



Flexible, multi-mOdal and Robust FREIGHt Transport

D1.3 FOR-FREIGHT system architecture & technology specifications

Document Summary Information

Grant Agreement No	101069731	Acronym	FOR-FREIGHT
Full Title	Flexible, multi-mOdal and Robust FREIGHt Transport		
Start Date	01.09.2022	Duration	40 months
Project URL	https://www.for-freight.eu/		
Deliverable	D1.3 FOR-FREIGHT system architecture & technology specifications		
Work Package	WP1 – SotA analysis, Use Case Definition and Solution Design		
Contractual due date	M12	Actual submission date	31/08/2023
Nature	Report	Dissemination Level	Public
Lead Beneficiary	CSLS		
Responsible Author	CSLS		
Contributions from	CERTH, ABS, BEIA, DHL, IMEC, CSLS, FVP, MDM, EBOS, WINGS, ZSI, AIA, COEL		

Revision history (including peer reviewing & quality control)

Version	Issue Date	% Complete	Changes	Contributor(s)
V0.1	04.05.2023	10	Initial Deliverable structure	CSLS (Chiara Iorfida, Ana Isabel Mayor)
V0.2	27.06.2023	25	Final structure on the deliverable set. Mapping of the For-Freight Outputs, first draft on sections on inputs of T1.3, technological validation, business validation methodology and risk assessment	CSLS Chiara Iorfida, Ana Isabel Mayor), FV (Alicia Enríquez, Jorge Feliu), EBOS (Philippos Philippou), CERTH (Georgia Ayfantopoulou, Sofoklis Dais), WINGS (Sokratis Barmounakis)
V0.3	06.07.2023	60	Finished sections on inputs for T1.3 and business validation. First draft on section on system architecture overview, contributions included from all three use case's partners on technological validation and risk assessment.	CSLS (Chiara Iorfida, Ana Isabel Mayor), FV (Alicia Enríquez, Jorge Feliu), DHL (María Ramírez), MDM (Rafael Villa), IMEC (Ngoc Quang Luong, Raúl Cuervo Bello), ABS (Tiago Alves), AIA (Zagas Panagiotis), COEL (Mary Chatzidiamanti), BEIA (Stefan Stefanescu), WINGS (Orestis Manos).
V0.4	11.08.2023	80	Final contributions on system architecture overview section, risk assessment section and commercialisation analysis.	BEIA (Stefan Stefanescu), GP (Andra Marcu), IMEC (Ngoc Quang Luong, Raúl Cuervo Bello), FV (Alicia Enríquez, Jorge Feliu), EBOS (Philippos Philippou)
V1.0	28.08.2023	100	Addressing comments from Peer Review and Quality Assurance review of V0.4. Minor changes across the document. Gave final format to the whole document.	CSLS (Chiara Iorfida, Ana Isabel Mayor, Pablo Ferrer), FV (Alicia Enríquez, Jorge Feliu), DHL (María Ramírez), IMEC (Ngoc Quang Luong, Raúl Cuervo Bello), ABS (Tiago Alves), BEIA (Stefan Stefanescu, Cornelia Alexandru), EBOS (Philippos Philippou), WINGS (Sokratis Barmounakis), CERTH (Georgia Ayfantopoulou, Sofoklis Dais).

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¹ According to FOR-FREIGHT's Quality Assurance Process for reports:

4 months before Deliverable's Due Date: Table of Contents ready to be reviewed by WP leader/ Technical Manager/ Quality Manager

3 months before Deliverable's Due Date: 50% should be complete. Review by the Quality Manager (& Technical Manager for software).

2 months before Deliverable's Due Date: 80% should be complete. Review by the Quality Manager. (& Technical Manager for software).

1 month before Deliverable's Due Date: 100% should be complete. Review by the Quality Manager and Peer Reviewers.

M: Sent to PC for Submission to the EC after addressing all comments by Quality Manager and Peer Reviewers

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Glossary of terms and abbreviations

Abbreviation / Term	Description
ABS	ALLBESMART LDA
AI	Artificial Intelligence
AIA	ATHENS INTERNATIONAL AIRPORT S.A.
API	Application Programming Interface
ATG	ASOCIATIA TEHNOPOL – GALATI
BEIA	BEIA CONSULT INTERNATIONAL SRL
CERTH	CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
C-ITS	Cooperative Intelligent Transport Systems
CO2	Carbon dioxide
COARRI	Container discharge/loading report message
COEL	COSCO SHIPPING Lines Greece
COPRAR	Container discharge/loading order message
CSLS	COSCO SHIPPING Lines Spain
DHL	DHL EXEL SUPPLY CHAIN SPAIN SL
DSS	Decision Support System
E2E	End to End
GHG	Greenhouse Gases
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FTP	File Transfer Protocol
FVP	FUNDACIÓN DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCIÓN Y ESTUDIOS COMERCIALES DE VALENCIAPORT
GA	Grant Agreement
GOLD	GOLDAIR EXYPIRETISEIS EDAFOUS ANONIMI ETAIREIA
GUIs	Graphical User Interface
HTTP	Hypertext Transfer Protocol
IMEC	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM
IoT	Internet of Things
KPI	Key Performance Indicator
ML	Machine Learning
MDM	Metro De Madrid
MVP	Minimum Viable Product
OBU	On-board Unit
SCADA	Supervisory Control and Data Acquisition
sotA	State of the Art
TBD	To Be Decided
TcCFR	TELECOMUNICATII CFR SA
TRL	Technology Readiness Level
T&L	Transport and Logistics
UC	Use Case
WINGS	WINGS ICT SOLUTIONS INFORMATION & COMMUNICATION TECHNOLOGIES IKE
WMS	Warehouse Management System

WP	Work Package
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1 Executive Summary

Deliverable 1.3 “FOR-FREIGHT system architecture & technology specifications” is the third report listed in WP1 WP1 “SotA analysis, Use Case Definition and Solution Design”. It is a report on the architecture and specifications of the initial version of the E2E FOR-FREIGHT system including the testing & validation methodology and solution design/development risk assessment. It is the output of Tasks 1.3 and 1.4 and is based on inputs provided by tasks 1.1 and task 1.2.

This report mainly focuses in three tasks:

- The testing and validation methodology of the developed FOR-FREIGHT solutions (T1.3). Testing and validation methodology that is elaborated in this deliverable entails the acceptance test procedures for conducting both the technological and business validation of the FOR-FREIGHT platform and solutions.
 - As far as the technological validation is concerned, procedures are defined for collecting the data feeds from the logistics nodes, systems and sensors and other relevant equipment, stating also how these feeds will be used and analysed by the FOR-FREIGHT Platform to produce and present the necessary data in a user-friendly form. Threshold limits for the benchmarking of the results will also be defined per target KPI based on the requirements stemming from each use case.
 - For the business validation it will be adapted the lean Startup methodology that centres around the main motivations of a business. The inputs include apart from the business case itself, end-user feedback from their direct engagement in the trials of the T&L use cases. For this purpose, a questionnaire’s structure type detailing the relevant content to include has been prepared so each use case can adapt it in each iterative cycle of the business solution’s validation. Also, the specific instructions for organizing focused group workshops directly engaging other T&L actors have been set. The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialization potential so as to progress to the next step of creating a service product portfolio.
- The design of the FOR-FREIGHT end-to-end system architecture for the central platform (T1.4). The design of such platform will be based on the requirements and specifications analysed and established on T1.2, as well as the integration approach of the various logistics systems and components. In this deliverable is included an overview of the initial system architecture describing the scope of the platform, the system architecture at a high level, the components and subsystems and the integration points. The outcome of this task will be used by WP2 as the reference for the software and testbed development/upgrades.
- Risk Analysis of the design/development of the central FOR-FREIGHT platform and the solutions. The risk analysis of the developments and their evaluation, together with the mitigation strategies are identified and analysed and this output will feed into the project solutions development and assessment of WP2 and WP3 respectively.

This report will be the base for building deliverable D1.4 “FOR-FREIGHT system architecture & technology specifications (Revised version)” and also sets the base of the holistic evaluation framework that has been developed together with T1.2 and T3.5 “Evaluation, lessons learned and best practices” for defining and validating results with corresponding KPIs (before-after) and generating insights per testing case and utilized multimodal solution.

2 Introduction

Task 1.3 has the objective to define a detailed testing and validation methodology to be used for the evaluation of the proposed use cases, in order to maximize the gained insights. It also provides an overview of the architecture of the FOR-FREIGHT platform, targeting the facilitation of multimodal / multi-stakeholder T&L trials and enabling the validation of the FOR-FREIGHT use cases.

Initially, the deliverable defines the system architecture overview by detailing the scope of the platform, main back-end and front-end components as well as the integration challenges and barriers for its interoperability.

The document then details both technological and business validation methodologies to evaluate the FOR-FREIGHT solutions and use cases, by defining KPIs and data collection baseline as well as the business strategy for market launch.

Finally, it defines the risk assessment process in order to identify, content and monitor risks that may occur during the use case development.

This deliverable also refers to the Implementation Objective 3. The Objective is focused on the validation of the FOR-FREIGHT solutions in real-life multimodal/multi-stakeholder environments using real end-user data, based on carefully designed UCs that will showcase the maturity and business-readiness of the solutions (TRL \geq 7), demonstrating the superior performance (in terms of capacity, resource efficiency, sustainability, reduced emissions and cost) of the integrated, multi-stakeholder logistics chain management delivered by FOR-FREIGHT, compared to the current fragmented logistics operations.

2.1 Mapping FOR-FREIGHT Outputs

This section presents the FOR-FREIGHT 's Grant Agreement (GA) commitments, as extracted from the formal deliverable and task description, in respect to their outputs and work to be performed. Purpose is to aid the reviewer finding the specific sections of the document where the respective tasks' requirements are addressed but also to guide the author through and serve as a check list to address everything that is needed to be addressed.

Table 2.1.1 Adherence to FOR-FREIGHT's GA Deliverable & Tasks Descriptions

FOR-FREIGHT GA Component Title	FOR-FREIGHT GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D1.3 FOR-FREIGHT system architecture & technology specifications	"Report on the architecture and specifications of the initial version of the E2E FOR-FREIGHT system including the testing & validation methodology and solution design/development risk assessment."	Chapter 3	Chapter 3 will collect a summary of the results from tasks 1.1 and 1.2 which serve as inputs for Task 1.3.
		Chapter 4	Chapter 4 is an overview of the initial system architecture describing the scope of the platform, the system architecture at a high

			<p>level, the components and subsystems and the integration points.</p>
		<p>Chapter 5</p>	<p>Chapter 5 will provide the description of the technological validation methodology, by detailing KPI baseline definition and data collection for baseline scenario. This chapter will collect the activities from FOR-FREIGHT’s use cases, by describing its KPI’s baseline values and the procedure for the data collection baseline from the logistics nodes, systems and sensors and other relevant equipment that will serve as an input to the solutions. It will also describe the means of verification of the KPI’s.</p>
		<p>Chapter 6</p>	<p>Chapter 6 will provide the description of the business validation methodology, describing the lean start up methodology to be applied and defining how it will be applied identifying all the tasks participating in it. The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialisation potential so as to progress to the next step of creating a service product portfolio.</p>
		<p>Chapter 7</p>	<p>Chapter 7 collects risk analysis performed</p>

			regarding the design of the solutions and FOR-FRUGHT central platform and also for all three Use Cases. Also, mitigation actions are defined.
TASKS			
Task 1.1 Task 1.2	<p>“Task 1.1 This task will perform a comprehensive assessment of “the current way of working”, focused on the various dimensions that explain the current situation of the Transport and Logistics sectors. In this manner, Task 1.1 will consider, i) Transport and Logistics Operational models assessment in order to characterise the performance and existing interrelation among key intermodal transport and logistics agents (shipping lines, port authorities, port terminals, customs, rail and road operators, etc.), ii) Business models addressing the value chain under which the transport and logistic agents are engaged along transport routes and logistic corridors, iii) Technological and legacy systems analysis to identify current platforms architectures and information exchange protocols and formats, with focus on the existing and non-existing standardised data exchange and iv) Current T&L data standardisation initiatives, thus aligning the current efforts in the field with the FOR-FREIGHT Use Cases (e.g. ship-port interface information exchange, port terminals standards, etc.). Task 1.1 results will serve as inputs for Tasks 1.2, 1.3, as well as to subsequent WPs.”</p> <p>“Task 1.2 This task will be responsible for the detailed description of the requirements analysis and Use case refinement must have based on the SotA and logistics study stated in T1.1. Co-design processes for the design of the solutions will take place as an internal exercise concerning project partners and regarding the process during which the technology/SW developers co-design suitable solutions with the project end-users. This task will first focus on the functional requirements definition gleaned from the analysis of the existing practices and management systems currently in place in</p>	Chapter 3	The inputs from Task 1.1 and 1.2 are collected in chapter 3 summarizing its results.

	<p>order to identify the stakeholder's communications methods, weakness, challenges and potential opportunities to improve multimodal transports in each of the logistics areas identified. These requirements will be mapped to the UC scenarios and translated into technical requirements and selection of the most appropriate technologies to support the field trials for achieving a more efficient and effective multimodal freight transport to increase flexibility, service visibility and reduce logistics costs. The 3 Use Cases will be accordingly detailed providing specific goals and target KPIs, which will act as input to Task 1.3 Testing and Validation methodology execution. The Use Case requirements will also act as a driver for the necessary supported functionality of the FOR-FREIGHT end-to-end solution design and architecture, hence as input to Task 1.4.</p>		
Task 1.4	<p>"This task is responsible for designing the FOR-FREIGHT end-to-end system architecture for the central platform. The design of such platform will be based on the requirements and specifications analysed and established on T1.2, as well as the integration approach of the various logistics systems and components."</p>	Chapter 4	<p>The input from Task 1.4 is collected in chapter 4 which includes an overview of the initial system architecture describing the scope of the platform, the system architecture at a high level, the components and subsystems and the integration points.</p>
Task 1.3	<p>"The testing and validation methodology to be elaborated in this task entails the acceptance test procedures for conducting both the technological and business validation of the FOR-FREIGHT platform and solutions. In particular, as far as the technological validation is concerned, procedures will be defined for collecting the data feeds from the logistics nodes, systems and sensors and other relevant equipment, stating also how these feeds will be used and analysed by the FOR-FREIGHT Platform to produce and present the necessary data in a user-friendly form. Threshold limits for the benchmarking of the results will also be defined per target KPI based on the</p>	Chapter 5	<p>Chapter 5 will provide the description of the technological validation methodology, by detailing KPI baseline definition and data collection for baseline scenario. This chapter will collect the activities from FOR-FREIGHT's use cases, by describing its KPI's baseline values and the procedure for the data collection baseline from the logistics nodes, systems and sensors and</p>

	<p>requirements stemming from each use case. For the business validation we will use the lean start-up methodology that centres around the main motivations of a business. The inputs will include apart from the business case itself, end-user feedback from their direct engagement in the trials of the T&L use cases. The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialisation potential so as to progress to the next step of creating a service product portfolio. For this purpose, we will use a set of questionnaires, surveys and focused group workshops directly engaging other T&L actors.”</p>		<p>other relevant equipment that will serve as an input to the solutions. It will also describe the means of verification of the KPI's.</p>
		Chapter 6	<p>Chapter 6 will provide the description of the business validation methodology, describing the lean start up methodology to be applied and defining how it will be applied identifying all the tasks participating in it. The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialisation potential so as to progress to the next step of creating a service product portfolio.</p>
Task 1.4	<p>The risk analysis of the developments and their evaluation, together with the mitigation strategies will be identified and analysed in Task 1.4 and this output will feed into the project solutions development and assessment (of WP2 and 3 respectively).</p>	Chapter 7	<p>In order to make sure that the use case testing and validation as well as the solution design and development are going to take place as expected, main risks have been identified, evaluated and analysed and relevant mitigation actions have been provided.</p>

2.2 Linkage to other project outputs

Table 2.2.1 Links to other Project Outputs/ Work

WP Number	Task Number	Deliverable Number related	Content
WP1	T1.1 T1.2 T1.4	D1.1 D1.2	<p>The legacy system, state-of- the-art and logistics standards analysis performed in T1.1 together with the definition and requirements from the Use Cases in T1.2 are the baseline for the work carried out in T1.3.</p> <p>The risk analysis of the developments and their evaluation, together with the mitigation strategies will be identified and analysed in Task 1.4 and this output will feed into the project solutions development and assessment (of WP2 and 3 respectively).</p>
WP2	T2.1 T2.2 T2.3 T2.4 T2.5	D2.1 D2.2 D2.3	<p>WP2's main focus is to implement the solutions (SW, HW and integration) designed considering the requirements defined in WP1 tasks and to deliver the E2E functional FOR-FREIGHT platform/solution. T2.1 will monitor and keep the pace of developments across the different trial sites following the internal co-design process from WP1. T2.2, T2.3 and T2.4 will perform the T&L use case implementation based on technical, business and deployment considerations and targeting specific KPIs defined in T1.2-T1.3. All WP2 tasks will be part of the development of the business validation methodology regarding the testing of the solutions in order to find the most suitable.</p>
WP3	T3.1 T3.2 T3.3 T3.4 T3.5	D3.1 D3.2 D3.3	<p>WP3 is responsible for the execution of the planned trial in the three UC locations. Based on the analysis and definition performed in WP1 a detailed planning and set-up will be carried out in T3.1. Each of the trials will perform in T3.2, T3.3 and T3.4. T3.5 will evaluate the trial trials results. All WP3 tasks will be part of the development of the business validation methodology regarding the testing of the solutions in order to find the most suitable.</p>
WP4	T4.1	D4.2	<p>The findings in T1.1 and T1.2 together with the market opportunity analysis and feasibility study developed in T4.2 set a base for T1.3 and T1.4 in</p>

			terms of commercial opportunities and needs to address by the FOR-FREIGHT solutions.
WP6	T6.3	D6.1	Initial version of project's Quality Handbook, including a risk management overview that is applied in chapter 7.

2.3 Deliverable Overview and Report Structure

In this section a description of deliverable D1.3's structure is provided outlining the respective chapters and a summary of their content.

Chapter 3 collects the relevant inputs for task 1.3 from tasks 1.1 and 1.2. Task 1.1 was focused on detailing the SotA report, containing the analysis of the current practices, technologies, systems and standards utilized including pain-point analysis and recommendations for improvements. While task 1.2. was mainly focused on the definition of the functional requirements and the mapping of those requirements to the specific UC scenarios, translating them into technical requirements and selecting the most appropriate technologies to support the field trials for achieving a more efficient and effective multimodal freight transport to increase flexibility, service visibility and reduce logistics costs.

Chapter 4 analyses the architectural design and provides an overview of the initial system architecture describing the scope of the platform, the system architecture at a high level, the components and subsystems and the integration points.

Chapter 5 comprises the technical validation methodology. This chapter collects the activities from the FOR-FREIGHT's use cases, by describing its KPI's baseline values and the procedure for the data collection baseline from the logistics nodes, systems and sensors and other relevant equipment that will serve as an input to the solutions. It will also describe the means of verification of the KPI's.

Chapter 6 provides the description of the business validation methodology, describing the lean start up methodology to be applied and defining how it will be applied identifying all the tasks participating in it. The validation will allow to identify those use cases that have the highest commercialisation potential.

Chapter 7 comprises risk analysis performed in regards of the design of the solutions and the FOR-FREIGHT central platform together with specific risk assessment of all three Use Cases. The main risks have been identified, evaluated and analysed. Also, relevant mitigation actions have been provided.

The results of this deliverable are closely linked and have received inputs from T1.1, T1.2. and T1.4. The outputs of T1.3 are reflected in this deliverable D1.3 will also serve as inputs for T1.4, as well as to subsequent FOR-FREIGHT Work Packages (WPs).

3 Input: Use case business model, technology, legacy systems and requirements

FOR-FREIGHT project comprises the development of three different Use Cases to be developed in Spain, Greece and Romania with the aim of achieving a more efficient and effective multimodal freight transport to increase flexibility, service visibility and reduce logistics costs. This section considers the lessons learnt from the analysis performed in T1.1 *Legacy system, SotA and logistics standards analysis*, T1.2 *Requirements analysis and Use case refinement*, and T1.4 *FOR-FREIGHT solution architecture & design* to establish the link between tasks T1.1, T1.2 and T1.4 with T1.3 *Testing & Validation methodology* and ensure continuity and coherence within the project development.

3.1 Input from T1.1: Business model, technology, and legacy system

Task 1.1. *“Legacy system, state-of-the art and logistics standards analysis* Task 1.1 is part of WP1 *“SotA analysis, Use Case Definition and Solution Design”*.

Task 1.1 was focused on detailing the SotA report, containing the analysis of the current practices, technologies, systems and standards utilized including pain-point analysis and recommendations for improvements. All this was reported in D1.1 *“Report on Current Multimodal T&L Practices & Recommendations for Improvement”*. Deliverable 1.1 also provides a specific framework of the different project partners and their role within the sector, which served to lay the groundwork for the project.

Find below an extract of D1.1 summing up the results of weaknesses and potential improvements’ analysis performed in the three Use Cases.

The key challenges detected for the business and operational models’ analysis - interconnection of stakeholders, mainly of networks and transport modes, the lack of technologies available on the market and the lack of standardisation - were in line with those observed for the analysed technologies and the existing legacy systems, in which the major barriers were the absence of interoperability to enable information exchange, technical limitations and the lack of accessibility to the systems due to the sensitivity of the information.

Focusing on the pains related to business models and operational processes in the FOR-FREIGHT project, it has been found that, in general terms, there are challenges in the interconnection of networks and transport modes, resulting in inefficiencies in the transfer of goods between different transport modes and in the communication between different stakeholders. Low digitisation is also a highly relevant pain related to business models and operational processes. There are labour-intensive tasks and a lack of real-time access for cargo visibility, affecting the safety of workers and operations and increasing errors, congestions, delays and environmental impacts. Finally, the lack of mature solutions and technologies for their application, poor collaboration among the parties involved (technology enablers-technology demanders and between stakeholders in the logistics chain) and regulations and governmental law and practices are also hindering the digitisation and integration of stakeholders' systems.

From the analysis of the pains of the business and operational models, we identified that there is a set of gains that sums up the path and trends of these benefits:

- The operational efficiency aims to improve through the use of real-time data systems.
- The digitalization of processes also leads to more accurate and faster processes, supported by the use and integration of new technologies.
- In terms of operational sustainability, the reduction of externalities from last mile stands out.
- The trial sites will also bring benefits in terms of governance and network, by enabling better coordination and collaboration among different stakeholders in the supply chain.

Thus, this analysis also finds new opportunities by allowing the transition to new lines of business and the deployment of new commercial solutions, accelerating the development of T&L applications towards this commercial deployment.

On the other hand, the main pains observed for the analysed technologies are related to the absence of interoperability with external systems for enabling the exchange of information, contributing to create information silos. In most cases, the absence of interoperability is directly the result of the multiple proprietary legacy systems operation with several data incompatible formats and the lack of interfaces to create unified management systems. Complementing this main aspect, other pains related to the existing low levels of digitalization and data unavailability can also be identified in several stakeholders, thus limiting the potential exploitation of specific technology solutions.

Pains like data privacy restrictions, lack of interoperability, system unavailability and technology restrictions are considered as relevant limitations for the integration of existing systems in FOR-FREIGHT architecture. The main pains observed with respect to the existing legacy systems are related to technical limitations (obsolescence, low compatibility) and the lack of accessibility to these systems within the project due to the sensitivity of the information managed. However, the analysed systems also show some gains since they already offer a wide availability for exploiting historical data and some of them have available external interfaces that enable their potential interaction with other external systems.

Finally, regarding standardization, the lack of common standards and frameworks is a relevant problem at all operational processes within the field of T&L that leads to ineffective operations at each stage of the supply chain and significantly limits the possibility of establishing interoperability between actors. The set of data standards considered in FOR-FREIGHT shows us that there is a need to establish a common set of language, data ownership, governance and framework of rules, which ultimately will impact on the capability to reflect end-to-end data connectivity and information on all elements (goods in all states, location, cargo condition, transport means, routes, categories, etc.), reduce paperwork and constraints, and improve digital platform's interoperability and visibility of the whole T&L chain. The lack of transparency is also identified as a key barrier as there are instances where users are not aware of the standards that exist. As a result, T&L data standardization could overcome inflexible processes or even stand-alone systems' models.

Table 3.1.1.1,

Table 3.1.2 and Table 3.1.3 provide a first approximation to the documentation of the use cases and summarise the first recommendations for improving business processes and operations of the three Trial Sites actors, linking the identified pains of the actors involved with the potential solutions. This input has been further refined and narrowed down by T1.2 to define the limits for the benchmarking of the results per target KPI and act as a driver for the necessary supported functionality of the FOR-FREIGHT end-to-end solution design and architecture, hence as input to T1.3 and T1.4.

The added value of T1.1 is that it provides a comprehensive analysis of the T&L sector, identifies areas for improvement serving as a basis for the refinement of the FOR-FREIGHT use cases which Task 1.2 aims, helping to ensure that the project is focused on addressing the most pressing needs of the T&L sector and providing maximum value to stakeholders involved in the project. Additionally, the analysis of weaknesses and potential improvements, both in the T&L sector and in the context of the stakeholders, has also contributed to the development of the T1.3, helping to build the risk assessment section of D1.3. More specifically, the connection established in D1.1 between existing challenges, possible solutions and technologies to overcome them and the project partners who can potentially provide or develop such technologies and solutions, has provided T1.3 with a clear understanding of the gaps in terms of available technologies and legacy systems and how these will affect each use case to realise the proposed/envisioned tools to address their pains. Finally, the mapping of the existing issues and needs of FOR-FREIGHT's T&L stakeholders and the operational and business improvements they expected to achieve in the project, has also been used to propose and design the solvers or functional modules of each use case in T1.4.

Table 3.1.1: Spanish Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential solution	End-users	Technical partners
Information silos across different domains	<ul style="list-style-type: none"> - Delays in original documentation/paper-based documents (ALL). - Access to external systems and data streams owned by Port Community stakeholders (FVP). - Interconnecting networks and transport modes (MDM). 	Bird's eye view of the end-to-end multi-modal transport process based on integrated information from multiple related platforms.	AI/ML	DSS on use of resources and end-to-end multimodal transport planning optimization.	CSLS interested in.	IMEC - Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport FVP - AI-based algorithms for maritime and terrestrial routing
				DSS for the optimization of resource utilization and E2E multimodal transport planning.	DHL interested in; MDM potential beneficiary.	IMEC - Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport
			Blockchain	Blockchain for time reduction in administrative and operational processes.	DHL and MDM interested in.	FVP and CSLS - Supply chain governance based on Blockchain technology: provided by a Hyperledger Fabric blockchain platform.
Lack of standardisation	<ul style="list-style-type: none"> - Lack of uniformity in standards for interoperability between different logistics actors (ALL). - Data governance/data security as information along a multimodal transport is shared between diverse actors (customer, consumer, logistics company, metro, maritime company (ALL). 	- Improve data flow between T&L stakeholders by common standardisation criteria, increasing the interoperability among the different utilised systems and enhancing multimodal transport.	Blockchain	Blockchain for time reduction in administrative and operational processes.	DHL and MDM interested in.	FVP and CSLS - Supply chain governance based on Blockchain technology: provided by a Hyperledger Fabric blockchain platform.

	<ul style="list-style-type: none"> - Lack of common vocabulary/terminology between different transport modes (ships, truck, subway, etc) (ALL). - No interaction between (legacy or other) systems (planning, routing, business, traffic systems) between different companies from different sectors (ships, truck, subway, etc) (ALL). - Very limited interoperability among the involved stakeholders leading to delays and time-wastes and non-automated transfer of goods (CSLS). 	<ul style="list-style-type: none"> - Regulated access to different levels of information based on each user's access rights. 				
<p>Low digitalisation / automation of processes</p>	<ul style="list-style-type: none"> - Lack of well-established infrastructures in the case of a new business model that need to be implemented (i.e., lockers in metro stations, cages for metro wagons, etc) (ALL). - Technical feasibility of the proposed solution and technical difficulty in implementing the solution in certain stations (MDM). - To ensure the safety chain of the transported goods (MDM). - Lack of infrastructure foundation (MDM). - Digitalisation trends (MDM). - Multiple manual tasks leading to intensive manual labour and increased probability of errors (CSLS). - Absence of track and trace system on real-time for cargo visibility (CSLS). - High emissions related to the conventional transport modes (trucks) (CSLS). - Solutions for KPI calculation and monitoring (CSLS). 	<ul style="list-style-type: none"> - Door-to-door tracking of the entire process and full awareness of the cargo's location, status and current custodian. - Automated processes, reducing errors and guaranteeing up-to-date information (Blockchain/smart contracts). 	IoT	IoT sensors for real time tracking.	DHL and MDM interested in.	CERTH – Monitoring Sensors (OBU sensors) as the ones used in the Greek UC.
			Blockchain	Blockchain for time reduction in administrative and operational processes.	DHL and MDM interested in.	FVP and CSLS - Supply chain governance based on Blockchain technology: provided by a Hyperledger Fabric blockchain platform.
			AI/ML	Traffic analytics and dynamic vehicle routing models.	DHL and MDM interested in.	CERTH - ML models for demand and lead time forecasting.
				DSS on use of resources and end-to-end multimodal transport planning optimization.	CSLS and DHL potential beneficiaries.	FVP - AI-based algorithms for maritime and terrestrial routing

Suboptimal resource planning of the processes	<ul style="list-style-type: none"> - Lack of visibility of the goods along the supply chain process (ALL). - Longer delivery times based on non-real time information (ALL). - Congestions in cities due to growth of the e-commerce (DHL). - Congestions in ports/hubs and lack of visibility (CSLS). - Sub-optimal planning of resources (e.g., human resource, HW, vehicles, equipment, human labour) (DHL). - No simulation of potential scenarios/situations applied along the supply chain process supporting decision-making process (CSLS). 	<ul style="list-style-type: none"> - Door-to-door tracking of the entire process and full awareness of the cargo's location, status and current custodian. - Improved decision-making process and inefficiencies reduction (Digital Twins) for optimization of transport routes based on multiple real-time and historical factors. - Sustainable process management and reduced GHG emissions based on transport optimization and time-wastes reduction. - Innovative transport mode (subway) to execute the last mile delivery decreasing traffic congestions and emissions and increasing safety and speed. Distribution with vans/small trucks in urban areas will be switched by existing subway network. 	AI/ML	<p>DSS on use of resources and end-to-end multimodal transport planning optimization, providing real-time door-to-door tracking, forecast of optimal routing and ETA for the entire process.</p>	CSLS, DHL, MDM interested in.	<p>IMEC - Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport</p> <p>FVP - AI-based algorithms for maritime and terrestrial routing</p>
			Digital Twin	<p>DSS for the optimization of resource utilization and E2E multimodal transport planning.</p>	DHL interested in; MDM potential beneficiary.	<p>IMEC - Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport</p>
			IoT	<p>Digital Twin application for DSS.</p>	CSLS, DHL, MDM interested in.	<p>CERTH will support DT.</p>
			5G	<p>IoT sensors for real time tracking.</p>	DHL interested in	<p>Technical partners still need to confirm IoT availability.</p>
			5G	<p>5G based solution for enhancing safety and road transport efficiency (fuel consumption and travel times).</p>	DHL and MDM potential beneficiaries.	<p>ABS - C-ITS Platform and C-V2X test network.</p>

Table 3.1.2: Romanian Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential Solution	End-users	Technical partners
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Information silos across different domains	<ul style="list-style-type: none"> - The transfer of goods from seagoing vessels to railways is not a continuous, logically integrated process, but a fragmented one (ALL). - Delays in original documentation/paper-based documents (ALL). - The transfer between river vessels and railways is ordered by the beneficiaries of the goods (ALL). - Lack of data transfer between stakeholders (ALL). 	<p>Full view of the end-to-end process to users, including real-time door-to-door tracking information.</p>	Digital Twins	<p>Digital Twins solution for Galati port.</p>	INLAND SHIPPING, TcCFR, Port Galati	BEIA – Digital Twins
			Blockchain	<p>Supply chain governance based on Blockchain technology.</p>	INLAND SHIPPING, TcCFR, Port Galati	BEIA - Blockchain
Lack of standardisation	<ul style="list-style-type: none"> - Lack of uniformity in standards (ALL). - Lack of common vocabulary/terminology (ALL). - No interaction between legacy (or other) systems related with planning, routing, business, traffic, etc. (ALL). - Aspects regarding data governance and data security (ALL). 	<p>Providing functionalities for efficient multimodal logistics, ensuring compatibility with existing and emerging EU logistics standards, including 3rd party applications.</p>	Blockchain	<p>Supply chain governance based on Blockchain technology.</p>	INLAND SHIPPING, TcCFR, Port Galati	BEIA - Blockchain
Low digitalisation / automation of processes	<ul style="list-style-type: none"> - Intensive manual labour is still needed for transshipment which results in inefficient use of resources (ALL). - Low digitalization and historical data available, so there is no real-time common operational picture possible (ALL). - Lack of investments in new technologies (i.e., no possibility of tracking goods in real time) (TCCFR). 	<ul style="list-style-type: none"> - Provide an accurate real-time position of the cargo / container, and provide complete remote monitoring capabilities for logistics operators and users. - Automatic ETA update of the ship in the port of Galati, based on historical and real-time tracking data. 	IoT	<p>IoT sensors for tracking.</p>	INLAND SHIPPING, TcCFR, Port Galati	BEIA - IoT sensors and video cameras.
			5G	<p>4G/5G network coverage.</p>	INLAND SHIPPING	TCCFR - 5G commercial coverage.
			AI/ML	<p>AI/ML solutions for Galati port.</p>	INLAND SHIPPING, TcCFR	CERTH - ML models for demand and lead time forecasting.

<p>Suboptimal resource planning of the processes</p>	<ul style="list-style-type: none"> - Congestions in ports/hubs and lack of visibility due to the non-synchronizations between unloading/loading and handling activities with significant loss of time and uneconomical use of resources (ALL). - Congestions in cities due to the military conflict at the Ukrainian border (ALL). 	<ul style="list-style-type: none"> - Reduced GHG emissions based on carbon footprint analysis. - Automatic reservation to railway companies, using a unique cargo ID, based on precise ETA. - Suggestions from the decision support system (DSS) to the port authorities, the logistics operator and the customs agencies, regarding the necessary resources to be reserved (staff, vehicles, etc.), depending on the size of the goods, the type and the exact ETA. - Notification and advice from DSS to rail freight operators on the required storage space and resources to be available at the exact time of arrival of the goods. 	<p>AI/ML</p>	<p>AI/ML solutions for Galati port.</p>	<p>Port Galati</p>	<p>CERTH - ML models for demand and lead time forecasting.</p>
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Table 3.1.3: Greek Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential solution	End-user	Technical partners
<p>Information silos across different domains</p>	<ul style="list-style-type: none"> - Keeping up with the information flow: No a-priori knowledge on what type of container arrives at the port, when, at what quantity, and ETA at the airport warehouses (ALL). - Delays in original documentation/paper-based documents (ALL). - No interaction intra-domain and inter-domain between various systems (Customs, airlines, forwarders, airport) Interconnecting networks and transport modes (ALL). 	<p>Full view of the end-to-end process towards users including the cargo's real-time location, status (temperature, humidity, vibrations, luminosity, etc.).</p>	<p>IoT</p>	<p>IoT sensors for real-time and status tracking.</p>	<p>GOLD, COEL, AIA potential beneficiaries.</p>	<p>AIA - Building Management Systems – SCADA. WINGS – On-board Unit (OBU) devices with multiple IoT sensors and backend system support. GOLD, CERTH and WINGS - Temperature and Monitoring Sensors.</p>
			<p>5G</p>	<p>4G/5G network coverage.</p>	<p>GOLD, COEL, AIA potential beneficiaries.</p>	<p>AIA - WiFi and 4G commercial coverage (only Wifi needed). WINGS – legacy and backend support</p>

						systems integration leveraging 4G and 5G commercial coverage.
Lack of standardisation	<ul style="list-style-type: none"> - Lack of uniformity in standards for interoperability between different logistics actors (ALL). - Non-standardized processes (ALL). 	<ul style="list-style-type: none"> - Improve data flow between T&L stakeholders by common standardization criteria, increasing the interoperability among the different utilised systems and enhancing multimodal transport. - Different levels of access to information for different platform users based on their level of authorization/clearance. 	Big Data & Cloud Computing	Platform for monitoring different datasets related to warehouses' status, arrivals prediction, truck/vessel/cargo position and cargo status/condition	GOLD, COEL, AIA potential beneficiaries.	WINGS – backend support system platform.
				Seamless data exchange and authorization tool for certifying service providers and users.	GOLD, COEL, AIA potential beneficiaries.	CERTH - FENIX Connector attached to the Greek Transport & Logistics Observatory.
				Cloud solution for matching the supply and demand of storage space for logistics service providers and users.	GOLD, COEL, AIA potential beneficiaries.	CERTH - Virtual Freight Center.
Low digitalisation / automation of processes	<ul style="list-style-type: none"> - Delays during Customs clearance processes (ALL). - Lack of shipment visibility and difficulties for real time data (COEL). - Communication between stakeholders mainly via phone and e-mail (COEL). - Delays in original documentation/paper-based documents (ALL). - No interaction between various systems (Customs, airlines, forwarders, airport) interconnecting networks and transport modes (AIA, GOLD). - Keeping up with the information flow (GOLD). 	<ul style="list-style-type: none"> - Tracking of a specific container/ITU onboard a ship heading for Piraeus Port, using a unique Identification code/ Bill of Lading number (ID). - Automated update of truck's and ship's ETA at the port of Piraeus based on historical and real-time door-to-door tracking data (available to all stakeholders, via commonly agreed APIs). 	IoT	IoT sensors for real-time tracking.	GOLD, COEL, AIA potential beneficiaries.	CERTH and WINGS - Monitoring Sensors.
			5G	4G/5G Network coverage for real-time updates.	GOLD, COEL, AIA potential beneficiaries.	AIA - WiFi and 5G 4G commercial coverage (only Wifi needed). WINGS – legacy and backend support systems integration leveraging 4G and 5G commercial coverage.
			AI/ML	Traffic analytics and dynamic vehicle routing models.	GOLD and COEL potential beneficiaries.	CERTH - ML models for demand and lead time forecasting.
DSSs on logistics operators concerning space necessary, cargo arrival forecasting and	GOLD and COEL potential beneficiaries.	WINGS - AI/ML workflows supported by the WINGS backend and DSS platform (data				

				optimized resource allocation and routing.		ingestion, processing, etc.).
			Big Data & Cloud Computing	Databases and the monitoring different data sets related with containers, arrival predictions of truck and ships and forecasting.	GOLD, COEL, AIA potential beneficiaries.	WINGS – WINGS backend and DSS platform.
Suboptimal resource planning of the processes	<ul style="list-style-type: none"> - Unpreparedness when a container arrives at the airport due to lack of freight monitoring data (e.g. ETA at the airport) (ALL). - Lack of uniformity in standards for interoperability between different logistics actors (ALL). - Non-standardized processes (ALL). 	<ul style="list-style-type: none"> - Advice from the Decision Support System (DSS) towards the port and airport authorities and customs agencies, regarding the necessary resources to be reserved (personnel, vehicles, etc.), based on the cargo size, type and accurate ETA. - Advice from the DSS to the logistics operator regarding the resources to be reserved for the unloading, reloading and transport of the cargo from the port to the AIA. - Automated booking of airline reservation using a unique cargo ID, based on accurate ETA. - Notification and advice from the DSS to the airport cargo handlers regarding the necessary storage space, and resource to be available at the exact arrival time of the cargo. 	AI/ML	Traffic analytics and dynamic vehicle routing models.	GOLD, COEL, AIA potential beneficiaries.	CERTH - ML models for demand and lead time forecasting.
				DSSs on logistics operators concerning space necessary, cargo arrival forecasting and optimized resource allocation and routing.	AIA, COEL potential beneficiaries.	WINGS – WINGS backend and DSS platform.

3.2 Input from T1.2: Requirements

Task 1.2 “Requirements analysis and Use case refinement” is part of WP1 “SotA analysis, Use Case Definition and Solution Design”. T1.2 mainly focused on two tasks:

- The definition of the functional requirements based on the analysis of the existing practices and management systems currently in place in order to identify the stakeholders’ communication methods, weakness challenges and opportunities to improve multimodal transport in each of their logistics areas.
- The mapping of those requirements to the specific UC scenarios, translating them into technical requirements and selecting the most appropriate technologies to support the field trials for achieving a more efficient and effective multimodal freight transport to increase flexibility, service visibility and reduce logistics costs.

With the implementation of FOR-FREIGHT, Spanish UC will integrate all the currently disconnected information from the different stakeholders (Valencia Port and Madrid warehouse and last mile distribution) and used with a DSS to optimize the entire set operations. In the Greek UC, FOR-FREIGHT will allow the Port and Airport segments to work in a much more unified and standardised way, sharing data for improved resource planning. Romanian UC will integrate historical data, real-time tracking data, and legacy systems into FOR-FREIGHT solution, allowing interoperability of rail and port processes.

FOR-FREIGHT platform differentiating innovations is to effectively integrate exiting practices and management systems still in use by different stakeholders and allow the exchange of information among them. A key finding in T1.2 in this respect has been that there are a set of general technical requirements that need to be solved prior to any UC implementation: data format unification and accessibility management. Current scenarios comprise several disconnected systems operating independently and managing information in a varied range of formats. Existing information silos, lack of standardisation and interoperability and low digitalisation and automation will only be solved if these requirements are met.

Task 1.2 was focused on the specific analysis and redefinition of each of the three UCs (Spain, Greece, Romania), taking also into account the analysis performed in Task 1.1. The refinement of the UC’s comprised an analysis of current physical and information flows in the UCs, identification of pains and challenges in those flows and a definition of the TO-BE scenarios once FOR-FREIGHT is implemented. Functionalities for each of the UCs were derived from that exercise along with the selection of technologies/systems/components that will enable them. Table 3.2.1 shows the connection among those required functionalities defined in T1.2 and the SotA technologies that will be integrated for each of the UCs.

Table 3.2.1: List connecting required functionalities defined in T1.2 and the SotA technologies that will be integrated for each of the UCs

Technology	Partner	Systems/Devices/Infrastructure	Link with Other Projects	Status	TRL	FR
Spanish Use Case						
IoT	CERTH	Monitoring Sensors (OBU sensors)	ORION	Available	7	ES-FR6 ES-FR8
5G	ABS	C-ITS Platform and C-V2X test network	C-ROADS.EU	Available	8	All
Blockchain	FVP CSLS	Hyperledger Fabric blockchain platform	PLANET	Available	5	ES-FR3 ES-FR4 ES-FR7
Digital Twins	CERTH	Digital Twin	Various	Available	7	ES-FR8 ES-FR9 ES-FR10
AI/ML	FVP	AI-based algorithms for maritime and terrestrial routing	PLANET	Available	4	
	CERTH	Machine learning models for demand and lead time forecasting	WareM&O, DeliNet, Development	Available	7	

	IMEC	Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport	N/A	Available	9	
Federal connectivity	CERTH	FENIX Connector attached to the Greek Transport & Logistics Observatory	FENIX, FENIX2.0	Available	8	Optional
Greek Use Case						
IoT	AIA	Building Management Systems - SCADA	CHARIOT, SATIE, FORESIGHT	Available	8	GR-FR5 GR-FR6
	WINGS	WINGS Chariot	VITAL-5G, 5GMOBIX	Available	8	
	WINGS	Temperature Sensors (OBU sensors)	N/A	Available	9	
	CERTH, WINGS	Monitoring Sensors (OBU sensors)	VITAL-5G, 5GMOBIX, ORION	Available	7	
5G/4G/Wi-Fi	AIA	WiFi and 4G commercial coverage	STARGATE, 5G-TOURS	Available	8	All
	WINGS	5G commercial coverage	5G-MOBIX, 5G-ROUTES, 5G-CARMEN, VITAL-5G, Hexa-X	Available	9	
Cloud and Edge Computing	WINGS	WINGS Chariot and WINGSPARK	VITAL-5G, 5G-MOBIX, 5G-CARMEN, 5G-ROUTES	Available	8	GR-FR1 GR-FR2 GR-FR3 GR-FR4 GR-FR5 GR-FR7 GR-FR8 GR-FR9
	CERTH	Virtual Freight Center	WareM&O	Available	8	
	CERTH	Smart Supply Chain and Intelligent Intermodal Corridor Management system	SmartCorridors	Available	7	
	CERTH	Terminal Operating System	CloudYMS	Available	9	
	IMEC	Multi-Access Edge Computing (MEC) system, MEC Application Orchestrator (MEAO)	5G-CARMEN, VITAL-5G	Available	8	
Big Data and Digital Twins	CERTH	Digital Twin	Various	Available	8	GR-FR3 GR-FR4
AI/ML	CERTH	ML models for demand and lead time forecasting	WareM&O, DeliNet, Development	Available	7	GR-FR5 GR-FR7 GR-FR8 GR-FR9
	WINGS	AI/ML models for route optimization, ETA prediction, resource management (e.g., warehouse management system DSS)	VITAL-5G	Available	6	
Federated connectivity	CERTH	FENIX Connector attached to the Greek Transport & Logistics Observatory	FENIX, FENIX2.0	Available	8	Optional
Romanian Use Case						
IoT	BEIA	Monitoring Sensors (OBU sensors)	VITAL-5G	Available	7	RO-FR2 RO-FR3 RO-FR6
5G	TCCFR	5G commercial coverage	VITAL-5G, iGENIOUS	Available	7	All
Digital Twins	BEIA	Grafana	VITAL-5G	Available	8	RO-FR7

Blockchain	BEIA	Collecting data during the project. Data obtained from commercial data bases	Sealed Grid, Testbed2, Defraudify, PIMEO-AI	Available	7	RO-FR7
AI/ML	CERTH	ML models for demand and lead time forecasting	WareM&O, DeliNet, etc.	Available	7	RO-FR7 RO-FR 8 RO-FR9 RO-FR10

Project KPIs, mid-term, and long-term outcomes relate to the functionalities were defined in task 1.2. KPIs originally defined, were carefully reviewed for each of the UCs and connected to the mid-term expected outcomes (EO) and long-term expected impacts (EI). This allowed us to connect each of the functional requirements defined for the different UCs to specific KPIs, EOs and EIs. Ensuring that FOR-FREIGHT platform not only reaches the project objectives but would also be prepared for further exploitation.

4 System architecture overview

4.1 Scope of the platform

The FOR-FREIGHT platform is a cloud-based, objective-customized, and role-based-designed system, which brings operational benefit to all involved participants in the scope of the project. The system entails a wide range of technical solutions, from IoT, AI/ML to Big Data Management, for tackling the challenges identified in three trial sites: Spanish, Greek, and Romanian use cases. Within FOR-FREIGHT scope, the architecture design prioritizes the following functionalities:

- Model the logistics network based on operational specification.
- Translate the KPIs and operational expectations into technical challenges (e.g., prediction, simulation, optimization, decision support/recommendation, etc.).
- Propose the integration of technical modules which drives the multi-modal logistics service towards its goals and expectations. To mitigate useless efforts, the platform joins forces among existing assets (legacy systems), built-in solvers (which fall on expertise of internal technical providers), and external (third-party) applications.
- Orchestrate the operation of above integrated solutions, including monitoring, life cycle handling and data exchange.
- Support tracking, visualization, output viewing and exportation of all included functionalities, on a user-role-based manner.

The design will be kept lightweight, where the construction begins with maximal intersections among all use cases, and then tailor-made use-case-specific components are put on top of the underlying prototype.

4.2 High-level system architecture

As shown in Figure 4.1, the FOR-FREIGHT cloud-based platform is composed of connected layers, as follows.

Services Layer: in this project, *an* end-to-end pipeline of interconnected logistics entities characterized by predefined KPIs is known as a service, containing nodes and edge functions on graph-based representation. They are the interfaces that offer functionalities throughout the different stages of the use cases scenarios. For example: the optimization of the transportation time between a seaport and a city, using strategically located Distribution Centers and depots. Via this layer, all services within use cases from Spanish, Greek or Romanian trial sites will be able to select from the repository the modules necessary to build their end-to-end operational T&L pipeline and to link them with the appropriate I/O elements (end-devices, vehicles, etc.).

Requirement Translator Layer: this component translates the specification in Services layer into technical requirements, and then proposes the relevant modules to solve them. For instance, the warehouse resource utilization optimization must be translated into the task of predicting the number of vehicles, volume of storage spaces, or number of labor hours need to be reserved to meet the upcoming cargo flow, or the task of recommending the assignment of those resources in order to avoid future shortage. As a result, the appropriate demand/capacity resource predictors, or real-time resource planners would be included in the service. In addition, this layer also allows users to customize the integrated modules when some objectives are modified or adapted.

Modular Layer: This backbone component is a repository storing modules to be invoked by services towards their goals. First, the legacy systems comprise existing practices and management systems that are used by the different partners. Second, the core solvers integrate relevant information and operations from logistic services and resource management to achieve efficiency and efficacy in the supply chain. Solvers can provide time optimization, time prediction, real-time recommendations and data analysis based on a handful of inputs provided by the legacy systems and the third-party applications, which can be used to generate potential

decisions. Alongside are third-party applications which provide data and tooling for basic information like weather, traffic, and simulations. Although they are already used by certain legacy systems, their contributions are also integrated into the central platform for a centralized use of the standardized data from these systems.

Message Translators Layer: The message translators are designed to overcome the challenges of the integration of data, which include access restrictions, wide diversity of formats, lack of centralization of the sources and the availability of the information. They are placed between the layers of the external systems and the central platform to process data from different sources, to be collected, anonymized, and formatted before they are integrated in the platform and later shared among the systems.

Central Data Platform Layer: This layer handles various data tasks requested by modules within service, in a centralized and secured manner. More specifically, it parses the normalized request forwarded by the Message Translator layer, controls its validity, processes or executes via data hub/data lake and then returns the results. The data requests range from acquisition (download, extraction) to update, syncing, replication, removal, or deletion, removal, or deletion.

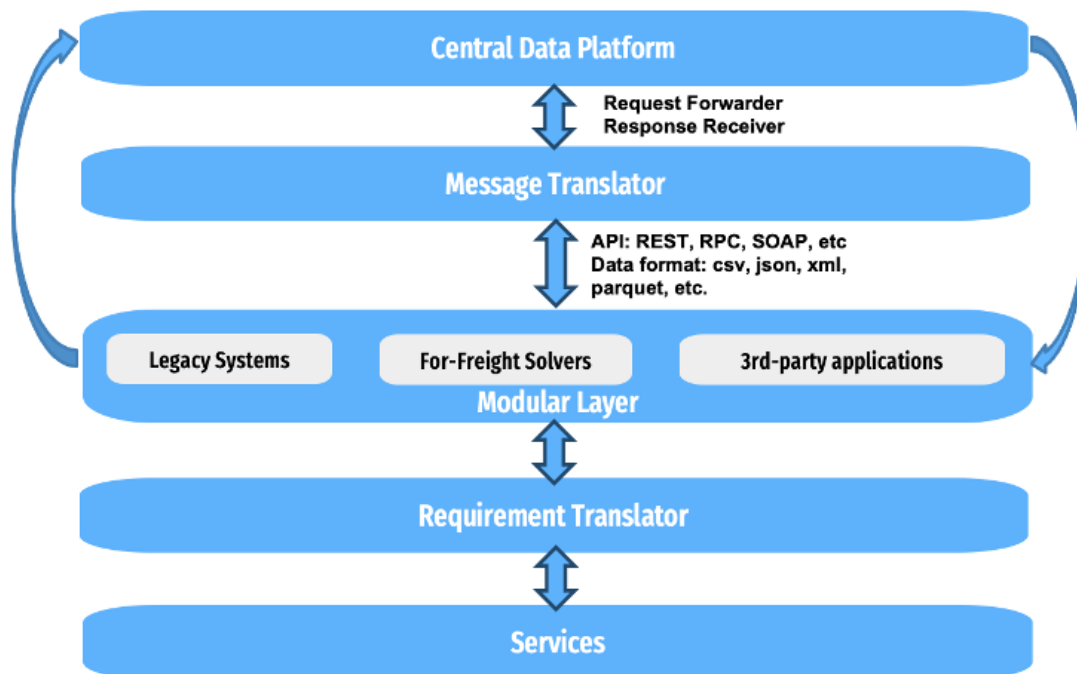


Figure 4.2.1: FOR-FREIGHT high-level system architecture

Before deep-diving into details, it's noteworthy that the aforementioned platform architecture is highly adaptive to FOR-FREIGHT context, where functional analysis and three use cases' specification (as outputs of T1.1 and T1.2) are the lodestar to build its layers and components. This adaptation can be seen in different angles:

- Firstly, the use-case-oriented solvers are designed to tackle the gaps in the "current way of working" flowchart, in synergies with existing assets/systems, to cover desired KPIs. The solutions are lightweight, with minimal implementation efforts, yet still cover all requirements specified in D1.2
- Secondly, the platform architecture synthesizes all use cases requirements in managing and governing data when designing components of the message translator, ensuring that diverse data sources, formats, or transmission protocols can be efficiently normalized and harmonized.
- Thirdly, the central data platform is adaptive to the use case's specific needs of data exchange (both historical and real-time sources) across modules, towards smooth and flawless data flow.
- Last but not least, the platform enables creating multiple scenarios per service (via service layer). They can operate in different environments but still can inherit the pre-trained systems, in order to avoid

duplications. This functionality allows various stakeholders to optimize their tailored objectives, in parallel with the global KPIs of the entire service.

4.3 Components and subsystems

4.3.1. Service Layer

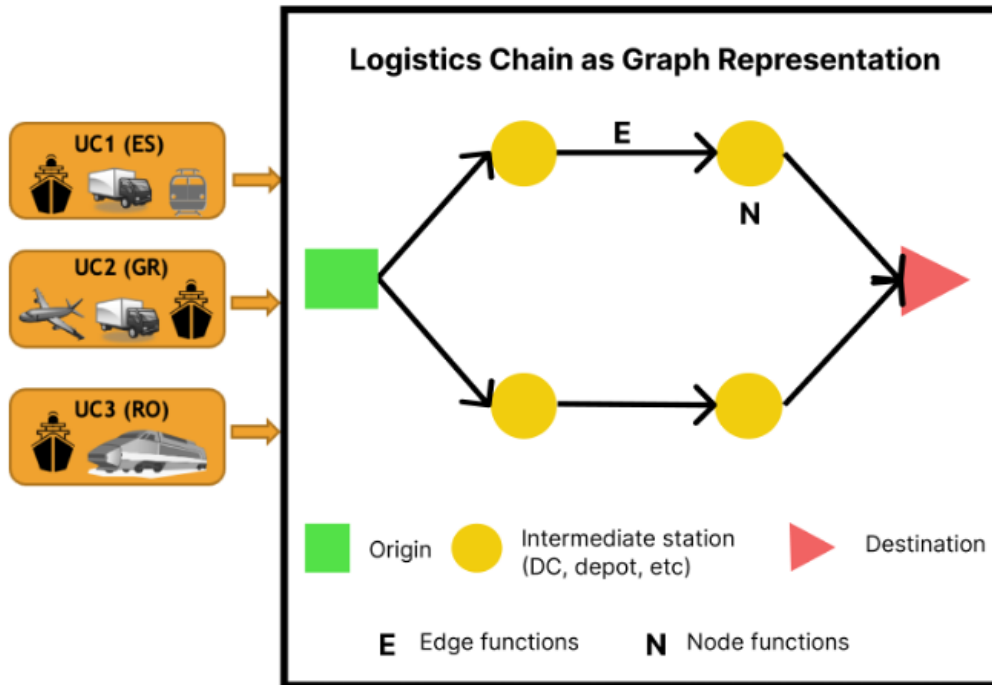


Figure 4.3.1: Multi-modal Transport Service as Graph Representation

The service layer generates the graph representation for a multi-modal transport system, given its composition, activities and KPI expectation.

In this directed graph:

- Node represents logistics hubs, such as sea – or air – ports, warehouses, distribution centers, depots, or final delivery destination.
- Edge connects two nodes, in which cargo is transported from one to the other.

In accordance with major goals to achieve, as well as the concrete KPI criteria to be satisfied, this layer can also:

- Allow service managers to create **multiple scenarios**, corresponding to their multiple sub objectives they wish to achieve in parallel. For example, the above graph representation could be used for three different scenarios:
 - 1) ensure end-to-end visibility (freight tracking)
 - 2) minimize the transport time from origin to destination, and
 - 3) maximize resource utilization at all logistics hubs.

It is obvious that different scenarios necessitate different sets of functional modules. However, if there are some overlaps among them, the service layer supports the reuse of those that have already been constructed, instead of initializing everything from the beginning. In the above example, end-to-end tracking modules in 1) can be used in 2) and 3), whereas time predictors in 2) can be exploited by 3) to support resource planning, and so on. It is important to note that, while outputs are sharable among different scenarios, the service layer supports creating separated environments under which each can operate. This ensures better monitoring and life-cycle

management of scenarios, as they vary among them. The **service scenario monitoring and life-cycle management** will be further clarified as a joint effort between T1.4 and T2.5.

- allow each scenario to manage all functional modules it needs. In other words, the service scenario can manually or automatically (via event trigger) train, execute, update (finetune), suspend, stop, or restart a given module.
- define mechanism to integrate and ensure inter-operability among all functional modules.

While the functional modules vary in objectives/roles, they belong to one of the three main types:

- Edge functions: modules to be deployed for a transport route. For instance: time, cost, emission as predictive indicators; real-time freight tracking; weather/traffic/incident updates; etc.
- Node functions: modules to be deployed at a logistic hub. For instance: dwelling time estimation, resource capacity/demand prediction, resource utilization optimizer
- Graph-level functions: modules to support decisions at graph level. For instance: end-to-end route recommendation, end-to-end route re-computation due to road incidents, etc.

4.3.2. Requirement Translator Layer

Until now, one question has been raised: what are the functional modules to be exploited by the service (with graph representation)? It is the main responsibility of the requirement layer. Starting from the graph's edges, nodes, together with defined KPIs and goals, this layer:

- interprets them into **technical challenges** (e.g., prediction, simulation, optimization, decision support/recommendation, etc. with adaptive granularity).
- suggests the list of essential modules that need to endow the service towards these ends.
- connects with modular layer to retrieve and then place modules in the right position in the graph representation where they should reside.
- allows service managers to tailor the functional modules based on their preferences/constraints: inserting, removing modules. This circumstance might occur where the service managers would like to simplify the implementation (e.g., due to time constraints), or to stretch priority on certain aspects, or even to downsize the scope due to lack of infrastructure or data. By this customization, the service managers are fully aware of the fact that initial goals might not be entirely reached.

4.3.3. Modular Layer

The modular layer is the repository which provides the wide range of modules to be integrated in multi-modal service graph (service layer) in order to fulfil its ultimate goals. Each module can be considered as a complete, full-fledge application where service can pull, plug in, and invoke in both offline and real-time manners. In other words, FOR-FREIGHT platform supports two forms of deployment:

- **Cloud based deployment:** the module is deployed on cloud repository. The service layer is allowed to either send requests in real time or trigger events to train, fine-tune (using newly observed situations) or execute to acquire outputs. With this method, it is not necessary to have the module installed or stored in each service's local branch. This deployment becomes handy when the module needs to be retrained on the fly with real-time observations being fetched from time to time.
- **Local deployment:** The module is provided as an application on an alike marketplace. Service layer pulls it, plugs it in and executes it locally. It's preferable to have a module deployed this way in the case where this module works principally with historical and/or static data, with relatively long update period.

Depending on the origin (provider), these modules can be categorized into legacy systems, solvers, and third-party applications.

4.3.3.1. Legacy Systems

Legacy systems are the functioning assets of different use case partners and stakeholders that contribute to build the end-to-end multi-modal operational service within FOR-FREIGHT project. These systems vary from (historical, real-time) datasets, tracking or localization systems, to warehouse management software's, etc. The identification of such facilities plays an important role for the architecture design and use case implementation, as it helps to avoid module duplication, as well as to downplay redundant workload by adding on top of existing functionalities rather than building everything from scratch. The detailed list of such systems can be found in D1.2.

4.3.3.2. For-Freight Solvers

Within FOR-FREIGHT scope, a solver is a functional module which solves a specific problem raised by the end-to-end, multi-modal transport scenarios. This specific problem has not been tackled or entirely solved by the legacy systems and therefore will be done by technical partners of the project. FOR-FREIGHT use cases might need leveraging the synergy of various solvers to achieve their KPI expectation.

With respect to use case specific situations, such as operational bottlenecks, performance shortcomings, current infrastructure or functional requirements, tailor-made solvers are proposed and designed (at high level) for use case wide implementation. The per-use-case solvers description is depicted in D2.1. It provides guidelines to implementation phase (Task 3.2, 3.3, and 3.4). In this report, Table 4.1 lists out the most common types of solvers, among them some are sharable across use cases, which basically cover all essential needs described in D1.1 and further refined in D1.2.

Table 4.3.1: Overview of proposed solvers to cover FOR-FREIGHT use cases.

Solver Type	Functionality Overview	Proposed Technologies	Applied Use cases	Potential Developers
ETA Predictor	Predict the arrival time of cargo (vessel, container, pallet, cage, or parcel) at a logistic hub (port, warehouse, depot, etc.)	<ul style="list-style-type: none"> Regression model Temporal predictive model 	<ul style="list-style-type: none"> UC1 UC2 UC3 	<ul style="list-style-type: none"> IMEC FVP CERTH WINGS PCT GOLD
Dwelling Time/Duration Stay Predictor	<p>Predict the total stay duration of the cargo <u>at a logistics hub</u>, from the moment of arrival until its departure from this hub.</p> <p>This includes dwelling time and service time (loading, unloading, custom clearance, storage, other intra hub services, etc.).</p>	<ul style="list-style-type: none"> Regression model Temporal predictive model 	<ul style="list-style-type: none"> UC1 UC2 UC3 	<ul style="list-style-type: none"> IMEC FVP CERTH WINGS GOLD AIA PCT
Per-sub-route Transport Cost and Emission Predictor	<p>Predict the transport cost or environmental footprint to carry a freight from A to B</p> <p>(For instance: Port – Warehouse, Warehouse – Depot, Depot to metro station, etc.)</p>	<ul style="list-style-type: none"> Regression model Temporal predictive model 	<ul style="list-style-type: none"> UC1 UC2 UC3 	<ul style="list-style-type: none"> IMEC FVP CERTH WINGS
Resource Capacity or	Predict the capacity or demand of <u>logistics resources/infrastructures</u>	<ul style="list-style-type: none"> Regression model Temporal predictive model 	<ul style="list-style-type: none"> UC1 UC2 UC3 	<ul style="list-style-type: none"> IMEC FVP CERTH WINGS

Demand Predictor	<p>in near future horizon (e.g., for every hour within 24 hours ahead)</p> <p>Capacity refers to the percentage of available resource, which can be seen as shortage risk indicator. Whereas demand refers to the amount of resource that needs to be reserved due to upcoming cargo flow.</p>			<ul style="list-style-type: none"> • PCT • AIA • GOLD
Real-time Routing Recommender	<p>Recommend (<u>before journey</u>) the E2E route planning which optimizes the transport time, cost, emission, or their combination, given transport/freight constraints.</p> <p>Recommend (<u>during journey</u>) the adapted route to cope with real-time incidents (e.g., road blockage, congestion, extreme weather, strike, etc.). The adapted planning ensures optimized remaining journey in terms of transport time, cost, emission, or their combination, given transport/freight constraints.</p>	<ul style="list-style-type: none"> • Optimization methods (Genetic algorithms, PSO, etc.) 	<ul style="list-style-type: none"> • UC1 • UC2 • UC3 	<ul style="list-style-type: none"> • IMEC • CERTH • WINGS
Next Transport Recommender	<p>Recommend the next transport (e.g., aircraft or train together with schedule) to put a cargo in order to optimizes the transport time, cost, emission, or their combination, given transport/freight constraints.</p>	<ul style="list-style-type: none"> • Regression model • And/or Optimizers (Generic Algorithm, PSO, etc.) 	<ul style="list-style-type: none"> • UC2 • UC3 	<ul style="list-style-type: none"> • IMEC • CERTH
Warehouse Planning Optimizer	<p>Optimize slotting and location assignment; load plans to maximize truck utilization and minimize transportation costs. Distribute workload for equipment based on estimated demand to improve inventory management and cost reduction</p>	<ul style="list-style-type: none"> • Optimizers (Generic Algorithm, PSO, etc.) • Bin Packing Algorithms • Ant colony optimization algorithm • Time Series Analysis 	<ul style="list-style-type: none"> • UC2 	<ul style="list-style-type: none"> • IMEC • CERTH • WINGS • AIA • GOLD
Localizers (Freight Tracking)	<p>Real-time tracking (update coordinates) of container/pallet/cage/package/parcel</p>	<p>Real-time tracking of the cargo location, status, and conditions.</p>	<ul style="list-style-type: none"> • UC1 • UC2 • UC3 	<ul style="list-style-type: none"> • IMEC • CERTH • WING • BEIA • Inland Shipping

				• TCCFR
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4.3.3.3. Third-party applications

Beside existing assets and core modules to develop, FOR-FREIGHT use cases can also benefit from a wide range of external open-source or licensed applications, which complement the functionalities of their operational scenarios. The exploitation of these external applications, which are also called 3rd party applications, towards flexible and adaptable KPIs, would mitigate useless implementation effort over the attempt of building any required feature from scratch.

Table 4.3.2 mentions some examples of applications which FOR-FREIGHT use cases need from external providers for implementation in Task 3.2, 3.3 and 3.4.

Table 4.3.2: Overview of proposed third-party applications to cover FOR-FREIGHT use cases.

Application	Functionality	Applied Use cases	Suggested Providers
Traffic	Provide traffic state (speed, count) prediction and anomaly detection: congestion, accident, roadwork, etc.	<ul style="list-style-type: none"> • UC1 • UC2 • UC3 	
Weather	Provide real-time and forecasted weather information, over wind, rain, storm, visibility, etc.	<ul style="list-style-type: none"> • UC1 • UC2 • UC3 	
Simulation	Generating data of edge (sub routes) or node (warehouse, distribution centre) where historical data is missing or insufficient. This data will be used for analysis, prediction, or optimization purposes.	<ul style="list-style-type: none"> • UC1 • UC2 • UC3 	<ul style="list-style-type: none"> • AIMSUN • ACSIM
Blockchain	Transport Orders digitalisation	<ul style="list-style-type: none"> • UC2 • UC3 	

Figure 4.3 illustrates solvers to be called by a multi-modal service, for optimizing the transport time from a deep-sea port to last miles (city). The graph representation shows possible sub-routes (edge) together with modality, and the intermediate centers/stations (node). Historical and real-time operational data shared by the port, warehouses, depots, truck, and metro companies are retrieved to train predictive models. Besides, internal stakeholders provide IoT technologies for tracking freight end to end, which helps to keep predictive indicators up to date. Starting with these legacy systems, the service needs to equip with a number of functions (solvers): analyzing data to detect anomalies (Data Analyzer), predicting arrival time at a specific hub (ETA predictor), recommending the route to minimize total transport time (Time Optimizer), and recomputing the plan real-time based on road incidents (Real-time Recommender). In addition, these solvers necessitate additional data to enhance their accuracy, including Weather and Traffic forecasting. Also, due to the lack of historical records of truck travel between the distribution center to metro depot, the time predictor on this sub-route requires simulated data. Weather, Traffic, and Simulator are external pieces (third-party applications) to be fetched for this service functional implementation.

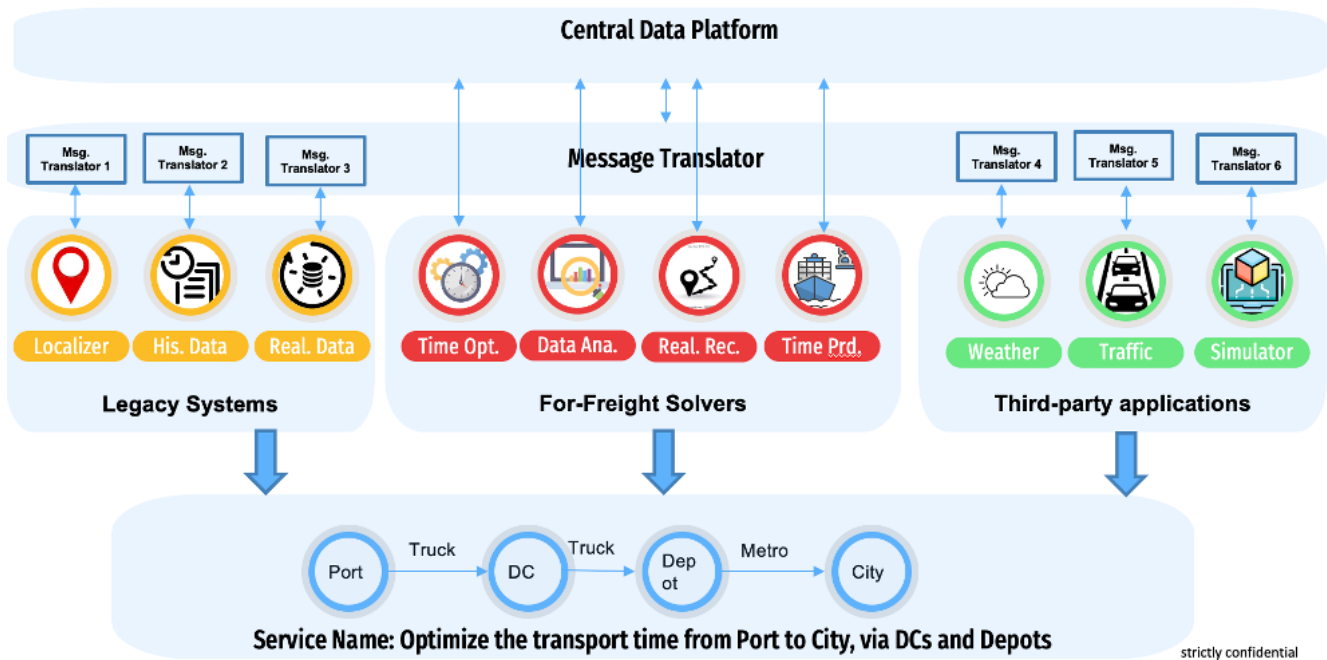


Figure 4.3.2: Example of solvers called by a service to optimize the transport time from seaport to city.

4.3.4. Message Translator Layer

Legacy systems, FOR-FREIGHT solvers and third-party applications come from various providers, hence differ from each other in terms of data transmission protocol, data security regulations, or data formatting. Some examples of these specific discrepancies can be listed: (1) the truck historical data needs to be anonymized, so that no identity of truck or truck drivers could be disclosed; (2) the time predictor accepts only csv format to be fetched for its training/ fine-tuning; (3) the weather service needs File Transfer Protocol (FTP), whereas central data platform supports only HTTP, etc.

These modules need to be harmonized/standardized before their communication to exchange data. This can be done via the message translator: it acts as a wrapper putting on each module to translate its outputs to become valid for external use, without internal modification. The standardized outputs will be then communicated to the central data platform, which orchestrates the data exchange. It is worth highlighting that the message translator is designed only for legacy systems and third-party applications. On the contrary, FOR-FREIGHT solvers, which are developed by internal partners, encapsulate these steps as their built-in functions. This can be seen on Figure 4.1, where solvers communicate directly to the central data platform, and not via message translator as in legacy systems or third-party applications.

The following processing stages will be implemented in a message translator:

- **Data Anonymization:** this step hashes the identity of logistics entities, e.g., vessels or labors, to ensure privacy and confidentiality.
- **Data Conversion:** this step converts data from a given type to the standard one. For instance, csv, xml, or parquet data is converted all into json, which is required by the central data platform.
- **Data Formatting:** this step standardizes the format of some data types, such as date/time, currency, coordinates, measurement units, etc. to be merged or integrated into other data sources.
- **Data Transmission Standardization:** this function sets up the transmission protocol which allows data exchange across application via central data platform.

4.3.5. Central Data Platform

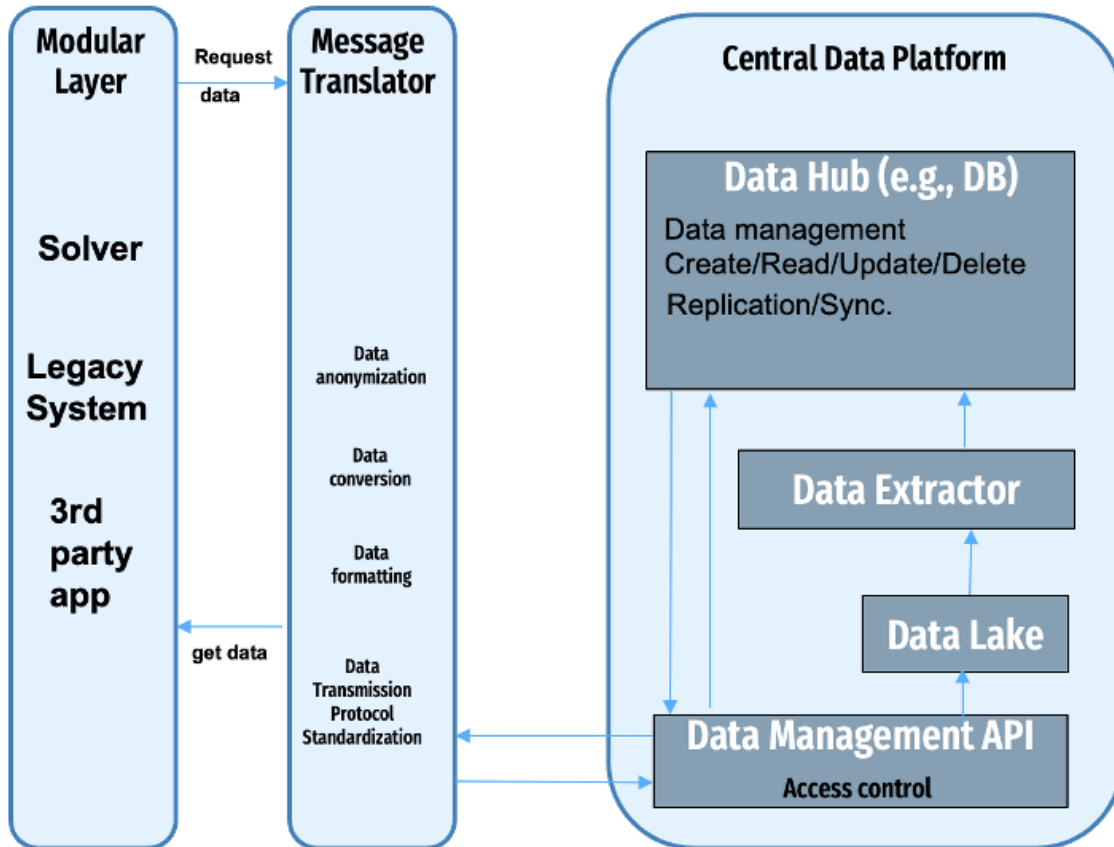


Figure 4.3.3: The central data platform and its connection to the other layers.

The central data platform plays an orchestration role for sharing and manipulating data across different stakeholders (via modular layer) within FOR-FREIGHT cloud system. At this moment, we design it as a centralized storage system, supporting a wide range of data requests under secured role-based mechanisms. The design will be implemented for each use case, in Task 2.5.

Once a data request is sent by a module (solver, legacy system, or third-party application), it will be first handled by the message translator. There, the data undergoes pre-processing stages (anonymization, formatting, conversion), whereas the pre-defined data transmission protocol is standardized. Next, the entire package will be transferred to the central platform. On this platform, the processing flow is as follows:

The Data Management API receives the data request. First, it verifies the validity of the request. For example, if the sender would have the rights for this request, or if the request details would be erroneous. In case where not all conditions are satisfied, it transfers the corresponding response to the module (sender) via Message Translator layer. Otherwise, it seeks the location on the data warehouses (hub, branch, storage location for the indicated version) and forwards the package further there. At the time being, the architecture entails two types of data warehouses, including Data Hub and Data Lake, to support flexibility of implementation. Task 2.5 developers can consider employing only the Data Hub, or the combination of the two, to make the platform more powerful while being in line with development capability. Data Lake is a data repository, storing vast amounts of raw data in various formats, which can be used for analytics or visualization purposes. Besides, Data Hub is not only for storage but rather serves for data exchanging purpose. It stores standardized, harmonized data, and also manipulates them (using underlying built-in functions such as create, read, update, delete, replicate, or sync) before exchanging or sharing. From the above insights, the central data platform can determine an appropriate data exchange strategy:

If data is mainly for storage purposes, without further manipulation process, it can be placed in the Data Lake. In case where part of it needs (e.g., specific version, time range, subset of features, etc.) to be shared, the platform would extract (thanks to Data Extractor bridging between Data Lake and Data Hub) and send it to Data Hub for further processing. Otherwise, Data Management API can transfer it directly to Data Hub.

Depending on data request, the Data Hub might store, update, or return the curated piece of data. The result of processing is encapsulated in the data response package, which will be transferred back to the sender via the Message Translator.

It is noteworthy that the designated platform works in a centralized manner. Data communication with local warehouses can still be conducted via adapted APIs. However, it is required to be thoroughly examined to ensure data integrity and security. This challenge will be further investigated in the next coming time, as a joint force between T1.4 and T2.5.

4.4 Dashboard

The dashboard contains front-end components of the platform which provide GUIs, APIs or features to support user-adapted needs. The users (e.g., T&L stakeholder, or customer/end user), once logged-in, will be redirected to the main page displaying active function they can perform. Figure 4.4.1 displays principal items of the dashboards, whereas Table 4.4.1 details functionalities, applicable users, and potential developers.

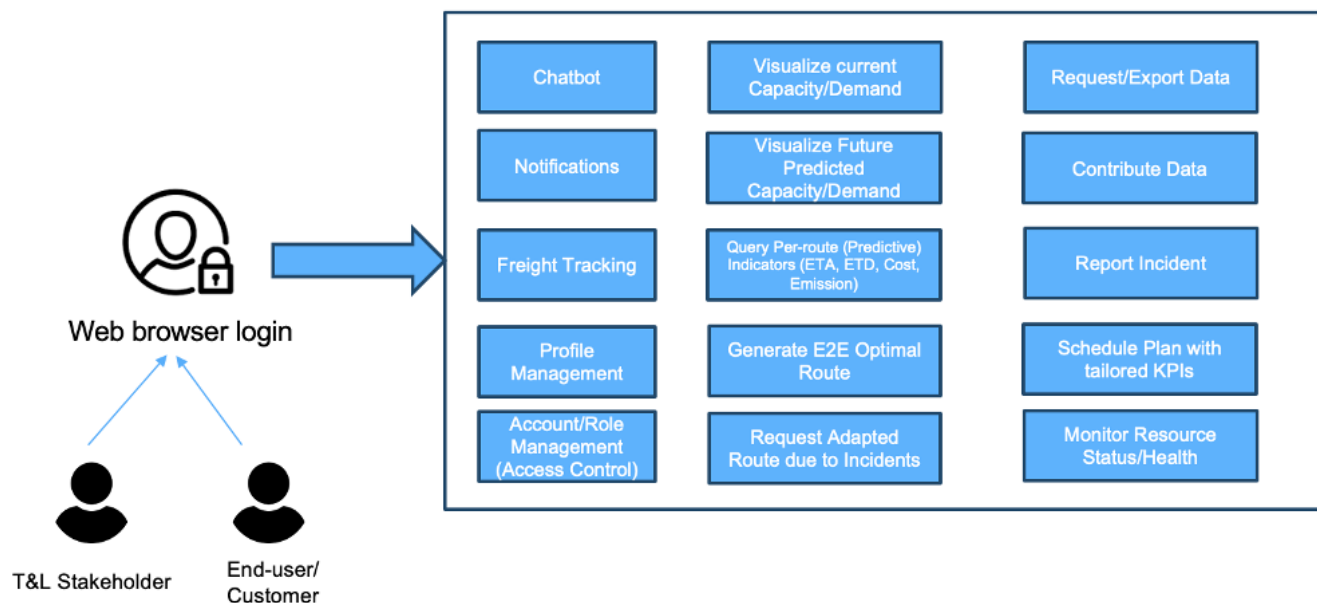


Figure 4.4.1: Overview of FOR-FREIGHT dashboards

Table 4.4.1: . Explanation of FOR-FREIGHT dashboards functionalities

Dashboard Item	Functionality	Users	Proposed Developers
General and Administration items			
Chatbot	Facilitate search or query via chatbot conversation	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS
Notification	Get notifications on platform updates (version/feature/message), or any changes over logistics network.	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS
Profile Management	Update profile details, reset/change password, etc.	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS
Account Management/ Permission Grant	<ul style="list-style-type: none"> Add/remove/disable accounts. Approve/reject permission request. 	Admin	CERTH WINGS ABS AIA BEIA EBOS
Tracking and Monitoring			
Freight tracking	Real time tracking of freight (door-to-door tracking): position, delivery status	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS

Resource status/health monitoring	Monitor status of logistics resource (e.g., truck, wagon, etc.)	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS
Visualization			
Current resource capacity/demand	Visualize the available/active resource (machine, vehicle, labor, storage space, etc.), as well as the reserved one at the time being.	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS
Future (predicted) resource capacity/demand	Visualize the available/active resource (machine, vehicle, labor, storage space, etc.), as well as the reserved ones predicted over future horizons (e.g., every hour within 24 hours ahead).	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS
Per-route predictive indicators	(ETA, ETD, cost, emission, etc.)	T&L Stakeholder	
Recommendation (DSS)			
E2E Route	Query the E2E route, before the journey, to satisfy certain KPIs (time, cost, emission, or all).	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS
Adapted route due to incident	Query the update route, during the journey, given real-time incidents, to satisfy certain KPIs (time, cost, emission, or all).	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS

Adapted plan with tailored KPI/expectation	Query the update route, during the journey, when KPIs have been modified (e.g., only time is concerned instead of time, cost, and emission criteria of the initial plan).	T&L Stakeholder	CERTH WINGS ABS AIA BEIA EBOS
Data Management and Exploitation			
Request/Export data	Request to download data. Export real-time data or outputs of other functionalities.	T&L Stakeholder Customer/End-user (limited public data)	CERTH WINGS ABS AIA BEIA EBOS
Contribute data	Upload, update (historical/ real-time) data – manually, automatically (periodically)	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS
Report Incidents	Update data of observed incidents. Report needs admin’s approval.	T&L Stakeholder Customer/End-user	CERTH WINGS ABS AIA BEIA EBOS

Table 4.3. Explanation of FOR-FREIGHT dashboards functionalities.

4.5 Integration Points

As previously mentioned, the technologies involved in the cloud-based platform face integration challenges and barriers due to the lack of interoperability among the systems and because of the formats of the data managed. To address these problems, it is necessary to develop and integrate APIs and create standardized interfaces to enable the interconnection between these systems. The following proposals aim to break the gaps and bridge the diverse components within the platform, towards a fully integrated architecture.

Data standards definition: These standards include common formats, transmission protocols, and schemas. This allows a smoother exchange of information between systems, which increases compatibility.

Data Extraction: The collaboration among stakeholders involved in the legacy systems and the third-party applications is fundamental to resolve technical alignment between the sources of information. This comprises the definition of standards, fulfillment of technical limitations and the modernization of systems where it is needed. The legacy systems/third-party applications that need to be integrated should be identified to determine the data sources and formats they provide. Then, develop a collection of connectors to interact with the systems, to allow the extraction and transformation of data into a unified format.

Data Transformation: The proliferation of highly diverse systems can lead to redundancies regarding data integration. To avoid duplication, data is consolidated using mapping techniques to recognize differences in data structures between legacy systems.

Data Security: Security is a key factor during data manipulation. The means of data transfer must implement robust measures to protect sensitive information. The anonymization techniques offer protection by replacing identifiable information with anonymized equivalents. Towards these ends, the **message translators** need to be implemented as a middleware integrated in the central platform. They are intermediaries between the legacy systems or the third-party applications and the platform, handling the data transformation based on the aforementioned standards. These translators should be accessed through APIs as the systems can interact with each other using standardized communication protocols in a controlled and secure manner.

5 Technological Validation methodology

5.1 Scope and methodology

The testing and validation methodology to be elaborated in this task entails the acceptance test procedures for conducting the technological validation of the FOR-FREIGHT platform and solutions.

Procedures will be defined for collecting the data feeds from the logistics nodes, systems and sensors and other relevant equipment, stating also how these feeds will be used and analyzed by the FOR-FREIGHT Platform to produce and present the necessary data in a user-friendly form. Threshold limits for the benchmarking of the results will also be defined per target KPI based on the requirements stemming from each UC, this is understood as the definition of the target values for the set KPI's.

The technological validation of both FOR-FREIGHT solutions and central platform will be performed measuring some KPI's. Digital Key Performance Indicators (KPIs) are a way to track technology validation progress. But to avoid wasting time and resources, it must be made sure that it is correctly defined what logistics process is being managed with each KPI and the expected threshold. This was covered in Task 1.2 in which for each of the three use cases, some KPI's description, their target objectives and the logistics processes that will be measured by this KPI's were defined. Also, in Task 1.2, KPIs were connected to the mid-term expected outcomes (EO) and long-term expected impacts (EI) which allowed us to connect each of the functional requirements defined for the different UCs to specific KPIs, EOs and EIs. Now, we need to define the data collection methodology from logistics nodes, systems and sensors that will feed the solutions and allow to calculate this set KPIs that will allow the technological validation and will also contribute to assess the impact of the solutions implemented within FOR-FREIGHT.

To organize the data collection and KPI calculation from the different actors, an excel file common tool has been generated in collaboration between the partners in charge of Task 1.2, Task 1.3 and Task 3.5 (see [Annex I](#)).

This excel has been conceived to be used in order to gather the information required in T1.2, T1.3 and T3.5 regarding all three use cases of the project. In this way we avoid overlaps between tasks and as it gets totally filled in, we obtained a summary of all the requirements, expected outputs of the use cases and possible input data sets that business partners can provide to the technical partners. Therefore, with all this information, technical partners can start to outline the fundamental elements of the solutions and the central platform to be developed by FOR-FREIGHT. Then, this would serve as an input for T1.4, and tasks included in WP2 which are responsible for the solutions design and implementation in the use cases.

5.1.1 KPI baseline definition

In Task 1.3. each use case will define each KPI baseline measurement by providing the actual values if available or estimating the actual value in case they do not have the possibility or tools to measure it. Also, the means of verification of each KPI will be defined, in other words, the conceptual definition of how the calculation must be made after applying the solutions developed within the scope of FOR-FREIGHT.

The detailed information per each use case gathered is the following:

- Use case involved
- Scenario if applicable in which the use case is developed (covered by task 1.2)
- Target ID (covered by task 1.2)
- Target description (covered by task 1.2)
- Target expected value (covered by task 1.2)
- KPI ID
- KPI description
- KPI baseline value
- KPI ex-post value (will be covered by task 3.5)
- Comparison baseline/ex-post measurement (this will be covered by task 3.5)

- Technology applied to calculate the KPI (covered by task 1.2)
- Logistic process measured by the KPI (covered by task 1.2)
- Partner/s that become responsible to provide the calculation supported by the developed solution/s within de project (covered by task 1.2)
- Means of verification, details on how the KPI must be calculated
- Mid-Term expected outcomes, relates each KPI defined to which mid-term expected outcomes of the project contributes (covered by task 1.2)
- Long-Term expected impacts, relates each KPI defined to which long-term expected impacts of the project contributes (covered by task 1.2)

5.1.2 Data collection baseline definition

In Task 1.3, with the help of all the involved partners, all the data to be collected from each logistics nodes, systems and sensors and other relevant equipment to feed the FOR-FREIGHT platform/solutions have been analyzed. It has also been gathered with the help of the common tool excel file generated by Tasks 1.2, 1.3 and 3.5 and shared with all the partners involved in the three use cases.

Data collection baseline refers to the specific data per each KPI that could be made available to the FOR-FREIGHT project considering the expected outcomes and technologies that will be used to develop the final solutions. This data has been listed and detailed for each use case and scenario, if applicable, and per each of its KPI's.

Definition and details of data collection baseline are the following:

- Use Case
- Pilot site/Scenario
- KPI ID
- KPI baseline description
- Data description provided
- Data origin/source
- Data format
- Data owner
- Frequency of collection
- Confidentiality
- Technology(ies) that will be feed by this data provided

5.1.3 KPI and Data collection ex-post definition

The KPIs and the data collection ex-post will be covered by Task 3.5 once the project advances and the final different solutions have been implemented and validated. Since the final solutions will be obtained after three iterative cycles (all details for business validation methodology described in the section 6 below), possibly the final version of the data collected from the different partners could be slightly different from that specified in this deliverable. This deliverable collects the data per each KPI that could be made available to the FOR-FREIGHT project considering the expected outcomes and technologies that will be used to develop the final solutions. But at this stage, there are not any solution/s developed yet. At this early-stage technical partners are still revising requirements and expected outputs defined by business partners and they will continue to work together for the design of the preliminary solutions.

The information gathering on KPIs and data collection ex-post will also be documented in the common tool excel file generated by Tasks 1.2, 1.3 and 3.5, so it will be easier to do the final analysis and comparison between pre FOR-FREIGHT KPI's measurements and ex-post KPI's measurements.

5.2 Use case KPI and data collection baseline

In this section all the information gathered regarding KPI baseline definition and data collection baseline definition is presented separate per use case and scenario if applicable.

5.2.1 Spanish trial

Spanish UC is divided in two scenarios:

- Valencia Port: activities where containers will be unloaded from the vessel and loaded either on a truck or on train plus truck for DHL's warehouse destination in Madrid.
- Madrid: activities carried out from DHL warehouse to final customer (last-mile distribution) through Metro de Madrid network.

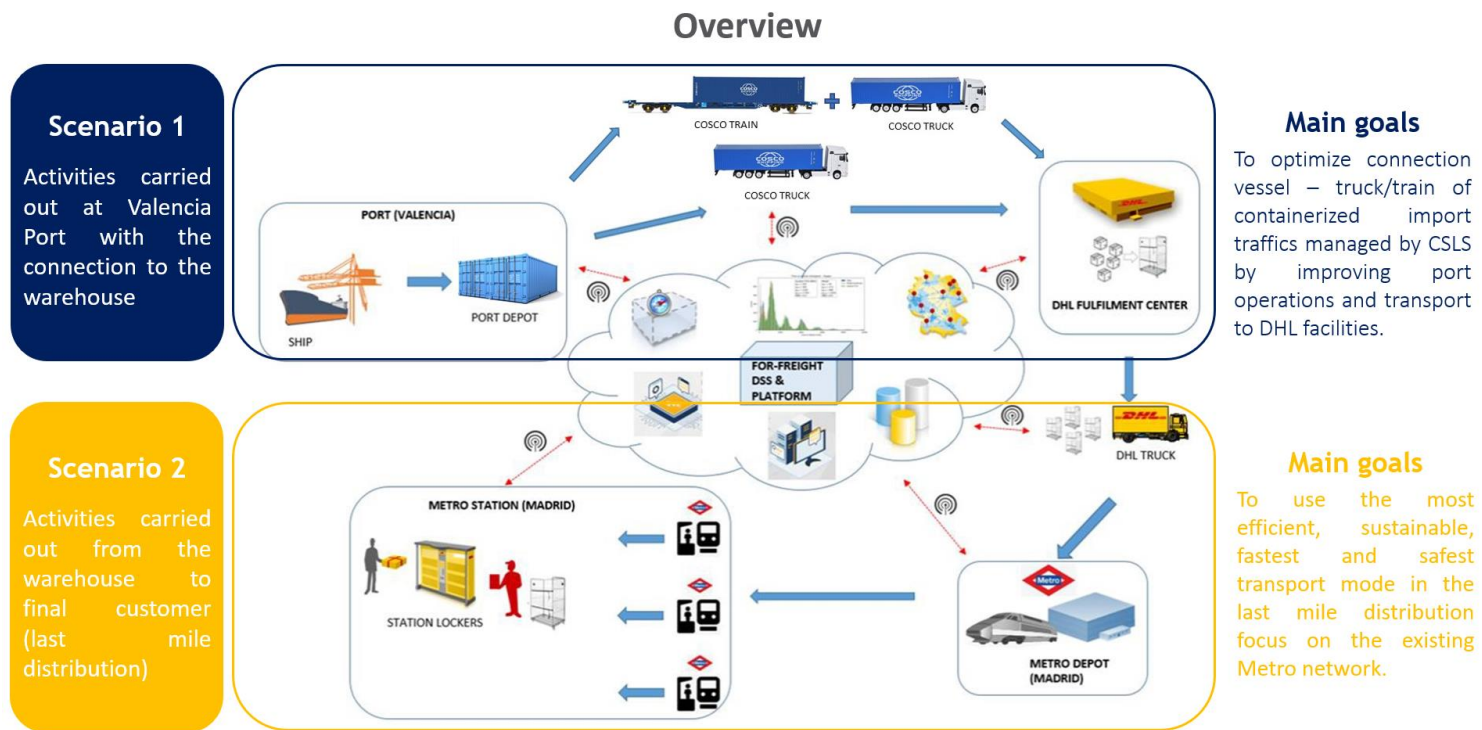


Figure 5.2.1: Scheme of Spanish Use Case

5.2.1.1 KPI baseline

Following the methodology defined in Section 5.1.1, KPI information related to KPI ID number, description, baseline value and means of verification has been provided for both scenarios of the Spanish UC.

The Table 5.2.1 details for Scenario 1 the baseline values and verification means, also providing updates on technology(ies) and responsible partners for the calculation and the logistics process measured through KPIs.

Table 5.2.1: Spanish Trial - Scenario 1 KPI baseline information

Target description	Target value	KPI_ID	KPI description	KPI Baseline value	Technology applied	Logistics process measured	Partner responsible for the calculation	Means of verification
Improve forecast planning	>15%	ES1/1_1	Current on-time delivery ranges	~60% of shipments	AI/ML Blockchain Digital Twins	Transport orders process	CERTH/FV	Dates of cargo unload in port Truck ETA and updates on the ETA DT use to simulate optimal scenario for container on time delivery
		ES1/1_2	Errors, accidents	18% as ratio of disputes	Blockchain Digital Twins	Transport incidences or damage on container or cargo during the transport.	CERTH/FV	Availability of cargo status and location in real time and registered events to be visible from a BC solution with different access profiles depending on the agent.
		ES1/1_3	Time to set-up an end-to-end multimodal freight transport with multiple stakeholders: time since we receive the transport request from customer and	2 days	AI/ML Blockchain Digital Twins	Process since we receive the transport request from customer and we arrange the transport to be carried out (incl. Optimal decision	CERTH/FV	Measuring time since we receive the transport request from customer and we arrange the transport to be carried out (incl. Optimal decision between truck/train)

			we arrange the transport to be carried out.			between truck/train)		
		ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	~4 days	AI/ML Blockchain Digital Twins	Process since we receive the transport request from customer to arrival at final destination, this also includes the transit time (incl. Optimal decision between truck/train)	CERTH/FV	Measuring time since we receive the transport request from customer to arrival at final destination, this also includes the transit time (incl. Optimal decision between truck/train)
Reduce container staying at the port	>15%	ES1/1_5	Trucks' waiting time at the Terminals	~ 2 hours	AI/ML Blockchain Digital Twins	Time trucks spend at the terminals between terminal entry and exit.	CERTH/FV	Tracking the waiting time trucks spend at the terminals between terminal entry and exit. DT use for simulation on reducing truck dwell time
		ES1/1_6	Loading time in the terminals	~ 1-2 hours	AI/ML Blockchain Digital Twins	Cargo loading process	CERTH/FV	Measuring/ Tracking the waiting time since truck arrives to the terminal to the load of the container on it DT use for simulation on reducing truck dwell time
		ES1/1_7	ITU/container dwell time in port	9,6 full	AI/ML Blockchain Digital Twins	Container's stay at port before exiting terminal on the way to DHL's warehouse	CERTH/FV	Measuring time between discharge of the container (COARRI) and terminal gate's exit (CODECO) DT use for simulation on optimal planning, selecting

								optimal transport mode (truck / train)
Reduce GHG emissions	>15%	ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train + truck	0,3 t CO2e	AI/ML Digital Twins	GHG emissions of transport (train+truck/truck) between port and DHL warehouse	CERTH/FV	Measurements of the tracking distance travelled in terms of emissions produced on the trip from the port to DHL warehouse.
Transport Orders digitalisation	20%	ES1/1_9	Number of transport orders fulfilled through Blockchain	0	Blockchain	Transport orders filled through BC	FV	Transport orders fulfilled using the blockchain-based system.

The Table 5.2.2 details for the Scenario 2 the baseline values and verification means, also providing updates on technology(ies) and responsible partners for the calculation and the logistics process measured through KPIs.

Table 5.2.2 Spanish Trial - Scenario 2 KPI baseline information

Target description	Target value	KPI_ID	KPI description	KPI Baseline value	Technology applied	Logistics process measured	Partner responsible for the calculation	Means of verification)
Reduction of Operational Costs	>12%	ES1/2_1	Current operational cost	2.25€/parcel	AI/ML IoT Digital Twin 5G Blockchain	DHL warehouse arrival of container, unloading, storage, van loading, transport to MDM Depot.	DHL MDM	Measuring the operational cost AS-IS (courier) vs TO-BE (MDM) of the full process from DHL warehouse to end destination for an average parcel. For the calculation of the Operational Cost. The

								following areas will be measured: air pollution, accident cost, distance travelled, noise cost, congestion cost, climate change cost, etc., according to the EC Handbook of External Cost of Transportation.
		ES1/2_2	Missed deliveries	~ 10%	AI/ML IoT Digital Twin 5G	1) DHL warehouse arrival of container, unloading, storage, van loading, transport to MDM Depot. 2) Loading into MDM trains, unloading at MDM stations, opening rolling cages and placing parcels into lockers.	MDM DHL	Comparison of the average missed deliveries AS-IS (Warehouse+last mile courier) vs TO-BE (warehouse+MDM last mile distribution). Identification of the point within the process where missed deliveries are most frequent. IoT sensors will allow to identify the exact location of each of the parcels within DHL warehouse, roller cages, van, etc. in real time. Information will be transmitted through 5G. Parcels (units) will be assigned an individual code upon arrival at DHL warehouse depending on the final destination (MDM final station). Parcels will be grouped in rolling cages according to their code. Each roller cage will have a IoT sensor device for tracking. For tracking missed deliveries the process will be: 1) scanning individual parcel codes before loading into the rolling cages; 2) real-time

								tracking of rolling cages, with assigned parcel codes, from DHL warehouse to MDM Depot to MDM final destination; 3) final scanning of the individual parcels at MDM final station before placing it in the assigned lockers.
		ES1/2_3	Number of vehicles required for last mile delivery with average loading	~ 75 units/van	AI/ML IoT Digital Twin 5G	1) Rolling cages loading with parcels at DHL warehouse and 2) van loading with those rolling cages that will head MDM Depot.	DHL	Measurement of 1) the average number of parcels per rolling cage, 2) the number of rolling cages loaded per van, 3) number of vehicles in circulation carrying those roller cages to MDM depot (units/vehicle)
Reduction of External Costs (environmental +social cost)	>80%	ES1/2_4	GHG emissions	~ 0.88 Kgs/stop (75 units/van, 10 stops/hour, 50 stops/route)	AI/ML IoT 5G	1) Delivery route planned from DHL warehouse to MDM Depot + 2) delivery route planned from MDM Depot to final station.	DHL MDM	Comparison of the average GHG emissions with the AS-IS situation (courier stopping 6 times per hour with an average load of 75 units per van), with the TO-BE situation (MDM last mile delivery to station lockers). The following areas will be measured: GHG of MDM emissions, DHL van/truck from warehouse to MDM Depot emissions, average load of parcels per roller cage and of roller cages per van/truck.
Reduction of transport times from DHL warehouse to final destination	>10%	ES1/2_5	Average loading/unloading time per parcel	~ 96 seconds/parcel (considering 75 parcels/van requires 2	AI/ML IoT Digital Twin	1) Parcels loading time into rolling cages and 2) rolling cages loading time into vans.	DHL	The following areas will be measured: 1) time to complete the loading of a roller cage with the assigned parcels and 2) time to load vans/trucks with the roller cages. The result will be

				hours to be loaded)				calculated in second required per parcel. AS-IS vs. TO-BE scenarios will be compared.
		ES1/2_6	Average urban delivery times for the average number of units in 1 vehicle	5 hours circulation/ route for 75 units/van/route	AI/ML IoT Digital Twin 5G	1) Delivery route planned from DHL warehouse to MDM Depot + 2) delivery route planned from MDM Depot to final station.	DHL MDM	Comparison of the time required in the AS-IS (courier with 10 stops per hour and 6 min per stop) with TO-BE (MDM last mile distribution) for a given number of parcels.
		ES1/2_7	Missed deliveries	~ 10%	AI/ML IoT Digital Twin 5G Blockchain	1) DHL warehouse arrival of container, unloading, storage, van loading, transport to MDM Depot. 2) Loading into MDM trains, unloading at MDM stations, opening rolling cages and placing parcels into lockers.	DHL MDM	Comparison of the average missed deliveries AS-IS (Warehouse+last mile courier) vs TO-BE (warehouse+MDM last mile distribution). Identification of the point within the process where missed deliveries are most frequent. IoT sensors placed in roller cages will allow to identify the exact location of each of the parcels (with an individual code related to the final MDM station destination) within DHL warehouse, roller cages, van/truck, etc. in real time. Information will be transmitted through 5G.
		ES1/2_8	Average number of stops per route carried out by 1 vehicle (van) to deliver an average of 75 parcels	~ 50 stops/route	AI/ML IoT Digital Twin 5G	1) Delivery route planned from DHL warehouse to MDM Depot + 2) delivery route planned from MDM Depot to final station for a	DHL MDM	Comparison of the number of stops, for a comparable amount of parcels, for the AS-IS (last mile courier) scenario and the TO-BE scenario (MDM last mile).

						comparable set of parcels.		
		ES1/2_9	Average delivery loading per van	~ 75 units	AI/ML IoT Digital Twin 5G	1) Rolling cages loading with parcels at DHL warehouse and 2) van/truck loading with those rolling cages that will head MDM Depot.	DHL MDM	Measurement of 1) the average number of parcels per rolling cage and 2) the number of rolling cages loaded per van/truck.

5.2.1.2 Data collection baseline

Following the methodology defined in Section 5.1.2 data collection baseline for the Spanish UC has been described for both scenarios.

Table 5.2.3 describes for Scenario 1 data collected for baseline and needed for KPI calculation, per each KPI defined the related data is provided. [Annex I](#) provides more detailed information on data source, format, owner, frequency of collection, level of confidentiality and technology involved.

Table 5.2.3 Spanish Trial - Scenario 1 Data collection baseline description

KPI ID	KPI Baseline description	Data Description
ES1/1_1	Current on-time delivery ranges	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck
		Delivery Order Rail

		Acceptance Confirmation into Rail Terminal
		Release confirmation of the Rail Terminal
		Acceptance Confirmation into the depot of the empty container
		Shipment data: Data of import containers arriving to Valencia
		Vessel schedules: Data on ETA/ETD of vessels
		Train schedules: Data on ETA/ETD of trains
		Estimation on train and truck costs
ES1/1_2	Errors, accidents	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck
		Acceptance Confirmation into Rail Terminal
		Release confirmation of the Rail Terminal
		Acceptance Confirmation into the depot of the empty container
		Shipment data: Data of import containers arriving to Valencia
ES1/1_3	Time to set-up an end-to-end multimodal freight transport with multiple stakeholders: time since we receive the transport request from customer and we arrange the transport to be carried out.	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal

		Transport Order Request
		Delivery Order Truck
		Shipment data: Data of import containers arriving to Valencia
		Vessel schedules: Data on ETA/ETD of vessels
		Train schedules: Data on ETA/ETD of trains
		Estimation on train and truck costs
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Discharge List COPRAR
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Discharge Confirmation COARRI
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Release confirmation of the Port Terminal
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Transport Order Request
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Delivery Order Truck
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Delivery Order Rail
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Acceptance Confirmation into Rail Terminal
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Release confirmation of the Rail Terminal
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Acceptance Confirmation into the depot of the empty container
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Shipment data: Data of import containers arriving to Valencia
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Vessel schedules: Data on ETA/ETD of vessels
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Train schedules: Data on ETA/ETD of trains
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Estimation on train and truck costs

ES1/1_5	Trucks' waiting time at the Terminals	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck
		Release confirmation of the Port Terminal
		Shipment data: Data of import containers arriving to Valencia
ES1/1_6	Loading time in the terminals	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck
		Release confirmation of the Port Terminal
		Shipment data: Data of import containers arriving to Valencia
ES1/1_7	ITU/container dwell time in port	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck

		Delivery Order Rail
		Acceptance Confirmation into Rail Terminal
		Release confirmation of the Port Terminal
		Shipment data: Data of import containers arriving to Valencia
		Vessel schedules: Data on ETA/ETD of vessels
		Train schedules: Data on ETA/ETD of trains
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Discharge List COPRAR
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Discharge Confirmation COARRI
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Release confirmation of the Port Terminal
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Transport Order Request
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Delivery Order Truck
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Delivery Order Rail
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Acceptance Confirmation into Rail Terminal
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Release confirmation of the Rail Terminal
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Acceptance Confirmation into the depot of the empty container
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Shipment data: Data of import containers arriving to Valencia
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Vessel schedules: Data on ETA/ETD of vessels
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Train schedules: Data on ETA/ETD of trains
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Estimation on train and truck costs

ES1/1_9	Number of transport orders fulfilled through Blockchain	Discharge List COPRAR
		Discharge Confirmation COARRI
		Release confirmation of the Port Terminal
		Transport Order Request
		Delivery Order Truck
		Delivery Order Rail
		Acceptance Confirmation into Rail Terminal
		Release confirmation of the Rail Terminal
		Acceptance Confirmation into the depot of the empty container
		Shipment data: Data of import containers arriving to Valencia
		Vessel schedules: Data on ETA/ETD of vessels
		Train schedules: Data on ETA/ETD of trains
		Estimation on train and truck costs

Table 5.2.4 describes for Scenario 2 data collected for baseline and needed for KPI calculation, per each KPI defined the related data is provided. [Annex I](#) provides more detailed information on data source, format, owner, frequency of collection, level of confidentiality and technology involved.

Table 5.2.4: Spanish Trial - Scenario 2 Data collection baseline description

KPI ID	KPI Baseline description	Data Description
ES1/2_1	Current operational cost	Loading and route plan

		Parcel Label info
		Load capacity per train and available timetables
		Number of trains available for delivery
		Number of packages transported per station
ES1/2_2	Missed deliveries	Parcel Label info
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels, 3) parcel ungrouping at MDM station for lockers placement
		Real-time tracking data from sensors in roller cages
		Delivery confirmation (customer picking up parcel from MDM lockers)
ES1/2_3	Number of vehicles required last for mile delivery with average loading	Parcel Label info
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels
		Number of vehicles in circulation
		Load capacity per train and available timetables
		Number of trains available for delivery
ES1/2_4	GHG emissions	Loading and route plan
		Parcel Label info
		Load capacity per train and available timetables
		Number of trains available for delivery

		Number of packages transported per station
		Parcel Label info
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels
		Number of vehicles in circulation
ES1/2_5	Average loading/unloading time per parcel	Parcel Label info
		Parcel label scanning checkpoints info: 2) roller cages loading with parcels. This provides the exact time when parcel is taken from storage space into rolling cage.
		Real-time tracking data from sensors in roller cages. This will provide exact time of vehicle leaving DHL warehouse with full rolling cages.
ES1/2_6	Average urban delivery times for the average number of units (parcels) in 1 vehicle	Real-time tracking data from sensors in roller cages. This will provide the time required to deliver from DHL warehouse to MDM Depot and to final station destination.
ES1/2_7	Average number of stops per route carried out by 1 vehicle (van) to deliver an average of 75 parcels	Parcel Label info
		Parcel label scanning checkpoints info: 2) roller cages loading with parcels.
		Real-time tracking data from sensors in roller cages. This will provide the number of stops of the vehicle containing those roller cages in the route from DHL warehouse to MDM Depot
		Loading and route plan
ES1/2_8	Average delivery loading per van	Loading and route plan
		Parcel Label info
		Load capacity per train and available timetables
		Number of trains available for delivery

		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels, 3) roller cages loaded into the vehicle
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5.2.2 Greek trial

The Greek UC combines Sea Port, Airport (air-freight) and road transport (truck) for an end-to-end optimization with DSS and real-time monitoring and control capabilities.

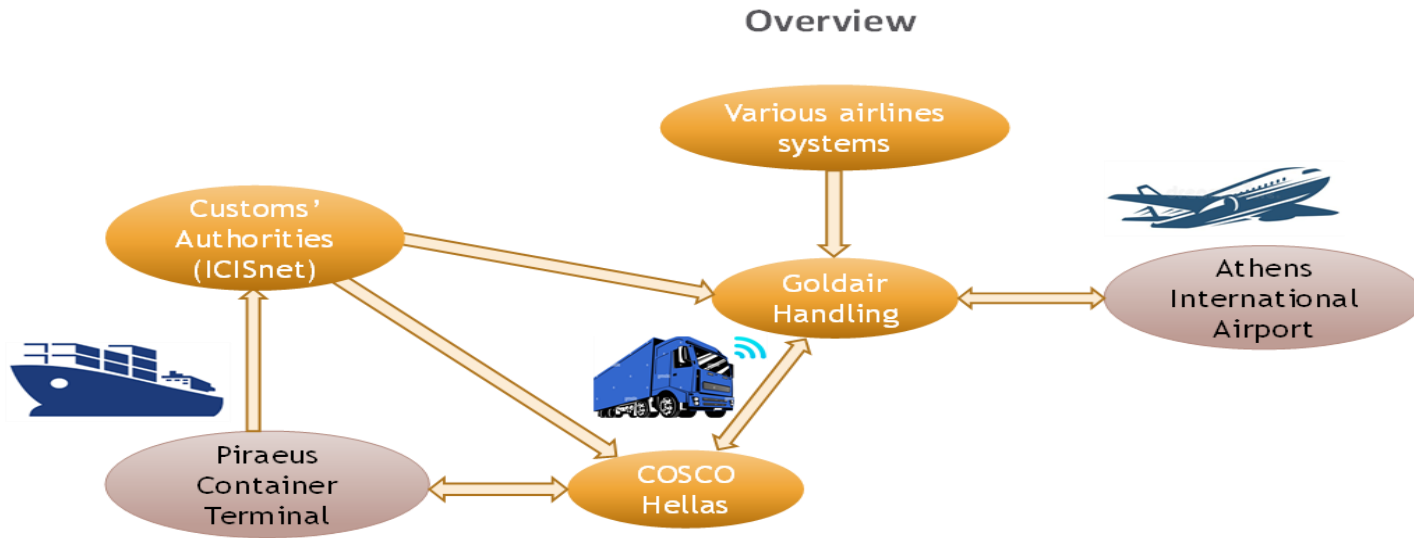


Figure 5.2.2: Scheme of Greek Use Case

5.2.2.1 KPI baseline

Following the methodology defined in Section 5.1.1, KPI information related to KPI ID number, description, baseline value and means of verification has been provided for Greek UC.

Table 5.2.5 details the baseline values and verification means, also providing updates on technology(ies) and responsible partners for the calculation and the logistics process measured through KPIs.

Table 5.2.5: Greek Trial - KPI baseline information

Target description	Target value	KPI_ID	KPI description	KPI Baseline value	Technology applied	Logistics process measured	Partner responsible for the calculation	Means of verification
Reduction of the container idle time at the port/airport	>25%	GR2_1	Container idle time at port	1-3 working days	5G, AI, (Big) Data Processing	Container stay at port warehouse	COEL	Estimate time savings due to automization of some processes (e.g. file exchange)
		GR2_2	Container idle time at the airport	4-6 hours	5G, AI, (Big) Data Processing	Container processing at airport warehouse	GOLD	Measure average truck waiting time by the end of the pilot application
		GR2_3	Truck waiting time at terminal	2-3 hours	5G, AI, (Big) Data Processing	Cargo loading/unloading process	COEL/GOLD	Estimate waiting time reduction via data analytics/simulation
Reduction of the customs clearance process time	>20%	GR2_4	Customs clearance process time	3-4 hours	Legacy systems integration	Customs clearance	COEL	Estimate time savings due to automization of customs clearance process
Increased end-to-end capacity due to optimization of resource utilization	>20%	GR2_5	Truck transportation time ex. port to airport	1.5-2 hours	5G, AI, (Big) Data Processing	Port-to-airport transport	COEL	Estimate travel time/distance saved due to best route selection
Increased efficiency of	>15%	GR2_6	Current cargo handling capacity at	40,000 tonnes per year	Artificial Intelligence (AI)	Cargo storage	GOLD	Estimate improvement using advanced data analytics to highlight the change

the storage space			the airport hub					
Reduction of errors	>20%	GR2_7	Mishandling errors	40 per year	Artificial Intelligence (AI)	Cargo handling	GOLD	Estimate improvement using advanced data analytics/forecasting to highlight the change
		GR2_8	Errors, accidents and errors that caused delays (not mishandling)	5-6 incidents per month	Artificial Intelligence (AI)	Cargo processing	GOLD	Estimate improvement using advanced data analytics to highlight the change

5.2.2.2 Data collection baseline

Following the methodology defined in Section 5.1.2 data collection baseline for the Greek UC has been described for both scenarios.

The Table 5.2.6 describes for Scenario 1 data collected for baseline and needed for KPI calculation, per each KPI defined the related data is provided. [Annex I](#) provides more detailed information on data source, format, owner, frequency of collection, level of confidentiality and technology involved.

Table 5.2.6: Greek UC Data collection baseline description

KPI ID	KPI Baseline description	Data Description
GR2_1	Container idle time at port	Vessel arrival notice
		Cargo departure
GR2_2	Container idle time at the airport	Truck arrival notice

		Import warehouse
		TBD with GOLD (System estimating the waiting time of the trucks in the (un)loading warehouse points)
GR2_3	Truck waiting time at terminal	Truck arrival notice
		Cargo departure time
		Truck arrival notice at the warehouse
		import WMS
GR2_4	Customs clearance process time	Customs' clearance order
		Customs' clearance notice
GR2_5	Truck transportation time ex. port to airport	Cargo departure time
		Truck arrival notice at the warehouse
GR2_6	Current cargo handling capacity at the airport hub	Cargo storage
GR2_7	Mishandling errors	Cargo handling
GR2_8	Errors, accidents and errors that caused delays (not mishandling)	Cargo processing

5.2.3 Romanian trial

The Romanian use case's scenario comprises a container transported by Inland Shipping, unloaded in Galati port and loaded as rail cargo, using a unique identification code. Based on historical and real-time tracking data, ETA will be automatically updated a complete view of end-to-end process to users tracking is allowed. DSS will advise port authorities, logistics operators and custom agencies on resources needs. Rail freight operators will also be advised by the DSS on required storage space and resources according to the updated ETA. Automatic reservation of railway companies will also be possible.

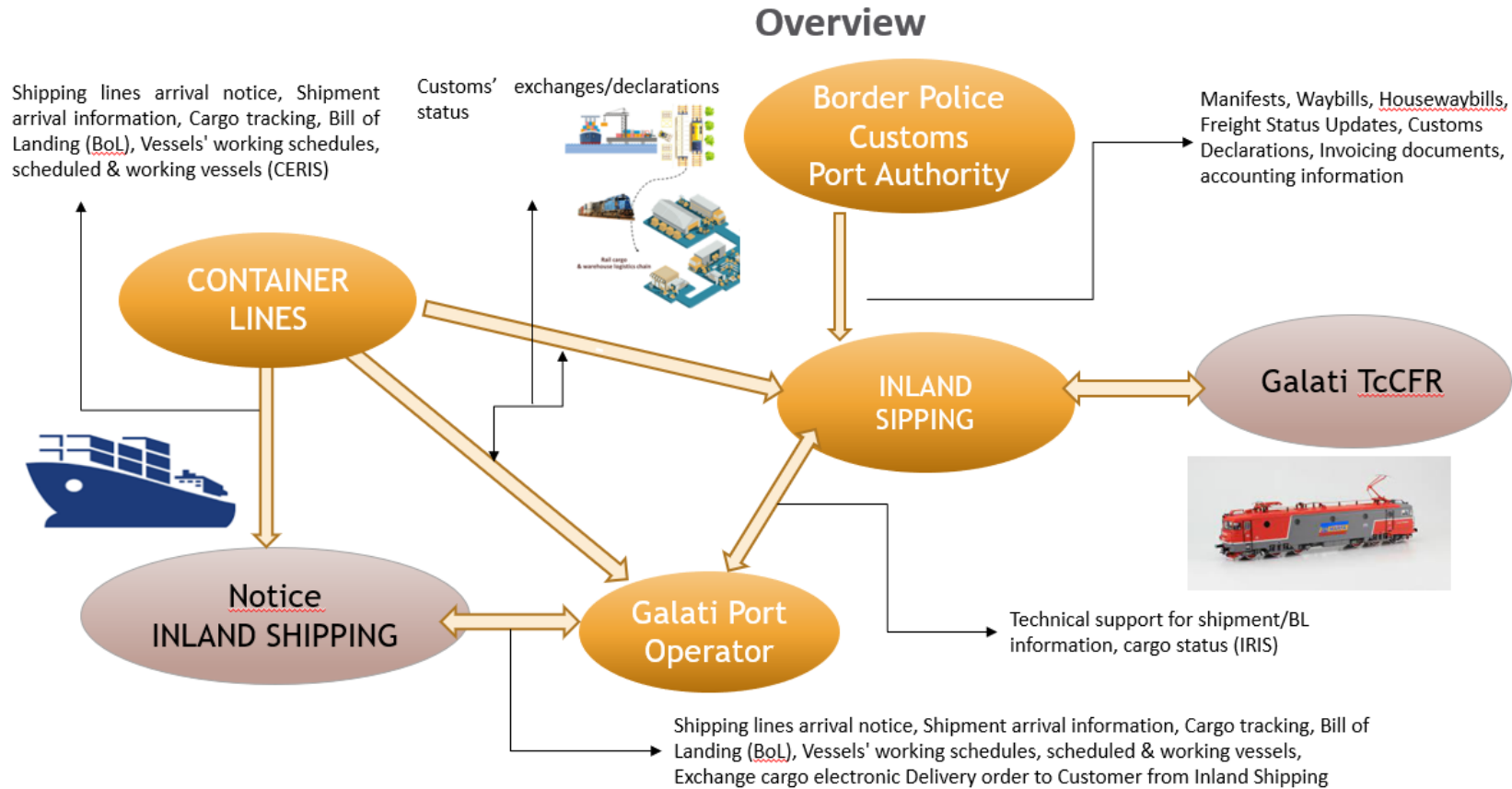


Figure 5.2.3: Scheme of Romanian Use Case

5.2.3.1 KPI baseline

Following the methodology defined in Section 5.1.1, KPI information related to KPI ID number, description, baseline value and means of verification has been provided for Romanian UC.

The Table 5.2.7 details the baseline values and verification means, also providing updates on technology(ies) and responsible partners for the calculation and the logistics process measured through KPIs.

Table 5.2.7: Romanian Trial KPI baseline information

Target ID	Target description	Target value	KPI_ID	KPI description	KPI Baseline value	Technology applied	Logistics process measured	Partner responsible for the calculation	Means of verification
RO1	Increased end-to-end capacity due to optimization of resource utilization	20%	RO3_1	Improve existing capacity utilisation	60%	Digital Twin Blockchain IoT 5G AI/ML	Cargo arrival in Galati Port	Inland Shipping/ ATG	DT use to simulate optimal scenario for container on time delivery
RO2	Decrease loading/unloading time	20%	RO3_2	Loading / unloading time in the terminals	2 hours	IoT AI/ML	Cargo loading/unloading process	Inland Shipping/ ATG	Estimate time savings due to automization of some processes
RO3	Reduction of routing errors	20%	RO3_3	Errors, accidents and error caused	15% as average	Digital Twin Blockchain IoT 5G AI/ML	Port to Railway transport	ATG / TcCFR	Estimate improvement using advanced data analytics
RO4	Reduction of accidents	30%	RO3_4				Port to Railway transport	ATG / TcCFR	Estimate improvement using advanced data analytics
RO5	Reduction of the container idle time	25%	RO3_5	Container idle time at the port	30 days	AI/ML	Custom clearance	Inland Shipping/ ATG	Measuring time between discharge of the container

									and terminal gate's exit
			RO3_6	ITU Dwell time in port	30 days	AI/ML Digital Twin IoT 5G	Cargo storage	Inland Shipping/ ATG	Estimate time savings due to automization of some processes
RO6	GHG emissions	15%	RO3_7	Reduction of fuel quantity	15%	Digital Twin Blockchain IoT 5G AI/ML	GHG emissions of transport (train+truck/truck) between port and DHL warehouse	BEIA	Measurements of the tracking distance travelled in terms of emissions produced on the trip from the port to the Railway.
			RO3_8	Changes in energy sources	20%	IoT, 5G	AV vehicles for cargo loading/unloading operations	Inland Shipping/ ATG	Estimated reduction of GHG emissions by replacing the fuel.
			RO3_9	Changes in the F-gases used as refrigerant	10%	IoT, 5G	Changes in the F-gases used as refrigerant	Inland Shipping/ ATG	Estimated reduction of GHG emissions by replacing the refrigerants gases.

RO7	Document digitalization	80%	RO3_10	There is no communication infrastructure between Port authorities and operators and railways authorities and operators	0	5G	5G infrastructure operational in Galati Port	BEIA	Document digitalization and data flow
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5.2.3.2 Data collection baseline

Following the methodology defined in Section 5.1.2 data collection baseline for the Romanian UC has been described for both scenarios.

The Table 5.2.8 describes for Scenario 1 data collected for baseline and needed for KPI calculation, per each KPI defined the related data is provided. [Annex I](#) provides more detailed information on data source, format, owner, frequency of collection, level of confidentiality and technology involved.

Table 5.2.8 Romanian Trial Data collection baseline description

KPI ID	KPI description	Data Description
RO1	Improve existing capacity utilisation	When the goods leave for the port of Galati, notifications about the volume of the goods and their destination are sent between DSS to port authorities, logistics operators, customs agencies, and railway operators, so that the transfer of the goods can be scheduled according to the ETA. Also, by using the For- Freight platform the port and railway management will be more efficient.
RO2	Loading /unloading time in the terminals	Inland Shipping ensures the loading/unloading operations of the containers
RO3	Errors, accidents and error caused	The possibility of receiving notification from the DSS regarding the available storage spaces and resources will decrease the waiting

		time and will contribute to defining the appropriate route for transshipment.
RO4		The operations of loading/unloading, storage and the relationship with the customs authorities for receiving all the necessary documents and approvals are coordinated and supervised by the Shipping Agent. Also, the digital solution offered will automate processes that now are manually executed and the number of human accidents will decrease.
RO5	Container idle time at the port	Management of empty containers available in the warehouse by using DSS.
RO6	ITU Dwell time in port	Reducing time for ship spends at port securing the vessel, discharging or loading cargo, and other activities.
RO7	Reduction of fuel quantity	Data collection from air quality measurement stations in the Galati port area
RO8	Changes in energy sources	Data collection from air quality measurement stations in the Galati port area
RO9	Changes in the F-gases used as refrigerant	Data collection from air quality measurement stations in the Galati port area
RO10	Communication infrastructure between Port authorities and operators and railways authorities and operators	Connecting the communication infrastructure between Inland Shipping, port authorities, logistics operators, customs agencies and railway operators

5.3 Verification framework

The technology validation will finalise with the verification of tests that will be conducted in each use case in order to demonstrate potential improvements that can be reached with the implementation of FOR-FREIGHT solutions. Task 1.3 will provide procedures for contacting the verification framework, that will be performed in Task 3.5 responsible of the analysis and evaluation of trials results carried out in the use cases. The verification framework will consist of performing a comparison between baseline and ex-post measurements per each KPI defined in T1.2. The baseline KPI value is collected in T1.3 and reported in the excel file common tool for Tasks 1.2, 1.3 and 3.5 as well as in the Section 5.2 of this deliverable. The baseline values measure the current situation of logistics processes analysed in each use case, while the ex-post values will measure the future situation considering the use of FOR-FREIGHT solutions. Once collected both values, the comparison will be done per each KPI defined by using the following formula:

$$Comparison = \frac{KPI_{ex-post\ value} - KPI_{baseline\ value}}{KPI_{baseline\ value}}$$

This result will be used for benchmarking with the target KPI in order to verify if achieved and demonstrate potential improvements achievable with the use of FOR-FREIGHT solutions.

6 Business validation methodology

In this section it is introduced the methodology that will be used for performing the business validation of the solutions developed within FOR-FREIGHT project.

The design of a structured ideation process reduces risk, minimises the costs of implementing the idea, speeds up the product's market launch and avoids both unnecessary losses and the creation of a product of no value to the consumer. The validation of business ideas also makes it possible to determine if the timing of the implementation and development of the idea is right, and if the solution is efficient enough for the market.

The validation of a business idea is the process by which a set of relevant information is collected to determine the relevance and potential return on investment of the application of a new product/solution, as well as the resources required for its development. The main goal is to understand the viability and potential demand for the service. By validating an idea, the success potential is confirmed.

The solution's validation comprehends the activities of explaining the solution's appropriateness to stakeholders and it also involves managing some test plans and evaluation of the testing results.

6.1 Lean Startup methodology definition

Within FOR-FREIGHT's project, the proposed business validation strategy to be used is the Lean Startup methodology. Lean start-up methodology centers around the main motivations of a business.

One of the main reasons that new developed products fail, it's because they don't fit the needs of the market. In other words, there is a mismatch between what they offer and what people need. Lean Start-up methodology aims to eliminate this problem by helping to develop and refine products based on customer feedback before building out a final product and bringing it to launch.

Lean start-up methodology is a blend of previously identified learning-by-doing methods [5]t draws inspiration from blended approaches such as discovery-driven planning that similarly urge teams to articulate their underlying assumptions and to get data to iterate them [6] and it builds on some existing principles of experimentation (i.e., hypotheses and their testing). However, the novel point introduced is its strong emphasis on interviewing customers and its shorthand visualization of the core components of the business idea [3].

Popularized by Steve Blank and Eric Ries [1], [2][8], the Lean Startup method aims to iterate business ideas, helping entrepreneurs make an early decision about their feasibility. To that end, it encourages entrepreneurs to make explicit their assumptions about a business idea (i.e., formulate hypotheses) and then probe them (i.e., interview customers).

Lean start-up methodology of business management and product development is designed to deliver products to customers at a quicker pace focusing on product features that have been validated through solution's testing results together with explicit customer feedback at various stages in the product development cycle.

A core component of Lean Startup methodology is the build-measure-learn feedback loop as the represented in Figure 6.1.1.

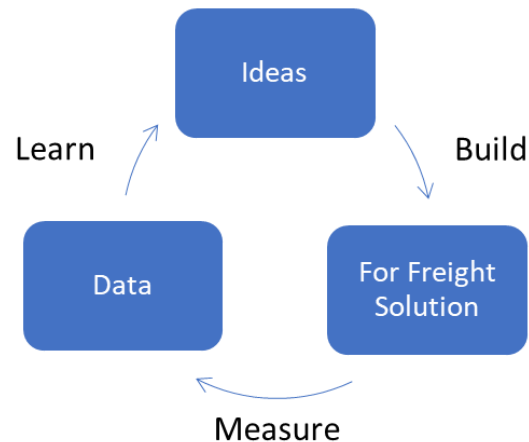


Figure 6.1.1: Scheme of Lean Startup Methodology

The first step is figuring out the problem that needs to be solved and then developing a minimum viable product/solution (MVP) to begin the process of learning as quickly as possible. A minimum viable solution/product is a bare-bones version of the product containing just enough features to be used by early adopters. It should be built using the minimum amount of time and resources and provide enough feedback to enable the validation of the idea.

Once the MVP is established, some testing will need to be set in order to get measurements and learn from the evaluation of the obtained results. Also, customer feedback will be incorporated through some questionnaires/surveys and focused group workshops directly engaging other T&L actors. In that way the testing is both qualitative, utilizing customer interviews, and quantitatively, using measures to assess costs and benefits and prevent waste.

So the inputs of the Lean Startup methodology will include apart from the business case itself, end-user feedback from their direct engagement in the trials of the T&L actors of the three use cases.

The corresponding outputs will be validations that will allow to identify those use cases that have the highest commercialization potential so as to progress to the next step of creating a service product portfolio.

6.2 Lean Startup methodology application

In this Deliverable 1.3, the methodology will be described from a theoretical point of view, and it needs to be applied by the different tasks involved in the creation, implementation, testing and the evaluation of the FOR-FREIGHT general platform and the different specific solutions to be developed in each of the use cases.

- First step – Ideas/design

In the first step, design, existing insights from observations and previous experiments are used to formulate testable hypothesis and design suitable experiments [7].

In our case, this first step of the cycle is identified with Tasks 1.1 *Legacy system, state-of-the-art, and logistics standards analysis (M1-M6)* and 1.2 *Requirements analysis and Use case refinement of the project (M1-M9)*. In these tasks the state of the art is revised, the solutions and technologies that the different technical partners could provide are checked and the business stories of the three use cases and the requirements of the problems to be solved by FOR-FREIGHT project is revised.

This step will set the problems to be solved and the requirements to match by the different solutions and the general platform that will be developed.

- Second step – Building of the solutions

In the building step, the researcher builds physical or virtual prototypes or models to conduct the experiments [7]. The higher the fidelity and functionality of the prototype, the stronger the generated evidence [7].

This step is identified with the following FOR-FREIGHT's tasks:

- Task 1.4. *FOR-FREIGHT solution architecture & design (M4-M12 & M20-M24)*. This task is responsible for designing the FOR-FREIGHT end-to-end system architecture for the central platform. The design of the platform will be based on the requirements and specifications analyzed and established on Task 1.2, as well as the integration approach of the various logistics systems and components.
- Task 2.1 *Development planning, coordination & knowledge exchange (M6-M28)*. This task will monitor and keep the pace of developments across the different trial sites following the internal co-design process following the common implementation cycles (prototyping, testing, upgrading, verifying). The task will guarantee that all developed solutions in the trial sites are compatible and have the proper interfaces for interworking with the central FOR-FREIGHT platform. This task's aim is to guarantee the suitability of the developed solutions with the envisioned use cases.
- Task 2.2 *Sea port - last-mile solution development, integration & testing (M8-M28)*, T2.3 *River port - Rail solution development, integration & testing (M8-M28)*, T2.4 *Airport - Sea port solution development, integration & testing (M8-M28)* and T2.5 *FOR-FREIGHT platform development & trial site solutions integration (M10-M28)*. This tasks' aim is to realize the solutions envisioned for the three project use cases as defined in T1.2 in a manner compatible with the overall FOR-FREIGHT platform design.

So, in this part of the cycle, an MPV of the UC's solutions and the central FOR-FREIGHT Platform should be developed to be tested in the next step of the cycle.

- Third step – Measurement/ Obtaining data

Then the experiment should be run either in a more controllable laboratory setting or in a real setting to get higher external validity (Thomke, 2003).

The tasks identified with this part of the cycle are:

- Task 3.1 *Planning, setup of field trials and operational management (M13-M27)*. In this task the general guidelines and trial preparation methodology to be followed will be defined.
- Task 3.2 *Sea port - last-mile trials (M17-M37)*, 3.3 *River port - Rail trials (M17-M37)* and 3.4 *Airport - Sea port trials (M17-M37)*. These tasks are responsible for the experimentation in each trial site: the proper execution of the defined UCs and the proper collection of data and KPI.

In this step the MVP's developed will be tested by the different use cases' environments. These initial experiments are conducted to determine if the envisioned value proposition matches the targeted customer requirements which will be evaluated in the next step of the cycle.

- Forth step – Evaluation/Learning

Finally, the outcomes are analyzed by comparing them to the expected outcome. If the hypothesis addressed by the experiment is answered sufficiently, the experimentation cycle can be stopped ([7]), otherwise the researcher reenters the design step with a modified experimental design adjusted with the help of previous insights.

This part of the cycle corresponds to Task 3.5. *Evaluation, lessons learned and best practices (M13-M38)*. The task is responsible for the analysis and evaluation of the trial results performed in T3.2, 3.3 and 3.4 based on obtained metrics and KPIs their post-processing the finally the validation of the UCs.

The evaluation will be performed both in qualitative and quantitative ways. The quantitative evaluation will be based on the measurement results (i.e., KPI's) from the implementation of the MVP. To perform the qualitative evaluation, it is proposed to carry out an internal focused group workshop per cycle directly engaging T&L actors as the stakeholders of the use cases and the horizontal partners such as EBOS, TIC4.0 and ZSI that will assist with the evaluation and validation of the solutions. There must be 1 focus workshop per use case in each cycle applying lean start up methodology so all the solutions and the central platform functionalities will be presented. The evaluation within the workshops will be done by using a set of questionnaires, surveys...that must be defined covering the whole points specify in Section 6.2.1.

The conclusions on this evaluation based on measurements resulting from the solutions implementation and obtaining feedback from the 'initial customers' in the workshops, will feed the solution design (T1.4 and T2.1-T2.5) in an iterative process (M20-M36) to enable refinements, improvements, and optimization aspects. It could also help to provide insights for commercialization (WP4).

So, the evaluation process consists of the extraction of useful insights and lessons learned from each trial site. Then the build-measure-learn cycle continues, redesigning via a series of small adjustments, or iterations. Bigger innovations, or pivots, occur when customer input suggests a concept isn't working and a greater rethinking is needed. The result of the application of the Lean Startup methodology is that the market dictates the product rather than the other way around.

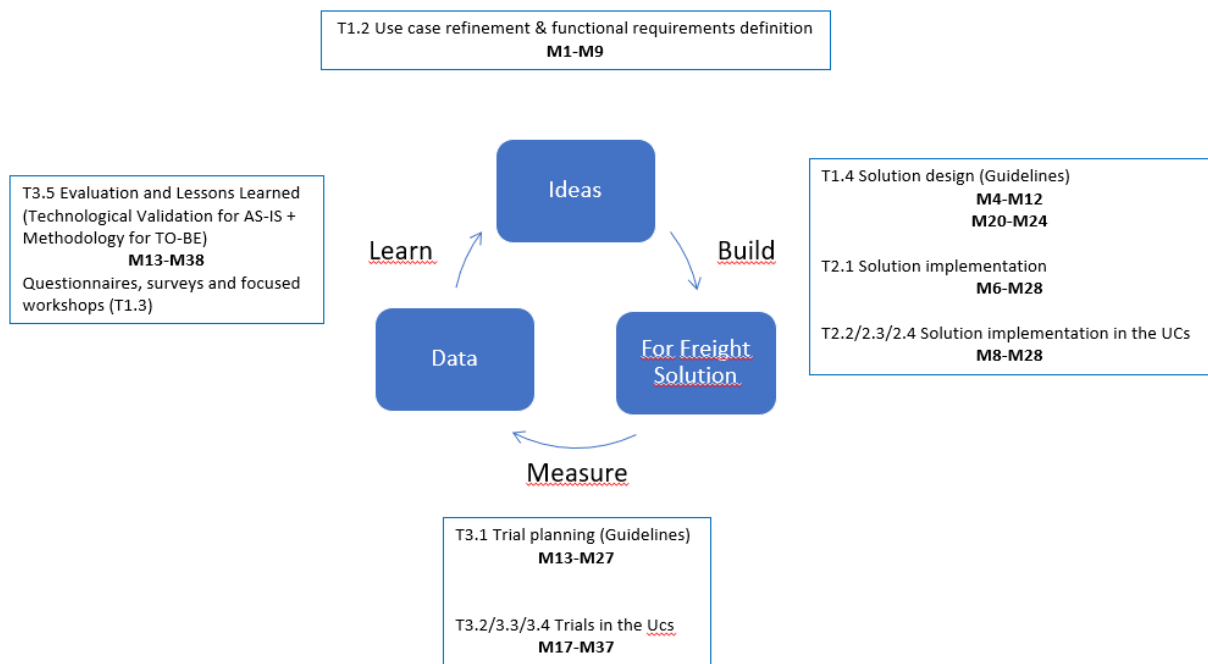


Figure 6.2.1: Scheme of Lean Startup Methodology adapted to FOR-FREIGHT Project.

Applying the Lean Startup methodology to FOR-FREIGHT project, minimum 3 iteratives cycles will be perform in each use cases in order to find the best solution to satisfy the requirements set by business partners in T1.2 and T1.3.

Table 6.2.1: Schedule proposal for Business Validation Methodology of FOR-FREIGHT Project.

Step of Business Validation Methodology	1st Cycle MVP solutions	2nd Cycle MVP solutions	3rd Cycle MVP solutions
Ideas - Design	M1 – M9	M19	M26
Building of the solutions	M12 – 15	M21 – M22	M27 – M28
Measuring/Obtaining data	M17	M24	M30
Evaluation - Learning	M18	M25	M32

6.2.1 Qualitative validation definition

The validation reduces the risk, speeds up the delivery of a value-creating service in the market, and minimizes the costs. The purpose of the qualitative validation of the solutions isn't to come up with a perfect solution but to make sure your idea has potential and a real demand.

For instance, some of the feedback received might not lead to the creation of a successful product. However, this feedback is best used to identify which aspects of the product aren't working and which ones may need to be refined. If you can effectively learn from the results of the product testing, you should be able to develop a product that meets the needs of your target customers.

6.2.1.1 Focused group workshop

As defined in previous section to perform the qualitative evaluation, it is proposed to carry out an internal focused group workshop per cycle directly engaging the stakeholders of the use cases and the horizontal partners such as EBOS, TIC4.0 and ZSI that will assist with the evaluation and validation of the solutions.

There must be 1 focus workshop per use case in each cycle applying lean start up methodology so all the solutions and the central platform functionalities will be presented. The evaluation within the workshops will be done by using a set of questionnaires, surveys...that must be defined covering the whole points specify in 6.2.1.2.

Focused workshops are expected to be performed during third and fourth step of the business validation methodology in each cycle. Planned date periods for the workshops defined in Table 6.2.2.

Table 6.2.2: Planning for date periods for the development of the internal focused workshops proposed.

Internal focused workshops expected dates	1st Cycle MVP solutions	2nd Cycle MVP solutions	3rd Cycle MVP solutions
Month of the project	M17 – M18	M24 – M25	M30 – M32

The structure of workshops should cover the following points:

- Description of the functionalities of the solution/s.
- Reporting of the results obtained by the quantitative evaluation/s.
- Questionnaire/s to be answered by the participants to cover the qualitative validation of the solution/s.

6.2.1.2 Questionnaire format

Questionnaires must be defined to collect the information from the stakeholders and horizontal partners regarding the solution/s (MVP) developed in each iterative cycle. The proposed solution is presented to the customer to learn if it solves the problem and how much the customer is willing to pay for the solution.

Regarding the structure of the questionnaire, it should be separated the sections listed below. Each section should include specific questions that allow to perform the qualitative evaluation of the solution/s, by collecting feedback and key recommendations from users for potential improvements. The sections to follow are:

- Technological section, to evaluate performance from a technical point:
Questions to figure out if the solution/s developed accomplishes each and all the technological requirements set at the beginning of the process, i.e., is the speed of calculations sufficient? Is the visualization of the results relevant? Are the systems' functions well integrated? Can multiple queries be accommodated?
- Environmental section:
Questions to figure out if the solution/s developed accomplishes each and all the environmental requirements set at the beginning of the process.
- Economical section:
Questions to figure out if the solution/s developed accomplishes each and all the economical requirements set at the beginning of the process.
- Business section:
Questions to figure out if the solutions/s is developed improve business processes and efficiency, i.e., is the service usable and feels secured? Are the business segments clearly shown? Are access rights clear for the user? Is user onboarding easy? Do you need a technical person to guide you through? Are you saving time by using the services compared to before?
- Commercialization / Market Analysis section:
Questions related to the complexity of the solution/s: Is the solution easy to implement, does it need new knowledge and skills?
Questions related to compatibility of the solution/s when to be applied by the target customers. Is your idea perceived to be consistent with the needs of potential adopters? How appealing is your idea to the relevant adopter categories?
Questions related to actual advantages: is the idea perceived to outperform competition? How is it perceived to be better? Is it actually better?
Questions related to identify the target market and possible commercialization to share the solution/s after the project.

Each use case leader will be the responsible for the customization of the questionnaire according to specific use case's requirements, including additional questions, then collect and analyze results.

In response to feedback gather by the qualitative validation altogether with the results of the quantitative validation, the solution/s or the target market can be fine-tuned or both and start over a new cycle. The final goal is to test whether the business model is repeatable and scalable. This/These results of the final FOR-FREIGHT solution/s validated and developed could also feed the commercialization analysis.

The business validation process culminates after the solution has been developed and expanded and can be replicated for the testing and implementation meeting all the business requirements set during the process. Despite the challenges inherent in generating new business solutions, such as its possible failure, its associated benefits are exponentially greater often culminating in the creation of a new business.

6.3 Commercialization Analysis

The market launch is the main test of the solution success. Consumer feedback, as well as the performance of the solution, will allow any company to adjust the innovation strategy in a targeted way, based on the data

collected. Collecting these data is crucial because it allows obtaining the real opinions and reactions of sample of the potential market.

In the D4.2, the use case business framework focuses on commercialization plans for each use case. SWOT analyses identify strengths, weaknesses, opportunities, and threats. Customer problems and value propositions highlight the unique benefits of FOR-FREIGHT's solutions. Initial commercial opportunities are assessed, and business model canvases present the operational and financial aspects.

The exploitable results section details stakeholders, target groups, and competition in each market. Market analysis and go-to-market strategy methodology provide a general framework for the project's commercialization. Feasibility analysis evaluates the viability of the solutions. Opportunity analysis and licensing potential explore potential licensing avenues. Finally, a financial analysis template offers financial insights for decision-making.

Overall, the FOR-FREIGHT business plan envisions a comprehensive commercialization approach to address the logistics industry's challenges, improve efficiency, and drive sustainable practices. With tailored strategies for different markets, the project aims to revolutionize freight management and contribute to economic and environmental advancements in the transportation sector.

Methodology for D4.2:

- Assessing the commercial background of the project
- Questionnaires addressed to all the partners in the project in order to develop a commercial SOTA and set the market context
- Commercialization plans for each use case
- Feasibility study
- Market opportunity and licensing potential

T4.1 interacts closely with T1.1 and T1.2, in order to contribute to the co-design process of the FOR-FREIGHT solutions with the findings of the market analysis study and the insights/inputs received by external stakeholders (from the partner-network of the project partners), thus ensuring that the FOR-FREIGHT solutions will be address commonly and widely agreed multimodal transport challenges. The findings in T1.1 and T1.2 together with the market opportunity analysis and feasibility study developed in T4.2 will set a base for T1.3 and T1.4 in terms of commercial opportunities and needs addressed by the FOR-FREIGHT solutions.

7 Risk Assessment

FOR-FREIGHT project requires a risk assessment process to identify, content and monitor risks that may occur during the project life span. [4] is the international reference standard that provides the management process to identify, prevent and manage all impending risks. Figure 7.6.3.1 shows the risk management process to follow in the context of this reference.

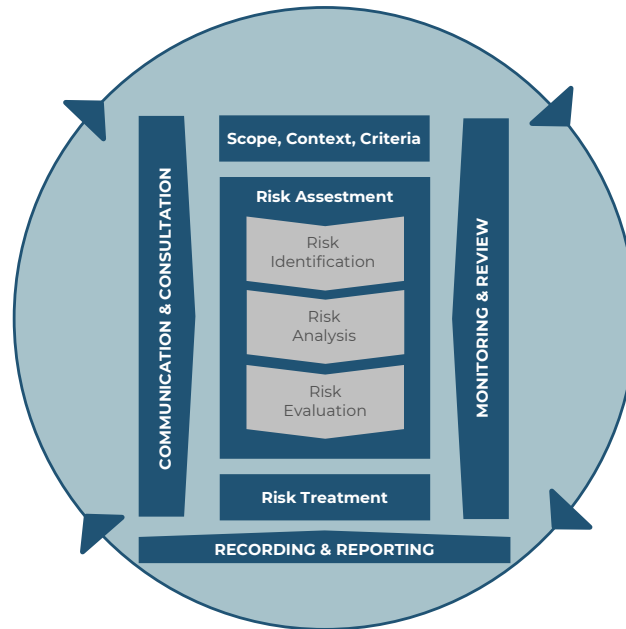


Figure 7.6.3.1: Risk Management Process

The risk management process should be an integral part of management and decision-making and integrated into the structure, operations and processes of the organisation. It can be applied at strategic, operational, programme or project levels.

In order to make sure that the use case testing and validation as well as the solution design and development are going to take place as expected, main risks have been identified, evaluated and analysed and relevant mitigation actions have been provided.

7.1 Risk identification and analysis

In order to be in line with the risk methodology defined in D6.1 for the FOR-FREIGHT project, the identification and analysis of risks in each use case will be done using the table shown in the figure below.

Extracted from D6.1, figure below, shows the relationship between the possibility of a risk happening and the estimated effect on the project in a quick and easy way to spot critical risks vs less critical ones. Thus, from its use actions are diverted to the risks that matter. Risks can be classified as quantity-based or quality-based depending on the nature of the risk involved. In the case of quality-based risks, evaluation is based on accepted and agreed quality criteria in terms of project objectives and quality targets set.

Risks which fall under the Likely - almost - certain likelihood and critical impact zones are the ones to closely monitor and of course of higher priority than the rest.

		Likelihood				
		Rare (<5%)	Unlikely (5-25%)	Possible (25-50%)	Likely (50-75%)	Almost certain (>75%)
Consequence - Impact	Catastrophic - Critical	High	High	High	Extreme	Extreme
	Major	Moderate	Moderate	High	High	Extreme
	Moderate	Low	Moderate	Moderate	High	High
	Minor	Low	Low	Moderate	Moderate	High
	Insignificant	Low	Low	Low	Moderate	Moderate

Figure 7.1.1: Risk Analysis

Following the above analysis, the evaluation will decide based on the nature of the risks (likelihood and impact) the level and frequency of monitoring, who needs to be involved and in which priority. If one classifies above in patterns of actions, then:

- Low Risk (green areas): Standard processes should monitor and manage the risk (review periodically and adjust outputs to cover possible issues)
- Moderate Risk (Yellow area): The risk owner (Task leader or WP leader) will manage the risk as needed and inform project management of actions. Mitigation measures come in force.
- High Risk (Orange areas): Risk owner manages risk, informs in writing the project team and the coordinator and escalates to the committee. Mitigation measures come in force; Contingency plan (if any) is also activated.
- Extreme risk (Red areas): Project management and Committee escalates to Project Officer level if policy dictates same. Contingency measures applied and further consultation takes place.

7.2 Mitigation actions

The measures are preventive i.e., they are designed to reduce the impact of a risk or even remove completely. Decision lies with the effort and resources required but of course primary criteria remain the impact that a risk possesses on the project’s outcomes. Possible decisions for measures are shown below:

- No-action risk: Possibility to happen and impact is low, no immediate action is taken apart from designing the corrective action. Nevertheless, the risk remains in radar and frequently reviewed. If action is necessary, action is taken.
- Avoid risk: An example would be not to develop a certain product which imposes a risky feature but remain within the project scope.
- Risk protection: Impact and likelihood are moderate to high therefore all actions aiming to minimize impact or remove risk altogether. Decision based on needed effort/ cost and whether benefit for risk protection outbalances the cost.

7.3 Solution design/development general risk assessment

Risk assessment on the solution design and development of the general platform of FOR-FREIGHT and the corresponding UC's solvers has been performed and collected in the Table 7.3.1 following the risk methodology defined above.

Table 7.3.1: Risk analysis on the solution design and development of the general platform of FOR-FREIGHT and the corresponding UC's solvers

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi -Mo-Ma-Cr)	Risk	Risk-Mitigation measures
Proposed solvers are redundant, unrealistic, or do not meet UC's needs or expectation	P	Ma	High	Thoroughly study D1.2, have system designed reviewed by UC stakeholders, periodical and per-request feedback request on functionalities.
Cost overruns: The platform development effort exceeds project budget	U	Mo	Moderate	Relevance sorting of modules, identification of must-have and nice-to-have solutions.
Lack of historical/real-time data to ensure models' performance and freshness	U	Mo	Moderate	Scope the model in accordance with data possibility, use Simulation to generate part of missing data
Proposed platform brings unequal benefit to involved partners during implementation, resulting in degradation of trust or commitment	U	Mo	Moderate	Platform design must allow UC partners to customize the system towards multivariate benefit objectives, assessment of benefit over time during implementation and via feedback in order to ensure timely adaptation towards harmonized benefit.
Solvers are excessively use case specific and hard to extend or upscale if needed.	P	Mo	Moderate	Ensure generalization and extensibility in model design, exchange/collaboration across use cases for inheritance of overlap features.
Unauthorised access to sensitive logistics data, leading to insufficiency of collected data and as a consequence, inefficiency of built models.	P	Ma	High	Implement strong data encryption, access controls, user authentication, and regular security audits.
Difficulty on integration of different components (legacy	P	Ma	High	Compatibility testing, standardized data formats, clear communication

systems, solvers and third-party applications) due to incompatibility of protocol, data format and deployment environment				channels among stakeholders, robust data governance
Insufficient involvement of key stakeholders, leading to misalignment and poor adoption.	R	Ma	Moderate	Involve stakeholders early and consistently, gather feedback, and ensure their needs are considered throughout the design process.
Political instability, regulatory changes, and environmental factors impacting logistics chains (e.g., war, extreme weather conditions, etc.)	P	Mo	Moderate	Stay informed about geopolitical situations, diversify supply chain sources, and consider environmental sustainability in planning.
Third-party vendors for technology and services delivery disruption, affecting solution’s full-fledge features.	U	Mo	Moderate	Maintain regular and transparent communication with third-party providers

7.3.1 Spanish trial

Risk assessment on the Use Case 1 – Spanish Trial has been performed and collected in the Table 7.3.2 following the risk methodology defined above.

Table 7.3.2: Risk analysis on the Use Case 1 – Spanish Trial

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi -Mo-Ma-Cr)	Risk	Risk-Mitigation measures
Integration of existing translation tool	U	Mi	Low	Development of API
Integration of global and local internal COSCO system	U	Mo	Moderate	Definition of the levels of anonymization and filtering of the data
Integration of data from DHL’s TMS and WMS	U	Mo	Moderate	Definition of the levels of anonymization and filtering of the data. Definition of the time scope and specific areas of historical data to be integrated.

Interaction of DHL's internal systems with FOR-FREIGHT	U	Ma	High	Definition of the levels of anonymization and filtering of the data.
Partners feeding all the required historical data	P	Ma	High	Report the required data for each technology and solver, highlighting its relevance, and draw up a workplan for UC's partners to provide the data. On top of that, regular meetings/ email contact will prevent failure to collect the necessary information.
Not satisfactory interaction and coordination among UC's partners	U	Ma	Moderate	Agile methodology, end-users directly collaborating to the development. Constant flow of emails and meetings
Lack of well-established infrastructures that need to be implemented (i.e., lockers in metro stations, cages for metro wagons, etc)	U	Mi	Low	Define the infrastructure development that is required in early stages. The close interaction with MDM/DHL will reduce this risk
Requirements in terms of components and devices	U	Mo	Moderate	Define the needs of each scenario. Decide what are the best available solutions/components/technologies matching those specific needs.
Mismatches in achieving the objectives initially set out in the KPIs	P	Mi	Moderate	Regular monitoring, review and feedback to identify potential misalignments of the KPIs

7.3.2 Romanian trial

Risk assessment on the Use Case 2 – Romanian Trial has been performed and collected in the Table 7.3.3 following the risk methodology defined above.

Table 7.3.3: Risk analysis on the Use Case 2 – Romanian Trial

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi-Mo-Ma-Cr)	Risk	Risk-Mitigation measures
Lack of communication between different operators, local authorities and between authorities and operators.	U	Mi	Low	Regular meetings, AGILE methodology

Overcrowding of the T&L Chain with the risk of blocking the river ports due to the Ukrainian conflict	P	Ma	High	Functional maintenance of the port activity
Lack of implementation infrastructure	U	Mi	Low	Ensuring E2E coverage of internet services
Change of consortium partners	P	I	Low	Backup solution for replacement
The migration of the population from the conflict zone and the blocking of port activities	U	Mo	Moderate	Involvement of local authorities
Adaptation of the infrastructure to the new volumes of operations	P	Mi	Moderate	Government investments in infrastructure

7.3.3 Greek trial

Risk assessment on the Use Case 3 – Greek Trial has been performed and collected in the Table 7.3.4 following the risk methodology defined above.

Table 7.3.4: Risk analysis on the Use Case 3 – Greek Trial

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi-Mo-Ma-Cr)	Risk	Risk-Mitigation measures
A single platform module does not achieve the expected TRL.	U	Mo	Moderate	Preliminary testing will be conducted (either physically or virtually) during each development step/version of each individually developed component to ensure its functionality.
Integration among systems (e.g., HPCS, Goldfreight, AODB) that belong to different stakeholders (COEL, GOLD, AIA) may be hindered as certain interfaces may not be accessed due to authorization conflicts or complexity.	L	Mi	Moderate	The close interaction between WP2 & WP3 will reduce the probability of this risk. Moreover, potential authorization restrictions may be tackled by the implementation of synthetic interfaces/emulated systems.

<p>Expected KPIs' improvements are not adequately achieved during the trial phase</p>	<p>U</p>	<p>Mi</p>	<p>Low</p>	<p>Periodical meetings/calls between stakeholders will be conducted during the entire flow of the project. Any problems will probably be detected & addressed in early stages or at least in a timely manner.</p>
<p>Snowball effects in case of delays due to unforeseen factors (e.g., potential Covid-19 re-outbreak)</p>	<p>U</p>	<p>Mo</p>	<p>Moderate</p>	<p>All partners have experienced the recent pandemic, and some of them were working in relevant R&D projects during that period. There is recent experience on how to handle critical issues on such projects via teleworking, thus minimizing the impact of the risk.</p>

8 Conclusions

The results of D1.3 are closely linked and will serve as inputs for Tasks 1.4 and 3.5 as well as to subsequent FOR-FREIGHT Work Packages.

This deliverable has first presented an overview of the architecture of the central FOR-FREIGHT platform identifying the functionalities that should be covered in accordance with the requirements identified by the three trial sites. The system entails a wide range of technical solutions, from IoT, AI/ML to Big Data Management, for tackling the challenges identified in three use cases (Spanish, Greek, and Romanian).

The architecture has been defined at a high level in this deliverable and it will be developed during the project and the final version will be published in D1.4. In this deliverable an initial version of the components and subsystems of the platform drafting the possible solutions/solvers for each UC and the potential developers which will still be discussed in Task 1.4 and WP2 have been defined. Also, it is included a brief description of the dashboard which contains front-end components of the platform providing GUIs, APIs or features to support user-adapted needs and the proposed developers. In this deliverable it has also been drafted the proposal of integrating points to break the gaps and bridge the diverse components within the platform, towards a fully integrated architecture.

The deliverable has then presented both technological and business validation methodologies to evaluate both FOR-FREIGHT solutions and use case results.

Regarding the technological validation methodology, an excel file common tool for T1.2, T1.3 and T3.5 has been defined in order to organize data collection and KPI calculation for both baseline and ex-post situation. Per each use case, KPI baseline has been provided in order to measure the actual situation of logistics processes involved. Data to be collected from each logistics nodes, systems and sensors involved in each use case has been identified in order to feed the FOR-FREIGHT solutions and allow the calculation of KPIs.

Regarding the business validation of the solutions, this evaluation is based on measurements resulting from the solutions implementation and obtaining feedback from the 'initial customers' in the proposed workshops using questionnaires that will feed the solution design (T1.4 and T2.1-T2.5) in an iterative process (M20-M36 of the project) to enable refinements, improvements, and optimization aspects. This methodology could also help to provide insights for commercialization (WP4). The result of the application of the Lean Startup methodology is that the market dictates the product rather than the other way around.

Finally, to make sure that the use case testing and validation as well as the solution design and development are going to take place as expected, main risks have been identified, evaluated, and analysed and relevant mitigation actions have been proposed.

This report will be the base for building D1.4 "FOR-FREIGHT system architecture & technology specifications (Revised version)" to be submitted by month 24 of the project and also sets the base of the holistic evaluation framework that has been developed together with T1.2 and T3.5 "Evaluation, lessons learned and best practices" for defining and validating results with corresponding KPIs (before-after) and generating insights per testing case and utilized multimodal solution.

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Annex I: FOR-FREIGHT Use Cases' Data Collection details per each UC and KPI.

KPI ID	KPI description (Column G in KPI Contribution tab)	Data Description	Data Origin/Source	Data Format	Data owner	Frecuency of collection	Confidentiality	Technology (ies)feeded by	Use case's involved
ES1/1_1	Current on-time delivery ranges	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Delivery Order Rail	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Rail Terminal	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into the depot of the empty container	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
		Estimation on train and truck costs	CSLS	XML	CSLS	Once	Private		
ES1/1_2	Errors, accidents	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Rail Terminal	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into the depot of the empty container	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		

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ES1/1_3	Time to set-up an end-to-end multimodal freight transport with multiple stakeholders: time since we receive the transport request from customer and we arrange the transport to be carried out.	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
		Estimation on train and truck costs	CSLS	XML	CSLS	Once	Private		
ES1/1_4	Delivery lead time in inland transport: time since we receive the transport request from customer to arrival at final destination, this also includes the transit time	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Delivery Order Rail	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Rail Terminal	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into the depot of the empty container	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
		Estimation on train and truck costs	CSLS	XML	CSLS	Once	Private		

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ES1/1_5	Trucks' waiting time at the Terminals	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
ES1/1_6	Loading time in the terminals	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		

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ES1/1_7	ITU/container dwell time in port	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Delivery Order Rail	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
ES1/1_8	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck or train+truck	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	ML/AI Digital Twins	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Delivery Order Rail	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Rail Terminal	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into the depot of the empty container	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
		Estimation on train and truck costs	CSLS	XML	CSLS	Once	Private		

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ES1/1_9	Number of transport orders fulfilled through Blockchain	Discharge List COPRAR	PCS	EDIFACT	FV	Monthly	Private	Blockchain	UC1 Scenario 1
		Discharge Confirmation COARRI	PCS	EDIFACT	FV	Monthly	Private		
		Release confirmation of the Port Terminal	PCS	XML	FV	Monthly	Private		
		Transport Order Request	CSLS internal system	E-mail	CSLS	Monthly	Private		
		Delivery Order Truck	PCS	XML	FV	Monthly	Private		
		Delivery Order Rail	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into Rail Terminal	PCS	XML	FV	Monthly	Private		
		Release confirmation of the Rail Terminal	PCS	XML	FV	Monthly	Private		
		Acceptance Confirmation into the depot of the empty container	PCS	XML	FV	Monthly	Private		
		Shipment data: Data of import containers arriving to Valencia	CSLS internal system	XML	CSLS	Monthly	Private		
		Vessel schedules: Data on ETA/ETD of vessels	CSLS internal system	XML	CSLS	Monthly	Private		
		Train schedules: Data on ETA/ETD of trains	CSLS	XML	CSLS	Once	Private		
		Estimation on train and truck costs	CSLS	XML	CSLS	Once	Private		

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KPI ID	KPI description (Column G in KPI Contribution tab)	Data Description	Data Origin/Source	Data Format	Data owner	Frecuency of collection	Confidentiality	Technology (ies) fedded by	Use case's involved
ES1/2_1	Current operational cost	Loading and route plan	DHL (TMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Load capacity per train and available timetables	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of trains available for delivery	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of packages transported per station	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
ES1/2_2	Missed deliveries	Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML DT	UC1 Scenario 2
		Parcel label scanning checkpoints info: 1)arrival at DHL warehouse, 2) roller cages loading with parcels, 3) parcel ungrouping at MDM station for lockers placement	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML DT IoT 5G	
		Real-time tracking data from sensors in roller cages	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML DT IoT 5G	
		Delivery confirmation (customer picking up parcel from MDM lock)	DHL MDM	XML	MDM	Real-time	Private	AI/ML DT IoT 5G	
ES1/2_3	Number of vehicles required last for mile delivery with ave	Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel label scanning checkpoints info: 1)arrival at DHL warehouse, 2) roller cages loading with parcels	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML IoT DT 5G	
		Number of vehicles in circulation	DHL	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Load capacity per train and available timetables	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of trains available for delivery	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	

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ES1/2_3	Number of vehicles required last for mile delivery with average	Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML IoT DT 5G	
		Number of vehicles in circulation	DHL	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Load capacity per train and available timetables	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of trains available for delivery	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
ES1/2_4	GHG emissions	Loading and route plan	DHL (TMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Load capacity per train and available timetables	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of trains available for delivery	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of packages transported per station	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML IoT DT 5G	
Number of vehicles in circulation	DHL	XML	DHL	Real-time	Private	AI/ML IoT DT 5G			
ES1/2_5	Average loading/unloading time per parcel	Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel label scanning checkpoints info: 2) roller cages loading with parcels. This provides the exact time when parcel is taken from storage space into rolling cage.	DHL MDM	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Real-time tracking data from sensors in roller cages. This will provide exact time of vehicle leaving DHL warehouse with the full rolling cages.	DHL MDM	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	

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ES1/2_6	Average urban delivery times for the average number of units (parcels) in 1 vehicle	Real-time tracking data from sensors in roller cages. This will provide the time required to deliver from DHL warehouse to MDM Depot and to final station destination.	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
ES1/2_7	Average number of stops per route carried out by 1 vehicle (van) to deliver an average of 75 parcels	Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel label scanning checkpoints info: 2) roller cages loading with parcels.	DHL MDM	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Real-time tracking data from sensors in roller cages. This will provide the number of stops of the vehicle containing those roller cages in the route from DHL warehouse to MDM Depot	DHL MDM	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Loading and route plan	DHL (TMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
ES1/2_8	Average delivery loading per van	Loading and route plan	DHL (TMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	UC1 Scenario 2
		Parcel Label info	DHL (WMS)	XML	DHL	Real-time	Private	AI/ML IoT DT 5G	
		Load capacity per train and available timetables	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Number of trains available for delivery	MDM	XML	MDM	Daily	Private	AI/ML IoT DT 5G	
		Parcel label scanning checkpoints info: 1) arrival at DHL warehouse, 2) roller cages loading with parcels, 3) roller cages loaded into the vehicle	DHL MDM	XML	DHL MDM	Real-time	Private	AI/ML IoT DT 5G	

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KPI ID	KPI description (Column G in KPI Contribution tab)	Data Description	Data Origin/Source	Data Format	Data owner	Frecuency of collection	Confidentiality	Technology (ies) fedded by	Use case's involved
GR2_1	Container idle time at port	Vessel arrival notice	PCT	email	COEL	Real-time	Private	5G, AI, (Big) Data Processing	UC2
			COSCO ERP	XML					
			COSCO ERP	SQL, .NET and EDI					
			COEL	email					
		Cargo departure	OBU	JSON, XML, CSV	WINGS				
			PCT	XML	COEL				
GR2_2	Container idle time at the airport	Truck arrival notice	OBU	JSON, XML, CSV	WINGS/AIA	Real-time	Private	5G, AI, (Big) Data Processing	UC2
			Truck driver						
		Import warehouse	GOLD	XML,Cargo Iq,EDI, email,telex					
		TBD with GOLD (System estimating the waiting time of the trucks in the (un)loading warehouse points)	GOLD, GoldFreight, AIA,WINGS	XML,Cargo Iq,EDI, email,telex					
GR2_3	Truck waiting time at terminal	Truck arrival notice	OBU	JSON, XML, CSV	WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2
		Cargo departure time	OBU	JSON, XML, CSV	WINGS	Real-time	Private		
			PCT	XML	COEL	Real-time	Private		
		Truck arrival notice @ the warehouse	OBU	JSON, XML, CSV	WINGS	Real-time	Private		
		import WMS	OBU,Truck company, COEL(PCT, HPCS), GOLD,GoldFreight	XML,Cargo Iq,EDI, email,telex	WINGS,AIA,COEL(PCT)	Real-time	Private		
GR2_4	Customs clearance process time	Customs' clearence order	Customer,COEL(HCPS,ICISnet)	XML,email	OEL(PCT) ,Customs Authoritie	Real-time	Private	Legacy systems integration	UC2
		Customs' clearance notice							
GR2_5	Truck transportation time ex. port to airport	Cargo departure time	OBU,PCT	JSON, XML, CSV	WINGS,COEL	Real-time	Private	5G, AI, (Big) Data Processing	UC2
		Truck arrival notice @ the warehouse	OBU	JSON, XML, CSV	WINGS				
GR2_6	Current cargo handling capacity at the airport hub	Cargo storage	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2
GR2_7	Mishandling errors	Cargo handling	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2
GR2_8	Errors, accidents and errors that caused delays (not mishandling)	Cargo processing	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2

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KPI ID	KPI description (Column G in KPI Contribution tab)	Data Description	Data Origin/Source	Data Format	Data owner	Frecuency of collection	Confidentiality	Technology (ies) fedded by	Use case's involved
GR2_1	Container idle time at port	Vessel arrival notice	PCT	email	COEL	Real-time	Private	5G, AI, (Big) Data Processing	UC2
			COSCO ERP	XML					
			COSCO ERP	SQL, .NET and EDI					
			COEL	email					
		Cargo departure	OBU	JSON, XML, CSV	WINGS				
			PCT	XML	COEL				
GR2_2	Container idle time at the airport	Truck arrival notice	OBU	JSON, XML, CSV	WINGS/AIA	Real-time	Private	5G, AI, (Big) Data Processing	UC2
			Truck driver						
		Import warehouse	GOLD	XML,Cargo Iq,EDI, email,telex					
		TBD with GOLD (System estimating the waiting time of the trucks in the (un)loading warehouse points)	GOLD, GoldFreight, AIA,WINGS	XML,Cargo Iq,EDI, email,telex					
GR2_3	Truck waiting time at terminal	Truck arrival notice	OBU	JSON, XML, CSV	WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2
		Cargo departure time	OBU	JSON, XML, CSV	WINGS	Real-time	Private	5G, AI, (Big) Data Processing	
			PCT	XML	COEL	Real-time	Private	5G, AI, (Big) Data Processing	
		Truck arrival notice @ the warehouse	OBU	JSON, XML, CSV	WINGS	Real-time	Private	5G, AI, (Big) Data Processing	
		import WMS	OBU,Truck company, COEL(PCT, HPCS), GOLD,GoldFreight	XML,Cargo Iq,EDI, email,telex	WINGS,AIA,COEL(PCT)	Real-time	Private	5G, AI, (Big) Data Processing	
GR2_4	Customs clearance process time	Customs' clearance order	Customer,COEL(HCPS,ICISnet)	XML,email	OEL(PCT) ,Customs Authorities	Real-time	Private	Legacy systems integration	UC2
		Customs' clearance notice							
GR2_5	Truck transportation time ex. port to airport	Cargo departure time	OBU,PCT	JSON, XML, CSV	WINGS,COEL	Real-time	Private	5G, AI, (Big) Data Processing	UC2
		Truck arrival notice @ the warehouse	OBU	JSON, XML, CSV	WINGS				
GR2_6	Current cargo handling capacity at the airport hub	Cargo storage	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2
GR2_7	Mishandling errors	Cargo handling	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private		UC2
GR2_8	Errors, accidents and errors that caused delays (not mishandling)	Cargo processing	GOLD internal system, WINGS	XML	GOLD,WINGS	Real-time	Private	5G, AI, (Big) Data Processing	UC2

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KPI ID	KPI description (Column G in KPI Contribution tab)	Data Description	Data Origin/Source	Data Format	Data owner	Frecuency of collection	Confidentiality	Technology (ies)feeded by	Use case's involved
RO1	Improve existing capacity utilisation	When the goods leave for the port of Galati, notifications about the volume of the goods and their destination are sent between DSS to port authorities, logistics operators, customs agencies, and railway operators, so that the transfer of the goods can be scheduled according to the ETA. Also, by using the For- Freight platform the port and railway management will be more efficient.	Inland Shipping	XML	Inland Shipping	Real-time	Private	Digital Twin Blockchain IoT 5G AI/ML	UC3
RO2	Loading /unloading time in the terminals	Inland Shipping ensures the loading/unloading operations of the containers	Inland Shipping	XML	Inland Shipping	Real-time	Private	IoT AI/ML	UC3
RO3	Errors, accidents and error caused	The possibility of receiving notification from the DSS regarding the available storage spaces and resources will decrease the waiting time and will contribute to defining the appropriate route for transshipment.	Inland Shipping, ATG	XML	Galati Port	Real-time	Private	Digital Twin Blockchain IoT 5G AI/ML	UC3
RO4		The operations of loading/unloading, storage and the relationship with the customs authorities for receiving all the necessary documents and approvals are coordinated and supervised by the Shipping Agent. Also, the digital solution offered will automate processes that now are manually executed and the number of human accidents will decrease.	Inland Shipping, ATG	XML	Galati Port	Real-time	Private	Digital Twin Blockchain IoT 5G AI/ML	UC3
RO5	Container idle time at the port	Management of empty containers available in the warehouse by using DSS.	Inland Shipping, ATG	XML	Inland Shipping	Real-time	Private	AI/ML	UC3
RO6	ITU Dwell time in port	Reducing time for ship spends at port securing the vessel, discharging or loading cargo, and other activities.	Inland Shipping, ATG	XML	Inland Shipping	Real-time	Private	AI/ML Digital Twin IoT 5G	UC3
RO7	Reduction of fuel quantity	Data collection from air quality measurement stations in the Galati port area	Beia	XML	Beia	Real-time	Private	Digital Twin Blockchain IoT 5G AI/ML	UC3
RO8	Changes in energy sources	Data collection from air quality measurement stations in the Galati port area	Beia	XML	Beia	Real-time	Private	IoT, 5G	UC3
RO9	Changes in the F-gases used as refrigerant	Data collection from air quality measurement stations in the Galati port area	Beia	XML	Beia	Real-time	Private	IoT, 5G	UC3
RO10	Communication infrastructure between Port authorities and operators and railways authorities and operators	Connecting the communication infrastructure between Inland Shipping, port authorities, logistics operators, customs agencies and railway operators	Beia	XML	Beia	Real-time	Private	5G	UC3