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PortForward

D1.2 – Use case restrictions & requirements

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Abbreviations

AdsP MTC	*Autorità di Sistema Portuale del Mar Tirreno Centrale*
AIS	Automatic Identification System
APB	Port Authority of Baleares
AR	Augmented Reality
CCTV	Closed Circuit Television
CMMS	Computerized Maintenance Management System
DSS	Decision Support Scheduling
ECH	Empty Container Handling (equipment)
GIS	Geographic Information System
GPS	Global Positioning System
GS	Green Scheduling
HPS	High Pressure Sodium Lamp
ICT	Information and Communication Technologies
IMV	Internal Movement Vehicles
IoT	Internet of Things
IT	Information Technologies
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LPWAN	Low Power Wide Area Network
PAD	Port Authority Dashboard
PDB	*Ports de Balears* (Port Authority of Balearic Islands)
PMIS	Port Management Information System
PTI	Pre-Trip Inspection
RFI	*Rete Ferroviaria Italiana* – Italian Railway Network
RFID	Radio-Frequency Identification
RO-RO	Roll-on/Roll-off
R/S	Reach Staker
RTG	Rubber Tyred Gantry Crane
SAMOA	Meteorological and Oceanographic Support System of the Port Authority
SAT	Salerno Auto Terminal
SCT	Salerno Container Terminal
TEU	Twenty-foot Equivalent Unit
TMHG	*Tarnsportwerk Magdeburger Hafen GmbH*
TOS	Terminal Operating System
TPCS	Tuscan Port Community System
UWB	Ultra Wire Band
VTS	Vessel Traffic Service
WP	Work Package

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Executive Summary

PortForward project proposes a holistic framework that will lead to smarter, greener and more sustainable ports through the implementation of innovative ICT solutions to improve exchange of information flows between port and port community, a tighter integration with different modes of transport and the hinterland/city environment, and the adoption of green technologies to reduce the environmental impact and resource consumption of port operations.

The project is currently developing the specifications of the PortForward framework. After a preliminary analysis of end users expectations and goals, which was documented in deliverable D.1.1, a set of use cases has been developed in order to describe at high level what kind of interactions there will be between the systems, processes and stakeholders of each of the ports involved as use cases of the project (Baleares, Livorno/Piombino, Magdeburg, Naples/Salerno, and Vigo), and the PortForward framework.

In order to carry out this task, consortium partners have continued the activities that had been initiated for the analysis of end users' expectations and needs, analyzing the information collected through a set of technical visits to the use case ports, combined with specific meetings with key stakeholders of the corresponding port community. In parallel, the project continues the collection of additional feedback from external port-related stakeholders through an online questionnaire.

The use case analysis carried out at each port includes a port introduction, which recaps the main findings from D1.1 that will be more relevant for the use case. This is followed by a summary of the use case(s) proposed for the port. For each use case it is explained its relevance both from the point of view of the opportunities that it will provide to test and validate the PortForward framework, and from the point of view of the potential impact that can be achieved for the port. The use case includes as well an analysis of the main decision makers and stakeholders involved, the expected improvements and how they could be assessed qualitatively and/or quantitatively, and potential drawbacks and restrictions that shall be properly managed.

For the Baleares ports, three use cases are proposed. The first one will address the optimization of yard management and operations scheduling for RoRo and/or bulk cargo transportation from the logistic and environmental point of view. The second case will focus on the improvement of centralized supervision and management operations of the port authority, as well as on the development of advanced maintenance strategies. The third use case will focus on the prediction of port-city interactions from the point of view of the demand for city attractions and services by the people arriving to the port through cruise ships, ferryboats, and recreational vessels.

The use case in the port of Vigo will focus on the application to the container terminal of PortForward's Green Scheduler and sustainability assessment through Life Cycle Assessment methodology (LCA). The use case encompasses three different aspects of the management and scheduling processes: yard space allocation, yard crane management, and Internal Movement Vehicles (IMVs) scheduling and deployment.

In the ports of Livorno and Piombino, two use cases are proposed. The first one will develop advanced assistance services for port pilots, addressing the difficult ship maneuvering within the port of Livorno due to the limited width of the port access channel and the low depth of the quays and docks. The second use case will focus on assistance to goods control and inspection within port boundaries to ensure security and enforcement of the legal framework.

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For the ports of Naples and Salerno, a global use case has been defined that addresses three closely interlinked issues, namely: logistics and multimodal relations with the surrounding environment, optimization of freight management, and access to data related to environmental and social impact of port activities on the surrounding areas.

Lastly, the port of Magdeburg will focus on the application of advanced monitoring of port operations applied on one hand to multi-purpose storage areas for automated analysis of occupation and handled goods, and on the other hand to external transportation traffic (on public roads) between the different port terminals, as data basis for a future slot management.

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1 Introduction

1.1 Context of this Report

This is the second report produced by Work Package 1 (WP1) of PortForward project, "Stakeholder needs and technical requirements", and it corresponds to the second out of four WP1 tasks, T1.2 "Use case restrictions & requirements".

The final objective of WP1 is to produce the technical requirements specification for the development of the PortForward framework, and to define a set of KPIs that will be used for assessment of the technical, business, environmental and social impact of PortForward. The technical requirements specification will be produced in task T1.3 "Technical specifications", while the KPIs will be elaborated in task 1.4 "KPI definition".

Task T1.2 corresponds to an intermediate stage of WP1. After the completion of the analysis of end users' expectations and goals in task T1.1, task T1.2 uses this output in order to carry out a deeper analysis of the PortForward use cases, which lays the foundations for the subsequent requirements specification and KPI definition.

WP1 outputs will be used by several tasks in other work packages. For instance, WP2 will carry out the design of the PortForward framework architecture based on the technical specification produced in T1.3, and this architecture will in turn guide the technical developments in WP3, WP4, WP5, and WP6. The KPI definition in T1.4 will be used as reference for designing the PortForward Dashboard in T6.4. It shall be highlighted that the use case analysis carried out in Task 1.2 will be a fundamental basis for their subsequent validation within WP7, which will also make use of the KPIs defined in T1.4 for impact assessment. Figure 1 shows the more direct relationships between the WP1 tasks, and tasks in other PortForward work packages.

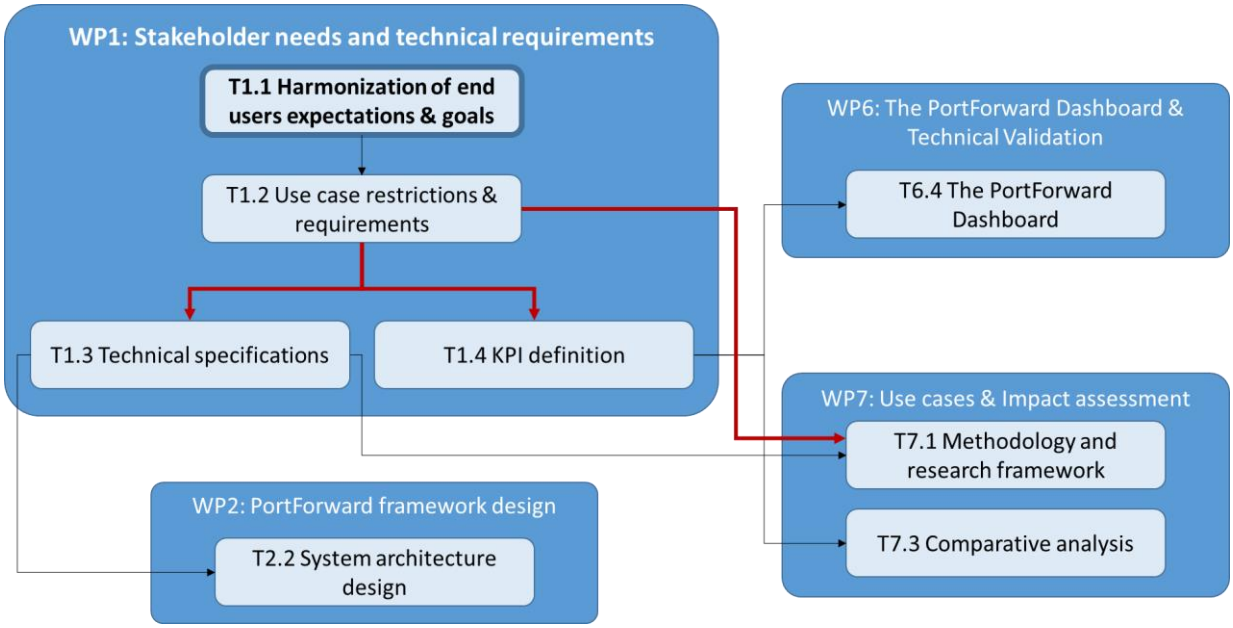

Figure 1 – Direct relationships between WP1 tasks and other PortForward tasks

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1.2 The PortForward Framework

The outputs of Task 1.2 will ultimately guide the development of the PortForward framework. In its initial conception, this framework will consist of the following components:

- **Sensor layer (IoT-Enabled Port):** in charge of collecting data from the real physical port environment, including port legacy monitoring & control systems, newly deployed sensors, human feedback from the field, city open data, etc. The sensor layer may make use of different communication protocols for transmitting their data.
- **Middleware layer (Connectivity):** in charge of gathering and pre-processing data from the sensor layer, so that these data can be processed and consumed by the upper layers of the framework. The middleware layer will enable integration of and interoperability with heterogeneous data sources.
- **Application layer (PortForward Cloud):** this layer hosts the core functionalities of the PortForward framework. These will consist on one hand on a set of advanced specialized services based on heterogeneous data, namely: a smart logistics platform, a remote management and maintenance platform, a green scheduler for yard operations, a set of AR-based support tools, and an intelligent recommendation system. On top of these specialized services, the application layer will provide a set of transversal tools for data visualization, analysis, and decision-making. These are the Decision Support System, the Virtual Port representation, and the PortForward Dashboard.

According to the description above, Figure 2 shows the structure of the proposed PortForward framework.

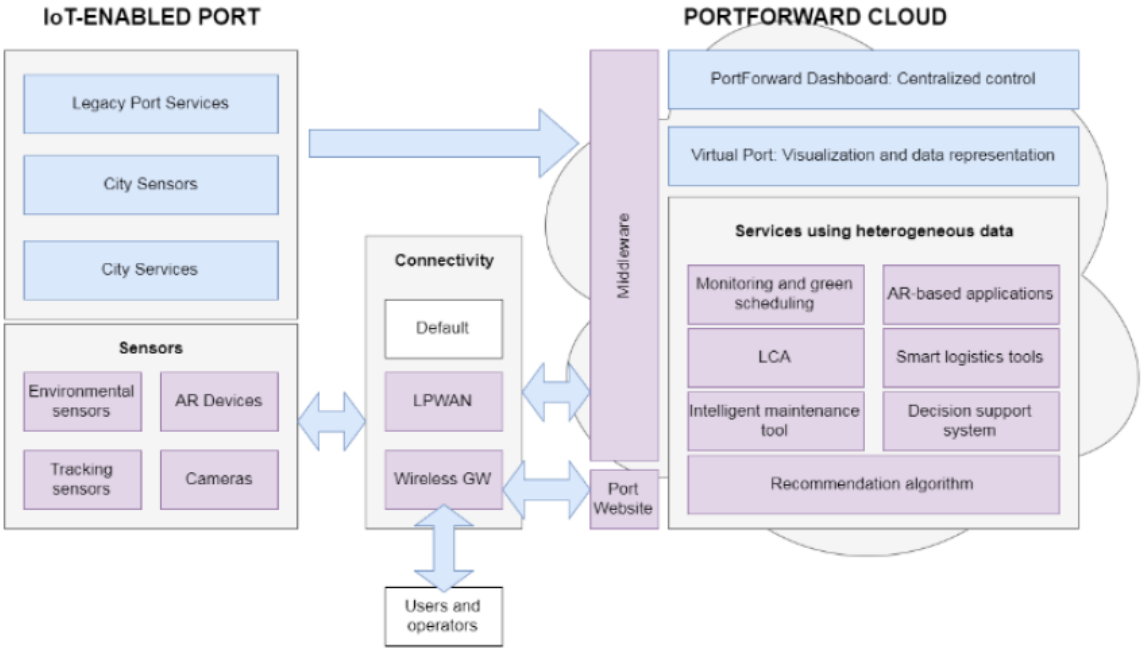

Figure 2 – PortForward framework

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1.3 Methodology

According to the global WP1 approach, Task 1.2 can be interpreted as the second step or activity in a standard system requirements engineering process, following the previous requirements elicitation activity, i.e. the collection of needs and expectations from stakeholders, which was performed in Task 1.1. Using this initial input, PortForward partners have carried out a deeper analysis in order to start outlining how the PortForward framework will address the collected needs and expectations. The use case is an analysis tool typically utilized in requirements engineering for capturing system requirements, i.e. what the system is supposed to do [1]. The ultimate goal of the use case is to specify the system behavior, through the description of the interactions of different actors with the system.

In the case of PortForward, the aim is to describe a complex framework, which shall be able to integrate data from legacy port systems, enabling at the same time the integration/provision of new IoT devices, services, and user interfaces. Besides, this framework shall be able to cope with the needs and expectations of different ports, which have different operatives, legacy systems, organizational structures, and therefore different priorities. Considering this context, the approach adopted by PortForward is to consider each of the ports participating in the project as a use case. This means that the use case analysis carried out in this report aims to define at a high level what types of interactions are expected between the PortForward framework and the different port systems and actors, thus describing how this framework is envisioned to address stakeholder expectations and needs. For the Baleares and the Livorno/Piombino ports, the use case has been subdivided respectively into three and two different parts, due to the heterogeneity of the interventions planned for these ports. Each of the rest of the ports has been analyzed as a single use case. This does not exclude that in successive iterations of the technical developments of PortForward framework, this initial set of use cases are further split up in order to describe with more detail each of the specific interactions of each actor with the framework, for each of the ports.

The requirements elicitation process carried out in Task 1.1 was based on different activities such as technical visits to the ports combined with focus groups/workshops with port stakeholders, and the analysis of technical documentation provided by the port authorities. The information obtained through these activities has been complemented with additional exchange (through emails, conference calls, etc.) between the PortForward technical partners and the Port Authorities, in order to complete the use case analysis within Task 1.2.

The use case implementation will involve the processing of data gathered from different sources within each of the use cases. This collection and processing of data will be done according to the guidelines that have been defined within deliverable D11.2 of PortForward "POPD – Requirement No.2", which aims to ensure that collection, use, and processing of personal data is done according to the ethical requirements of the project and in compliance with applicable regulations. More details about the processing of data per each specific use case will be elaborated during the use case implementation within WP7 of the project.

1.4 Structure of the report

This report is structured according to the different use case ports that are members of PortForward consortium. Therefore, sections 2 to 6 of the report present the analysis carried out for each use case. Each of them has been elaborated according to a common structure, which consists of the following subsections:

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- **Port introduction:** the aim of this subsection is to provide a synthesis of the port information that was already analyzed by PortForward partners in deliverable D1.1. The motivation for including this introduction is in first place to facilitate the understanding of the context of this document to all readers, even if they have not read the previous report. In second place, this synthesis has a stronger focus on the information more relevant for introducing the use cases that will be explained later. For instance, the description of some processes, systems, or stakeholders of the port which were mentioned in D1.1 may have been omitted if they are considered to have little relevance for the implementation of the use case. The port introduction is structured according to the following outline:
    - *Port general information:* this subsection includes a synthetic overview of key port data (location, main areas, main figures, etc.)
    - *Main stakeholders identified:* this subsection describes the main port stakeholders more relevant for PortForward use cases.
    - *Key port processes:* this subsection summarizes the main port processes that could be targeted by PortForward for improvement and optimization, including logistic processes (RoRo/containers), passenger-related operatives, maintenance strategies and procedures, environmental and energy management, security and safety policies, etc.
    - *Relevant interactions with hinterland transportation and urban environment:* this subsection highlights the main interactions of each use case port with hinterland transportation and urban environment that are relevant for the scope of PortForward.
    - *Expectations and goals to be addressed by PortForward:* this subsection provides a summary of the main economic, environmental and social expectations and goals from the point of view of port authorities that could be addressed/fulfilled through the implementation of PortForward technologies.
- **Use case description:** this subsection contains the analysis of the actual use case. For the ports of Baleares and the ports of Livorno and Piombino, this analysis has been split into three and two use cases respectively, due to the heterogeneity of topics that are going to be addressed. The analysis of each use case consists of the following subsections:
    - *Summary:* the objective of the summary is to present the specific context of the proposed use case, and the main assumptions regarding current port operations, systems, data, and stakeholders that are going to be addressed within the use case.
    - *Rationale:* this subsection provides more detail on the motivations for selecting this use case, including the relevance for port stakeholders (and potentially external stakeholders) of the issues to be addressed or improved, the suitability of the use case for supporting the assessment and validation of specific PortForward technology components and services, and the feasibility of the use case implementation (e.g. availability of needed data).
    - *Structured description:* this subsection provides more details of different elements of the use case. These may include a deeper identification of the main decision maker(s) and stakeholders involved, the expected impacts/benefits, the quantitative and qualitative parameters that will be improved, the potential side

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effects that shall be managed, the specific restrictions (regulatory, operational, social, etc.) that shall be considered, and/or an outline of the main costs items involved in the use case implementation (e.g. needed equipment, maintenance requirements, etc.).

- *Typical assessment procedure and tools/services required:* lastly, the use case analysis provides more technical details about the tools and services that will be required for the implementation, the availability of data and potential gaps that should be addressed, and the desired technical outcomes of the use case.

Lastly, this report presents in the conclusions (Chapter 7) the main elements in common contained in the use cases, and provides more detail about the next steps to be followed in order to finalize the development of the PortForward specifications, consisting of the technical requirements, and the KPI definition.

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2 Ports of Baleares

2.1 Port Introduction

2.1.1 Port General Information

The table below provides a synthetic overview of the main features, activities and figures of the five ports managed by the Port Authority of Balearic Islands (PDB).

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Table 1 – Main facts of Baleares Ports

			Port of Palma	Port of Alcúdia	Port of Mahón	Port of Ibiza	Port of La Savina
Location			Southwest of Majorca Island, in the city of Palma de Mallorca	Northeast of Majorca Island, in the municipality of Alcúdia	Southeast of Menorca Island, in the municipalities of Mahón and Es Castell	Southeast of Ibiza Island, in the municipality of Ibiza	Northwest of Formentera Island, in the municipality of Formentera
Main port areas			Commercial Quays West ('Poniente') Quays Marina Docks West Breakwater	Commercial dock Small crafts dock (fishing quay and marina) Coal unloading terminal Terminals for butane and propane gas	Cós Nou Quays Sports Marina Poniente Quay Fishing Quay Cruise Quay Levante Quays	Botafoc breakwater (for fuel discharge and for berthing of large cruise ships) Commercial quays Passenger quays	Breakwater quay Central quay Inter Quay Commercial quay Fishing quay 'Levante' Commercial quay End Commercial quay
Main activities	**Cargo transportation**	**Description**	Cargo transportation in all Balearic ports consist of RoRo cargo, solid bulks, and liquid bulks. General RoRo cargo is the most important part of cargo transportation, except for the case of Alcúdia, where solid bulk traffic is higher than general RoRo traffic due to the coal supply for the nearby thermal power plant.				
		Figures (2017)	Liquid bulks: 1,022,151 tonnes Solid bulks: 210,805 tonnes General cargo: 8,096,175 tonnes	Liquid bulks: 52,657 tonnes Solid bulks: 1,248,011 tonnes General cargo: 831,492 tonnes	Liquid bulks: 188,759 Tonnes Solid bulks: 23,649 Tonnes General cargo: 434,128 Tonnes	Liquid bulks: 289,789 tonnes Solid bulks: 115,84 tonnes General cargo: 2,595,313 tonnes	Solid bulks: 13,101 tonnes General cargo: 287,692 tonnes
	Passenger traffic	**Description**	Regular lines and cruise ships. Palma is one of the main	Regular lines and cruise ships. Lower	Regular lines and cruise ships. Variable trend in	Regular lines and cruise ships. Increasing	Regular lines and occasionally, cruise ships.

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			Port of Palma	Port of Alcúdia	Port of Mahón	Port of Ibiza	Port of La Savina
			cruise ports in the Mediterranean	relevance of cruise traffic.	number of cruise ship passengers	relevance of cruise ship traffic in the last years	The port is the only point of access of passengers to the island.
		Figures (2017)	1,673,210 cruise passengers 925,809 regular lines passengers	1,869 cruise passengers 400,417 regular lines passengers	115,104 cruise passengers 130,829 regular lines passengers	340,334 cruise passengers, 522,638 regular lines passengers	2,074,261 regular lines passengers
	Moorings for recreational vessels	**Description**	All Balearic ports are equipped with moorings for recreational vessels. The Port Authority manages directly part of these moorings, while other companies manage the rest through licenses/concessions.				
		Figures (2017)	4,953 indirect management / 2,168 direct management	729 indirect management / 101 direct management	799 indirect management / 684 direct management	1,212 indirect management / 15 direct management	154 indirect management
	Shipbuilding/ repair/ maintenance	**Description**	The port of Palma concentrates most of the ship repair and maintenance activities in Balearic Islands and is a reference in the sector.	Although with much lower relevance than in Palma, the rest of Balearic ports also host ship repair and maintenance activities.			
	Fishing	**Description**	Fishing is a traditional activity still present at all Balearic ports but with low economic relevance compared to the rest of activities.				

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2.1.2

2.1.2 Main stakeholders identified

- **Ferryboat shipping companies** for transportation of passengers, cars, and/or cargo. Most of the cargo is Ro-Ro (cars, trucks with drivers, and truck platforms without driver). There is also traffic of solid and liquid bulk materials, e.g. *Trasmediterránea, Baleària, Transportes Marítimos Alcudia S.A.* These stakeholders shall be involved in the use case for logistic and environmental optimization of yard management and operations scheduling for freight transportation in the port of Palma, and potentially, the port of Alcúdia. At least one of the stakeholders shall be directly involved in the proof of concept for this use case, while the rest of shipping companies shall be considered as stakeholders that could provide insight into their own business processes, and that could be informed of the results of the use case for potential replicability.
- **Cruise companies**, e.g. *AIDA Cruises, TUI Cruises, Costa Cruceros, Pullmantur*, etc. These stakeholders shall be involved for the development of the use case for prediction of port-city interactions associated to the arrival of cruise ships to the city of Palma. Direct involvement of one stakeholder could be desirable for retrieving additional data that could enrich the prediction algorithm. General involvement of other stakeholders of this category may be desirable for capturing additional insights into their business processes and explore opportunities for replicability of the use case.
- **Public stakeholders:** Balearic Islands Regional Government, Consells Insulars, municipalities (Palma, Alcúdia, Mahón, Es Castell, Ibiza, Formentera). The regional government will be a key stakeholder, as they are responsible for the deployment of a LoRaWAN network that will provide coverage to all Balearic Islands (IoTIB network). As LoRaWAN is one of the key connectivity protocols to be considered by PortForward, it is needed that the project coordinates with this initiative, either for taking advantage of the LoRaWAN network if it is deployed in the port use case area within the time framework of the project, or in case that the project needs to carry out its own deployment, to make sure that it will be interoperable with IoTIB network. Municipalities, in particular the municipality of Palma, shall be involved for the use case for prediction of port-city interactions, in order to help determine the most valuable insights that could be provided by the prediction algorithm.
- **ICT providers**: Prodevelop (supplier of Posidonia software for port operations management). IDASA Sistemas (supplier of CMMS). MallorcaWifi.com: managers of WiFi network. These stakeholders shall be involved in order to help determine the most suitable communication interfaces with their systems that could be used by PortFoward in order to get access to data repositories needed to implement the use cases. This is especially relevant for the use case focusing on the optimization of surveillance, management and maintenance operations in the port of Palma (and potentially, in the port of Mahón), but in the other two as well.
- **Other**: University of Baleares (developer of air quality monitoring system). This stakeholder shall be involved, as it is responsible for the development of the air quality monitoring system deployed in the port of Palma. The objective of this involvement would be to assess how the data provided by this system could be used for the use case focused on logistic and environmental optimization of yard management and operations scheduling for freight transportation in the port of Palma, and potentially, for the port of Alcúdia. Furthermore, these data could also be harnessed by the use case for prediction of port-city interactions.

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2.1.3 Key port processes

Main processes of the port targeted by PortForward are:

- **Ro-Ro cargo transportation:** freight transportation in the Balearic Islands consists mainly of Ro-Ro operations, complemented with transportation of bulk solids and liquids. There is no container traffic. Accordingly, any optimization of freight transportation processes (either from the logistic or the environmental point of view) addressed by PortForward should put the focus first on Ro-Ro traffic, since it is by far the most important modality of transport in all Balearic ports. The case of Alcúdia is an exception, as the relevance of coal unloading operations, which involve additional environmental concerns, surpasses that of Ro-Ro traffic. Ro-Ro traffic consists of three main categories: cars (a large share of which are dedicated to the car rental market associated to tourism), trucks with driver, and truck platforms without driver.
- **Arrival of cruise ships:** it is well known that in spite of its positive impacts on the economy of the Balearic Islands, citizens do not always have a positive perception about cruise ship traffic. The reasons for this dissatisfaction derive mainly from frequently overcrowded public city spaces due to the sudden arrival of thousands of cruise passengers, while the resources consumption (water, fuel, etc.), and potential air and noise pollution coming from the cruise ships is also an important concern.
- **Coal unloading operations in Port of Alcúdia:** as mentioned in the Ro-Ro cargo transportation process, the Port of Alcúdia is a special case within the Balearic Islands ports due to the special relevance that coal unloading operations have in this port, which surpasses that of Ro-Ro cargo transportation both in terms of traffic volume associated, and of the environmental impact of such operations, which may be further exacerbated by adverse weather conditions. Therefore, the Port Authority is looking into potential solutions for mitigating the negative impacts of this process.
- **Maintenance of port infrastructure assets:** the Port Authority is currently in the process of digitizing the management of port assets maintenance operations through the implementation of a specific software platform for this purpose. In a first stage, this platform will enable the implementation of corrective and preventive maintenance activities. However, the Port Authority expects that with the maintenance data collection that will be enabled by this platform, it will be possible in the future to go a step forward and implement predictive maintenance strategies. Among the assets managed by the Port Authority, lighting assets are one of the most important due to their impact on the energy consumption of the organization.
- **Global supervision of port operations (Port Control Centre):** One of the key processes for the Port Authority is the central surveillance and management of port systems from the Control Centre of each port, which is largely a responsibility of the port police. The staff of the Control Centres have to process large amounts of data in different formats (text, videos, audio communications, etc.), coming from different sources (each of the port systems accessed from the control centre) and through different user interfaces. The challenge for the Port Authority is therefore to find a way to support the staff in port control centres to focus on the most relevant information at each moment, while at the same time enabling them to

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have a more efficient, seamless remote control of port systems, including the remote access to port systems from a different port.

2.1.4 Relevant interactions with hinterland transportation and urban environment

In the framework of PortForward project, the most relevant interactions of the port with hinterland transportation and urban environment have been already described in section 2.1.3 for two key processes: the cruise ship traffic at the different Balearic ports (which have a higher impact on the ports of Palma and Ibiza), and the coal unloading operations at the Alcúdia port. Further details of how these two interactions can be addressed by PortForward are provided below:

- **Cruise ships calls at Balearic ports:** the two main concerns are the environmental impact of cruise ships during their stay at the port of call, and the social impact associated to the arrival of large crowds of cruise ship passengers to the city. To address the first impact, the Port Authority is assessing its real influence on air pollution by analyzing the data provided by the air quality monitoring system deployed at the Port of Palma. First findings of this analysis point out that ferryboats may actually have a higher impact on air pollution than cruise ships [2]. To address the second impact, both the Port Authority and the municipality of Palma can resort to the data provided by the tool for measurement of people flows in the city based on the detection of WiFi-enabled devices through the free WiFi network that has been deployed.
- **Coal unloading operations in Alcúdia port:** coal unloading operations, which is one of the key processes within the port of Alcúdia, can have a clear negative impact on the air quality of the port surroundings. There is currently no air quality monitoring system deployed in Alcúdia, but the Port Authority has already developed the plan for replicating the installation carried out in the port of Palma. Therefore, data from this air quality monitoring, together with weather data, vessels operation data, etc., can be harnessed in order to plan coal unloading operations in the most optimal manner for minimizing the impact on the environment.

2.1.5 Main current port systems and data repositories relevant for PortForward

- **Posidonia:** this is a port management software platform that enables the integration of port stakeholders and relevant information systems. This system is the cornerstone of the digital strategy of APB, and as such, it intends to integrate data from, and make data accessible to the rest of information and managements systems of the Balearic ports. Therefore, all PortForward use cases shall analyze the potential interactions with Posidonia that will be needed, either from the point of view of accessing the platform for retrieving relevant data for the use case, or from the point of view of inserting into the platform new data generated by the use case.
- **AIS (Automatic Identification System):** this system provides information about vessels operatives, and therefore it is an important data source for the use cases, especially for the optimization of logistics, and the prediction of port-city interactions. PortForward may need to access data directly from AIS, but since this system is also integrated with Posidonia, data could be obtained from the latter.

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- **SAMOA (Meteorological and Oceanographic Support System of the Port Authority):** this system provides ports with customized oceanographic and meteorological information. PortForward can harness this information for the use cases that need to incorporate weather data in order to support different decision-making processes, such as the optimization of yard operations from the environmental point of view.
- **Fleet management system:** the Port Authority has all its vehicles equipped with a GPS-based geolocation system for enabling fleet management. The actual use of this system is scarce. PortForward may make use of the data provided by this system, or even extend the system to other vehicles not belonging to the Port Authority (e.g. heavy duty vehicles used by shipping companies) in order to support logistic optimization of yard operations.
- **CMMS (Computerized Maintenance Management System):** APB is currently deploying this software platform in order to support information management for all port maintenance processes. As such, the platform will be the basis for building a repository of historic maintenance data. In a first phase, the CMMS will enable the implementation of corrective and preventive maintenance strategies. PortForward may need to access the data stored in this platform in order to support the use case related to optimization of maintenance operations. Building on historical data, this PortForward use case may support the implementation or predictive maintenance strategies.
- **Lighting management system:** APB is in the process of modernizing the lighting control systems of its ports in order to achieve more efficient management and maintenance strategies that can lead to lower operational costs, both in terms of energy savings, and of maximization of the lifespan of the luminaires. The PortForward use case related to optimization of maintenance operations aims to support more efficient management strategies of port lighting systems through the potential implementation of a smart sensor for additional data collection of luminaires operation, and through the advanced analysis of historical operational and maintenance data in order to support predictive maintenance strategies.
- **Air quality monitoring system:** APB has deployed a monitoring system of air quality parameters, noise levels and meteorological data in the port of Palma that will be replicated in the rest of Balearic ports. PortForward can harness the data provided by this system in order to support the use cases related to logistic and environmental optimization of yard management and operations, and to provide further insights into port-city interactions.
- **WiFi network and WiFi-enabled devices monitoring/localization:** the municipality of Palma, in collaboration with the APB, has deployed a free of cost public WiFi network in the port area as well as in other key areas of the city of Palma. This network is capable of detecting WiFi-enabled devices within its coverage area. This feature allows estimating in real time the degree of occupation of different city locations, and tracking the itinerary followed by each device. PortForward use case related to the prediction of port-city interactions aims to make use of the localization data provided by the WiFi network, combined with other data sources, in order to provide further insights into the most likely behaviour that can be expected from passengers that arrive to the city by maritime transport, with special focus on cruise ship passengers.
- **Access control systems:** APB has access control systems that help to manage the people/vehicles flows that go into/exit from different port areas. The access control points

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usually have the presence of port staff for surveillance of these flows. They may be equipped with access barriers, video cameras, automatic number plate recognition systems, and audio intercom systems. PortForward may need to interface with access control systems in order to support the use case related to logistic optimization of yard management and operations. The aim would be to integrate some of the systems or data sources available at these points (e.g. the number plate data read at the access control) with other relevant information systems in order to streamline the incoming flows of vehicles, and thus improve the performance of logistic operations.

- **Port Control Centre:** the Port Control Centre can be considered as a system of systems that provides centralized surveillance and management capabilities for different port systems, namely: AIS, Posidonia, access control systems, camera systems, etc. The level of integration among these systems differ for each APB port, for instance, the Port of Ibiza is equipped with the more advanced Port Control Centre, as it allows remote tele-operation of port installations. PortForward will address the Port Control Centre in Palma, which presents a lower level of integration among the different systems. In the framework of the use case related to the optimization of surveillance and management operations, PortForward aims to provide a more unified interface to the different systems, in order to avoid that the control centre operators are overloaded with data coming from different sources, and helping them to focus on the most critical information and alerts at a given instant.

2.1.6 Expectations and goals to be addressed by PortForward

- Economic expectations and goals:
    - To manage the port based on criteria of optimization, profitability, efficiency, sustainability, and public service.
- Environmental expectations and goals:
    - To integrate environmental considerations in port processes related to operational planning.
    - To foster continuous improvement and an adequate environmental performance in all port installations, acting as facilitators in the port community, giving support to the deployment of environmental management systems and creating awareness of port workers, clients and users, so that interest groups perceive APB ports as Green Ports.
    - To develop studies and research in topics related to port activities and environment protection, collaborating with other organizations.
    - To foster the innovation processes that look for solutions that minimize the environmental impact of the port activities in the surrounding environment.

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2.2 Use Case #1 description. Logistic and environmental optimization of yard management and operations scheduling for freight transportation.

2.2.1 Summary

Due to the insular condition of the Balearic Islands, transportation of freights is one of the key processes that take place at their ports, since they are the point of entry for almost all the supplies to the islands. As it has been already described, most of the freights are transported as Ro-Ro cargo, followed by transportation of bulk solids and liquids. Only in the case of the port of Alcúdia, the relevance of bulk solids transportation surpasses that of Ro-Ro cargo due to the proximity of the thermal power plant of *Es Murterar*, which needs to be supplied with coal. Although there are plans to close progressively this highly polluting power plant [3], this process will take a long time and before its completion, an adequate environmental management of coal-related operations is needed.

Regarding Ro-Ro freight transportation, three main types of cargo can be differentiated:

- **Cars:** All newly manufactured cars that arrive to the Balearic Islands must be transported by sea. A significant amount of these cars is dedicated to the car rental market, which is a very important activity in the Balearic Islands due to tourism. New cars may be or not already registered (i.e. with an assigned license plate number), a fact that must be considered for any attempt to perform automated identification, tracking or positioning of these cars.
- **Trucks with driver:** A large quantity of goods arrive to the Balearic Islands loaded in trucks with their own driver. Drivers take care of loading the truck into the ferryboat, they travel as regular passengers in the same vessel as the trucks, and then take care of unloading the truck once it arrives to its destination. It shall be noted that imports far outweigh exports in the Balearic Islands, this means that most trucks arrive fully loaded to the Balearic Islands, and depart from there empty in the majority of cases.
- **Truck platform without driver:** The remaining part of Ro-Ro freight transportation corresponds to truck platforms without driver. These platforms must be loaded to/unloaded from the vessels with heavy duty vehicles, usually through the combination of tractor, gooseneck, and rolltrailer. Similar to the case of trucks with drivers, most platforms arrive fully loaded to the Balearic Islands and depart empty from there.

In addition to the type of freight cargo, it shall be considered as well the type of vessel used for its transportation. There are two main types:

- **RORO ships:** vessels completely devoted to the transportation of wheeled cargo, including cars, trucks, trailers, etc.
- **ROPAX ships:** variation of RORO vessels that allows the combination of freight vehicle transport with passenger accommodation.

Logistic processes at the APB ports may vary depending on the type of vessel. In the case of ROPAX ships calling at the port of Palma, cars and trucks carried in the vessel usually leave directly the port without any intermediate storage in the yard, except for the case of the Old Quay area. On the contrary, in the case of RORO vessels, tractors are used to unload the platforms from the ship, and they are parked in the yard until a truck driver comes to pick them up. For instance, in the case of the

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shipping company Trasmediterránea, it manages an area in the Old Quay of 27,000 m^2 for the intermediate storage/parking of cars, trucks, and platforms. This area is divided into two zones: one assigned to the cargo arriving at the port (cars and usually loaded trucks and platforms), and other assigned to the cargo leaving the port (cars and usually empty trucks and platforms), normally departing to Barcelona or Valencia.

In the cases where there is any kind of intermediate storage in the port yard, the following issues arises:

- Trucks that enter the port need to be identified in order to be granted access to the yard. In some cases, a truck driver may need to go through two different access control points, one managed by the Port Authority, and the other managed by the company operating through license/concession in the port area. In the latter, the driver shall be provided with indications about the location within the yard where the truck shall be parked. Besides, truck drivers that are going to travel on the vessel need to get their boarding pass in an intermediate point. These procedures involve a small delay for trucks to embark. Even if this is just a small amount of additional time for each individual truck, globally it represents an opportunity for optimization of traffic flows at the port access controls, a reduction of stay times at the yard, and therefore an increase in the throughput of shipping companies operating at the port.
- Identification and tracking of goods arriving at the port is done through manual or semi-automatic processes. In the case of trucks and platforms, an operator manually notes downs their number plate, and the area within the yard where they are stored. In the case of vehicles, which have to be checked by an external expert, their identification is based on barcodes, since not all vehicles have number plates. The operator then reads these barcodes with a handheld barcode scanner.
- The operations of the auxiliary machinery (e.g. tractors) used to handle the truck platforms are only partially monitored, as only the hours of operation are recorded for maintenance purposes. Therefore, the shipping company currently has no insight into the throughput of each machine per work shift, or into the efficiency of the movements of the machinery within the yard.
- Stowage planning is usually not a very critical issue at the port of Palma (as well as in the rest of Baleares ports) due to the previously mentioned fact that except for vehicles, most of the RoRo cargo that depart from the port consists of empty trucks and truck platforms. Therefore, optimization of loads distribution in the vessel, which in other cases could have a high impact on the vessel safety and on its fuel consumption, may have a negligible effect for the case of Palma. Nevertheless, it would be interesting to showcase how stowage optimization concepts could be integrated with RoRo cargo traffic flows optimization and tracking.

All the issues listed above can be addressed through a tighter integration between port authority and shipping companies' information systems, an intelligent use of already available technologies such as automatic number plate recognition, and the deployment of real time location systems at the yard. These improvements could contribute to a higher throughput of the cargo traffic flows, and a more optimal use of the limited available space and of the auxiliary machinery.

Regarding the operations with solid bulks, these can have an impact on the environment for certain types of cargo, especially for the case of coal unloading operations in the port of Alcúdia, due to the

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associated emissions of carbon particles and dust. To address this problem, the Port Authority has recently deployed some mitigation measures [4], such as the installation of a 3-meter high barrier of vinyl tarp placed on a mesh support along the 160 metres of the upper side of the seawall, complemented with water sprayers. This system helps reduce the suspended carbon particles, and thus improve the air quality.

This measure mitigates the problem once that the coal unloading operations have started. However, impacts on the environment can be further reduced if the operations themselves are scheduled when other influencing variables, such as current air quality levels and meteorological conditions, have more optimal values.

The Port Authority is planning to deploy in the port of Alcúdia an environmental monitoring system similar to the one already installed in the port of Palma. This could be a source of air quality and meteorological data for assessment of the potential impact of upcoming coal unloading operations, which, if needed, could be rescheduled or interrupted until the conditions become more favourable.

Other data that could be used for this process are weather forecasts obtained from online services for modelling the expected evolution of meteorological conditions. Other influential factor is the topography of the surrounding area (e.g. heights of buildings, land elevations, etc.), which can be considered as a static feature that shall be incorporated into the modelling process.

Lastly, the data of upcoming operations shall be extracted from other port systems, e.g. AIS, Posidonia, in order to propose rescheduling actions based on the analysis of the rest of parameters previously mentioned.

It shall be considered that, although coal unloading operations are the most critical from the environmental point of view, logistic operations associated to other types of cargo also have some sort of associated impact, so the proposed optimization could be extended to other logistic operations taking place at the port.

2.2.2 Rationale

With this use case, PortForward aims to prove its suitability on one hand to support optimization of port logistic processes by enabling a tighter integration between the information systems and data sources of the port authority and those of the shipping companies, and a more precise tracking of logistic operations. On the other hand, the use case aims to showcase how the fusion of heterogeneous data sources can support the introduction of environmental considerations into the planning of logistic processes.

The main port issues addressed/improvements targeted by PortForward within this use case will be the following:

- Reduction of time of stay of RoRo cargo in port yards in order to decrease operational costs of cargo transportation companies operating at the port.
- Improved tracking of cargo handling operations, thus providing more insight into the efficiency of the processes, and helping to identify potential bottlenecks and support decision-making processes to mitigate them.
- As a consequence of the previous two points, the use case is addressing a optimal use of the yard space, which shall lead to a higher throughput per port area unit. This is especially

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interesting in the case of the Port of Palma, as the geographical constraints and the needs of other port activities (e.g., maintenance, repair and restoration of ships, which has an increasing relevance in the port of Palma) do not allow an extension of the space dedicated to port logistic operations.
- Real time assessment of potential environmental impact of logistic operations based on the analysis of heterogeneous influential factors.
- Support to decision-making process for rescheduling of logistic operations based on the previous assessment.

It is expected that the use case implementation will support the evaluation of several components and services of the PortForward framework, namely:

- The PortForward IoT middleware that will support the integration of heterogeneous data sources form devices already deployed at the port.
- The introduction of new tracking devices for monitoring machinery operations at the yard. It shall be assessed more carefully whether this is a case for testing innovative tracking technologies that can be provided by consortium partners (e.g. iMEC) or on the contrary, whether the consortium shall resort to COTS solutions to put the focus of innovation on the integration and advanced processing of tracking data. LoRaWan and DASH7 are potential wireless technologies to be assessed for the localization/tracking of assets.
- The potential use of LPWAN technologies provided by PortForward for the transmission of IoT data.
- The smart logistic tool applied to the optimization of RoRo cargo flows.
- Assessment on the potential environmental impacts considering the influence of heterogeneous data into the schedules of logistic operations.

2.2.3 Structured description

The use case involves the following main stakeholders and decision makers:

- PortForward project partners more directly involved in the use case:
    - Acciona will coordinate the use case and will work on the optimization of RoRo cargo traffic flows.
    - Leitat will work on the data fusion of environmental, meteorological and other parameters for the incorporation of environmental considerations into the logistic operations scheduling processes.
    - IMEC can provide support for integration and processing of new or already existing IoT data sources through its IoT middleware platform, and will assess the introduction of new tracking/location technologies to support the use case. Besides, IMEC has developed a proprietary low-cost multi-parameter air pollution sensor that could potentially be used to gather air quality data (in static locations or mounted on vehicles) in case that there is a need to complement the environmental network that APB is deploying. Since IMEC provides a cross support to all PortForward use cases, their degree of involvement in Baleares will need to be balanced with their involvement in the rest of use cases.
    - APB (see next point)

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- The Port Authority of Baleares from a double point of view:
    - For the optimization of logistic flows, as it is the organization managing the main access controls to the port and the information systems that shall be integrated more tightly with those from the shipping companies operating at the port. The Port Authority owns as well identification systems (e.g. automatic number plate recognition) that could be integrated into the use case. Through this integration, the Port Authority would improve its support to companies operating in the port to streamline their processes, thus contributing to increase the competitiveness and economic results of the port.
    - For the incorporation of environmental parameters assessment into the logistics planning processes, as the Port Authority is the ultimate responsible for the compliance of port operations with environmental regulations. Furthermore, the Port Authority is responsible as well for the port-city relations, an area within which the concern of citizens about the potential environmental impacts of port activities is a key topic. Therefore, the implementation of the use case will help the Port Authority to showcase how effective measures are taken in order to address those impacts.
- Shipping companies operating at the port:
    - For the transportation of RoRo cargo, the two largest shipping companies operating at Baleares are Trasmediterránea and Baleària. For the development of the use case, only Trasmediterránea will be directly involved. Baleària is a stakeholder that in principle should be informed of the development of the use case so that they can provide feedback for ensuring its replicability. For the development of the use case, it shall be noted as well that Trasmediterránea owns the auxiliary machinery used to handle the truck platforms. Besides, as mentioned before, since some concepts such as stowage optimization may be difficult to validate in the context of the port of Palma, Trasmediterránea could provide complementary cases of study in Valencia or Barcelona (ports where the company has connecting routes to Palma), where stowage optimization would make more sense and could be tested. Through the implementation of the use case, it is expected that the shipping companies will be able to improve their operational efficiency indicators, which means that they will be able to provide a better service to their customers.
    - For the case of coal-related operations in the port of Alcúdia, the shipping company in charge is Transportes Marítimos Alcudia. It will be studied what degree of involvement will be needed from this company. Direct involvement would be needed if in the framework of the use case a real re-scheduling of operations based on environmental parameters were done. However, use case testing may be limited to the analysis of data and the generation of recommendations, so in that case, the involvement of this stakeholder could be limited to the provision of feedback during the development. The motivation for this type of stakeholder will be to receive additional support from the Port Authority in order to ensure the compliance of its logistic activities with environmental regulations.
- Dock workers (stevedores). These stakeholders shall be considered especially for the case of optimization of RoRo cargo handling, as they are the ones operating the auxiliary machinery used for the handling process. They must be informed of, and provide consent to any

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monitoring system/procedure of their work that may be implemented in the framework of the use case.

- Shipping companies' customers.
    - For transportation of RoRo cargo, the main direct customers are road haulage companies, self-employed truck drivers, and freight forwarders. They are directly involved in the use case for any real testing of integration of information and identification/tracking systems for optimization of traffic flows. They are ultimate beneficiaries of the use case implementation, as it shall lead to higher logistic efficiencies, such as decrease of time stays in the port, which will produce immediate economic benefits for them.
    - For coal-related operations, the ultimate customer is the thermal power plant of Es Murterar, owned by the electric utility company Endesa. In principle, they do not need to be directly involved in the use case, but any environmental optimization proposed within the use case shall ensure that the supply of coal to the plan is guaranteed.
- Other external stakeholders
    - Companies hired by shipping companies for checking the cars arriving at the port, and are therefore a part of the logistic processes that are going to be optimized within the use case.
    - University of Baleares, as the stakeholder that has designed the environmental monitoring network already deployed in the port of Palma and that is planned to be extended to the rest of APB ports.
    - IBETEC as the public company of the regional government of Baleares in charge of the development of IoTIB, the LoRaWAN public network that is expected to provide full coverage throughout the territory of the Balearic Islands. PortForward may need to interact with this stakeholder in case that LoRaWAN is chosen as the base communication technology for the collection of data from IoT devices involved in the use case.

Through the implementation of the use case, PortForward expects to achieve the following impacts, which will be assessed through qualitative and quantitative parameters that shall be formalized in a later step through the definition of appropriate KPIs:

- Optimized logistic traffic flows associated to RoRo cargo transportation. This impact could be assessed through the following parameters:
    - Average stay times of trucks in the yard.
    - Average load times of vessels.
    - Traffic throughput in the yard (daily, weekly, monthly, yearly, etc.)
- Optimized productivity of cargo handling operations. This impact could be assessed through the following parameters:
    - Number of unitary handling operations per machine and work shift.
    - Reduction of bottlenecks in handling operations.
- Introduction of environmental parameters in the scheduling of port logistic operations. This impact could be assessed through the following parameters:
    - Average measured air quality levels.
    - Reduction of number of episodes of air pollution above acceptable thresholds.

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In addition to the positive impacts, the use case shall consider potential side effects or negative impacts that could be involved, and that have to be managed in order to mitigate them. Among them, it can be highlighted:

- Security issues in port access controls and information systems: the implementation of the use case may involve the integration of information systems and identification systems (e.g. automate number plate recognition) from the port authority and from the shipping companies, so it is essential that this integration does not originate any security breach in those systems. Any potential processing of personal data must comply with the applicable regulations.
- Rejection of monitoring technologies by dock workers: dock workers (especially stevedores) may perceive negatively the introduction of tracking technologies into the machinery that they operate. Therefore, it is important to make them understand that the main purpose is to help them to carry out their work in the most efficient way, and ensure that any potential processing of personal data is done in compliance with the relevant regulations.
- Economic impact of logistic operations re-scheduling based on environmental factors: the inclusion of environmental considerations into the operations scheduling decision-making process may not always lead to the optimal choice from the purely economic point of view. Hence, it is essential for the use case development to assess the acceptable degree of 'flexibility' of logistic operation schedules, in order to ensure that environmentally based optimizations do not imply undesirable economic consequences, e.g., rescheduling of coal unloading operations in Alcúdia shall not put at risk the supply of coal to the thermal power plant of Es Murterar.

2.2.4 Typical assessment procedure and tools/services required

The implementation of the use case may need the integration and/or development of the following tools, services, and systems:

- Information systems:
    - Terminal operation system used by the shipping company: although the space managed by Trasmediterránea at the Old Quay cannot be considered a terminal itself, but rather a space reserved for its operations granted through a licensing procedure, the company actually uses Gestpark [5], a specialized software for management of port terminals and yards for vehicles and RORO goods. Therefore, the use case will have to analyse potential interactions (data imports/exports) with this system.
    - Access control system of the Port Authority: an interface between the access control system used by the Port Authority and the shipping company information systems will be needed in order to implement concepts to speed up traffic flows entering the port.
    - Posidonia/AIS: access to data from these systems will be needed in order to collect information about planned/actual vessel movements and operations.
- Identification systems
    - Automated number plate recognition: this is a system already available at the access controls of the Port Authority, so the use case shall analyse the possibility of integrating its readings.

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  - Barcode readers: as mentioned above, barcodes are currently used for identification of transported vehicles. The use case shall assess the potential benefits and feasibility of integrating the readings performed by operators with handheld scanners.
  - New identification systems: the use case shall assess the potential benefits and feasibility of testing alternative identification technologies for supporting better tracking of goods. For instance, the use of RFID tags attached to truck platforms, paired with RFID readers installed in the auxiliary machinery, could automate the tracking of handling operations within the yard.
- Tracking/location technologies: tracking of RoRo cargo handling operations (mainly truck platforms without driver) with auxiliary machinery will need the deployment of the most suitable technology for localization. This could be based on GPS, and/or RTLS based on RFID, UWB, etc. For the use case development, it will be needed to assess the different technology alternatives in terms of cost, precision, ease of deployment, etc.
- Environmental monitoring sensor networks: the use case aims to use data from environmental monitoring sensor networks which are either already deployed (port of Palma) or that will be deployed in parallel to PortForward project. This network provides not only data about air quality/air pollution levels, but also data about noise pollution levels and weather parameters.
- Weather information systems: the use case shall assess the need of complementing the measurements of actual weather parameters that can be collected from the sensor network described above with weather forecasts that could be obtained from online services. Alternatively, the suitability of using data from the SAMOA customized oceanographic and meteorological service can be assessed.
- Geographical information systems: as explained above, modelling of environmental impact of logistic operations may need to take into consideration the topography of the surrounding area. Relevant data such as existing buildings and their heights, land elevations, etc., could be extracted from GIS tools.
- Connectivity technologies: the use case shall assess the most optimal connectivity technology in order to collect data from IoT devices. In principle, LoRa would be the first choice, since it is the technology of reference proposed by PortForward for transmission of this type of data, but other alternatives could be used.
- User interfaces: the use case shall assess what types of user interfaces will be used and/or provided to visualize and analyse the information generated. From the PortForward proposed interfaces, i.e. the Virtual Port visualization, and the Dashboard, the use of the former is in principle discarded for this use case, while the latter could support part of the visualization, e.g. for assessment of environmental parameters and the subsequent decision making process regarding logistic operations scheduling. However, for the optimization of RoRo transport flows, since the main beneficiaries will be the shipping companies, it may make more sense to use of the interfaces provided by their currently used tools, e.g. the terminal management software previously mentioned.

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2.3 Use Case #2 description. Optimization of supervision, management and maintenance operations

2.3.1 Summary

Port Authorities in Spain are in charge of providing general port services, which include, among others:

- Coordination and control of maritime and land traffic.
- Coordination and control of operations associated to other port services and commercial activities.
- Management of signalling, beaconing and other navigation aids, both for approximation and access of vessels to the port, and for interior beaconing.
- Lighting of common areas.
- Cleaning of common maritime and land areas.
- Port police services.
- Emergency prevention and management.

The provision of these services involves the management of several assets and port systems, of different levels of complexity, scattered throughout the entire port area. Therefore, Port Authorities shall be equipped with adequate tools supporting the daily supervision and operation of these assets and systems, as well as for defining and implementing efficient maintenance strategies and plans for them.

Daily supervision and operation of assets and systems require the collection, monitoring, and analysis of huge quantities of data, in order to support multitude of tasks that have to be carried out around the clock to keep up with constantly changing port conditions. In this context, the Port Authority acts as mediator between several types of stakeholders, including those from shipping companies, stevedoring organizations, cargo handling operators, agents, etc. The main objectives of global supervision of assets and systems shall be [6]:

- Ensuring safety and security of port operations, avoiding for instance collisions, accidental ship groundings, or potential damages to vessels or port civil infrastructure.
- Protecting the maritime and land environment in the port area, ensuring environmental compliance of the different port general processes and preventing environmental risks associated to port operations.
- Maximising the efficiency of port operations, through the minimization of waiting times for all stakeholders involved in the transport chain.

The Port Control Centre is the central hub from which the overall supervision of operations and management of port systems is carried out. The typical core system of a Port Control Centre is the VTS (Vessel Traffic Service), which main purpose is the improvement of safety and efficiency of navigation, the safety of life at sea, and the protection of the marine environment and/or the adjacent shore area, worksites and offshore installations from possible adverse effects of maritime traffic [7]. The VTS makes use of different technologies, such as AIS, CCTV, etc. in order to monitor vessel movements and ensure their safety within the port area of influence.

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In the case of the Port of Palma, these functions are carried out mainly through the Port Operations Management System Posidonia. As it has been described in section 2.1, this platform is planned to integrate data from several information systems, and it is integrated as well with vessel monitoring systems such as AIS. However, the operators at the Port Control Centre of Palma do not interact only with Posidonia and AIS, but also with other additional systems, namely:

- CCTV and video wall.
- A phone-based control system for the access barriers.
- An emergency system (fire alert and public address system)
- A communication network monitoring system, which is used for surveillance of the main communication nodes/cabinets of the network, including the functionalities of intrusion detection, smoke/flood detection, and loss of connectivity.

Therefore, operators have a risk of information overload due to the multiplicity of user interfaces to which they have to pay attention. Each system may generate different alerts or messages, and the operator must be able to focus on the ones with highest priority.

Furthermore, in the case of the Baleares ports, remote operation of assets takes on special relevance due to the multiplicity of ports managed by the Port Authority. If operators are given the possibility of managing for instance a system of Port of La Savina from the Port Control Centre of Palma, this would help to make a more efficient use of the human resources of the Port Authority, because currently there is a need to have at least one operator in each port at all hours, which makes little sense in ports with very low activity, especially during the night.

On the other hand, from the point of view of maintenance, Computerized Maintenance Management Systems (CMMS) constitute a key supporting tool. These software products help organizations to carry out maintenance operations more efficiently, by planning preventive maintenance activities and managing corrective maintenance, keeping track of maintenance work orders, maintenance costs, spare parts inventory, maintenance history of equipment, etc.

In the case of Baleares Ports, the Port Authority is currently deploying a CMMS software for managing maintenance processes at all ports, within the framework of a global plan for improvement of maintenance processes, defined by APB. This software shall be used by the Preservation and Maintenance department of the APB, which is composed by around 40 workers of different profiles, e.g. engineers, administrative staff, maintenance managers, maintenance technicians, etc., managing about 40 maintenance subcontracts, with an annual budget around 11 million euros [8].

This software shall provide support to several maintenance tasks and management procedures, namely:

- Tracking and management of issues and failures related to Port Authority systems and installations, keeping a history for each system/installation.
- Planning and scheduling of maintenance tasks and of the associated inspection tasks.
- Warehouse management for control of spare parts inventory.
- Generation and follow-up of work orders for maintenance staff and maintenance subcontracts, keeping track of materials, resources and work hours employed.
- Analysis of current or historic information of assets to support planning of new maintenance strategies/operations based on the control of budgets, costs, interventions carried out, technical features, analysis of recurrent failures, etc.

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The Port Authority uses domain model in order to define the elements that have to be managed by a CMMS. This model is summarized below:

- Asset: element on which maintenance operations are carried out in order to ensure their proper operation or to solve an issue or failure, e.g. lifts, dock esplanade, HVAC system, etc.
- Work Order: Specific intervention carried out on an asset to ensure its proper operation or to solve an issue or failure, e.g. technical inspection of lift, fixing a HVAC equipment, cleaning an esplanade, etc. Work orders may be corrective, if they are carried out to solve the malfunction of an asset, or preventive if they are carried out ensure the correct operation of the asset.
- Port: each of the five ports managed by the APB. Each maintenance intervention is carried out in one of these ports.
- Resource: human or material resource needed for carrying out each maintenance intervention. The resource may be internal if they are hired/purchased directly by APB, or external if they do not belong to APB, but have been contracted by APB to carry out a maintenance intervention.
- Warehouse: physical space where internal material resources are stored for using them in maintenance interventions.
- Contract: relation between APB and a third party whereby the latter must provide human and/or material resources to the former in order to carry out work orders.

The business model of APB maintenance plan encompasses the following actors or user profiles with their corresponding activities:

- **Maintenance managers**. Their main business activities are:
    - Management of maintenance contracts. A large share of maintenance interventions, especially the preventive ones, are carried out through external maintenance contracts. Maintenance managers shall register the contracts in the CMMS and carry out a follow-up of their interventions.
    - Data exploitation: Analysis of data within the system in order to make decisions aiming at a more effective and efficient management of maintenance operations.
- **Maintenance officers.** Their main business activity is the management of work orders, following up issues since their creation until their closure.
- **Maintenance operators.** They are in charge of executing work orders. There are two types of operators:
    - **Maintenance technicians:** internal human resources of APB in charge of carrying out work orders, usually of corrective nature, or inspecting work orders carried out by subcontractors. Following these inspections, they may update information of assets.
    - **Subcontractors:** external resources subcontracted by APB usually for carrying out preventive interventions, but also corrective ones. Subcontractors carry out work orders and can as well update information of assets during checking and inspection tasks, and plan preventive maintenance interventions. For the latter, the subcontractor shall introduce within the CMMS all preventive interventions planned in the framework of their respective contract.

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Through the implementation of the CMMS, APB will gradually build a repository of maintenance data with information about corrective and preventive maintenance interventions, use of resources and costs, equipment issues/failures and downtime periods, etc. These data could be leveraged in order to get insights for supporting the elaboration of more advanced maintenance strategies (e.g. predictive maintenance), capable of determining the best time to perform a maintenance intervention on a given asset. This type of maintenance shall be based on the actual condition of the equipment (condition-based maintenance), which assessment can be supported through the installation of sensors to capture specific operational parameters of the equipment.

The APB is in the process of upgrading the lighting systems in all its ports. For instance, specific interventions have already been made in this direction in the port of Mahon some years ago [9]. These interventions consisted on the replacement of the previously existing lamps by High Pressure Sodium lamps (HPS lamps) of higher efficiency. These lamps allowed the implementation of some degree of automated control. For instance, by using an astronomical timer, it is possible to adjust the working hours of the lamps according to the sunset time throughout the year. Furthermore, by using ballasts, it is possible to select different lighting levels, so that during the periods with lower lighting requirements, a lower lighting level is established in order to save energy. At any given moment, it is possible to override the automated functions with manual control actions. Besides, the system allows remote management through GSM-GPRS.

This is a typical scenario for implementing advanced maintenance functionalities. Lighting systems involve a significant investment for the APB, so optimal maintenance strategies are essential in order to maximize the lifetime of the equipment. As the trend is that further upgrades of lighting equipment include remote management functionalities, it could be possible to deploy IoT devices for collecting further insights in the operational parameters of the lamps. The combination of these data with the maintenance information collected through the CMMS could lay the foundations for developing a predictive maintenance strategy for the port lighting systems.

2.3.2 Rationale

Through the implementation of this use case, PortForward aims to prove on one hand the suitability of the PortForward dashboard as a unified interface enabling seamless access to indicators, alerts and data coming from heterogeneous port systems, thus helping port control centre operators to focus the attention on the most critical parameters for decision-making processes, while avoiding information overload. On the other hand, the use case shall be able to showcase how PortForward can support the implementation of advanced maintenance strategies through the analysis of historical data and the potential integration of innovative IoT devices for equipment condition monitoring.

With this use case, the project aims to achieve improvements in different management areas, namely:

- Improved capability of port control centre operators to prioritize information for decision-making processes.
- Increased capabilities of port control centre operators to carry out management actions from a central location, even for remote ports.
- As a consequence of the previous point, it will be possible to make a more efficient use of human resources for supervision and management of port operations.
- Implementation of advanced maintenance strategies, contributing to lower maintenance costs, increased lifetime of assets, and lower downtime periods of equipment.

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This use case can support the evaluation of various components and services of the PortForward framework, namely:

- The PortForward middleware, which can support the integration of data from monitoring devices for condition-based maintenance, and the integration of other data sources already available at the port.
- The potential use of LPWAN technologies provided by PortForward for the transmission of IoT data.
- The potential use of PortForward decision support system integrated with PortForward dashboard, for supporting port control centre operators with information filtering and decision-making processes.

2.3.3 Structured description

For the correct implementation of this use case, the following stakeholders and decision makers shall be involved:

- PortForward project partners more directly involved in the use case:
  - Acciona will coordinate the use case and will work on the PortForward Dashboard adaptation for port control centre operators.
  - Leitat will focus on the development of predictive maintenance strategies and models related to the lighting system of the port.
  - IMEC support may be needed for integration and processing of data sources through its IoT middleware platform.
  - Fraunhofer support may be needed for implementation of decision support system integrated with the PortForward Dashboard.
  - APB (see next point)
- The Port Authority of Baleares from a double point of view:
  - For the implementation of the PortForward Dashboard, they shall support the selection of data sources, indicators and alerts from different sources that shall be integrated, and the definition of the criteria for information prioritization and decision-making processes. Through the use case, APB seeks to make a more efficient use of human resources for supervision of port operations.
  - For the development of advanced predictive maintenance strategies, APB is responsible for the management of all maintenance contracts and of the CMMS software package. Although at an initial stage their main focus is the management of corrective and preventive maintenance interventions, their final aim is to be able to develop advanced predictive maintenance strategies.
- External stakeholders:
  - Maintenance subcontractors: the subcontractors directly involved in the maintenance of lighting systems shall at least be informed of the use case objectives and how it will be implemented.
  - IBETEC as the public company of the regional government of Baleares in charge of the development of IoTIB, the LoRaWAN public network that is expected to provide full coverage throughout the territory of the Balearic Islands. PortForward may need

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to interact with this stakeholder in case that LoRaWAN is chosen as the base communication technology for the collection of data from IoT devices involved in the use case (potentially, for monitoring condition of equipment for maintenance purposes).

Through the implementation of the use case, PortForward expects to achieve the following impacts, which will be assessed through qualitative and quantitative parameters that shall be formalized in a later step through the definition of appropriate KPIs:

- Increased efficiency of use of human resources for supervision and management of port operations
  - Average idle times of operators
  - Volume of data/indicators/alerts correctly managed by operators
- Lower maintenance costs
  - Cost of human and material resources investment in maintenance
  - Average lifetime of assets
- Higher quality of service: reduced number of failures and downtime periods.
  - Average number of failures per type of equipment
  - Average downtime periods per type of equipment

In addition to the positive impacts, the use case shall consider potential side effects or negative impacts that could be involved, and that have to be managed in order to mitigate them. Among them, it can be highlighted:

- Potential rejection of PortForward dashboard by port control centre operators: the Dashboard may be perceived negatively by the potential end users if they do not see a clear added value in terms of helping them in their daily supervision and management tasks, but rather as an additional interface that will imply additional workload for them.
- Security and reliability issues in port supervision and management systems: the integration of PortForward Dashboard involve the integration of several data sources from port systems, so it shall be guaranteed that this integration does not cause any security breach of any faulty behaviour in the operation of these systems.

2.3.4 Typical assessment procedure and tools/services required

The use case may require the integration and/or development of the following tools, services, and systems:

- Information systems: one of the main aspects of the use case will be the integration of heterogeneous data sources, indicators, and alerts from several systems. Some of the candidate systems for integration are:
  - Posidonia
  - AIS
  - CCTV
  - Access control systems
  - Emergency system

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  - Communication network monitoring system
  - CMMS
- Monitoring systems: the implementation of advanced predictive maintenance strategies may require the introduction of new IoT devices for monitoring specific equipment operational parameters, thus supporting condition-based maintenance.
- Connectivity technologies: in case that novel IoT devices are deployed for condition monitoring, the use case shall asses the most optimal connectivity technology in order to collect data from these devices. In principle LoRa would be the first choice, since it is the technology of reference proposed by PortForward for transmission of this type of data, but other alternatives could be used.
- User interfaces: in this use case the main interface provided will be the PortForward Dashboard. For the implementation of the advanced predictive maintenance strategies the use case could utilize the user interface currently provided by the CMMS.

2.4 Use Case #3 description. Prediction of port-city interactions

2.4.1 Summary

The Balearic Islands manage lots of traffic related with its ports, including port operators, vessel crew, tourists from a cruiser or recreational vessel owners. Due to these specific circumstances, there is a strong synergy among the different cities of the Balearic Islands and its ports. On the one hand, a substantial part of visitors and tourists income from the vessels and cruisers that arrive to the island, improving its economy. On the other hand, the port makes itself a more attractive destination to luxury cruisers and recreational vessels since the nearby cities provide entertainment and activities, as well as, those activities require goods that may be transported by sea, increasing its vessel traffic.

The aim of this use case is to improve this synergy even more, by creating anonymous profiles of users and provide the city estimations of their actions, based on heterogeneous data like docked ships, meteorological data and prediction and activities available within the city (i.e. a high number of tourists in the docks could trigger a reinforcement in the buses and taxis in the port).

This use case will classify different profiles and provide predictions in different areas.

Regarding the profiles, some examples of them would be:

- **Workers of the port**: This profile identifies people located within the boundaries of the port that work with the different machinery and do not make use of the same services and entertainments as the tourists. Some people that fit this profile would be crane and truck operators.
- **Tourists**: This profile identifies sporadic visitors of the port and city that do not use to have a private mean of movement, uses public transportation, rented cars or bikes and is interested in the attractions and activities of the city. Some people that fit this profile could be cruiser passengers.
- **Recurrent visitors**: This profile identifies visitors that go to the port in a usual manner (i.e. each Saturday), these people usually arrive and leaves in its own transportation and do not usually make use of the same services and entertainments as the tourists. Some examples of this kind of visitors are owners of luxury boats that are docked in the port or fishers.

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Regarding the predictions, some examples of them are:

- **Prediction of movements within the city**: With the objective of improving the security and avoid issues related with mass affluence of people to certain attractions or events. This kind of predictions could also help with the creation of future events and give an estimation of the interest that the public would show.
- **Prediction of needs**: Related with the previous prediction, the system could raise alarms to reinforce the public transportation means considering a concrete event with a notable interest from the public's side. In the same line, if there are not many tourists within the city, the public transportation services can reduce its schedules to improve the environment.
- **Creation of profiles**: The system should be able to generate the profiles themselves using heterogeneous data from different sources.

To achieve these ambitious results, the correlation of different, heterogeneous data using software technologies and techniques is needed. Some of the data that has been identified at this moment is:

- **Weather data**: The weather can vary greatly the predictions of movements and needs, for example, cold rainy days could reduce the interest of the tourist group to go to the beach.
- **Ship data**: To create the profiles of the users, the data of the ship where they arrived can provide some tips about the purpose of their travel. In the same line, knowing the arrival time of a vessel can help with the planification of public transportation in real time.
- **Location data**: In order to train the system, the location data of previous users is necessary, in the same line, the location of users can determine the precision of the predictions and allow the system to keep learning.
- **Event data**: The data of the events expected in the cities can help with the movements within the city.

Finally, related to the technologies needed to process and provide the needed intelligence for the system, some algorithms and technologies have already been identified:

- **Big data ingestion**: Some techniques related with big data, like streaming processing, can be implemented if the amount of information cannot be processed by different means.
- **Artificial intelligence**: Some algorithms and techniques of artificial intelligence will be used to perform the different predictions of the system. Some of these algorithms could be Collaborative filtering to predict movements based in the different interactions of similar profiles, to create the different profiles clustering and classification algorithms can be used, and to predict complex situations that cannot be covered by normal means, neural networks and different deep learning algorithms can be used.

2.4.2 Rationale

As it was indicated in the previous chapter, there is a strong synergy among cities and ports in the case of the Balearic Islands, but still, ports are considered closed black boxes and the direct interaction among them are limited to a specific situation. In the scope of PortForward project, this issue will be addressed by improving the exchange of information among parties making, from one side, the city more attractive to future visitors and investors and, for the other side, integrating the port into the city by providing information to the city to avoid bottlenecks, security issues and act accordingly to the visitors received from the port.

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The main issues that will be improved in the scope of the project will be:

- Increase the information exchange among parties involved in PDB use case, this will include but will not be limited to: Port authority, IT service providers, Public transportation consortiums/companies, Municipalities, etc.
- Avoidance of bottlenecks in traffic, events and attendance with the predictions based on profiles of visitors through the port.
- Increase the transportation availability in peak hours and moments with accurate predictions of arrivals and departures.
- Improve the environment of the urban and port areas with the synchronization of the data available from different environmental agencies.
- Increase the security of public events, places and attractions with the estimation of visitors to them.

The usage of the next technologies is expected for the correct development of this use case:

- **PortForward Dashboard**: With the objective of providing the involved stakeholders a usable UI where they can access the data generated by this use case and make better decisions. To fulfil this objective, this data will be accessible through the PortForward Dashboard service.
- **New tracking devices**: The usage of the already deployed tracking system in the city and port of Palma for people and the new tracking system for assets may be used to help with new predictions of positions and locations.
- **Integration of already available systems into the PortForward framework**: Some of these services are the AIS ship tracking, the actual tracking system of people and visitors of the port, the weather stations of the port and municipality of Palma and any other service available that may provide insights to the prediction algorithms.
- **PortForward IoT Middleware**: The IoT Middleware will be used to communicate the tracking devices and new sensors deployed with the backend infrastructure, so this use case will also make use of it to provide this data for the prediction algorithms.

2.4.3 Structured description

This use case involves mainly the next stakeholders during the development and during the exploitation phases, achieving notable improvements for them:

- PortForward partners involved in the use case:
  - **LEITAT**: As main developers of the solution, LEITAT will act as the coordinators of the use case with the collaboration of PDB and ACCIONA.
  - **PDB**: As exploitation site's owner, PDB will provide insights on their infrastructure, access to the services already available within the domains of the port and their expertise with passengers and other stakeholders related with the port. PDB will act as the main contact point between their systems and other stakeholders, this includes providing access to the predictions.
  - **ACCIONA**: As Dashboard leaders, ACCIONA will provide their expertise related with the visualization of information.
- Public organizations and consortiums:

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  - **Municipality of Palma**: The municipality of Palma will collaborate with the use case by providing access to the planned events in the city, as well as the available open data related with weather and air quality stations. On the other hand, the municipality and its dependent agencies may have access to the predictions to
  - **Public transportation companies**: The public transportation dependent of the municipality of Palma may have access to the predictions of the PortForward system and reinforce their fleets when peaks are detected.
  - **Security bodies**: Public security bodies, such as the police, may access the predictions through the port authority and the municipality to coordinate deployments or reinforcements based on them and other actions like temporary traffic deviations.
  - **Public open data agencies**: Other public agencies like AEMET (Weather Agency of Spain) may provide access to their APIs and open data to improve the prediction system.
- Other stakeholders:
  - **Tracking system providers**: The private company that developed the tracking of people that is already deployed in Palma and the port, will provide access to this data to perform the location predictions.
  - **Port visitors**: Through the usage of the prediction systems, port visitors should expect an increase in the efficiency of the transportation, as well as better preparation from the public bodies in terms of security and optimizations in the terms of responses to crowded events.

On the other hand, some negative aspects are to be expected due to the nature of the predictions and should be mitigated:

- **Incorrect predictions**: As a self-learning system, the limitation of the data that we can include in the scope of the project to perform the training and due to the human nature, the predictions are subject to failure and may not be accurate in specific situations (i.e. overestimation of a concert attendance due to external circumstances). Due to this, the predictions should be considered a guidance or suggestion, not as the absolute truth.
- **Usage of data for unethical reasons**: The predictions and its attached data may be used for unethical reasons like increasing the price of an attraction dynamically by using the attendance predicted. For this reason, all the predictions should be managed through the port authority.
- **Privacy issues**: The predictions will always produce anonymized data but at some early stages of the data gathering, there may be some personal information that will be deleted and anonymized during the preprocessing stage. It is important to maintain this information as separated as possible from the result and create truly anonymous data to avoid privacy issues with GDPR.

2.4.4 Typical assessment procedure and tools/services required

For the correct development of this use case, the integration within the PortForward framework of the next services, systems and data is needed:

- **Location services**: As said before, in order to train the predictions, the data related to location is needed so the algorithms can correlate the different events together.

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- **Weather services**: One valuable input to the service will probably be the weather data. For this, we have considered to integrate the weather system already available at the port, the data available from the government and municipality and national agencies like AEMET.
- **Ship tracking service**: The AIS service of the port should be integrated into the predictions to achieve a better accuracy related with the different kind of visitors.
- **User interface**: Developed within the PortForward project, the PortForward dashboard will be used to display the results of the predictive system.
- **Municipality touristic services**: In case of being available, the predictive system can gain a very relevant source of information in the form of touristic events, locations and attractions to achieve better predictions ahead of time.
- **PortForward connectivity**: To receive data related to the new tracking devices of PortForward, the wireless connectivity deployed in the port will be used.

Further services and data may be used to this development in case it is found to be relevant to the training of the algorithm.

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3 Port of Vigo

3.1 Port Introduction

3.1.1 Port General Information

Excellent natural harbour, with 14,000 hectares of sheltered water, the port of Vigo is protected from storm by the Cies Islands and the peninsula of Morrazo, so it's operational 365 days a year.

The land Service Area (SA) of the Port of Vigo covers an area of 2,572,577 sqm over five municipalities. On the left side of the estuary, the SA extends along the municipalities of Vigo, Redondela and Vilaboa. On the north side, along the municipalities of Moaña and Cangas.

Figure 3 – Service Area of Port of Vigo

Most of the infrastructure and port facilities for freight, passenger and fishing are located, however, in the municipality of Vigo (over a total of 2,048,854 sqm). In the remaining SA are located sections of lands of public port domain, that hold a number of concessions, mainly docks for fishing traffic with cold stores and warehouses, besides facilities for shipbuilding and repair, being interrupted by beaches, which are excluded from the service area.

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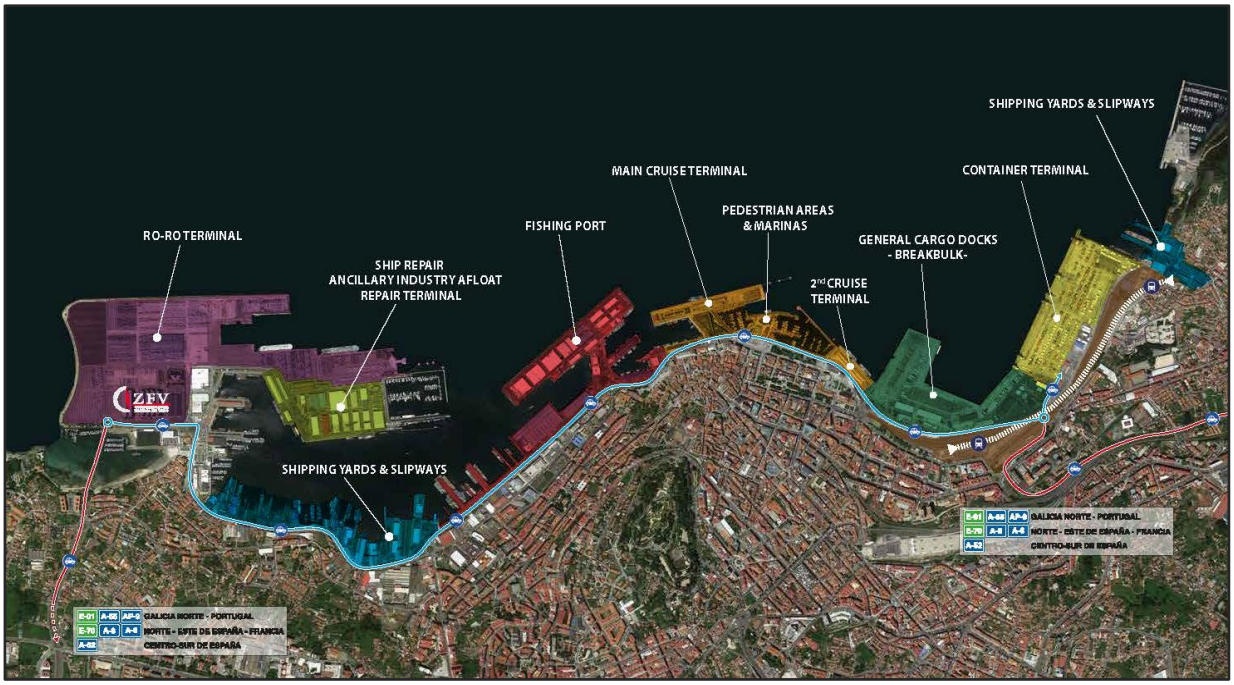

Figure 4. Areas of activity in the Port Services Area – Vigo municipality

Main areas of activity in the municipality of Vigo are detailed briefly hereafter.

Comercial Quay area

- **Container Terminal (Guixar)**

  The use case study for Green Scheduling and the sustainability assessment of the Port Operations (based on the Life Cycle Assessment methodology) will be focused on this Terminal.

  The development of Guixar basin came along the arrival of the railway, although currently is wholly devoted to container traffic, holding the port's container terminal, given in concession to Termavi. It has 762 m of berthing line and depth over 17 m. These features and a depot area of more than 180,000 m2, make it the main container terminal in the region.

  It hosts more than 80 regular maritime services that link Vigo with the main ports of the world, handling more than 200,000 TEUs every year, what makes Vigo the 8th Spanish port in terms of container traffic.

  The terminal is highly automated, with advanced software systems. Due to the characteristics of the traffics at the port of Vigo, Guixar terminal is specialised in Reefer containers, with more than 1300 connection points inside the terminal, although all types of container are handled.

  The terminal equipment includes 5 container cranes: Feeder, Panamax, Post-panamax and Superpost-Panamax. It also has 7 transtainers of 40 tons and 9 reach stacker of 45 tons.

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One of the most important assets of this Terminal comes from its intermodality, as it has direct access to road, highway and the adjacent railway terminal. This ensures an effective link with North, South and Centre of Spain, as well as with Portugal.

Other key feature of the Port located in this area is the container X ray scanner (CSI U.S.A. initiative) and the Megaports project, with its spectroscopic portal monitor, reinforcing the security of the port and all its traffics.

General cargo docks (breakbulk) Several quays devoted to loading and uploading of conventional general cargo:

- Arenal Quay: With a length of 523 m and a depth ranging from 10 to 14 m, is divided into 2 alignments; one of them devoted to general cargo and the other one for bulks, both liquid and solid.
- Transversal Quay: With a length of 515 m, it has 3 alignments, in which are mainly handled rough granite blocks and other conventional general cargo such as timber, minerals and salt.
- Comercio Quay With a length of 300 meters, multipurpose wharf devoted to general cargo. This pier can be used for cruise ships berthing at time of saturation of the specialized Terminal.

Cruises Quay

With an area of 62,125 sqm, a berthing line of 552 meters and a depth of 12 m, the pier located in the central city area is primarily aimed at the Cruise Terminal, besides being sometimes used for docking warships, research vessels and large sailboats.
Recently it has completed the enlargement of the mooring line of this pier, with three structures known as "DUQUE DE ALBA", thus reaching the 700-meter of berthing line, long enough to simultaneously accommodate two of the largest cruise ships currently existing.

Fishing Port

This space has a land area of 236,953 sqm and it includes four basins (unloading, supplying and mooring), the fishing port itself, and areas dedicated to fish farming and cold storage.

In the fishing port currently coexist 5 fish markets: deep-sea fishing, coastal fishing and big-sized fish, inshore fishing and seafood market.

Shipyards

There are 6 main shipyards in this Beiramar area, but there are other 36 slipways on both sides of the Estuary. Tere are 16 dry docks withing the service area of the Port, in Beiramar, Teis, Moaña and Espiñeiro.

Bouzas Port Area

Bouzas Port Area hosts the largest port terminal and operating industrial facilities of the Port of Vigo, with almost 860,000 m^2. It is divided into 2 main areas according to the activities that are carried out in each one.

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- **The Ro-Ro Terminal:** This is a **specialised terminal in RO-RO general cargo traffics.** It has five fixed ramps and one mobile ramp for vessel berthing, and an adjoining open air storage area of some 400,000 m^2. These ramps range from 150m length and 8m depth to 369m and 14m depth. Therefore, they are perfectly capable of hosting any of today´s large carriers. The main activity in this terminal relates to new vehicles, 75% of them for export purposes and the remaining 25% for import.
- **Repairs Dock:** It is the other large area within the port area of Bouzas. In addition to the berthing line available for ships that need to make repairs afloat, this dock has an area of more than 200,000 m^2 dedicated mainly to repair and shipbuilding, in which are located the main companies of the ancillary sector of the mentioned shipyards.

Main figures of Port of Vigo are shown in the below table to summarize the overall activity throughout a year.

Table 2 – Port of Vigo Main Figures

The Port Figures (year 2017)	
Total Port Traffic	**4,233,682 t**
GENERAL CARGO (Tn)	**3,637,840 t**
Total TEUs	219,438 units
UTI's Ro-Ro	17,868 units
Break Bulk	1,047,429 t
BULKS	**329,387 t**
New vehicles	666,709 t - 485,598 u
Fresh Fish (Tn)	89,127 t
Frozen Fish (Tn)	650,030 t
Granite (Tn)	397,646 t
Metal (Tn)	246,661 t
Slate (Tn)	59,451 t
"Goods" Industrial Value	**M 12,354.06 €**
"Turnover"	**M 26,164 €**

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3.1.2 Main stakeholders identified

Main stakeholders related with the Vigo use case are detailed:

Terminal Operator Companies - "Termavi" is the concessionary company of the Container Terminal (Guixar). It should be involved in the in the use case for Green Scheduling and sustainability assessment in Port of Vigo. Other company central in the container management is Transglobal, responsible for monitoring and maintenance (including cleaning operations of containers).

The involvement of other stakeholders coming from shipping and logistic companies could be useful to assess the potential replicability of the use cases in different quays (Progeco, Kaliedo, Suardiaz, Berge Maritima…)

Public stakeholders - Some of the public stakeholders related with the Port of Vigo management are Adif, Aduana de Vigo. Capitanía Marítima, Xunta de Galicia, Puertos del Estado, Inspección de Sanidad Vegetal, SOIVRE, Cámara de Comercio, Parque Nacional Illas Atlánticas, Concello de Vigo (Vigo City Council), CZFV…).

Port Services Provider: pilots, mooring and stevedoring**… (**Práticos de Vigo, Botamavi, Sagep…).

Container shipping companies– Main companies operating in the Termianl are: Maersk, MSC, CMA-CGM, Wec-Lines, Hapag Lloyd, Hamburg-Sud, APL, OPDR, Evergreen, Eimskip, Samskip, One, Macs, Cosco, China Shipping, Yang Ming.

Others: Association of logistic companies (Logidigal, ACOESPO, ASETRANSPO…).

3.1.3 Key port processes

Vigo Use Case will focus on the Container Terminal. We will detail key process on this Terminal:

Container Cargo Transportations: Termavi is the responsible of the logistic management. The yard can store up to 350.000 TEUS**.** There are 1.160 reefer plugs. TOS has automatic guidance for taking decisions about which RTG has to make each gate operation, but it is possible to select manually too at the control operations center. The average movements of containers per year is about 200.000 TEU. The yard capacity has been created to stack 4 high at RTG lines and reach stackers also. The R/S can assist R.

The fleet of 7 RTGs make around 112 moves per hour. The 30% of these moves are un-productive. In the other hand, the yard has 9 reach-stackers (R/S). Maritime operations are made with R/S and the RTGs are in charge of gate operations.

One RTG travels around 234 kms per month and each R/S around 750 kms monthly. Get in mind R/S is going to every place inside the terminal.

TG lines in case overload in any RTG line.

The current fleet of IMVs are 20**,** but each gang used to nominate actually 3 IMVs per gang. With a maximum of 5 gangs, it results around 15 IMVs working at the same time. The average distance travelled per IMV is around 2250 kms monthly.

The terminal can receive up to 55 trucks per hour, with a great oscillation between peaks and troughs.

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Maintenance of port infrastructures

Port Authority is implementing a digital platform (SMART VIPORT) to integrate stakeholders and Port Authority data and enable real time information to support Port Manager in the decision-making.

Global supervision of port operations

From the Control Center, Port Authority manage and supervise operations throughout analysis of different data sources

3.1.4 Relevant interactions with hinterland transportation and urban environment

The distribution and geographical situation of the service area of the Port Authority of Vigo, which runs parallel to the coast, occupying a significant part of the coastline of the five municipalities where it is located, require constant coordination and communication between the Authorities, port and the different political and social stakeholders of these municipalities involved. This policy is developed through programs of visits to the port and promotion of training or sports activities in the port area, among others.

Within the port of Vigo, three modes of transport converge: sea, road, and railway, thus enabling integrated chains of maritime-terrestrial transport. The economic efficiency and the environment of these transport chains are conditioned by the efficiency with which the modes of transport are coordinated.

3.1.5 Main current port systems and data repositories relevant for PortForward

Posidonia – port management software platform that enable the integration of port stakeholders and relevant information systems.

AIS – provide information about the vessels

SAMOA – provide information about meteorological and oceanographic conditions

Lighting – Port Authority plan to install a lighting control system in the common areas. Luminaries inside the Terminal are manage by the Terminal Operator Company (Termavi)

WiFi – available in the entire Container Terminal

Port Control Center – manage by the Port Authority. Administer different data sources (Posidonia, AIS, SAMOA, control access, camera, alarm, emergencies…)

3.1.6 Expectations and goals to be addressed by PortForward

Within the use case of Port of Vigo, the sustainability performance of container terminal operations/activities will be assessed at the beginning of the project (base case scenario), in order to know the main environmental, economic and social hotspots. Next, these hotspots will be addressed with the Green Yard Scheduling with the objective of implementing improvement measures, and to

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enhance the sustainability of container terminal operations/activities. Finally, after the implementation of the Green Yard Scheduler, the environmental, economic and social impacts of the container terminal will be calculated again, in order to evaluate the environmental, economic and social impact savings and benefits achieved (green scenario).

Economic expectations and goals:

- To evaluate the cost of the different Container Terminal operations/activities by using the Life Cycle Costing methodology, in order to detect the main economic impact contributors (the most expensive operations/activities).

- To calculate the average fuel/energy consumption of the different Container Terminal operations/activities considered in the sustainability assessment (vessels charging, vessels discharging, internal movement of vehicles, movements effectuated by cranes, transtainers (RTG) and reach takers (R/S), reefer containers, containers cleaning (only when required)) and the economic expenses associated to these fuel/energy consumptions.

- To establish a set of economic and/or socio-economic indicators useful to be integrated in the Green Yard Scheduling Platform and to evaluate the costs of Container Terminal operations/activities in real time.

- To propose economic efficiency measures for the different Container Terminal operations/activities analysed, according to the results obtained by the Life Cycle Costing analysis, in order to reduce their associated costs.

- Improve logistic efficiency to enable higher - competitiveness of stakeholders operating in the port.

- Develop new tools to manage and integrate information in real time to allow better performance and improve decision-making.

Environmental expectations and goals - To evaluate the environmental impact contributions of the different Container Terminal operations/activities, in order to detect the main environmental impact contributors.

- To calculate the average fuel/energy consumption and the potential CO_2 emissions generated by the different Container Terminal operations/activities considered in the sustainability assessment: vessels charging, vessels discharging, internal movement of vehicles, movements effectuated by cranes, transtainers (RTG) and reach takers (R/S), reefer containers, containers cleaning (only when required).

- To establish a set of environmental indicators useful to be integrated in the Green Yard Scheduling Platform and to evaluate the environmental performance of Container Terminal operations/activities in real time.

- To propose environmental improvement measures for the different Container Terminal operations/activities analyzed, according to the results obtained by the environmental analysis, in order to reduce their environmental impacts (including their carbon footprint).

Social expectations and goals:

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- To determine the main stakeholders (e.g.: population from Vigo city, Policy Makers, Logistic companies, workers, etc.) involved in the Container Terminal operations/activities.

- To establish a set of fields of social impact (e.g.: quality of life, health & safety, equal opportunities, fair wages, community engagement, sustainable territory, etc.) for the Container Terminal operations/activities and a set of social indicators useful to be integrated in the Green Yard Scheduling Platform.

- To evaluate the social impacts and benefits associated to the different Container Terminal operations/activities (by using the social indicators) and to detect the main social impact contributors.

- To propose social improvement measures for the different Container Terminal operations/activities analysed, according to the results obtained by the social analysis, in order to increase social benefits and to better integrate Port and city activities.

3.2 Use Case Description

3.2.1 Summary

Green Scheduling and Sustainability of operations

PortForward's Green Scheduler (GS) and Sustainability Assessment by applying the Life Cycle Assessment methodology (LCA) will be implemented in this use case.

The container terminal, given to concession to Termavi, register an average movement of containers per year about 220,000 TEU. All types of container are handled, however, due to the characteristics of the traffic is specialized in reefer container with more than 1,300 connections points inside the terminal.

Yard scheduling decision aim to improve current management and scheduling processes for three areas: the storage yard, the yard cranes and the Internal Movement Vehicles (IMVs).

1. Yard space allocation

Yard capacity has been created by increasing the maximum stacking height of containers with 5 4 high at the RTG lanes and 6 5 High at the Fork Park. Diesel oil consumed in the container terminal was 678,222 liters and electricity consumed was 577,849 kWh.

2. Yard Crane Management

Most of the cranes used are rubber-tyred gantry cranes (RTGs) which are capable of travelling between zones and thus offer great flexibility. The RTGs typically operate areas of the yard allocated to the storage of full containers. Areas to the yard dedicated to empty container storage (Fork parks) are operated by specialized Empty Container Handling equipment (ECHs Forks). --This additional lifting capacity is aimed at increasing performance and lower operating costs

-

3. IMV Scheduling & Deployment

IMVs form an essential link in the flow of containers in the terminal. The allocation of IMVs needs to be carefully managed.

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The figure below summarizes the scope of the sustainability assessment and the system boundaries of this study. Only the life cycle stages of operation and maintenance will be considered in this assessment. The construction stage (including the raw materials, energy and other resources used during the construction stage of machinery, equipment, vehicles, etc.) will be out of the scope of the study.

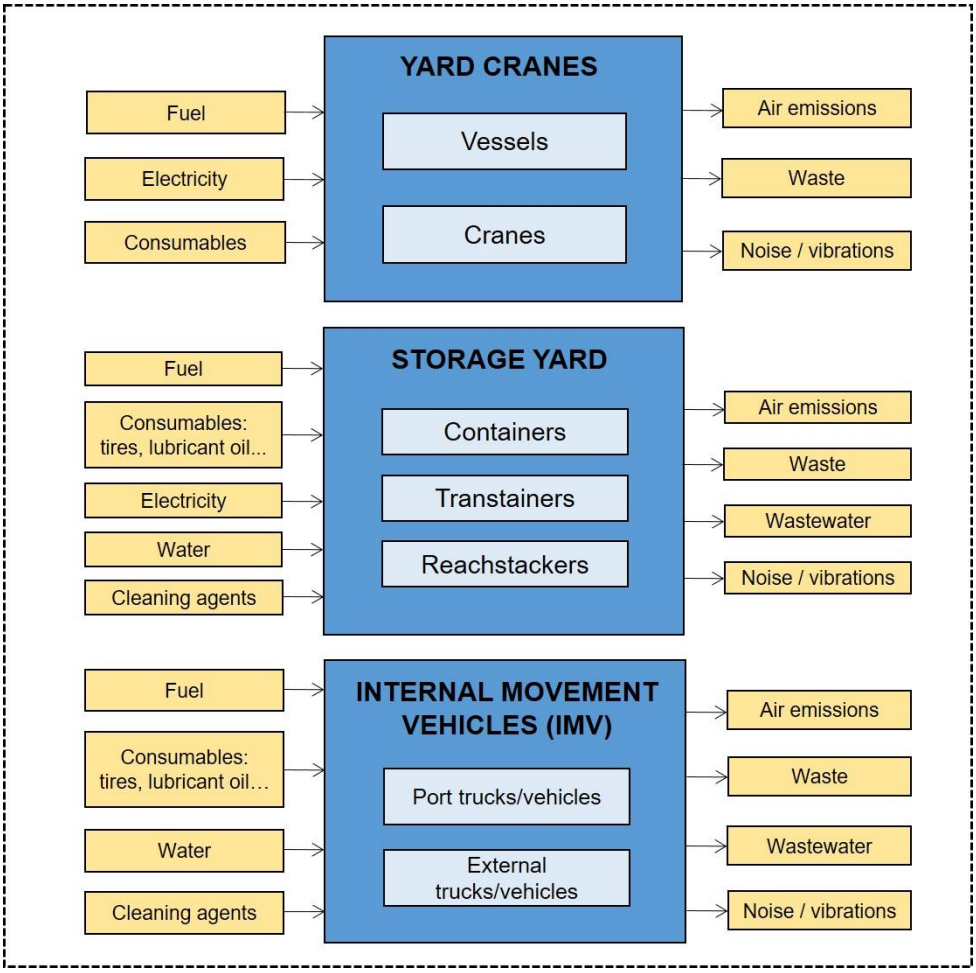

Figure 5. System boundaries of the sustainability assessment

3.2.2 Rationale

With the implementation of this use case, PortForward will try to optimize logistic processes both operationally as environmentally. More relevance will be given to parameters significantly affecting to port sustainability. To achieve the objectives proposed, a better integration of all data sources and information will be conducted.

The main port issue addressed/improvements aims in this use case as:

- Reduction of container cargo time of stay in port yard.
- Improved tracking of cargo handling operations.
- Identify potential bottlenecks and support decision-making process to mitigate them.

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- Achieve a optimal use of the yard space.
- Real time assessment of potential environmental impact of logistic operations.
- Support to decision-making process for rescheduling of logistic operations.
- Reduction of fuel emissions associated to container terminal operations/activities.
- Reduction of electricity consumed during the container terminal operations/activities.
- Reduction of CO2 emissions generated by container terminal operations/activities.

3.2.3 Structured description

Main stakeholders and decision makers in this use case are:

PortForward partners directly involved in the use case:

- **Brunel**- will coordinate the use case and will develop the multi-objective model of Green Yard Scheduling and will develop the Green Scheduler
- **LEITAT**- will work on sustainability assessment and will determine the environmental and sustainability indicators for the PortFoward platform
- **IMEC** – will provide support for integration and supporting data
- **VIGO** – will provide Brunel and Leitat all information they require from Port Authority as well as the Terminal Operator Company
- **Other external stakeholders**

Through the implementation of the use case, PortForward expects to achieve the following impacts:

- Optimize the logistic traffic flow.
- Improve productivity of cargo operations.
- Introduce environmental and sustainability parameters in the GS.
- Reduce the CO_2 emission generated by logistic traffic flow.
- Reduce the energy consumption (fuel and electricity) associated to logistic traffic flow.
- Increase the sustainability of logistic traffic flow in Ports.

Throughout the use case development, it will be detailed quantitative and qualitative parameters to measure the operational performance and the effectiveness of the Portforward solutions (KPIs).

The use case may consider potential side effects that could be involved:

- Integration of data sources may not affect to security and data protection.
- Integration of environmental parameters in the GS may not produce undesirable economic consequences.

3.2.4 Typical assessment procedure and tools/services required

The use case should integrate different sources of information:

- Information system:
    - Terminal Operating System and monitoring information – data used and compiled by Termavi to manage logistic operations.

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  - Port Authority – data compiled from port authority: control access, Posidonia/AIS.

- Identification systems:
  - Automate number of plate recognition: system already available in the port control access (Port Authority).
  - Tracking technologies: tracking of cargo operations by the Terminal Operator Company (GPS and Camera system).
  - Whether information: provide by different online services and the meteorological and oceanographic system (SAMOA).

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4 Ports of Livorno and Piombino

4.1 Port Introduction

The ports of Livorno and Piombino are a multipurpose port system, relying on a wide array of deep and short sea connections. Perishable products, containerized cargo and break bulk are among the most common freight handled in these two ports.

The two ports combined handle more than 41 million freight, of which 33 million are handled in the port of Livorno. In the first half of 2018, the port of Livorno reached over 10 million tons handling of Ro-Ro, mostly with Mediterranean countries and islands, and more than 4 million tons containerized cargo, mainly with Northern and Southern Americas. The ports are now managed by a single Port Authority System, which is not directly involvement in operations and has to steer port development and overall port land management.

Other public administrations are therefore committed to provide efficient and smooth port operations, the coast guard as far as maritime accessibility is concerned, the customs agency in relation to the goods clearance and the phitosanitary office for plants and agricultural products imports, to cite but a few.

As a consequence, the issues related to port controls and inspections are of the outmost importance, as the smooth processing of goods can enhance the competitiveness of the port vis-à-vis other major competitors.

Another issue is related to maritime accessibility. Thanks to the effort of port pilots, vessels up to 9,000 TEUS can now enter the commercial port. Nonetheless, the port of Livorno still faces major constraints when it comes to accessibility to the newest generations of cargo vessels, including Ro-Ro and car carriers, due to a narrow channel that connects the quays to the sea (just some 90 meters wide) and limited depth of berths (maximum 13 metres). Shipping companies and terminals are calling for more safety in navigation within port and, for the time being, only IT tools can support pilots and ships in the difficult maneuvering in port waters.

Subsequently, two use cases have been identified in the framework of the PORT FORWARD project:

- Pilot assistance to ship manoeuvring in port waters.
- Assistance to goods control and inspection within port boundaries.

The both through means of augmented reality or assisted reality, to improve the quality, reliability and efficiency of port activities. Assisted reality should improve communication among on-field operators and control rooms and quick exchange of information.

4.1.1 Port General Information

The tables below report the current handling of the port of Livorno and the port of Piombino:

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Table 3 – Ports of Livorno and Piombino Main Figures

	2016	2017	Δ 2017/2016
AdSP del Mar Tirreno Settentrionale			
Total traffic (ton)	**41.138.919**	**41.070.163**	**-0,2%**
Liquid Bulk	8.406.941	8.893.694	5,8%
Dry Bulk	2.497.878	2.033.946	-18,6%
Containerized Cargo	9.196.116	8.027.301	-12,7%
Ro-Ro	19.009.823	20.409.216	7,4%
Other General Cargo	2.028.161	1.706.006	-15,9%
Vessels Number	**36.341**	**36.128**	**-0,6%**
GT	305.989.539	319.030.137	4,3%
Containers (TEU)	**800.475**	**734.085**	**-8,3%**
Passengers (units)	**9.599.316**	**9.723.851**	**1,3%**
Ferry	8.746.358	8.989.352	2,8%
Cruise	852.958	734.499	-13,9%
Ro-Ro units	**626.160**	**680.226**	**8,6%**
Commercial vehicles (units)	**596.677**	**658.051**	**10,3%**
Port of Livorno			
Total traffic (ton)	**32.815.851**	**33.702.171**	**2,7%**
Liquid Bulk	8.362.816	8.835.225	5,6%
Dry Bulk	831.615	757.048	-9,0%
Containerized Cargo	9.196.116	8.027.301	-12,7%
Ro-Ro	12.413.062	14.420.456	16,2%
Other General Cargo	2.012.242	1.662.141	-17,4%
Vessels Number	**7.211**	**7.429**	**3,0%**
GT	204.663.537	210.609.060	2,9%
Containers (TEU)	**800.475**	**734.085**	**-8,3%**
Passengers (units)	**3.283.841**	**3.217.255**	**-2,0%**
Ferry	2.475.906	2.518.475	1,7%
Cruise	807.935	698.780	-13,5%
Ro-Ro units	**389.961**	**448.357**	**15,0%**
Commercial vehicles (units)	**596.677**	**658.051**	**10,3%**

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	2016	2017	Δ 2017/2016
Port of Piombino			
Total traffic (ton)	**5.497.731**	**4.787.206**	**-12,9%**
Liquid Bulk	44.125	58.469	32,5%
Dry Bulk	1.666.263	1.276.898	-23,4%
Containerized Cargo	0	0	-
Ro-Ro	3.771.424	3.407.974	-9,6%
Other General Cargo	15.919	43.865	175,6%
Vessels Number	**14.989**	**14.829**	**-1,1%**
GT	55.112.349	59.933.932	8,7%
Containers (TEU)	**0**	**0**	-
Passengers (units)	**3.210.601**	**3.348.772**	**4,3%**
Ferry	3.208.654	3.342.877	4,2%
Cruise	1.947	5.895	202,8%
Ro-Ro units	**142.503**	**138.312**	**-2,9%**
Commercial vehicles (units)	**0**	**0**	-

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Figure 6, Map of the port of Livorno.

Green areas highlight rail connections, in yellow the Ro-Ro dedicated areas and the red area the projects single gate for customs controls.

Latest data available show that the port of Livorno has a mainly regional role, with high specialization for Ro-Ro traffic (it ranks first in Italy for this kind of traffic) and a foreland which is mostly focused on short sea distances. The port has a surface of over 2 million square meters and some 11,000 meters quays. Piombino is much smaller, with 2,300 squares meters, but is projected to grow up to 6,500 meters thanks to on-going works.

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4.1.2 Main stakeholders identified

For the two use cases, that have been identified, we may list the following stakeholders:

Port pilot assistance:

- Port pilots (as users of the service and technical specifications providers).
- Coast Guard (as far as legal framework and navigational issues are concerned).

Goods controls and inspections:

- Customs agency (as user of the service and technical specification provider).
- Terminal operators (for expected benefits in the smoothness of port operations).

Other stakeholders have been already contacted by the Port Authority system, especially with reference to the second use case. They are, inter alia, the phitosanitary office, the Health protection office. Among the terminal operators to be involved, we can quote Terminal Darsena Toscana, the largest container facility in the port, and terminal Lorenzini, the second biggest container terminal in the port of Livorno. They handle together more than 700,000 TEUS per year.

It should be borne in mind that the IT providers for MONICA and TPCS platform are stakeholders to be considered in the framework if these two Use Cases.

4.1.3 Key port processes

We therefore identify the following port processes:

- Logistic processes, mainly related to containerized cargo, through easier controls and safer navigation within the port.
- Security, in relation to better detection of hazards in the port and early identification of risks.
- Safety, especially when it comes to safe navigation in port waters.
- Passenger related activities can be affected as long as passenger ships are concerned.

Logistic processes are the core competence of private operators, including terminals that are authorized to handle freight and to load and unload cargo from ships.

Security and safety are enforced by public authorities, notable the Coast guard as far as maritime traffic is concerned, and the Customs agency in relation to freight inspections and clearance of goods. Shippers and freight forwarders are notified about the controls and status of delivery of cargo through the Port Community System TPCS, which is owned and run by the Port Authority.

4.1.4 Relevant interactions with hinterland transportation and urban environment

Cargo security checks and controls have an impact on efficiency of intermodal transport, since unitized cargo has to be shipped through either road or train. More efficient customs controls have also an impact on city-port relations, because road congestion and the solution of jams for entering

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the port is an issue for most port cities, including Livorno. The identified stakeholders can commit also for intermodal transport and interfaces with port hinterland.

4.1.5 Main current port systems and data repositories relevant for PortForward

The relevant port systems and repositories for both uses cases are the Tuscan Port Community System (TPCS) and the Monitoring and Control Architecture (MONICA). The former ensures efficient operations as for cargo processes within port, terminal operator/shipping agent and haulers interfaces and verification of status of customs clearance. The latter is the overall monitoring system of the port, enhancing controls of the whole port area, including ship berthing, course and speed, thanks to close cooperation with the Italian Coast Guard. Both systems store data on cargo and infrastructure, which can be used for the Port Forward activities.

4.1.6 Expectations and goals to be addressed by PortForward

The Port Forward project can meet the demand of local port community for safer and more efficient navigation of bigger ships in port waters. Currently, vessels up to 9,000 TEUs can sail the port, which is still significantly lower the maximum figure (19,000 TEUs). Moreover, the larger the vessel is, the greater the impact is in case of accident and loss of cargo. Local Port Community calls also for faster control of cargo and for speeding up inspection when needed.

These activities aim therefore at:

- Increasing the port competitiveness vis-à-vis other ports, capable of accommodating larger vessels.
- Boosting the speed and quality of controls, through new technologies.
- Ensuring safety and security within port boundaries.

4.2 Use Case #1 description. Port Pilots Assistance

4.2.1 Summary

The port of Livorno has been mainly built during the twenties of last century, when traffic volumes and ships were significantly smaller than in present times. Port access channel is only 90 meters wide, largely below what is considered today enough to allow the safe sailing of ships over 40 meters width. In addition to this, the depth of quays and docks is insufficient for new generations of cargo vessel, as it reaches 13 meters maximum. Works are ongoing to cope with this challenge, but as major improvements are expected later than 2023, IT tools can support difficult ship maneuvering within the port.

The first use case will provide port pilots with assisted reality sensors, by means of smart glasses, to know in real time the sea conditions, wind speed, gusts and other possible hazards to navigation. These information will be retrieved by the already existing platform MONICA, which is in turn linked to the sea traffic monitoring system run by the Italian Coast Guard. This platform will therefore give data on speed, course and direction of the vessel, and the use case will consequently assess and test how to provide this information to pilots on the bridge.

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Smart glasses, assisted reality and the port monitoring will be the needed tools to implement this use case.

4.2.2 Rationale

This use case stems from the need for better control and safety in ships' navigation. As the ships size grows steadily, and port infrastructure is not yet up-to-date, IT tools can support in the short-medium term the maritime accessibility of the port. Pilots bear a great responsibility when assisting captains in port waters, and they have therefore shown interest to means to improve safety conditions of their work.

4.2.3 Structured description

- The main decision makers are port pilots; other stakeholders are the coast guard and the Port Monitoring System provider
- The motivation is to increase safety of navigation in the port
- Enhanced navigation and assistance to ships when manoeuvring in the port
- No. of accidents occurred to ships in navigation within the port;
- Easiness of ship navigation, even in rough weather conditions;
- No side effect are expected;
- Liability for any accidents lies nonetheless in the pilot. The captain is responsible for the course and right manoeuvring of the ship
- This Use case will roughly cost 25,000 euros for the equipment and 40,000 euro for the development.

4.2.4 Typical assessment procedure and tools/services required

- Smart glasses will be required. Interfaces with MONICA platform will be also needed.
- Smart glasses should be consistent with the needs of navigational issues; they should be easy to be carried, they should not hamper visibility for the pilot.
- Smart glasses are already available, especially for indoor uses; The port monitoring system is already operational, but should be connected with on-field devices such as the smart glasses to be brought by pilots; Smart glasses should be used also in an outdoor environment.
- Data will be retrieved from MONICA, which has the course and direction of the ship, along with the weather conditions (wind speed, gusts).

4.3 Use Case #2 description. Assistance to goods control and inspection within port boundaries

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4.3.1 Summary

The port of Livorno is a multipurpose logistic node, handling a wide variety of unitized cargo. Freight shipped in containers can be inspected by competent authorities and this verification takes time that results in additional costs for the logistic chain. On the other hand, controls are needed to ensure security and enforcement of the legal framework. Cargo inspections for imported containers can take as long as 2.9 days, to give an official result. In this context, it is important to help inspectors and operators to carry on smoothly controls and verify risks, in close connection with other involved competent bodies.

For the time being MONICA platform provides information on dangerous goods handled with containers. This information, however, cannot be delivered to operators on the field to carry on their controls. There aren't IoT sensors available to enhance this communication among devices and the platform.

The port of Livorno should be the first Italian port to test 5G communication, through the COREALIS (port of the Future Call) project. The COREALIS project is, like PORT FORWARD, on-going. This implementation will improved speed and easiness of communication among devices and MONICA platform.

Assisted reality can improve the exchange of information between the inspector and the competent authority, can enhance the early detection of risks or suspicious substances, and it can cope with emergencies.

Assisted reality is intended to deal with critical situation, to link the operator on-field with the competent body and to store and process data on cargo within the port monitoring platform MONICA.

4.3.2 Rationale

Competent bodies, i.e. the Customs agency, have shown interest to improved control and security measures in the port. Physical inspections, when carried on, need to report and integrate data with the overall port monitoring architecture. Data will be then retrieved by the port monitoring system MONICA, which processes also data related to cargo, which will provide the inspectors with exact localization of freight to be inspected and will be in turn fed with the outcomes of the inspections. It is very useful if the smart glasses work as scanner of stored and containerized cargo, thus improving the speed and the effectiveness of physical inspections.

4.3.3 Structured description

- The main decision maker is the Customs agency; other stakeholders the terminal operators along with the port monitoring provider.
- The motivation is to increase security and easiness of freight controls in the port.
- The improvement is the enhancement of security and control of freight flows.
- Length of physical inspections of containerized cargo.
- Smoothness of controls and enhancement of more specific control on cargo.
- No side effect are expected.
- This use case will roughly cost 25,000 euros for the equipment and 40,000 euros for the development.

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4.3.4 Typical assessment procedure and tools/services required

- Smart glasses will be required. Interfaces with MONICA platform will be also needed.
- Smart glasses should be able to detect the kind of cargo, recognise it and help communication through either video or radio to the control room of the Customs agency.
- Smart glasses should scan packages, container and detect possible suspicious substances.
- Smart glasses should ease the work on the field, enhance communication among the inspectors and the customs agency.

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5 Ports of Naples and Salerno

The ports of Naples and Salerno, together with Castellammare di Stabia -, are part of the Campania port system. The governing institution of the system is the "Autorità di Sistema Portuale del Mar Tirreno Centrale (AdSP MTC)" (Port Authority System). -It is - legal entity under public law and administrative autonomy. It has financial, budgetary and administrative functions.

In the following paragraphs - we will give a more detailed description of both Naples and Salerno ports.

5.1 Port Introduction

Naples

The port of Naples, located in the middle of the Mediterranean Sea, along the ideal route between Suez and Gibraltar, is one of the main ports for commercial traffics and shows constant increases in passenger traffic.

It- stretches for about 5.600 m along the - coastline that flanks the old town. It measures a total of about 4.400.000 m^2, of which about 2.700.000 m^2 of water surface and about 1.700.000 m^2 of in-land areas. The latter are used for different purposes (passengers, shipbuilding, and commercial activity in its components of freight traffic, oil, containers, cruise traffic, ship repair industry and yachting), and have 14 piers (7 - *source: www.porto.napoli.it*).

Figure 7 - Overview of the port of Naples

The port of Naples has many functions and represents, in terms of turnover and direct employment, a primary industrial reality of the Campania Region. From the tourist area of the port, located in the historic centre of Naples, depart hydrofoils and ferries to the islands of the Gulf and to Sorrento. The traffic of hydrofoils has been separated from that of ferries, from the "Beverello" and "Mergellina" piers depart hydrofoils, while from "Calata Porta di Massa" depart ferries.

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The "Stazione Marittima", on the other hand, hosts the cruise ships and the company "Terminal Napoli S.p.A" manages it. Its main shareholders are: Costa Crociere, MSC, Royal Caribbean and Alilauro S.p.A. In the local traffic- field (< 20 miles), the port of Naples is the leader, by a 50% share of Italian traffic. It is also a fundamental hub for the transport of goods and passengers to the major islands (Sicily and Sardinia). If the maritime transport in the Mediterranean Sea foresees a growth rate between 7% and 9% per year, the port of Naples in the last 4 years - has already shown a strong increase just for local traffic. As far as "Highways of the Sea" is concerned, whose lines lead to Sicily, represents 49% of the sector's traffic. Shipbuilding and ship repair are other important industrial sectors for the port's activities, -which continue to invest to ensure capacity and high quality standards.

In order to confirm its important position at both national and international context, all the functions already present need to be strengthened; this- assumes the development of passenger traffic, containerized goods and Ro-Ro goods. In addition, some of the infrastructures need to be completed in the short term. Specifically, as for the completion of the "Nuova Darsena di Levante" for the handling of containers, the new road and rail link and the maintenance of the seabed.

However, there are important limits to the development of the port itself because commercial containers, passengers and goods (Ro-Pax and Ro-Ro) traffics are devoid of a rational organization of spaces and dedicated infrastructure, as well as technical-nautical services, scattered over the port territory and without adequate space dedicated - maritime and land operations. Significant obstacles to the development of freight traffic are also due to the condition of the railway line and the connection between the port and the -motorway network.

Salerno

The port of Salerno is located in a very favorable geographical position for commercial traffic in the Mediterranean, - and it has an efficient network of connections with the hinterland (central and southern Italy). These characteristics therefore allow the port to serve the maritime traffic of large areas of the Mediterranean, playing a key role in the Italian maritime economy. The strong and easy interaction between the port and the hinterland - road and highway connection networks - is an important aspect that simplifies the import and export activities, determining a traffic trend that is showing a significant growth rate.

In 2010, the Port Authority of Salerno -got the approval of the technical-functional adaptation of the "Port Development Plan" in order to adapt the port of Salerno to the dimensional values of the newest ships, with an higher load capacity but also more ecological. In this way, the port of Salerno is the absolute forerunner for all Italian ports. Therefore, following recent infrastructural interventions, the port, in its current configuration, offers the possibility of accommodating even large ships.

The port has a total area of 1.700.000 m^2 of which 500.000 m^2 consists of land areas, 250.000 m^2 for storage and handling, and 250.000 m^2 for traffic roads and service areas. The port area consists of two ports:

- *commercial port*, which is located in the west of the city.
- *tourist port*, located about half a mile east of the - the commercial port.

The port offers 24 berths and 4 piers with a depth between 11 and 14 meters. The piers are public, which means that theallocation - of the mooring pier is determined daily in view of the program and

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the daily request from the ships. The commercial port of Salerno is developed on the following "Moli/Banchine" (Table 4):

Table 4 – - Quays, Berths" of the Port of Salerno

	Total surface area of quay (m^2)	Storage area surface (m^2)	Moorings length (m)	Mooring places (n)
Molo di Ponente	58.000	31.000	563	22-24
Banchina Rossa	51.000	37.000	226	20-21
Molo Trapezio	187.000	133.000	890	13-19
Banchina Ligea	54.000	34.000	250	11-12
Molo 3 Gennaio	39.000	13.000	446	7-10
Total	389.000	248.000	2.375	

The commercial area extends from the border with the Municipality of Vietri sul Mare (Salerno) to the beginning of "3 Gennaio" pier. It is divided into three operational macro-areas, as shown below in Figure 8 (*source: www.porto.salerno.it*):

- Terminal A (Ligea/ 3 Gennaio piers) which has a surface area of 37.143 m^2 and handles various goods;
- Terminal B (Trapezio pier), which occupies 120.975 m^2 and handles goods in containers.

Terminal C (Banchina Rossa/ Ponente piers), which handles Ro-Ro traffic and the "Highways of the Sea", and occupies a surface area of 80.500 m^2.

Figure 8 - Overview of the port of Salerno

There are three access roads to the commercial area:

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- at the root of the “Molo di Ponente”;
- at the root of the “Molo Trapezio”, with access to “via Ligea”;
- at the root of the “Molo 3 Gennaio”, with access to “via Porto” .

The gates open to vehicular transit are those of the Molo di Ponente and the Molo Trapezio. The access road to Molo Manfredi is located at the end of the road of the same name.

5.1.1 Port General Information

The AdSP MTC manages the following two ports:

- Naples

Table 5 – Main data of Port of Naples

Location
South Italy, Campania Region
Main activities
Passenger traffic (regular lines and cruise ships) Cargo transportation (container, Ro-Ro, dry bulks, liquid bulks, general cargo) Shipbuilding, repair
Main areas
Stazione Marittima - management of cruise ships Beverello and Mergellina - depart hydrofoils Calata Porta di Massa - depart ferries Molo Bausan - specialised in lo-lo and Ro-Ro traffic Molo Flavio Gioia - specialised in lo-lo traffic
Main figures (2017)
Number of local and ferry passengers: 6.684.772 Number of cruise passengers: 927.458 Liquid bulks: 5.070.719 tonnes Solid bulks: 6.200.432 tonnes General cargo: 11.158.934 tonnes Total goods: 22.430.085 tonnes (*source: “ESPO sheets”*)

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- Salerno

Table 6 – Main data of Port of Salerno

Location
South Italy, Campania Region
Main activities
Cargo transportation (container, Ro-Ro, general cargo) Passenger traffic (regular lines) Fishing
Main areas
Molo Ligea and Molo 3 Gennaio - specialised in various goods Molo Trapezio - handles goods in containers Banchina Rossa and Molo Ponente - managed the Ro-Ro traffic and the "Highways of the Sea"
Main figures (2017)
Number of local and ferry passengers: 680.672 Number of cruise passengers: 65.615 General cargo: 14.838.120 tonnes Total goods: 14.968.690 tonnes (*source: "ESPO sheets"*)

5.1.2 Main stakeholders identified

There is a large cluster of social, economic and administrative stakeholders that are related to the activity that takes place in "AdSP del Mar Tirreno Centrale".

Naples

In the port of Naples, the main stakeholders are:

- **Terminal Flavio Gioia S.p.A (TFG)**, is a multipurpose terminal that covers an area of 33.000 m^2, but not enough to accommodate the different types of traffic. The solution identified by the Company was the division of the quays: the quays with a depth of about 10 meters were intended for the traffic of various goods; the quays with a depth of about 12.50 meters to container traffic. In 2017, in the various goods sector, 100.382 containers in TEUs and 147.643 tonnes of various goods were handled at the terminal. Since 2015, the terminal has been equipped with a container positioning system on the dock based on "military grade" GPS

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technologies. Thanks to the high precision of about 50 cm, TFG operations have reached very high operating levels. The management software system is now able to accurately track and store the position of the containers and detect some other features, without the manual intervention of the operators.

- **GAROLLA S.r.l.,** is a company that has been managing a Coastal Depot in the port of Naples since 1957, on behalf of third parties, for the storage and handling of liquid bulk products, classified in category "C" (flash point > 65°C), excluding toxic products. The depot currently consists of 39 above-ground metal tanks with fixed roofs. All products of National, Community and Foreign origin, may be stored under the customs and tax warehousing arrangements for excise, and duties. Each tank is equipped with a calibration table certified by the Customs Agency and with electronic level gauges of the radar type with data transmission in the control room. The management and control system are carried out remotely via PLC (Programmable Logic Controller).
- **Terminal Napoli S.p.A.,** is a Company owned by: Costa Crociere, Royal Caribbean Cruise Line, MSC Crociere, Marinvest, Alilauro. The monumental building of Stazione Marittima was built in 1936 to meet the needs of the maritime sector at the beginning of the century, which essentially required transoceanic connections. Since 1997 Terminal Napoli S.p.A., by deed of concession of the Port Authority, manages its spaces that have been subject to restoration and reorganization, in accordance with the original architectural lines. The building, overlooking Piazza Municipio, in the heart of Naples where the sea laps the city sinuously, is unique in its kind. The cruise terminal includes all the piers near the Stazione Marittima. It guarantees daily reception and assistance for thousands of passengers, managing operations of embarkation/disembarkation and transit. It has 7 piers for mooring, for a total of 1.100 meters long and up to 11 meters deep, and 7 mobile walkways.

Salerno

In the port of Salerno the main stakeholders are the terminal operators related to commercial processes. These are:

- **Grimaldi Group S.p.A.,** established in 1947 is a fully integrated multinational logistics Group specialising in maritime transport of cars, rolling cargo, containers and passengers. Grimaldi Euromed, one of the Group's most important companies has been since the mid-1990s-at the centre of remarkable development in the shipment of European finished vehicles and integrated logistics. More recently, it has also become a driving force behind the "Highways of the Sea" and Short Sea Shipping concepts in the Mediterranean area by deploying a fleet of modern Ro/Ro and Ro/Ro-Passenger ships which are operating on Italian cabotage and international routes linking Italy, Greece, Spain, Tunisia, Malta, Libya, Montenegro and Morocco.
- **Salerno Container Terminal S.p.A. (SCT)**, which operates at Molo Trapezio (Gallozzi group); Manages the handling of 80% of the containers in the entire port. The connection with the Spoke&Hubs ports of the Mediterranean is -operated at least weekly, often two or three times a week according to a fixed schedule. The terminal also has two 150 metres railway tracks for refrigerated containers.

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- **Salerno Auto Terminal S.r.l. (SAT)**, a company that belongs to the Grimaldi group. Since summer 2012, FCA - perfoming as hub (central and exclusive point for collection, sorting and distribution) has chosen the port of Salerno for the new 500L produced in the plants near Belgrade. Salerno Auto Terminal and Grimaldi Euromed manage the transport of cars, rolling stock (new and used) semi-trailers and, in very small quantities, containers (the latter only on Ro-Ro ships). The main processes they deal with are embarkation, disembarkation, logistics (movement within the port and from the port) and transhipment.

Salerno Container Terminal represents a valuable link between sea and land carriers involved in the handling of goods. The large number of different stakeholders that use the services of the terminal demonstrates the effectiveness of the role it plays. These belong to the following categories:

- *Shipping companies*: the list of lines that use the SCT as a terminal operator includes many of the most important shipping companies in the world, which allow you to connect Salerno with the main economic areas of the planet such as Canada, United States, Far East, Northern Europe, etc.
- *Freight forwarders*: they use the services offered by the shipping lines, which in turn use the SCT terminal.
- *Road haulage companies*: the traffic in transit through the terminal involves a myriad of companies in the transport sector.
- *Import and export companies*: Over 500 companies of raw materials, semi-finished products, finished products and consumer goods use the SCT for their commercial exchanges. The terminal, in fact, is a powerful tool for access to domestic and foreign markets, which offers these companies the opportunity to compete on the international scene. This consideration is all the more valid in the case of companies in Southern Italy, which have always been forced to deal with the infrastructure deficit that penalizes territory.

5.1.3 Key port processes

The main processes of the port that could be optimized by PortForward are as following:

Logistic Processes – Container

The strategic geographical position in the heart of the Mediterranean, places the port of Naples at the centre of international trade routes, representing one of the main connections between Northern and Southern Europe. Container handling has grown in the last ten years, confirming the port of Naples as one of the most dynamic realities in the Mediterranean.

The container traffic of the port is managed by the wharfs: Bausan, Flavio Gioia, Calata Pollena, Calata Granili and occasionally also by the Vittorio Emanuele II one.

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Figure 9 Port of Naples overview (Source: https://porto.napoli.it/mappa-interattiva/)

The Figure 9 highlights the yards "Bausan, Flavio Gioia, Calata Pollena, Calata Granili and Vittorio Emanuele II", areas marked in orange and yellow. Those are the spaces dedicated to Container traffic in the port.

Container-related logistic operations provided by terminal operators do not consist just in the containers management, but also include some complementary and accessory specialist activities, as followings:

- Weighing of goods by balance.
- Counting, separation, marking, sampling, measurement of goods.
- Handling of goods and containers with shuttle vehicles.
- Repair and reconstruction of packaging in general.
- Filling and emptying containers.
- Repair, washing, fumigation and extraordinary maintenance of containers.

FOCUS BOX: Container Reefer
A special attention is paid to the logistic processes of **container reefer**. In the terminal there are operators (E.G. Terminal Flavio Gioia S.p.A.) who carry out a deep preventive maintenance check (PTI, Pre-Trip Inspection) of each refrigerated container before delivering it to the customer. The Pre-Trip Inspection consists of: • High temperature steam cleaning (to remove dirt and odours); • Checks to ensure that the interior of the container is appropriate to the specifications of the product category to be stored inside (such as food); • Motorisation controls to ensure that machines are operating according to predefined standards;

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- Verification that the container correctly reaches the necessary temperatures in relation to the goods it will contain.

Once the checks have been completed, the inspection is documented on a label affixed to the container. By indicating: date, time and name of the person who performed the operations, in order to keep track of all steps.

The efficiency of container-related logistic processes management is one of the main factors of competitiveness, on which often depends the choice of the port in which to land by the shipping companies. In order to ensure the competitiveness of the port, it is essential to monitor the performance of the entire port network, especially in a delicate -traffic such as the container. The "**Port Authority Dashboard (PAD)**" [M. Ferretti, A. Parmentola, F. Parola, M. Risitano (2017)] is a multi-dimensional monitoring tool based that allows to monitor the internal processes in port activities and the governance capabilities simplifying the cooperation between all the stakeholders who are involved in commercial activities and lastly improving the level of whole-port service. For instance, as for the internal processes, the key performance indicator "**Dwell Time**" allows to calculate container's –dwell time the in the stocking area, waiting to be loaded. In this way it is possible to identify inefficiencies in the management of the containers and to make better use of the wharf's spaces.

Logistic Processes – RO-RO

The port of Salerno has faced some significant challenges related to its geographical location and, consequently, to the limited space available, which have cast doubt as for future, development perspectives.

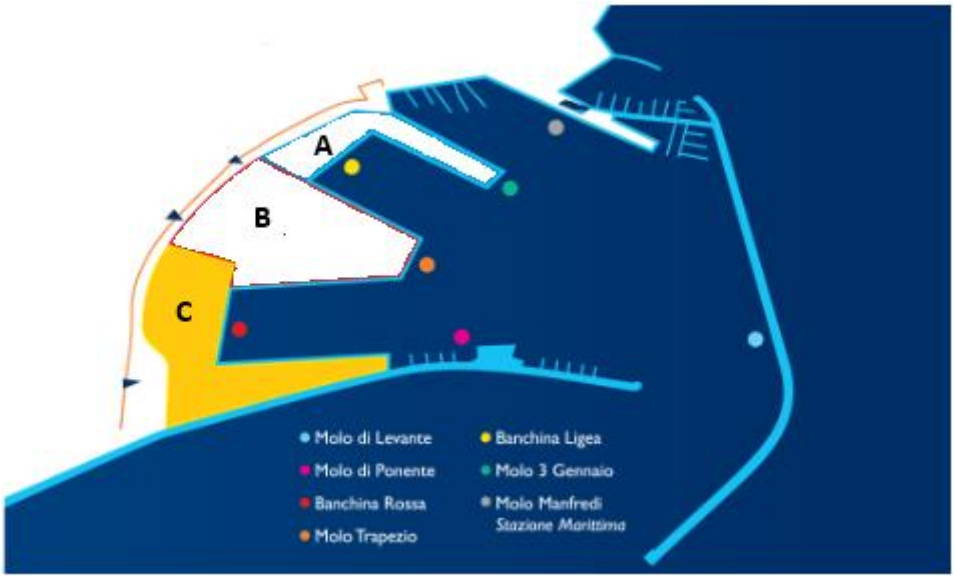

Figure 10 Banchina Rossa and Molo Ponente: RO-RO-dedicated areas (Source: http://www.porto.salerno.it/)

The Figure 10 highlights "Banchina Rossa and Molo Ponente", area C marked in yellow. Those are the spaces dedicated to Ro-Ro traffic in the port. In the Port of Salerno the RO-RO traffic accounts

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for a significant share of the business carried out, playing an important role for the import/export of cars (Car-Carrier) and for the traffic of trailers to the main Mediterranean ports.

The traffic of the wheels in the port of Salerno is mainly related to the handling of trucks and semi-trailers, accompanied and unaccompanied and new factory vehicles. Since 2001, the Port of Salerno has been included in the new maritime transport system of short sea shipping called "Autostrade del Mare" (- Motorways of the Sea). The main routes of this mid-short distance circuit are scheduled to and from Malta, Tunis, Cagliari, Palermo, Messina, Augusta and Valencia.

Also, thanks to the implementation of these new regular lines, RO-RO and RO-PAX traffic has recorded high growth rates in the last 15 years.

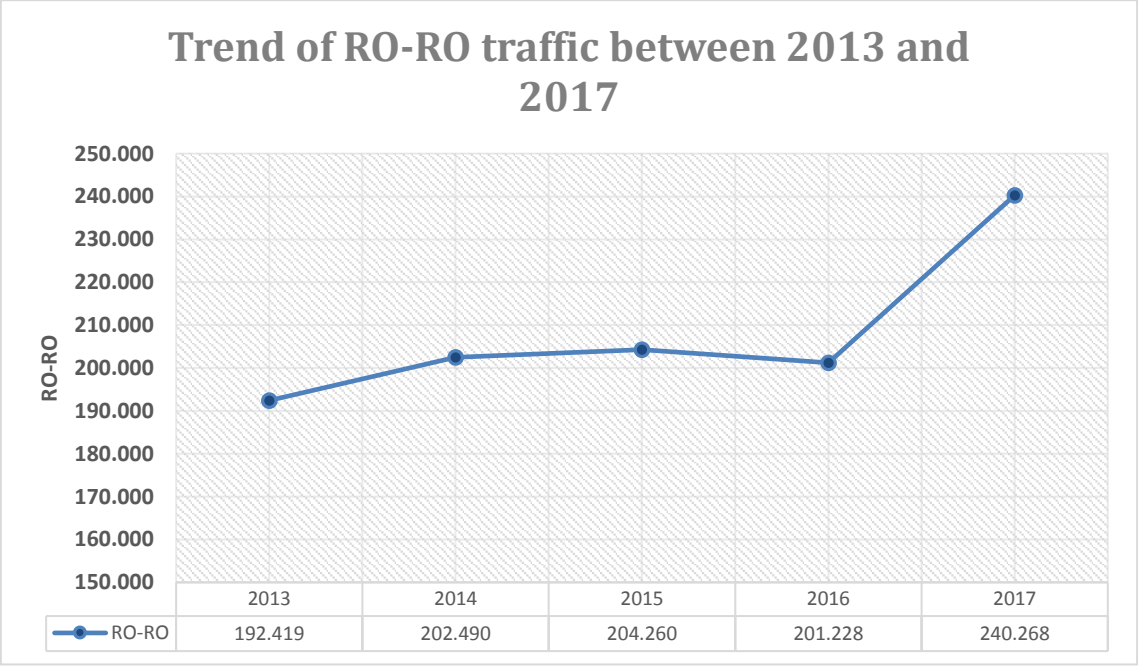

Figure 11 RO-RO traffic trend between 2013-2017 in the port of Salerno [10]

The Figure 11 shows the trend of RO-RO traffic (in/out) between 2013 and 2017. The line graph above shows that by 2013 the RO-RO traffic increased by almost 25%.

Considering the impossibility of the port to grow inland, both for the mountainous morphology of the coast, and for the urban structure, the management of logistic processes related to the loading and unloading of cars and trailers must be carefully planned and carried out within often very limited timescales. These critical issues could be targeted by PortForward with the use of the Port Authority Dashboard to optimize the management of time and spaces, thanks to the monitoring of logistics processes related to parking and loading / unloading activities.

Passenger-related operatives – Short Sea Shipping

Concerning the short sea shipping in the port of Naples, the volume of passengers has increased significantly in recent years so much so that it ranks second in Italy, with over 6.5 million passengers in 2017 (Messina-Milazzo ranks first with over 7 million passengers).

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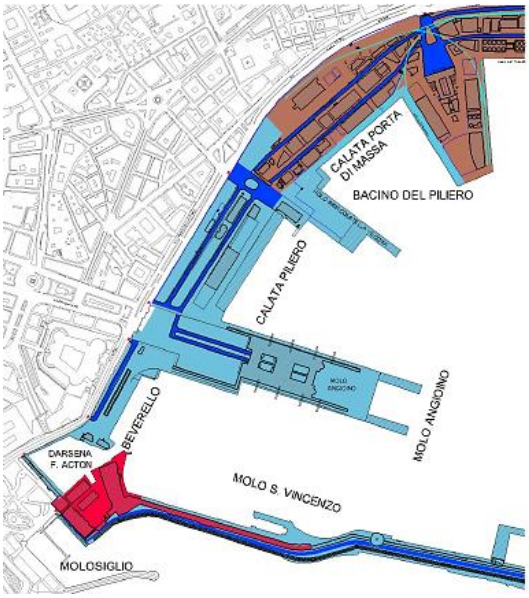

Figure 12 Port of Naples, passengers-dedicated areas (Source: https://porto.napoli.it/passeggeri/)

The Figure 12 shows the port's passengers-dedicated areas. The wharf Beverello and Calata Porta di Massa are dedicated to the short - sea shipping to Ischia, Capri, Procida, Ventotene and Ponza. The wharf Angioino and Pisacane (occasionally) are dedicated to cruise traffic.

Figure 13 Port of Naples, short sea shipping between 2013 and 2017 [10]

The Figure 13 shows the short sea shipping trend in the port of Naples. The traffic –rose by 14% in the five-years period. This result is due not only to the geographical position, which inevitably attracts customers living in the central-southern areas of the country, but also to the commitment shown by the main players in the sector aimed to improve and strengthen the reception services. Many projects have been started with local, national and industry associations in order to improve and optimize the

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management capacity of the approximately 6.5 million short sea passengers, which arrive every year in the port.

In order to efficiently manage such heavy traffic, a careful planning of activities and a certain degree of coordination between the various players is necessary in order to reduce as much as possible the congestion of both shipping and passenger traffic.

Also in this context, as for the logistic processes one, the Port Authority Dashboard could be a suitable tool to improve the efficiency of the services offered by players, through the monitoring of docking activities and the collecting of passengers flow data. By analyzing these ones, it is possible to evaluate the quality of performance, in order to guarantee a high degree of efficiency of operatives.

For instance, considering the key performance indicator "**Ship Turnaround Time**", it is possible to calculate the time elapsing between ship's arrival in the port and its departure. It is an indicator that would allow to evaluate the performance of the connections with the Gulf islands, which represents the most relevant share of passenger traffic, in order to identify any critical issues. Consider a speedboat that takes on average more time than the others to disembark and embark for the same route, creating "traffic" in the wharf, making the waiting and the trip longer and causing delay and therefore damage also to other operatives.

Furthermore, through indicators such as quay occupation and average load per ship, the supply of transport services could be monitored in order to manage it more efficiently and avoid imbalances. Those objectives we would like to achieve at the end of the project.

Maintenance – strategies, procedures and supporting tools

The fundamental aim of maintenance planning is to ensure that the interventions deemed necessary are carried out with - biggest cost savings possible and that the work performed meets the criteria of productivity and efficiency. The essential feature of maintenance planning is its ability to predict faults hindrances and to prepare a set of procedures for fault prevention and possible rectification, through an economic and technical balance between complementary systems and interlinked.

As far as the port of Naples is concerned, the "Technical - Department" is responsible for the maintenance of the common parts in the port area. The maintenance is divided into ordinary and extraordinary. The ordinary one concerns goods belonging to the AdSP such as buildings, sewers, horizontal and vertical signs. It provides for the restoration of buildings, quays, roads and squares in case of damage.

As for the port of Salerno, the square in which SCT operates has a total area of about 80.000 m^2. Of these, about 70.000 are reserved for the actual storage of containers, while the - remaining is used for the primary infrastructures needed to carry out terminal activities (operating offices, workshop for the repair of mechanical equipment, workshop for small repairs of containers, etc.)..

In particular, the task of the workshop for the repair of mechanical equipment is to check periodically the correct functioning of the equipment and protective devices at work, planning the maintenance of the mechanical parts and their possible repair.

Maintenance is handled at two different levels:

- *routine maintenance*: it is entrusted to specialized external companies that work on a daily basis and that intervene on the basis of the time intervals suggested by the same companies that build the equipment.

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- *extraordinary maintenance*: since breakdowns in the machinery could occur at any time, the structure also has internal teams consisting of mechanics and electricians, who intervene in case of - emergency. These teams are organized into four daily shifts, to cover all possible malfunctions that could occur during the 24 hours.

The timeliness with which repairs are carried out depends on the point in the production chain where the fault occurred. In the event of a breakdown in a truck, for example, there will immediately - others ready to -cope with - its absence, thus making the need for its repair less urgent. It is clear that things would change dramatically if one of the quayside cranes failed. In that case, in fact, there would be a risk of interrupting the entire production cycle of the Terminal, with enormous damage to the company in terms of costs and times. In such a case, therefore, the intervention of the repair teams should be as timely as possible.

According to statistics available at the headquarters of the SCT, it was found that -- 80% of downtime, which occurs inside the terminal, is due to the breakage of the spreader with which the vehicles are equipped. According to experts, in fact, this is the most delicate and dangerous element of the machinery, and its repair requires considerable expense in terms of time and money.

In addition to planning maintenance and carrying out any repairs, the "Workshop" is also specifically equipped for the cleaning of mechanical equipment and for the collection and purification of water resulting from washing.

While the AdSP MTC, instead, is responsible for ensuring the routine and extraordinary maintenance of the common parts in the port, including that for the -dredging of the seabed. For this reason, and for those listed above, linked to private operators, it is necessary to use a tool for monitoring activities (e.g. Port Authority Dashboard) related to maintenance. It is easy to assume, for example, an indicator that monitors the status of maintenance orders, taking into account information such as the amount budgeted and the amount spent.

Security – Goods, passengers and port operations

A further important competitive factor for ports is the security of goods, passengers and operations. For shipping companies, in order for one port to be more attractive than another, the security plays an important role as it is translated into terms of reliability.

As for **goods,** in the port of Naples, some terminal operators (e.g. Terminal Flavio Gioia S.p.A.) feature a continuous security monitoring system, capable to ensure the container security through: a thermic perimeter surveillance software, a system of internal and external surveillance and a continuous access control software.

Regarding **passengers,** an important landmark for cruisers passengers is the Maritime Station. Built in 1936 and located at the Angioino Wharf, it offers information, assistance, control services to passenger. The cruise passengers safety management is carried out on the airport model, involving checks on both people and luggage, through tools like the body scanner.

Staff ensures that embarkation/disembarkation operations are carried out in complete safety, by checking tickets, documents and managing the flow of passengers. It is important not only to guarantee the effectiveness of the service, but also to speed up operations and thus streamline the entire process of embarking and disembarking passengers.

As far as port **operations** -are concerned, It is well known that port operations are by their own nature dangerous, so it is very important to adopt an accident monitoring system. Through indicators that

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detect the number of accidents, distinguishing them by operators and type of activity during which they occurred. In this way it could be easier to investigate the causes, plan interventions and implement prevention systems.

5.1.4 Relevant interactions with hinterland transportation and urban environment

Interactions – hinterland transportation

- **Goods – road**

The goods arriving in and departing from the port of Naples travel mainly by road, insofar it currently does not have the infrastructure to connect it efficiently to the national railway network.

The existing connections of Naples Port with the external road network are the following:

- **on the urban level,** by the following gates: Immacolatella, Pisacane, Del Carmine, S. Erasmo and Vigliena, which give access to the urban coastal route.
- **on the highways level**, through the Bausan gate, which gives access to the highway "A3 Naples-Salerno".

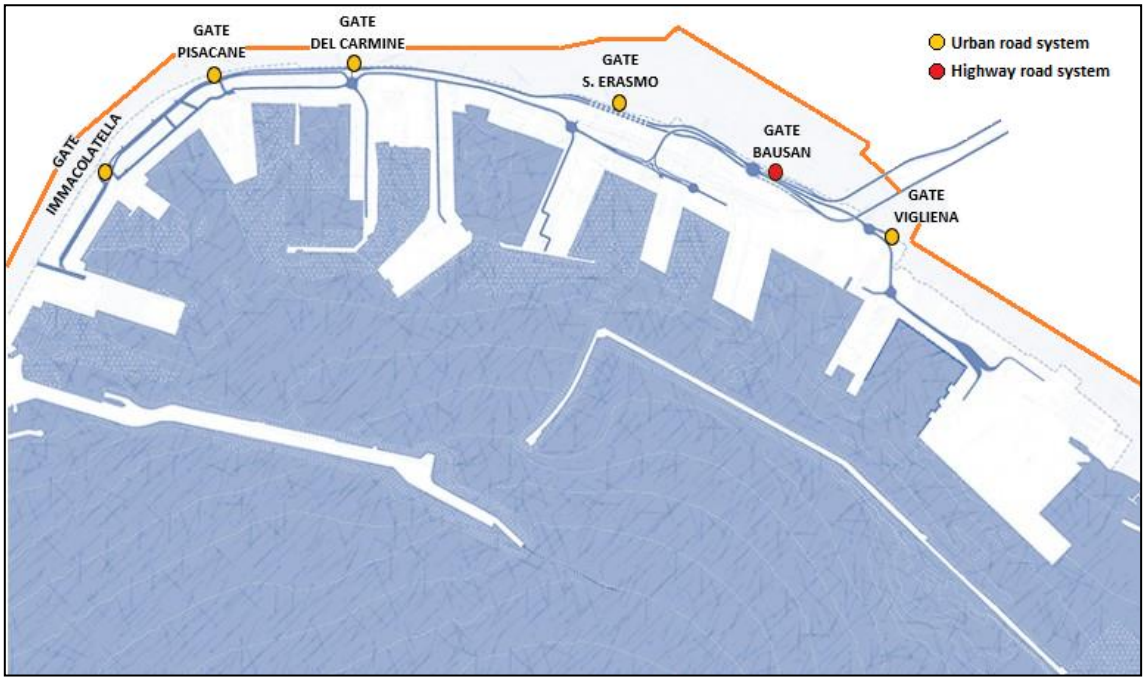

Figure 14 Port of Naples, urban and highway road systems gates. (Source: Google Map – own elaboration)

The Figure 14 shows a map of the port of Naples, pointing out the gates currently in use. The main traffic flows pass through the Bausan gate, with a strong commercial containerized component and also gathering a significant share of the flows to the ferry terminal.

- **Goods – rail**

Since the inauguration of the "Napoli Centrale" railway station in 1867, the port area was connected to the railway service. Changes in the urban structure, commercial activities, port infrastructures and a number of changes in management policies, led to the – end of the service in 2014.

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The railway connections inside the port of Naples is now limited only to a terminal that serves as a container handling system for both sea and road transport. The terminal has taken the name of "Terminal Flavio Gioia" and is managed by a private company even if, as said, at the moment the railway traffic is suspended from 2014.

The traffics growth in the Mediterranean, followed by the social and infrastructural development that Naples is facing, has pointed out the necessity to realize an intermodal transport system between the port and the railway, essential condition for the development of the port activities and the growth of the "industry-port". After the agreement signed between AdSP and RFI (Rete Ferroviaria Italiana - Italian Railway Network) the planning for the realization of a new station and railway terminal located the port with a module of 750 meters has begun. The realization of this project is strategic for the – freight villages of Campania, which, in this way, will become a port extension, with regular rail connections to the latter.

However, there is currently a "**Shuttle**" service between the "Interporto Sud Europa (I.S.E.)" located in Marcianise and the Port of Naples, although extremely limited. The connection has a frequency of one couple of trains per day, one into and one out from the port, managed directly by "Servizi I.S.E." (which is controlled by the I.S.E.), in partnership with Trenitalia. In the I.S.E., an area has been set up for the handling and storage of containers, for which a series of connections with other Italian ports are being planned. The shuttle service from the port of Naples, highlights the back-port function of the inperports and the importance of a railway relationship between the port and the interports of Campania, in order to develop greater logistical flows.

- **Passengers**

Line 1 of the underground connects the port of Naples to the main neighborhoods and the city's hinterland. The gate that allows a direct access to the port (almost completed) is located at the Angioino wharf, not far from the Maritime Station, easily reachable by foot both cruise passengers and from Beverello wharf, which is used for shortsea shipping.

Passengers can also take advantage of the **Alibus** service, which connects the port, airport and central railway station via a continuous bus line.

As for passenger traffic in the port of Salerno, it has grown in recent years. Reaching the number of around 680,000 passengers in 2017, it recorded an increase of 24% over the previous year. The sharp decrease in cruise traffic, almost halved between 2016 and 2017, has been - offset by the increase in short and deep sea shipping. The huge flow of passengers, compared to the size of the port area, has also - led to an increase in the number of tourists who are often no longer just in transit to reach other destinations, such as the Amalfi Coast, but also visit the city. The mobility of passengers towards the port and the Amalfi Coast is ensured by **the bus lines**, which also reach the suburban area of the new tourist port "Marina d'Arechi".

The port is also directly connected with the subway of Salerno through the stop "Centro Storico - Via Monti", reachable -on foot in a few minutes, which also allows to reach the suburban area of the Arechi Stadium.

Interactions – urban environment

Ports and cities are historically strongly linked and have developed in close relationship. Specifically, the opportunities for - enabling of international trade benefited the development of many port cities significantly. However, over the time there has been a reverse trend in many -cities: ports have become increasingly disconnected from cities, both in spatial and economical terms. If the latter,

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negative interactions between port and city have often eroded the close relationship between them, they - have led to -become port and city two separate identities.

The main both positive and negative interactions between port and city concern the following fields: land use competition, economy, water use competition and - employment

- **Economy and labour (Naples)**

The port of Naples is one of the largest in Italy, with an area of almost 1.7 million sqm, and among the most important ones in Europe for short sea shipping. Due to its - size and traffic, the port generates a significant economic spin-off, with a positive impact on the city's economy.

Table 7 – Passenger-related economy figures induced by cruise passengers [11]

Expenses \ Years	2012	2013	2014	2015	2016
PAX expenses on the ground	41,66	39,84	37,76	43,04	44,28
PAX excursions	76,26	72,93	69,13	78,80	81,07
Tot. PAX expenses	117,91	112,77	106,89	121,84	125,35
Tot. Crew expenses	10,48	10,03	9,50	10,83	11,14
Total spin-off (Crew + PAX)	**128,39**	**122,79**	**116,39**	**132,67**	**136,49**

The Table 7 above shows the passenger-related economy induced by cruise passengers. The amounts are in millions of euros and they rose during the five-years period by 6%.

But not just the cruise, also the deep and short sea shipping and shipbuilding, generate a significant economic. Value added, through high volumes of revenue, with a significant impact on the economy of the city.

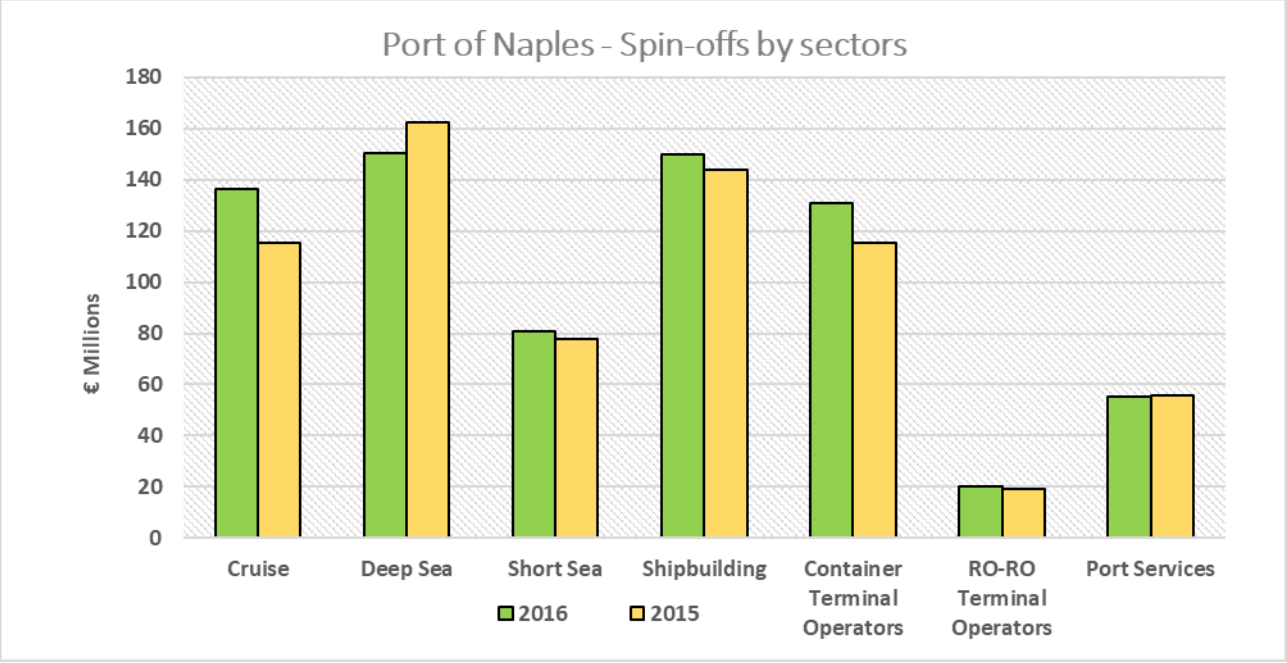

Figure 15 Port of Naples. Spin-offs by sectors [11].

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The Figure 15 shows the port-related economy induced by different sectors. Shipbuilding and Deep Sea are the sectors that – affect the most, through high volumes of revenues. Cruise data are also relevant, showing an average daily expenditure per passenger of €36, higher than UE average of €27.

FOCUS BOX: Yacht sector spin-off

The **large yacht segment** (over 50 metres) is growing strongly in Italy. This can be seen by the increase in values year-on-year as regards:

- operating yachts with a length of more than 50 metres
- order book
- average dimension

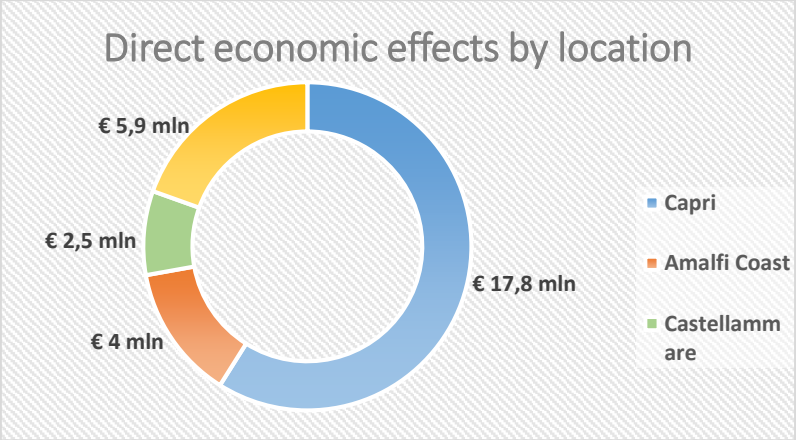

Figure 16 Direct economic effects in Campania by major tourist harbours [12]

The Figure 16 shows the direct economic effects for the main Campanian touristic ports in 2017, featuring that Capri generates over 58% of the spin-off, by itself.

In detail, the sector's activity in the Gulf of Naples has generated spin-off effects for €54,58 million and more than 400 workplaces (involving €9.4 million in income from employment).

In this scenario, socio-economic indicators, such as employment (direct and indirect), are very important as they provide a measure of the social and economic contribution of the port to the development of the local area. The data of the indicators allow to evaluate the trade-off between negative externalities related to the port and the benefits for the local community. Often there has been a tendency to overestimate the positive impacts of ports, resulting in a lack of reliability of the reported data, affecting the credibility of port management both in the view of the population and stakeholders.

In this regard, the **PAD (Port Authority Dashboard)** is a tool that can allow the elaboration of socio-economic indicators in a more rigorous approach. For instance, the "*Port Labour Indicator"*, which relates to the direct and indirect employment impact of the port, as well as to port safety.

- **Environmental impacts (Naples)**

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Air pollution is, today, one of the great - sources of pollution affecting the largest and more populated cities, significantly compromising both human health and activities and Naples is not exempt of this problem.

Referring to the research document "*F. Varriale. Activities of the port of Naples and Pollution from PM10. (2009)*" it was possible to examine the impact on the city by the different emission sources and, specifically, to assess the impact of port-related activities. Both the most polluting sources and the most - relevant ones in Campania and, specifically, in Naples have been considered. In detail, the following have been considered: cars, heavy goods vehicles and buses, residential facilities, port activities, airport activities, and thermoelectric power plants.

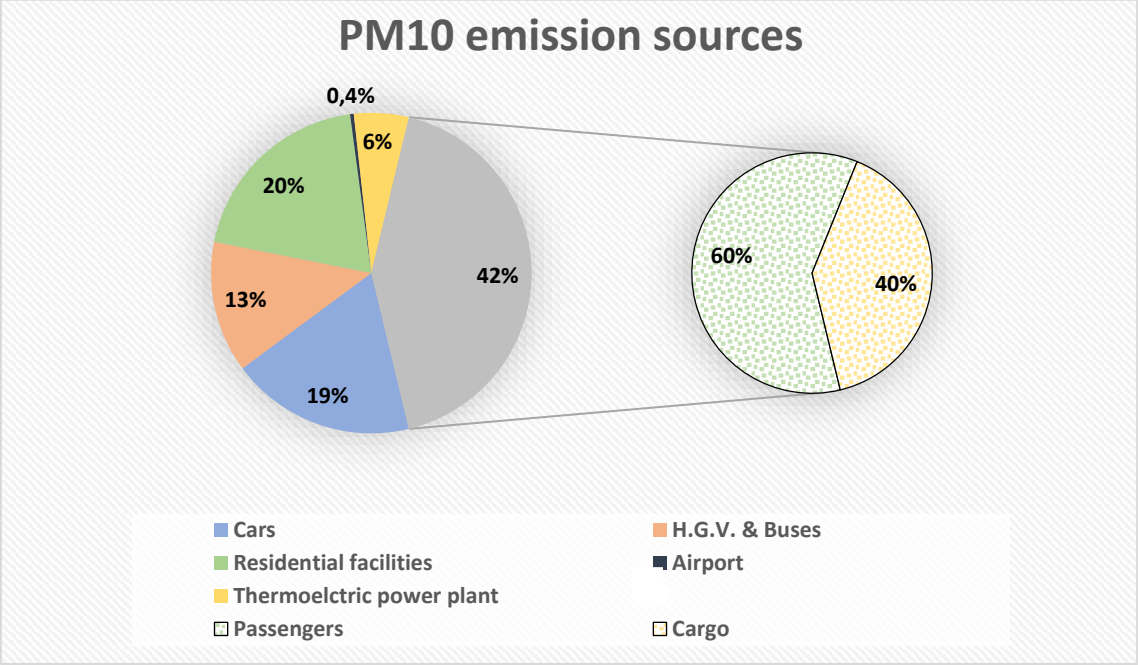

Figure 17 Port of Naples, PM10 emissions by sources [13]

The pie chart in Figure 17 above shows PM10 emissions by sources. The port accounts for 42,4% of the city's total PM10 emissions, of which 60% is produced by passenger traffic and 40% by cargo one.

The analysis of the annual data for the period 2006, 2007 and 2008 shows that in 2007 there has been an increase in port activity which has produced an estimated increase in PM10 emissions of 5.87%. - Vis-à-vis this increase, there was no change in the number of days on which the maximum permitted concentration of PM10 in the atmosphere was exceeded: 70 exceedances in 2006 and 70 exceedances in 2007.

These results show that port activities have contributed to the increase in PM10 emissions, but only marginally.

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- **Water use competition (Salerno)**

Built between 70s and 80s on a bathing area, the current port area of Salerno has often been identified as a source of noise, traffic and pollution both by sea and air. Port activities generate negative externalities, affecting, for instance, the quality of sea water. As it often happens in coastal cities, the relationship that people have with the sea is very strong in Salerno and, for this reason, despite the great boost it has given to the economic development of the city, the port is often accused of having aggravated the state of health of the sea. In Salerno there is a strong water use competition between the port activities and the population habits. The formers seek to expand their business, encouraging operations that have a direct impact on the waters of the sea, such as the following: dredging, extension of wharves and naval gigantism. In the other hand, there is a population that is increasingly reducing the number of bathing areas and the quality of the sea.

To mitigate this competition, the institutions have introduced policies that take into account both needs through, for instance, projects to control and limit the pollutants that flow into the sea due to port activities and beach redevelopment projects.

5.1.5 Main current port systems and data repositories relevant for PortForward

The sequence of operations that characterizes the port logistics chain and the need of carrying out them promptly and in compliance with current regulations, requires a constant exchange of information. In this sense, an increasingly important role is represented by InformationCommunication Technologies (ICT), the diffusion of which has produced systems capable of reducing bureaucratic slowness through the creation of technological infrastructures and standardised IT procedures capable of connecting the systems of each individual subject participating in logistics and port processes. One of the most important systems active in the ports of Naples and Salerno since 2014, as in many other Italian ports, is PMIS - Port Management Information System. It is a data management and storage system managed by the Command of the Coast Guard for the elaboration of administrative practices related to the arrival and departure of ships and for the supervision of maritime traffic in the port. The ports of Naples and Salerno are equipped with a PMIS Centralized system, a particular computer system in which data and applications from multiple user terminals reside and they are managed in a single processing node, and are finally stored in a special centralized archive.

PMIS is structured into the following three functional macro areas

- Master data for the management and configuration of the port.
- Control for the supervision of intra-port traffic.
- Administrative procedures for the management of ships arrival and departure procedures.

The functional macro area Master data, contains all the information related to the port (eg. docks, etc..) and is used for the entry of data on ships (eg. entry of data and documentation on ships that will arrive in port).

The functional macro area Control concerns the supervision of traffic within the port and it implements many functions useful for planning activities related to the departure and arrival of ships. Some of these functions, for example, allow:

- the visualization of the ships in port on a cartographic map, which is constantly updated on the basis of both ship movements inserted by the operators and the position data transmitted by the VTS system.

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- the control of the movements of ships within the port waters and the management of the services provided to the ship during its stay in port (pilotage, mooring, use of tugs, water supply, etc.).
- the visualization of images acquired by cameras located in the port areas and the possibility of pointing the cameras automatically on areas of interest.

In addition to these operations of monitoring and management of remote systems, PMIS allows you to manage all the procedures related to any emergency situations or violations of the Code of Navigation. In the latter case, the system identifies the authorities to be alerted and the actions to be taken.

The macro area of Administrative Procedures includes the functions for the management of ship arrival and departure practices, some of which can also be accessed by external users (e.g. shipping agents, port system authorities and terminal operators). For example, the function named "Ship Voyage Management" collects all the information regarding the arrival and departure of a ship, and it useful to coordinate the activities of ship handling from vessel sightings to the exit from the port waters. This function is mainly managed by Coast Guard users, Port Authorities users and terminal operators. Within the macro area of Administrative Procedures, the essential information for the creation of Plan Berth is stored and documents relating to the management of waste and dangerous goods are inserted. In particular, the function Management of dangerous goods on the ground side is used by operators of Coast Guard or Port Authority, that are responsible for the control of dangerous goods, by agents/shippers who must forward the requests for storage and by terminal operators who communicate the movements of dangerous goods stored in their parks. Finally, among the many functions offered by this system, the Customs -Ship Manifest Management function is very important because it allows to manage all the requirements related to customs manifests.

The system described above implements the concept of Single Window, which consists in the possibility for an economic operator to forward administrative formalities to several institutions all at once and at a single entry point (single interface). The Single Window acts as a centralizing body for data provided by the operator. It collects and distributes them to all interested parties who are connected to the interface and reducing, in this way, the inefficiencies due to administrative procedures.

In line with this objective, PMIS is expected to be able to communicate with:

- the main platforms for logistics operations management at national level, such as UIRnet, the first national logistics platform that, thanks to tracking and tracing technologies, enables the constant dialogue among intermodal actors and allowing an optimal management of flows from/to supply chain nodes.
- the information systems of some of the main stakeholders in the port sector, such as AdSP and terminal companies.

An information system adopted by terminal companies, able to access the data contained in the PMIS could provide, in real time, numerous advantages to the management of activities. The system currently used by the terminal company Salerno Container Terminal, which operates in the port of Salerno, is described below. As you will see, some of the expected applications by this system (e.g. "Vessel" application) contain information that, for example, could be sent by PMIS that constantly collects and updates them.

Salerno

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Salerno Container Terminal is equipped with the COSMOS software system for a complete management of the containers, starting from the initial contact with the shipping company, up to the control of the position of the container inside the storage area. It consists of a central database with a series of software applications for yard management, area optimization, ship arrival planning, and messaging with external users (Figure 18). The COSMOS system has been developed with the primary objective of connecting the Terminal with the Navigation Lines that belong to it. Accesses are also provided for other users (Shipping Agent, Freight Forwarder), and each of them can access the system for specific functions. The shipping company, for example, may decide to provide access credentials to the Agents representing it, allowing them to consult a series of data useful for managing the ship's voyage.

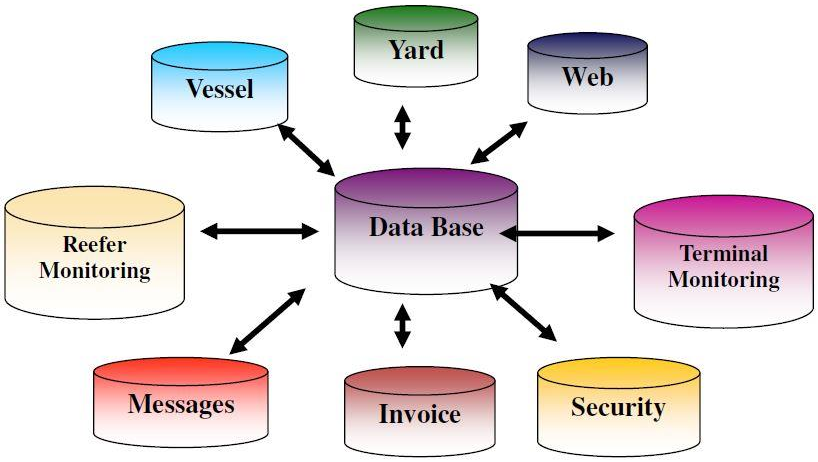

Figure 18 - COSMOS, central database and software applications

Yard

Using the "Yard" application, at any time it is possible to export all the information relating to the containers and their position on the yards through a detailed graphic interface (Figure 19).

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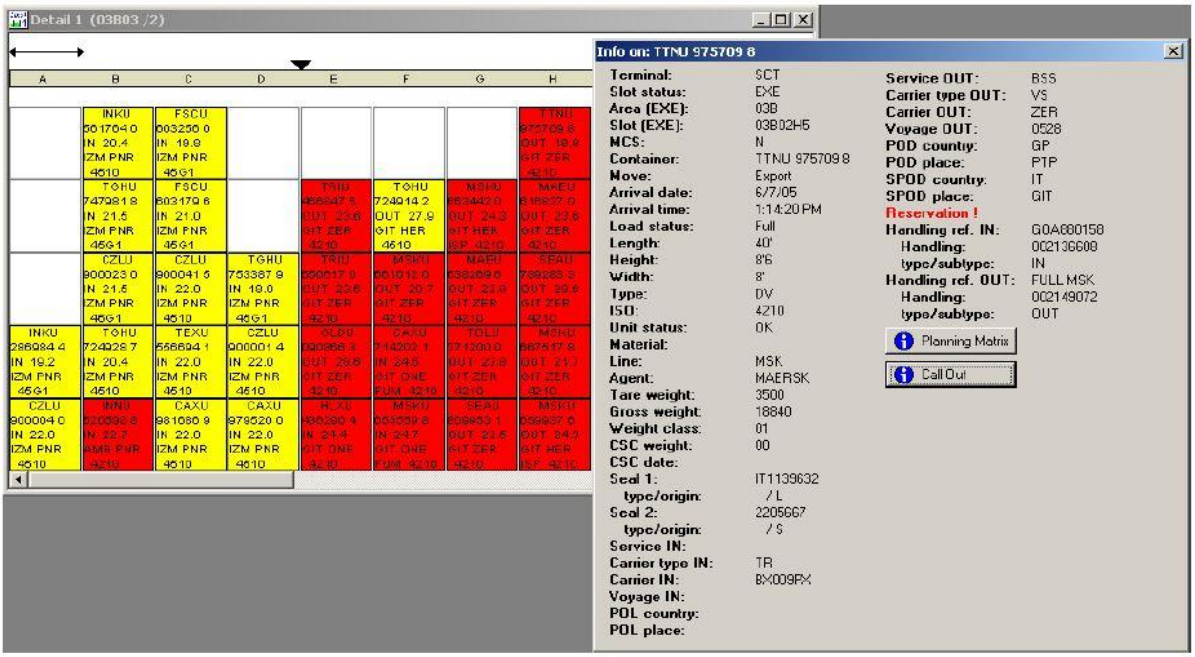

Figure 19 - A graphic interface of the "Yard" software application

Vessel

Through the "Vessel" application, the Terminal Operator has the possibility to check in real time the expected dates of arrival at the Port of all the ships belonging to the shipping companies operating in the Container Terminal of the Port of Salerno. Integrated with the other applications, specifically the "Yard", which manage the Terminal's equipment and the execution times of the various activities, "Vessel" is also able to provide support to the Terminal Operator on the best dock position for the specific ship arriving. It minimises the number of cranes to be associated with that ship, and optimises the sequence of quayside operations to carry out the loading/unloading process of the goods.

Terminal Monitoring

SCT it is able to control the execution times of the various operations, and any bottlenecks, using the tool "Terminal Monitoring". It allows visualizing the optimal position of all units entering the Terminal to reduce shifts. A tool that can decide what measures to take to optimize processes.

e-Terminal

The "e-Terminal" web application allows the COSMOS system to be opened to the outside world, providing a series of information to accredited users. This is the only way in which Freight Forwarders are connected to the Terminal Container. The main functions are as follows:

- *Consultation of historical data*: it is possible to trace the information relative to a specific container through the number that identifies it, to visualize the relative movements, the customs documents.
- *Order management*: authorized users use "e-Terminal" to create various types of orders (full and empty container picking).

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- *Public Data Visualization*: the "Questions of Approach" and the relative information associated with them, for ships directed to the Terminal Container, can be visualized with appropriate search functions.
- *Reporting*: different types of reports can be generated and saved on a PC.

e-Custom

The "e-Custom" software application, active since March 1, 2014, is based on a real-time link between the AIDA system of the Customs Agency and the COSMOS system of Salerno Container Terminal. Based on this connection, SCT automatically receives all customs information relating to containers landed in its Terminal. If Customs has to carry out checks on a container, it must be placed in the verification area before being released to the final customer. Through this software link, therefore, SCT prepares promptly to carry out the controls, without any -idle time, aligning itself with the assessments of Customs.

GRASP

The COSMOS system integrates the "GRASP" application for remote monitoring of refrigerated containers. It is possible to display parameters such as temperature, humidity, oxygenation, power supply (current, voltage, frequency), and remotely control set-point values. The interface with the COSMOS system is via xml.

The technologies developed within the PortForward project (IoT, Big Data, RFID, Data Mining) enabling this one and other interconnections between the different information systems of private and public subjects that operate along the logistic-port chain, will allow the constant flow of piers of data on which the indicators present in the PAD can be calculated.

5.1.6 Expectations and goals to be addressed by PortForward

During the development of the Task. 1.1 a number of questionnaires were administered to different stakeholders, both private and public, through which it was also investigated the expectations and objectives that could be addressed by PortForward. From the analysis of these, it emerges that one of the main expectations is to overcome the current bureaucratic, regulatory and structural limitations. This could sometimes represent a preliminary and fundamental step to the implementation of the use case and the effective achievement of the objectives set.

With regard to "Terminal Flavio Gioia S.r.l.", a company that carries out the activity of multi-purpose Terminal Operator as a concessionaire in the port of Naples, among the innovations of PortFowrard of greatest interest are the followings that allow the monitoring of: performance, environmental impacts and decision support. Specifically, it would be desirable to implement a dashboard for measuring performance in the port (PortForward Dashboard) connected with the company information system through automatic updating.

From the analysis of the questionnaires, in addition to the economic barriers that could emerge when the implementation of innovations requires the hiring of more staff (such as in the case of Terminal Flavio Gioia S.r.l.), there also others of infrastructural, bureaucratic and technical nature. It is clear that one of the objectives that could be addressedd by PortForwrad is also to address these limitations with the competent authorities, an action complementary to the effective adoption of innovations.

From the questionnaire submitted to the Italian Naval League - Section Salerno, the organization expects that the technical-environmental problems caused by the current conditions of the port

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infrastructure are addressed as a priority and does not consider it possible to pay attention to the implementation of PortForward technologies, without first solving the problems that currently afflict the port. Specifically, in the within of the management of the harbour traffic, with reference to the Port Masucci, the main challenge is to improve the management, overcoming the criticalities that occur in the winter period, in case of wind of Libeccio and Ponente. The port is protected from the north winds (Tramontana and Grecale) by the mountainous profile, while the port infrastructure does not guarantee adequate protection from the wave motion generated by the winds coming from the south (Libeccio and Ponente). This involves both the flooding of the pier and the need to moor boats elsewhere. The authorities have been promising to – make the port safer - for about 40 years, without this being followed up.

Therefore, considering what emerged from the various interviews made, it emerges the need to address the current barriers that have long plagued the ports of Naples and Salerno, in parallel with the implementation of technologies.

5.2 Use Case Description

5.2.1 Summary

The ports of Naples and Salerno are a complex system to which a plurality of subjects with different activities contribute in terms of work organization, execution of production operations and critical profiles of each reality. These two realities, therefore, can ideally be represented as a single large complex and composite company which productivity is given by the activities of individual companies operating in it in different sectors (various goods, containers, ferries, cruises, shipbuilding, construction activities related to port infrastructure, activities related to port operations, provision of various services etc.).

In the ports of Naples and Salerno, "port activities" means all services in the port area, consisting of ones to ships, cargo and passengers-related, and services to such activities. The quality of these port's services and the performances it can offer depend closely by the level and quality of the technology used to manage them. The need to optimize the processes that underlie the activities carried out in the port area, requires the introduction of innovative solutions that can meet the increasing need to reduce management time and operating costs: the main objective is to improve the overall performances of the port.

The use case proposed below concerns the ports of Naples and Salerno, which together with that of Castellammare di Stabia are part of the port system of the Campania Region. The governing institution of the system, as described in the previous paragraphs, is the "Autorità di Sistema Portuale (AdSP) del Mar Tirreno Centrale" (Port Authority System).

In a context where ports are the cornerstone of world trade, for Naples and Salerno the search for continuous improvement in performances is fundamental. The present use case is aimed, through the identification of appropriate technologies, at maintaining a high level of competitiveness of the port. MAR.TE., the lead partner for the use case, will focus on a number of closely interlinked issues, such as:

- Logistics and multimodal relations with the surrounding environment.
- Optimisation of freight management including access to and share of smart information (e.g. expected flows of goods, control phases, etc.) at appropriate levels.

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- Access to data related to the environmental and social impact of port activities on the surrounding areas, with specific regard to densely inhabited areas; reduction of environmental impact through the implementation of appropriate actions and plans.

One of the tools that will be implemented through the "PortForward" project, the multidimensional PortForward Dashboard, will allow a proactive management of the port system and the definition of specific indicators for the monitoring of port performance in different port areas (e.g. Logistics and Port Operations, Socio-economic, etc.). Another technology identified, on which this case of use will be focused, is represented by the Green Scheduler (GS), which provides support to all operators who have to make strategic decisions in the port area, according to strict environmental policies.

5.2.2 Rationale

MAR.TE. will analyse and study the characteristics of the main ports included in "AdSP del Mar Tirreno Centrale", Naples and Salerno, in order to assess the port performances and monitor the relevant aspects for the port community (i.e. terminal operators, shipping lines, forwarders, agents, pilots, users, service providers, port cities and connected communities, etc.). These port stakeholders will be able to access to a platform for the management of administrative and operational processes in the port area in order to automate and optimise the entire logistic chain.

The success of this case study depend-s on the involvement of port operators who provided an accurate perspective on the different activities of the project. This allowed an indispensable feedback to align the expectations and especially the needs of the operators themselves on the implementation of new technologies.

The main criticalities that have emerged from the analysis of the questionnaires administered to stakeholders concern aspects related to bureaucracy and the management of space, which is often reduced. In a terminal like Terminal Flavio Gioia, for example, the criticality is given by the narrowness of the spaces. Unlike a factory, where the work programme is rigid, here the variables are many: from the time of arrival of the ship (it can be delayed due to weather conditions), to customs controls. From here comes the need to equip oneself with a tool that is able, possibly in real time, to monitor operational performance.

For the ports of Naples and Salerno, the elaboration of the present use case will represent the starting point for the achievement of the following objectives:

- Monitoring of port activities, with particular reference to the areas that are considered to be strategic for port competitiveness (social, economic and environmental).
- Improvement of efficiency of operations through real time traceability technologies and stowage plans optimization during the whole load/unload process, with specific regard to roll-on/roll-off cargo.
- Reduction of environmental impact, through the implementation of actions and plans in order to become a low-carbon or even zero-carbon port, consistently with European and national Climate and Decarbonisation Agenda.

The analysis resulting from the data collection of this use case will allow to validate dedicated solutions and modules that will be developed for the implemented technological platform, which is the central element of the project "PortForward".

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5.2.3 Structured description

The ports of Naples and Salerno already use both Intelligent Transport Systems (ITS) and a Port Authority Dashboard (PAD) as a tool for monitoring and proactive managing of the port system. Starting from the analysis of the studies on port, we could define a proposal of a multi-dimensional performance measurement dashboard. In our approach, the topic of port performance measurement could be undoubtedly relevant for the entire port community (i.e. terminal operators, shipping lines, forwarders, agents, pilots, users, service providers, port cities and connected communities, etc.) coordinated by the Port Authority. To develop the proposal PortForward Dashboard (PFD), it is relevant to study the main port characteristics that influence the strategic objectives and performance measurement models such as: the nature of objectives of Port Authorities (i.e. public, private or hybrid); the functions of port (e.g. cargo, passengers, industrial, cruise, etc.).

As has been observed in the introduction, one of the most important freight traffic in the port of Salerno is the Ro-Ro freight transport (car, truck). Similarly, in the local traffic sector (< 20 miles), the port of Naples is the leader, accounting for 50% of Italian traffic. The present case of use is developed taking into account the main logistic processes (Terminal Operation, Consolidation/Distribution, Storage/Warehousing, etc.) taking into account the port performance just described.

In this context, the main stakeholders identified by MAR.TE. in the port of Naples are: “Terminal Flavio Gioia S.p.A”; “GAROLLA S.r.l.”. In the port of Salerno, instead, the following stakeholders have been identified: “Grimaldi Group S.p.A.”, “Salerno Container Terminal S.p.A. (SCT)”, “Salerno Auto Terminal S.r.l. (SAT)”.

In a first step, the involvement of the stakeholders took shape during the visits to the ports of Naples and Salerno, organized by MAR.TE in the context of the PortForward project. In a second step, a questionnaire was -delivered to the main operators involved. The aim of the survey is to gather the needs and expectations from all types of port stakeholders, and how these needs and expectations can be satisfied through the implementation of a “Port of the Future” vision.

The solutions proposed in this use case aim at increasing the competitiveness of the whole logistics sector at local and national level, in the interest of all key players in the maritime industry. In particular, these technologies will promote the introduction of technologies in the maritime industry such as IoT, Big Data, RFID, etc. This will allow operators such as “Terminal Flavio Gioia S.p.A.”, “GAROLLA S.r.l.” and “Grimaldi Group S.p.A.”, to adopt fast and flexible business models, ensuring a high level of service while respecting the environment. In particular, the existing solutions, comprising such systems as Automatic Identification System (AIS), Vessel Traffic Services (VTS) and SafeSeaNet, show that there is a need for setting forth guidelines for and architecture of maritime intelligent transport systems. Solutions, projects and concepts as well as experience gained in creating intelligent transport systems in road transport may be useful in the maritime sector.

For the operators involved in the use case, the project will generate an increase in direct and indirect employment rates linked to port activities. In particular, direct employment will be the result of increased traffic flows and improved intermodality, while indirect employment will be a consequence of the development of satellite activities. The professional figures will also be used for the maintenance, management and supervision of the tools implemented. Some of these figures will be used on a continuous basis, such as management and supervision personnel, while others will be used only occasionally for ordinary or extraordinary maintenance, creating a significant multiplicative employment process.

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5.2.4 Typical assessment procedure and tools/services required

The technologies implemented in the use case require the support of different support tools, depending on their nature. These are heterogeneous technological systems, supported by both innovative and older ones.

One of these is the RFID (Radio Frequency Identification) system which, although not a very recent technology, could be used to support the operation of the Dashboard. It is a system for the automatic identification of objects, animals or people based on the remote reading of information contained in an RFID tag, by using RFID readers. Basically, it records the data related to the traceability of the product, allowing to identify and/or store the same data automatically (Automatic Identifying and Data Capture or even AIDC), through particular electronic devices, called tags or transponders, which exchange data in radio frequency. A reading system interrogates these storage devices, but can also update the information contained; despite its name, a reader (or: "reader") is not only able to read but also to write information.

The RFID system could be an important support tool for the implementation of the Dashboard. The direct, automatically updated link between the RFID, the Dashboard and the organization's information system could allow the electronic tracking of container handling both within the port areas and on port to port journeys to facilitate the informative dialogue with the terminal operators.

The Green Scheduler focuses on the environmental sustainability of port operations and the trade-offs involved with economic and operational objectives.

In order to assess the environmental impact of port activities, it could be monitoring the diffusion and lifting of dust and the emission of airborne pollutants caused by:

- Ships movement and docking;
- Port vehicles during the loading and unloading of goods and handling operations inside the yards;
- Vehicles movements from induced traffic.

The monitoring procedures could be carried out by a network of sensors that sent the data detected to a computer system, in order to elaborate them through a specific software.

The tools to support the implementation of the use case described above are illustrative, not an exhaustive list. During the development activities of the use case it may be necessary to use other tools or services in order to be effectively implemented.

In addition, the evaluation of the results achieved will be an important activity, not only to detect any gaps with regard to the objectives set, but also to highlight areas of optimization and future development.

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6 Port of Magdeburg

6.1 Port Introduction

6.1.1 Port General Information

Today the Port of Magdeburg (TRANS*PORT*WERK Magdeburger Hafen GmbH → TMHG), being the biggest inland port in Central Germany, owns six terminals, which are located at the river Elbe. Some of these terminals (e.g. the Hase-Terminal) are operating as multi-purpose-terminals for the handling of different kinds of goods. The terminals are not located in one closed area. They are embedded as connected single locations in a large industrial area. The following figure gives an impression about the geographical plan of the port structures and the surrounding economical areas.

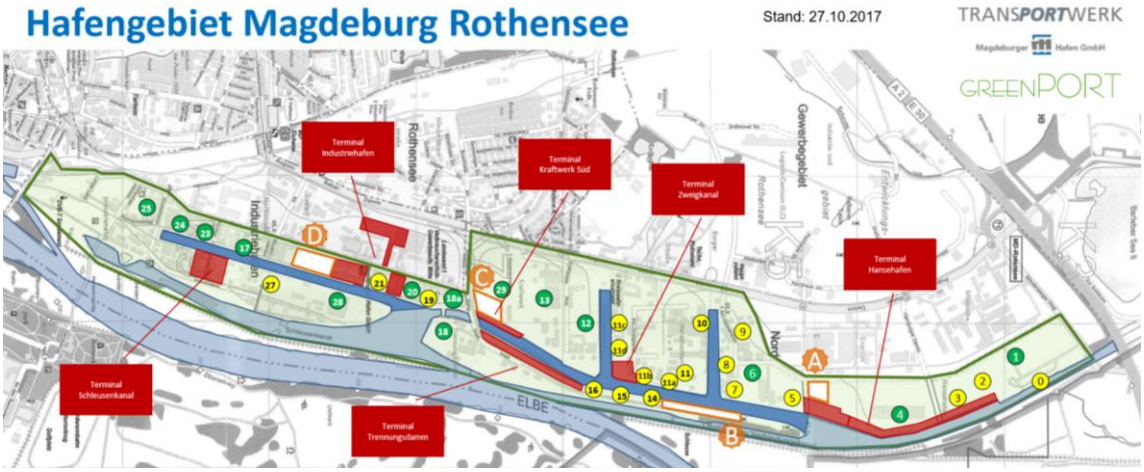

Figure 20 – Overview of the port of Magdeburg

Formerly working on classical port objectives like providing infrastructures and development of port-relevant areas the TMHG today is also a logistic service partner and system provider and manager of multimodal transport logistic chains. This includes handling and storage of various heterogeneous cargo.

6.1.2 Main stakeholders identified

The TMHG runs the port operation and the business on its own responsibility as an independent economic entity.

Beside this there are various stakeholders connected to the port operation on a secondary level, as described in D1.1. For the defined Smart Logistics Use Case of the port especially the following stakeholders are relevant:

1. State capital City of Magdeburg. The TMHG is 95% owned by the City of Magdeburg. Road transportation between the different port terminals takes place on public roads of the city.
2. Suppliers, sub-contractors, service providers. These companies take part in the port services in a supporting role. Their business are positive affected by the port. In the Use Case especially

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external transport service provider and handling service providers (e.g. for heavy-duty cargo) will be affected.

3. The employees of the port are stakeholders, which are also interested in an optimized and sustainable operation of the port. Port employees will mainly interact with the aimed Use Case solutions.

6.1.3 Key port processes

The following processes and services will be addressed by the Use Case (for the complete list of provided services of TMHG, please see D1.1):

General services

- Coordination of traffic (Pick-Up, Delivery) in the dock areas.
- Provision and management of multi-modal transport logistics chains.

Port services

- Handling and Storage of different freights.
  - Container
  - Bulk & Break Bulk (General Cargo)
  - hazardous cargoes
  - heavy duty
- Commissioning of freights.
- Renting and leasing of areas.

Commercial services

- Logistic services – transport of freights from their origin location to the port and transport from the port to their next destination in the hinterland area.
  - Container
  - Bulk & Break Bulk (General Cargo)
  - hazardous cargoes
  - heavy duty

6.1.4 Relevant interactions with hinterland transportation and urban environment

The port of Magdeburg is a hinterland port. One of its primary purposes is the distribution of freights to the seaports and the distribution of freights from the seaports to its hinterland area. In order to fulfil the working tasks which result from this purpose, the port of Magdeburg has established a suitable trimodal infrastructure system. The railway is owned by the port. The road transport to the hinterland

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and external destinations is performed with the support of sub-contractors as well as the in- and outgoing traffic with inland ships.

6.1.5 Main current port systems and data repositories relevant for PortForward

Today a fibre-optic cables system connects all terminals and the port administration. From all relevant locations and working places in the port the employees get access to the company intranet. The operation in the docks, the trimodal freight handling and the communication from the workers in the docks to the employees in the port administration are supported additionally by radio communication solutions. Most terminal sites are equipped with video surveillance systems.

Several working tasks of the locational and operational management are solved with the use of classical office tools. Specific data base solutions support the work of employees in the port administration. A freight management system supported by office tools and company-specific database solutions is in use.

Furthermore, a maintenance system supporting a Lifecycle monitoring of the facilities, the infrastructures and the operating equipment gives a holistic view to the actual state of the port and the necessary maintenance activities in the future.

A traffic controlling system gives report about the in- and outgoing vessels. The system works also autonomously. Because of this, the responsible operators have a full overview about the in- and outgoing traffic.

6.1.6 Expectations and goals to be addressed by PortForward

Economic expectations and goals

The results of the PortForward project are intended to increase the efficiency of the production and logistics concepts at the Port of Magdeburg. The term production stands for port handling operations. The implementation of novel technology solutions, as they are planned in PortForward, should also lead to efficiency increases and cost reductions, as well as to qualitative improvement in the handling and operating processes.

The handling of general cargo has a special significance for the TMHG from an economic point of view. Because of that, these processes shall be focused within PortForward. The Port of Magdeburg expects to achieve improvements in efficiency and quality through targeted technology developments, especially in this segment.

Environmental expectations and goals

The Port of Magdeburg integrated the term "GREENPORT" in the company logo. It has incorporated the ecological design of the location and the operational processes into the mission statement of the company. The port hopes that PortForward supports this fundamental concern of the company. Based on that the Use Case shall support the improvement of resource and energy efficiency in the production and logistics processes.

Social expectations and goals

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The integration of innovative and state-of-the-art technologies is an integral part of the mission statement and long-term strategy of the Port of Magdeburg. In addition to improvements in the production and logistics concepts, the port expects positive effects for the social environment and the general working environment of the port location.

The port wants to offer a modern work environment with effective tools to its employees. As the port processes are mainly connected to physical stress and stress based on the complexity of single operations, innovative solutions, like in PortForward, shall assist the employees as also facilitate and increase the satisfaction and identification of employees with their work.

6.2 Use Case Description

Two different Smart Logistics use cases are planned for the Port of Magdeburg and will be further described below. These use cases will be based on IoT- and camera-based data gathering in different port environments and address:

- the monitoring of defined multi-purpose storage areas to automatically document their occupancy and the handled goods.
- the monitoring of external transportation traffics (on public roads) between the different terminals of the port as data basis for a future slot management.

Both use case applications shall be integrated into the virtual port model by implementing the port specific digital twin. By that, process related real-time data will be directly entered into the digital and virtual model of the port.

6.2.1 Summary

Context

As described in 6.1.1 many terminals of the Port of Magdeburg are operated as multi-purpose terminals. The different terminal areas as also additional warehouses are connected via public roads, the port-own railway and the inland waterway. Especially the terminals designated to general cargo are used for the handling and storage of very heterogeneous goods – e.g. in the Hanse-Terminal general cargo ranging from single pallets, to ISO containers, to heavy duty cargo and dangerous goods. All these goods are handled and stored in a shared terminal area. For that reason it is not feasible to define designated storage areas as these are used highly dynamic.

Because of the distribution of the different terminals and warehouse within the port area there is the additional challenge to track and trace especially the traffic of external truck shipping companies. The truck drivers are currently told to which terminals they should drive, but there is no control of the actual truck movements.

Scenario assumptions

- Multi-purpose usage of indoor and outdoor storage areas.
- Distributed delivery and pick-up traffics between the different terminals.
- Gathering sensor data of the current processes (monitoring) in the handling and storage areas can improve the respective processes and the process planning.

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Measures and technologies involved

- Measuring area occupancy of the storage area with camera systems and image analysis.
- Localization of handling operations (storage / retrieval) (camera based / GNSS based). connected with identification of stored good (e.g. barcode scanning of delivery notes).
- Localization of external vehicles in transport traffic between terminal (GNSS based).
- Relation to the spatial model and the process model of the digital twin for localized objects and processes as also of occupancy measurement.

6.2.2 Rationale

In the sense of 'Smart Logistics', the optimization of storage operation in port terminals as well as the traffic management between individual terminals are typical core problems of ports. These are addressed accordingly by the two targeted applications. For the sensor-technical recording of the storage conditions in the port of Magdeburg, there is an increased complexity due to the strong mixed use with highly heterogeneous logistics objects as well as high dynamics, which prevent a fixed assignment of defined storage areas. The creation of a sensor-based occupancy monitoring of storage areas thus offers potential added value for port terminals with mixed use, which is often found in smaller ports and inland ports.

The application for tracking road traffic between different terminal areas is in principle a relevant topic for all ports. For the use case of the Port of Magdeburg, the port-individual implementation on the basis of existing processes is in the foreground. Implementation of this application involves an analysis of existing approaches in other ports as well as other nodes with similar issues (e.g. automotive plants). For the implementation in Magdeburg, the use of IoT sensor modules will be focused in order to demonstrate and evaluate the technical potential of the IoT for the traffic monitoring. In addition to the benefits for the port, the IoT-based monitoring also generates effects for the public traffic in the area of the port.

Integrating both applications into the virtual port model and the digital twin, the data of the use cases will provide relevant inputs to the Decision Support System which will provide recommendations on different time scales:

- real-time DS: supporting operational processes, e.g. in cargo handling.
- short-time DS: supporting process planning, e.g. scheduling of handling processes.
- long-time DS: supporting strategical and structural planning, e.g. investment into new resources.

6.2.3 Structured description

	Use Case **Storage Area Monitoring**	**Use Case** **Inter-Terminal Truck Traffic Monitoring**
Decision Makers / Stakeholders	- Port of Magdeburg	- Port of Magdeburg - Transportation service providers

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		- City of Magdeburg (public roads)
Motivations	- Multi-purpose usage of storage areas - Handling of heterogeneous general cargo with referring requirement of dynamic usage of storage areas - Currently often not efficient utilisation of storage areas / no seamless identification of goods and storage locations often causing efforts for searching goods	- Currently no monitoring oft ruck traffics between terminals causing inefficiencies in scheduling handling operations
Expected Improvements	- Optimization of storage area utilization and reduction of search efforts	- Optimization of the slot management (reduction of waiting times and better scheduling of handling operations) - Reduction / optimization of traffic between terminals
Quantitative Parameters	- Degree of area utilization - Rate of handling operation per object - Search efforts - …	- Time of truck in terminal (including waiting time) - Traffic between terminal - …
Qualitative Parameters	- tbd	- reduction of traffic between terminals - …
Possible Side Effects	- tbd	- tbd
Restrictions	- Consideration of cargo specific requirements (e.g. dangerous goods / heavy-duty cargo) - Spatial and process restrictions based on the existing infrastructure and equipment	- Agreement of external trucking companies for tracking of trips between the terminals → to be clarified - …
Cost Estimates	- tbd	- tbd

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6.2.4 Typical assessment procedure and tools/services required

For the implementation of the use cases, the procurement and integration of sensor systems in the port environment is required. These will be connected to the individual subsystems according to the PortForward architecture under development.

At the same time it will be examined to what extent the camera systems available in the Saxony-Anhalt Galileo Test Bed can be used in the Hanseterminal for the defined applications. In particular, an examination of the available image qualities is required here for the purpose of image-based storage area monitoring.

For the evaluation of the use cases the quantitative and qualitative parameters mentioned in section 6.2.3 are relevant.

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7 Conclusions

This report has presented the analysis of the use cases that are proposed to be developed in the ports participating in PortForward project. This work has involved a deeper analysis of the end users' expectations and needs that had already been captured within deliverable D1.1 through different activities, including technical visits to the ports and dedicated meetings and focus groups with key port stakeholders. The process of collecting additional feedback from external stakeholders through an online questionnaire is still ongoing, and will be later incorporated into the PortForward framework specification, and use case impact assessment methodology definition processes. Thus, this external feedback will contribute to ensuring further scalability and replicability of PortForward framework for its application in other port scenarios.

Each of the use cases proposed will allow testing and validation of different architectural components, services, and interfaces of the PortForward framework, applied to different usage scenarios and port processes, with the involvement of several categories of stakeholders and interacting with multiple legacy port systems and data repositories. Expectations, needs and business goals of PortForward ecosystem were gathered and harmonized. The specific restrictions and requirements of the different use cases were identify. These will influence the development of PortForward ecosystem and the experimental activities to be carried out for its validation.

Hence, the combination of all use cases will enable a complete validation of all PortForward framework components and services, and the capabilities of this framework to integrate with heterogeneous port legacy systems and processes. Basing on the use case analysis carried out, the specifications of the PortForward framework will be defined, consisting on one hand on the specification of the technical requirements, and on the other hand on the definition of the PortForward KPIs. These two activities will in turn guide the technical development of the PortForward architecture, components, and services, and their subsequent testing and validation in the ports participating in the project, according to the interaction scenarios that have been defined in the corresponding use cases.

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