Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era

COREALIS
THE PORT OF THE FUTURE

D1.3 Port of the Future Needs and Requirements

Document Identification			
Status	**Final**	**Due Date**	30/11/2018
Version	2.0	**Submission Date**	30/01/2020
Related WP	WP1	**Document Reference**	D.1.3
Related Deliverable(s)	D1.1, D3.1	**Dissemination Level**	PU
Lead Participant	AdSPTS	**Document Type:**	R
Contributors	CNIT, PCT, ICCS, Steveco, VPF, MOSAIC, Marlo, ERICSSON, NEC, VTT, Deltares	**Lead Authors**	Silvia Ferrini (AdSPTS) Alexandr Tardo (CNIT)
		Reviewers	Anil Goyal (NEC)
			Carlos Morillo (MOSAIC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768994. The content of this document reflects only the authors' view and the European Commission is not responsible for any use that may be made of the information it contains.

Document Information

List of Contributors	
Name	**Partner**
Toni Lastusilta	VTT
Teresa Pepe	ERICSSON
Allister Slingenberg	Deltares
Wiebe de Boer	Deltares
Tomasz Dowgielewicz	Marlo
Carlos Morillo	MOSAIC
Irene Chausse	MOSAIC
Anil Goyal	NEC
Jääskeläinen Heikki	Steveco
Amalia Nikolopoulou	ICCS
Georgios Tsimiklis	ICCS
Giannis Kanellopoulos	ICCS
Carles Pérez Cervera	VPF

Document History			
Version	**Date**	**Change editors**	**Changes**
0.1	20/10/2018	Silvia Ferrini/ Alexandr Tardo	1st preliminary draft
0.2	12/11/2018	Silvia Ferrini/ Alexandr Tardo	Document for peer review
0.3	23/11/2018	Silvia Ferrini/ Alexandr Tardo	URs extraction methodology added
0.4	27/11/2018	Silvia Ferrini/ Alexandr Tardo	MOSAIC Review added
0.5	27/11/2018	Silvia Ferrini/ Alexandr Tardo	NEC Review added
0.6	09/12/2018	Silvia Ferrini/ Alexandr Tardo	Added RTM
0.7	14/12/2018	Silvia Ferrini/ Alexandr Tardo	ICCS Chapter #2 Review added
0.8	17/12/2018	Silvia Ferrini/ Alexandr Tardo	Improved list of URs and added HaminaKotka contribution
0.9	03/12/2018	Silvia Ferrini/ Alexandr Tardo	Improved formatting and incorporated input form ICCS

Document History			
Version	**Date**	**Change editors**	**Changes**
1.0	04/01/2019	Silvia Ferrini/ Alexandr Tardo	Final version to be submitted
1.1	20/01/2020	Silvia Ferrini/ Alexandr Tardo	TOC Restructuring to focus on innovations
1.2	21/01/2020	Carles Pérez Cervera	TAS, Incubator and JIT Shuttle updates
1.3	23/01/2020	Anil Goyal	PREDICTOR updates
1.4	23/01/2020	Wiebe de Boer	PoFSG update
1.5	29/01/2020	Tomasz Dowgielewicz	Marketplace update
1.6	29/01/2020	Irene Chausse	CFO update
2.0	30/01/2020	Silvia Ferrini/ Alexandr Tardo	Final version for resubmission

Quality Control		
Role	**Who (Partner short name)**	**Approval Date**
Deliverable leader	Silvia Ferrini (AdSPTS) / Alexandr Tardo (CNIT)	30/01/2020
Quality manager	Athanasia Tsertou (ICCS)	30/01/2020
Project Coordinator	Angelos Amditis (ICCS)	30/01/2020

Table of Contents

List of Tables

List of Figures

List of Acronyms

Abbreviation / acronym	Description
3GPP	Third Generation Partnership Project
A2A	Authority to Authority
A2B	Authority to Business
AD	Automated Driving
AGS	Automated Gate System
AIS	Automatic Identification System
AID	Automatic Incident Detection
APCS	Antwerp Port Community System
AVI	Automatic Vehicle Identification
B2B	Business to Business Service
B2G	Business to Government Service
CCAM	Cooperative, Connected and Automated Mobility
CITS	Cooperative Intelligent Transport System
DVRC	Document Valid for Container Release
e-BL	Electronic Bill of Landing
EDIFACT	Electronic Data Interchange For Administration, Commerce and Transport
ERP	Enterprise Resource Planning
ETSI	European Telecommunication for Standards Institute
G2G	Government to Government Service
GPS	Global Positioning System
IaaS	Infrastructure as a Service
ICS	Import Control System
ICT	Information & Communication Technology
IEEE	Institute of Electrical and Electronic Engineers
IMO	International Maritime Organization
IOS	Inter-Organizational System
IPCSA	International Port Community Systems Association
IS	Information System
IT	Information Technology
ITS	Intelligent Transport System
ITU	International Telecommunication Union
LL	Living Lab

Abbreviation / acronym	Description
M2M	Machine To Machine Communication
MMA	Inward Cargo Manifest
NSW	National Single Window
OBU	On Board Unit
OCR	Optical Character Recognition
PaaS	Platform as a service
PCS	Port Community System
PMS	Port Monitoring System
RFID	Radio Frequency Identification
RTLS	Real-time locating systems
RTM	Requirements Traceability Matrix
SaaS	Software As a Service
SOA	Service oriented Architecture
TAS	Truck Appointment System
TPCS	Tuscan Port Community System
TOS	Terminal Operating System
UR	User Requirements
V2X	Vehicle to Everything Communication
VBS	Vehicle Booking System
VMRS	Vessel Movement Reporting System
VTS	Vessel Traffic Service
VTIS	Vessel traffic Information System
WSN	Wireless Sensor Network
XML	eXtensible Markup Language

Executive Summary

The current document provides a set of needs and requirements based on the user scenarios derived in T1.3 for each involved Living Lab of the project: *Piraeus*, *Valencia*, *Antwerp*, *HaminaKotka* and *Livorno*. The main aim of the document is to provide the starting point for the developments within the COREALIS project. The current set of User Requirements will be used to extract the corresponding set of the System Requirements (to fed the Scoping Documents) to properly assess the innovations' development within COREALIS Living Labs.

Since the state of the art of ICT solutions has been widely discussed both in Deliverable 1.1 - Port of the Future Challenges, Enablers and Barriers and in Deliverable 3.1 - Intra Terminal Operations State of the Art, only aspects of interest in the purpose of the document will be taken into consideration.

Aspects of interoperability and integration between COREALIS innovations and existing ICT infrastructures in single Living Lab will be discussed, while the integration is not the purpose of this document, since it will be addressed in Work Package #6. Instead we intend to provide some current examples (as in the case of the port of Livorno) that can provide the reader with a high level vision of the problem.

Initially a *User Requirements Extraction Methodology* is presented. The methodology presents then the User Requirements in relation to the main COREALIS innovations, Living Labs and Scenarios. Both Functional and Non-Functional requirements per innovation have been taken into the consideration. Finally, all requirements are presented in form of *Requirements Traceability Matrix* (RTM). This will allow to track and monitor the way requirements are fulfilled within the development activities. The current list may be subject to future changes as well as updates, depending on the further improvements of the related scenarios.

1. Introduction

1.1 Purpose of the Document

The main aim of the document is to provide the starting point for the developments within the COREALIS project by means of well-defined set of user requirements. This is achieved through a mapping between scenarios and requirements as well as through a general overview of the state of the art of the current ICT infrastructure in COREALIS Living Labs.

1.2 Intended Readership

The deliverable is addressed to any interested reader since the document's dissemination level is public. The presented deliverable should be considered as a reference for the first mapping between technical scenarios to be implemented in each LL and corresponding needs and requirements.

1.3 Relationship with Other COREALIS Deliverables and Tasks

This deliverable is the final part of the *Work Package 1 – Port of the Future Needs and Requirements*, and it is linked to the following deliverables/tasks/WPs:

- **D1.1** – Port of the future challenges, enablers and barriers, which includes an overview related to the current ICT infrastructures.
- **T1.3 – COREALIS User Stories and Scenarios**, which includes a list of scenarios to be implemented in each LL. Based on those scenarios it has been possible to map the corresponding requirements.
- **D3.1 – Intra Terminal Operations State of the Art**, that provides the current state of the art of the intra-terminal operations and represents a baseline for the integration/development activities of the T3.2 and T3.4.
- **WP5 – LL Scoping Documents**, which includes technical aspects to assess the innovations development, based on the System Requirements definition.
- **T8.4 – Data Management Plan**, which includes a plan presenting all data types which the LLs intend to collate and the necessary approvals needed from national data protection authorities.

2 ICT Innovations (Ports and Logistic Context)

2.1 Introduction

In the last decades, we have witnessed profound changes in maritime transport, which have modified the balance between capital and labor at seaports. Ports are now increasingly becoming capital-intensive industries, while in the past they used to be labor-intensive. This change has generated an excess of employees in most ports around the world. The development of containerized transport is another factor that has significantly modified ports' operations. Containers have allowed large cost reductions in cargo handling, but they have also imposed new needs on ports in terms both of equipment and proper ICT implementation.

Globally, major maritime carriers are demanding improvements in the efficiency of port operations. Cargo carried by ships must be loaded and unloaded quickly with minimal dwell time in the port. Commercial road and rail carriers are placing these same demands on port operators. Both the commercial drivers and railway companies expect reduced wait times, or dwell, for their equipment and operators upon arrival in the port area. This is driving the implementation of more efficient processes and new technologies in the terminals as well. As an essential gateway in global supply chains, ports need to integrate a variety of networks and involved actors in order to coordinate the flows of cargo, property rights, and payments. In this regard, a port can be seen as a part of a cluster of organizations where the performance of the network, performing various activities in value-creating logistics chains, is a collective effort requiring an alignment of partners and business processes. Information management and the process of digital transformation play a critical foundation for such alignment, lower transaction costs, and may help to compensate constraints of ports like inadequate infrastructure, capacity bottlenecks, and accessibility problems (e.g., due to traffic congestion).

Regarding the development of port operations from the beginnings of containerization, we see that digitalization and integration, facilitated through the adoption of innovative information technology (IT) and information systems (IS), have enabled a high degree of automation and streamlining in port procedures, in particular in container terminals. It is possible to find different evidences of this:

In reference to CT Lorenzini:

"Lorenzini & C. makes continuous investments in new technologies. Year after year, improvements have been introduced regarding a wide range of sectors. The main areas of intervention have been: security, safety, maintenance of means of transport, productivity and privacy. These are all aspects on which the possibilities offered by information technology have marked a progress in terms of performance" [1].

In reference to the Port of Virginia:

"The Port of Virginia realized the need for information systems capable of scheduling and tracking the anticipated arrival of motor and rail freight carriers in the port area. Daily container movement and crane operations must be pre-planned" [2].

In reference to the World Maritime day held in 2017:

"To effectively and efficiently deliver goods around the globe, the modern maritime sector relies on information and communication technologies (ICTs) to facilitate the safe and reliable delivery of goods." [3].

In reference to the Port of Singapore:

"A blockchain trial which tested shipping from China to Singapore has been deemed a success by its operating partners, carrier Pacific International Lines (PIL), terminal operator PSA International (PSA) and the Singaporean branch of the technology giant IBM." [4].

In reference to the Port of Montreal:

"The Canada Border Services Agency and the Port of Montreal have signed on for a trial run of a technology that aims to streamline freight shipping using the power of blockchain. The federal customs agency and the country's second-biggest port said they're dipping their toes into a digital database that functions as a "distributed ledger," sharing and syncing up data from ocean carriers, ports and wholesalers from Singapore to Peru." [5].

As can be seen from these considerations, due to the technological progress in recent decades, a near total dependence of day-to-day port operations on ICT can be recognized. Consequently, those systems have become an indispensable element of ports and play a critical role in the overall success of port operations. Regarding the developments in ICT, however, it is also possible to see that ports are usually lagging behind and fail to fully integrate and utilize applied ICT for addressing current and future challenges.

In that sense we could say that new needs and requirements (arisen from ports side) have pushed the ports and logistics firms to develop their investments in new technologies and innovations of information and communications technology (ICT). The ports and logistics sector has already used new technologies to a certain extent but seven innovations have recently gained uprising significant attention in this sector: Automation, Autonomous Transport, Machine to Machine Communications, IoT & Big Data, Virtual and Augmented Reality, Cybersecurity – Blockchain and new Pervasive and Disruptive Communication Technologies.

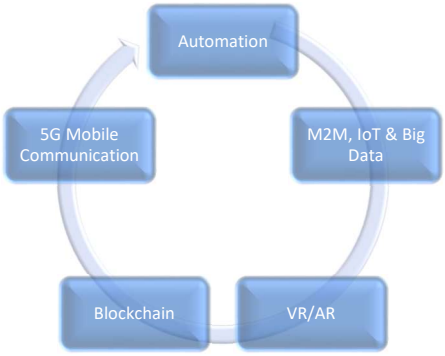


Figure 1: ICT Innovations with the highest impact on ports and logistics.

In the following years, port and logistics will encounter more substantive changes as automation becomes dominant and operations are directed in real time by a wide range of sensors and intelligent software [6].

While some enabling technologies (communication technologies, WSNs, real time location systems, etc.) are essential for the measurement, collection, and transmission of data, integrated information systems are required to store, manage, analyze, and disseminate information and knowledge to support decision processes of various stakeholders. Existing information systems in the port area can be simply classified according to their scope of operations. In [Figure 2], a classification of information systems in ports is presented. It is possible to distinguish between information systems that are accessible by the overall port community and external stakeholders, providing auxiliary information services for port and administrative procedures in general, and information systems that focus on either terminal, seaside, or hinterland operations.

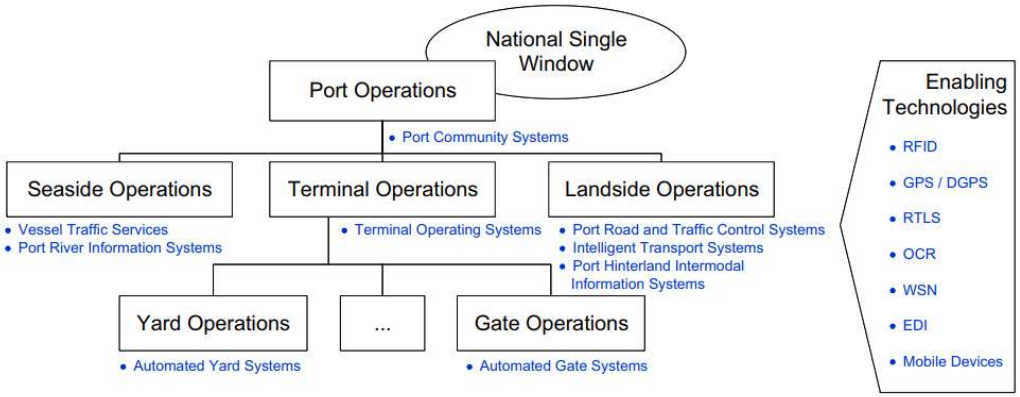


Figure 2: Classification of current port related Information Systems and enabling Technologies.

Commonly, information systems on lower layers are vertically aligned and integrated with information systems on overlying layers. For example, automated gate systems access a terminal operating system that receive and store information from external

parties through a PCS. As a result, a scalable horizontal integration of multiple information systems is possible facilitating a basis for smooth information flows.

The reader is referred to section 3 of Deliverable D1.1 [7] for an overview on digital and technological developments at ports as well as emerging disruptive technologies. To complement this work, we further provide a mapping of some of the most relevant technologies included in D1.1, to the COREALIS ports.

2.2 ICT in COREALIS Ports

Using information and communications technology (ICT) in ports is essential to ensure accurate, real-time control and pre-planning for port management operations. ICT applications benefit trade facilitation at ports by decreasing time, cost and human error during vessel and cargo operations, and many ports are therefore using ICT as a key tool in their operations.

For an overview on current ICT solutions at ports, the reader is referred to section 3.3 of Deliverable D1.1. The deliverable provides a starting snapshot for the understanding on how new management and operational solutions could be developed through the new available Information Technologies including: National Single Window (NSW), Port Community System (PCS), Vessel Traffic Service (VTS), Terminal Operating System (TOS), Port Monitoring System (PMS), Truck Appointment System (TAS), Intelligent Transport System (ITS) and Port Hinterland Intermodal Information System. We provide here a mapping to the COREALIS ports of some of the most relevant of these technologies and more specifically, the Port Community System, the Terminal Operating System and the Port Monitoring System.

2.2.1. Port Community Systems in COREALIS Ports

At first, it is very important to keep into consideration the integration between a PCS and other ICT innovations, also because the implementation of some COREALIS modules will be based on integration (see the Truck Appointment System that will be implemented at the Port of Valencia). For this reason a mapping and description of the PCS, currently used in COREALIS related ports, is presented in [Table 1] and [Table 2]:

Port	PCS	Name
Port of Antwerp	Available	Port of Antwerp Community System [8]
Port of Piraeus	Available	Hellenic Port Community System
Port of Livorno	Available	Tuscan PCS [9]

Port of Valencia	Available	Valenciaport PCS [10]
Port of HaminaKotka	Not Available	-

Table 1: PCSs in Ports involved into COREALIS.

PCS	Description
Port of Antwerp	APCS is a network of systems and solutions for electronic communication in the port of Antwerp. APCS permits exchange of data between business to government (B2G), business to business (B2B) and between government agencies (G2G). It has been developed in partnership between the Antwerp Port Authority, customs and private companies. • APCS facilitates efficient exchange of electronic messages and information. It connects the Port Authority, customs, shippers, shipping companies, shipping agents, forwarders, terminal operators, road and rail carriers, barge operators and logistics service providers. • The information exchange uses efficient, standardised and exchangeable messages. The network supports EDIFACT and XML versions of electronic standard messages, as well as other formats including scanned documents and documents generated in other ways. • All participants keep working in their own applications but are connected to the system using a unique identification. Via the network they send and receive electronic messages to their business partners and government agencies. Some examples relevant for shippers and forwarders could be taken into consideration: • Tracking & tracing of container status. • Booking of inland transport. • Customs declaration (e.g. excise duties). • Electronic invoicing and processing of invoices. • Shipping instructions for bill of lading.
Port of Piraeus	The Hellenic Port Community System (HPCS) is an ever-developing system aiming at the constant optimisation of its operation and the operation of the hellenic port community as a whole. It has been developed as a modular system that can allow any Greek port or port stakeholder to offer its services via a common platform while taking advantage of the established interfaces with current stakeholders such as container terminal operators, rail operators, warehouse operators, the Greek Customs, shipping agents, transport companies etc. More than 80 services are currently offered via the HPCS including vessel and rail schedules, delivery and transport orders, submission of Certificates of Origin, Warehouse orders, application forms etc. HPCS is a member of the International Port Community Systems Association (IPCSA).
Port of Livorno	The TPCS (Tuscan Port Community System) is the Port Community System of the Port Authority of Northern Tyrrhenian Sea. The TPCS platform digitalizes and simplifies the information flows of import and export operations. It is currently used by: • Terminal operators • Shippers • Maritime Agencies • Institutional Bodies • Freight Forwarders • Carriers • Ship Forwarders To access the TPCS is sufficient to have a computer, an internet connection and the service's credentials. Further applications are not required.

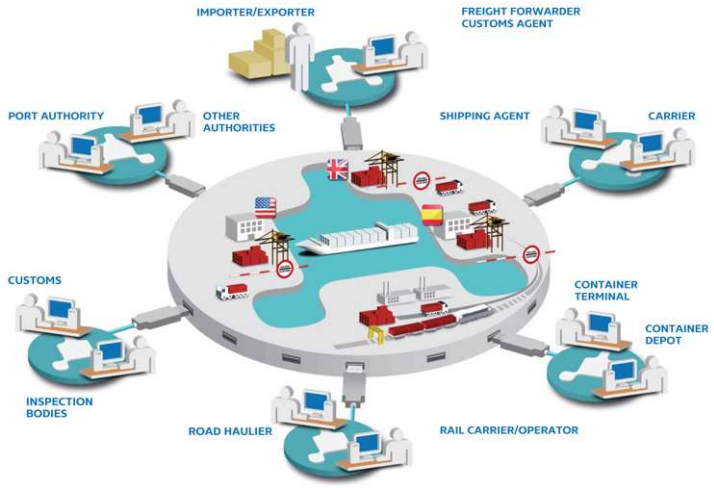
	The TPCS manages ship voyage and freight arriving in Port. Particularly, TPCS provides functions for the transmission of: • The Inward Cargo Manifest (MMA); • The Inward Loading List containing information for both the unloading and the gate-out tasks. In Import, the TPCS enables to speed-up the containers release by the terminal operators to the carriers, printing the DVRC document.
Port of Valencia	Valenciaport PCS is an open and neutral electronic platform that allows a safe and smart information exchange between public and private agents in order to improve our competitive position as a Port Community.  **Figure 3:** Valenciaport PCS - Services to Customers. Valenciaport PCS optimizes, manages and automatizes port and logistic processes in an efficient way by a single data transfer as well as connecting transport and logistic networks. Valenciaport PCS services supplies advanced management procedures to its users, which are: • A better transaction efficiency • Resources optimization • Process automation • Costs saving • Error reduction • Time saving • Better client support Companies working in the ports of Valencia, Sagunto and Gandia through Valenciaport PCS have additional capabilities to add value to the services they offer to their customers: • Shipping Agents • Terminals • Freight Forwarders • Shippers • Road Carriers • Depots • Port Authority

Table 2: PCSs Overview and Description.

2.2.2. Terminal Operating Systems in COREALIS Ports

As regards the context of the Terminal Containers involved in COREALIS project, the table below shows the solutions that are currently used for the management of intra-

terminal operations. Since these are proprietary solutions, the aspect of interoperability and integration plays an important role. In order to ensure a proper level of integration, it is necessary to identify both the information that must be taken from the TOS and the interfaces that must be used to achieve this objective. This obviously requires the staging and definition of the agreement between the involved parties.

Port	Terminal	TOS Name
Port of Antwerp	No CT Involved	-
Port of Piraeus	PCT	CATOS [11]
Port of Livorno	Lorenzini	STEP [12]
Port of Valencia	No CT Involved	-
Port of HaminaKotka	Steveco	NAVIS N4 [13]

Table 3: COREALIS CT's Terminal Operating Systems available.

2.2.3. Port Monitoring Systems in COREALIS Ports

As regards the concept of a Port Monitoring System, as described in D1.1, is not a very widespread concept in the context of world ports. MONI.C.A [14] is the real-time 3D monitoring and control platform of the Port of Livorno. In addition to the 3D and real-time visualization, MONI.C.A enables the continuous updating of AIS data (for the ship positioning), the acquisition of lists of both passengers and dangerous goods, information related to ship, traffic management, ship's voyage (reachable by the interaction with the system of Harbour Authority, PMIS). MONI.C.A features a 3D rendering module providing an ergonomic interface with the final user. This does not preclude future M2M interaction getting rid of the human in the loop and boosting automation. Operators can discover the images detected by cameras, set trigger values and discover real-time readings on sensors, are visually notified when dangerous goods are carried by vessels and can look into it at the detail level of a single container.

Benefit	Benefit Description
A Closer Community	A unique convergence platform to host A2A and A2B applications under the responsibility of a dedicated Sea Port Technical Unit.
A resource shared with Public Administrations	Feeding the Open Data set owned by other Public Administrations.
A Safer Settlement	Risk management in real-time, zone by zone.

More Effective Operational Processes	Reliable and integrated processes allow to reduce dead time and inefficiency.
Sustainable Growth	Real-time measurement of waiting time, consider the accessibility of the terminal, detect pollution indicators.
Standardized Levels in the Quality of Service	Sticking to well-defined and widely accepted quality levels: define specially profiled development strategies of high impact.

Table 4: List of Benefits.

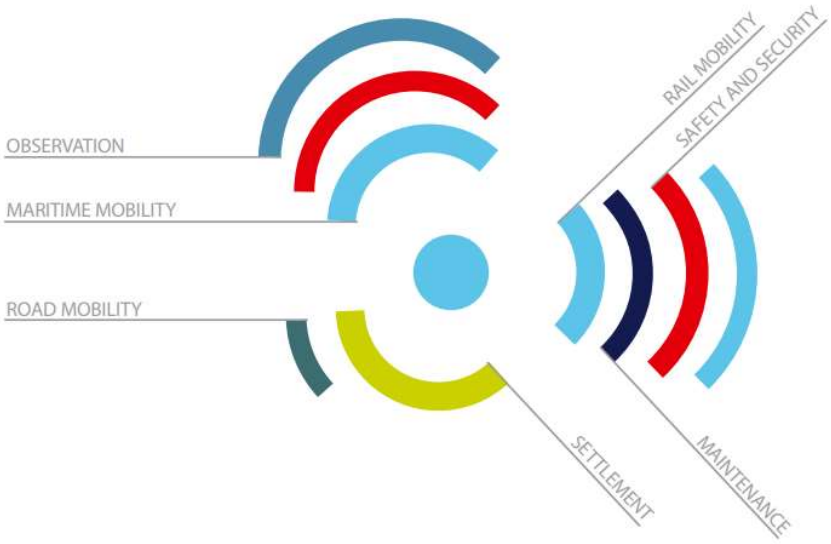


Figure 4: MONI.C.A – Functional Areas.

As it could be seen in the figure above, there are several examples of functional areas related to the PMS operativity. Referring to the PMS in usage at the Port of Livorno:

- **Settlement**: Livorno is an industrial seaport hosting production, assembly, and storage facilities. MONI.C.A considers plants, terminals, berths, and buildings as living entities generating and consuming events.

- **Maritime Mobility**: MONI.C.A gathers signals coming from the seafront, originated by vessels (e.g. announcing details about their cargo). Scheduled and actual berthing of vessels is recorded. As Livorno is also a cruise and ferry terminal, this information can be used in turn by travellers.

- **Rail Mobility**: Livorno features 60 Km of railways. The detailed map of stations, links, and rail crossings is managed by MONI.C.A. Railways

operations usually affect the seaport and its logistics satellites (i.e. the freight village and the off-site stores). MONI.C.A manages them in an integrated way.

- **Road Mobility**: The Port of Livorno features a direct access to the Livorno – Florence highway, also connecting the docks with the freight village. MONI.C.A manages the mobility of trucks and private vehicles with the objective of regulating the traffic, thus avoiding congestion and accidents. The proximity with the Livorno city centre is also considered as an issue.

- **Observation**: By means of a heterogeneous set of sensors (i.e. implanted, embedded in personal equipment, and on-board vehicles) MONI.C.A gathers information as a magnifying lens focusing on the selected resource, point of interest, vehicle, store, etc. This information can be processed, handed to other systems, visually rendered to operators on shift.

- **Maintenance**: Together with ordinary operations requiring a real-time processing of the data coming from active sensing units, MONI.C.A is a powerful tool to plan specific refurbishing actions towards those resources not complying with the expected quality of service any more.

- **Safety and Security**: MONI.C.A is a security platform intended to follow logistics and transportation with the aim of catching eventual violations related to the aspects covered by Service Level Agreements. Whenever safety issues or risks are detected, hazard warnings and reports are generated. These records are also used off-line for risk analysis and assessment.

2.3 Conclusions

The ICT world is constantly evolving. New communication, management and representation technologies are already available nowadays. The ports and logistics sector has already affected by the use of some of those technologies such us IoT systems, M2M communications and Big Data management systems. Others are still under study and experimentation (5G networks, Blockchain and VR).

Over the next decade the sector will witness more substantive changes as automation becomes more widespread and operations are increasingly directed and optimised in real time by sensors and intelligent software. In agreement with the State-of-the-Art overview provided in Deliverable D1.1, five innovations have been identified as relevant and will affect almost all aspects of the management processes at ports.

Many benefits have been widely exposed and discussed about these technologies:

- **Automation**: better control over port emissions, saving of time and resources, improved stability, long term benefits.

- **M2M, IoT & Big Data**: accurate telematics data collection across vehicles in real-time, increased asset reliability and availability, minimized risk with new systems and applications, improved responsiveness and decision making, improved flexibility and resource utilization, improve safety measures and increase satisfaction of terminal operation and other tenants of the seaports, increase the quality and efficiency of the port as an important link in the supply chain.

- **VR/AR**: elimination of manpower based operations, elimination of paper-based port operations, reduction of the time spent at the port area, reduction of possible accidents, availability of additional information and services for the port/terminal operator.

- **Blockchain**: secure validation of each transaction between all parties (terminal, ship agent, carrier, hinterland transport, port authority, etc.). For further information, refer to the reading of the Annex 1.

- **Disruptive Communication Technologies (5G)**: fast transmission of a large amount of data, new AR/VR based services, support to a wide range of use cases that all have different speed, latency, security and capacity requirements, extension of the Internet connectivity of the sensing systems.

The importance of integrated information systems will continue to grow, in particular because of current challenges faced by many ports around the globe. Recent technological developments, such as cloud computing and big data technologies, open new doors for improvement based on an integration of multiple data sources, decision analytics, and meta-analytics, but also imply huge requirements on the underlying IT/IS landscape. Consequently, the focus should be put on the integration of legacy systems and enabling technologies acting as data sources for highly scalable and distributed computing platforms using cloud computing, which are able to collect, store, process, and analyse data in real-time and thus provide advanced decision support.

Among all the innovations currently present in the ports, there are also those related to intelligent transport systems (ITS). The need for a high level of automation in port operations has, in fact, led many software houses to produce software solutions that natively present integration with these systems. For example, in the case of the port of Livorno, a Vehicle Booking System (VBS) is already in the process of being released, which is able to interact with the OneM2M platform, currently used for the publication

/ reading of the information coming from OBUs (On Board Units) installed on vehicles. For further information on this topic, please refer to the Annex 2 - Cooperative Intelligent Transport System.

3 COREALIS Innovations - User Requirements Extraction Methodology

In this chapter requirements coming from User Scenarios of each LL are collected and classified. A common methodology for the User Requirements extraction is presented as well.

Figure 5: User Requirements extraction methodology.

The starting point is represented by the identified User Needs that has been possible thanks to previous activities such as User Surveys, Desk Research activity, Focus Groups' inputs and User Scenarios definition. Some relevant parameters have been used for the User Requirements identification in order to provide all relevant information that are able to improve (and best describe) a specific User Requirement (e.g: Unique ID, Classification, Data Need, Physical Material Need, Prioritization, etc.). The User Requirements are classified as *Functional* and *Non-Functional*. In this context, *Functional* requirements specify the system functionalities (what the system should be able to do) while *NON-Functional* requirements specify how the system should behave:

- **Functional**: specifies something that system should do (specific system functionality), thus services that the LL's innovations should provide (e.g: how the innovation/system should react to particular inputs or how the system should behave in particular situations);
- **NON-Functional**: describes how the system works (performance, time, throughput, utilization, scalability, capacity, availability, reliability, security, regulatory, data integrity, interoperability, usability, etc.). In other words, constraints on the services or functions offered by the innovation/system (e.g: timing constraints, constraints on the development process, standards, etc.).

Each User Requirement comes from the related User Scenario and it is associated to the relative innovation as well as to the main Living Lab. For the convenience, in this document we are going to consider each innovation, the linked Living Lab and the relative scenario to be implemented. This will allow us for a better monitoring and tracking of the fulfillment and achievement of the user requirements within the project.

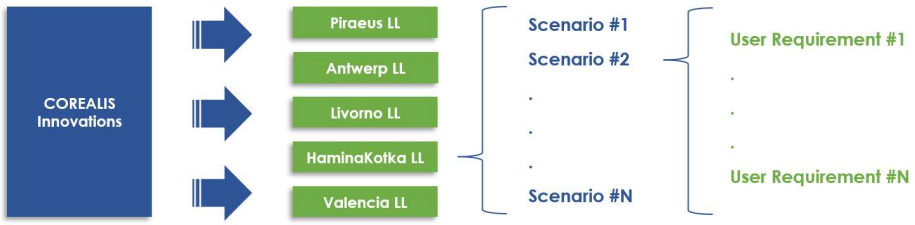


Figure 6: User Requirements based on the User Scenarios and related Innovations.

On one side, *Generic User Requirements* will be provided and divided for each innovation. These requirements will address common features of the considered innovation and they will be applicable for each involved Living Lab. On the other side, also *Specific User Requirements* (if any) will be provided in relation to the innovation developments within the specific Living Lab. In order to classify the set of the user requirements, the following template is going to be considered:

Attribute	Description
User Requirement Unique ID	A unique ID of the requirement, following the format: ▪ **InnovationName_URsType_GEN_AscendingNumbering** ▪ **InnovationName_URsType_Livinglab_AscendingNumbering** The first one refers to *Generic User Requirements*, where **URsType** specifies the type (functional or non-functional) of the considered requirement. The second one refers to *Specific User Requirements*.
Functional or Non-Functional	A classification of the requirement to *Functional* (F) and *Non-Functional* (NF).
Type of Non-Functional Requirements	In case of *Non-Functional Requirements*, the following categorization is used: ▪ **Performance** ▪ **Legal** ▪ **Security** ▪ **Privacy** ▪ **Availability** ▪ **Reliability** ▪ **Regulatory** ▪ **Integrity** ▪ **Confidentiality** ▪ **Interoperability** ▪ **Usability**
Classification of Requirement	A classification of the *Requirements* in order to make clear the contribution of the innovations to the objectives of the project: ▪ **Port-Hinterland Connections** ▪ **Intra-Terminal Operations** ▪ **Sustainable Growth** ▪ **Operational Efficiency** ▪ **Innovation Incubator** ▪ **Sustainable Development**
Title	A comprehensive title of the requirement.
Description	Detailed description of the requirement.
Data Need	In case there is a need of specific data to accomplish the requirement, it has to be specified.
Physical Material needed	In case there is a need of physical material to accomplish the requirement, it has to be specified.
Prioritization	**MUST**, **SHOULD**, **COULD** (eventually *out of scope*).

Work Package	The related WPs to which the requirement applies.
Related COREALIS System	The reference to the COREALIS Innovation to which the requirement applies.
Other LL applying the same requirement	It has to be specified if the same requirement applies to more than one LLs. In case a similar requirement applies to other LL, then a reference should be provided.
Dependency	In case of a direct dependency to another requirement, it has to be specified.

Table 5: User Requirements Template.

Moreover, for further information on the User Scenarios, the reader is referred to the public Trello boards: 1) Port of Valencia, 2) Port of Livorno, 3) Port of Piraeus, 4) Port of Antwerp and 5) Port of Haminakotka. Finally, a custom Requirement Traceability Matrix (RTM) is presented. The purpose of the RTM is both to ensure that all requirements defined for a system are tested and that requirements are not lost during the validation process. In our case the RTM will be represented by an inventory of port requirements. The RTM, together with the complementary information coming from the Data Management Plan (WP8) and Risk Register, will provide a full set of data related to the needs and requirements from each Living Lab and will be used as the input for the WPs of the higher level.

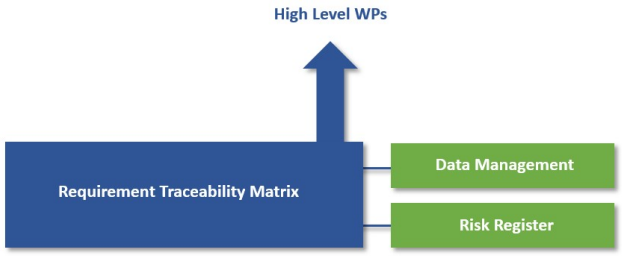


Figure 7: High Level WPs input.

Note that the matrix may be subject to continuous updates, when necessary, in relation to the evolution/integration of each scenario.

3.1 COREALIS Innovations and linked Living Labs

In this paragraph the current set of innovations within the COREALIS project are listed and linked to the proper Living Lab as well as to the proper set of Scenarios. For further details regarding the User Scenarios please refer both to the *T1.2 – COREALIS User Stories and Scenarios* and to the *Scoping Documents* per Living Lab.

COREALIS Innovation	Linked Living Lab	Linked Scenarios
TAS	*Valencia LL*	Scenario_1
	HaminaKotka LL	Scenario_2
RTPORT	*Livorno LL*	Scenario_1, Scenario_2
PORTMOD	*HaminaKotka LL*	Scenario_1
	Livorno LL	Scenario_4
PoFSG	*Piraeus LL*	Scenario_3

	Livorno LL	Scenario_3
	HaminaKotka LL	Scenario_3
Predictor – Asset Management	*Piraeus LL*	Scenario_1
Energy Assessment Framework	*Piraeus LL*	Scenario_2
Cargo Flow Optimizer	*Antwerp LL*	Scenario_1, Scenario_2a, Scenario_2b
Market Place & Chassis Brokerage Platform	*Antwerp LL*	Scenario_3
Innovation Incubator	*Valencia LL*	Scenario_3
JIT Rail Shuttle Service	*Valencia LL*	Scenario_2

Table 6: COREALIS Innovations per Living Lab.

Note that the ascending numbering of the scenarios are referred to different Living Labs. For the instance, *Scenario_3* refers not to the same scenario valid for all Living Labs but to the specific one within each Living Lab so that *Scenario_3* from Antwerp LL is different from the *Scenario_3* at Livorno LL.

3.2 Truck Appointment System – TAS

The Advance Truck Appointment System (TAS) is a system aiming at optimizing road transport processes and ensuring optimal operations with predefined time slots for container delivery/pick-up operations. On one side, with the new TAS, terminal operators will be able to define the capacity for the land operations thanks to the implementation of a time slot-based system. On the other side, logistics operators, shipping agents and truck companies will be able to plan their operations and select the most suitable time slot to perform them:

- Container terminal operators are able to define the capacity for each of the time slots in the TAS, based on a list of preferences (yard equipment availability, vessels berthed, etc.) and use TAS information to plan operations;

- Transport operators are able to book available time slots to deliver/pick-up containers to/from the container terminals.

TAS is expected to be deployed both at Valencia LL and HaminaKotka LL. For the case of HaminaKotka LL, a light version of this innovation is going to be implemented. This version will not include the ETA calculation mechanism, as for the case of Valencia LL.

The following *Generic User Requirements* for this innovation are derived:

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_1**

Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Configurable definition of a time-slot in the TAS booking system.
Description	The TAS must support the configuration of the capacity for each of the time slots in the booking system, with the following parameters: i) Different terminals/places to perform delivery/pick-up operations; ii) Different types of queues (import/export, full/empty, etc.); iii) Different slot configuration (days, hours, duration, etc.); iv) Different capacities per slot.
Data Need	Terminal working hours schedule, breaks, time slot definition, workload capacity.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 7: TAS_F_GEN_1.

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	User Interface.
Description	The system must have a user interface accessible from web browsers and mobile systems (smartphones and tablets). This interface must allow users to see real-time information about truck driving status, allowing to perform at least pre-booking, booking and cancellation operations. Moreover, the interface must be user-friendly, including (where possible) auto filling fields, scroll-down lists, selection boxes and date/calendar fields.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 8: TAS_F_GEN_2.

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	Reservation of a preferred slot.

Description	The transport operator must be able to reserve a slot according to an assigned Transport Order. It must also have the opportunity to change or cancel an order based on an order's unique id.
Data Need	Slot date and time, Terminal Name and type of queue, Transport Order Number, Transport Company, Vehicle Plate Number.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 9: TAS_F_GEN_3.

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_4**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	User registration and profile configuration
Description	Both Terminals and Transport Operators shall have distinct profiles and functionalities depending on each separate role. Transport Companies will have standard and superuser roles, this latter being able to edit, enable/disable other users of the same company. Users and superusers will be able to pre-register their vehicle fleet plate numbers and drivers, and configure notifications of successfully created booking and amendment by SMS or e-mail. Terminals will have Administrator and User role, all being able to see the booked slots in their terminal, by type of queue, transport company and booking data. Admin user is the role with most rights, view and functionality.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 10: TAS_F_GEN_4.

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_5**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	Dashboard and reporting.
Description	Both Terminals and Transport Operators must be able to see the relative bookings by means of a dashboard. The must be able to apply filters based on date, time period, terminal, type of queue, transport company, transport order number,

	vehicle plate number, status (cancelled/booked) and driving status. These data must be exportable using common reporting formats (.csv and .pdf).
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 11: TAS_F_GEN_5.

Attribute	Description
User Requirement Unique ID	**TAS_F_GEN_6**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	Container Terminals and Transport Operators feedback exchange.
Description	The system must allow feedback exchange (in form of questions/answers) between Container Terminals and Transport Operators, allowing to measure KPIs such as user's response time. Feedbacks will be displayed as unread/replied messages within the user's profile.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 12: TAS_F_GEN_6.

Attribute	Description
User Requirement Unique ID	**TAS_NF_GEN_1**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Legal/Privacy
Classification of Requirement	Port - Hinterland Connections
Title	GDPR Compliance
Description	TAS shall comply with GDPR requirements for Users and Company privacy data protection. Sensitive personal information shall require explicit acceptance of the User.
Data Need	Privacy Statement to be published in the TAS, user's written acceptance on privacy policy.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.

Dependency	N/A

Table 13: TAS_NF_GEN_1.

Attribute	Description
User Requirement Unique ID	**TAS_NF_GEN_2**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Integrity/Security
Classification of Requirement	Port - Hinterland Connections
Title	Data integrity and authentication procedures.
Description	The system must be a safe environment, granting the data integrity. Users must be validated only by authorized profiles of each company. Each user must be authenticated by means of personal username and password.
Data Need	Username and Password.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	Generic requirement for both Valencia LL and HaminaKotka LL.
Dependency	N/A

Table 14: TAS_NF_GEN_2.

3.2.1 Valencia Living Lab

For the case of Valencia LL, the TAS must provide a system for the calculation of the ETA of the trucks. The ETA will be calculated based on the truck GPS position. In case the ETA deviates from the assigned slot, the TAS system will inform the interested users and will automatically assign a new appointment if there is available capacity in the slot that coincides with the ETA. If there is no free capacity in the slot matching the ETA, the system will assign a position in the virtual queue.

The following *Specific User Requirements* for this Living Lab are derived:

Attribute	Description
User Requirement Unique ID	**TAS_F_Valencia_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port - Hinterland Connections
Title	ETA Calculation.
Description	The system must display trucks estimated time of arrival (ETA) to the assigned Terminal and selected queue in each booking for both Terminals and Transport Companies to be aware of the driving status (early, in time, late). ETA calculation must be based on current GPS location and it must be shown on the user's device. Moreover, the system must calculate the ETA at regular interval (~ 10 minutes).

Data Need	GPS trucks position.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	TAS
Other LL applying the same requirement	specific requirement for Valencia LL.
Dependency	N/A

Table 15: TAS_F_Valencia_1.

3.2.2 HaminaKotka Living Lab

For the case of HaminaKotka LL, a light version of the innovation is expected to be used. Only booking system for Terminal Operators as well as for Transport Operators must be available. TAS Generic User Requirements are applied in this case. No Specific User Requirements are needed.

3.3 RTPORT for 5G-enabled smart terminal operations

The RTPORT module aims at providing a fully automated management system for the case of general cargo. The main aim of the RTPORT module is to design and set up a pervasive 5G network in a Container Terminal providing advanced assisted services to the Container Terminals operators. RTPORT module will allow to pick up the specific general cargo in a shorter time than by means of usual human-driven communications. It will also allow a better management of the cargo in itself (optimal placement, optimal forklift call and optimal loading/unloading of the cargo) by means of VR/AR-based devices/services. This will reduce significantly the total number of operations per unit and improve the intra-terminal operational efficiency. This module is expected to be deployed only in Livorno LL.

The following *Generic User Requirements* for this innovation are derived:

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Interaction between Container Terminal operators and the cargo management system.
Description	The interaction with the main system and the container terminal operators must be allowed by means of an application running on their smart devices (i.e: tablets). Devices must be both portable (for the case of on-field operators) and fixed (for the case of forklifts' drivers). This application must allow operators to perform the following activities: 1) cargo data registration, 2) vessel loading operations and 3) cargo transfer/management operations.
Data Need	Cargo and forklifts data.
Physical Material needed	Tablets.
Prioritization	MUST

Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 16: RTPORT_F_GEN_1.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	General Cargo geometric data retrieving.
Description	The system must be able to get geometric data of the unloaded cargo (from the truck) and combine those data with logistics data (destination and weight of the cargo) from the bar code reader. All data must be stored within a RDBMS.
Data Need	Cargo Geometric Data, Cargo Logistics Data.
Physical Material needed	Tablet with dedicated app, measurement device based on the LIDAR technology and the bar code reader.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 17: RTPORT_F_GEN_2.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	General Cargo optimal storage.
Description	The system must be able to compute the optimal placement position in the storage area and guide the forklift driver to the designed area by means of VR/AR-based assisted service.
Data Need	Cargo data, GPS data.
Physical Material needed	Tablet with dedicated app.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 18: RTPORT_F_GEN_3.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_4**
Functional or Non-Functional	F

Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Cargo loading operations and assisted positioning.
Description	The system must be able to select the cargo to transfer based on specific request from the terminal operator, choose a proper forklift based on its availability as well as on its distance from the selected cargo and guide the forklift driver to the proper location within the storage area, providing him cargo handling information. The system must be able to assist the positioning of the selected cargo by using VR/AR, indicating which cargo should be moved and where it should be placed.
Data Need	Vessel loading plan, GPS data, WDR cameras data.
Physical Material needed	Tablet with dedicated app and WDR cameras.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 19: RTPORT_F_GEN_4.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_5**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	User Interface for the management of the forklifts.
Description	The control room operator must be able to interact with the Yard Vehicles Management System by means of a User web-based Interface, accessible through a browser. The user interface must allow to monitor the forklifts status (busy/available), their GPS position on the yard as well as to visualize the assigned cargo info (cargo ID, length, width and height). The business logic behind the User Interface must be able to apply a custom algorithm, based on the lowest distance as well as on the forklift's status, in order to identify the proper forklift for the assigned handling operation. This information must be sent to the main control system which will start the assisted handling VR/AR-based services.
Data Need	Cargo Data, GPS Data.
Physical Material needed	Terminal's Control Room WorkStation (PC/Laptop).
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 20: RTPORT_F_GEN_5.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_GEN_1**
Functional or Non-Functional	NF

Type of Non-Functional Requirements	Availability
Classification of Requirement	Intra-Terminal Operations
Title	General System/Service Availability.
Description	The system availability must be 99.999%, guaranteeing less than 6 minutes of downtime per year. This must be evaluated on the basis of the system architecture of the mobile network.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 21: RTPORT_NF_GEN_1.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_GEN_2**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Reliability
Classification of Requirement	Intra-Terminal Operations
Title	General System/Service Reliability.
Description	The system reliability must be more than 99%. This must be evaluated on the basis of the MTBF of the parts belonging to the mobile network.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 22: RTPORT_NF_GEN_2.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_GEN_3**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Confidentiality/Integrity
Classification of Requirement	Intra-Terminal Operations
Title	Data confidentiality and integrity.
Description	Data confidentiality as well as data integrity must be guaranteed by instantiating a Virtual Private Network (VPN). This VPN must use encryption and tunneling mechanism to encapsulate encrypted data into a secure tunnel, making data unreadable without proper decryption key. Data must be accessible only using the local installed network, by means of authorized on-field devices.
Data Need	N/A
Physical Material needed	N/A

Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 23: RTPORT_NF_GEN_3.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_GEN_4**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Security
Classification of Requirement	Intra-Terminal Operations
Title	Server access and users management.
Description	All access to servers must be handled by proper user accounts. All authorized users will be provided with a specific account with password giving them the proper rights depending on their level of authorization. A designated system administrator will manage all access accounts and rights for the specific operations on the system. Moreover, the system administrator must be able to handle all the accesses by means of an automated event log system. A list of all the personnel having access to the logistics application must be maintained and update on a regular basis.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	**RTPORT_NF_GEN_3**

Table 24: RTPORT_NF_GEN_4.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_GEN_6**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	On-field devices communication.
Description	All devices including the cameras on poles are not fixed infrastructures and must be able to communicate with the Main Control System (server) via wireless connection.
Data Need	N/A
Physical Material needed	LIDAR, WDR Cameras, Tablets.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 25: RTPORT_F_GEN_6.

3.3.1 Livorno Living Lab

Based on the operational needs from the Container Terminal, that has been chosen for the deployment of the RTPORT module (CT Lorenzini), and further technical as well as infrastructural needs, the following *Specific User Requirements* for the Livorno Living Lab are also considered:

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_Livorno_1**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Performance
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Mobile network E2E latency (4G/5G).
Description	The system must be able to perform remote video processing, image and context recognition as well as AI processing to guide drivers and workers with VR/AR-based services. For this purpose for the case of 5G NR, the guaranteed E2E latency must be less than 10ms, while for the case of 4G connectivity it must be less than 20ms.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 26: RTPORT_NF_Livorno_1.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_Livorno_2**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Performance
Classification of Requirement	Intra-Terminal Operations/Operational efficiency
Title	Real-time video streams from WDR cameras.
Description	The system should be able to provide real-time video streams, from the high definition WDR cameras, to the forklift drivers guaranteeing up to 15Mbps bandwidth in order to support the container terminals operators with the highest quality of service.
Data Need	N/A
Physical Material needed	N/A
Prioritization	SHOULD
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 27: RTPORT_NF_Livorno_2.

Attribute	Description
User Requirement Unique ID	**RTPORT_NF_Livorno_3**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Performance
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	5G NR network coverage.
Description	In order to provide the service within the Container Terminal Lorenzini area, device communication must be guaranteed within a range of at least 2500m^2.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	N/A

Table 28: RTPORT_NF_Livorno_3.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_Livorno_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Cargo identification by QR code.
Description	A unique identification for the cargo must be provided since an ID code is not always available on the cargo after its arrival at the port. The system must be able to associate a unique ID, when the cargo is unloaded from the truck. This ID is coded using a QR code attached to the cargo. The QR codes are pre-printed and attached to the cargo by the Terminal Container Lorenzini operators at the arrival. The system must be able to read this code by means of the application running on the tablets.
Data Need	Logistics data associated to the QR code, Waybill.
Physical Material needed	Printed QR codes, Tablets.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	**RTPORT_F_GEN_2**

Table 29: RTPORT_F_Livorno_1.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_Livorno_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Optimal cargo distribution in the storage area.

Description	When the main system receives the cargo registration data through the application running on the smart device, it must be able to compute the proper position within the storage area, taking into account the current placement of the cargo already stored.
Data Need	Cargo data and GPS data.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	**RTPORT_F_GEN_3**

Table 30: RTPORT_F_Livorno_2.

Attribute	Description
User Requirement Unique ID	**RTPORT_F_Livorno_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Optimal cargo distribution in the storage area.
Description	In order to allow the proper forklift identification, the system must be able to exchange data with the OneM2M (machine-to-machine) ETSI-compliant standard platform, allowing the communication both with the AdSPMTS port monitoring system MonI.C.A and with the yard vehicles management system.
Data Need	Cargo data and GPS data.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	RTPORT
Other LL applying the same requirement	N/A
Dependency	**RTPORT_F_GEN_4**

Table 31: RTPORT_F_Livorno_3.

3.4 PORTMOD – Process Modelling for vessel pit-stop operations

PORTMOD aims to become a simulation software tool that assists in improving Container Terminal operations. It aims to offer capabilities to identify bottlenecks and evaluate different operational strategies, like job dispatching and location of stacks. In order to identify bottlenecks one goal is to develop a visualisation capability that allows to visualize container movements in a terminal. We aim to develop a simulation capability that will provide an estimation on the operational efficiency when a new operational scenario is analysed. The combined visualization and simulation capabilities enables to compare scenarios and optimise operational performance. PORTMOD will be built on open source software that will enable it to be expandable

beyond the currently developed capabilities, e.g. to consider stuffing, truck loading and unloading related activities.

PORTMOD is expected to be deployed both in HaminaKotka Living Lab (within Kotka Container Terminal operated by *Steveco*) and Livorno Living Lab (within Container Terminal *Lorenzini*). *Specific User Requirements* for both HaminaKotka and Livorno Living Lab will be given because of the different emphasis on port needs. No *Generic User Requirements* are given. The system requirements will be common because the aim is to develop one version of PORTMOD that ports may use.

3.4.1 HaminaKotka Living Lab

The following *Specific User Requirements* for the HaminaKotka Living Lab are also considered:

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_HaminaKotka_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	PORTMOD Interface
Description	PORTMOD will have a standalone interface. The interface will enable terminal operator to evaluate different capabilities provided by PORTMOD, for example, the visualisation of container flows inside the terminal area in order to give an overview of the operation.
Data Need	Historical data from Terminal Operating System.
Physical Material needed	N/A
Prioritization	SHOULD
Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 32: PORTMOD_F_HaminaKotka_1.

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_HaminaKotka_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Machine Movement Optimization
Description	Improve Container Terminal (CT) operations by modelling tool PORTMOD. The primary goal is identify and optimize machine movements, location of stacks and vessels in order to minimize the total driving distances in the process.
Data Need	Historical data from Terminal Operating System.
Physical Material needed	N/A
Prioritization	MUST

Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 33: PORTMOD_F_HaminaKotka_2.

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_HaminaKotka_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Evaluation of Straddle Carrier Pooling
Description	One goal is to enable the evaluation of straddle carrier pooling. Currently the straddle carriers are designated to specific vessel loadings. Pooling means that the straddle carriers will execute the most optimal task and is not bound to a specific vessel loading process.
Data Need	Historical data from Terminal Operating System.
Physical Material needed	N/A
Prioritization	SHOULD
Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 34: PORTMOD_F_HaminaKotka_3.

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_HaminaKotka_4**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Evaluation of Different Yard Area Layouts
Description	One goal is to analyse the performance of different container yard area layouts and infrastructure changes. The main KPI will be driven distance (km), from which can be derived pollution-, time- and cost (€) KPI´s.
Data Need	Historical data from Terminal Operating System.
Physical Material needed	N/A
Prioritization	COULD
Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 35: PORTMOD_F_HaminaKotka_4.

3.4.2 Livorno Living Lab

The following *Specific User Requirements* for the Livorno Living Lab are also considered:

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_Livorno_1**

Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	User Interface for Terminal Container operators.
Description	The system must provide a standalone interface. The interface must allow terminal operator to visualise the container flows inside the terminal area in order to give an overview of the whole operation. The container flow visualisation must be provided on monthly/yearly basis. Users must be able to interact with this interface by filtering the historical data (by time intervals, resources and container types) as well as by visualizing the container movements within the matched container yard layout map.
Data Need	Historical containers data from TOS.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 36: PORTMOD_F_Livorno_1.

Attribute	Description
User Requirement Unique ID	**PORTMOD_F_Livorno_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Intra-Terminal Operations/Operational Efficiency
Title	Data format definition.
Description	The system must allow the uploading of the historical data by means of text files, e.g.csv-formatted files. The system must also allow to define the container yard layout map, including road network, by means of text files.
Data Need	Historical containers data from TOS.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP3
Related COREALIS System	PORTMOD
Other LL applying the same requirement	N/A
Dependency	N/A

Table 37: PORTMOD_F_Livorno_2.

3.5 PoFSG – Port of the Future Serious Game for improved decision making

The PoFSG is an innovative and interactive training and simulation tool that is used to assess the feasibility and sustainability of the socio-economic and environmental/physical development of a port within the surrounding coastal and urban area. The tool is able to visualize the anticipated impacts, positive as well as negative, related to social, economic and environmental aspects. Mainly, PoFSG is developed for

port planners and stakeholders that want to explore future sustainable port-city development. It provides clarity on port-city stakeholders roles and responsibilities. This simulating tool includes cards with measures that can be selected by players and a digital environment where the measures can be simulated and the effects visualized.

The PoFSG is expected to be deployed within three different Living Labs: Piraeus LL, Livorno LL and HaminaKotka LL in order to simulate different scenarios based on the needs of each port, providing at the same time the impacts related to the involved stakeholders' decisions.

The following *Generic User Requirements* for this innovation are derived:

Attribute	Description
User Requirement Unique ID	**PoFSG_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable Development/Sustainable Growth
Title	Game rounds and events.
Description	The game must be capable to involve at least 10 different stakeholders, divided in small groups by category (e.g., government, port authorities, financial investors, NGOs and terminal operators). The game will consist of 2-3 different rounds. Each round represents a 10-years period. Stakeholders must choose a game scenario from a range of available scenarios. Each group must select the team captain and decide strategy during the first round for the selected scenario. Stakeholders from each group must select only 2 measures that fit their adopted strategy and reach a common decision. The effects on People-Planet-Prosperity (PPP score) of stakeholders' measures must be measured and displayed within the simulation environment. Unexpected events must be taken into consideration by the game, triggering conflicts and alternative actions from the stakeholders.
Data Need	N/A
Physical Material needed	Stakeholders, cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	Generic requirement for HaminaKotka LL, Livorno LL and Piraeus LL.
Dependency	N/A

Table 38: PoFSG_F_GEN_1.

Attribute	Description
User Requirement Unique ID	**PoFSG_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable Development/Sustainable Growth
Title	Interaction between users (stakeholders) and the simulation environment.
Description	The game must provide a wide set of gamecards including different measures in the categories port development/expansion, regulation, cultural services, hinterland connection, logistic capacity, environment, energy systems and strategic planning. The gamecards must have a QR code to be scanned in order to easily insert the measures in the digital environment. The game must give

	feedback on selected measures in terms of visualization as well as their effects on the PPP scores.
Data Need	N/A
Physical Material needed	Stakeholders, cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	Generic requirement for HaminaKotka LL, Livorno LL and Piraeus LL.
Dependency	N/A

Table 39: PoFSG_F_GEN_2.

3.5.1 Piraeus Living Lab

Piraeus Living Lab is participating in user scenario of port-city connectivity in the PoFSG. Exploring sustainable growth measures and their impacts will provide indispensable support to decision-making in a changing port policy on Piraeus port. Through PoFSG, a capacity building and knowledge transfer process is taking place on Piraeus port for green-port connectivity implemented in the LL. The process requires awareness for the needs of green environment.

The following *Specific User Requirements* are considered:

Attribute	Description
User Requirement Unique ID	**PoFSG_F_Piraeus_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable growth
Title	Impact assessment of the sustainable port-city development.
Description	The game must provide a scenario on sustainable port-city development (including hinterland, mobility as well as the urban connectivity), allowing all involved stakeholders to explore measures in the port-city as well as different hinterland connections by means of gamecards.
Data Need	N/A
Physical Material needed	Stakeholders, cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	N/A
Dependency	**PoFSG_F_GEN_1**, **PoFSG_F_GEN_2**

Table 40: PoFSG_F_Piraeus_1.

3.5.2 Livorno Living Lab

Livorno Living Lab considers both 1) *Emerging, disruptive and cutting-edge technologies* (such as 5G) for port ICT infrastructure and 2) *Sustainable and climate*

proof port development aspects through the usage of the PoFSG simulating tool. These aspects are expected to be assessed during the playable session of the game with the relevant stakeholders from the Livorno Port Community.

The following *Specific User Requirements* are considered:

Attribute	Description
User Requirement Unique ID	**PoFSG_F_Livorno_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable Development
Title	Impacts assessment of the investments in emerging technologies (5G).
Description	The game must include measures and events related to innovations for the Port of Livorno (5G) and be able to (qualitatively) assess their potential effects on People, Planet and Profit. Stakeholders must be able to select these measures from a wide range of measures and are triggered to look at them from different perspectives. The game must be able to drive the stakeholders to the potential benefits and risks of investments in new technologies.
Data Need	N/A
Physical Material needed	Cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	N/A
Dependency	**PoFSG_F_GEN_1**, **PoFSG_F_GEN_2**

Table 41: PoFSG_F_Livorno_1.

Attribute	Description
User Requirement Unique ID	**PoFSG_F_Livorno_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable Development
Title	Impact assessment of the climate change adaptation and sustainable port-city development.
Description	The game must allow Port of Livorno stakeholders to explore measures (and related events) for climate change adaptation and sustainable port-city development, including their perspectives. The game must be able to assess the impacts of "green" measures considering both cleaner shipping as well as the usage of LGN filling stations installation.
Data Need	N/A
Physical Material needed	Cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	N/A
Dependency	**PoFSG_F_GEN_1**, **PoFSG_F_GEN_2**

Table 42: PoFSG_F_Livorno_2.

3.5.3 HaminaKotka Living Lab

In HaminaKotka Living Lab, the game considers the transition from traditional fuel-based to renewable energy sources. The following aspects are taken into account: 1) *advantages and disadvantages of electrification of machinery and automation in container operations*, 2) *use of renewable energy for port operations* and 3) *changes in the port layout to improve the energy efficiency of the port*.

The following *Specific User Requirements* are considered:

Attribute	Description
User Requirement Unique ID	**PoFSG_F_HaminaKotka_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Sustainable Development
Title	Measures that facilitate the energy transition.
Description	The game must include measures that facilitate the energy transition scenario, in terms of 1) electrification of machinery 2) using renewable energy 3) plan energy efficiency measures. The game must allow stakeholders to (qualitatively) assess the potential social, environmental and economic effects of these measures.
Data Need	N/A
Physical Material needed	Cards and simulation tool.
Prioritization	MUST
Work Package	WP4
Related COREALIS System	PoFSG
Other LL applying the same requirement	N/A
Dependency	**PoFSG_F_GEN_1**, **PoFSG_F_GEN_2**

Table 43: PoFSG_F_HaminaKotka_1.

3.6 Predictor for a circular-economy inspired asset management

The Predictor tool provides a powerful predictive analytics module that goes beyond classic ERP static preventive maintenance tools. It enables monitoring and dynamic prediction of the total life-cycle cost of port assets that improves over time. The Predictor comprises multiple analytics algorithms: 1) *descriptive*: in order to aggregate similar data from various assets and determinate recurring phenomena as well as their impact; 2) *predictive*: in order to foresee the impact of assets' state changes and their effect on port inventory; 3) *anomaly detection*: in order to compare events with patterns and detect anomalies in the assets. With Predictor coupled with these optimization algorithms, the port of Piraeus will have a Just-In-Time Inventory, will optimise renewals decisions and support circular economy concepts by allowing a longer use/reuse of port assets. This innovation is expected to be deployed only in Piraeus Living Lab. The following *Generic User Requirements* are derived:

Attribute	Description
User Requirement Unique ID	**PREDICTOR_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Predictor user interface.
Description	Predictor must be delivered as Graphical User Interface (GUI) which should be accessible through maintenance engineer's smart device (tablets or desktop). By means of this interface, maintenance engineer must be able to enter the part for which he wants to produce a predictive maintenance schedule. For this purpose, the user must be able to store historical maintenance/breakdown and telemetry data in a dedicated server in order to train a machine learning model. Then, predictor module must learn a machine learning model specific to selected part using these historical data. Once the training is completed, engineer must be able to produce predictive maintenance schedule for real-time truck telemetry data stored at specific location in server. Finally, engineer must be able to take a desired action based on predictive maintenance schedule.
Data Need	Historical truck maintenance schedule, historical truck breakdown data, historical truck telemetry data and real-time truck telemetry data.
Physical Material needed	Tablet/Desktop.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	Predictor - Asset Management
Other LL applying the same requirement	Generic requirement for Piraeus LL.
Dependency	N/A

Table 44: PREDICTOR_F_GEN_1.

Attribute	Description
User Requirement Unique ID	**PREDICTOR_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Predictor output format.
Description	Predictive maintenance schedule must be saved in .csv format at specific location corresponding to real-time truck data for a specific part. The stored .csv file must be easily accessible and engineer must be able to see the truck IDs for which specific part is going to fail.
Data Need	Historical truck maintenance schedule, historical truck breakdown data, historical truck telemetry data, real-time truck telemetry data and spare parts availability/usage data.
Physical Material needed	Tablet, Desktop.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	Predictor - Asset Management
Other LL applying the same requirement	Generic requirement for Piraeus LL.
Dependency	**PREDICTOR_F_GEN_1**

Table 45: PREDICTOR_F_GEN_2.

Attribute	Description

User Requirement Unique ID	**PREDICTOR_F_GEN_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Spare parts identification.
Description	Based on the predictive maintenance schedule, maintenance engineer must be able to communicate the required spare parts to warehouse manager. Then warehouse manager identifies the spare parts purchasing needs (based on current availability of spare parts). Predictive maintenance schedule must be capable to reduce the overall availability of yard equipment due to longer and more frequent proactive maintenance.
Data Need	Historical truck maintenance schedule, historical truck breakdown data, historical truck telemetry data, real-time truck telemetry data and spare parts availability/usage data.
Physical Material needed	Tablet, Desktop.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	Predictor - Asset Management
Other LL applying the same requirement	Generic requirement for Piraeus LL.
Dependency	**PREDICTOR_F_GEN_2**

Table 46: PREDICTOR_F_GEN_3.

3.6.1 Piraeus Living Lab

Additional *Specific User Requirements* are derived for the case of Piraeus Living Lab:

Attribute	Description
User Requirement Unique ID	**PREDICTOR_NF_Piraeus_1**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Interoperability
Classification of Requirement	Operational Efficiency
Title	Historical maintenance data extraction and consolidation.
Description	The system must be able to consolidate data from different data sources available at the Port of Piraeus (Enterprise Asset Management System, Truck Monitoring System, Maintenance Ledgers, Spare parts Inventory, Manufacture Maintenance Schedules), by using a common identifier (yard equipment number). In case this identifier is not universal within all data sources, data processing must take place before data are submitted to the system.
Data Need	Historical truck maintenance schedule, historical truck breakdown data, historical truck telemetry data, real-time truck telemetry data and spare parts availability/usage data.
Physical Material needed	Tablet, Desktop.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	Predictor - Asset Management
Other LL applying the same requirement	N/A

Dependency	N/A

Table 47: PREDICTOR_NF_Piraeus_1.

Attribute	Description
User Requirement Unique ID	**PREDICTOR_NF_Piraeus_2**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Interoperability
Classification of Requirement	Operational Efficiency
Title	Telemetry data extraction.
Description	Real-time telemetry data must be collected from controllers installed on Piraeus yard equipment via the wireless network and transmitted in batch mode to the system.
Data Need	Real-time truck telemetry data.
Physical Material needed	Controllers.
Prioritization	MUST
Work Package	WP3
Related COREALIS System	Predictor - Asset Management
Other LL applying the same requirement	N/A
Dependency	N/A

Table 48: PREDICTOR_NF_Piraeus_2.

3.7 Energy Assessment Framework & Green Cookbook

Energy Assessment Framework is capable to analyse and model energy consumption and efficiency of ports, through metering and collecting data from container terminal. It explores novel and cost-effective solutions for reducing energy consumption of the terminals as well as for improving energy efficiency in the whole network of the port and the connected port city. Moreover, Energy Assessment Framework investigates the option of large-scale use of renewable energy for the ports of the future, including costa, benefits, technical challenges and solutions. A Green Cookbook for green energy solutions will be produced and published as a guideline for decision makers of the ports for identifying and selecting green, efficient and cost-effective solutions, which may not only benefit the ports, but also the society as a whole. The Asset Management Framework is expected to be deployed only within the Piraeus LL. Only Specific User Requirements are available.

3.7.1 Piraeus Living Lab

This analysis is expected to be conducted within the port of Piraeus. Energy Assessment requires access to the power consumption data and the relative cost related data. Aggregate power consumption data will be extracted from the Power Consumption monitoring system of PCT while relative cost related data can be extracted from the ERP system. The following *Specific User Requirements* are derived:

Attribute	Description

User Requirement Unique ID	**COOKBOOK_F_Piraeus_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Power consumption identification.
Description	The system must be able to identify power consumption patterns, profile and assess top consumers and define consumption percentage replaceable by renewable energy sources.
Data Need	Historical power consumption data.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP4
Related COREALIS System	Energy Assessment Framework
Other LL applying the same requirement	N/A
Dependency	N/A

Table 49: COOKBOOK_F_Piraeus_1.

Attribute	Description
User Requirement Unique ID	**COOKBOOK_F_Piraeus_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Power consumption percentage replaceable.
Description	Power required for identified power consumption percentage replaceable by renewable energy sources cannot be generated due to physical limitations (space available and landscape limitations).
Data Need	Replaceable power consumption percentage, landscape data.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP4
Related COREALIS System	Energy Assessment Framework
Other LL applying the same requirement	N/A
Dependency	**COOKBOOK_F_Piraeus_1**

Table 50: COOKBOOK_F_Piraeus_2.

3.8 Cargo Flow Optimiser for Ocean/Rail & Inland Waterway

The Cargo Flow Optimiser pursues the smart organization of containers placed on a port's terminal with different destinations and modes of transport. It helps in the reduction of storage time at ports and increases the percentage of use of more sustainable transport modes, by using real time vessel data sharing and rail/barge data for cargo bundling and consolidation. Cargo Flow Optimiser is able to predict how many containers are going to arrive or leave the port for a certain day/week/month and their arrival/leaving mode of transport. Cargo Flow Optimiser is expected to be deployed only within Antwerp Living Lab. The Cargo Flow Optimizer is expected to

be deployed only within the Antwerp LL. Only Specific User Requirements are available.

3.8.1 Antwerp Living Lab

The following *Specific User Requirement* are derived:

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Cargo arrivals prediction
Description (3-4 lines)	The CFO shall calculate the prediction of the cargo arrivals to the Port of Antwerp.
Data Need	Gate-in, Gate-out
Physical Material needed	No
Prioritization	Should
Work Package	WP2
Related COREALIS System	COREALIS CFO – Data driven Cargo Flow prediction
Other LL applying the same requirement	N/A
Dependency	N/A

Table 51: CFO_F_GEN_1

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	European destination definition
Description (3-4 lines)	The CFO shall have the option for the user to define a European destination
Data Need	NA
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	N/A

Table 52: CFO_F_GEN_2

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Truck routes
Description (3-4 lines)	The CFO should calculate and suggest the best truck routes available in terms of shortest path, CO_2 emissions and estimated price
Data Need	Auto roadways map
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance Route CO_2 emissions Route price

Table 53: CFO_F_GEN_3

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_4**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Rail connections
Description (3-4 lines)	The CFO should calculate and suggest the best rail connections available in terms of shortest path, CO_2 emissions and estimated price
Data Need	PoA connectivity data, europan railways map
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance Route CO_2 emissions Route price

Table 54: CFO_F_GEN_4

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_5**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections

Title	Barge connections
Description (3-4 lines)	The CFO should calculate and suggest the best barge connections available in terms of shortest path, CO_2 emissions and estimated price
Data Need	PoA connectivity data, European Inland waterways map
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance Route CO_2 emissions Route price

Table 55: CFO_F_GEN_5

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_6**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Short-sea vessel connections
Description (3-4 lines)	The CFO could calculate and suggest the best shortsea vessel connections available in terms of shortest path, CO_2 emissions and estimated price
Data Need	PoA connectivity data
Physical Material needed	No
Prioritization	Could
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance Route CO_2 emissions Route price

Table 56: CFO_F_GEN_6

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_7**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Route duration
Description (3-4 lines)	The CFO should calculate and display the duration of every suggested route. The duration will depend on the selected mode of transport.
Data Need	PoA Connectivity Data – Transit time and schedules for barge and rail
Physical Material needed	No
Prioritization	Must

Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	N/A

Table 57: CFO_F_GEN_7

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_8**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Route distance
Description (3-4 lines)	The CFO should calculate and display the distance of every suggested route. The distance will depend on the selected mode of transport.
Data Need	PoA Connectivity data – Terminal rail distance, Terminal barge distance
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	N/A

Table 58: CFO_F_GEN_8

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_9**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Route price
Description (3-4 lines)	The CFO should calculate and display the price estimation of every suggested route. The price will depend on the selected mode of transport and the distance travelled.
Data Need	Container Cost
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance

Table 59: CFO_F_GEN_9

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_10**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Route CO_2 emissions
Description (3-4 lines)	The CFO should calculate and display the CO2 estimation of every suggested route. The duration will depend on the selected mode of transport, the distance travelled and national emission factors
Data Need	Distance travelled in every country, factors for calculating energy consumption and greenhouse gas emissions for traction current and power from the national grid
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Route distance

Table 60: CFO_F_GEN_10

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_11**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	Insert intermediate stops
Description (3-4 lines)	User should be able to insert intermediate stops and stating the number of containers the forwarder wants to ship to every destination
Data Need	N/A
Physical Material needed	No
Prioritization	Could
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	Destination Definition Number of TEUs definition

Table 61: CFO_F_GEN_11

Attribute	Description
User Requirement Unique ID	**CFO_F_GEN_12**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections

Title	Cargo demand prediction
Description (3-4 lines)	The CFO shall calculate the cargo prediction on a specific area, time range and mode of transport. This prediction will allow to discover new shared transport services.
Data Need	Gate-in, Gate-out
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Data driven Cargo Flow prediction
Other LL applying the same requirement	N/A
Dependency	N/A

Table 62: CFO_F_GEN_12

Attribute	Description
User Requirement Unique ID	**CFO_NF_GEN_1**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Technical
Classification of Requirement	Port-Hinterland Connections
Title	CFO User Interface
Description (3-4 lines)	The CFO will have a user interface to showcase some of the CFO functionalities and will be accessible from web browsers from PCs, smartphones or tablets. The interface will be user-friendly and will include, among others, the suggested routes on a map highlighting the route selected by the user, an autofill field for the destination, a date field, a mode of transport selection option.
Data Need	N/A
Physical Material needed	No
Prioritization	Must
Work Package	WP5
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	N/A

Table 63: CFO_NF_GEN_1

Attribute	Description
User Requirement Unique ID	**CFO_NF_GEN_2**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Technical
Classification of Requirement	Port-Hinterland Connections
Title	Previous day and the next day
Description (3-4 lines)	Visualize on the CFO user interface the option of previous day and next day according to the date selected by the user

Data Need	N/A
Physical Material needed	No
Prioritization	Could
Work Package	WP5
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	N/A

Table 64: CFO_NF_GEN_2

Attribute	Description
User Requirement Unique ID	**CFO_NF_GEN_3**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Legal requirement
Classification of Requirement	Port-Hinterland Connections
Title	GDPR compliance
Description (3-4 lines)	The Multimodal Inland Optimizer must be GDPR compliant, it will take into account GDPR requirements for users and company privacy data protection. Sensitive personal information shall require explicit acceptance of the user and personal data won't be collected unless necessary.
Data Need	N/A
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner
Other LL applying the same requirement	N/A
Dependency	

Table 65: CFO_NF_GEN_3

Attribute	Description
User Requirement Unique ID	**CFO_NF_GEN_4**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Security
Classification of Requirement	Port-Hinterland Connections
Title	Security
Description (3-4 lines)	CFO shall be a safe environment and grant the integrity of the data contained in it. Users shall be created and validated only by authorized profiles of each Company or the Terminal Administrator.
Data Need	N/A
Physical Material needed	No
Prioritization	Must
Work Package	WP2
Related COREALIS System	COREALIS CFO – Multimodal inland planner

Other LL applying the same requirement	N/A
Dependency	N/A

Table 66: CFO_NF_GEN_4

3.9 Cloud-Based Marketplace & Chassis Brokerage

Cloud-Based Marketplace & Chassis Brokerage platform allows to overcome a lot of issues related to the delivery of services necessary for transporting, storing or handling containers as well as general cargo. In fact, extra traffic is created in the port area to transport the equipment from one location to the other. This innovation provides a booking functionality so that users (terminal operators and transport operators) can act as a offeror making it available for carries to book their equipment and services. Equipment owners benefit from this system as it provides a best possible use of the assets. For the carriers/shipper this equipment optimization leads to a shorter waiting time at the port and a lower demurrage risk.

The marketplace Platform is expected to be deployed only within Antwerp LL. Only *Specific User Requirements* are available.

3.9.1 Antwerp Living Lab

The following *Specific User Requirement* are derived:

Attribute	Description
User Requirement Unique ID	**MARKETPLACE_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Marketplace: Brokerage platform.
Description (3-4 lines)	Platform to book equipment owned by PoA for efficient planning and use of assets. Needs to collect data on assets, locations and enable booking them with platform available to users.
Data Need	Availability and schedules of stakeholders' operations.
Physical Material needed	No
Prioritization	Must
Work Package	WP5
Related COREALIS System	COREALIS Marketplace
Other LL applying the same requirement	N/A
Dependency	N/A

Table 67: MARKETPLACE_F_GEN_1

Attribute	Description
User Requirement Unique ID	**MARKETPLACE_F_GEN_2**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Marketplace: Availability for stakeholders
Description (3-4 lines)	Platform must be available over web browser for stakeholders of Port of Antwerp so that PoA can manage access for their customers
Data Need	Data on stakeholders and location of terminal
Physical Material needed	No
Prioritization	Must
Work Package	WP5
Related COREALIS System	COREALIS Marketplace
Other LL applying the same requirement	N/A
Dependency	N/A

Table 68: MARKETPLACE_F_GEN_2

Attribute	Description
User Requirement Unique ID	**MARKETPLACE_F_GEN_3**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Operational Efficiency
Title	Marketplace: Users
Description (3-4 lines)	Platform must enable logins for users of different types and levels who can manage assets and post bookings to the platform. PoA can manage users over the whole platform and within stakeholders
Data Need	Users' data and their privileges
Physical Material needed	No
Prioritization	Must
Work Package	WP5
Related COREALIS System	COREALIS Marketplace
Other LL applying the same requirement	N/A
Dependency	N/A

Table 69: MARKETPLACE_F_GEN_3

3.10 Innovation Incubator

The Innovation Incubator consists in the organization of the Hackathon event that will help to create synergies between start-ups, IT companies and entrepreneurs with the port community of the Port of Valencia. The objective of this hackathon is to present the main concerns and challenges of the port community and see if new ideas and technologies can be useful to overcome them. The most relevant ideas will be selected

and awarded in the hackathon to be further developed in an incubator scheme. Only Valencia Living Lab is expected to host the Hackathon event.

Due to the nature of this event (cooperation framework between the port community and SMEs as well as start-ups), only *Generic User Requirements* can be considered:

Attribute	Description
User Requirement Unique ID	**INCUBATOR_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Innovation Incubator
Title	Hackathon organization online platform and venue.
Description	For the organization of the hackathon, there must be an online platform where hackers (participants of the hackathon) must be able to communicate between them and exchange information. Besides, this platform must share information about the hackathon organization. There must be a venue that will host the event and where hackers must be able to communicate with experts and coaches.
Data Need	N/A
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP8
Related COREALIS System	Innovation Incubator
Other LL applying the same requirement	N/A
Dependency	N/A

Table 70: INCUBATOR_F_GEN_1.

Attribute	Description
User Requirement Unique ID	**INCUBATOR_NF_GEN_1**
Functional or Non-Functional	NF
Type of Non-Functional Requirements	Legal/Privacy
Classification of Requirement	Innovation Incubator
Title	GDPR Compliance
Description	Hackathon registration must comply with GDPR requirements for participants and Company privacy data protection. Sensitive personal information must require explicit acceptance of the User.
Data Need	Privacy Statement to be published in the Hackathon website, user's written acceptance on privacy policy.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	Innovation Incubator
Other LL applying the same requirement	N/A
Dependency	**INCUBATOR_F_GEN_1**

Table 71: INCUBATOR_NF_GEN_1.

3.11 Just-In-Time Rail Shuttle Service

Just-In-Time Rail Shuttle Service is a feasibility study for the corridor Valencia-Zaragoza to boost rail traffic share thanks to the optimization of the rail processes and it covers the design of the physical and operational solution (service characteristics) to minimize the container yard movements in the container terminal and optimize the loading/unloading operations of the containers in the train. This study analyses the state-of-the-art of the infrastructure and will identify the improvements that are needed in order to offer a competitive service. Besides, it assess the potential demand aiming at defining the optimum service characteristics. The actors/users involved in this study are: 1) railway undertaking, 2) railway operator manager, 3) railway operator trader, 4) shippers, 5) terminal operators and 6) shipping agencies. This study is expected to cover not only the needs on infrastructure upgrades, but also operational characteristics, information flows and systems and business models. This study is expected to be performed only for the case of Valencia Living Lab.

Due to the nature of this study, only *Generic User Requirements* can be considered:

Attribute	Description
User Requirement Unique ID	**JIT_F_GEN_1**
Functional or Non-Functional	F
Type of Non-Functional Requirements	N/A
Classification of Requirement	Port-Hinterland Connections
Title	JIT Rail shuttle scope.
Description	This study must cover the needs on infrastructure upgrades, the operational characteristics, information flows and systems as well as business models. The study must physically involve the railway operators, terminal operators, shippers and shipping companies. Also the study must provide the current state-of-the-art about the current rail infrastructure, potential demand of the Valencia-Zaragoza corridor, costs of the operations.
Data Need	SotA and information exchanged between the railway operators.
Physical Material needed	N/A
Prioritization	MUST
Work Package	WP2
Related COREALIS System	JIT Rail Shuttle
Other LL applying the same requirement	N/A
Dependency	N/A

Table 72: JIT_F_GEN_1.

3.4 RTM – Requirements Traceability Matrix

Projects often have a lot of requirements and project managers need to have a system or process to trace all of the requirements that they have already met and still need to meet. Requirements tracing provides a link between the requirements and innovations developed to verify the requirements. The requirements traceability matrix is a grid that links the requirements from where the origin is to where the deliverables are. Implementation of this tool ensures that each of the requirements provides additional business value by linking it to the project and business objectives. Tracking the innovation requirements throughout the COREALIS project life cycle, ensures that all requirements approved and documented are delivered at the end of the project. Moreover, it also provides a structure to manage the changes in the innovation scope.

The RTM is presented below in detail. This matrix is an essential input for the Scoping Document associated to each LL and will allow to keep track of all the requirements set for the implementation of each single innovation. Moreover, the direct relationship between the proposed matrix and the test phase is available on redmine by means of the following link: https://redmine.iccs.gr/projects/corealis/dmsf?folder_id=8079.

Innovation	Requirement ID	Living Lab	Requirement Type	Prioritization	Versioning
Truck Appointment System	TAS_F_GEN_1	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_F_GEN_2	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_F_GEN_3	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_F_GEN_4	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_F_GEN_5	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_F_GEN_6	Valencia, HaminaKotka	F	MUST	Alpha Version
Truck Appointment System	TAS_NF_GEN_1	Valencia, HaminaKotka	NF	MUST	Alpha Version
Truck Appointment System	TAS_NF_GEN_2	Valencia, HaminaKotka	NF	MUST	Alpha Version
Truck Appointment System	TAS_F_Valencia_1	Valencia	F	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_1	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_2	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_3	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_4	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_5	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_NF_GEN_1	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_NF_GEN_2	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_NF_GEN_3	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_NF_GEN_4	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_F_GEN_6	Livorno	F	MUST	Alpha Version

RTPORT	RTPORT_NF_Livorno_1	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_NF_Livorno_2	Livorno	NF	SHOULD	Alpha Version
RTPORT	RTPORT_NF_Livorno_3	Livorno	NF	MUST	Alpha Version
RTPORT	RTPORT_F_Livorno_1	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_Livorno_2	Livorno	F	MUST	Alpha Version
RTPORT	RTPORT_F_Livorno_3	Livorno	F	MUST	Alpha Version
PORTMOD	PORTMOD_F_Livorno_1	Livorno	F	MUST	Alpha Version
PORTMOD	PORTMOD_F_Livorno_2	Livorno	F	MUST	Alpha Version
PORTMOD	PORTMOD_F_HaminaKotka_1	HaminaKotka	F	SHOULD	Alpha Version
PORTMOD	PORTMOD_F_HaminaKotka_2	HaminaKotka	F	MUST	Alpha Version
PORTMOD	PORTMOD_F_HaminaKotka_3	HaminaKotka	F	SHOULD	Alpha Version
PORTMOD	PORTMOD_F_HaminaKotka_4	HaminaKotka	F	COULD	Alpha Version
PoFSG	PoFSG_F_GEN_1	HaminaKotka, Livorno, Piraeus	F	MUST	Alpha Version
PoFSG	PoFSG_F_GEN_2	HaminaKotka, Livorno, Piraeus	F	MUST	Alpha Version
PoFSG	PoFSG_F_Piraeus_1	Piraeus	F	MUST	Alpha Version
PoFSG	PoFSG_F_Livorno_1	Livorno	F	MUST	Alpha Version
PoFSG	PoFSG_F_Livorno_2	Livorno	F	MUST	Alpha Version
PoFSG	PoFSG_F_HaminaKotka_1	HaminaKotka	F	MUST	Alpha Version
Predictor	PREDICTOR_F_GEN_1	Piraeus	F	MUST	Alpha Version
Predictor	PREDICTOR_F_GEN_2	Piraeus	F	MUST	Alpha Version
Predictor	PREDICTOR_F_GEN_3	Piraeus	F	MUST	Alpha Version
Predictor	PREDICTOR_NF_Piraues_1	Piraeus	NF	MUST	Alpha Version
Predictor	PREDICTOR_NF_Piraues_2	Piraeus	NF	MUST	Alpha Version
Energy Assessment Framework	COOKBOOK_F_Piraeus_1	Piraeus	F	MUST	Alpha Version
Energy Assessment Framework	COOKBOOK_F_Piraeus_2	Piraeus	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_1	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_2	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_3	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_4	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_5	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_6	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_7	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_8	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_9	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_10	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_11	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_F_GEN_12	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_NF_GEN_1	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_NF_GEN_2	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_NF_GEN_3	Antwerp	F	MUST	Alpha Version
Cargo Flow Optimiser	CFO_NF_GEN_4	Antwerp	F	MUST	Alpha Version
Marketplace Brokerage Platform	MARKETPLACE_F_GEN_1	Antwerp	F	MUST	Alpha Version
Marketplace Brokerage Platform	MARKETPLACE_F_GEN_2	Antwerp	F	MUST	Alpha Version
Marketplace Brokerage Platform	MARKETPLACE_F_GEN_3	Antwerp	F	MUST	Alpha Version
Innovation Incubator	INCUBATOR_F_GEN_1	Valencia	F	MUST	Alpha Version
Innovation Incubator	INCUBATOR_NF_GEN_1	Valencia	NF	MUST	Alpha Version
JIT Rail Shuttle Service	JIT_F_GEN_1	Valencia	F	MUST	Alpha Version

4 Conclusions

In this document an overview has been presented on aspects related to technological innovations that are taking place in the ports around the world. Concepts like automation, next-generation mobile communications, machine-to-machine communications, computer security and augmented /virtual reality are now the main topic regarding the ICT field. Their application in the port context is undoubtedly a valid reason for both research and investment as they allow both to enable new services and to optimize and render already existing services more efficient. For this reason, particular attention has been paid to the compatibility and interoperability aspects with existing legacy systems and currently used in many European and non-European ports. A wide-ranging research was conducted to obtain information on the use of new technologies in ports all over the world.

A methodology for defining and extracting user requirements has been provided. The mapping between the innovations to be implemented and the user requirements is essential to ensure correct implementation, as it allows monitoring the evolution and progress of each individual innovation. The proposed approach was based on the mapping between the COREALIS Innovations and related Living Labs. User Requirements per innovation have been then formulated. Finally a global view of the User Requirements has been provided by means of the *Requirements Traceability Matrix*.

The output of this document represents the basis for the advancement of both WP5 and WP6 activities.

References

[1] Container Terminal Lorenzini – Information Technology. Available at: https://www.lorenziniterminal.it/en/information-technology/

[2] Port of Virginia – Global Supply Chain. Available at: https://www.mhlnews.com/global-supply-chain/ocean-ports-lead-way-logistics-technology-advancements

[3] World Maritime Day, 2017. Available at: https://news.itu.int/world-maritime-day-six-ways-icts-can-help-to-connect-ships-ports-and-people/

[4] Port Technology – Blockchain Trial in Singapore. Available at: https://www.porttechnology.org/news/successful_blockchain_trial_concludes_in_singapore

[5] CBSA and Montreal port dip toe into blockchain to tug shipping into digital age. Available at: https://business.financialpost.com/pmn/business-pmn/cbsa-and-montreal-port-dip-toe-into-blockchain-to-tug-shipping-into-digital-age

[6] Digitalization and ICT Innovations: a Focus on Port Logistics. Available at: https://www.docksthefuture.eu/digitalisation-and-ict-innovations-a-focus-on-port-logistics/

[7] D1.1 – Port of the Future challenges anablers and barriers. Available at: https://redmine.iccs.gr/projects/corealis/dmsf?folder_id=4302

[8] Electronic Solutions – Port of Antwerp. Available at: https://www.portofantwerp.com/sites/portofantwerp/files/Product%20Sheet%20eServices_LR.pdf

[9] Tuscan Port Community System. Available at: https://tpcs.tpcs.eu/login-en.aspx

[10] Maximum Operational Optimization - ValenciaportPCS. Available at: https://www.valenciaportpcs.com/en/

[11] CATOS – A full integrated container terminal operating system. Available at: http://www.tsb.co.kr/en/sub01_01_01.php

[12] STEP – Terminal Operating System. Available at: https://www.copas.nl/

[13] N4 Terminal Operating System. Available at: https://www.navis.com/en/products/terminal-solutions/n4-terminal-operating-system/

[14] MoniCA – The Monitoring and Control Platform of the Port of Livorno. Available at: https://www.youtube.com/watch?v=4UU2s1l6riw&feature=youtube. MoniCA - Web Service. Available at: https://www.monicapmslivorno.eu/

[15] 5th ITS Cooperative Mobility Services Plugtest – Livorno IT – 9/18 Novembre 2016. Available at: https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/5th_ITS_CMS_PLUGTEST_REPORT_FINAL.pdf

[16] Automated Driving Progressed by Internet of Things. Available at: http://autopilot-project.eu/

[17] SaaS vs PaaS vs IaaS: What is The Difference and How To Choose. Available at: https://www.bmc.com/blogs/saas-vs-paas-vs-iaas-whats-the-difference-and-how-to-choose/

[18] Successful Blockchain Trial Concludes in Singapore. Available at: https://www.porttechnology.org/news/successful_blockchain_trial_concludes_in_singapore

[19] Port of Rotterdam – Blockchain Technology Field Lab. Available at: https://www.portofrotterdam.com/en/news-and-press-releases/port-authority-and-municipality-of-rotterdam-launch-blockchain-technology

[20] ROboB Starts First Blockchain Project in the Port of Hamburg. Available at: https://www.dakosy.de/en/news/detail/article/robob-starts-first-blockchain-project-in-the-port-of-hamburg/

[21] ZIM introduces the First Pilot Bill of Lading based on Blockchain Technology. Available at (Italian): https://www.corrieremarittimo.it/shipping/zim-introduce-primo-pilota-bl-basato-sulla-tecnologia-blockchain/

[22] Port of Antwerp - Blockchain based system for the Container Release. Available at: https://www.i-scoop.eu/blockchain-smart-port-project-case-container-release-port-antwerp/

Annex 1: Cybersecurity and Blockchain

Cybersecurity is not a new concept but it is growing in importance as the number (and impact) of attacks has quietly risen in recent years. Given the importance of the terminals that they operate, port operators are a likely target for attacks, especially as automation increases the damage that such an attack would bring. Cybersecurity entails the safeguarding of computer networks and the information they include from penetration and from malicious damage or disruption. Cybersecurity can be seen also as a collection of tools, methods, security concepts, security safeguards, guidelines, risk management methods, processes, educations, insurances, and technologies. This collection can be used to protect the assets of cyberspace, organizations, and users. Cyber-attackers usually target port operators inside the port area because operators tend to have fewer security controls than the port itself and are therefore easier to attack. For ports, cyber-threats include, for example, an action to delete operational data containing time schedules and information for container shipments. The amount of information that a port holds itself, large monetary transfers and the number of stakeholders attract cyber-attackers to target ports and port facilities. For example, cyber-attackers may gain access to commandeer a ship, close a port or its terminal, access delicate information such as pricing documents or time schedules, and change manifests or container numbers.

The key concern of cybersecurity is that today, individuals with a bare minimum of equipment and knowledge of cyberspace or its techniques can launch a cyberattack. Usually, smaller cyber-attackers aim to draw attention to how easily the ICT systems of organizations and ports can be hit, but cyberattacks are also happening on a large scale with severe consequences. Although five cyber-threats have been identified so far (cyber-criminality, cyberespionage, cyberterrorism and cyberwar), new threats continue to emerge. Especially for ports the threats focus on cyberespionage and cyber-criminality, because their data systems contain huge amounts of information relating to transport schedules and customers. Vulnerabilities are usually malfunctions or gaps in ICT systems. It is necessary for ports to compare their strategies and processes in order to cooperatively enhance their resilience to cyberattacks. Some suggestions for future research could be:

- What existent cybersecurity frameworks do ports use or have they used?
- How do ports see their current situation in respect to cyberattacks?
- What is the concrete number of systems in the ports that rely on information and communication technologies (e.g: PCS, PMS, TOS, etc.)?
- How are the information and communication technologies of ports protected from cyberattacks?

Supply chain management and logistics in particular require a secure and reliable flow of goods. This must be achieved in combination with faster, cheaper and more efficient

processes. One of the most important ways to attain such efficiency is by capturing and sharing data. For logistics, this means that there is real-time access, reliability, visibility and integration of relevant data in order to allow for the right processes to happen at the right time. Especially in the port, where cargo makes a switch between different transport modes and routes, such data is of tremendous importance. In an optimal situation, all information that both leads cargo to its destination and monitors it is available and accessible to all relevant parties in an online environment.

Blockchain is a decentralised ledger technology used by a business network to exchange digital or physical assets securely. Each member of the network is granted access to an up-to-date copy of this encrypted ledger so they can read, write and validate transactions. Once a transaction is validated using a consensus process, it is instantly committed to all ledgers in the network. The net result is faster, private, confidential and auditable business-to-business interactions among suppliers, distributors, financial institutions, regulators or anyone wishing to make a secure exchange. Blockchain creates a permanent, digitised chain of transactions that are grouped in blocks and cannot be altered. The use of blockchain, as a secured, decentralized and encrypted public ledger, could be used in various applications in shipping and bring a revolution on the way the trade is performed.

Figure 8: A transparent, secure and robust certification system and document flow will benefit the whole supply chain.

As blockchain technology becomes more established in different sectors, supply chain IT experts and developers are also looking at its potential and use in the logistic sector. Blockchain represents the key element for the creation of the Digital Supply Chain. The disruptive technology is regarded as a potential means of establishing the integration of the different actors in the supply chain, enhancing the information flow among them and ensuring the security as well as the cost effectiveness. In port logistics, blockchain has the potential to transform and disrupt port processes by documenting, validating and securing each event in the chain. In that sense the blockchain can add value to port

logistics and port digitalization in a number of ways. These are related to building trust, provision of secure data, visibility, network expansion and integration of supply flows.

The validity of the information stored on the blockchain is ensured by an encryption mechanism. This provides a solution for the complex process of writing information and validating information on the ledger. The complex mechanism not only ensures the validity of the information, but also prevents fraud. Some examples of the interest in blockchain could be found below:

"A blockchain trial which tested shipping from China to Singapore has been deemed a success by its operating partners, carrier Pacific International Lines (PIL), terminal operator PSA International (PSA) and the Singaporean branch of the technology giant IBM." [18].

"The Municipality of Rotterdam and the Port of Rotterdam Authority have jointly launched (2017) a field lab for the development of concrete applications and solutions based on blockchain technology. The new applied research lab has been christened BlockLab." [19].

"The IHATEC research project RObоB – Release Order based on Blockchain - was officially launched at DAKOSY, the operator of the Port Community System for the Port of Hamburg, in cooperation with the Technical University of Hamburg and numerous associated partners." [20].

"ZIM introduces the first Bill of Lading pilot based on blockchain technology." [21].

"*Blockchain smart port case: efficient and secure container release in the port of Antwerp.*" [22].

Adapting a blockchain technology could have the following advantages for the shipping industry.

- **Quick processing time and real-time updates**: Instead of mailing the documents to various parties, the exchange of information can become instantly and procedures which currently take weeks to be completed even within a few minutes. The software code of blockchain will also automate tasks that are typically accomplished manually;
- **Higher accuracy**: Since all the execution of contracts and other processes are automated, the errors are much less possible;
- **Full Transparency**: The information is stored in a place where everyone can have access provided that he has the required access key. This gives full transparency to market participants and also the counter-party risk is easier evaluated when anyone can have access to the transactions previously performed by each party;
- **Increased security**: All information is encrypted, something which adds security by its own. Also, the fact that the users can not interfere with the system

and change the information stored into blockchain, protects the market from fraudulent activities and various documentary manipulations;

- **Cost Saving**: A big part of the trade financing costs is related to documentation, procedural delays, discrepancies or errors. These costs can be omitted and total cost currently spent to various intermediaries will be avoided and replaced by a much cheaper cost of the blockchain.

Blockchain is definitely a crucial invention, but it is important to understand that it is not a solution to everything. There are many cases in which blockchain is not applicable and could even harm business. Blockchain should only be used if a large number of people are involved, if there is a limited amount of trust between them, but there are clear incentives to work together, and if data needs to be immutable. Blockchain can cope with high coordination and establishes trust between parties. However, it requires a clear incentive and if it does not actually add value, then it could be a great waste of time and energy to invest in it.

Name	Description
Wave	This blockchain application aims to eradicate the Bill of Lading. It connects the manufacturer and the purchasing company by building a blockchain application where the parties involved in the supply chain gain access to the information on shipments.
Provenance	This supply chain solution provides physical products with a seamless digital passport that ensures transparency and trust. This will prevent the selling of stolen or fake goods by having an auditable account of the journey for all physical products.
Fluent	This blockchain application enables fast, low-cost, simple and secure invoicing and payment systems for the global supply chain.
SolasVGM	A blockchain-based application that creates a collaborative ecosystem between all landside parties, load point, shipper, driver, booking party, terminal and shipping line. The application gives parties involved in the supply chain access to the cargo's Verified Gross Mass (VGM).

Table 73: current blockchain solutions.

Annex 2: Cooperative Intelligent Transport Systems (C-ITS)

The latest in a series of Plugtests™ interoperability events for Intelligent Transport Systems (ITS) Cooperative Systems has been organised by ETSI, in partnership with ERTICO [15]. This event was hosted by CNIT, from 9 to 18 November 2016 in Livorno, Italy. The support of the Livorno Port Authority, the Tuscan Regional Government, Autostrade, TIM and AVR (the FI-PI-LI highway operator) allowed to provide an exceptional test infrastructure including a harbour test track, a highway test track and access to the FI-PI-LI traffic control centre. Participating companies from the automotive sector tested the interoperability of their solutions. In addition they ran tests to assess their compliance with ETSI ITS Release 1 developed by the ETSI ITS technical committee. The event also included M2M use cases, gathering experts from both public and private organizations specializing in ITS and IoT technologies and implementations. At this Plugtest many C-ITS platforms demonstrated their interoperability by participating at state of the art safety use cases. The test results showed that the V2X technology is deployable in the near term and that it provides the necessary performance to meet use case requirements of today. Furthermore, the M2M and infrastructure use cases were successfully tested and as a result it can be stated that the V2X technology is capable of meeting requirements of use cases of tomorrow.

The AUTOPILOT's demonstrations were held recently in Livorno as well (18/19 October 2018). AUTOPILOT (*AUTOmated driving Progressed by the Internet of Things*) is an EU-funded project that started in January 2017 [16]. It is now reaching its mid-term point. After Tampere (Finland), Livorno (Italy) has been the second pilot site. Several Use Cases have been demonstrating during the session (at Livorno Cruise Terminal):

- **Highway Use Case – IoT assisted speed adaption due to slippery road**: sensors placed along the highway detect a relevant presence of water on road surface. This event triggers a warning that is notified in advance to the vehicle by the IoT. The AD (Automated Driving) system reduces its speed and the vehicle reaches the interested area moving at an appropriate speed;
- **Highway Use Case - IoT assisted speed adaption and lane change approaching roadworks**: a roadworks event is planned by traffic/road operator and a temporary speed limit is associated with the event. The AD vehicle has to reduce its speed approaching the roadworks area, performing a lane change, travelling at the temporary speed limitation and increasing again the speed at the end of roadwork area;
- **Urban Use Case - IoT assisted speed adaption at traffic light crossroads**: an AD vehicle autonomously adapts its speed in order to cross the intersection without violating the traffic light phases and considering other vehicles moving in front;

- **Urban Use Case - IoT assisted speed adaption with fallen bicyclist**: a bicyclist falls down in a "smart" urban environment. The hazard warning is broadcasted to the vehicles by IoT based services. AD cars, approaching the accident area have to reduce their speed and to stop.

Annex 3: Compliance and Interoperability Aspects

Several ICT innovations and Legacy Systems in ports have been discussed in the Chapter 2 of this deliverable (refer to the reading of D1.1 – Port of the future challenges, enablers and barriers – Chapter 3).

The main purpose of this Annex is not to analyze the level of interoperability and integration between the various innovations (which will be implemented in each LL), rather it is to introduce the issue by bringing some concrete examples. This is because the integration process will be extensively developed in Work Package # 6. The case of the Port of Livorno, which is currently trying to develop a complete service-oriented stack, will be presented as an example. Here the integration process plays a crucial role, since it is necessary to ensure compatibility with existing legacy systems.

Compliance and interoperability aspects are strictly related to the available ICT infrastructure. It is not only about a compliance with used standard communication protocols or logistics ones. It is about the compliance with the full cloud based stack used in sea Ports (cloud based approach is the most common). There are usually three models of cloud service to compare: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS):

- **SaaS - Software as a Service**: is the top layer and most basic form of cloud computing. It follows multitenant architecture in which all users share a common infrastructure. In this, the software and associated data are deployed and hosted on the internet which is accessed by the user via a web browser. The customer can use the software by using the SaaS provider's license and is subjected to pricing on the basis of pay per use. In this layer a single application with customizable configuration can be used by many customers. The advantage is that it requires zero installation of the software and hardware structures and is capable of being accessible from anywhere with an internet connection;
- **PaaS – Platform as a Service**: provides computing platform which primarily includes resources like operating system, programming language, database, web server that automatically scales to meet the application demands. In this model, developers with proprietary APIs develop an application that will run in a specific environment and further controls software deployment and configuration settings. Thus the app is confined to a particular platform using which it was developed. PaaS reduces the cost and complexity of application deployment by casting off the need to buy and manage the underlying hardware and software and to provision hosting capabilities;
- **IaaS – Infrastructure as a Service**: provides infrastructure like unlimited storage and computing power for developers without requiring any physical hardware on site. It is the base layer for cloud computing which basically deals

with virtual machines, storage, servers, networks, load balancers, and the IaaS cloud providers supply these resources on-demand. Minimal requirements to build IaaS cloud employs: Hypervisor – VMM (Virtual Machine Monitor), and Networking topology – public or private. IaaS mitigates the need for a data center, and maintaining hardware at the local level. Examples include Amazon Web Service (AWS), Rackspace and Windows Azure.

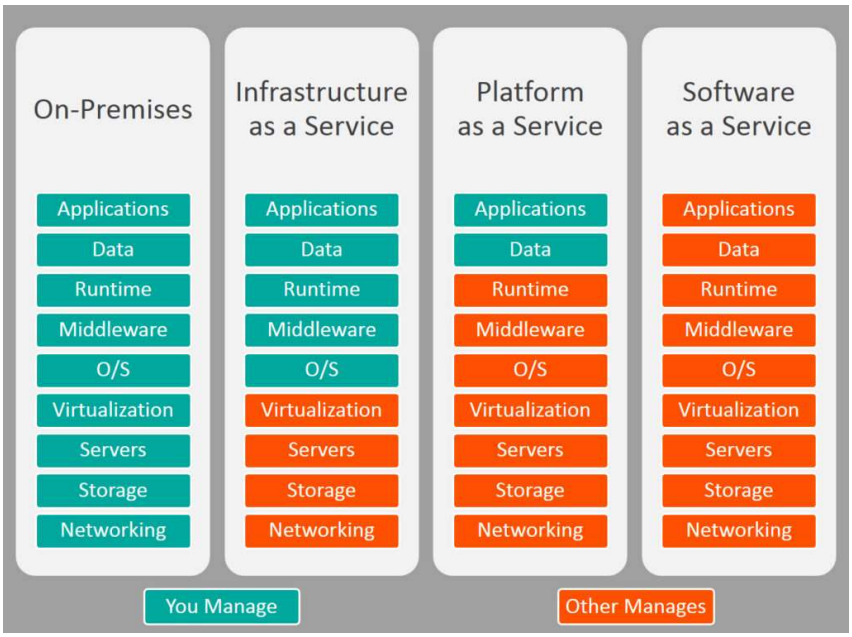


Figure 9: key differences between SaaS, PaaS and IaaS. [17]

As evidenced, compliance and interoperability aspects should be taken into consideration at any level. As you can imagine, the knowledge of the state of the art of your own ICT architecture plays an important role in identifying any problems that may hinder the integration process. For better understanding of this problem let us take into consideration the case of Port of Livorno.

Port of Livorno ICT Infrastructure is a Cloud and SOA based architecture, structured as following:

- **SaaS**:1) re-designing and encompassing all applications, 2) All digital apps are expected to run at SaaS layer;
- **PaaS** a middleware of services oriented to M2M: 1) custodial, access and information retrieval, 2) I/O from the Internet of Port Communities, 3) external repositories;
- **IaaS**: 1) connecting the port in itself (LAN), 2) connecting the port with other nodes along the transport and logistics chain, 3) pervasive monitor and control port activities gathering data from humans and machines.

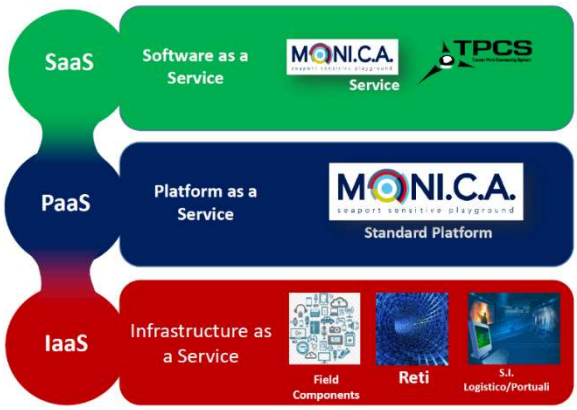


Figure 10: Cloud Model at the Port of Livorno.

As illustrated in the figure below, compliance and interoperability aspects are present both at IaaS, PaaS and SaaS layers. For example, taking into consideration the implementation of RTPORT module is necessary to keep in mind that:

- **IaaS Layer**: 5G radio equipment should be compliant with the existing physical infrastructure in order to permit a proper level of integration. The compliance at this level is basically related to the current Communication Standards: 4G – 3GPP Release 8, 3G – 3GPP Release 4 (UMTS)/Release 5 (HSPA), WiFi - IEEE 802.11. Of course, if a high interoperability level with existing WSNs is required, the compliance with other standards should be taken into consideration: 6LoWPAN – IEEE 802.15.4, NB-IoT – 3GPP Release 13, Vehicular Networks - ETSI ITS-G5. If the requested level of interoperability is related to a lower level of communication, some protocols are needed to be considered:

Type of Protocol	Current Protocols
Infrastructure	IPv4/IPv6, RPL
Identification	EPC, uCode, IPv6, URIs
Discovery	Physical Web, mDNS, DNS-SD
Data Protocols	MQTT, CoAP, AMQP, Websocket, Node
Device Management	TR-069, OMA-DM
Semantic	JSON-LD, Web Thing Model

Table 74: list of available protocols at lower layer.

- **PaaS Layer**: at this level RTPORT could be seen as a Platform as well, since it provides a service to the final user (or maybe to other platforms). This means that a proper level of interoperability requires the corresponding compliance (when needed) with existent digital platforms (e.g: PCS and PMS) to be guaranteed. Interoperability aspects with other digital platforms depends on both the technology used to implement or develop it and the common communication interfaces. This means that it is impossible (regardless) to evaluate the level of a possible integration. In this context, the widely used

standard for information exchange and the interaction with Nation Single Windows is of great importance: UN/EDIFACT - ISO 9735;

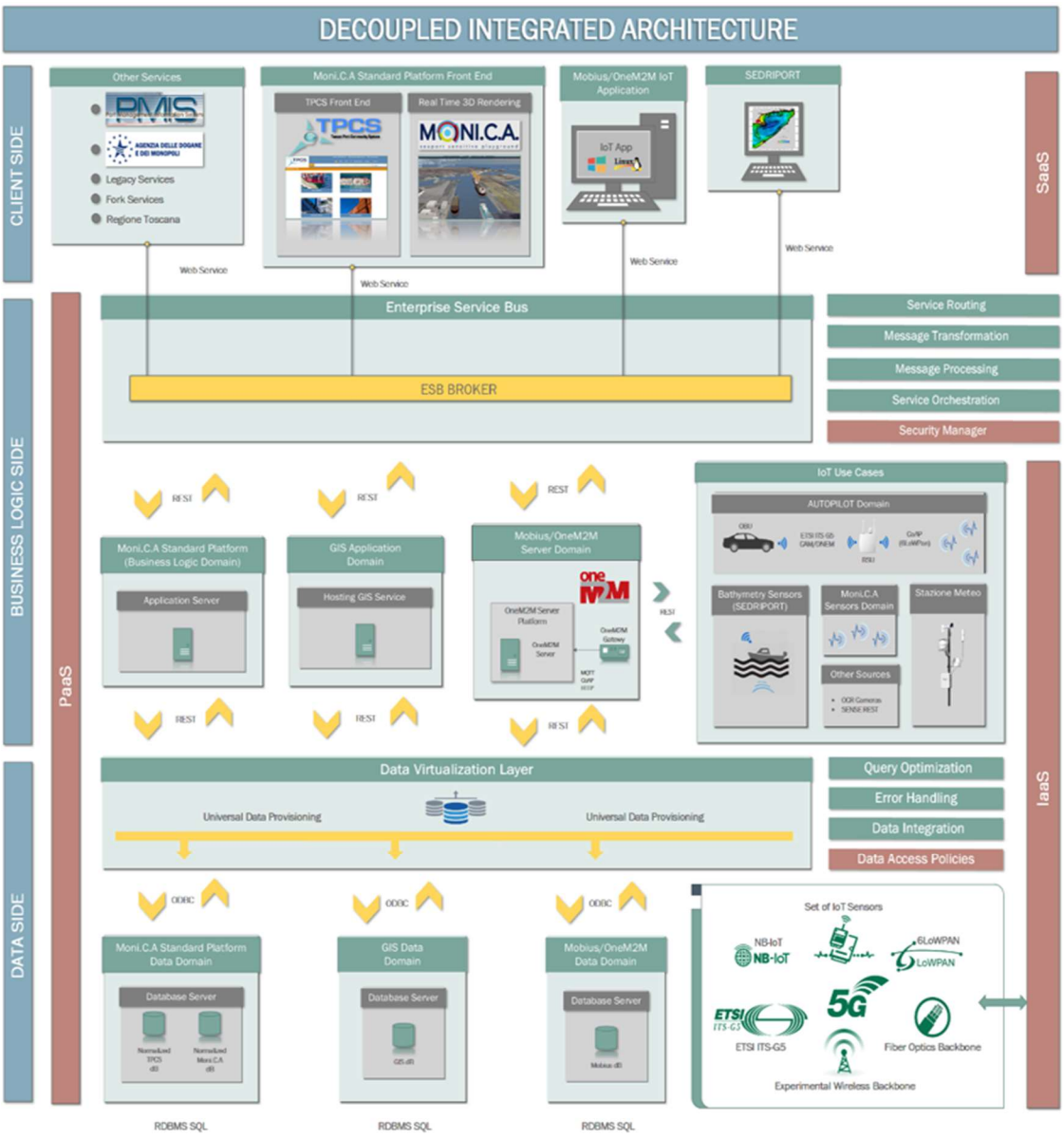


Figure 11: standard, integrated and service oriented ICT architecture at the Port of Livorno.

- **SaaS Layer**: at this level the entire platform (RTPORT) has been made available to the user and has already been integrated at the lower levels.

As can be seen the aspects of interoperability and compliance between different solutions that need to be implemented on COREALIS, strongly depend on the ICT architecture actually available and can (or must) ensure interoperability at different levels. It has been shown (by way of example) as in the case of the port of Livorno, this translates into ensuring compliance at both the infrastructure and the platform level. The world of ports is a world made up of different platforms that cooperate independently from each other (except for some common aspects). Obviously this is not the best approach possible in this sense, considering that communication between

the various platforms is made through the implementation of non standard APIs. In addition to the example of the platform stack for the case of the Port of Livorno (developed with many open source solutions) it is also possible to bring an example of proprietary solutions. The concept of Port Operating System is a concrete example of overcoming of the trend mentioned above:

- **SOGET**: is part of the new generation of Port Community System developed by SOGET. It is an information system that allows Port Authorities to have an efficient vessel call management, services to vessels, cargo flows (even for hazardous goods), concession management, waste management as well as customer relationships. The solution automates and optimizes day-to-day procedures aiming to enhance the competitiveness of the Port Authority thanks to fluid flows of cargo. Based on Microsoft technologies, SOGET Port Operating System is interoperable with Vessel Traffic Systems, Terminal Operating Systems and shipping lines IT systems. SOGET Port Operating System brings fluidity to data exchanges between stakeholders involved in the vessel's calls;
- **iPortman**: the solution facilitates vessel operations, berth and pilotage planning and operation, planning and managing all supplementary services and special services provided by the port. It allows to: 1) Manage the entire marine operations, including vessel registration, port security, vessel traffic management, flotilla management like tugs, barges, launches etc, 2) Permit cargo from a safety point of view, tracks nomination of the vessels, their arrival and anchorage operation, the related resource planning and utilization, 3) Track the vessels at anchorage, vessels at berth and expected vessels to port, 4) Track sail-out details including marine closure, berthing details, shifting/warping details, un-berthing details, anchorage details and service details;
- **IPOS**: Integrated Port Operating System (IPOS) covers all operational activities of the port. The system caters to Vessel, Port, Cargo, Container, Rail and Operation Resource activities in five modules. The activities comprises of all transactions at the Port including Vessel, Sheds, Gate activities, Import and Export processing, Container Stuffing and Stripping (de-stuffing), Cargo Receipt and delivery, Labour/Equipment Booking, Documentation, Resource Allocation, Rail documentation and operations and the terminal management.