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PortForward

Use Cases set up report

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Abbreviations

AdSP MTC	Autorità di Sistema Portuale del Mar Tirreno Centrale
AdSP MTS	Autorità di Sistema Portuale del Mar Tirreno Settentrionale
AIS	Automatic Identification System
APB	Port Authority of Baleares
API	Application Programming Interface
AR	Augmented Reality
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
GYS	Green Yard Scheduling
HTTP	Hyper Text Transfer Protocol
ICT	Information and Communication Technologies
IMV	Internal Movement Vehicles
IoT	Internet of Things
IP	Internet Protocol
IT	Information Technology
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LPWAN	Low-Power Wide Area Network
MSC	Mediterranean Shipping Company
PA	Port Authority
PAD	Port Authority Dashboard
PDB	Ports de Balears (Port Authority of Balearic Islands)
PF	PortForward
R/S	Reach Staker
RO-RO	Roll-on/Roll-off
RTG	Rubber Tyred Gantry Crane
TEU	Twenty-foot equivalent
TOS	Terminal Operating System
TPCS	Tuscan Port Community System
TRL	Technology Readiness Level
UC	Use Case
VTS	Vessel Traffic Service
WP	Work Package
WTO	World Trade Organization

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Executive Summary

One of the main objectives of WP7 is to create an evaluation system to demonstrate the impact that the implementation of the PortForward project technologies has on port processes. WP7 activities aim to verify the effectiveness and efficiency in real environments of the technologies developed in the laboratory. Possible corrective actions will be implemented so that each tool reaches the level of technological maturity TRL 6, as foreseen in the Work Package 7.

MARTE created an Excel tool - the Evaluation Tool - to support the application of the methodological approach developed for WP7. It has the objective to backing and keep consistent the activities put in place to test the impact of the technologies. In other words, the Evaluation Tool can guide the different phases of the testing activities by collecting the key information in a standard way for all of the nine Use Cases.

This report introduces the Evaluation Tool, which, in this phase of the project, aims at collecting information about the objectives, the metrics for measuring the impact of technologies and the frequency of these measurements. According to the information indicated in the deliverables D1.2 and D1.3 of the project, the objectives of each Use Case will be selected from a list conveniently indicated in the methodological approach (deliverable 7.1). The definition of a shortlist of objectives will facilitate - in the following activity of WP7 (Task 7.3) - the comparison between the different Use Cases. Once the objectives have been identified, quantitative and qualitative metrics have to be selected in order to assess the impact of new technologies in a clear and measurable manner. It is important to underline that at this phase of the project the KPIs defined should not measure the performance related to port activities but only the impact of new technologies, in terms of effectiveness and efficiency. For each of the metrics, the report will provide the measurement plan that will be applied during the testing phase in the relevant environment. The measurements will allow the continuous comparison between the technology providers and the users, in order to verify the degree of satisfaction with the objectives achieved in view of those set.

Ultimately, the activities reported in this deliverable will standardize the evaluation process of Use Cases, allowing, during the subsequent tasks, a comparative analysis among the nine Use Cases foreseen by the PortForward project. At the same time, the information collected in this report will be critical to guide the next testing phase.

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1 Introduction and PortForward context

WP7 coincides with the phase 3 of the project "Demonstration Activities". It implyes implementation, integration and testing of PortForward tools in a real contexts.

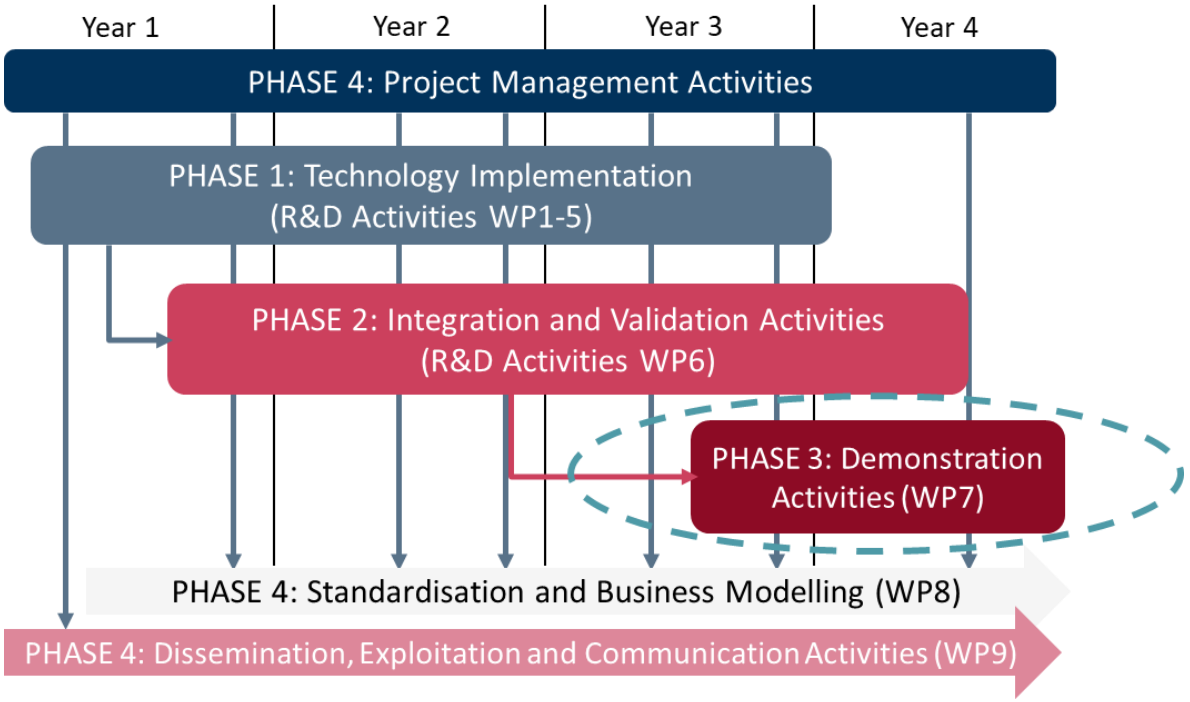

Figure 1 - Project phases

PortForward foresees 9 Use Cases to test as many technologies involving ports or groups of ports:

- Use Case 1 (UC1) – Ports of Baleares
- Use Case 2 (UC2) – Ports of Baleares
- Use Case 3 (UC3) – Ports of Baleares
- Use Case 4 (UC4) – Port of Vigo
- Use Case 5 (UC5) – Ports of Livorno and Piombino
- Use Case 6 (UC6) – Ports of Livorno and Piombino
- Use Case 7 (UC7) – Ports of Naples and Salerno
- Use Case 8 (UC8) – Port of Magdeburg
- Use Case 9 (UC9) – Port of Magdeburg

Each of them has been thought to analyse the impact of a specific technological solution designed to improve port processes. Them have been described in the analysis carried out in deliverable D1.2 "Use Case restrictions & requirements". Therefore, the description of Use Cases, reported in deliverable 1.2, represents the starting point for the definition of the technical specifications and realization of Use Cases in WP7 (Figure 2).

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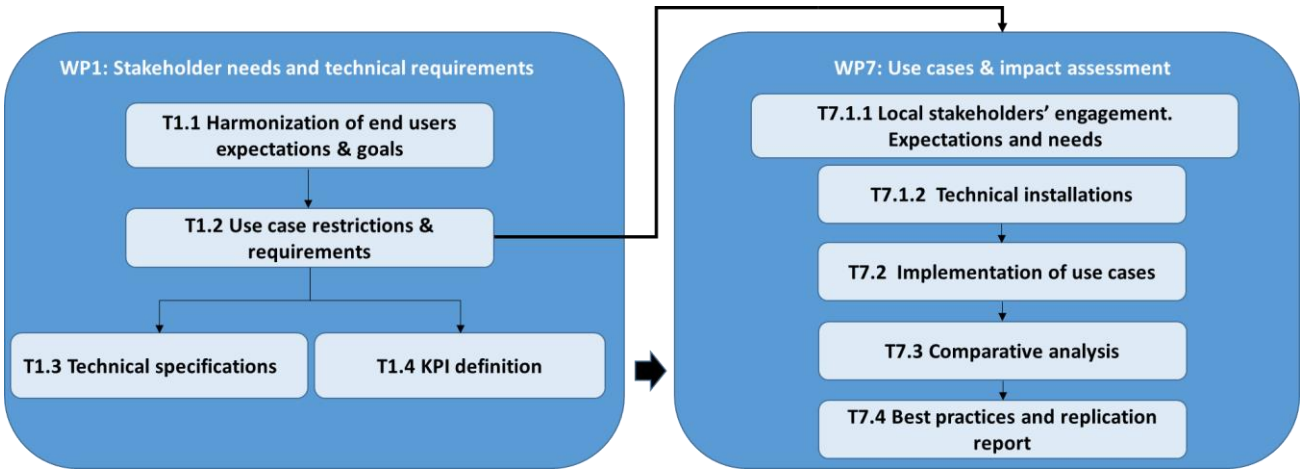

Figure 2 - Relationship between WP1 tasks and WP7

The objective of WP7 is to create an evaluation system that allows to demonstrate the impact that the implementation of new technologies has on processes in the port area. The procedure aims at verifying the requirements of the technologies developed by technological partners in real contexts in order to support any eventual corrective action. The key goal is to let each PF tool achieve the level of technological maturity TRL 6[1]. Therefore, it will be fundamental the collaboration of Port Authorities both in the testing phase and in the analysis of the results in order to identify lesson learned. It will provide the requirements for the development and optimization of the tools that will be subsequently proposed on the market.

The phases of the proposed methodology are the main subject of the WP7 activities listed below:

- Task 7.1 "Methodology and research framework" divided into two complementary sub task:
  - Task 7.1.1 "Local stakeholders' engagement. Expectations and needs" and
  - Task 7.1.2 "Technical installations";
- Task 7.2 "Implementation of Use Cases";
- Task 7.3 "Comparative analysis";
- Task 7.4 "Best practices and replication report".

Task 7.1.1 has been already completed and it led to the elaboration of D7.1 "Use Case requirements and evaluation metrics". This report contains a description of the methodology and the main tools for the collection and analysis of the data that will be adopted.

Task 7.1.2, to which this deliverable D7.2 "Use Case setup report" refers, concerns the development and application of the first step of the methodological approach. For each Use Case, the project partners described the Use Case objectives and defined the evaluation metrics to evaluate the extent of the achievement of these objectives. The following tasks continue in the application of the

[1] A high-fidelity system prototype that adequately addresses all critical scalability issues is operated in a relevant environment to demonstrate operations under critical environmental conditions (TRL 6).

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evaluation framework through the development of activities more focused on data collection and analysis. In particular:

- Task 7.2 concerns the description of the implementation of the Use Cases.The technical partners will evaluate a set of items into a structured check list to identify the status of the development of the technology, as well as to describe the environment where it will be introduced. These activities will support the analysis of the Technical Readiness Level (TRL) of what have been developed so far.
- Task 7.3 consists of the administration of the questionnaires for the evaluation of qualitative aspects related to customer satisfaction. Based on the information collected and the analysis of the evaluation metrics for measuring the expected results, a comparative analysis is carried out.
- In the end, the task 7.4 based on the results from the comparative analysis, will provide mapping of Use Cases, lesson learned of each Use Case and drill down of the best case.

1.1 Structure of the report

The deliverable D7.2 "Use Case setup report" is the output of the T7.1.2 "Technical installations". It corresponds to the second out of five WP7 deliverables. It is important to underline that this is the first deliverable after the COVID 19 outbreak. Thus a paragraph about the impact of the world wide infection on ports and maritime industry has been introduced (Paragraph 1.2)

This task marks the beginning of the application of the evaluation methodology described in deliverable D7.1 whose first steps are the identification of the key goals and the definition of the evaluation parameters and the scheduling of the measurements (Figure 3).

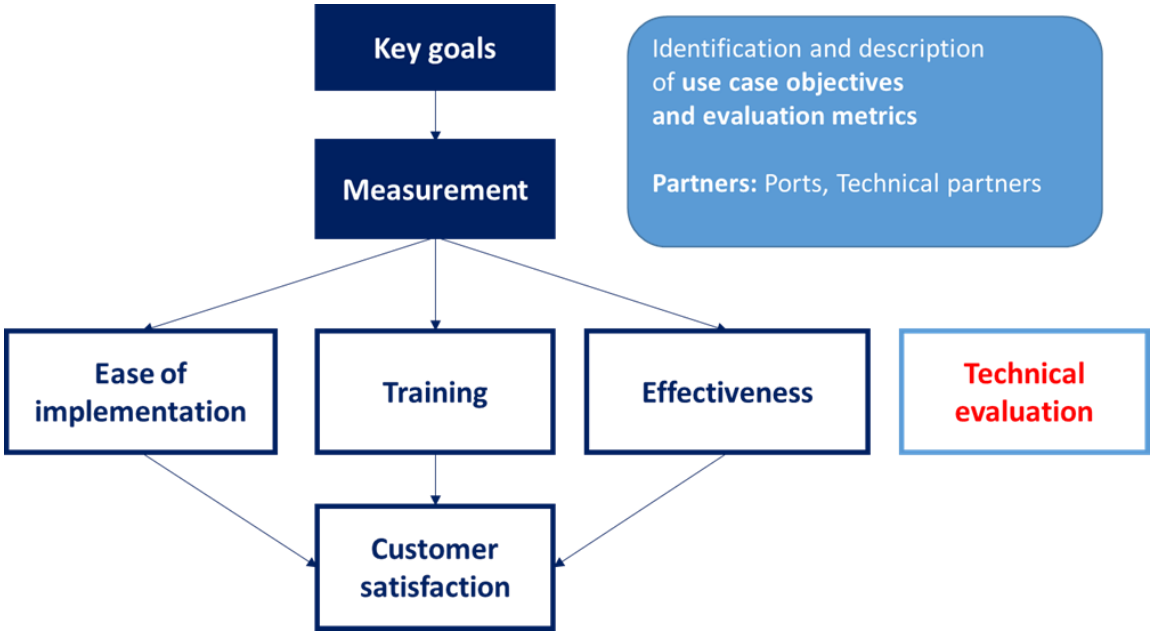

Figure 3 – D7.2 Use Cases set up report

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In the first part of the report for each Use Case will be defined:

- the objectives to be achieved through the adoption of the chosen technology;
- the main parameters in order to assess the level of achievement of results during the development of the PF tools;
- the plan to collect measures of identified KPIs..

The report includes 12 chapters. The chapter 2 contains a brief recall to the methodology and description of its application for the identification and description of the Use Case objectives and evaluation metrics. The contents of this section will be guidelines for reading and understanding the following chapters.

Chapters 3 to 11 contain the data related to each Use Case. They present the same structure, which consists of the following subsections:

- *Use Case number "x": Title*. A summary of the information reported in deliverable D1.2 and the main elements that characterize each Use Case (Background, Processes, Stakeholders, PortForward tools).
- *Use Case objectives*. The identification of the stakeholders needs translated into Use Case objectives. They will be classified with respect to the different categories, each of them identifying the need from which the investment originates ("Strategic", "Informational", "Transactional", "Transformational", "Organizational", "Operational", "IT infrastructure", "Managerial" , "Others").
- *Definition of evaluation metrics.* A measurement system that ensures the continuous alignment of the proposed technological solution with the expectations of the Port Authority/Company. Therefore, the project partners will develop specific metrics for the monitoring and the evaluation of the Use Cases. The Key Performance Indicators (KPIs) may be of a quantitative or qualitative nature.
- *Measurement plan.* A table showing the type of metrics adopted and the time of detection. For each metric the result (ex-ante and ex-post), timing and frequency of the measurement process will be reported. In addition, the project partners will be describe the method of measurement and the source of the data.

In the end, chapter 12 reports a brief reference to the deliverable objective and the considerations on the data collected and inserted in the two sections of the evaluation tool.

1.2 First assessment of COVID-19 impact on the project implementation

The coronavirus epidemic (COVID-19) represents an unprecedented threat to the global economy. The diffusion of the infection has generated an immediate crisis in global demand that has dramatically affected all sectors, including maritime transport. Data provided by the World Trade

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Organization[2] (WTO) predict that for the year 2020 international trade in goods will be reduced in a range between 13% and 32%. Inevitably, downturn of trade patterns will have an impact on maritime transport as shipping accounts for about 85% of the international world's trade in goods.

Ever since the epidemic outbreak, authoritative entities and associations at European and national level (all over Europe) have published interesting studies assessing the economic implications of the state of emergency in the shipping sector. The experts in the sector, members of PortEconomics[3], Professor Theo Notteboom and Professor Thanos Pallis, have realized a weekly "Port Economic Impact Barometer" to assess the economic implications of the state of emergency in the maritime transport. The barometer consists of a dashboard that provides a visual summary of the results collected through the administration of a questionnaire. The survey contains six questions periodically submitted to Port Authorities and port operators around the world every week. The percentages indicated by the blue bars in Figure 4 show the level of impact of COVID-19 contagion during the period from April 6th to June 7th 2020. ***The values on the picture show the decrease as a percentage of the turnover of the item analysed compared to the same period of the previous year***.

The values show that the passenger market is the most affected one by the COVID-19 emergency. The outbreak of the pandemic has drastically reduced the number of passenger's vessels. This has caused damages above all to the segment of the ferries and the cruise ships with the total or partial cancellation - in many Countries - of the port calls foreseen also for the summer season. Compared to the same period of last year, from week 15 (6 - 12 April) passenger ship calls fell by more than 70% (except for week 20, which fell by 68%). The peak (-85%) was recorded in week 19 (4 - 10 May). For the year 2020, in the cruise sector, is estimated a loss of 70% to 80% of total passengers with a significant impact on the tourism sector.

Container traffic also decreased consistently in the sample under the analysis of PortEconomics. In this regard, due to the uncertainty of virus evolution and recovery processes in countries, the company Drewry Shipping has published a study in which it sets three scenarios differing in the timing of the economic recovery. The "base scenario", to which Drewry attributes the higher probability (50%), foresees for 2020 a reduction of the container handling in the world by 0.5%, equal to about **4 million TEU** (the global throughput has been of 801 million TEU). Supply chain disruptions, reduced demand and global economic uncertainty will imply this reduction in traffic. The starting assumption is that the peak of the virus around the world will occur during the second and third quarters of 2020 while the global economy only starts to recover in the last three months of the year.

[2] The World Trade Organization (WTO) is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to ensure that trade flows as smoothly, predictably and freely as possible.

[3] PortEconomics is a web-based initiative aiming at generating knowledge about seaports. It is developed and empowered by the members of the PortEconomics group, that are actively involved in academic and contract research in port economics, management, and policy. The teaching activities of the participating scholars include specialized courses on port economics management, planning and policy.

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	Week 15 World April 6	Week 16 World April 13	Week 17 World April 20	Week 18 World April 27	Week 19 World May 5	Week 20 World May 12	Week 21 World May 19	Week 23 World June 2
Container vessels	41%	41%	53%	39%	45%	43%	53%	45%
Other cargo vessels	41%	39%	47%	44%	42%	46%	51%	42%
Passenger vessels	77%	77%	76%	71%	85%	68%	73%	74%
Trucks (cross-border)	43%	41%	35%	37%	38%	26%	28%	23%
Trucks (in/out port)	37%	33%	35%	35%	16%	15%	23%	8%
Rail services	28%	21%	32%	13%	22%	17%	19%	14%
Inland barge services	41%	23%	40%	21%	19%	21%	20%	20%
Foodstuff & medical supplies	35%	34%	33%	25%	25%	20%	14%	16%
Consumer products	27%	28%	25%	18%	19%	9%	12%	13%
Liquid bulk	21%	22%	20%	15%	20%	17%	13%	17%
Dry bulk	16%	17%	13%	12%	17%	13%	10%	9%
Dock workers	16%	16%	16%	22%	19%	17%	16%	13%
Technical-nautical services	7%	9%	4%	12%	11%	6%	8%	7%
Harbor master services	4%	8%	7%	10%	4%	8%	10%	5%
Port authority	28%	22%	22%	26%	16%	22%	12%	12%
Truck drivers	no data	no data	21%	16%	12%	9%	11%	10%

Figure 4 - Port Economic Impact Barometer Dashboard

One phenomenon increasing during this period, which has negatively affected the container industry globally, is the cancellation of services and routes by shipping companies (i.e. “blank sailing”). Blank sailing has mainly affected trade routes with the Far East, where the pandemic originated. “About 39% of the ports in that area are reporting that the number of container vessel calls fell from 5 to 25% compared to a normal situation”. (Source: Port Economic Impact Barometer). In such a scenario, European ports will face several challenges. Primarily, the misalignment between supply and demand that will lead to overcapacity in container terminals will have to be addressed because the volumes (and especially the growth path) of demand that was assumed before the COVID-19 will not materialise.

Moreover, the Covid-19 emergency, especially in the first phase of the pandemic, highlighted the strategic role that ports play in ensuring the continuity of the supply chains of essential goods for the community, businesses and operators. For this reason, ports are implementing new levels of governance organisation. Most of them have set up committees to monitor developments in the crisis and propose guidelines to try to limit the impact of the “Corona virus” as much as possible. Some ports have ceased providing services considered non-essential to prioritise and ensure the continuity of their core port activities (e.g. maritime access, docking and cargo operations) and in the mean time reduce the exposition of workers to risks of infection.

The pandemic has also clearly affected the activities of the PortForward project as the partners had to reorganise their operating procedures by the virus containment measures imposed by their respective governments. In particular, the pandemic has changed the priorities of port partners and it has generated both decisional and operational difficulties (due to the limited interaction modalities) that will affect the project demonstration phase. This phase of the project includes testing of technologies at port sites, which, as mentioned above, may be subject to changes and delays.

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A very interesting aspect, which come out during the of emergency, concerns the need to give a new impulse to the process of digitisation of the port sector. In this sense, this unexpected scenario confirms the importance of the PortForward project, offering starting points to think about new technological solutions to support ports in carrying out mitigation and resilience actions in emergency management.

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2 Implementation of the methodological approach

The execution of WP7 marks the beginning of phase 3 "Demonstration activities" of the PortForward project. As established in the project, the technologies will be demonstrated in relevant environment (Technology Readiness Level 6 – TRL 6). Therefore, the main objectives of the WP7 are to run experimental activities in real settings related to different typologies of port operations and to assess the development process of the Use Cases and achieved results. To this end, the methodology, elaborated and applied within WP7, evaluates the development process of each Use Case in order to highlight any critical issues and engage the corrective actions in order to ensure its success.

The methodology takes into account:

- the different types of technologies implemented in each Use Case, essentially software solutions;
- the main aspects to be assessed in relation to these technologies in order to ensure their success during the implementation process and in the learning and use phases.

The model is based on a revised version of ISO/IEC 9126 (E., Colonese, 2006) which defines quality standards for the production of new software. The technical standard reports the quality characteristics of the software and the metrics for the evaluation of these characteristics. It comprises four sections:

1. quality model;
2. external metrics;
3. internal metrics;
4. quality in use metrics.

In a software project, the quality characteristics of the software and the metrics for its evaluation defined within ISO/IEC 9126 facilitate common understanding objectives and goals. It can be used by purchasers, developers, auditors, quality assurance personnel, from different perspectives and for various purposes, such as for example for the definition of software quality requirements in technical specifications and the elaboration of technical offers produced in response to customer requests. Figure 5 shows the methodology proposed in WP7.

The methodology consists of three main sequential stages.

The first phase, to which this report refers, involves the following two activities:

1. the identification and description of the Use Case objectives ("**Key goals**" - Figure 5);
2. the definition of key performance indicators to measure the intermediate and final results achieved, also specifying the timing and frequency of the measurements ("**Measurement**" - Figure 5).

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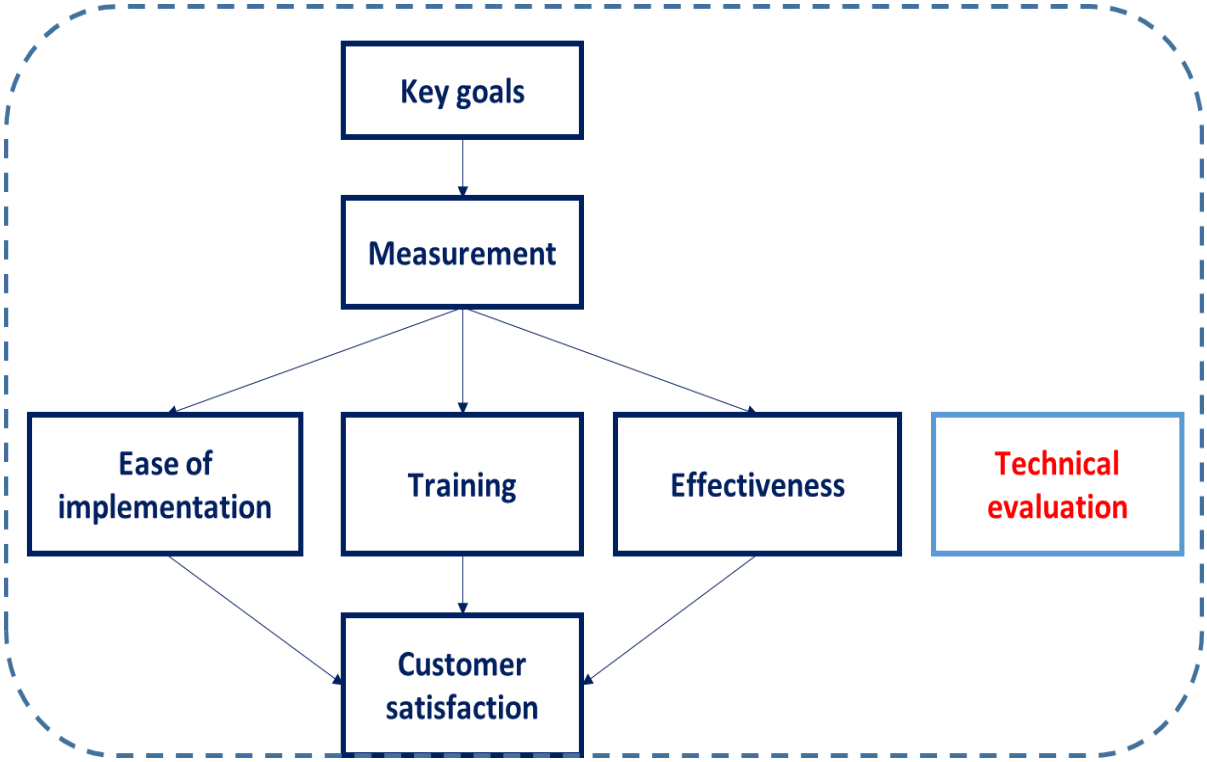

Figure 5 - Methodological approach

The analysis of the information reported in the deliverables D1.2 "Use Case restrictions & requirements" and D1.3 "Technical requirements specification" is essential for the execution of these activities. For each of the nine Use Cases, the deliverable D1.2 includes the Use Case description, the main assumptions regarding current port operations, systems, data and stakeholders involved within the Use Case. While the D1.3 contains a comprehensive overview on technical requirements by the Use Cases. Based on these analyses, each project partner identify the Use Case data. These elements are:

- background;
- processes;
- stakeholders who will be directly involved in the development of the Use Case (key actors) and those who will be the potential users;
- the actors who will be responsible for implementing and providing the technology (Technical partners);
- PortForward Tool (description of technologies).

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They are the data that uniquely identify each Use Case. The methodology proposes a classification of the Use Case objectives with respect to the nine categories indicated in Table 1 below.

Table 1 - Classification of the Use Case objectives

Strategic	To acquire a new competitive advantage through the adoption of ICT systems that ensure the alignment between operational level and business strategy
Informational	To allow quick and easy access to data and ensure the accuracy of information
Transactional	To reduce operational and communication costs by, for example, installing advanced technologies, web servers and data storage servers
Transformational	To equip itself with new technologies to meet the needs dictated by new processes (change management or business process reengineering)
Organizational	To reorganize the work model or to increase the morale and satisfaction of employees with the business objectives of the organization
Operational	To optimize the execution of activities reducing time and resources employed
IT infrastructure	To increase the resources already in use (pure ICT investment)
Managerial	To improve the monitoring and management of processes at the managerial level
Others	This includes actions not covered by the remaining categories, such as investments in ICT systems based on the need to upgrade the systems in use, etc.

Source: Saleem et al. 2017

Based on the information listed above, each partner, responsible for its own Use Case, will indicate the type of objective it intends to achieve.

This classification of objectives can support a shared understanding between providers and users of the technology and it can facilitate lean decision-making processes during the design and installation of technological system.

Each partner will insert Use Case data and objective categories in Sheet 1 of the evaluation tool (Excel tool) created for each Use Case (Table 2). It will be reported in the paragraph “Use Case objectives” for each Use Case.

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Table 2 – Use Case data (UC7)

Use Case title	**Monitoring of port performance in different port areas**
Key Actors	Port Authority of Naples/Salerno
Stakeholders	Coast Guard, Terminal operators, Shipping companies, Customs office
Technical Partners	MARTE
Objectives	Informational Operational Managerial

The second activity consists of the definition of a system of metrics to measure the level of achievement of the set objectives. The measurement system ensures the continuous alignment of the proposed technological solution with the expectations of the Port Authority/Company.

In deliverables 1.2 and 1.3 the project partners have already partly identified and described the process aspects and related metrics they intend to evaluate. Therefore, in this phase of the project each partner can replace, integrate or validate the list of key performance indicators previously identified. Moreover, each partner, responsible for its own Use Case, will develop a table showing the metrics adopted and the timing of detection (Table 3). Each partner will insert the data in the Table 3 of the Sheet 1 of the evaluation tool.

Table 3 - Measurement plan

KPI name		Time of Measurement		Frequency of Measurement
		Ex Ante	Ex Post	
1	KPI $^{UCx}{}_{1}$			
2	KPI $^{UCx}{}_{2}$			
3	KPI $^{UCx}{}_{3}$			
4	KPI $^{UCx}{}_{4}$			
5	KPI $^{UCx}{}_{5}$			
6	KPI $^{UCx}{}_{6}$			
7	KPI $^{UCx}{}_{7}$			
8	KPI $^{UCx}{}_{8}$			
9	KPI $^{UCx}{}_{9}$			
10	KPI $^{UCx}{}_{10}$			

Then for each metric, the results (ex-ante and ex-post) and frequency of the measurement process will be reported (Table 4). Each partner will insert the data in the Table 4 of the Sheet 2 of Evaluation tool. In addition, the method of measurement and the source of the data will be described.

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Table 4 - Evaluation metrics

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
KPI UCx 1	*value*	*value*	*value*	*value*	0
KPI UCx 2					0
KPI UCx 3					0
KPI UCx 4					0
KPI UCx 5					0
KPI UCx 6					0
KPI UCx 7					0
KPI UCx 8					0
KPI UCx 9					0
KPI UCx 10					0

The Table 3 and Table 4 will be reported in the paragraph "Measurement plan" for each Use Case. After the setting phase (Use Case data, Use Case objectives, Evaluation metrics), the second stage of the methodology begins. The object of the second phase is the evaluation of the Use Case from the customer and the provider point of view. According to the proposed model, from the customer's point of view, questionnaires will be administered in order to detect the perception that the customer has of the technology with respect to the following three dimensions of analysis[4]:

- Ease of implementation. It evaluates the characteristics and specifications of the technology related to the installation and its use;
- Training adequacy. It assesses the adequacy and effectiveness of training activities in order to enable users to employ the technology;
- Effectiveness. It considers the aspects related to the functionality of the system.

To these is added a fourth questionnaire on the customer satisfaction developed in order to detect the overall degree of satisfaction of technology, also taking into account the individual factors considered in the three dimensions of analysis (ease of implementation, training adequacy and efficiency solution).

The questionnaires include two sections. The first section requests some information about the respondent (e.g. organization, role, possible years of experience in the IT sector). The second section contains a list of questions for the respondent. He can answer by marking one score on a 5-point

[4] The dimensions of analysis identified are associated with the different types of quality identified in ISO/IEC 9126 (internal, external, in use). The dimension "ease of implementation" can be, for example, associated with "external quality", while the dimension "effectiveness" can be associated with both "external quality" and "quality of use.

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rating scale (1 = low, 5 = high). These items will focus aspects of the analysis and measurement that are transversal to all technologies and processes involved in the different Use Cases.

According to the proposed model, from the provider's point of view each technical partner will elaborate an assessment of the state of the art of the technologies and infrastructures used in the execution of the process(es) to be improved. They will identify aspects such as, for example, robustness, reliability, maintainability. The technical evaluation can be associated with the "internal quality" of the new solution proposed for each Use Case. The assessment procedure aims at verifying compliance in relevant environment with technical requirements of the new technology identified in the design phase. Based on the selected characteristics, they identify the parameters to be included in a checklist, which it will support the demonstration activities in order to test the laboratory prototypes in relevant environment (TRL 6). The port authorities involved or companies operating within the ports' facilities will provide access to the test sites for the setup of the technical equipment needed to run the experiments.

The third and final step of the methodology consists in analysing the data collected in the previous steps. The data are elaborated in the "Evaluation tool". In addition, a comparative analysis of all Use Cases will be developed in order to identify the best case. This analysis will provide useful indications to understand the critical issues and success factors related to the implementation of a new technology in the port sector. The lesson learned will provide strategic statements in order to facilitate innovation and competitiveness of ports, according to the Port of the Future perspective.

In the following chapters for each Use Case the activities related to the first step of the methodology will be developed.

The next WP7 deliverable will specify further details and tools for the implementation of phase 2 and phase 3 of the methodology.

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3 Use Case 1: Stevedoring, Ro/Ro terminal handling and logistic service optimization

In the Ports of Balearic Islands, transportation of freights is one of the key processes, since they are the point of entry for almost all the supplies to the islands. The most of the freights are transported as Ro-Ro cargo.

Within the Ro-Ro freight transportation, it can be identify three main types of cargo:

- **CARS:** All the new cars that arrive to the Balearic Islands must be transport by sea, through Ro-Ro ships. Most of these cars are property of the car rental companies. In addition, private cars can arrive with driver.

- **TRUCKS (with driver):** A large number of trucks arrive to the Balearic Islands with their own driver. Drivers take care of loading the truck into the Ro-Ro ship; 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. Most trucks arrive fully loaded to the Balearic Islands, and depart from there empty in the majority of cases.

- **TRUCK PLATFORMS (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 (MAFIs), usually these vehicles are drive by the stevedores. Similar to the case of trucks with drivers, most platforms arrive fully loaded to the Balearic Islands and depart empty from there.

Cars and trucks with driver usually leave directly the port without any intermediate storage in the yard. On the contrary, in the case of new cars and truck platforms (without driver), MAFIs 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.

In the case of the 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 zone assigned to the cargo arriving at the port (cars and usually loaded trucks and platforms).
- Other zone 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, some issues arises, like: 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

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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.

Other issue is that the 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.

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:

- Optimization of the Ro-Ro cargo stowage.
- 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 smart logistic tool applied to the optimization of RoRo cargo flows.
- The PortForward IoT middleware that will support the integration of heterogeneous data sources form devices already deployed at the port.
- Assessment on the potential environmental impacts considering the influence of heterogeneous data into the schedules of logistic operations.

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 stowage. Acciona will implement a service to optimize RoRo cargo stowage providing decision support for stowage planning on RoRo ships. In fact, profits are

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likely to be missed out on due to manual stowage planning, and a mathematical approach to the stowage problem may yield significant increased profits.

- APB, for the optimization of logistic flows 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.

- 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. 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.

- Shipping companies' customers:

  - For transportation of Ro-Ro 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.

RO-RO STOWAGE OPTIMIZATION TOOL:

The aims of this tool is to provide decision support for stowage planning on Ro-Ro ships. While commercial stowage planning software for stowage Ro-Ro ships already exists, as Autoload[5] this type of software is used mainly as a visual aid for cargo planners; however, it does not provide any decision support in terms of calculating an optimised stowage plan.

[5] Autoship. *Autoload SPS Ro-Ro* [Software] [21.05.2012]. Available from:

http://cargomanagement.autoship.com/productsservices/stowageplanning/ro-ro.htm

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Ship laytime could increase significantly and deck cargo spaces are likely to be missed out on due to the manual stowage planning, and a mathematical approach to the stowage plan may yield significant reductions of the ship laytime that consequently will increased gains.

Cargo stowage problems in maritime traffic are strongly linked to the buoyancy and stability of the ship. The tool consider the stability as well as the trim control of the Ro-Ro ship.

The following lines describe the Ro-Ro stowage problem.

Problem formulation:

In the following, we assume that the route of the Ro-Ro ship has been fixed: Palma – Valencia and vice versa. A planner has the ship available for a predefined number of days, and the ship will go along the predefined route making two port calls, Palma and Valencia.

The Ro-Ro ship may pick up different types of cargo. A cargo consists of a number of vehicles (cars and trucks) and other rolling equipment (trucks' platforms). Each different cargo has a known height, width, length, and weight. Some cargoes are considered mandatory to carry. This corresponds to a situation where the freighter has long-term contracts. Cargoes that are not mandatory to carry may be available, and we refer to these as optional cargoes.

Figure 6 - Example of mandatory and optional cargoes

The Ro-Ro has a specified number of decks, and each deck has a certain length and width. Some of the decks may be adjusted up and down within certain limits, so the height of the decks is not predefined. Although each deck is a continuous space, the deck is divided into several logical lanes, and each cargo (vehicle, truck, platform, etc.) must be assigned to one lane. The configuration of the ship must be decided when the ship is empty.

When the Ro-Ro is stowed, there are certain stability constraints that need to be taken into consideration. If too much cargo is placed on one side of the ship, the ship will lean to this side. This angle is called roll angle. If too much cargo is placed either in the front or the back of the ship, it will lean forward or backward. This angle is called trim angle. In addition, if too much cargo is placed on higher decks, the ship becomes less tolerant to sidewise instability.

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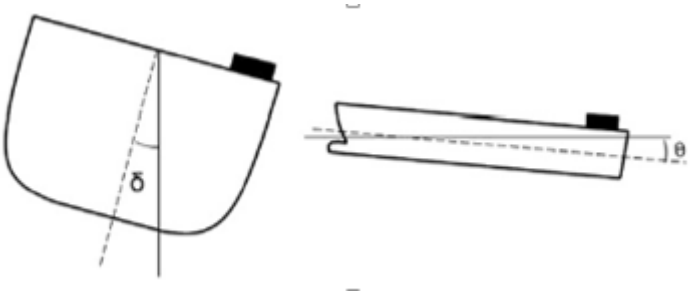

Figure 7 - Roll (δ) and trim (θ) angles

Mathematical model:

The mathematical model to solve the Ro-Ro stowage problem defined below is to decide upon a deck configuration with respect to height, to decide which optional cargoes to carry, and to decide how to stow all cargoes on board the ship.

The algorithm needs the following inputs files:

- **Ro-Ro ship:**
  - Name of Ro-Ro ship
  - Lightweight of the Ro-Ro ship
  - Centre of gravity of the Ro-Ro ship (lightweight)
  - Maximum roll angle
  - Maximum trim angle
  - Number of decks
  - Number of lanes per deck
  - Length, width and height of the deck
  - Number of spaces
  - Centre of gravity of each space
- **Cargo:**
  - Number of mandatory cargoes
  - Number of optional cargoes
  - Length, width and height of each cargo
- **Port:**
  - Number of ports
  - Departure port
  - Delivery port

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The Ro-Ro stowage optimization tool is an optimization algorithm that is essentially an iterative procedure starting with some initial guess point/solution with an aim to reach a better solution or ideally the optimal solution to a problem of interest.

In this case, the algorithm is the optimization (maximization) of the 'benefit function', defined as the benefit obtained by carrying an optional load of each type of cargo, minimizing the possible loss of time and consequently ship laytime, that occurs in the movements of cargo due to errors in the stowage that could affect the stability of the Ro-Ro ship. In addition the tool take into account minimize the possible losses of time incurred when a distribution of cargo is needed in intermediate ports.

The tool use a linear function (boundary conditions are linear as well) based on Lagrange multiplier.

Solution of the optimization problem:

The algorithm has been programmed in 'Mosel' language because this language includes by default a natural number optimization algorithm (MILP- Mixed-Integer-Linear-Programming). The problem is solved starting with the 'relaxed linear problems', removing the restriction of natural variables. The initial problem is a simple linear problem that will be solved using the Lagrange multiplier. Then, one of the variables resulting from this initial optimization is chosen, which should be natural, and if it is not it is imposed restrictions to ensure that it is natural.

For example, the first result could have been optimal = 6.3. In this case, this variable would be eliminated from the problem; instead imposing the following constrains $x \geq 6$ and $x \leq 7$. The next step is to generate two new problems, one relaxed linear with $x \geq 6$ and another relaxed linear with $x \leq 7$. The algorithm has a branched structure, in which each branch of the problem is divided into two sub-problems as restrictions are removed. The optimum is found by evaluation the benefit function among all the natural solutions generated at the end of the tree.

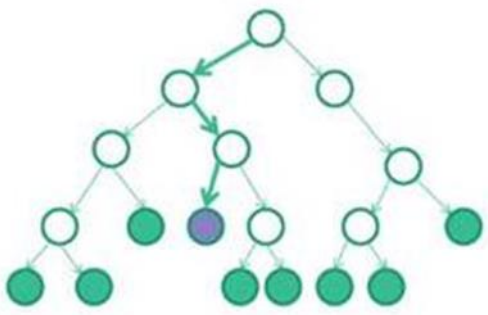

Figure 8 - Example of how the solution is chosen using MILP algorithm

The next figure shows a scheme of the resolution process of the problem with the Ro-Ro stowage optimization tool.

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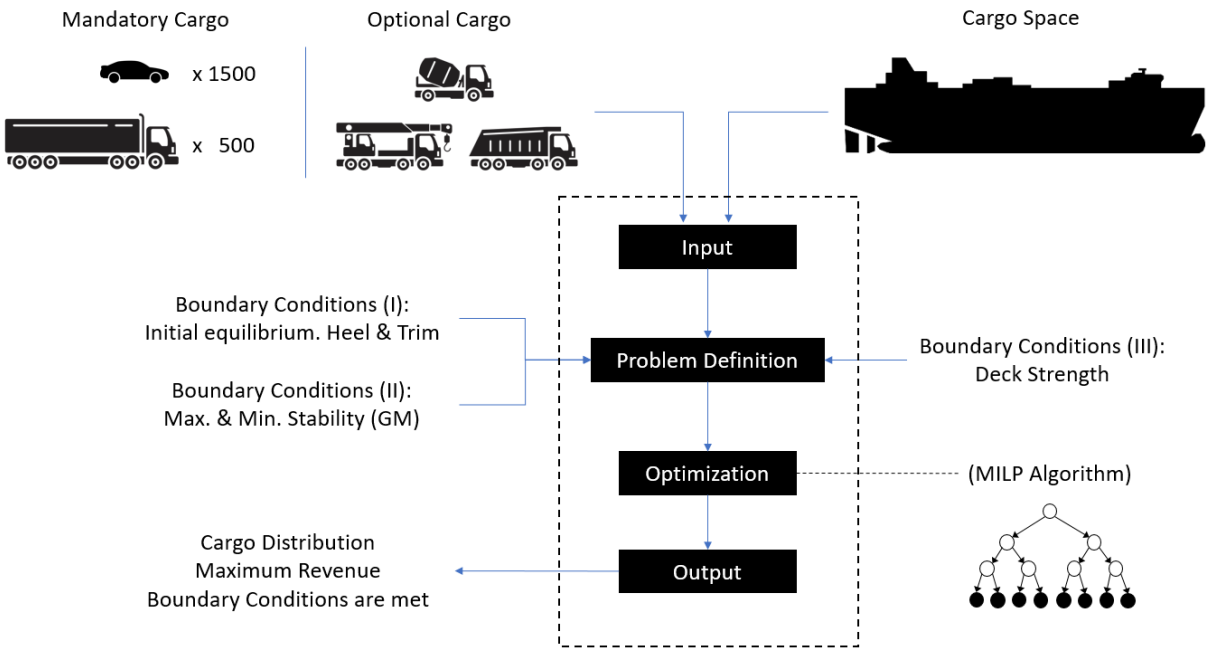

Figure 9 - Ro-Ro stowage optimization tool

3.1 Use Case objectives

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, which are the following:

- Optimized logistic traffic flows associated to Ro-Ro cargo transportation. This impact could be assessed through the following parameters:
    - **KPI 1**: Average stay times of trucks in the shipping company terminal.
    - **KPI 2**: Average load times of vessels.
    - **KPI 3**: Traffic throughput in the terminal (daily, weekly, monthly, yearly, etc.).
    - **KPI 4**: Number of vehicles (cars, trucks, platforms and other cargoes) stowed per Ro-Ro ship.

- Introduction of environmental parameters in the scheduling of port logistic operations. This impact could be assessed through the following parameters:
    - **KPI 5**: Average measured air quality levels.
    - **KPI 6**: Reduction of number of episodes of air pollution above acceptable thresholds.

According to the methodology of the project, the objectives chosen are the following:

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- **Informational.**
- **Operational**.

The following table shows the "Use Case data". It is reported in the Sheet 1 of the 'Evaluation tool'.

Table 5 - Use Case data: UC1_RoRo stowage optimization

Use Case title	**RoRo stowage optimization**
Key Actors	Ports of Baleares (APB)
Stakeholders	Shipping company (Trasmediterránea), Shipping terminal workers (stevedores)
Technical Partners	ACCIONA, LEITAT, IMEC
Objectives	Informational, Operational,

3.2 Definition of evaluation metrics

Once the KPIs associated with this use case has been identified in the previous section, the measurements has to be defined. These measurements will make up the chosen KPIs.

The measures collected will be raw numbers that in and of themselves have limited usefulness, but ultimately need to be related to each other to extract the most meaningful information possible. Measures are the lowest level of detail in the methodology and in this case: Ro-Ro stowage optimization are found in analytics reports, and/or corporate databases of the shipping company Trasmediterránea. Specifically, these data (historical data, before the implementation of the tool) must be gather from the stowage registers of the Ro-Ro ships that cover the routes Palma – Valencia and vice versa. In addition, the new data will be collected in collaboration with Trasmediterránea stowage crew.

Relevant **measures** to gather:

- Time of stay of the trucks in the terminal before embark.
- Total load time of a Ro-Ro ship.
- Number of cars stowed per deck in a Ro-Ro ship.
- Total number of cars stowed in a Ro-Ro ship.
- Number of trucks stowed per deck in a Ro-Ro ship.
- Total number of trucks stowed in a Ro-Ro ship.

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- Number of platforms stowed in a Ro-Ro ship.
- Total number of platforms stowed in a Ro-Ro ship.
- Number of other cargoes stowed per deck in a Ro-Ro ship.
- Total number of other cargoes stowed in a Ro-Ro ship.
- Roll & trim angle of the Ro-Ro ship before to ballast per stowed deck.

Related to the environmental parameters the data will be provided by the air quality measurement sensors previously installed by the APB. Moreover, it will take as measures the reduction of number of episodes of air pollution above acceptable thresholds: study of correlation of pollution parameters, and how daily activities at port premises and surrounds, affects to this episodes.

Once the Relevant Measures has been identified it possible to determine the metrics. Metrics must be calculations of measures and should be expressed as ratios, averages, rates, or percentages. It is equally important that metrics be defined by a time frame.

The **metrics** will be the following:

- Average stay times of trucks in the shipping company terminal.
- Average load times of vessels.
- Percentage of cars, trucks, platform and other cargoes per deck in a Ro-Ro ship.
- Ratio between number of cargoes and spaces per deck in a Ro-Ro ship.

Percentage of total number of cargoes stowed in a Ro-Ro ship with the new tool compared to the historical data of Trasmediterránea.

3.2.1 Measurement plan

The aim of this section is to provide the measurement plan (timing and frequency) for the assessment of the impact of this use case. The measurement plan is shown, in the Table 6. In this table is possible to see the KPIs adopted and the time of detection. For each KPIs the results (ex-ante and ex-post), timing and frequency of the measurement process will be reported.

Table 6 - Quantitative evaluation metrics (timing and frequency): UC1_RoRo stowage optimization

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Average stay times of trucks in the shipping terminal			monthly
2	Average loading times of vessels			monthly
3	Traffic throughput in the shipping terminal			monthly
4	Number of vehicles (cars, trucks, platforms and other cargoes) stowed per Ro-Ro ship			monthly
5	Averaged measured air quality level			monthly
6	Reduction of number of episodes of air pollution above acceptable thresholds			monthly

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Table 7 – Quantitative evaluation metrics: UC1_RoRo stowage optimization

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Average stay times of trucks in the shipping terminal					monthly
Average loading times of vessels					monthly
Traffic throughput in the shipping terminal					monthly
Number of vehicles (cars, trucks, platforms and other cargoes) stowed per Ro-Ro ship					monthly
Averaged measured air quality level					monthly
Reduction of number of episodes of air pollution above acceptable thresholds					monthly

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4 Use Case 2: Services by Port Authorities

As mentioned at the use case 1 section, for the Ports of Balearic Islands, transportation of freights is one of the key processes and most of the freights are transported as Ro-Ro cargo. The service associated with this use case will be developed with the collaboration of the shipping company Trasmediterránea.

Regarding Ro-Ro freight transportation, the service that will be develop for this use case will be focus on the on the optimization of the working hours of the auxiliary vehicles use to move the trucks platforms without driver, the Mafis.

Figure 10 - Trasmeditrránea's MAFI and rolling platform moved by a MAFI

The operations of the Mafis 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 Mafi per work shift, or into the efficiency of the movements of each vehicle within the terminal.

Through the implementation of this use case, PortForward aims to prove on one hand the optimization of the logistic work of the shipping Ro-Ro companies related to the Mafis' cargo movements within the terminal and between the terminal and Ro-Ro ships and vice versa. On other hand, the suitability of the PortForward dashboard as a unified interface enabling seamless access to indicators, alerts and data coming from heterogeneous system, thus helping shipping company operators to focus the attention on the most critical parameters for decision-making processes, while avoiding information overload.

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

- Optimization of the Mafis' working hours.
- 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.

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- Improved capability of the shipping company operators to prioritize information for decision-making processes.
- Because of the previous point, it will be possible to make a more efficient use of human resources for supervision and management of the terminal operations.
- Implementation of advanced maintenance strategies, contributing to lower maintenance costs, increased lifetime of assets, and lower downtime periods of equipment.

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

- The introduction of new tracking devices for monitoring Mafis' operations at the terminal. 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 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 the shipping company operators with information filtering and decision-making processes.

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 development of the Mafis's tracking system. In addition, ACCIONA will work on the PortForward Dashboard adaptation for shipping company operators.
    - 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 for the implementation of the PortForward Dashboard, they shall support the selection of data sources, indicators and alerts from different sources that shall be

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integrated, and the definition of the criteria for information prioritization and decision-making processes.

- External stakeholders:
    - Shipping company Trasmediterránea: This shipping company will collaborate with their MAFIs. These vehicles will need the deployment of a tracking system, which will be the most suitable technology for location. This will be based on GPS devices.
    - Dock workers (stevedores). These stakeholders shall be considered especially for the case of optimization of Ro-Ro 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 monitoring system/procedure of their work that may be implemented in the framework of the use case.

MAFIS' WORKING HOURS OPTIMIZATION TOOL:

ACCIONA has been develop this tool with the collaboration of the Shipping Company Trasmediterránea. The shipping company will collaborate with their MAFIs. The MAFIs are the vehicles that Trasmediterránea use to move the rolling platforms within the shipping terminal and to load/unload the Ro-Ro.

The application tool is based on the use of GPS technology. In each MAFI will be installed a GPS device.

The GPS device is made up of:

- A GPS with external antennas model FM6320 from manufacturer Teltonika.
- A bipolar GPS power cable with terminal connector for car cigarette lighter.
- A waterproof box to house the GPS device.

The system was designed for its installation in heavy vehicles. The waterproof box could be installed in existing compartments or on flat surfaces of the vehicle using a magnet. The device does not need a specific fastening system.

To action the device it need the engine ignition signal that comes from the vehicle's low-voltage electrical circuit, traditionally used to supply the vehicle's 12V electric cigarette lighter. The same cable powers both the GPS and its small backup battery.

The box does not have to be installed inside the MAFI's driver's cab, with the disadvantages that it has to the visibility of the driver, besides occupancy an unforeseen space in the vehicle.

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Figure 11 - GPS device installed in a vehicle

The ignition signal using the connection to the lighter, in some vehicles, also affects the quality of the data transmitted by the GPS, not in this case because there is not a physical disconnection of the battery, the device has a constant 24-hour power supply. The GPS device interprets activity also during those moments when the vehicle is off.

The "independence" of the vehicle's electrical system involves identifying the ignition signal through another type of event identified by the GPS, such as movement; the GPS model FM6320 has a configurable internal accelerometer that identifies the vibrations generated by the engine when it is running. Disconnection of the vehicle's electrical system also implies an autonomous supply of the GPS. The internal battery of the GPS allows an autonomy of 24 hours with operation at full power of the hardware; however, the operation of the GPS must be able to extend throughout the duration of the work, through limited activity in terms of maintenance. This involves a continuous, or discontinuous, battery powered external power supply. Disconnection of the vehicle's electrical system also implies an autonomous supply of the GPS. The internal battery of the GPS allows an autonomy of 24 hours with operation at full power of the hardware; however, the operation of the GPS must be able to extend throughout the duration of the work, through limited activity in terms of maintenance. This involves a continuous, or discontinuous, battery powered external power supply.

The MAFIs' working hours optimization tool has a user interface where is possible to visualize in several window the following information:

- **"RTNav" (Real Time Navigation):** in this window, the updated information of the MAFIs is shown on a map based on Google maps, in this case the maps will represent Trasmediterránea terminal within the Port of Palma. In this section is possible to see a summary table where is displayed information as: the MAFI is on or off, in maintenance, etc.

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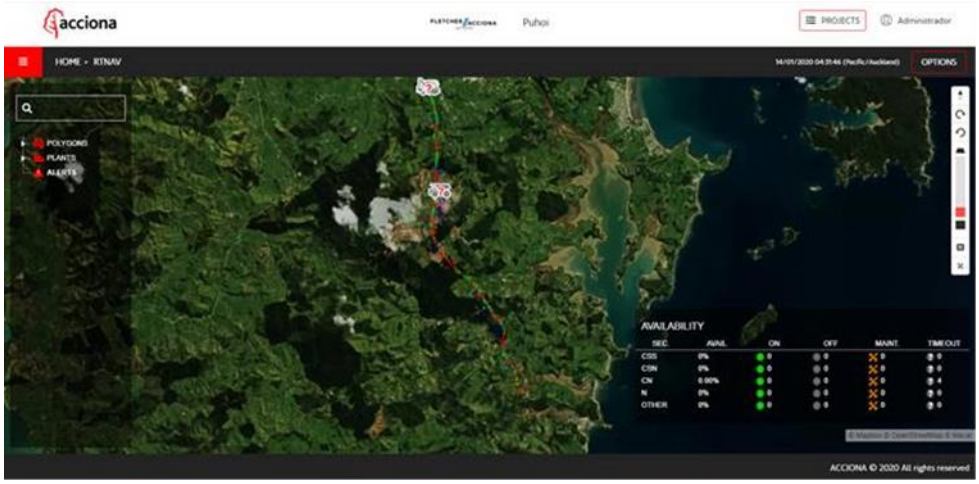

Figure 12 - Real Time Navigation display

- **MAFIs' fleet operation:** this window shows a summary of the operation data of the MAFI's. These data could be shown from a single MAFI or from all the MAFIs. The following data is displayed:

    - Availability (% disponibility).
    - On/off time.
    - Time in maintenance.
    - Summary of data of each MAFI: how long the MAFI was on, when was it last connection, when was the last alert, etc.

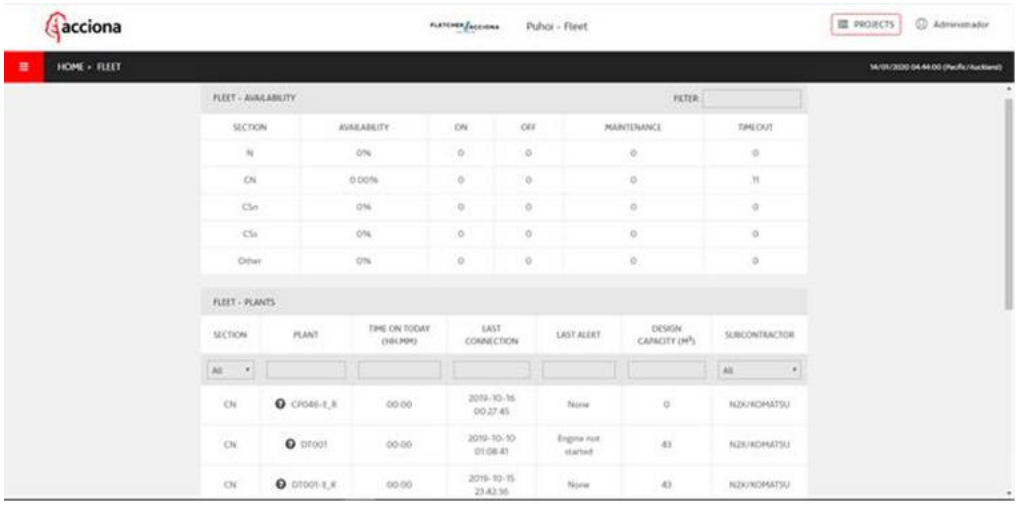

Figure 13 - MAFIs' fleet operation display

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- **Data consulting:** this window shows the section of data consulting. In this section is possible to see different indicators, like:

    - PRODUCTION
        - Loads: number of platforms/containers moved for each MAFI per day.
        - Total distance.

    - PERFORMANCE
        - Avg. load/h.
        - Avg. load cycle time.
        - Avg. Km/cycle.

    - Km BREAKDOWN
        - By zone.
        - By event.

    - TIME BREAKDOWN
        - By activity.
        - By zone.
        - By event.

In addition, the application has an ALERTS section. This section gives information, for example if a MAFI do not start its activity in the planned time.

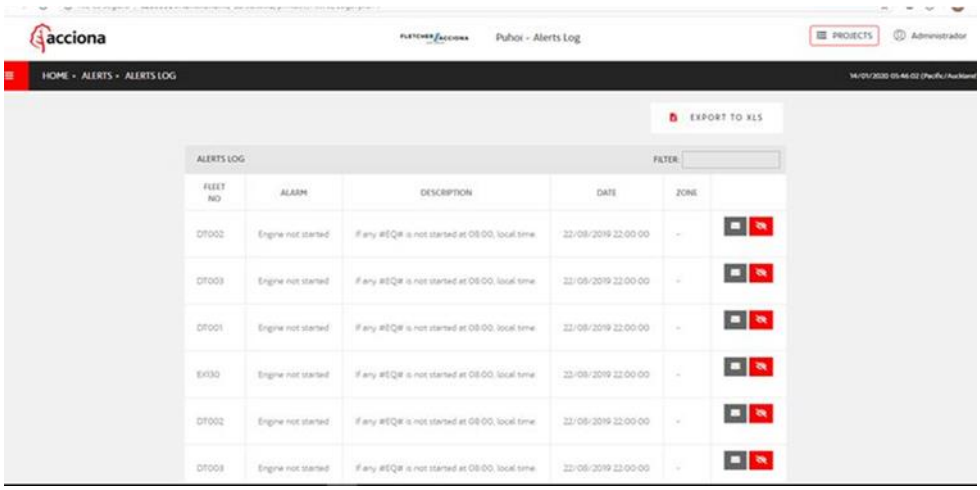

Figure 14 - Alerts display

Finally, the tool has its own Dashboard, where is possible to see the entire information sum up in tables and graphs, being possible to select the information needed in a specific moment.

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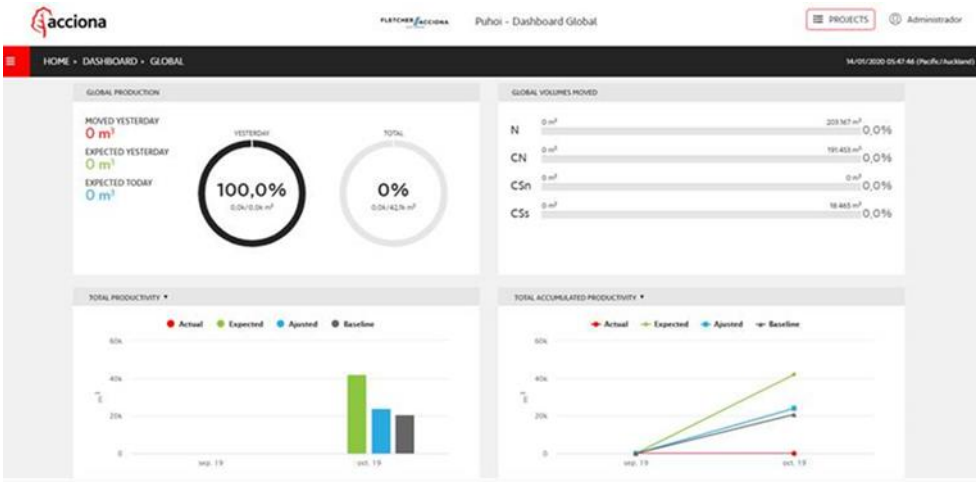

Figure 15 - MAFIS' working hours optimization dashboard

4.1 Use Case objectives

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, which are the followings:

- Optimized productivity of RoRo cargo handling operations. This impact could be assessed through the following parameters:
  - **KPI 1:** Number of unitary handling operations per machine and work shift.
  - **KPI 2:** Reduction of bottlenecks in handling operations.

- Lower maintenance costs:
  - **KPI 3:** Cost of human and material resources investment in maintenance.
  - **KPI 4:** Average lifetime of assets.

- Higher quality of service: reduced number of failures and downtime periods:
  - **KPI 5:** Average number of failures per type of equipment.
  - **KPI 6:** Average downtime periods per type of equipment.

According to the methodology of the project, the objectives chosen are the following:

- **Informational.**
- **Operational**.

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The following table (Table 8) shows the "Use Case data". It is reported in the Sheet 1 of the 'Evaluation tool'.

Table 8 – Use Case data: UC2_Mafis' working hours optimization.

Use Case title	**Mafis' working hours optimization**
Key Actors	Port of Baleares
Stakeholders	Shipping company (Trasmediterránea), Shipping terminal workers (stevedores), System suppliers
Technical Partners	ACCIONA, IMEC, IFF
Objectives	Informational, Operational,

4.2 Definition of evaluation metrics

Once the KPIs associated with this use case has been identified in the previous section, the measurements has to be defined. These measurements will make up the chosen KPIs.

The measures collected will be raw numbers that in and of themselves have limited usefulness, but ultimately need to be related to each other to extract the most meaningful information possible. Measures are the lowest level of detail in the methodology and in this case: Mafis 'working hours optimization are found in analytics reports, and/or corporate databases of the shipping company Trasmediterránea. Specifically, these data (historical data, before the implementation of the tool) must be gather from the stowage registers associated with the movements of platforms done by each Mafi in each stowage plan of the Ro-Ro ships. In addition, the new data will be collected in collaboration with Trasmediterránea stowage crew.

Relevant **measures** to gather:

- Total load time of a Ro-Ro ship.
- Number of platforms stowed by each MAFI in a Ro-Ro ship.
- Total number of platforms stowed by all the MAFIs in a Ro-Ro ship.
- Total time needed by each MAFI to stowed a Ro-Ro ship.
- Total time needed by all the MAFIs to stowed a Ro-Ro ship.

Once the Relevant Measures has been identified it possible to determine the metrics. Metrics must be calculations of measures and should be expressed as ratios, averages, rates, or percentages. It is equally important that metrics be defined by a time frame.

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The **metrics** will be the following:

- Average times of on and off each MAFI in each work shift.
- Average time of on and off each MAFI to stowed a Ro-Ro ship.
- Average load times of vessels.
- Percentage of the total number of platforms stowed by each MAFI in a Ro-Ro ship.
- Ratio between the time needed for each MAFI to stowed a Ro-Ro ship and the time needed for all the MAFIs to stowed a Ro-Ro ship.
- Percentage of total number of platforms stowed in a Ro-Ro ship with the new tool compared to the historical data of Trasmediterránea.

4.2.1 Measurement plan

The aim of this section is to provide the measurement plan (timing and frequency) for the assessment of the impact of this use case. The measurement plan is shown, in the Table 9. In this table is possible to see the KPIs adopted and the time of detection. For each KPIs the results (ex-ante and ex-post), timing and frequency of the measurement process will be reported.

Table 9 – Quantitative evaluation metrics (timing and frequency): UC2_Mafis' working hours optimization.

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Number of unitary handling operations per machine and work			monthly
2	Reduction of bottlenecks in handling operations			quarterly
3	Cost of human and material resources investment in maintenance			four-month
4	Average lifetime of assets			biannual
5	Average number of failures per type of equipment			monthly
6	Average downtime periods per type of equipment			monthly

Table 10 – Quantitative evaluation metrics: UC2_Services by Port Authorities

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Number of unitary handling operations per machine and work					monthly

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Reduction of bottlenecks in handling operations					quarterly
Cost of human and material resources investment in maintenance					four-month
Average lifetime of assets					biannual
Average number of failures per type of equipment					monthly
Average downtime periods per type of equipment					monthly

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5 Use Case 3: Prediction of Port-City Interactions

Due its nature, where touristic and cargo coexist, 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 main idea behind, is to offer services to the users in order to offer them information and services devoted to reach / leave port facilities, to report possible delays on departure, or to support them to visit the city by offering recommendations and special offers according to their profiles.

This task, which includes positioning techniques is nowadays focus in try to mitigate Covid impact, by providing information about if visitor / user has been potentially exposed or for workers, to identify potential transmission chain.

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.

To deal with that, some techniques to be used are:

- **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,

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and to predict complex situations that cannot be covered by normal means, neural networks and different deep learning algorithms can be used.

With this use case, PortForward aims to offer some added value to improve the user experience, and as well to manage better internal processes, by identifying by positioning systems, possible build-up or trends, that will allow optimize the visit plan or port operations.

This is not fully related with special operative needs, but it is provided to enrich visitor experience and to try to drive them avoiding crowdy situations.

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.

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:
    - **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**:**

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  - **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.

The aim of this tool is not only limited to provide decision support for identify impact of visitors in main tourist places, as well to offer them special services, but to manage and monitor use of spaces in port premises.

To do that is required:

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- Infrastructure to capture spaces occupation
- Software platform, to anonymize it, and to process accordingly, able to support information generation
- Software app, to interact with users and obtain some specific information (provided by user)

Problem formulation:

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.
- **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.

5.1 Use Case objectives

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:

- Predictions:
    - **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.

    - **Needs estimation**: 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.

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- **Creation of profiles**: The system should be able to generate the profiles themselves using heterogeneous data from different sources.

- **Monitoring**

    - To identify risk of **potentially covid exposition** by no be complaint with social distances normative.

    - For workers and visitors (already registered) to identify **potential covid or other one transmission line** or if they are complaint with social distance recommendations.

To achieve these 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:

Table 11 - Use Case data: UC3_Prediction of Port-City Interactions

Use Case title	**Prediction of Port-City Interactions**
Key Actors	Ports of Baleares
Stakeholders	APB Municipality, Public transportation, Visitors, Tracking system providers
Technical Partners	ACCIONA, LEITAT
Objectives	Informational, Operational, IT Infrastructure

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5.2 Definition of evaluation metrics

The evaluation metrics are devoted to provide a compliance level estimation, which will allow us to verify if something is achieving the objectives or not. In other words, we will compare the with the KPIs.

Collected measures will be raw numbers that in and of themselves have limited usefulness, but ultimately need to be related to each other and with hystorical data, providing a detailed information about situation, specially by providing comparisons with data at some other moment, and specially versus defined thresholds.

Relevant **measures** to gather:

- Average queue time at
  - tourist attraction places
  - public transport station
- Crowd density at specific spots
- Feedback from user, starred system
- Position per time of people working at port premises
- Number of potentially contacts, especially relevant for Covid Purposes
- Number of warnings due disregarding social distance

5.2.1 Measurement plan

The aim of this section is to provide the measurement plan (timing and frequency) for the assessment of the impact of this use case. The measurement plan is shown, in the Table 912. In this table is possible to see the KPIs adopted and the time of detection. For each KPIs the results (ex-ante and ex-post), timing and frequency of the measurement process will be reported.

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Table 12 - Quantitative evaluation metrics (timing and frequency): UC3_Prediction of Port-City Interactions

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Average queue time at tourist attraction places			Monthly
2	Average queue time at public transport station			Monthly
3	Crowd density at specific spots			Monthly
4	Number of warnings due disregarding social distance			Monthly
5	Feedback from user, starred system			Monthly
6	Number of potentially contacts			Monthly

Table 13 - Quantitative evaluation metrics: UC3_Prediction of Port-City Interactions

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Average queue time at tourist attraction places					Monthly
Average queue time at public transport station					Monthly
Crowd density at specific spots					Monthly
Number of warnings due disregarding social distance					Monthly
Feedback from user, starred system					Monthly
Number of potentially contacts					Monthly

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6 Use Case 4: Green Scheduling and Sustainability of operation

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.

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.

We will focus on the Container Terminal in Port of Vigo. Key processes on this Terminal include:

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.

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.

Main stakeholders and decision makers in the use case are PortForward partners:

- **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.

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- **VIGO** will provide Brunel and Leitat all information they require from Port Authority as well as the Terminal Operator Company.

In addition, other 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 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…).

The TOS Information System used by Termavi sends terminal operations events to Obelisk, the cloud based IoT integration platform (described in D3.1), through the *ingest* HTTPs API. In order to secure data transportation (TOS--Obelisk--GYS), Obelisk uses an Identity and Access Management (IAM) platform that ensures Authentication and Authorization through OpenID Connect and UMA 2.0 standards respectively; each role needing access to data is given by IMEC a clientID and clientSecret pair. This mechanism allows fine-grained definition of (read/write) access rights to (sets of) data. Obelisk ensures data isolation through the concept of scopes for both streaming and storing of data events. The Green Yard Scheduler application consumes the data from Obelisk through the *metrics* HTTPs API for historical data queries and through the *sse* HTTPs API for (near-)real time events streams. **Container Terminal (Guixar)**

- 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.

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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.
- 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.

6.1 Use Case objectives

Use case 4 is concerned with the optimization of operations at the Vigo container terminal by considering multiple performance- and sustainability-oriented objectives. The main developments of the related work package (WP5) are the green yard scheduler (GYS) and sustainability assessment of operations through Life Cycle Assessment methodology (LCA). GYS is a decision support tool that will be working in connection with the terminal operating system (TOS), the IoT platform Obelisk (as described in D3.1), and the main information platform of the port authority called Smart ViPort. Three types of yard operations are defined in the scope of GYS: positioning of inbound and outbound containers, scheduling of yard cranes, and housekeeping activities during off-peak hours.

The primary objective of this use case is to assess and demonstrate the capability of the GYS to address the trade-off between conflicting performance- and sustainability-oriented KPIs. Along the same lines, the designated KPIs involve elements pertinent to terminal productivity (e.g. cargo stay duration, utilization of cranes, vessel turnaround time) as well as environmental impact and human wellbeing (e.g. reductions recorded in fuel consumption and CO2 emissions, distance travelled by yard equipment). Measurement of KPIs is necessary for the evaluation of the degree that PortForward addresses the economic, environmental, and social goals and expectations of Port of Vigo and its stakeholders as detailed in deliverables D1.1 and D1.2. In addition to the operational objectives, the use case also aims a better integration of all data sources managed by the port authority and terminal operator to ensure effective decision-making support in real time. In this regard, the objectives of use case 4 are categorized as informational and operational.

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Table 14 - Use Case data: UC4_Green Scheduling

Use case title	**Green Scheduling and sustainability of operations**
Key Actors	**Port of Vigo**
Stakeholders	**Port Authority (A.P. Vigo), Terminal Operators (Termavi, Transglobal), Public Stakeholders, Port Services Providers, Other Logistics Providers**
Technical Partners	**BRUNEL, LEITAT, IMEC**
Objectives	**Informational Operational**

6.2 Definition of evaluation metrics

More information on the KPI's are provided below:

1. **Container cargo time of stay in port yard**: The total duration of time that a single container spends in the container yard. The terminal operator keeps record of the start and finish times of container yard operations for each individual container.
   Unit: days
   Formula: Export: [Validation time of maritime out] - [Validation time of gate in]
   Import: [Validation time of gate out] - [Validation time of maritime in]

2. **Crane utilization**: Port of Vigo registers the time each crane is utilized by each vessel. This indicator quantifies the total time that cranes are used to load/unload a vessel.
   Unit: % utilization
   Formula: ([Operational time] / [Working hours]) * 100%

3. **Travel distance equipment:** The distance travelled by reach stackers (RS) and rubber tyred gantry cranes (RTG) within the container yard.
   Unit: kilometers/month
   Formula: [Distance travelled by RSs and RTGs between berth and container blocks within the measurement period]

4. **Reduced travel distance and waiting time of trucks**: The distance travelled by external (EMV) and internal vehicles (IMV) within the container yard. The terminal operator records the start and finish of each container operation as the registration and validation time, respectively.

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Unit: Distance: kilometers, Time: days
Formula: Distance: [Distance travelled by IMVs and EMVs within the measurement period]
Travel and waiting time: [Validation time] - [Registration time]

5. **Use of the yard space:** The percent occupation ratio of each container block in the yard area by the export and import containers
   Unit: % occupation
   Formula: ([Total number of containers in the block / [Total capacity of the block]) * 100%

6. **Reduction of fuel, electricity and CO2 emissions associated to container terminal operations/activities**: The fuel and energy consumption and associated CO_2 emissions of the container terminal operations after the implementation of the green yard scheduler
   Unit: m^3 of fuel; kWh of electricity; kg CO_2 eq.
   Formula: [m^3 of fuel consumed by yard equipment and vehicles within the measurement period]
   [kWh of electricity consumed by yard equipment within the measurement period]
   [CO_2 emissions associated to the yard equipment and vehicles within the measurement period]

7. **Vessel turnaround time**: Port of Vigo registers in real time the arrival and departure of all the vessels from the main entrance in the Port Service Area until the berthing line in each Terminal. The indicator measures the time of stay of each vessel quantified as the time from vessel mooring to unmooring in the container terminal (in days).
   Unit: days
   Formula: [Vessel arrival time at the berth] – [Vessel departure time from the berth]

8. **Human wellbeing** (e.g.: noise exposure from container terminal operations to population, air pollutants associated to container terminal operations to population, etc.): The impact of terminal operations on the wellbeing of the society in terms of environmental externalities (e.g. noise (in dBs), air pollution (in kg CO_2 eq.,))
   Unit: Noise: dB, Air pollution: kg CO_2 eq., CTUh, PM10 and PM 2.5.
   Formula: [Noise and air pollution levels within the measurement period -before and after the implementation of the GYS]

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6.2.1 Measurement plan

Table 15 - Quantitative evaluation metrics (timing and frequency): UC4_Green Scheduling

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Container cargo time of stay in port yard	01/06/2021	01/07/2021	monthly
2	Crane utilization	01/06/2021	01/07/2021	monthly
3	Travel distance equipment	01/06/2021	01/07/2021	monthly
4	Reduced travel distance and waiting time of trucks	01/06/2021	01/07/2021	monthly
5	Use of the yard space (% used, stacking height, congestion occurrences, etc.)	01/06/2021	01/07/2021	monthly
6	Reduction of fuel, electricity and CO2 emissions associated to container terminal operations/activities	01/06/2021	01/07/2021	monthly
7	Vessel turnaround time	01/06/2021	01/07/2021	monthly
8	Human wellbeing (e.g.: noise exposure of population, air pollutants exposure of population, etc.)	01/06/2021	01/07/2021	monthly

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Table 16 - Quantitative evaluation metrics: UC4_Green Scheduling

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Container cargo time of stay in port yard					monthly
Crane utilization					monthly
Travel distance equipment					monthly
Reduced travel distance and waiting time of trucks					monthly
Use of the yard space (% used, stacking height, congestion occurrences, etc.)					monthly
Reduction of fuel, electricity and CO2 emissions associated to container terminal operations/activities					monthly
Vessel turnaround time					monthly
Human wellbeing (e.g.: noise exposure of population, air pollutants exposure of population, etc.)					monthly

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7 Use Case 5: Pilot Assistance to ship manoeuvring in port waters

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 metres wide, largely below what is considered today enough to allow the safe sailing of ships over 40 metres width. In addition to this, the depth of quays and docks is insufficient for new generations of cargo vessel, as it reaches 13 metres maximum. Works are ongoing to cope with this challenge, but as major improvements are expected later than 2023, IT tools can support difficult ship manoeuvring within the port.

Key processes will include:

- Logistic processes, mainly related to 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, as long as passenger ships are concerned.

Security and safety are enforced by public authorities, notable the Coast guard as far as maritime traffic is concerned.

The main stakeholders for this use case are pilots. 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. Another stakeholder is the Coast Guard, as far as legal framework and navigational issues are concerned. Finally, the Port Monitoring System provider can be interested in collecting additional information into the platform.

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, weather conditions and other possible hazards to navigation. This 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 this information is shown in real time to pilots on the bridge by using the smart glasses.

7.1 Use Case objectives

These are the objectives to achieve with the use case:

- Increase the safety of navigation in the port;
- Enhance navigation and assistance to ships when manoeuvring in the port;
- Decrease the number of accidents occurred to ships in navigation within the port;
- Ease the ship navigation, even in rough weather conditions;

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- Share the responsibility for any accidents between the pilot and the captain, responsible for the course and right manoeuvring of the ship.

The objectives above belong to these categories, according to the classification indicated in deliverable 7.1 "Use cases requirements and evaluation metrics":

- **Informational** - to allow quick and easy access to data and ensure the accuracy of information: the information needed by the pilots is collected from a great quantity of sensors in the port area and official sources (e.g. national AIS system) that guarantee an excellent quality of the information. Moreover, the port is provided with a 5G network that assures a very quick exchange of data. In this way the pilots have quality real time data that are accessible very easily through the smart glasses during the maneuvers in the port area, and can increase the safety and security of the operations they perform.
- **Transformational** - to equip itself with new technologies to meet the needs dictated by new processes: the use case requires the usage of smart glasses that implement solutions of augmented reality. This transforms the operational processes that are currently required to pilots to maneuver the ships in the port.
- **Operational** - to optimize the execution of activities reducing time and resources employed: the usage of the smart glasses allows the pilots on the bridge to have all the needed information in real time, minimizing the necessity of interaction with the others on the land. The operations become smoother and quicker even in bad weather conditions and the security and safety of the operations is increased.
- **IT infrastructure** - to increase the resources already in use (pure ICT investment): the IT infrastructure already in place in the port (the Port Community System TPCS and the Monitoring and Control Application MoniCA) is enriched with solutions of augmented reality (smart glasses).

Table 17 - Use Case data: UC5_Pilot Assistance

Use Case title	**Pilot Assistance to ship maneuvering in port waters**
Key Actors	Port of Livorno
Stakeholders	Port pilots, Coast guard, IT providers (MONICA, TPCS -Tuscan Port Community System)
Technical Partners	UBIMAX
Objectives	Informational, Transformational, Operational, IT Infrastructure

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7.2 Definition of evaluation metrics

- Number of (near) accidents [pure number]: number of accidents or near accidents that have been avoided in the port area in 1 year;
- Lag time in data availability [seconds]: time between an event occurs and the event is shown on the device;
- Usability (indoor/outdoor) [{yes; partially; no}]: possibility to use the device in open areas;
- Access to data for pilots [{yes; partially; no}]: possibility for the pilots to access the needed data about the maritime traffic;
- Portability [{yes; partially; no}]: possibility for the pilots to carry the device in one hand.

7.2.1 Measurement plan

Table 18 - Quantitative evaluation metrics (timing and frequency): UC5_Pilot Assistance

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Number of (near) accidents			biannual
2	Lag time in data availability			biannual
3	Usability (indoor/outdoor)			biannual
4	Access to data for pilots			biannual
5	Portability			biannual

Table 19 - Quantitative evaluation metrics: UC5_Pilot Assistance

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Number of (near) accidents					biannual
Lag time in data availability					biannual
Usability (indoor/outdoor)					biannual
Access to data for pilots					biannual
Portability					biannual

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8 Use Case 6: Assistance to goods control and inspection within port boundaries

The port of Livorno is a multipurpose logistic node, handling a wide variety of unitized cargo. Competent authorities can inspect freight shipped in containers 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. IoT sensors to enhance this communication among devices and the platform are not available.

Key processes will include:

- Logistic processes, mainly related to easier and smoother controls.
- Security, in relation to better detection of hazards in the port and early identification of risks.
- Passenger related activities, 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 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.

The main stakeholders are the competent bodies, i.e. the Customs agency, that have shown interest to improved control and security measures in the port. Terminal operators are also interested in the use case for expected benefits in the smoothness of port operations. 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. The Port Authority has also contacted other stakeholders such as the phitosanitary office, the Health protection office. Finally, the IT providers for MONICA and TPCS platform are stakeholders to be considered in the framework of the use case.

Assisted reality can improve the exchange of information between the inspector and the competent authority, it 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. In fact, physical inspections need to report and integrate data with the overall port monitoring architecture. Data retrieved by MONICA will provide the inspectors with exact localization of freight to be inspected and, on the other hand, MONICA will be fed with the outcomes of the inspections. It is very useful that the smart glasses work as scanner of stored and containerized cargo, thus improving the speed and the effectiveness of physical inspections. Smart glasses can also

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help communication through either video or radio to the control room of the Customs agency, thus enhancing communication among the inspectors and the customs agency.

8.1 Use Case objectives

These are the objectives to achieve with this use case:

- Increase security and easiness of freight controls in the port;
- Enhance security and control of freight flows;
- Decrease the time needed to perform physical inspections of containerized cargo;
- Smooth controls and enhance more specific controls on cargo.

The objectives above belong to these categories, according to the classification indicated in deliverable 7.1 “Use cases requirements and evaluation metrics”:

- **Informational** - to allow quick and easy access to data and ensure the accuracy of information: the information needed by the inspector on the field can be obtained through electronic devices and in real time. The inspection can be shorter and it is easier for an operator to communicate rapidly with the central office in case of necessity. Moreover, the result of the inspection can be shared more easily and with shorter time.
- **Operational** - to optimize the execution of activities reducing time and resources employed: the usage of the smart glasses allows the operators on the field to have all the needed information in real time, allowing a better organization. The operations become smoother and quicker as operators can show in real time to colleagues at the remote office the goods that are inspected. Moreover, less personnel on field is required, with a reduction of costs for reaching the inspection area.
- **IT infrastructure** - to increase the resources already in use (pure ICT investment): the IT infrastructure already in place in the port (the Port Community System TPCS and the Monitoring and Control Application MoniCA) is enriched with solutions of augmented reality (smart glasses).

Table 20 - Use Case data: UC6_Inspection Assistance

Use Case title	**Assistance to goods control and inspection within port boundaries**
Key Actors	Port of Livorno
Stakeholders	Customs agency, Terminal operators, IT providers (MONICA, TPCS)
Technical Partners	UBIMAX
Objectives	Informational, Operational, IT Infrastructure

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8.2 Definition of evaluation metrics

- Duration of inspection [minutes]: time it takes to perform a physical inspection of goods;
- Efficiency of inspection [{yes; partially; no}]: if the time required to perform the inspection complies with the average time needed to perform that specific inspection;
- Communication between stakeholders (yard operator & inspector) [{yes; partially; no}]: possibility to establish a communication channel between the operator and the central offices;
- Usability [{yes; partially; no}]: possibility to use the device in open areas and remotely with respect to the central offices.

8.2.1 Measurement plan

Table 21 - Quantitative evaluation metrics (timing and frequency): UC6_Inspection Assistance

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Duration of inspection			biannual
2	Efficiency of inspection			biannual
3	Communication between stakeholders (yard operator & inspector)			biannual
4	Usability			biannual

Table 22 - Quantitative evaluation metrics: UC6_Inspection Assistance

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Duration of inspection					0
Efficiency of inspection					0
Communication between stakeholders (yard operator & inspector)					0
Usability					0

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9 Use Case 7: Monitoring of port performances in different port areas

MARTE proposed for the Use Case 7 the creation of the Port Authority Dashboard (PAD), a control dashboard for the Port Authority to increase the efficiency and effectiveness of port management and to facilitate the definition of strategic objectives. It allows disposing of all useful information in a clear, organised and suitable way to facilitate their best interpretation. It is a system of integrated visualization and retrieval of data and information, supporting analysis and interpretation of key phenomena on behalf of port management. The UE port development projects adopted as port definition the following: *"Port is an interconnected community of private and public actors wishing to use any innovative technological, organizational and financial solution to support growth. Port community is meant to promote expansion of trade through providing more efficient and effective services capable to assure competitiveness of clients, environmental sustainability and integration with hosting cities."*

The purpose of the PAD is to be a multi-dimensional instrument that will allow proactive management of the port as the interconnected community of private and public actors. Port actors wish to use any innovative technological, organizational and financial solution to support the expansion of trade through providing more efficient and effective services capable to assure the competitiveness of clients, environmental sustainability and integration with host cities. Therefore, PAD represents an instrument to support the Port Authority managers to assure an effective infrastructure utilization and to contribute to the economic and social development of the area in which the port is located.

The data that feed the PAD dataset refer to following areas:

1. Concessions.
2. Port infrastructures.
3. Ships movement.
4. Freight and passenger flows.
5. Economic and financial management
6. Environmental impact

PAD includes several indicators that allow monitoring the performance of the port according to the following **five perspectives of analysis** (Figure 16):

1. **the utilization of the port infrastructures** (*Infrastructures Effectiveness area*);
2. **the efficiency of port operations** for each business (*Port Operation area*);
3. **the financial performance** of the Port Authority's activities (*Economics & Finance area*);
4. **the market trends of the port** - in/out flows – (*Demand Trends area*);
5. **the aspects of port environmental policy and sustainability** (*Green Challenge area*).

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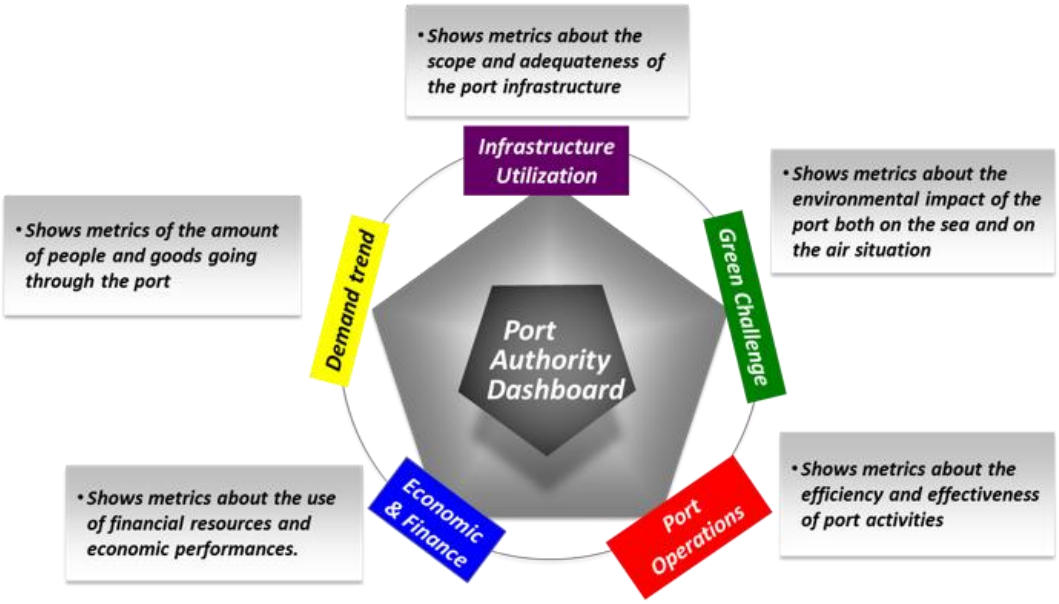

Figure 16 – PAD: the five perspectives of analysis

Each of the perspective is analysed through a small set of key parameters measuring trend of effectiveness and efficiency of the port over time.

Optimal utilization of the port area and port infrastructures is an important element of port strategies to improve attractiveness. Therefore, the monitoring and the efficiency achieved in the use of the resources available to the port (infrastructures and superstructures) are essential for the constant improvement of performance. As far as the law is concerned, the Port Authority is responsible for the ongoing management and future sizing of port infrastructures managed directly or then given in concession to specific operators. Through a balanced process of allocation and management of concessions, it is possible to combine the objectives of the Port Authorities with those of the private operators of the terminals or port spaces granted to them. The measurement of the effectiveness of the infrastructures is often not easy and provides consistent perspectives only if measured in the medium and long term.

In this context, characterized by heightened intra-port and inter-port competition, shipping operators expect ports to increase their capacity to handle higher cargo volumes in an optimal way. While connectivity is dependent on the efficiency of logistics services, port efficiency determines performance times. The entire port community is highly interested in operations efficiency and effectiveness. In terms of ports characteristics and costs, for instance, shippers focus on its connectivity, on-time performance and ease of transactions. For the indicators relating to the "Port Operations" area, it is advisable to analyse the indicators separately for each business, due to the type of operations is particularly different.

The increase in capital investments and the growing size of the financial resources absorbed by current operations determine for the operators of the ports the increase in financial needs to be covered. The self-financing and the use of traditional forms of coverage of needs is not always easy and this requires the Port Authorities to introduce more financial and managerial skills within their

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departments to support investment and financing decisions. Therefore, it has become essential for PA to develop monitoring systems that are increasingly oriented towards understanding the main financial dimensions connected to the definition of investment and financing choices for the infrastructures, as well as liquidity management and forecasting of available cash flows.

Furthermore, ports are now facing changes in economic and logistical systems, with very extensive and complex business networks. The logistical environment in which they operate thus generates a high degree of uncertainty. It is, therefore, necessary to monitor continuously the current situation and market trends. It is important to remember that there are different types of business. As far as the goods sector is concerned, many businesses may be divided into: Dry bulk, Liquid bulk, Container, Roll-on – Roll-off (Ro-Ro). As regards the passengers' sector, instead, the business can be distinguished: cruise, ferries (medium/long distance), local (short distance). The identification and evaluation of indicators related to the market trends in the port environment contribute to a better understanding of the dynamics in the European port sector. It particularly allows assessing the growth dynamics in European ports and the vulnerability of the European port system to exogenous shocks (e.g. economic crisis) and market consolidation.

Finally, along with improved economic efficiency, ports should provide other sustainability parameters, such as environmental protection. This is because ports can produce negative environmental impacts. The planning of port system activities must be made following energy and environmental sustainability criteria and the applicable European Union directives. In particular, the reduction of CO2 emissions is a major planning objective. The law directs the authorities constantly monitoring their planned activities, to achieve energy and environmental efficiency goals. For this reason, Port Authorities must adopt a monitoring system of activities. Through this system, the PAs can demonstrate their commitment to issues relating to the use of renewable energy sources and tools to promote environmental sustainability.

The KPIs belonging to each of the five dimensions of analysis have different frequency of data processing in line with the actual variability of the data over time. The processing intervals are:

- Monthly
- Quarterly
- Yearly.

Depending on the frequency, it is possible to identify a further classification of indicators that takes into account the area of application. Specifically, these are:

- Operative
- Of process
- Infrastructural.

The Figure 17 shows the areas to which the KPIs belong and the frequency with which the main variables that make up the PAD are measured.

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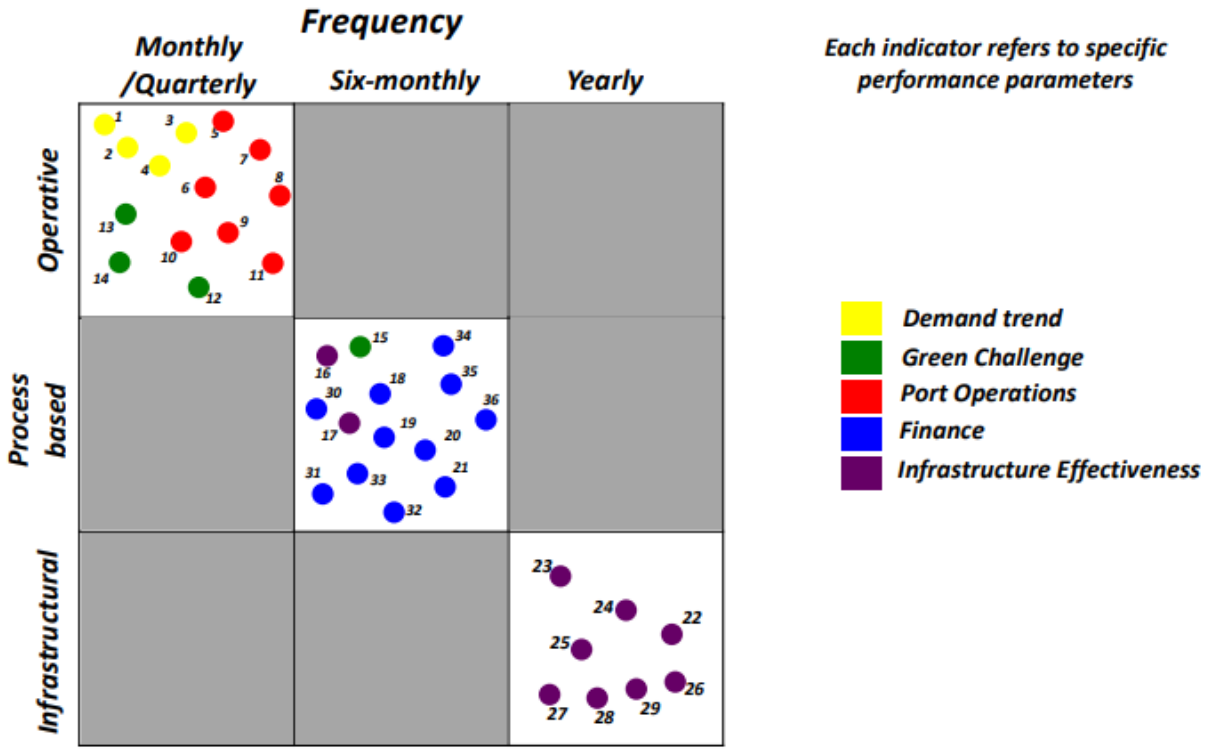

Figure 17 – Classification of KPIs according to the area of interest of application

As far as the technical-informatics aspect is concerned, the PAD offers a web-based interface with different customizable data visualization and analysis tools (e.g. different types of charts, tables) through business intelligence (BI) applications. It enables a comprehensive and intuitive overview of all the information, helping the user to focus on the data with higher priority at each moment and avoiding information overload. PAD consists of a dataset fed directly by the players, through a private section of the AdSP website. The main subjects that feed the repository are: Port Concessionaires, Coast Guard and Port Authority. Through a dedicated AdSP website interface, the players can access a private section, entering their login credentials (ID & Password). This guarantees maximum confidentiality and protection of the data entered by the different players. Players send autonomously the data related to their activity through a predefined format, able to standardize the data input. The tool provides a system for validation and verification of the consistency of the data received. Furthermore, the tool includes a control system to ensure that data are received on time and in the manner established. This system consists of alert messages sent automatically to operators, as a reminder. The Dashboard provides a section dedicated to statistics based on different data feeding PAD database. In this section, in addition to simple summary reports, enabled users can obtain statistical data with multiple comparison keys (dates, destination, etc.). The following Figure 18 shows the different types of graphical representation of statistics analysis.

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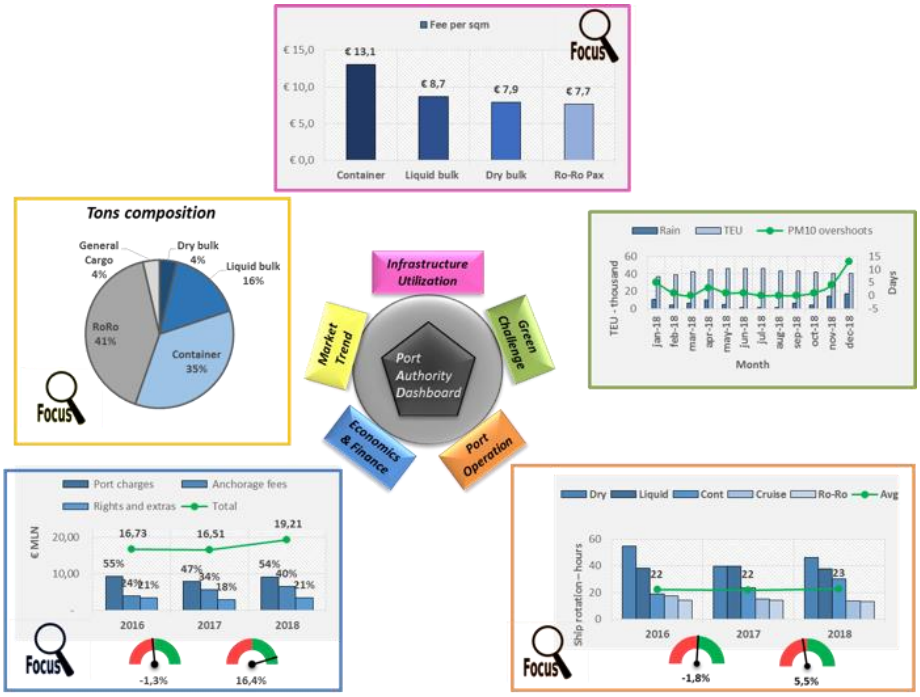

Figure 18 - Statistics for each analysis area

PortForward validated technologies will be demonstrated in relevant port Use Cases (TRL 6[6]). That is why one of the main objectives of Work Package 7 is to run experimental activities in real settings related to different typologies of port operations. In particular, the Use Case number 7 (UC7) involves the ports of Naples and Salerno. These ports, 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), that will provide access to the test sites for the setup of the technical equipment needed.

The development of the UC7 requires the full involvement of the following stakeholders: **Port Concessionaires, Coast Guard** and **Port Authority**.

The concessionaires are port operators who benefit from a port concession granted by AdSP MTC. A port concession is a contract in which a government authority transfers operating rights to private enterprise, which then engages in an activity conditional on government approval and subject to the terms of the contract. The concessionaires represent one of the main figures of the port system as they manage key port operations, such as: cargo handling and storage, vessel loading and unloading. For this reason, the analysis of information related to the activities of the concessionaires is essential in assessing the performance of the port system.

The following figure shows the stakeholders directly involved in the identified processes.

[6] A high-fidelity system prototype that adequately addresses all critical scalability issues is operated in a relevant environment to demonstrate operations under critical environmental conditions (TRL 6).

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Figure 19 - List of stakeholders involved in Use Case 7

The Coast Guard plays an important role in the execution of the processes as it ensures the safety of navigation operations and the protection of the marine environment. The Coast Guard is one of the bodies of the Italian Navy and it operates through numerous offices located along the Italian coast. Its main task is to ensure safety at sea through: safe control of navigation, search and rescue at sea, protection of the marine environment. As far as the monitoring of maritime traffic is concerned, the Coast Guard uses a high-tech system known as "*Vessel Traffic Service (VTS)*". This system guarantees a prompt intervention in case of accidents or presumed dangers by using sophisticated radar technology. Following its role of supporting navigation by constantly monitoring maritime traffic, the Coast Guard plays a fundamental role in maritime transport and in the sea-side operations of a port.

The Port Authority represents the administrative stakeholder. In Italy, the governing body of the port system is the "*Autorità di Sistema Portuale* (AdSP – Port System Authority)". The AdSP is a public not-for-profit entity of national importance subject to a specific legislative and regulatory framework with administrative, organizational, regulatory, fiscal, and financial autonomy. In particular:

- The Ministry of Infrastructure and Transportation oversees the AdSP and the National Court of Auditors controls its accounts.
- The control and monitoring functions become essential actions to set short and medium-long term objectives and to ensure their achievement.

The AdSP **plans the management and allocation of port areas** to concessionaires for commercial exploitation. Its **main functions** are:

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- the **planning, regulation, promotion, and control of port operations and services**, including the issuance of authorizations of use and concessions for commercial and industrial activities;
- the **maintenance** of common areas of the ports, including the seabed;
- the **coordination** of the administrative activities of other entities and public organs located in port and seaside areas;
- the **management** of port system activities by energy and environmental sustainability criteria.

The Port Authority is the main user of the PAD system. Therefore, the PA will have access to all the functionalities provided by the PAD. The other stakeholders can instead access them with limited properties.

9.1 Use Case objectives

The benefit of the PAD is to provide an integrated and significant view of a wide range of information, from different sources, related to various aspects of a system or process. Performance measurement and analysis systems are methodologies widely used in sectors that adopt strongly result-oriented strategies. Business managers use tools of this kind thanks to the continuous technological progress in data analysis and Information Technology (IT). The end-user of the PAD is the Port Authority that, by equipping itself with a tool based on data driven management, can perform its functions more effectively. Although Port Authorities in Europe are mostly public and not-for-profit entities, they have the task of managing port assets in the best possible way. In addition, PAs must meet the interests and needs of the port community to support a port's growth process and increase its competitiveness.

Ports are undergoing an evolutionary process, which is transforming them from berthing points to intermodal logistical nodes, part of a global network. As a result, the main port stakeholders are pushing for the digitization and simplification of many port processes and activities. In this scenario, ports' competitiveness increasingly based on the ability to optimize processes and activities, making them efficient and eco-friendly. Thus, the Port Authority has to deliver value to its stakeholders by employing any innovative technological, organizational and financial solution to achieve its goals and to measure the results achieved.

The development of the Use Case number 7 aims to achieve the key objectives belonging to the following categories (Figure 20), according to the classification indicated in deliverable 7.1 “Use cases requirements and evaluation metrics” (Table 1):

- “**Managerial**”: to improve the monitoring and management of processes at the managerial level.
- “**Operational**”: to optimize the execution of activities reducing time and resources employed.
- “**Informational**”: to allow quick and easy access to data and ensure the accuracy of information.

The main objective of UC7 certainly belongs to the “**Managerial**” category. This is because the PAD represents a support tool for port management - from which it is possible to extract constantly updated overtime information - on which to base the decision-making process and to verify and validate the objectives achieved. PAD can provide the port manager with data and measurements that detect

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medium to long-term deviations between expected and achieved objectives. This allows the port manager to take timely corrective actions to change the strategy adopted.

Effective port management consists of optimal use of resources and the execution of activities with reduced time and costs, ensuring at the same time high quality of service to port users. The PAD intends to pursue these objectives, belonging to the "**Operational**" category, thanks to a system of indicators articulated on the five areas of analysis to measure and evaluate the effective use of resources. The dashboard consists of a dataset in which data relating to port assets and resources are stored, together with all the information on their use (e.g. the berthing time of the ship). The dashboard processes the stored data to calculate statistics, identify trends and elaborate analyses based on the interpretation of KPIs. In this way, PAD allows the PA to control the use of port assets by detecting - through the indicators and their interrelation - potential partial uses, inefficiencies or wastefulness.

The accuracy of the information is the fundamental requirement for each dashboard. Port Authorities' investments in Information and Communication Technologies (ICT) help to reduce workload and operating costs. PAD offers easy access to a massive amount of stored data based on: a. automatic data retrieval; b. aggregation system; c. web-based interface with different customizable data visualization and analysis tools. Moreover, there is a control system to ensure that data are received on time and in an established manner, consisting of alert messages sent automatically to operators, both as memo and reminder. For these reasons, the PAD aims to achieve another key objective, the "**Informational**" one.

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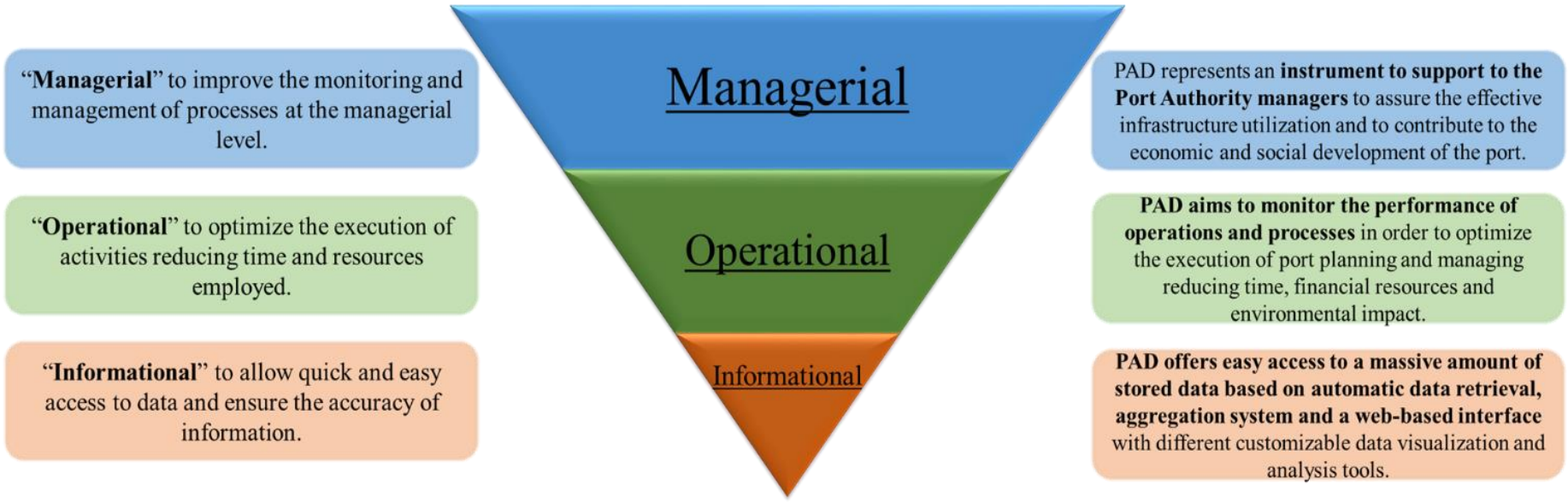

Figure 20 - Categories of objectives achievable by the Use Case 7

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Table 23 summarizes the main information provided until now in this chapter.

Table 23 - Use Case data: UC7_Monitoring of port performance

Use Case title	**Monitoring of port performance in different port areas**
Key Actors	Port Authority of Naples/Salerno
Stakeholders	Port Concessionaires, Coast Guard and Port Authority
Technical Partners	MARTE
Objectives	Informational, Operational, Managerial

9.2 Definition of evaluation metrics

This section aims to define a measurement system (list of Key Performance Indicators) that ensures the alignment of the Port Authority Dashboard with the expectations of the Port Authority. The evaluation metrics will assess the impact of the proposed new technological solution within Use Case number 7. The metrics represent specific and measurable information needed to verify the difference between the objectives achieved and those planned.

In order to consider the introduction of the new technology as successful, it is necessary that the objectives set by each partner - responsible for its Use Case - are achieved. Regarding the Use Case number 7, the objectives to be achieved with the introduction of the new technology have been associated to the three categories called “Managerial”, “Operational”, “Informational” (see the previous paragraph). These represent the expectations of the Port Authority (PA). PA with a data driven management tool based on an automated data collection system will be able to optimize the management of port activities:

a) from a managerial point of view, by adopting the optimal choice;
b) from an operational point of view, with efficient management of resources;
c) from an information point of view, by accessing at any time data and analysis made according to specific information needs.

The PAD, as a data driven management system, is an extremely innovative tool in the port management sector. To date, there are no integrated tools or procedures for the acquisition and analysis of data and information regarding, for example, environmental policy or port asset and infrastructure management. This gap is mainly due to the absence of effective and standardized processes and tools for data collection and exchange.

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The only data category to be communicated to the PA for the elaboration of periodic analyses are traffic data. However, this process, since it is not supported by an automatic data collection system; shows the following critical points:

- Frequent anomalies.
- High possibility of human error.
- Delays in sending data by individual operators.
- Need to send reminders.
- Lack of standardisation.
- Part of the data in printed form.

In a context of growth and development of the port system in Campania, traffic flows are increasingly large and difficult to monitor. The implementation of a data collection and analysis system, following a standard and automated format, can allow more accurate monitoring of port performance. Through the PAD this process will be improved and optimized:

- The system will be based on a data set consisting of data input directly loaded from the players, through a private section of the AdSP website[7].
- The system will process, in an automated way, statistics and Key Performance Indicators for goods, passengers and vehicles in transit. In addition to simple summary reports, enabled users will be able to obtain statistical data with multiple comparison keys (dates, destination, etc.).
- The service will provide a system of validation and verification follow-up of the consistency of the data received.
- A control system will ensure that data is received on time and in the manner established, using alert messages automatically sent to operators, both as memo and reminder.

Therefore, the evaluation system of the UC7 will consist of the definition of metrics that will measure the impact of the PAD on the process of collecting and analysing traffic flows. The Studies and Statistics Office of the AdSP of the Mar Tirreno Centrale has the task of collecting and analysing traffic flows of the ports of Naples, Salerno and Castellammare di Stabia, drawing up a monthly report.

Studies and Statistics Office voluntarily publishes traffic data every month according to the model provided by ESPO (European Sea Ports Organization)[8]. ESPO encourages the collection and sharing of traffic data between member ports for a long time, in order to monitor and communicate aggregated

[7] Through a dedicated interface of the AdSP MTC website it will be possible to access a private section by entering login credentials (ID & Password). This will guarantee maximum confidentiality and protection of the data entered by the various players.

[8] Founded in 1993 ESPO represents the seaports of the Member States of the European Union and has observer members from several other European countries. The ESPO mission is to influence public policy in the European Union in order to achieve a safe, efficient and environmentally sustainable European port sector, operating as a key element of a transport industry where free and undistorted market conditions prevail, as far as practicable.

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data on the performance of the sector over time. ESPO has developed the Rapid Exchange System (RES), based on port traffic figures provided by ESPO Members.

The ESPO Rapid data Exchange System includes quarterly data on the following traffics:

- Total tonnage: tonnage of goods carried, including packaging and including the tare weight of containers or Ro-Ro units (tonnes).
- Total liquid bulk (tonnes).
- Total dry bulk (tonnes).
- Total general cargo (tonnes).
- Containers (tonnes, TEU).
- The number of passengers.
- The number of vessels.

The objective of the impact evaluation is to demonstrate, through the measurement of specific performances, that the new technology has generated benefits[9]. Below is the list of defined metrics:

- **KPI$_1$**: Days of delay from the date of the publication of the monthly report of freight and passenger traffic statistics.
- **KPI$_2$**: Number of man-hours to draw up the monthly report of freight and passenger traffic statistics.
- **KPI$_3$**: Errors detected for each complete transmission of data by the concessionaire.

The positive evaluation takes place when the values detected during the measurements reach a predetermined threshold.

The first indicator focuses on the process of data collection and processing for the creation of the monthly report of freight and passenger traffic statistics. As already explained, the execution of this task is characterised by a number of inefficiencies due mainly to the constant delay in the sending of data by the dealers. The delay between the expected date of dispatch and the actual date of dispatch is usually about 10/15 days.

The second indicator considers the total amount of hours that the Studies and Statistics Office dedicates to the process of drawing up the monthly report of freight and passenger traffic statistics. The preparation of the statistical report is mainly divided into the three phases of data collection, standardization and aggregation. In each of them, for the reasons already given, inefficiencies and delays are generated and they take more time than necessary to carry out these operations. In particular, the absence of requirements for data standardization implies the need to perform different pre-processing operations on data received on the base of the type of traffic and the format and the method of sending the data chosen by the licensee.

[9] It should be noted that the indicators defined only cover a part of the objectives that the PAD intends to achieve.

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Finally, the third indicator measures the reliability of the Port Authority Dashboard because it detects the number of errors occurring for each complete transmission of data by each concessionaire. These errors may be due:

- network connection problems, when for example the message sent by the dealer is not received by the PAD server, generating the data lack;
- generic data entry errors when, for example, the concessionaire enters a non-compliant numerical data (e.g. format).

9.2.1 Measurement plan

This section provides useful information for the calculation of KPIs, such as the formula and the frequency with which the measurement will be carried out.

KPI_1: Days of delay from the date of the publication of the monthly report of freight and passenger traffic statistics

The AdSP MTC Studies and Statistics Office publishes on a given day of the month the report containing statistics on freight and passenger traffic for the previous month. Due to delays caused, for example, by concessionaires who send their traffic data late, it may happen that the date of publication of the report postpones by a few days. Through the following formula:

[Actual publication date - Scheduled publication date] [dd]

are calculated the days of delay in publication compared to what was previously planned. After the implementation phase a KPI close to zero is expected: this will show that by using the PAD it has been possible to reduce significantly the delay in publishing the report.

KPI_2: Number of man-hours to draw up the monthly report of freight and passenger traffic statistics.

The Study Office publishes every month a statistical report containing the results of the analysis carried out. The preparation of the report is mainly divided into three phases: collection, analysis and graphic elaboration of the results. Through the following formula:

*[Monthly man-hours referred to report elaboration/ Amount of monthly working hours] *100 [%]*

is calculated how much the work necessary for the elaboration of the statistical report weighs in percentage with respect to all the activities carried out by the Study Office.

This indicator detects the optimization of the execution of activities, in terms of reducing time and resources employed. After the implementation phase, a KPI close to zero is expected.

KPI_3: Errors detected for each complete transmission of data by the concessionaire.

The Port Authority invites all concessionaires to send their traffic data within a given day of the month. Errors may occur during the transmission of data due, for example, to connection problems

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between the concessionaires' peripheral systems and the PAD servers. The ratio between the number of errors detected and the total number of transmissions, calculated using the following formula:

*[Number of errors detected / Number of transmissions] *100 [%]*

A "transmission" represents the complete sending of all the data of a concessionaire to the Port Authority. This indicator measures the PAD impact on data quality. A KPI value close to zero will indicate that the PAD has improved the process of checking data accuracy.

The first detection of KPIs after the implementation of the PAD (ex – post) system will take place after 3 months the one carried out before the use of the PAD (ex – ante) (Frequency = quarterly).

Table 24 - Quantitative evaluation metrics (timing and frequency): UC7_Monitoring of port performance

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Days of delay from the date of the publication of the monthly report of freight and passenger traffic statistics.			Quarterly
2	Number of man-hours to draw up the monthly report of freight and passenger traffic statistics.			Quarterly
3	Errors detected for each complete transmission of data by the concessionaire.			Quarterly

Table 25 - Quantitative evaluation metrics: UC7_Monitoring of port performance

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Days of delay from the date of the publication of the monthly report of freight and passenger traffic statistics					Quarterly
Number of man-hours to draw up the monthly report of freight and passenger traffic statistics traffic.					Quarterly
Errors detected for each complete transmission of data by the concessionaire.					Quarterly

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10 Use Case 8: Dynamic Storage Monitoring

Background

Most of the terminals in the Port of Magdeburg are operated as multi-purpose terminals. E.g. the trimodal Hanse-Terminal is used for loading/unloading and storage of containers, dangerous goods, heavy-duty cargo and other break bulk. The storage of cargo (short term and also mid term) takes place in the storage areas of the terminal, which are not broken down into single storage locations. Due to the varying size of the stored cargos, it is not useful to mark storage locations on the ground.

Not having storage locations leads to a lack of documentation of stored cargos, thus resulting in comparably high search efforts and partly inefficient management of the storage locations (e.g. when storage areas need to be cleared for incoming cargos and other cargos need to be stored in different locations).

The idea of the use case is to develop and test a Virtual Storage Location Grid to enable a Dynamic Storage Monitoring. In the Virtual Twin model of the port a virtual grid is defined. Based on imaging sensors in the port infrastructure the current occupancy of the grid locations shall be automatically detected and be monitored in the Virtual Twin. When cargos are stored they need to be identified in parallel. The meta data of the cargo and the occupied storage grid locations are merged within the Virtual Twin.

Process

The planned process is described in the following table. This description is also part of D1.3.

Table 26 – Process steps of Dynamic Storage Monitoring

Process Step	Relevant Data / Messages	Architecture Elements involved
▪ Piece of freight arrives for storage o Free available storage areas are displayed by Virtual Twin o Piece is moved and stored in a free storage location o Operator is scanning the piece and Geo-Position is stored by mobile device	▪ Storage Event generated (Piece ID, location, timestamp)	▪ Virtual Twin GUI ▪ Scanning Device (incl. GNSS) ▪ IoT-Stack
▪ Camera / LiDAR infrastructure provides overview on storage area o With incoming storage event the current storage state is compared to previous state o New storage piece is detected o Position and size of piece are calculated from camera images	▪ Piece registered in Virtual Twin (Piece ID, image references location, size / shape, orientation, timestamp)	▪ Virtual Twin ▪ Camera / LiDAR Infrastructure ▪ (IoT Stack – if feasible)

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▪ Piece is represented in Virtual Twin ○ With ID and relevant meta data + position + image ○ Occupancy of virtual grid is updated	▪ Visualization of piece in virtual Twin GUI	▪ Virtual Twin GUI
When a piece of freight is dispatched the process steps are carried out vice versa – starting with displaying location of the piece for dispatch		

Stakeholders

The Port of Magdeburg (owner and operator of the port terminals) is the only stakeholder besides IFF as development partner.

Technologies

For the generation of dynamic 3D images of the storage situation in the terminal **LiDAR sensors** will be used. In the figures below the planning of the sensor positions within the terminal and a 3D image of a test measurement in the port environment are shown.

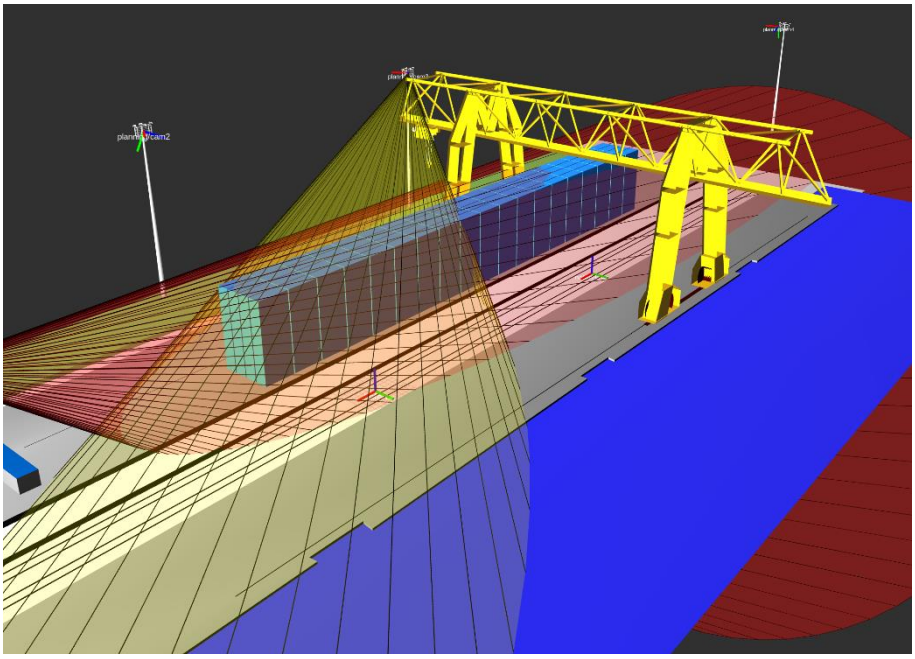

Figure 21 – 3D planning of LiDAR sensor positions within the port terminal

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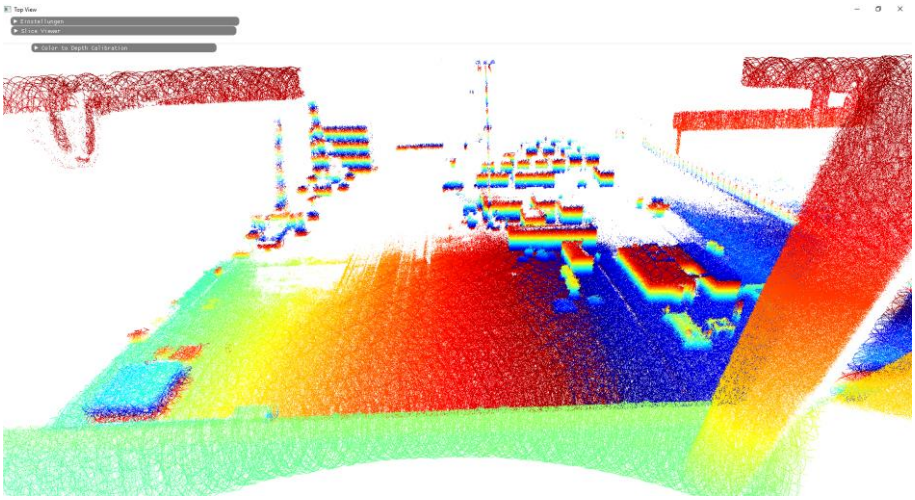

Figure 22 – LiDAR test measurement in the port terminal

As a fall back sensor system to detect the occupancy of storage locations, the existing camera infrastructures of the terminal can be used. Based on the distributed camera views a so called **Virtual Birds Eye View** [Borstell et al., 2012] is generated. This metric association of camera images can be used to analyse the occupancy of the storage areas.

The **Pre-Processing** of the 3D LiDAR data is integrating the 3D data of the single sensors into one point cloud. The data of this aggregated point cloud will be used to locate and detect objects with their contours within the observed area.

Mobile Devices (e.g. tablet computer) will be used by operators in the terminal to register single cargos that are stored. This registration is needed to provide the relevant meta data and a rough GPS position of the individual cargo piece to the further processing.

The **Storage Calculator** will classify the detected objects within the 3D point cloud and map these with event data from mobile devices. The merged data (meta data, location and orientation, classified contour) are send to the Virtual Twin model.

The **Virtual Twin** is the central user interface for the use cases of the Port of Magdeburg. Besides the spatial structures of the port, which can be used for strategic spatial planning, it will be used to visualize current operational processes and statuses. For the Dynamic Storage Monitoring, the occupancy of the storage area will be visualized in the Virtual Storage Location Grid. Furthermore the classified cargo contours will be visualized in the 3D model also providing all relevant meta data.

10.1 Use Case objectives

The objective of the use case is to develop and test a technical approach to improve the management of storage areas in multi-purpose terminals. With the planned implementation on the one side the technical approach using LiDAR sensors shall be tested and (if viable) demonstrated (objective ***IT Infrastructure***). On the other side, constantly updated information about the occupation of storage

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locations shall be provided to operators via the Virtual Twin model. As this enables quick and easy access to data and information, ***Informational*** is another objective of the use case. The provision of new information about the status of storage areas allows to optimize storage and handling operations. In addition, search efforts can be reduced. Thus, ***Organizational*** is the third objective.

Table 27 - Use Case data: UC8_Dynamic Storage Monitoring

Use Case title	**Dynamic Storage Monitoring**
Key Actors	Port of Magdeburg
Stakeholders	Operational Staff and Dispatchers of Port of Magdeburg
Technical Partners	IFF
Objectives	Informational, Organizational, IT Infrastructure

10.2 Definition of evaluation metrics

The main metric that the planned use case aims at, is the actual occupancy of the storage area within the port terminal. This metric shall be used for operational purpose to support handling operations and increase their efficiency.

- *Current Utilization Status per grid segment* [Occ/Loc]
  This metric is giving an overview which grid segments are currently occupied and which are available for storage of cargo.

However, for the purpose of the evaluation planned within this document, this metric is too granular and needs to be aggregated over longer time. This leads to the following evaluation metrics (see also D1.2 and D6.1):

- ***Average Storage Area Utilization*** [%]
  This metric indicated the general utilization of the monitored storage area. On a daily basis it is relevant status information – over a longer time period as statistic long term information it is relevant for strategical planning (e.g. if additional storage areas are required).
- ***Average Duration of Storage*** [ddd:hh]
  This metric indicates an average duration of storage in the monitored storage area. It is relevant as statistic long term information for strategical planning (e.g. if additional storage areas are required).
- ***Rate of handling operations*** [Ops/d]
  This metric gives a general overview on the amount of handlings in the monitored storage area. It can be further detailed in differentiating different kinds of operation (e.g. storage, retrieval, restore).

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Some of these metrics can be further specified for single locations of the storage are as following (but are not relevant for the evaluation purpose of this deliverable):

- *Average Utilization per grid segment* [%/Loc]
  This metric gives and an overview, which parts of the storage area are mainly utilized (and which are less utilized). It shall help to optimize the planning of handling and storage operation.
- *Average Duration of Storage per grid segment* [ddd:hh/Loc]
  This metric gives an overview, how long cargo is stored in different parts of the storage area. It shall help to optimize the planning of handling and storage operation.

All these metrics have not been recorded before in that specific way. Further analyses can be built on the data, which will be provided by the developed system. Especially also cargo-centred metrics can be developed.

10.2.1 Measurement plan

The defined metrics shall be provided by the developed solution in the frequency of measurement as described in the table below.

Table 28 - Quantitative evaluation metrics (timing and frequency): UC8_Dynamic Storage Monitoring

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	Average Storage Area Utilization			Monthly
3	Average Duration of Storage			Monthly
5	Rate of Handling Operations			Monthly

Table 29 - Quantitative evaluation metrics: UC8_Dynamic Storage Monitoring

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
Average Storage Area Utilization					Monthly
Average Duration of Storage					Monthly
Rate of Handling Operations					Monthly

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11 Use Case 9: Inter-Terminal Tracking

Background

The Port of Magdeburg consists of distributed terminals connected by public roads. Currently there is no tracking of port "internal" transports of assets. This leads to inefficient scheduling of handling operations in the single terminals. The inter-terminal tracking of assets shall be established using LoRaWAN based tracking devices. An enhanced transparency on the current positions and statuses of assets shall enable the optimization of asset utilization and reduce search efforts.

The assets shall be equipped with LoRa-Trackers containing GPS to enable their localization within the general port area. LoRaWAN connectivity for these trackers will be provided by LoRaWAN gateways in the port area. Status information of the single trackers shall be visualized within the Virtual Twin of the Port of Magdeburg.

Process

The planned process is described in the following table. This description is also part of D1.3.

Table 30 – Process Steps of Inter-Terminal Tracking

Process Step	**Relevant Data / Messages**	**Architecture Elements involved**
Registration of Asset and IoT-Tracker	Tracker-ID Asset meta data (e.g. name, defined storage location)	Asset Registration
Asset is moving	Tracker-ID Location data (e.g. once per minute) Movement status (moving)	Asset Tracking Visualization in Virtual Twin
Asset is stored	Tracker ID Location (last location before standby) Movement status (stored)	Asset Tracking Visualization in Virtual Twin
System status (e.g. once per hour)	Tracker ID Movement status Battery level	Asset Tracking

Stakeholders

The Port of Magdeburg (owner and operator of the port terminals) is the only stakeholder besides IFF and IMEC as development partners.

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Technologies

Assets of the port will be equipped with **LoRaWAN Trackers**. These contain a GPS and an acceleration sensor to automatically set the device into sleep mode, when the asset is not moving. The activity data are transmitted via the energy-saving LoRaWAN technology. Depending on the actual frequency of transmitted messages, the battery of the tracker shall last for several years.

The **LoRaWAN Gateway** receive the data of the trackers over long distance. In the first planning of the use case it is expected that two gateways can cover the complete area of the Port of Magdeburg.

The **Network Server** consolidates the received data from the gateways before they are transmitted to the IoT Middleware. If e.g. two gateways receive the same message from a tracker, the message will be forwarded only once to the Middleware.

The **IoT Middleware** of IMEC provides basic functionalities to store and process data of such IoT Trackers.

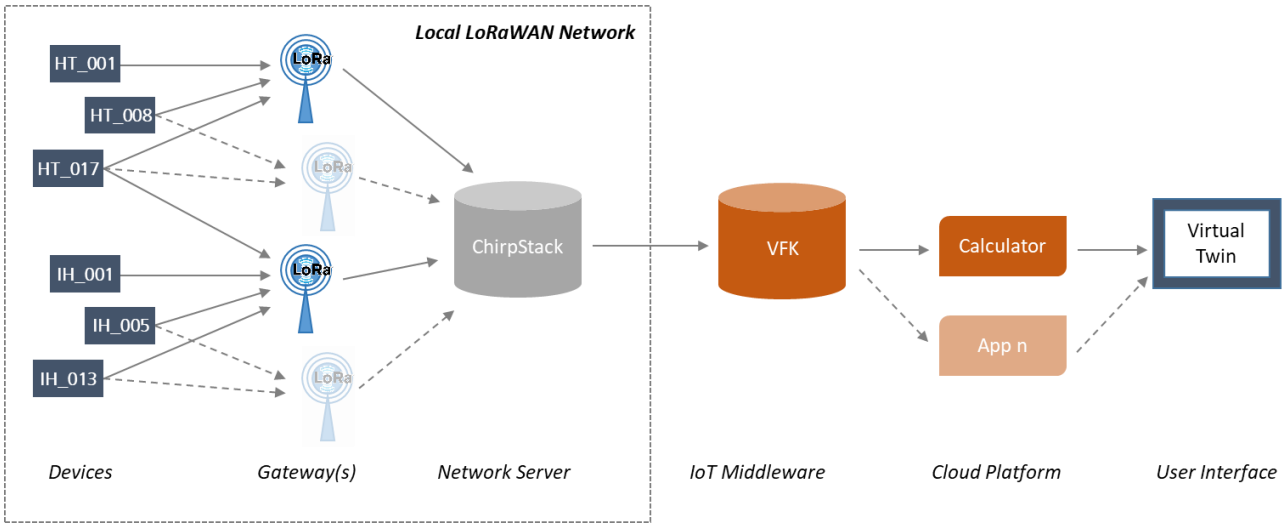

Figure 23 – Setup of the local LoRaWAN network for the use case Inter-Terminal Tracking

To gain additional information besides the pure location and status of an asset additional KPIs will be generated by the **Asset Tracking KPI Calculator**.

The **Virtual Twin** is the central user interface for the use cases of the Port of Magdeburg. Besides the spatial structures of the port, which can be used for strategic spatial planning, it will be used to visualize current positions and statuses of assets. Additionally the calculated KPIs per Asset will also be visualized.

11.1 Use Case objectives

The objective of the use case is to implement tracking devices to enhance the transparency of locations and statuses of moving assets. As a new technical infrastructure will be set up one objective of the

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use case is ***IT Infrastructure***. The constantly updated information about the position and status of assets shall be provided to operators via the Virtual Twin model. As this enables quick and easy access to data and information, ***Informational*** is another objective of the use case. The provision of new information about the assets allows to optimize handling operations and their management. In addition, search efforts can be reduced. Thus, ***Organizational*** is the third objective.

Table 31 - Use Case data: UC9_Inter-Terminal Tracking

Use Case title	**Inter-Terminal Tracking**
Key Actors	Port of Magdeburg
Stakeholders	Operational Staff and Dispatchers of Port of Magdeburg
Technical Partners	IFF, IMEC
Objectives	Informational, Organizational, IT Infrastructure

11.2Definition of evaluation metrics

Mainly the implementation of the LoRaWAN trackers enables a real-time overview on the position and the status (in use / not in use) of moving assets within the port area with its distributed terminals. Based on that activity tracking the following metric can be recorded for operational purpose and as basis for further evaluation metrics:

- *Location and Status per Asset* [Lat,Lon; Activity]
  This metric is giving an overview on the current location and the activity status of an individual asset. The activity can be moving or stored.

With an aggregation over a longer time period and over all or specific groups of assets the following evaluation metrics are defined:

- ***General Utilization of Assets*** [%]
  This metric is giving an overview on the utilization of all asset or a group of asset. In relation to the utilization of individual assets the planning of assets can be optimized (e.g. to even the utilization along assets of the same type).
- ***General Utilization Spots*** [GeoArea]
  This metric indicates in what areas assets or a group of assets is mainly used. This can help to optimize the allocation of assets across the terminals.

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These metrics can be further detailed for individual assets as following (not relevant for the evaluation purpose of this document):

- *Average Utilization per Asset* [%]
  This metric indicates how often in average an individual asset is used over time. It can be used for the strategic planning (e.g. reinvests).
- *Main Utilization Spots per Asset* [GeoArea]
  This metric indicates in what area (e.g. a specific terminal) an asset is mainly used. This can help to optimize storage locations of an asset (e.g. by reducing transportation of assets between different terminals).

All these metrics have not been recorded before in that specific way. Further analyses can be built on the data, which will be provided by the developed system.

11.2.1 Measurement plan

The defined metrics shall be provided by the developed solution in the frequency of measurement as described in the table below.

Table 32 - Quantitative evaluation metrics (timing and frequency): UC9_Inter-Terminal Tracking

KPI name		Time of Measurement		Frequency of Measurements
		Ex Ante	Ex Post	
1	General Utilization of Assets			Monthly
2	General Utilization Spots			Quarterly

Table 33 - Quantitative evaluation metrics: UC9_Inter-Terminal Tracking

KPI name	Ex Ante	Ex Post	Ex Post	Ex Post	Frequency of Measurements
General Utilization of Assets					Monthly
General Utilization Spots					Quarterly

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12 Conclusions

This report contains the results of the first step of the MARTE's methodology to assess the impact of each Use Case. Activity 7.1.2 aims to collect the first input data for the design and testing phase that will take place in the subsequent activity (T7.2) of the PortForward project. The report contains the following information for each Use Case:

- the objectives that each partner intends to achieve through the adoption of the proposed technology;
- the metrics for the impact assessment of the Use Case;
- the frequency with which metrics will be ovserved.

The methodology applied for the assessment of the impact of the Use Case provides for the collection of information in a standardised manner. This requirement arises from the need to allow a comparative analysis among the nine Use Cases foreseen by the PortForward project, thus achieving one of the main objectives of Work Package 7.

In order to ensure comparison of Use Cases, it was necessary to limit the number of objectives that the partners could indicate. To this end, the objectives were associated to one or more categories extracted from a shortlist that allowed representing the need for the implementation of the new technologies (*Source: AL-Ghamdi, A. S. A. M., & Saleem, F. (2018). General characteristics and common practices for ICT projects: Evaluation perspective*). The clear definition of the objectives (Section "Use Case objectives" in each chapter) represented a fundamental step towards achieving two important results. Pushing partners and port interlocutors to discuss how to measure the success of the implementation of the new technology helped them to clarify the real objectives and to fix the goals. In some occasions the change of priorities due to COVID-19 epidemic was causing mis-alignment among technological developers and receivers of the technical solutions. The discussion on how to measure the success helped fixing the needs to satisfy. On the other end declaring how to measure success also helped technological providers to figure out solution improvements.

The following Table 34 shows the objectives indicated for each Use Case. The only one indicated for all cases is the "Informational". In motivating the choice of this objective, the partners underlined the need for port operators to equip themselves with new technologies able to allow faster and easier access to the large amount of data they collect. At present, data are obtained in different ways (e.g. sensors located in the port area, traffic data sent voluntarily by the concessionaires, data bases provided by satellite operators, etc…) and are critical to curry out port activities. The achievement of an "Informational" type of objective allows end-users to carry out the same activities but in a more efficient and effective way. Among the objectives, the "Operational" objective is the second most selected. In a context characterized by high competition within the port and between different ports, it becomes strategic and indispensable to adopt tools that allow the optimization of resources ensuring a high quality of service. In this regard, the project partners - technology providers - have indicated how they intend to meet these needs and how the new tools will be able, for example, to increase the capacity to handle higher cargo volumes. No partner, instead, considered it appropriate to indicate the objectives "Strategic" and "Transactional".

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Table 34 - Objectives indicated by the partners for each Use Case

		Strategic	Informational	Transactional	Transformational	Organizational	Operational	IT Infrastructure	Managerial	Others
UC1	**Stevedoring, Ro/Ro terminal handling and logistic service optimization** (ACCIONA)		■				■			
UC2	**Services by Port Authorities** (ACCIONA)		■				■			
UC3	**Prediction of Port-City Interactions** (LEITAT)		■				■	■		
UC4	**Green Scheduling and Sustainability of operation** (BRUNEL)		■				■			
UC5	**Pilot Assistance to ship manoeuvring in port waters** (AdSP MTS)		■		■		■	■		
UC6	**Assistance to goods control and inspection within port boundaries** (AdSP MTS)		■				■	■		
UC7	**Monitoring of port performances in different port areas** (MARTE)		■				■		■	
UC8	**Dynamic Storage Monitoring** (FRAUNHOFER)		■			■		■		
UC9	**Inter-Terminal Tracking** (FRAUNHOFER)		■			■		■		
	Total	**0/9 (0%)**	**9/9 (100%)**	**0/9 (0%)**	**1/9 (11, 1%)**	**2/9 (22, 2%)**	**7/9 (77, 7%)**	**5/9 (55, 5%)**	**1/9 (11, 1%)**	**0/9 (0%)**

As anticipated, this report also collected the metrics that each partner will adopt for the assessment of the impact of the Use Case and the frequency with which it will be measured. The partners have indicated metrics of a qualitative and quantitative nature defined according to the specific technology as well as the port process on which it will have an impact (Section "Definition of evaluation metrics"). The measurements will require the full participation of stakeholders, mostly port concessionaires (e.g. Shipping Companies, Terminal Operators), Information Technology providers, Local Authorities and port service providers (e.g. pilots). The partners have defined the measurement plan (Section "Measurement plan") that they will share with the end-user in order to allow a joint preliminary assessment of the timing of the testing phase. The measurement plan will allow the

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continuous comparison between the technology provider and the end-user, in order to detect any deviations from the objectives set.

Finally, the report contains a first assessment of the impact of the COVID-19 (paragraph 1.2) emergency on maritime industry and PortForward project activities. The pandemic affected these activities because the partners had to reorganize their operational procedures due to the virus containment measures imposed by their governments. Furthermore, it has led to a change in the priorities of the port partners and the birth of complications in the decision-making on operational processes that will influence the next demonstration phase of the project. Thus, this phase, which will include the testing of new technologies at port sites, may be subject to delays.

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