parts of the data that is currently in PortCDM. We want you to indicate how important you think that the information presented in “Port Overview” is. Below different parts in the “Port Overview” are presented and we want you to choose between number one and five indicating how important you think that the information presented there is.

31. If you could choose which information that where displayed in the "Port Overview", what information would you prefer to see? Please also suggest how it can be presented.

32. When you chose a specific port call in PortCDM, you will see the "Overview", see picture above. We want you to choose between number one and five indicating how important you think that the information presented for the different parts available in the “Overview” are for you.
Appendix C  Activity 2 Deliverables

This appendix lists the MONALISA 2.0 Activity 2 deliverables.

- ATM report for MONALISA 2.0, MONALISA 2.0 – D2.0.7, 2015
- Collaboration in the Maritime Transport Ecosystem, MONALISA 2.0 – D2.3.1-12-3, 2015
- Dynamic Voyage Management Concept Description, MONALISA 2.0 – D2.3.1-4.2, 2015.
- Electronic STM Master Plan, MONALISA 2.0 – D2.5.2, http://stmmasterplan.com
- Envisioning Sea Traffic Management 2030, MONALISA 2.0 – D2.3.1-12-4, 2015
- Finding Information in the Maritime Transport Ecosystem, MONALISA 2.0 – D2.3.1-12-2,
- Flow Management Concept Description, MONALISA 2.0 – D2.3.1-4.3, 2015.
- Formal Safety Assessment Case, MONALISA 2.0 – D2.3.1-11, 2015
- Performance Assessment Case, MONALISA 2.0 -- D2.3.1-9, 2015
- PortCDM Concept Description, MONALISA 2.0 – D2.3.1-4.4, 2015
- PortCDM Validation Report, MONALISA 2.0 – D2.7.1, 2015
- Sea Traffic Management: A Holistic View, MONALISA 2.0 – D2.3.1-4.0, 2015
- Sea Voyage Costs, MONALISA 2.0 – D2.3.1-3.2, 2015
- STM – The Current situation, MONALISA 2.0 – D2.1.1, 2015
- STM – The Target Concept, MONALISA 2.0 – D2.3.1, 2015
- STM Master Plan, MONALISA 2.0 – D2.5.1, 2015
- STM Performance Framework, MONALISA 2.0 – D2.2.1, 2015
- Strategic Voyage Management Concept Description, MONALISA 2.0 – D2.3.1-4.1, 2015
- Target Business Description, MONALISA 2.0 – D2.3.1-3, 2015
- Target Concept Business Case, MONALISA 2.0 – D2.3.1-2, 2015
• Target Human Aspects Description, MONALISA 2.0 – D2.3.1-7, 2015

• Target Information-Systems and Information-Technology Description, MONALISA 2.0 – D2.3.1-6, 2015

• Target Institutional Description, MONALISA 2.0 – D2.3.1-1, 2015

• Target Systems Technical and Technology Description, MONALISA 2.0 – D2.3.1-5, 2015

• Target Transversal Aspects Description, MONALISA 2.0 – D2.3.1-8, 2015

Understanding the Maritime Transport Ecosystem, MONALISA 2.0 – D2.3.1-12-1
39 partners from 10 countries
taking maritime transport into the digital age

By designing and demonstrating innovative use of ICT solutions
MONALISA 2.0 will provide the route to improved

SAFETY - ENVIRONMENT - EFFICIENCY

Swedish Maritime Administration • LFV • SSPA • Viktoria Swedish ICT • Transas • Carmenta • Chalmers University of Technology • World Maritime University • The Swedish Meteorological and Hydrological Institute • Danish Maritime Authority • Danish Meteorological Institute • GateHouse • Navicon • Novia University of Applied Sciences • DLR • Fraunhofer • Jeppesen • Rheinmetall • Carnival Corp. • Italian Ministry of Transport • RINA Services • D’Appolonia • Port of Livorno • IB SRL • Martec SPA • Ergoproject • University of Genua • VEMARS • SASEMAR • Ferri Industries • Valencia Port Authority • Valencia Port Foundation • CIMNE • Corporacion Maritima • Technical University of Madrid • University of Catalonia • Technical University of Athens • MARSEC-XL • Norwegian Coastal Administration

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