Flexible, multi-mOdal and Robust FREIGHt Transport

D1.2 FOR-FREIGHT multimodal transport Use Case Definition

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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
ACCC	Airport Cargo Community Committee
AI	Artificial Intelligence
AIA	ATHENS INTERNATIONAL AIRPORT S.A.
AODB	Airport Operational Database
API	Application Programming Interfaces
ATG	ASOCIATIA TEHNOPOL – GALATI
BAPLIE	Bay Plan Including Empties message
BEIA	BEIA CONSULT INTERNATIONAL SRL
BMS	Building Management Systems
CERTH	CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
COARRI	Container discharge/loading report message
COEL	COSCO SHIPPING LINES (GREECE)ANONYMI ETAIREIA
COPRAR	Container Pre-Arrival message
CPS	Cyber-Physical Systems
CSLS	COSCO SHIPPING LINES SPAIN SA
D	Deliverable
DHL	DHL EXEL SUPPLY CHAIN SPAIN SL
DSS	Decision Support System

DUT	Unified Transport Document
EBOS	EBOS TECHNOLOGIES LIMITED
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EI	Expected impact
EO	Expected outcome
EU	European Union
euRIS	European River Information Services
FR	Functional Requirement
FVP	FUNDACIÓN DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCIÓN Y ESTUDIOS COMERCIALES DE VALENCIAPORT
GA	Grant Agreement
GHG	Greenhouse Gas
GOLD	GOLDAIR EXYPIRETISEIS EDAFOUS ANONIMI ETAIREIA
IATA	International Air Transport Association
ICT	Information and Communication Technology
IMEC	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM
IoT	Internet of Things
ITS	Intelligent Transport Systems
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
MDM	METRO DE MADRID SA
ML	Machine Learning
NAVR	COMPANIA DE NAVIGATIE FLUVIALA ROMANA NAVROM SA
OBUs	Onboard Units
PCS	Port Community System
PCT	Piraeus Container Terminal
RORIS	Romanian River Information Services
RTSP	Real Time Streaming Protocol
SCADA	Supervisory Control And ata Acquisition
SFTP	Secure File Transfer Protocol
SotA	State-of-the-Art
SQL	Structured Query Language
T	Task
T&L	Transport and Logistics

TCCFR	TELECOMUNICATII CFR SA
TEN-T	Trans-European Transport Network
TMS	Transport Management System
TOS	Terminal Operating System
TRL	Technological Readiness Level
UC	Use Case
UI	User Interface
URLLC	Ultra-Reliable Low-Latency Communications
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything
VAT	Value-Added Tax
WINGS	WINGS ICT SOLUTIONS INFORMATION & COMMUNICATION TECHNOLOGIES IKE
WMS	Warehouse Management System
WP	Work Package
XML	eXtensible Markup Language
XLS	Excel File format
ZSI	ZENTRUM FUR SOZIALE INNOVATION GMBH

1 Executive Summary

The deliverable D1.2 “FOR-FREIGHT multimodal transport Use Case Definition” is the second report of WP1 “SotA analysis, Use Case Definition and Solution Design”. It includes the outcomes of T1.2 “Requirements analysis and Use case refinement”. T1.2 mainly focuses on two tasks:

- Functional requirements definition 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.
- Mapping of those requirements to the specific UC scenarios, translate them into technical requirements and select 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.

D1.2 is structured in 6 main sections. Section 3 describes the methodology followed in the analysis and definition of the UCs and considers the lessons learnt from the analysis performed in T1.1 *Legacy system, SotA and logistics standards analysis*, to establish the necessary link between T1.1 and T1.2. Section 4 focuses on the specific analysis and definition of each of the three UCs (Spain, Greece, Romania), following the methodology defined in Section 3. Section 5 dive into the European and national regulatory framework relevant to the UCs through a Policy Scan and outlines the possible areas of impact of the innovations developed in FOR-FREIGHT.

The analysis and definition of the UCs carried out in the present D1.2 will be the immediate baseline for the work that will be performed in D1.3 and D1.4, which will design 1) the testing and validation methodology of the platform at the trial sites and 2) the architecture and component description of the FOR-FREIGHT system respectively.

2 Introduction

FOR-FREIGHT project aims to maximize the utilization of multimodal freight transport capacity and reduce the average cost of freight transport through the development of novel solutions and their integration with legacy logistics systems. This will enable more effective and sustainable management of goods and freight flows in airports, ports, inland terminals and various logistics nodes, taking into account the requirements of all involved stakeholders, and accounting for economic, environmental and social aspects. The collaboration among the different stakeholders will drive the deployment of three UCs multimodal trial facilities to enable real life trial in operational environments covering heterogeneous multimodal scenarios: seaport logistics and last mile delivery (UC1-Spain), seaport to airport (UC2-Greece) and river-port to rail cargo (UC3-Romania). The goal of this Deliverable D1.2 document is to provide a detailed definition of the FOR-FREIGHT three UCs, based on the Legacy Systems and SotA technologies analyzed in D1.1. The results of this deliverable are closely linked and will serve as inputs for tasks T1.3, 1.4 and T3.5 as well as to subsequent FOR-FREIGHT Work Packages (WPs).

This deliverable is connected with the implementation of the following objectives:

- Objective 1: to the design and development of novel and interoperable T&L solutions that will deliver increased T&L node operational capacity and increased efficiency and sustainability of multimodal and transhipment T&L services in multi-stakeholder environments, with reduced freight transport costs and reduced environmental footprint.
- Objective 2: To build and deliver three state-of-the-art T&L experimentation facilities based on real operational multi-stakeholder environments supporting multimodal & transhipment ITU logistics, recapitalizing on, and expanding/upgrading existing infrastructure and legacy systems from consortium partners and previous EU funded projects, capable to support collaborative / cooperative logistics operations with a high degree of automation.
- Objective 5: To ensure compatibility with existing and emerging EU logistics standards as well as promote and contribute to the standardisation of multimodal, multi-stakeholder end-to-end freight management solutions and to ensure compatibility with existing EU/global standards, while advancing and supporting a T&L cantered ecosystem bringing together key stakeholders (port/airport/rail/road operators), and to maximise the project´s impact through wide dissemination, communication, clustering and exploitation activities.

Through the output produced, D1.2 will deliver the baseline upon which the development of interoperable multimodal and multi-stakeholder T&L solutions will be designed (Objective 1) and delivered in the 3 UCs T&L facilities (Objective 2), proving compatibility with existing EU logistics standards and bringing together key stakeholders (Objective 5).

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: 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			
D1.2 FOR-FREIGHT multimodal transport Use Case definition	Report containing the requirements analysis results of the internal FOR-FREIGHT use cases and their detailed definition. It is the output of Task 1.2.	Chapter 3	Chapter 3 describes the Methodology followed in the UCs analysis and definition. It also analyses the connection of D1.2 with T1.1.
		Chapter 4	Chapter 4 defines in detail each of the three UCs following the methodology explained in Chapter 3. It considers the refinement, preparatory activities, business scenario, challenges and implementation plan.
		Chapter 5	Chapter 5 analyses the societal and environmental impact through Policy scan and Impact scan.
TASKS			
Task 1.2 Requirements analysis and Use case refinement	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	Chapter 3	Analysis of Legacy Systems and SotA technologies, based on D1.1, identifying challenges for integration in FOR-FREIGHT. General common functional requirements are defined according to it.

	with the project end-users. This task will first focus on the functional requirements definition learned from the analysis of the existing practices and management systems currently in place in 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.	Chapter 4	Each of the three UCs are defined in detail. The base is the analysis of SotA technologies and Legacy systems performed in T1.1 combined with the analysis of the AS-IS physical processes and flows of information. Pains, challenges and opportunities found in the AS-IS scenario allow to move forward in the design of the TO-BE scenarios with FOR-FREIGHT implemented in each of the UCs. The functional requirements to reach the TO-BE scenarios are defined accordingly as well as the technologies and components that need to be integrated. KPIs have been carefully refined for each of the UCs and connected to the mid-term expected outcomes (EO) and long-term expected impacts (EI).
		Chapter 5	An analysis of societal and environmental impact and standards has been carried out. This ensures that FOR-FREIGHT platform and all UCs address real world needs, have a societal and environmental impact and are standard compatible.

2.2 Linkage to other project outputs

Table 2-2: Links to other Project Outputs/ Work

WP Number	Task Number	Deliverable Number related	Content
WP1	T1.1 T1.3 T1.4	D1.1 D1.3	The legacy system, state-of- the-art and logistics standards analysis performed in T1.1 is the baseline for the Use Case analysis and definition carried out in T1.2

			According to the project specific goals and KPIs established in T1.2, the methodology for testing and validating FOR-FREIGHT platform technology will be established in T1.3. The design of such platform will be based on the requirements and specifications analysed and established on T1.4.
WP2	T2.1 T2.2 T2.3 T2.4	D2.1 D2.2 D2.3	WP2's main focus is to implement the solutions (SW, HW and integration) designed in WP1 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 T1.2. T2.2 and T2.3 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, based on the refinement of the Use Cases provided by D1.2.
WP3	T3.1 T3.2 T3.3 T3.4 T3.5	D3.1 D3.2 D3.3	WP3 is responsible for the execution of the planned trial in the three UC locations. Based on the analysis and definition performed in T1.2 a detailed planning and set-up will be carried out in T3.1. Each of the trials will Be performed in T3.2, T3.3 and T3.4. T3.5 will evaluate the trial trials results. All WP3 tasks will be based in the analysis and definition performed in T1.2 and contained in the present D1.2.
WP4	T4.1 T4.3	D4.1 D4.2 D4.3 D4.5	FOR-FREIGHT will address commonly and widely agreed multimodal transport challenges. All the pains and challenges described in the present D1.2 that FOR-FREIGHT solution will solve through its functional requirements answer to market and stakeholders needs. The socio-economic and environmental positive impact addressed in T4.3 is also addressed in D1.2 through a policy scan and impact scan on a first approach.

2.3 Deliverable Overview and Report Structure

In this section, a description of the present deliverable's D1.2 structure is provided, outlining each of its chapters and summary of their content.

Chapter 3 explains the methodology followed in the 4 of the deliverable. It defines a top-down approach for the analysis and definition of each of the UCs. It also analyzes the connection with T1.1 that will allow to identifying the specific legacy systems and SotA technologies that will be integrated in each of the UCs to meet the functional requirements defined.

Chapter 4 is divided in thee subchapters, corresponding to each of the UCs. It focuses on the specific analysis and definition, following the methodology defined in Chapter 3. The first step in all cases is the analysis of the AS-IS scenario of the physical and the information flows, followed by the definition of the TO-BE scenario once FOR-FREIGHT is integrated. The functional requirements are identified thanks to that analysis and comparison in connection with the Legacy Systems and SotA technologies that will enable them. KPIs, mid-term expected outcomes (EO) and long-term expected impacts (EI) are carefully connected with all the functional requirements. A first approach to the preparatory activities to enable the start of the UCs, the expected challenges and an implementation plan are also provided.

Chapter 5 provides a Policy Scan and Impact Scan to build an understanding of the framework conditions for a social and sustainable transition in the freight transport sector and how the innovation of FOR-FREIGHT corresponds to that.

3 Methodology

The present Deliverable D1.2 has followed a top-down approach for the analysis and refinement of each of the three UCs involved. The following steps have been followed for the final definition of the UCs:

AS-IS vs TO-BE process flow analysis

The first step has been analyzing the AS-IS situation of each of them in terms of the physical process and information flows to identify where the bottlenecks are, connect them with the pains defined in D1.1 and then, define the TO-BE situation once FOR-FREIGHT is implemented in them. This step has been critical to define in detail the roles of all the actors involved and how FOR-FREIGHT will interact with them and modify the way in which process and communications are currently carried out. Each UC has provided detailed diagrams of both AS-IS and TO-BE scenarios in terms of processes and information flow that can be found in Section 5.

AS-IS vs TO-BE information flow analysis

One core differentiation of FOR-FREIGHT project is not only to achieve the integration of several legacy systems in use by different stakeholders and allow an improved flow of data that nowadays comes in a varied range of formats, but also introduce optimization innovations that will further boost the efficiency of the involved operations. For this reason, once the TO-BE scenarios have been defined, a detailed analysis of all types of data and systems have been carried out.

Identification of Functional Requirements

The comparison between AS-IS and TO-BE scenarios in connection with the data and systems in use, has led to identify 1) both general functional requirements concerning data sharing that are critical for the development of any other functionality and 2) specific UC functionalities. To achieve this, the starting point has been the information regarding legacy systems contained in D1.1, from which each UC partners have provided a detailed update on it and identified the challenges for integration into the FOR-FREIGHT platform.

Selection of Technologies

The next step has been connecting those legacy systems with the SotA technologies defined in D1.1 that will enable their integration and reaching the TO-BE scenarios. Partners providing each of those technologies, their connection with previous projects, availability and TRL have been defined.

In parallel, but fully connected to this process, KPIs have been carefully refined for each of the UCs and connected to the mid-term expected outcomes (EO) and long-term expected impacts (EI). This has 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.

Once the UC had been redefined, preparatory activities have been detailed. These activities are essential to allow the start of the different trials. Activity description, period of execution and stakeholders involved have been set. They have also been categorized as blocking/non-blocking for the further UC development. Implementation of the trial sites has been defined considering preparatory activities as the starting point. Expected challenges are also described as well.

Finally, a general overview of the business scenario of each UC has been provided. This is divided in three stages: quick win solution, early drop solution and final solution.

This full process has been supported by two main tools in the form of excel documents where all partners have provided the requested information: Use Case Refinement tool and Use Case Common tool. The first gathered the base information from D1.1 upon which further detail is provided. The second one is a common tool for T1.2, T1.3 and T3.5. Both can be found in Annex I: Stakeholders´ Templates.

3.1 Connection with T1.1

FOR-FREIGHT project comprises the development of three different Use Cases (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*, to establish the necessary link between T1.1 and T1.2 *Requirement analysis and Use Case refinement* and ensure continuity and coherence within the project development.

3.1.1 Legacy systems

One of the core differentiating innovations of FOR-FREIGHT platform is to effectively integrate existing practices and management systems that are still in use by the different partners and allow the exchange of information among them to improve multimodal transport. Those legacy systems, already presented in D1.1, have been deeply analyzed in the current task in connection with the UCs. The restriction on the data that will be integrated, the challenges for their integration within the FOR-FREIGHT platform and the measures to overcome them have been specified for each of the Legacy Systems involved in Table 3-1.

Table 3-1: Legacy Systems Analysis

Global and local internal COSCO systems	
Partner	CSLS
Use Case	UC1_Spain: Blockchain & Digital Twins to support Decision Making Process in multimodal transport combined with Subway-based network for sustainable last-mile distribution.
To be integrated in the FOR-FREIGTH platform (data or system)	Historical data
Information managed	Shipping operations: inbound shipments arriving to Valencia Port, COPRAR, COARRI, BAPLIES, and DUTs (truck and rail).
Actors involved	Cosco Agency, Customs, Port Terminal, Customer, Truck/Train company, train Operator, etc.
Data format	XLS, EDIFACT, XML
Restrictions on data	COSCO cannot anonymize the data, FOR-FREIGHT platform should be able to anonymise it. Information will only be available for project partners involved in the UC1.
Challenges/barriers for the integration	Interoperability with COSCO internal system cannot be tested. Data anonymization and access restriction should be provided by FOR-FREIGHT.
ValenciaportPCS	
Partner	FVP
Use Case	UC1_Spain: Blockchain & Digital Twins to support Decision Making Process in multimodal transport combined with Subway-based network for sustainable last-mile distribution.
To be integrated in the FOR-FREIGTH platform (data or system)	Historical data
Information managed	Data on port call management, loading and unloading lists, road and rail transport, cargo tracking, cargo declaration, departures and arrivals, cargo booking.
Actors involved	Different members of the Port Community: shipping agent, port authority, customs, rail/road carriers, shipping lines, container terminal, container depot, etc.
Data format	XML, EDIFACT and JSON
Restrictions on data	Information cannot be shared with external parties. Information will only be made available to FVP internal developments within the project.
Challenges/barriers for the integration	Data should be anonymized and access restricted.
EDIFACT/XML to JSON translator	
Partner	FVP

Use Case	UC1_Spain: Blockchain & Digital Twins to support Decision Making Process in multimodal transport combined with Subway-based network for sustainable last-mile distribution.
To be integrated in the FOR-FREIGTH platform (data or system)	System
Information managed	Data sets received from CSLS: - BAPLIES, List of Discharge, Summary Declarations. - Transport Order documents (DUT).
Actors involved	Internal stakeholders: CSLS External stakeholders: customers, depot, port terminal, customs.
Data format	EDIFACT/XML -JSON
Restrictions on data	For internal security reason we cannot test the interoperability with our system. For this reason, we will share with the technical partners data needed for testing the solutions and we can simulate possibility of interoperability, but not real tests. Regarding data and results sharing, this can be done only if all confidential information is anonymized. This anonymization should be provided by FOR-FREIGHT.
Challenges/barriers for the integration	Use/exploitation of the system limited to FVP. An API should be developed for the exchange of information with external stakeholders.
TMS logistics Platform	
Partner	DHL
Use Case	UC1_Spain: Blockchain & Digital Twins to support Decision Making Process in multimodal transport combined with Subway-based network for sustainable last-mile distribution.
To be integrated in the FOR-FREIGTH platform	Historical anonymised data related to terrestrial shipments
Information managed	Shipment requests, transport routes and schedules, shipment status.
Actors involved	Transport agents, customers, DHL internal personnel
Data format	XML
Restrictions on data	Access only under specific access requests.
Challenges/barriers for the integration	Data should be anonymized and access restricted.
WMS Software	
Partner	DHL
Use Case	UC1_Spain: Blockchain & Digital Twins to support Decision Making Process in multimodal transport combined with Subway-based network for sustainable last-mile distribution.
To be integrated in the FOR-FREIGTH platform	Historical data.
Information managed	Warehouse management: receiving, put-away, storage, picking, packing and shipping data
Actors involved	DHL, customers
Data format	XML
Restrictions on data	Access only under specific access requests.
Challenges/barriers for the integration	Data should be anonymized and access restricted.
AODB Software	
Partner	AIA
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	Historical data
Information managed	Flight schedules and real-time updates on arrivals and departures of flights as well as parking positions and aircraft types.
Actors involved	AIA
Data format	XML

Restrictions on data	AODB information is limited for the partners involved in the development of the Greek UC.
Challenges/barrier for the integration	Data should be shared through an intermediate SFTP server or through the development of an API during the project lifetime.
BMS SCADA system	
Partner	AIA
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	Historical data.
Information managed	Access control, security doors, electromechanical equipment and fire control in the airport buildings, cargo areas and the apron of Athens Airport.
Actors involved	AIA
Data format	XML, JSON
Restrictions on data	BMS information is limited for the partners involved in the development of Greek UC.
Challenges/barrier for the integration	Data should be shared through an intermediate SFTP server or through the development of an API during the project lifetime.
The Greek Observatory of Transport and Logistics web application system (OPTIONAL)	
Partner	CERTH
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System
Information managed	Digital services inventory, infrastructure index – map and performance dashboard. Connectivity to the FENIX Federated Network through the integrated FENIX Connector functionality.
Actors involved	Public databases (e.g. EUROSTAT), private databases (e.g. operational data from logistics processes).
Data format	XML, JSON
Restrictions on data	The system will be accessed through a royalty-free basis and will be mainly available for the Greece testbed. It could be extended to cover other sites, if required.
Challenges/barrier for the integration	Data should be shared through REST API connectivity services.
FRETIS Terminal Operating System (OPTIONAL)	
Partner	CERTH
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System
Information managed	Container movements, gate check-in and check-out processes, vessel schedules, equipment utilization, turnover KPI's and various accounting related data.
Actors involved	Manual data information: V2V operators, gate security personnel, shipping agents etc. Automatic data input: Automatic Identification and Data Capture (AIDC) systems such as OCR, LPR, Damage Control and Weigh-in-motion systems.
Data format	XML, JSON, XLS, EDIFACT
Challenges/barriers for integration	The system will be accessed through a royalty-free basis and will be mainly available for the Greece testbed. It could be extended to cover other sites, if required. Deployment, customisation and development of FRETIS software for the UC might require a considerable effort.
Smart Corridors Data exchange & collaboration platform (OPTIONAL)	
Partner	CERTH
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System

Information managed	Supply chain relevant data: container ETA/ETC, loading/unloading status
Actors involved	Port authorities, terminals, rail operators, public authorities, last mile operators, etc.
Data format	JSON, XLS
Challenges/Barriers for integration	The platform is available for use during and potentially after the end of the FOR-FREIGHT project but a new use case for its deployment will have to be identified together with the necessary stakeholders to provide the required input data.
COSCO ERP software	
Partner	COEL
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System
Information managed	Shipment volume and dimensions, Destination and airline company, AWB number, customs status, remark for special cargo (i.e. DG, drugs, special equipment required, > 4T etc.) date/time of truck gate-out from port warehouse to the airport.
Actors involved	COEL
Data format	SQL, .NET and EDIFACT
Challenges/Barriers for integration	The access to this system is limited to COEL users and depending on the business case of any use case in FOR-FREIGHT.
HPCS	
Partner	COEL/GOLD
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System
Information managed	Real-time information about the truck gate-out time from warehouse system to COSCO ERP.
Actors involved	Port of Piraeus stakeholders: Piraeus Container Terminal (PCT), COEL users, port authority, terminals, customers, agencies, custom brokers, forwarders, etc.
Data format	XML
Challenges/barriers for the integration	All data shared should be considered confidential and access restricted to FOR-FREIGHT partners involved in UC2.
ICISnet software	
Partner	COEL
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System
Information managed	Business user information based on the VAT number: Customs´ transaction arrangements for shipment
Actors involved	Customs´ Authority and Customs Brokers, ground handling agents, shippers, consignees, forwarders, etc
Data format	XML
Challenges/barriers for integration	The system has a high degree of complexity. The use of the system in FOR-FREIGHT project will be made according to specific user rights for partners involved in Greece testbed.
GoldFreight WMS software	
Partner	GOLD
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	System

Information managed	Exchange of accounting, shipping and freight status documents like flight manifests, e-AirWaybills, housewaybills, freight status updates, customs declarations, invoicing documents, etc.
Actors involved	Ground Handling Agent (GOLDAIR), Airlines, Forwarders, Customs Authority (as an API)
Data format	XML, Cargo iQ, EDIFACT, email, TELEX, etc.
Challenges/barriers for the integration	This system is not compatible to multimodal transportation. The access to the information stored in this system will be provided on a royalty free basis for partners involved in Greece testbed.
Varied airline systems	
Partner	GOLD
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	Data
Information managed	Exchange of flight manifests, e-AirWaybills, Housewaybills, Freight Status Updates, Customs Declarations, Invoicing documents, accounting information.
Actors involved	Multiple stakeholders in Athens Airport like airlines, ground handling agents, forwarders, etc.
Data format	EDIFACT format, email and telex
Challenges/barriers for integration	These systems are not compatible with multimodal transportation.
Remote OBU-based monitoring and sensing	
Partner	WINGS
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	Vehicle and sensing real-time Data
Information managed	Truck on-board unit (OBU) vehicle and freight-specific sensing information, related to vehicle location, velocity, acceleration, temperature/CO2/light/humidity sensors
Actors involved	Port of Piraeus stakeholders: Piraeus Container Terminal (PCT), COEL users, port authority, terminals, customers, etc.
Data format	JSON formats
Challenges/barriers for integration	N/A
Infrastructure camera-based analytics (optional)	
Partner	WINGS
Use Case	UC2_Greece: Port-to-Airport multimodal freight transport: end-to-end optimization with DSS and real-time monitoring & control capabilities.
To be integrated in the FOR-FREIGTH platform	Infrastructure camera-based video feeds for feeding computer vision components
Information managed	Video streams capturing the GOLD premises and more specifically the truck (un)loading points, towards real-time availability/truck queue monitoring and as a results resource scheduling optimisation
Actors involved	Ground Handling Agent (GOLDAIR), Airlines, Forwarders
Data format	RTP/RTSP/RTMP
Challenges/barriers for integration	Optional feature, which several challenges related to infrastructure security/privacy issues
RORIS software application (option A for Romanian UC)	
Partner	NAVR
Use Case	UC3_Romania: River port to warehouse hub via railway network-Galati Port
To be integrated in the FOR-FREIGTH platform	Historical anonymised data.
Information managed	River transport tracking
Actors involved	Port Authorities, Customs and Border Police involved in Galati Port.

Data format	XLS
Challenges for the integration	Closed circuit system. It will be an advisory platform, which can extend monitoring beyond the T&L chain of the For-freight platform.
EuRIS platform (option B for Romanian UC)	
Partner	Inland shipping company/Agency
Use Case	UC3_Romania: River port to warehouse hub via railway network-Galati Port
To be integrated in the FOR-FREIGTH platform	System
Information managed	Data on real-time traffic image, position information of authorised vessels, notices to skippers, actual water levels, discharges, bridge clearance, water depth, route planning, expected arrival time.
Actors involved	Port Authorities, Customs, shipping company, shipping agency, vessel
Data format	XLS
Challenges for the integration	Effectively integrate and funnel the information provided to the different stakeholders.
IRIS software application	
Partner	TCCFR
Use Case	UC3_Romania
To be integrated in the FOR-FREIGTH platform	System
Information managed	Position of the train
Actors involved	Freight trains on the railway, Signal Command Centre, train stations
Data format	E1
Challenges/barriers for the integration	Obsolete support, hardware and software. Closed circuit system, used only by Romanian Railway Company. No historical data available.

As a result of the above analysis on Legacy systems and the challenges/barriers they may present for the integration in the FOR-FREIGHT platform, three general functional requirements have been defined:

- Data anonymization.
- Data Access restrictions.
- Data Translation.

These three functional requirements identified will be detailed in Section 4 for each of the UCs. The technical components needed to fulfil these requirements will be designed in T4.4. and will allow building and delivering the three UCs based on real operational multi-stakeholder environments and expanding and upgrading existing infrastructure and legacy systems from consortium partners and previous EU funded projects (Objective 2).

3.1.2 SotA technologies

The same procedure as with Legacy Systems has been followed with Technologies stated in D1.1 that will be integrated in the FOR-FREIGHT platform. In Table 3-2 we have identified their owners, the form in which these technologies will be integrated, the information they will manage and the challenges/barriers that we shall overcome for an effective integration.

Table 3-2: SotA Technologies Analysis

IoT	
Owners	CERTH (UC2, UC1), WINGS (UC2), GOLD (UC2), BEIA (UC3)
Use Case	UC1_Spain, UC2_Greece, UC3_Romania
Form upon which will be integrated in the FOR-FREIGTH platform	OBU, monitoring sensors

Information managed	Real-time tracking of the cargo location and status.
Challenges/barriers for the integration	Technology availability, lack of interoperability.
4G/5G/Wi-Fi	
Owners	ABS-ITS platform and C-V2X test network (UC1); AIA, WINGS (UC2); TCCFR (UC3)
Use Case	UC1_Spain, UC2_Greece, UC3_Romania
Form upon which will be integrated in the FOR-FREIGTH platform	Commercial coverage.
Information managed	End-to-end communication and interconnection of the diverse systems participating in the overall operations.
Challenges/barriers for the integration	Technology availability: lack of private 5G networks in certain areas where innovations can be applied.
Cloud and Edge computing	
Owners	WINGS (UC2), CERTH (UC1-UC3 if needed), IMEC (UC1-UC3 if needed)
Use Case	UC1_Spain, UC2_Greece, UC3_Romania
Form upon which will be integrated in the FOR-FREIGTH platform	Commercial coverage.
Information managed	End-to-end communication and interconnection of the diverse systems participating in the overall operations.
Challenges/barriers for the integration	Data availability, lack of interoperability.
AI/ML	
Owners	WINGS (UC2), CERTH (UC1, UC2 if needed), IMEC (UC1, UC2 if needed), FVP (UC1), BEIA (UC3)
Use Case	UC1_Spain, UC2_Greece, UC3_Romania
Form upon which will be integrated in the FOR-FREIGTH platform	DSS for resource optimization and end-to-end multimodal transport planning.
Information managed	Door-to-door tracking, forecast of optimal routing and ETA for the entire process.
Challenges/barriers for the integration	Lack of unified management systems via interfaces. Information stored in disconnected silos as a lack of common interfaces for extracting information.
Big Data and Digital Twins	
Owners	CERTH (UC1, UC2), BEIA (UC3)
Use Case	UC1_Spain, UC2_Greece (optional), UC3 _Romania (optional)
Form upon which will be integrated in the FOR-FREIGTH platform	Data Platform and Digital Twin.
Information managed	Application for DSS. Database for monitoring datasets related with containers.
Challenges/barriers for the integration	Lack of unified management systems via standardized interface. Connectors will have to be developed. Data availability, data will need to be provided by partners into the Digital Twin.
Blockchain	
Owners	CSLS (UC1), FVP (UC1), BEIA (UC3)
Use Case	UC1_Spain, UC3_Romania
Form upon which will be integrated in the FOR-FREIGTH platform	Hyperledger Fabric blockchain platform.
Information managed	Blockchain for time reduction in administrative and operational processes.
Challenges/barriers for the integration	Information to be registered in blockchain is stored in different systems and formats (EDI, XML). There is no API integrated in the system to exchange information with external systems.

The main challenges and barriers for the integration of these technologies are related once again with the lack of interoperability among systems and the formats of the data managed. This is directly connected with the general functional requirement of Data translation, resulting from the Legacy systems analysis, which will allow the information flow among different systems.

The interoperability of systems in most cases will also require the development and integration of APIs. Standardized interfaces will also have to be developed to enable the interconnection of systems. With these two technical requirements fulfilled for each of the technologies, the pains related to information silos, lack of interoperability, limitations of collaboration and lack of unified management systems will be solved.

As a conclusion from the Legacy Systems and SotA Technologies analysis, the following Table 3-3 summarizes FOR-FREIGHT general functional requirements identified and their technical requirements associated that will have to be developed to enable the start of the trials and affect all UCs. Partners responsible of the technical developments have been identified as well.

Table 3-3: FOR-FREIGHT General functional requirements

<table>
<tr><th>Functional requirement</th><th>Technical requirement</th><th>Technical Partner(s) responsible of development</th></tr>
<tr><td rowspan="4">Common system for information management</td><td>Data anonymization</td><td>IMEC</td></tr>
<tr><td>Data access restriction</td><td>IMEC</td></tr>
<tr><td>Data translation</td><td>FVP-IMEC</td></tr>
<tr><td>Development of standardised interfaces.
Development and integration of APIs.</td><td>IMEC</td></tr>
</table>

4 Use Cases definition

4.1 Use Case 1: Valencia-Madrid (ES)

Use Case 1 is based in Spain and combines Sea Port-road (truck/train) and subway (last-mile). Its target is to achieve a DSS for multimodal logistics targeting decision-making process, route optimization and GHG emission reduction through the integration of:

1. Individual management systems and historical data of involved stakeholders.
2. Intelligence provided by technologies such as Digital Twins, AI/ML, Blockchain, 4G/5G, Edge computing, or IoT components.

As a result, end-to-end multi-modal transport planning optimization from port, to central warehouse and to last-mile will be achieved.

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.

Madrid: activities carried out from DHL warehouse to final customer (last-mile distribution) through Metro de Madrid network.

4.1.1 Refinement

4.1.1.1 Process Flow: AS-IS vs TO-BE

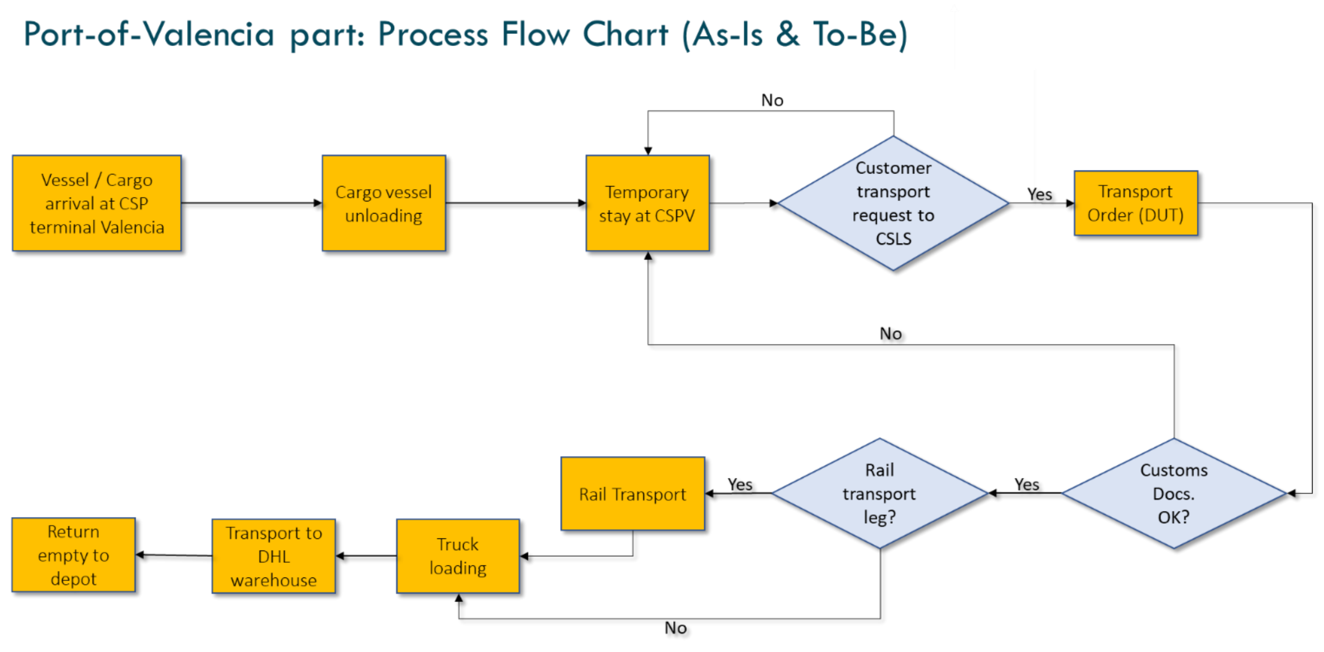

Figure 4-1: Port of Valencia physical process flow

The first step on the Spanish Use Case refinement has been mapping the current process flow and compare it to TO-BE scenario that is expected with FOR-FREIGHT implementation. Spanish trial site will not see changes in the process flow. Particularly in the Valencia Port part, the optimization will be not focused on the process flow, but on improving data visibility therefore optimizing transport planning, by the use of Digital Twins and ML based on AI. The Madrid part comprises the DHL warehouse part where processes will remain the same as they are currently performed when coordinating with last-mile distribution. Last mile comprises Metro de Madrid (MDM) Depot and Stations and it is a totally innovative part of the process that currently does not exist. As described in

D1.1, it replicates existing last-mile urban hubs, but incorporates an innovative mode of transport, MDM trains. Parcels at DHL warehouse will be picked and grouped in roller containers and then transported by the carrier to the MDM Depot. From that point, each roller container will be placed in the train before heading for the first station of their route, without any passengers, where the roller container will be unloaded and the parcels distributed in lockers at the station, from which final customer will pick them up.

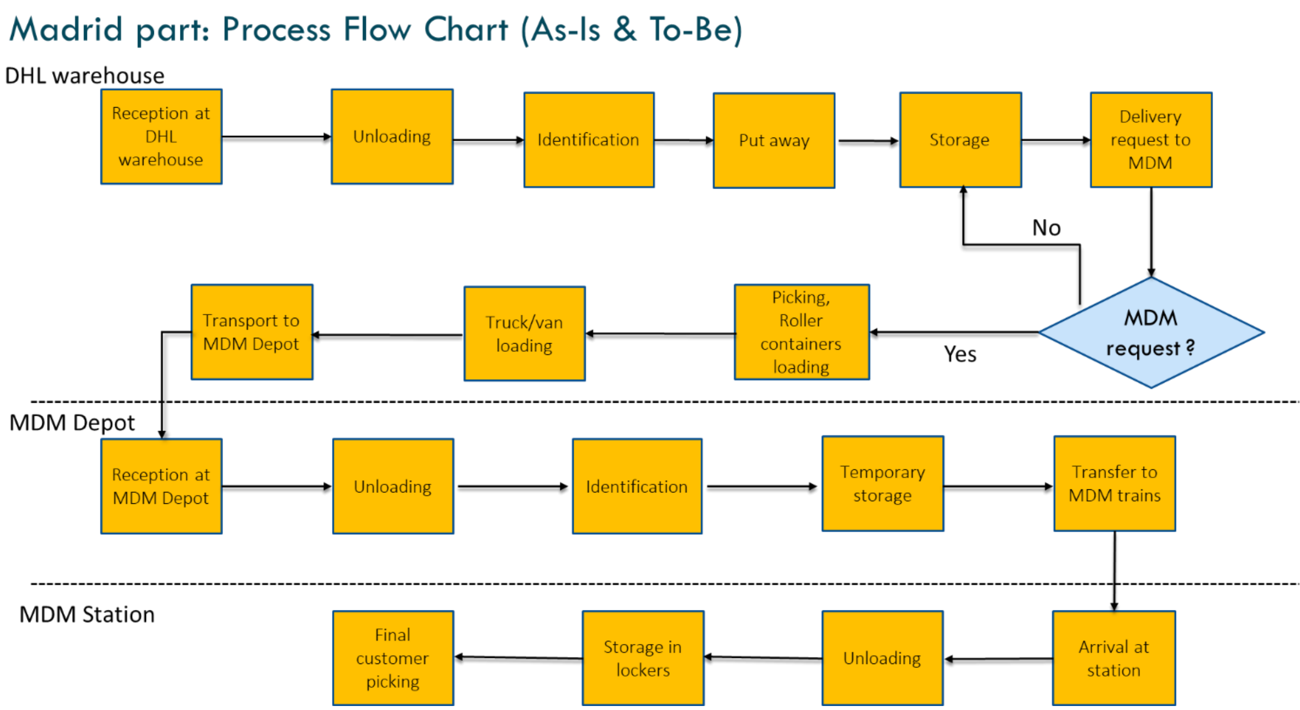

Figure 4-2: Madrid part (DHL warehouse-MDM Depot-MDM Station) physical process flow

With the whole process defined, the pain categories already defined in D1.1 are the target to be solved: information silos across different domains, lack of standardisation in the processes for interoperability, low digitalisation and automation, suboptimal resource planning. This has led to the identification of the main bottlenecks that FOR-FREIGTH implementation will solve: forecast planning (e.g. time to set-up an end-to end multimodal freight transport with multiple stakeholders), time of containers staying at port, orders digitalisation, optimization of transport times, reduction of GHG emissions and operational and external costs. Each of those blockages has been connected with specific KPIs to be achieved during the trials (See Annex II: KPIs and Objectives). KPIs originally defined in the proposal have been analysed, redefined and a quantifiable and measurable baseline value for each of them has been established. Table 4-1 shows this connection.

Table 4-1: Spanish Use Case KPIs

KPI ID	KPI target	KPI description	Baseline description
ES1/1	>15%	Improve forecast planning	Current on-time delivery ranges
			Errors, accidents
			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.

			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
ES2/1	>15%	Reduce container staying at the port	Trucks' waiting time at the Terminals
			Loading /unloading time in the terminals
			ITU/container dwell time in port
ES3/1	>15%	Reduce GHG emissions	GHG emissions (Tonnes of GHG emissions calculated as CO2 equivalents). Route from Valencia Port terminal to DHL Supply Chain warehouse in Madrid by truck
ES4/1	>20%	Transport Orders digitalisation	Number of transport orders fulfilled through Blockchain
ES5/2	>12%	Reduction of Operational Costs	Current operational cost
			Missed deliveries
			Average delivery van loading
ES6/2	>80%	Reduction of External Costs (environmental + social cost)	GHG emissions
ES7/2	>10%	Reduction of transport times from DHL warehouse to final destination	Average loading/unloading time
			Average urban delivery times
			Missed deliveries
			Average number of stops per route
			Average delivery van loading

4.1.1.2 Information flow: AS-IS vs TO-BE

To achieve the KPIs refined in previous section, ensuring the integration of the different methods and information exchange is critical. For that, the first step has been to clearly define the current information flow. Actors involved are:

- External stakeholders (Valencia part): Customer, CSP Logitren, Rail terminal, CSP Rail, carriers/truck/van drivers, final customer.
- Internal project partners (Valencia part): FVP (Port Terminal), CSLS, DHL, MDM.

Table 4-2 shows the information that is currently shared by the different stakeholders, the legacy systems involved and the data format used by each of them are also defined.

Table 4-2: Spanish UC information flow analysis

Stakeholders	Data	Source (from)	Destination (to)	Via (legacy system)	Owner of the data	Format
CSLS FVP Port Terminal	COPRAR /Discharge list	CSLS	Port Terminal	PCS	CSLS	EDIFACT
	Discharge confirmation/ COARRI	Pot Terminal	CSLS	PCS	CSLS	EDIFACT

	Release confirmation of the Port Terminal	PCS	CSLS	-	CSLS	XML
Customer CSLS	Transport order request	Customer	CSLS	E-mail	CSLS	E-mail
CSLS Trucker FVP	Delivery order truck	CSLS	Trucker	PCS	CSLS	XML
CSLS CSP Rail FVP	Delivery order Rail	CSLS	CSP Rail	PCS	CSLS	XML
CSLS Rail Terminal FVP	Acceptance confirmation into Rail Terminal	PCS	CSLS	-	CSLS	XML
CSLS Rail Terminal Trucker FVP	Release Confirmation of the Rail Terminal	PCS	CSLS	-	CSLS	XML
CSLS Depot Trucker FVP	Acceptance Confirmation into the depot of the empty container	PCS	CSLS	-	CSLS	XML
CSLS DHL	Delivery request	CSLS	DHL	E-mail	-	E-mail
	Delivery acceptance	DHL	CSLS	E-mail	-	E-mail
DHL	Label info	DHL	WMS	WMS	DHL	XML
	Storage info	WMS	DHL	WMS	DHL	XML
	Delivery request	DHL	TMS	TMS	DHL	XML
	Loading/ routing plan	TMS	DHL	TMS	DHL	XML
	Loading/ routing plan	DHL	Carrier	E-mail, phone	-	-
DHL Final cusotmer	Delivery request	Customer	DHL	E-mail, phone	-	-
	Acceptance	DHL	customer	E-mail, phone	-	-
DHL carrier	Pick up request	Carrier	DHL	E-mail, phone	-	-
	Pick up acceptance	DHL	Carrier	E-mail, phone	-	-
	Delivery confirmation	Carrier	DHL	AM+ app	DHL	-

Figure 4-3 and Figure 4-4 show graphically the flow of information in the AS-IS and TO-BE scenario for the Valencia part of the Spanish trial site. They consider 2 options respectively: truck and truck+train. These physical flows will remain in the TO-BE scenario.

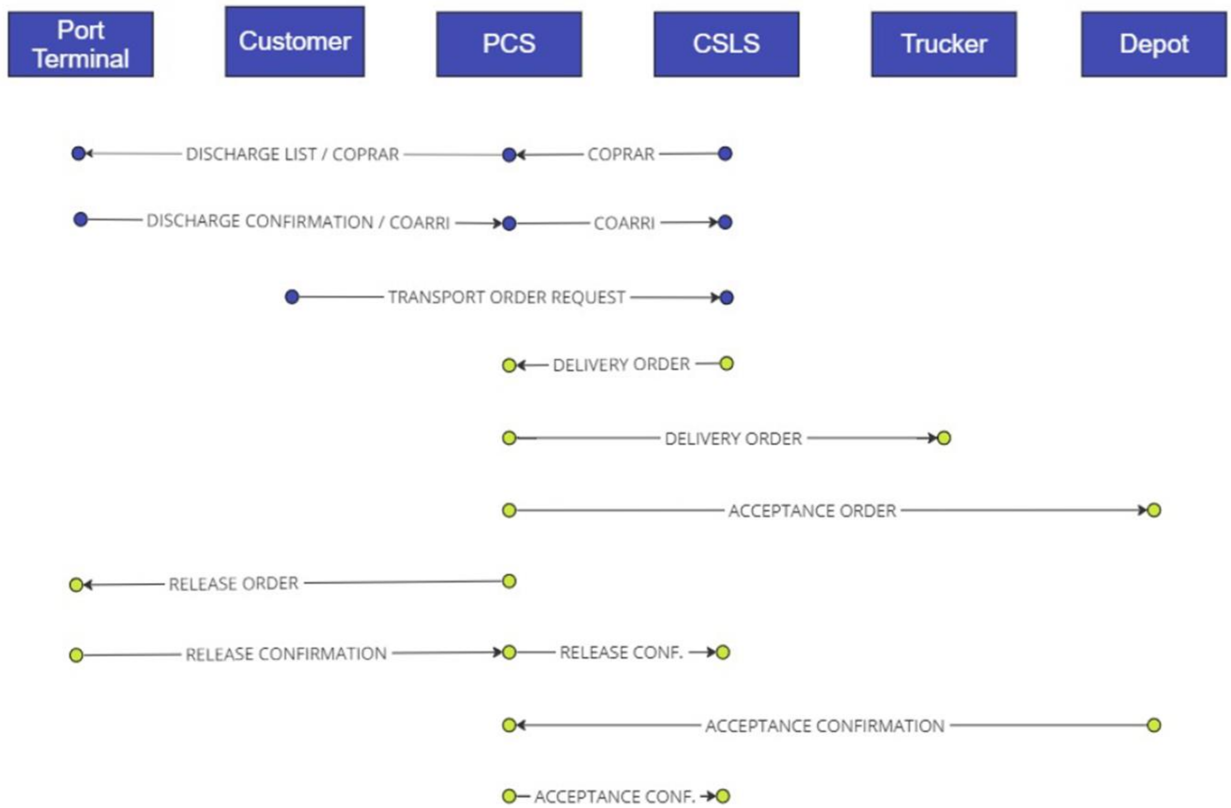

Figure 4-3: Spanish UC information flow of Valencia Port part (only truck scenario)

Figure 4-4: Spanish UC information flow of Valencia Port part (truck+train scenario)

Figure 4-5 and Figure 4-6 show the AS-IS information flow chart for the Madrid part of the Spanish trial site. It does not consider any flow between DHL and MDM as it is currently inexistent.

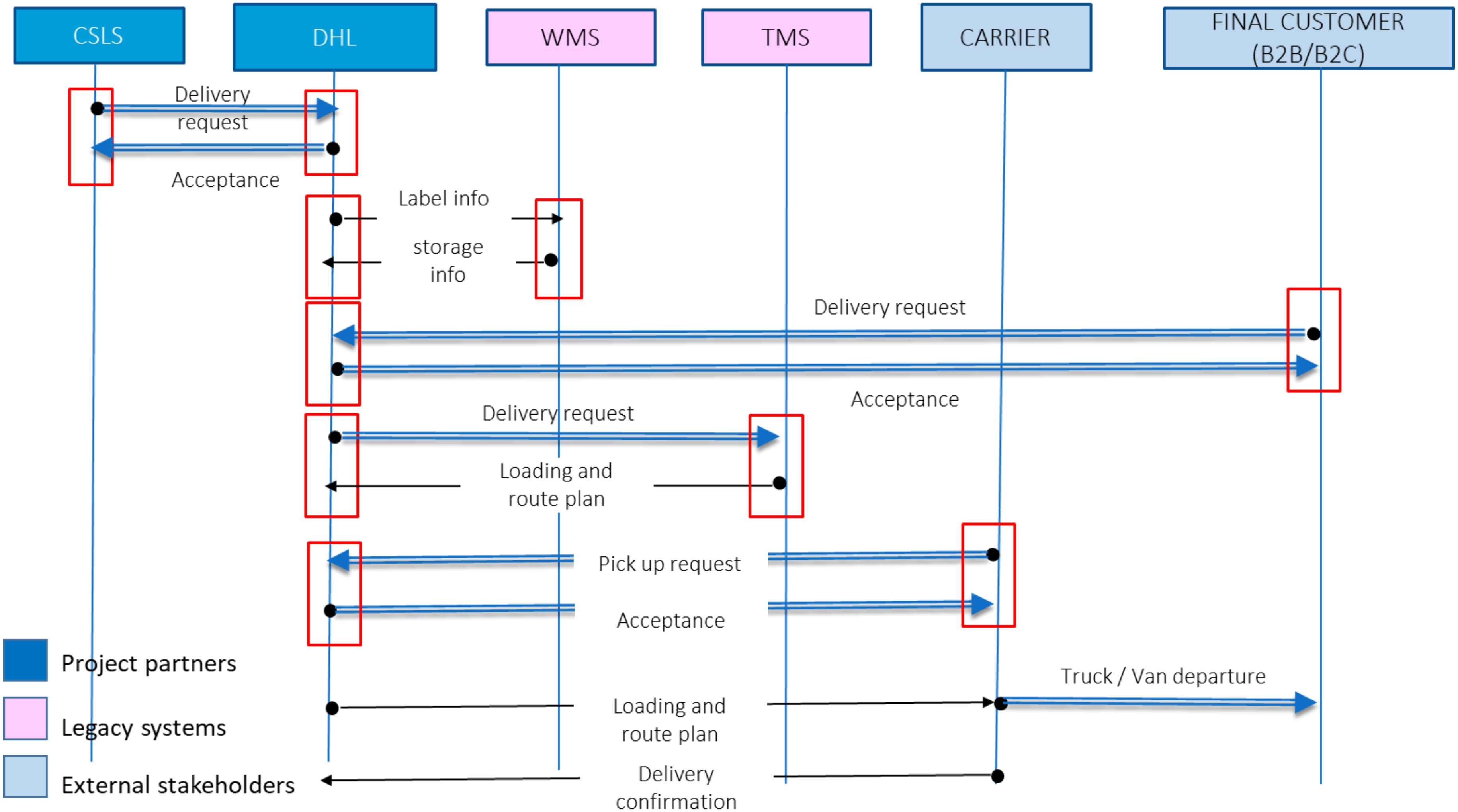

Figure 4-5: Spanish UC information flow of Madrid part (AS-IS scenario)

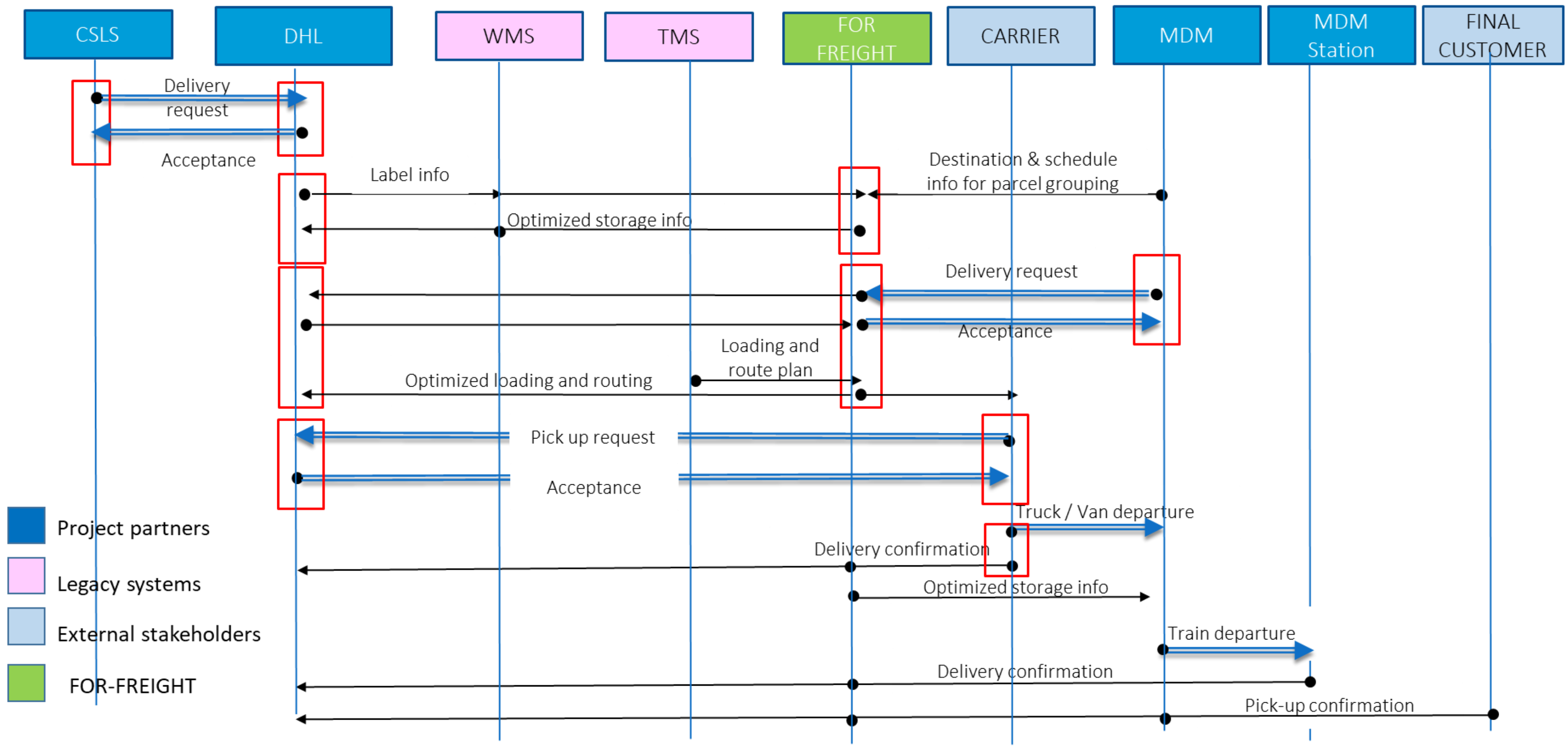

Figure 4-6: Spanish UC information flow of Madrid part (TO-BE scenario)

Considering the information contained in Table 4-2 and Figure 4-3, Figure 4-4, Figure 4-5 information silos are clear between Valencia and Madrid part and also internally. First of all, CSLS manages a vast amount of confidential information (e.g. COPRAR files, DUTs) that cannot be shared with any other external stakeholder despite directly affecting them. Train related companies are blind to any event occurring in the port that may directly affect them and the same happens to DHL, who is unable to adapt its resources in real-time as a result of the information flow being disconnected.

Multiple tasks are still performed manually and are not automated, such as communications between couriers and DHL that are performed via email or telephone and are entirely human dependent. The lack of interoperability is another clear problem identified as a result of both the information silos and the multiple proprietary legacy systems operating with several data incompatible formats.

Derived from this situation, resources (human, time, equipment space) are used in a suboptimal way and it is not possible to neither plan ahead nor adjust to unforeseen events. We can conclude that AS-IS scenario presents an absence of track and trace systems on real cargo visibility for all the stakeholders involved, blocked interactions between systems and suboptimal planning of resources. This situation implies high operational cost, high GHG emissions, delays in operations and inefficient multimodal, multi stakeholder end-to-end freight management.

With the pains identified in D1.1 clearly connected to the AS-IS scenario in the Spanish trial site, we have defined the TO-BE scenario considering the implementation of FOR-FREIGHT within it. FOR-FREIGHT will integrate the full information flow of the Valencia part and that is why the AS-IS and TO-BE scenarios of the information flow are the same (Figure 4-3 and Figure 4-4). In Valencia part, FOR-FREIGHT will integrate all the currently disconnected information from the different stakeholders, anonymize it when required, and translate it to a common format. Once that is achieved, all that data input will be used with a DSS to optimize the entire set operations.

In Madrid part, in addition to all the features required for the DSS, FOR-FREIGHT will become an actor in the flow of information. It will allow the real-time connection with Valencia Port for an optimized warehouse operation as well as the integration of MDM for the last-mile distribution. In particular, MDM will provide FOR-FREIGHT with daily information regarding destination of the parcels and schedules to be observed. FOR-FREIGHT will use that information to optimize DHL warehouse storage and picking steps, allowing for parcel grouping and loading into roller containers. FOR-FREIGHT will absorb information from DHL´s WMS and TMS and transform it into advice for improved operations (optimization of storage or routing plans) in real-time. Figure 4-6 represents the TO-BE information flow for the Madrid part of the Spanish UC.

4.1.1.3 Functional requirements

The situation defined in the previous section will be reached only when FOR-FREIGHT functional requirements are identified. In the Spanish UC, FOR-FREIGHT will act both as an integrated actor in the flow of information and as a DSS as a result of transforming that input. It will receive, anonymize, translate, store, process and forward data received from all stakeholders and their operating systems. In this sense, the first critical functional requirements are the anonymization of the data input and its translation to unify formats. These two functional requirements also affect the rest of the UCs as it has been described in Section 3.1 *Connection with T1.1* and will be later detailed for each of them. It will also be essential to define and develop different levels of security regarding accessibility and authorization for the different actors interacting with FOR-FREIGHT.

Once data anonymization, automated and secure exchange and processing are achieved, these are the specific functional requirements expected in the Spanish trial:

- Real-time data exchange and monitoring of container/material status/location.
- Digitalization and automation of administrative processes that now are manual.

- Multimodal transport planning and real-time adaptation through simulation tools.
- Resource (human, storage space, schedules) allocation planning and real-time adaptation through simulation tools.

Table 4-3 summarizes functional requirement (FR) that FOR-FREIGHT will allow in the Spanish UC and their connection with the project KPIs.

Table 4-3: Spanish UC Functional Requirements and project KPIs associated

FR ID	Data format unification	Project KPIs associated
ES-FR1	Translation of different data formats (XML, EDI, JSON) to a common one.	Project-level target, not relevant to specific UC KPI
ES-FR2	Data anonymization	
	Accessibility management	
ES-FR3	Integrate different UI for different actors.	Project-level target, not relevant to specific UC KPI
ES-FR4	Allow different levels of accessibility/authorization.	
	Automation of information exchange	
ES-FR5	Automated digitalization of administrative tasks.	**ES4/1**: >20% Transport Orders digitalization. **ES5/2**: >12% reduction of operational costs. **ES6/2**: >80% reduction of external costs.
ES-FR6	Real-time monitoring of container/parcel locations and conditions.	
ES-FR7	Real-time and visible flow of transport requests and acceptance.	
	Planning and management resources	
ES-FR8	Real-time routing and loading planning	**ES1/1**: >15% improve forecasting planning. **ES2/1:** >15% reduce container stay at the port. **ES3/1:** >15% reduce GHG emissions. **ES5/2**: >12% reduction of operational costs. **ES6/2**: >80% reduction of external costs. **ES7/2**: >10% reduction of transport times from DHL warehouse to final destination.
ES-FR9	Proactive planning of port (trucks at the terminal, loading/unloading, ITU/container dwell time in port) and warehouse operations (storage, picking, loading)	
ES-FR10	Resource allocation planning and adjustment.	

The first 4 FR (ES-FR1 to ES-FR4) refer to data format unification, security and accessibility management. Without them none of the rest FR will be achieved. Despite not being connected with any specific KPI, they are critical for the development and integration of existing systems and information into FOR-FREIGHT solution. FR regarding the automation of information exchange (ES-FR to ES-FR7) are connected with KPIs concerning digitalization of tasks (ES4/1) and reduction of costs (ES5/2, ES6/2). Planning and management resources (ES-FR8 to ES-FR10) are also connected with those cost reduction KPIs as a consequence of achieving the capacity of planning routes (ES1/1). All these FR of the Spanish UC are also connected with the following expected outcomes (EO):

- More efficient, effective and sustainable management of goods and freight flows in (air) ports and inland terminals, taking into account all costs (economic, social and environmental) of the proposed solutions/innovations, including externalities and possible rebound effects (EO1).
- Expanded throughput of the nodes thanks to increased operational efficiency and optimized use of assets and infrastructures, without expanding the physical facilities (EO2).
- Improved access to transshipment services at reduced costs (EO3).
- More visible and standardized services provided within the multimodal freight transport nodes, seamlessly accessible by end users to maintain continuous door-to-door tracking of freight locations and boost shifting cargo to more efficient and sustainable transport modes (EO4).

- Increased automation, digitalization, standardization and interoperability of processes, technologies and equipment, particularly intermodal transport units (ITUs) and cargo transport/transshipment procedures in multimodal freight transport nodes (EO5).
- A better integration of the various freight transport nodes into overall logistic chain (EO6).

It can be concluded that the Spanish UC will meet all KPIs established and each and every connected mid-term objectives, ensuring that FR here defined and that will be developed in the Spanish trial site are aligned with the pains defined in D1.1 and also with the needs of the logistic sector for an end-to-end multimodal and multi-stakeholder freight transport optimization through a DSS.

4.1.1.4 Technologies selected

Combining the analysis of technologies performed in D1.1 and the analysis and refinement of the Spanish UC, a set of technologies that will be integrated to allow the functionalities defined in the previous section is also defined. As in the rest of the UCs, these technologies will allow the effective integration of the legacy systems in use and their data towards achieving a DSS in the FOR-FREIGHT platform. The general categories of those technologies and their functions in the Spanish UC are:

- AI/ML: 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, resource utilization and E2E multimodal transport planning.
- Blockchain: supply chain governance based on Blockchain for time reduction in the administrative and operational processes, provided by a Hyperledger Fabric blockchain platform.
- IoT: sensors for real-time tracking.
- Digital Twin: application for DSS.
- 5G: solution for enhancing safety and road transport efficiency (fuel consumption and travel times).

These technologies will not be developed from scratch, but incorporated in the form of SotA components developed in previous EC-Horizon projects (C-ROADS.EU, VITAL-5G, 5G-CARMEN, Ingenious, FENIX, 5G-MOBIXC, PLANET) with a mature TRL (>TRL6). IMEC will provide the AI-based prediction and optimization algorithms for route planning optimization of multimodal freight transport. FVP will bring their machine learning AI-based algorithms for maritime and terrestrial routing. Both will be integrated in the DSS. Digital Twin will be supported by CERTH. Blockchain applications will be supported by FVP and CSLS. 5G will be provided by ABS to DHL and MDM with their C-ITS Platform and C-V2X test network. IoT sensors will be the same as the ones used in the Greek UC, provided by CERTH, and used by DHL and MDM.

Table 4-4 summarizes the technologies and systems that will be incorporated to FOR-FREIGHT in the Spanish UC, their current state of technical development (TRL) and their connection with the functional requirements (FR) defined for the Spanish UC.

Table 4-4: Spanish UC SotA technologies and systems connected to Functional Requirements

Technology	Partner	Systems/Devices/Infrastructure	Link with Other Projects	Status	TRL	FR
IoT	CERTH	Monitoring Sensors (OBU sensors)	ORION	Available	7	
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	7	Optional

All the functionalities defined for the Spanish UC will be met by the incorporation of the technologies selected to allow the integration of existing and disconnected systems in use, data sharing and processing towards a DSS. FOR-FREIGHT will host all those legacy systems, funnel the information provided by them and process it to act as a DSS. It will firstly anonymize and translate the data into a standard format, ending with existing information silos between Valencia and Madrid parts and the internal stakeholders involved in each of them, achieving interoperability as well. Simulation tools will allow an improved forecast of all the tasks and resources involved. As a result, a Blockchain and Digital Twin to support decision making process in multimodal transport combined with subway-based network for last-mile distribution will be achieved.

All the specific KPIs of the Spanish UC have been refined accordingly and connected to the different functional requirements as well as with the mid-term expected outcomes and long-term expected impacts to ensure the alignment of the UC definition with the general objectives and impacts. The detailed list containing the definition of EO, EI and their associated eoKPI and eiKPI can be found in Annex II: KPIs and Objectives. Here, Table 4-5 shows the summary of those connections.

Table 4-5: Spanish UC project KPIs and technologies applied connected with mid-term EO-long-term EI

Project KPIs				Mid-term- expected outcomes			Long-term expected impacts	
KPI ID	KPI target	KPI description	Technology applied	Expected Outcome-EO	eoKPI ID	General EO	Expected Impact-EI	eiKPI
ES1/11	>15%	Improve forecast planning	AI/ML Blockchain 5G IoT Digital Twin	EO1	eoKPI.2.1 eoKPI.8.1 eoKPI.9.4	EO6	EI1 EI2 EI3 EI4	eiKPI.11.1 eiKPI.12.1 eiKPI.12.2 eiKPI.13.1 eiKPI.14.1 eiKPI.15.1
			Blockchain IoT	EO1	eoKPI.2.2			
			AI/ML Blockchain Digital Twin	EO2 EO4	eoKPI.4.2 eoKPI.4.3 eoKPI.7.1 eoKPI.4.5 eoKPI.9.4			
			AI/ML Blockchain Digital Twin	EO4	eoKPI.8.1 eoKPI.9.4			
ES2/1	>15%	Reduction container stay at the port	AI/ML Blockchain Digital Twin	EO4	eoKPI.8.2			

			AI/ML Blockchain IoT Digital Twins	EO1 EO3	eoKPI.1.3 eoKPI.1.4 eoKPI.1.2 eoKPI.5.1			
			AI/ML Blockchain IoT Digital Twins	EO2 EO5	eoKPI.4.1 eoKPI9.2			
ES3/1	>15%	Reduction GHG emissions	AI/ML	EO1	eoKPI.3.1 eoKPI.3.2 eoKPI.3.3			
ES4/1	>20%	Transport Orders Digitalisation	Blockchain	EO3 EO5	eoKPI.6.1 eoKPI.9.4			
ES5/2	>12%	Reduction operational costs	AI/ML IoT Digital Twin 5G Blockchain	EO3	eoKPI.6.2			
			AI/ML IoT Digital Twin	EO1	eoKPI.2.1			
			AI/ML IoT Digital Twin 5G	EO1 EO2	eoKPI.1.4 eoKPI.1.5 eoKPI.4.2			
ES6/2	>80%	Reduction of external costs (environmental + social)	AI/ML IoT 5G	EO1	eoKPI.3.1 eoKPI.3.2			
ES7/2	>10%	Reduction of transport times from DHL warehouse to final destination	AI/ML IoT Digital Twin	EO1 EO3	eoKPI.1.2 eoKPI.5.1			
			AI/ML IoT Digital Twin 5G	EO4	eoKPI.8.3			
			AI/ML IoT Digital Twin 5G Blockchain	EO5	eoKPI9.1 eoKPI9.4			

			AI/ML IoT Digital Twin 5G	EO2	eoKPI.4.3 eoKPI.4.5			
			AI/ML IoT Digital Twin 5G	EO1 EO2	eoKPI.1.1 eoKPI.1.2 eoKPI.4.4			

4.1.2 Preparatory activities

We have defined in Table 4-6 the set of preparatory activities that will enable the start of the Spanish UC. These activities are classified as blocking/no blocking for the trial to begin as well as the partners involved in them and the month of completion.

Table 4-6: Spanish UC preparatory activities

Preparatory activity	Blocker (Y/N)	Month	Partners involved
Meetings to: 1. Identify which information/data is available from CSLS, DHL, MDM, FVP system required for optimising the flow. 2. Identify which of those data fields are accessible and which need anonymization. 3. Understand how to overcome accessibility restrictions.	Yes	M9	CSLS FVP DHL MDM
Definition of Digital Twin, Blockchain and IoT/5G technologies from third parties.	Yes	M9	CSLS DHL MDM FVP CERTH
Definition of the different levels of security	Yes	M9	CSLS DHL MDM FVP
Definition of the historical data to be fed into FOR-FREIGHT (type, time range, format)	Yes	M9	CSLS DHL MDM FVP
Definition of the specific administrative manual tasks that will be digitalized.	No	M9	CSLS DHL MDM FVP
Definition of the process to integrate translation tool.	Yes	M11	FVP IMEC

This set of preparatory activities are required to enable the start of Spanish UC. During Month 9 all the critical aspects still pending will be defined, enabling this way reaching the “quick win” solution by Month 12.

4.1.3 Use Case business scenario

By Month 12, the Spanish UC trial site will be in position to offer a blockchain-based system to improve transparency and traceability of documents and freight, reducing manual paperwork and improving reliability of data. Machine learning algorithms to optimise truck and train planning, reducing stay time will also be in place.

Digital Twin of the port and the warehouse will allow the simulation of optimal scenarios for transport and storage planning and for bottlenecks identification. The following functionalities will also be achieved in the Spanish "quick win" solution by Month 12:

- Decentralised system for sharing data and documents between different stakeholders.
- Use forecast predictions (historical and advanced data) to anticipate potential issues and disruptions for optimal container transport planning and parcel delivery.
- Real-time situation of the port and vehicles allowing a more accurate view of the processes and improving decision making for optimising.
- Real-time monitoring of the warehouse and tracking of parcels for the last mile distribution.
- Integrated MDM in the processes.

4.1.4 Expected challenges

The main challenges identified for the implementation of the Spanish trial site are identified in Table 4-7:

Table 4-7: Spanish UC challenges

Challenge	Measures to overcome it	Partner (s) responsible	Date expected
Integration of existing translation tool	Development of API	FVP/IMEC	M12
Integration of global and local internal COSO system	Definition of the levels of anonymization and filtering of the data	CSLS	M9
Partners feeding all the required historical data	Define the specific data required to be fed by each partner and the level of security required	All partners involved in Spanish UC	M9
Lack of well-established infrastructures that need to be implemented: lockers in metro station, roller containers	Define the infrastructure development that is required in early stages.	MDM DHL	M9

4.1.5 Implementation Plan

We have designed an implementation plan that comprises the activities of the Spanish UC. This is fully aligned with the overall project implementation plan. Preparatory activities will correspond with *T1.4 FOR-FREIGHT solution architecture & design* (M4-M12) and *T2.2 Sea Port –last mile solution development, integration and testing* (M8-M28). The execution phase of the trial corresponds to T3.2 *Sea Port-last-mile trials* (M7-37).

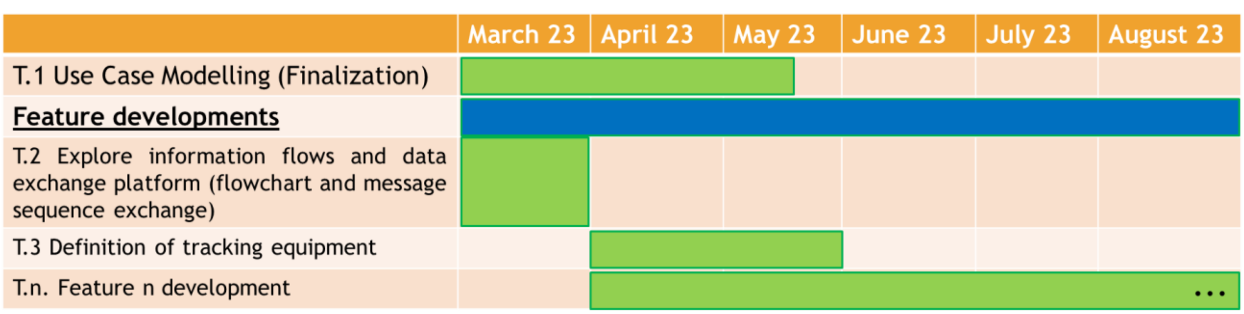

Figure 4-7: Spanish UC Implementation Plan

4.2 Use Case 2: Athens (GR)

Use Case 2 is based in Athens and focuses on the multimodal freight transportation from Sea Port of Piraeus to Athens Airport. As defined in D1.1, Greek Trial Site combines Sea Port, Airport (air-freight) and road transport (truck) and its target is to create a solution that integrates:

1. Information from the legacy individual management systems of all involved stakeholders, the field equipment and devices of their personnel and additional information.
2. Intelligence provided by newly deployed sensors, devices and Machine Learning and data analytics functions.

4.2.1 Refinement

4.2.1.1 Process Flow: AS-IS vs TO-BE

The first step on the Greek Use Case refinement has been mapping the current process flow and compare it to the optimised scenario that is expected with FOR-FREIGHT implementation. Greek Trial site aims at optimising several processes comprising the end-to-end Port-to-Airport process, targeting to solve all the pain categories already identified in D1.1: information silos across different domains, lack of standardisation in the processes for interoperability, low digitalisation and automation.

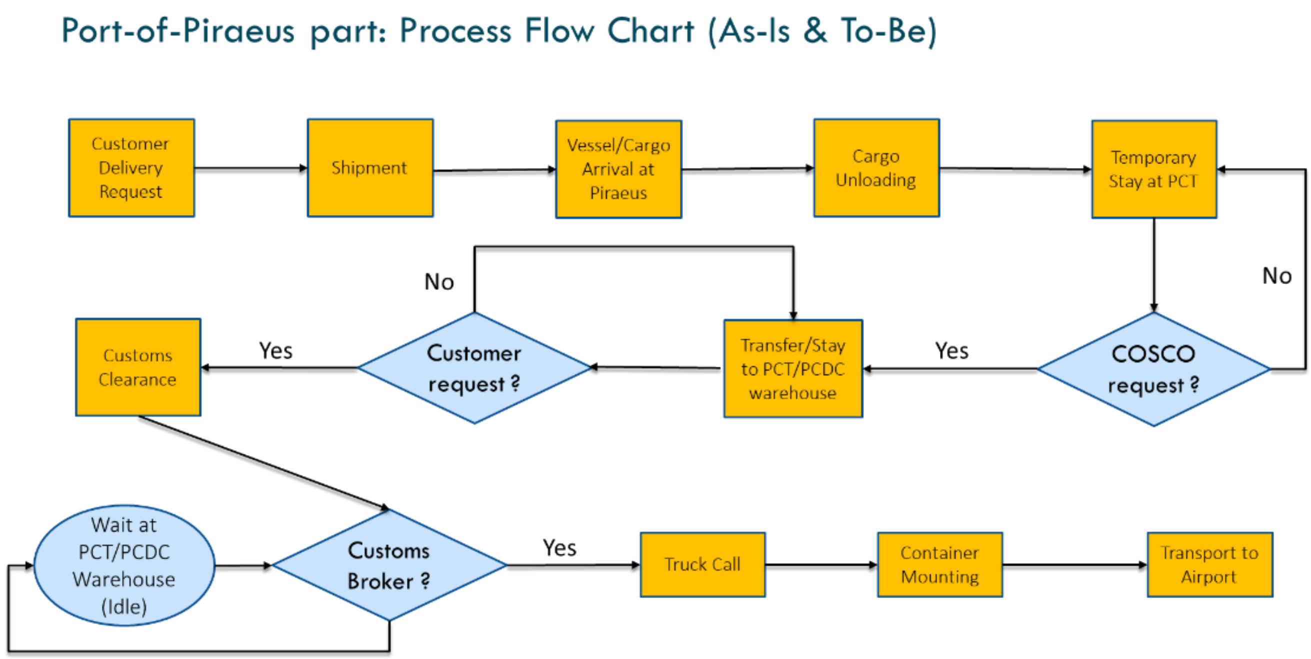

Figure 4-8: Port of Piraeus part physical process flow

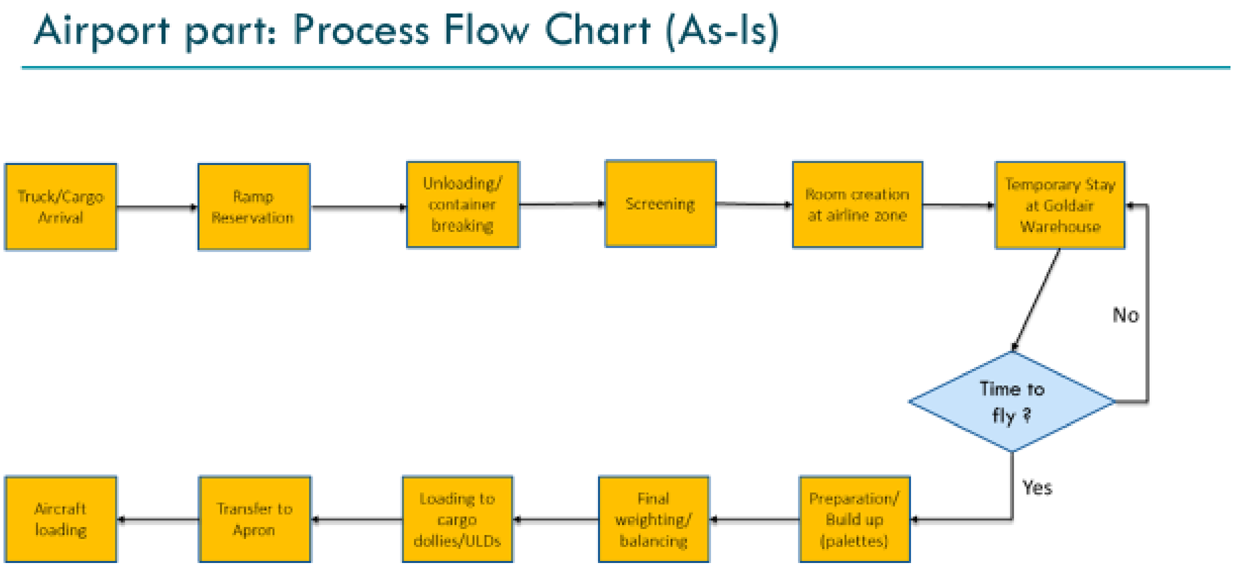

Figure 4-9: Athens International Airport part physical process flow (AS-IS scenario)

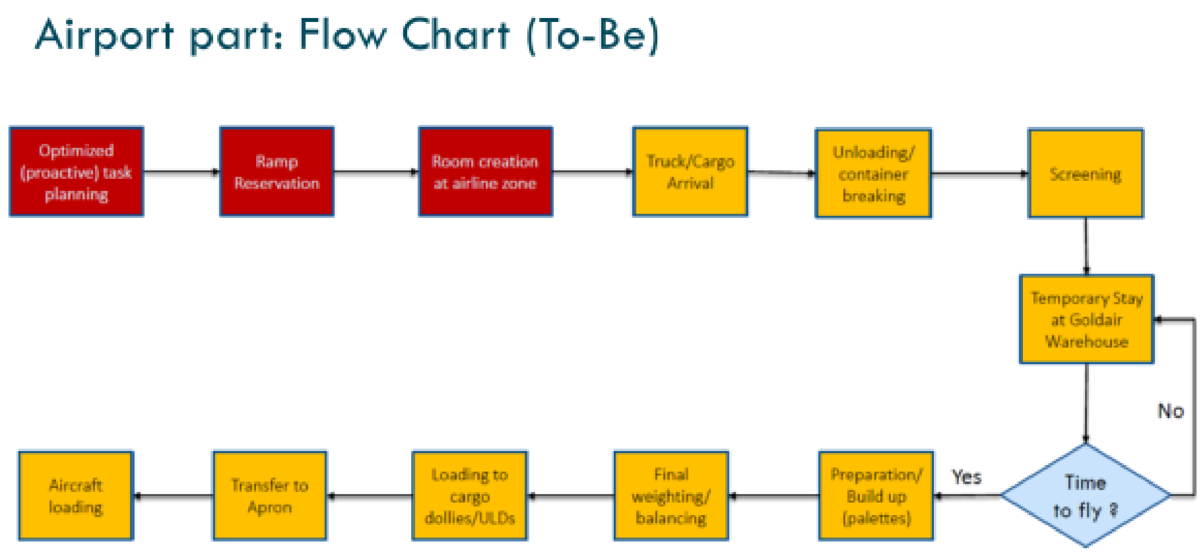

Figure 4-10: Athens International Airport part physical process flow (TO-BE scenario)

Current process flow in the Greek trial site is divided in two areas of operation:

1) Port of Piraeus: COEL manages the whole interaction and exchange of information with the Customs´ Authorities through ICISnet. This covers the shipment, cargo arrival, unloading, stay at PCT, Customs´ Clearance and transport to Athens International Airport.
2) Athens International Airport: once the container arrives at the Airport, GOLD manages the unloading, screening and storage at GOLD Warehouse (Goldair Handling Cargo Terminal) at the airport until the time to fly comes. GOLD exchanges with AIA all the required information and performs the cargo loading to the aircraft

Once the process flow is defined in its final form, the bottlenecks to be solved with FOR-FREIGHT have been identified: container idle time at port and airport, customs clearance process time, truck transportation time, cargo handling capacity, errors and accidents. Each of those conflictive areas has been assigned a specific KPI to be met during the trials (See Annex II: KPIs and Objectives). KPIs originally defined in the proposal have been analysed and redefined and a quantifiable and measurable baseline value for each of them has been established. Results of this can be seen in Table 4-8.

Table 4-8: Greek UC KPIs

KPI ID	KPI target	KPI description	Baseline description
GR1	>25%	Reduction of the container idle time at the port/airport	Container idle time at port
			Container idle time at the airport
			Truck waiting time at terminal
GR2	>20%	Reduction of the customs clearance process time	Customs´ clearance process time
GR3	>20%	Increased end-to-end capacity due to optimization of resource utilization	Truck transportation time ex. port to airport
GR4	>15%	Increased efficiency of the storage space	Current cargo handling capacity at the airport hub
GR5	>20%	Reduction of errors	Mishandling errors
			Errors, accidents and errors that caused delays (not mishandling)

4.2.1.2 *Information flow: AS-IS vs TO-BE*

For the achievement of those KPIs in the Greek Use Case, it is essential to improve the existing methods of exchanging information and data. It has been critical to identify what information is shared, by whom and how to be able to improve the overall process to achieve the KPIs defined. In this regard, the second step followed in the UC refinement has been a deep analysis of the data flow comparing the AS-IS and the TO-BE scenarios. Actors involved in the data sharing are:

- External stakeholders: customers, PCT, truck drivers, airlines, customs.
- Internal project partners: COEL, GOLD, AIA.

Table 4-9 shows in detail the AS-IS scenario regarding information shared definitions, the stakeholders sharing it, the legacy systems in use to share it and the data format.

Table 4-9: Greek UC information flow analysis

Stakeholders	Data	Source (from)	Destination (to)	Via (legacy system)	Owner of the via	Format
Customer COEL Airlines	Order request	Customer	COEL	Email/phone	-	email
	Booking request	Customer	Airline System	Email/phone		EDI, email, telex
	Acknowledge/ Acceptance	Airline	COEL/Customer	Email/phone	-	email

		COEL	Customer	Email/phon e	-	email
PCT COEL Customer	Vessel arrival notice	PCT	COSCO ERP	Email/phon e	-	-
		COSCO ERP	HCPS	COSCO ERP	COEL	XML
		COSCO ERP	COEL	COSCO ERP	COEL	SQL, .NET and EDI
		COEL	Customer	Email	-	email
	Cargo request	COEL	PCT	Email/phon e	-	-
	Cargo acceptance/acknowled ge	PCT	COEL	Email/phon e	-	-
	Cargo data input	COEL	COSCO ERP	COSCO ERP	COEL	SQL, .NET and EDI
COEL Customs´ Customer	Customs´ clearance order	Customer	COEL	Email, phone, or HPCS	PCT (for HPCS)	XML, email
	Customs´ clearance acceptance/acknowled ge	HCPS	COEL	HPCS (if used)	PCT	XML
	Customs´ clearance info	COEL	HPCS	HPCS	PCT	XML
		HPCS	ICISnet	ICISnet	Customs Authoritie s	XML
	Customs´ clearance info acceptance/acknowled ge	ICISnet	HPCS/COEL	ICISnet	Customs Authoritie s	XML
	Customs clearance status	HPCS	COEL	HPCS	PCT	XML
	Customs´ clearance notice	COEL	Customer	Email/phon e	-	email
COEL Truck driver PCT	Transport request	COEL	Truck driver	Phone	-	-
	Truck arrival notice	Truck driver	COEL	-	-	Truck presence at port
		Truck driver	PCT	-	-	Truck presence at port
	Cargo departure	PCT	HPCS	HPCS	PCT	XML
Truck driver GOLD	Truck arrival notice	Truck driver	GOLD	APP	WINGS /AIA	XML
	Cargo request	GOLD	Truck driver	APP	WINGS /AIA	XML
	Cargo acceptance/acknowled ge	Truck driver	GOLD	APP	WINGS /AIA	XML
	Ramp reservation	GOLD	Truck driver	APP	WINGS	XML

					/AIA	
GOLD	Import WMS	GOLD	GoldFreight	GoldFreight	GOLD	XML, Cargo iQ, EDI, EMAIL, TELEX
GOLD Airlines	Flight time inputs (schedules, arrival, departure, real-time updates)	AIA	Goldfreight	AODB	AIA	XML
	Flight manifest, e-Air Waybills, Housewaybills, Freight Status Updates, Customs Declarations, Invoicing documents, accounting information	GOLD	Airlines Systems	Goldfreight	GOLD	XML
	Aircraft parking slot	AIA	GOLD	AODB	AIA	XML

Figure 4-11 shows graphically that flow of information in the AS-IS scenario. Analysing both the information contained in Table 4-9 and Figure 4-11 two main categories of information silos are identified, Port and Airport. The only information shared among them are the Transport request and Acceptance between COEL and the truck driver and the Booking flight request and acceptance between COEL and Airlines systems. Any issue and updates regarding vessel status or customs´ that happens in the Port section directly affects the Airport section. This includes management and planning of the cargo transportation from the Port to the Airport, ramp reservation, unloading container, storage at airlines areas, stay at GOLD warehouse, preparation, loading, etc. With the current flow, Airport section is unable to plan their activities and accordingly manage their resources with time in advance so as to improve their operational efficiency.

The main reason behind this lack of communication is the lack of standardisation. Several systems (ICISnet, COSCO ERP, HPCS, GoldFreight, AODB) sharing data in several formats (XML, EDIFACT, email, telex, SQL, .NET, Cargo iQ) makes impossible for the information to effectively flow among stakeholders. In addition to that, several processes remain unautomated and depend of the manual input of information into the system by a person to allow the process to continue. This is the case of the truck driver being entirely responsible of providing the truck arrival notice and cargo request to the airport handling company.

Once we have analysed the AS-IS situation of the information flow in the Greek UC, we have defined how FOR-FREIGHT will have the capacity to change this situation by solving the pains identified. Figure 4-12 shows how FOR-FREIGHT will become one of the actors of the message sequence chart. FOR-FREIGHT will gather and allow the exchange of information between Port and Airport trial areas that now is simply not shared. This includes: cargo departure notice form Port, cargo information, customs clearance status, cargo real-time location, truck/cargo ETA, truck arrival notice. It will also provide flight recommendation to the customer before proceeding with booking. Information provided by truck driver will be automated: as soon as cargo departs and COSCO ERP notifies so to FOR-FREIGHT, GoldFreight system will have all the information required to coordinate with airport handling and airlines. Altogether, will allow the Port and Airport segments to work in a much more unified and standardised way, sharing data for improved resource planning.

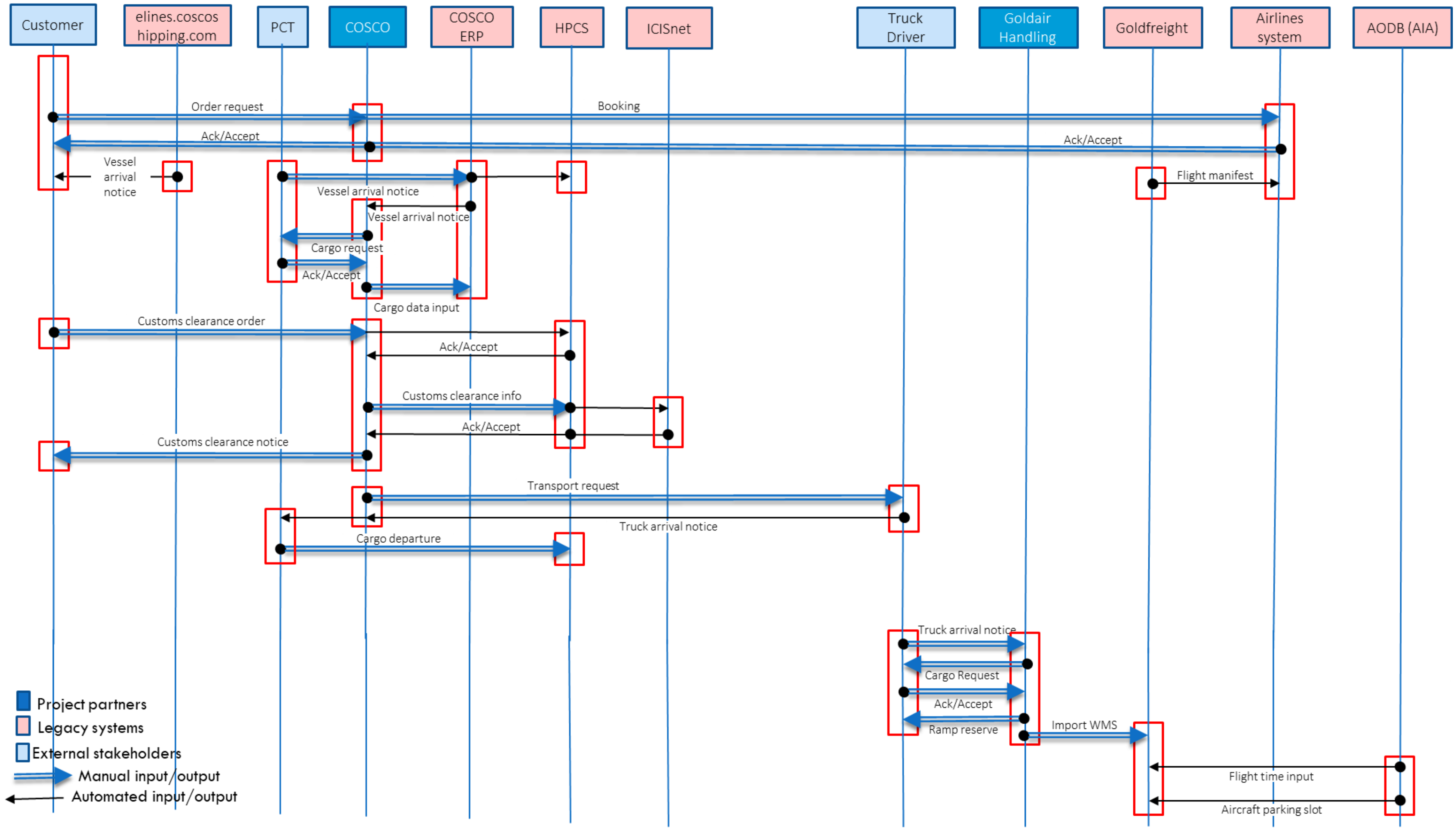

Figure 4-11: Greek UC overall information flow (AS-IS scenario)

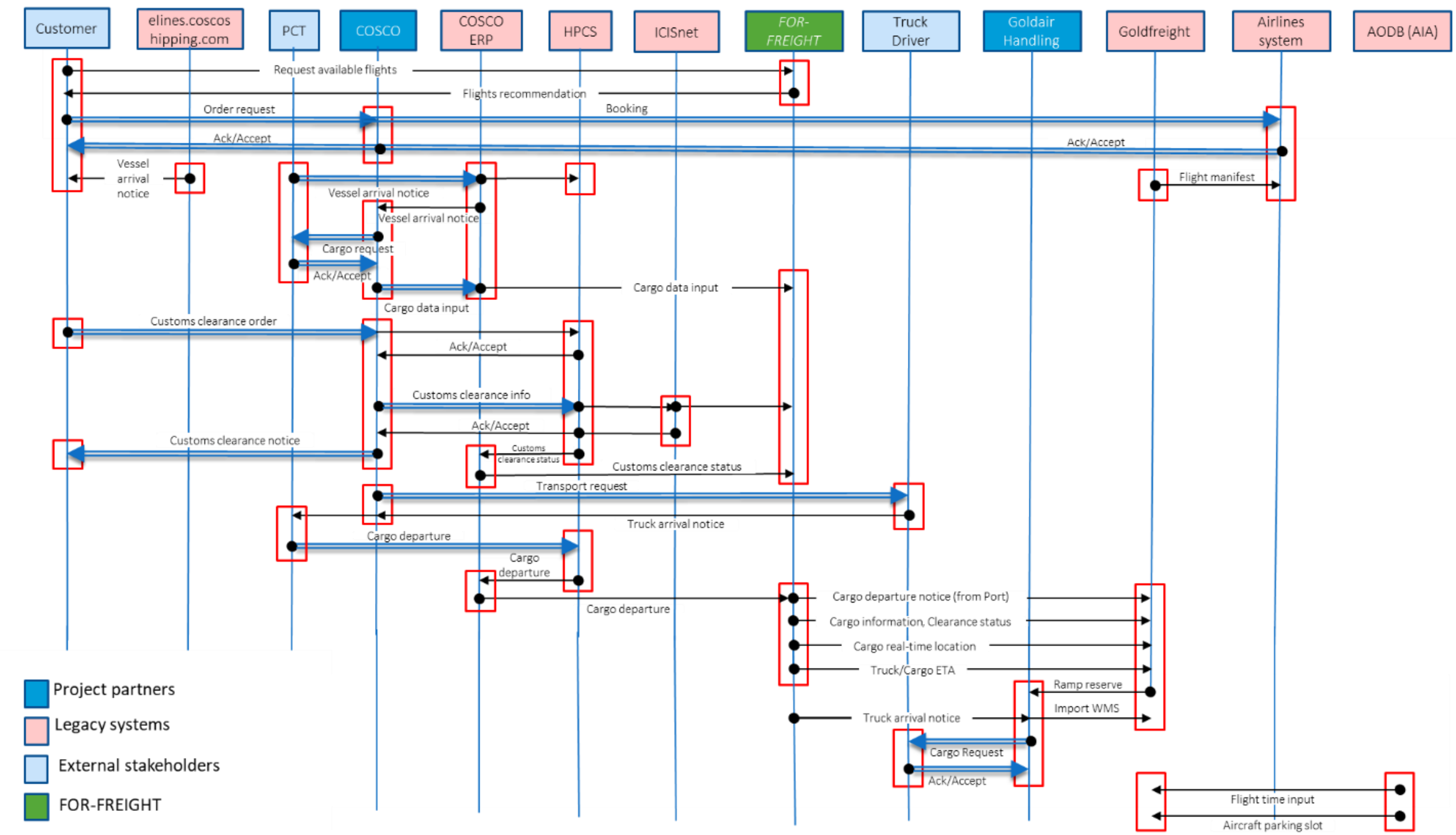

Figure 4-12: Greek UC overall information flow (TO-BE scenario)

4.2.1.3 *Functional requirements*

To reach the TO-BE situation defined in the previous section, it is necessary to identify FOR-FREIGHT functional requirements that will allow so. FOR-FREIGHT will act as an integrated actor in the flow, receiving, translating, storing and forwarding data from all the other stakeholders´ systems involved and in their different formats. Besides the role of the integration platform, FOR-FREIGHT will offer a set of novel services to the involved actors, such as monitoring, visualization and optimization services.

FOR-FREIGHT will receive data input from: the customers (email), COSCO ERP software (SQL, .NET, EDI), ICISnet software (XML), truck OBU monitoring and sensing information. It will send data to: FOR-FREIGHT users via respective UIs airline systems, GOLD through GoldFreight software (XML, Crgo iQ, EDI). For this, the first requirement of the Greek UC regarding data transmission is a translator to unify formats of data input/output. It is necessary to develop an interconnection hub for enabling data sharing from COSCO ERP (SQL, .NET, EDI) to GoldFreight (XML, Cargo iQ, EDI).

Other critical functional requirements are providing different interfaces and levels of accessibility/authorization for the different actors directly interacting with FOR-FREIGHT (customers, handling companies, airlines, etc.). These UI will have to be integrated into the GoldFreight legacy system. Integration and sharing of real-time (e.g. customs´ clearance notice, OBU monitoring sensor data streams) and non-real-time data (e.g. flight booking list).

With proper and automated data exchange achieved, the following functionalities are expected in Greek trial:

- Automated customs clearance electronic document exchange.
- Real-time monitoring of container locations (port-to-airport transportation).
- Container arrival prediction at airport warehouse.
- Automated/remote flight booking.
- Proactive planning of airport warehouse operations.

Table 4-10 summarizes functional requirements (FR) that FOR-FREIGHT will allow in the Greek UC and their connection with the project KPIs.

Table 4-10: Greek UC Functional Requirements and project KPIs associated

FR ID	Data format unification	Project KPIs associated
GR-FR1	Translation from/ to SQL, .NET, EDI from/to XML, Crgo iQ, EDI (COSCO ERP-GoldFreight software).	Project-level target, not relevant to specific UC KPI
GR-FR2	Real-time and non-real time data integration.	
	Accessibility management	
GR-FR3	Integrate different UI for different actors.	Project-level target, not relevant to specific UC KPI
GR-FR4	Allow different levels of accessibility/authorization.	
soft	Automation of information exchange	
GR-FR5	Automated customs clearance electronic document exchange.	**GR2**: >20% reduction of the customs' clearance process time.
GR-FR6	Real-time monitoring of container locations and conditions.	
GR-FR7	Automated/remote flight booking.	
	Planning and management resources	
GR-FR8	Container arrival prediction at airport warehouse.	**GR1**: >25% reduction of the container idle time at port/airport. **GR3**: >20% increased end-to-end capacity due to optimization of resource utilization.
GR-FR9	Proactive planning of airport warehouse operations.	

		GR4: >15% increased efficiency of storage space. **GR5**: >20% reduction mishandling errors.

Data format unification (GR-FR1, GR-FR2) and accessibility management (GR-FR3, GR-FR4) are the base upon which the rest of the Greek functional requirements will be built up. They are not directly connected with any project KPI, but are essential to develop and integrate FOR-FREIGHT solution. Automation of information exchange (GR-FR5, GR-FR6, GR-FR7) present a direct connection with the project KPIs related to customs´ clearance process (GR2). Developing the planning and management resources functionalities (GR-FR8, GR-FR9) will allow achieving all those KPIs concerning an optimization in the use of time, space and resources (GR1, GR3, GR4, GR5). When looking at the connection with mid-term expected outcomes (EO), these will be covered:

- More efficient, effective and sustainable management of goods and freight flows in (air) ports and inland terminals, taking into account all costs (economic, social and environmental) of the proposed solutions/innovations, including externalities and possible rebound effects (EO1).
- Expanded throughput of the nodes thanks to increased operational efficiency and optimized use of assets and infrastructures, without expanding the physical facilities (EO2).
- Improved access to transshipment services at reduced costs (EO3).
- More visible and standardized services provided within the multimodal freight transport nodes, seamlessly accessible by end users to maintain continuous door-to-door tracking of freight locations and boost shifting cargo to more efficient and sustainable transport modes (EO4).
- Increased automation, digitalization, standardization and interoperability of processes, technologies and equipment, particularly intermodal transport units (ITUs) and cargo transport/transshipment procedures in multimodal freight transport nodes (EO5).
- A better integration of the various freight transport nodes into overall logistic chain (EO6).

Functional requirements will not only cover the specific needs of the Greek trial by achieving its specific KPIs, but also meet all the mid-term expected objectives. This ensures that the functional requirements designed and developed during the trial are fully aligned with the general needs of the logistics sector.

4.2.1.4 Technologies selected

Based on the analysis of technologies carried out in D1.1 and the present analysis and refinement of the Greek UC, we have established the technologies that will be integrated to allow the functionalities defined in the previous section. These technologies will not substitute those legacy systems already in use, but allow their effective integration in the FOR-FREIGHT platform. The general categories of those technologies and their function in the Greek UC are:

- IoT: end-to-end communication of the diverse systems participating in the overall operations, involving legacy systems and devices, vehicle OBUs, sensors, etc.
- 4G/5G/Wi-Fi: end-to-end communication and interconnection of the diverse systems participating in the overall operations.
- Cloud Technology and Edge Computing: back-end and APIs enabling data ingestion, database management, data processing, AI/ML-based decision making, events' management, operational logic, etc.
- AI/ML: i) advice from DSSS to logistics operators; ii) cargo arrival prognosis; iii) optimized allocation of resources.

These technologies will be incorporated in the form of different SotA components developed in previous EC-Horizon projects (See Table 4-11). All of them are already available and have reached mature TRL (>TRL6). The partners providing them are WINGS (IoT, 5G (via commercial network), Cloud and edge computing, AI/ML), CERTH (when required-IoT, Cloud and edge computing, AI/ML), AIA (IoT, 5G), IMEC (Cloud and edge computing), GOLD (IoT).

WINGS Chariot platform will be used for real-time transmission of truck departure notice from port and for transmitting the ULD/cargo dollies location to the warehouse handles (GOLD). WINGSPARK cloud-based platform will be incorporated to automate ramp reservation/booking procedures for trucks approaching the area outside of GOLD's warehouse premises. These two platforms will allow monitoring datasets related to warehouses´, arrivals forecast, truck/vessel/cargo position and cargo status/condition.

Edge computing servers from CERTH and IMEC will allow the back-end operations and interconnection between the diverse systems and platforms involved in the end-to-end procedures through rest API mechanisms. Using FENIX Connector of the Greek Transport and Logistics Observatory (CERTH), FOR-FREIGHT platform will be able to exchange data seamlessly by connecting to the FENIX Federated Network as well as having an authorization tool for certifying service providers and users. CERTH´s Virtual Freight Center cloud solutions will allow matching supply and demand of storage space, when this is required by the pilot site. CERTH ML models for demand and lead time forecasting will provide advice from the DSS towards the port and airport authorities and customs´ agencies regarding resource allocation based upon cargo size, type and ETA and towards logistics operator for unloading.

Truck OBUs will be used for real-time truck monitoring (GPS, speed, acceleration, engine monitoring) and container monitoring (temperature, humidity, door open/close, camera snapshots).

4G/5G/Wi-Fi will allow end-to-end real-time communication and interconnection of the diverse systems participating in the overall operations (port arrival notice, ERP, customs clearance, air flight booking, etc.) in FOR-FREIGHT platform. This will be provided by the already set in place Wi-Fi coverage by AIA and the 4G/5G connectivity that will be provided via WINGS technologies, leveraging commercial MNOs' networks.

Table 4-11 summarizes the technologies and systems that will be incorporated to FOR-FREIGHT, their current state of technical development (TRL) and their connection with the functional requirements (FR) already defined for the Greek Use Case.

Table 4-11: Greek UC SotA technologies and systems connected to Functional Requirements

Technology	Partner	Systems/Devices/Infrastructure	Link with Other Projects	Status	TRL	FR
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
	CERTH	Virtual Freight Center	WareM&O	Available	8	

	CERTH	Smart Supply Chain and Intelligent Intermodal Corridor Management system	SmartCorridors	Available	7	GR-FR8 GR-FR9
	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	7	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	7	Optional

As a conclusion, all the functionalities defined for the Greek UC will be met by the incorporation of the above technologies and components to allow an improved an efficient integration of the existing legacy systems in place. FOR-FREIGHT will become an integrated actor in the flow of information, allowing its standardization and the automation of several actions that are now manually performed and disconnected. Existing information silos between the port area and the airport area will be now connected by FOR-FREIGHT allowing planning of resources required in advance. All specific KPIs of the Greek UC have been refined accordingly and connected to the different functional requirements as well as with the mid-term expected outcomes (EOs) and long-term expected impacts to ensure the alignment of the UC definition with the general objectives and impacts. The detailed list containing the definition of OE, EI and their associates eoKPI and eiKPI can be found in Annex 2. Table 4-12 shows here the summary of those connections.

Table 4-12: Greek UC project KPIs and technologies applied connected with mid-term EO-long-term EI

Project KPIs				Mid-term- expected outcomes			Long-term expected impacts	
KPI ID	KPI target	KPI description	Technology applied	Expected Outcome-EO	eoKPI ID	General EO	Expected Impact-EI	eiKPI
GR1	>25%	Reduction of the container idle time at the port/airport	5G, AI, (Big) Data Processing	EO1 EO4	eoKPI.3.3 eoKPI.8.4	EO6 EO3	EI1 EI2 EI3 EI4	eiKPI.11.1 eiKPI.12.1 eiKPI.12.2 eiKPI.13.1 eiKPI.14.1 eiKPI.15.1
			5G, AI, (Big) Data Processing	EO2	eoKPI.4.1			
			5G, AI, (Big) Data Processing	EO4	eoKPI.8.2			

GR2	>20%	Reduction of the customs clearance process time	Legacy systems integration	EO2	eoKPI.4.6			
GR3	>20%	Increased end-to-end capacity due to optimization of resource utilization	5G, AI, (Big) Data Processing	EO4	eoKPI.7.1			
	>15%	Increased efficiency of the storage space	Artificial Intelligence (AI)	EO2	eoKPI.4.4			
GR4	>20%	Reduction of errors	Artificial Intelligence (AI)	EO1	eoKPI.2.2			
			Artificial Intelligence (AI)	EO4 EO5	eoKPI9.4 eoKPI.8.1			

4.2.2 Preparatory activities

A set of preparatory activities have been defined in Table 4-13 to enable the start of the Greek UC. These activities are classified as blocking/no blocking for the trial to begin as well as the partners involved in them.

Table 4-13: Greek UC preparatory activities

Preparatory activity	Blocker (Y/N)	Month	Partners involved
Meetings to: 1. Identify which information/data is available from COSCO ERP system required for optimising the flow. 2. Identify which of those data fields are accessible 3. Understand how to overcome accessibility restrictions.	Yes	M9	WINGS COEL GOLD AIA CERTH
Definition of the tracking equipment	No	M9	WINGS
OBU and sensor testing	No	M12-M14	WINGS
Integration of HPCS with GoldFreight and AODB	No	M10-M4	WINGS COEL GOLD AIA

Once preparatory activities have been performed, Greek UC will start running to reach its "quick win" solution by Month 12. Task 2.*1 Development planning, coordination & knowledge exchange* (M6-M28) and Task 3.1 *Planning, setup of field trials and operational management* (M13-M27) will further define in detail the required preparatory activities.

4.2.3 Use Case business scenario

4.2.3.1 Quick win solution

By Month 14, the Greek UC trial site will be in position to offer a real-time freight/cargo data sharing from the Port to the Airport. This will increase visibility and transparency during freight transport. A hub for enabling data sharing from COSCO ERP to GoldFreight will also have been developed. The system/dashboard UI will be integrated into the GoldFreight legacy system. The specification of the services that we will provided are:

- Service that allows warehouse handlers (GOLD) to know the ETA of a cargo at the warehouse, as well as the type, volume, destination, content, customs status etc.
- ML model(s) that will optimize task planning in the airport warehouse, thus reducing idle/waiting times of trucks and cargo.
- Integration of an On-Board Unit (OBU) with IoT-enabled sensors on a truck, for monitoring freight status, truck real-time location, and average speed for calculating the ETA.

Functionalities envisaged by Month 12 are:

- Develop a system that will share real-time freight data between port & airport stakeholders.
- Use forecasts to calculate the Expected Time of Arrival at the airport's warehouse.
- Dynamic task scheduling for the airport warehouse handlers, taking into account the cargo's real-time location, individual features (e.g. for special condition cargo) and current flight schedules.

4.2.3.2 Early drop solution

By Month 16 the Greek UC will have achieved the next level of implementation with its “early drop” stage. This will include: (i) initial End-to-End integration between COSCO/Goldair legacy systems (i.e., COSCO ERP/ORIAN & Goldfreight); (ii) integrated data ingestion, processing and exposure to user (iii) first draft (design) of the AI-based (dynamic) scheduling solution in Goldair warehouse; (iv) truck OBU-based monitoring feature. Above features comprise the following services:

- Real-time or near real-time data/messages flow from Cosco ERP to Goldair's WMS (Goldfreight).
- Real-time location and cargo monitoring during travelling from Piraeus Port to the Athens International Airport.

Functionalities offered by this “early drop” solution will be:

- Real-time monitoring & awareness of freight coming from Piraeus Port.
- Estimated Time of Arrival (ETA) calculation will be available via the monitored and processed OBU-based incoming information, as well as additional WINGS Chariot's backend processing features
- Provision of awareness & transparency regarding the characteristics of incoming freight (e.g. volume, destination, airlines booking number, freight type, special cargo status etc.).

4.2.3.3 Final solution

Final solution implemented by Greek UC will include:

- Automated customs clearance – electronic document exchange.
- Real-time monitoring of container location (port-to-airport transportation).
- Container arrival prediction at airport warehouse.
- Automated/remote flight booking.
- AI-based proactive planning of airport warehouse operations.

4.2.4 Expected challenges

The main challenges identified for the implementation of Greek trial site are summarized in Table 4-14:

Table 4-14: Greek UC challenges

Challenge	Measures to overcome it	Partner (s) responsible	Date expected
Integration of the Greek T&L observatory Data platform	Development of specific FENIX connectors	CERTH	M14
Partners/legacy system owners exposing all required data into the Greek UC FOR-FREIGHT backend instance	Define the specific data required to be provided by each partner/legacy system owner	All Greek UC partners involved	M14
Accessing Piraeus Port and Athens Airport Legacy systems	Bilateral, as well as UC-level technical meetings to define requirements and technical specifications for the integration among the involved legacy systems.	WINGS	M14
AODB limited interoperability	Development of an API	AIA	M14
Limited access to COSCO ERP, HPCS and ICISnet	Bilateral, as well as UC-level technical meetings to define requirements and technical specifications for the integration among the involved legacy systems.	COEL	M14
Incompatibility of GoldFreight and Airline systems with multimodal transportation	Bilateral, as well as UC-level technical meetings to define requirements and technical specifications for the integration among the involved legacy systems.	GOLD	M14

The measures to overcome these technical challenges have their image on the specific set of activities that will be implemented in Greek trial site. The main responsible partner of developing each of those tasks has been also defined.

4.2.5 Implementation Plan

We have designed an implementation plan that comprises the activities of the Greek UC. This is fully aligned with the overall project implementation plan. Preparatory activities will correspond with *T1.4 FOR-FREIGHT solution architecture & design* (M4-M12) and *T2.4 Sea Port –Airport solution development, integration and testing* (M8-M28). The execution phase of the trial correspond to T3.4 Sea Port-Airport trials (M13-M38).

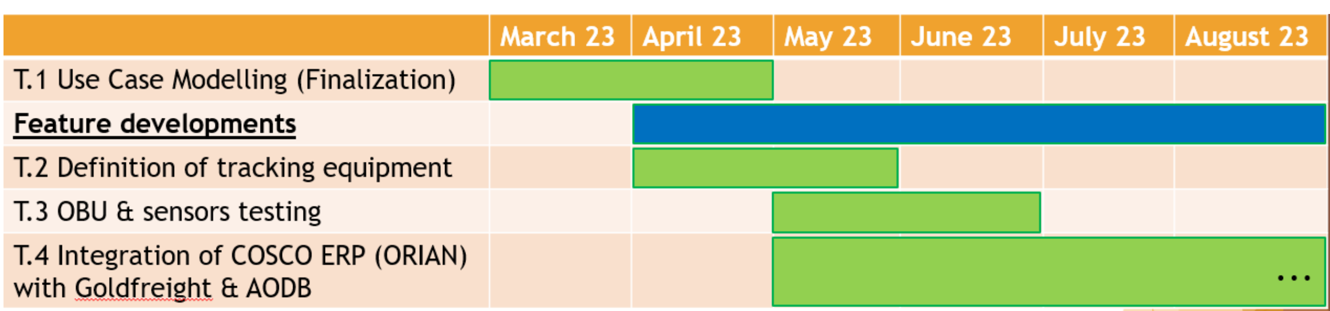

Figure 4-13: Greek UC Implementation Plan

After the implementation, unit and system testing activities will take place until the complete first "quick-win" solution, to be available on M16.

4.3 Use Case 3: Galati (RO)

Use Case 3 is based in Romania and combines Danube Galati Port and rail transport. The target is to combine information from all individual management systems (supplier, shipping agent, port authority, terminal operator, warehouse, railway operator) to allow: i) access to fluent and accessible information on transport flow and ii) optimization of resources. FOR-FREIGHT solution in the Romanian UC will integrate:

1. Information from the legacy individual management systems of involved stakeholders as well as data that is currently paper-based and non-digitalized.
2. Equipment: telemetry on Barges, pushers, railway wagons, sensors, GNSS trackers, IoT gateways, smartphones.
3. Intelligence provided by Digital Twins, 4G/5G/WiFi, IoT sensors and AI.

The defined scenario comprises a container transported by NAVROM, 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.

4.3.1 Refinement

4.3.1.1 Process Flow: AS-IS vs TO-BE

Aligned with the methodology followed in the other two UCs, the first step in for the redefinition of the Romanian UC has been mapping the current process flow and compare it to the optimized scenario that will be achieved with FOR-FREIGHT implementation. Existing process of transfer of goods from vessels to railway is not a continuous, logically integrated process, but a fragmented one pursued by independent operational systems of the various actors involved. There is no synchronization between loading and unloading and handling activities, resulting in severe delays in the railway running schedule and extra costs. In addition, intensive manual labor is still required for transshipment which results in inefficient use of resources. Low digitalization and a lack of historical data increase the impossibility of a common operational picture.

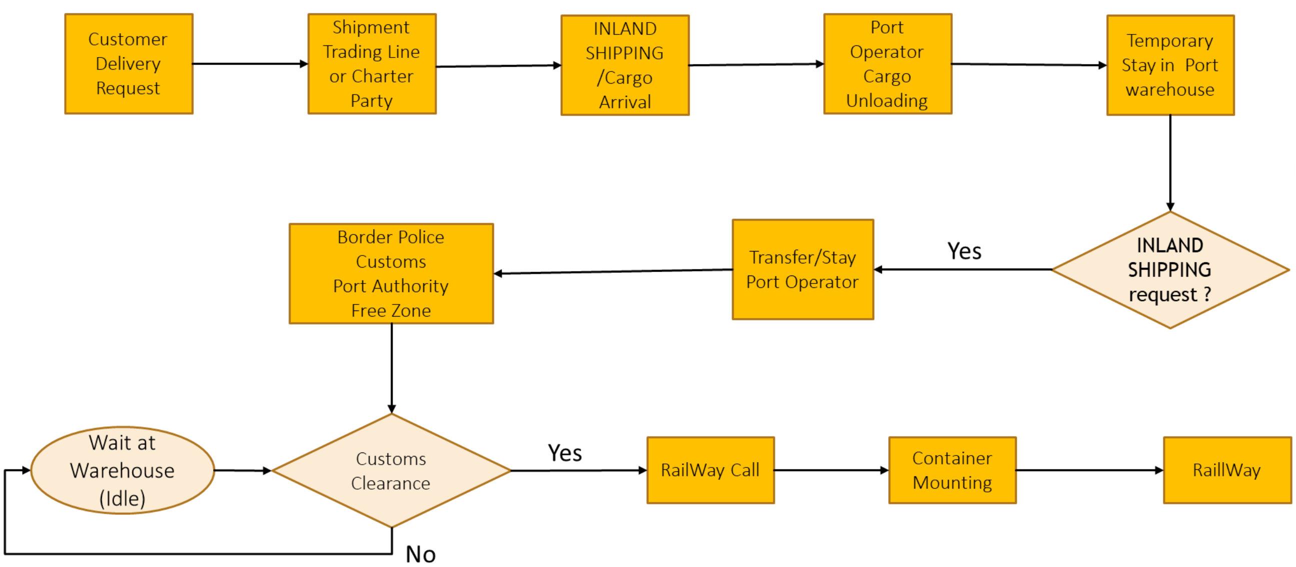

Figure 4-14: Romanian UC physical process flow

Romanian UC main target is to effectively connect all those disconnected elements and achieve a continuous process flow as shown in Figure 4-14. In this UC there is no possible comparison between the AS-IS and the TO-BE scenarios, simply because there will not be any substantial change in the physical process, rather than its improvement through the connection among stakeholders.

The main bottlenecks within the process flow in Figure 4-14 have been identified: end-to-end capacity, loading/unloading time, routing errors, accidents, container idle time and document digitalization. Each of those conflictive areas has been assigned a specific KPI to be met during the trials. As with the rest of the UCs, original KPIs defined in the proposal, have been analyzed and redefined. Table 4-15 shows the result of that analysis and refinement:

Table 4-15: Romanian UC KPIs

KPI ID	KPI target	KPI description	Baseline description
RO1	>20%	Increased end-to-end capacity due to optimization of resource utilization	Improve existing capacity utilization
RO2	>20%	Decrease loading/unloading time	Loading /unloading time in the terminals
RO3	>20%	Reduction of routing errors	Errors, accidents and error caused
RO4	>30%	Reduction of accidents	Errors, accidents and error caused
RO5	>20%	Reduction of the container idle time	Container idle time at the port
			ITU Dwell time in port
RO6	>15%	GHG emissions	Fuel quantity
RO7	80%	Document digitalization	There is no digital communication infrastructure between Port and railways

4.3.1.2 *Information flow: AS-IS vs TO-BE*

The existing information flow in the Romanian UC is highly fragmented and disconnected. Actors involved in data sharing are:

- External stakeholders: customer, Customs, Port Operator, Shipping Agency, Romanian Railway Company.
- Internal stakeholders: NAVR, BEIA, TCCFR.

Table 4-16 shows the information shared the stakeholders sharing it and systems used and the format:

Table 4-16: Romanian UC information flow analysis

Stakeholders	Data	Source (from)	Destination (to)	Via (legacy system)	Owner of the via	Format
Customer Shipping Ag.	Order request	Customer	Shipping Ag.	Email/phone	-	Email/phone
	Acceptance	Shipping Ag.	Customer	Email/phone	-	Email/phone
NAVR Shipping Ag.	Cargo request	Shipping Ag.	NAVR	Email/phone	-	Email/phone
	Acceptance	NAVR	Shipping Ag.	Email/phone	-	Email/phone
	Cargo Data	NAVR	RORIS	RORIS	NAVR	XML
	Vessel arrival notice	NAVR	Shipping Ag.	Email/phone	-	Email/phone
Shipping Ag. Port Operator	Request cargo operations	Shipping Ag.	Port Operator	Email/phone	-	Email/phone
	Acceptance	Port Operator	Shipping Ag.	Email/phone	-	Email/phone
	Vessel arrival notice	Shipping Ag.	Port Operator	Email/phone	-	Email/phone
NAVR Customs	Customs clearance order	NAVR	Customs	Email/phone	-	Email/phone
	Customs clearance acceptance	Customs	NAVR	Email/phone	-	Email/phone
Shipping Ag. Railway	Order request	Shipping Ag.	Railway	Email/phone	-	Email/phone
	Acceptance	Railway	Shipping Ag.	Email/phone	-	Email/phone
	Cargo data input	Railway	IRIS	IRIS	TCCFR	E1

As Figure 4-15 shows, two main information silos exist at the moment: port and railway. The railway does not receive any feedback from any of the events taking place in the port area. Cargo data input is only received by the software platform owned by NAVR (RORIS), but not shared with the rest of the actors involved. The same occurs with the railway cargo data, which is only fed into the IRIS system, but not shared with anyone else, making the process of freight transport by rail totally invisible for the rest of stakeholders. In addition to the disconnection of the actors involved, most of the task performed in the information flow are manual, such as the request/acceptance to the shipping agency or to the rail company which depend on a phone call. Another example in this sense, is the position of the train being transmitted by radio from the engineer to the signalman at the station and by IRIS system between the signalman and the Traffic Command Center, by entering data into the system from each station, after train has passed.

The two legacy systems in place (RORIS and IRIS) are both closed circuit systems that belong to the companies operating them, NAVR and Romanian Railway Company respectively. Access from any external stakeholder is not allowed. For this reason, they will be advisory platforms, which could be extended beyond the T&L chain of the FOR-FREIGHT. None of them has historical data on port nor rail operations that could be fed into FOR-FREIGHT. With all these limitation as a starting point for the Romanian UC, a second alternative (scenario B, Figure 4-16) is being studied in which the RORIS closed system may be replaced by the euRIS platform where the sharing of information shared can be personalized and managed. euRIS platform would automatically share and manage information with customer, shipping line, shipping agency and Port Operator regarding route planning, vessel position, traffic images or expected arrival time among others. Figure 4-16 shows the improvement in the connection among stakeholders that euRIS would allow.

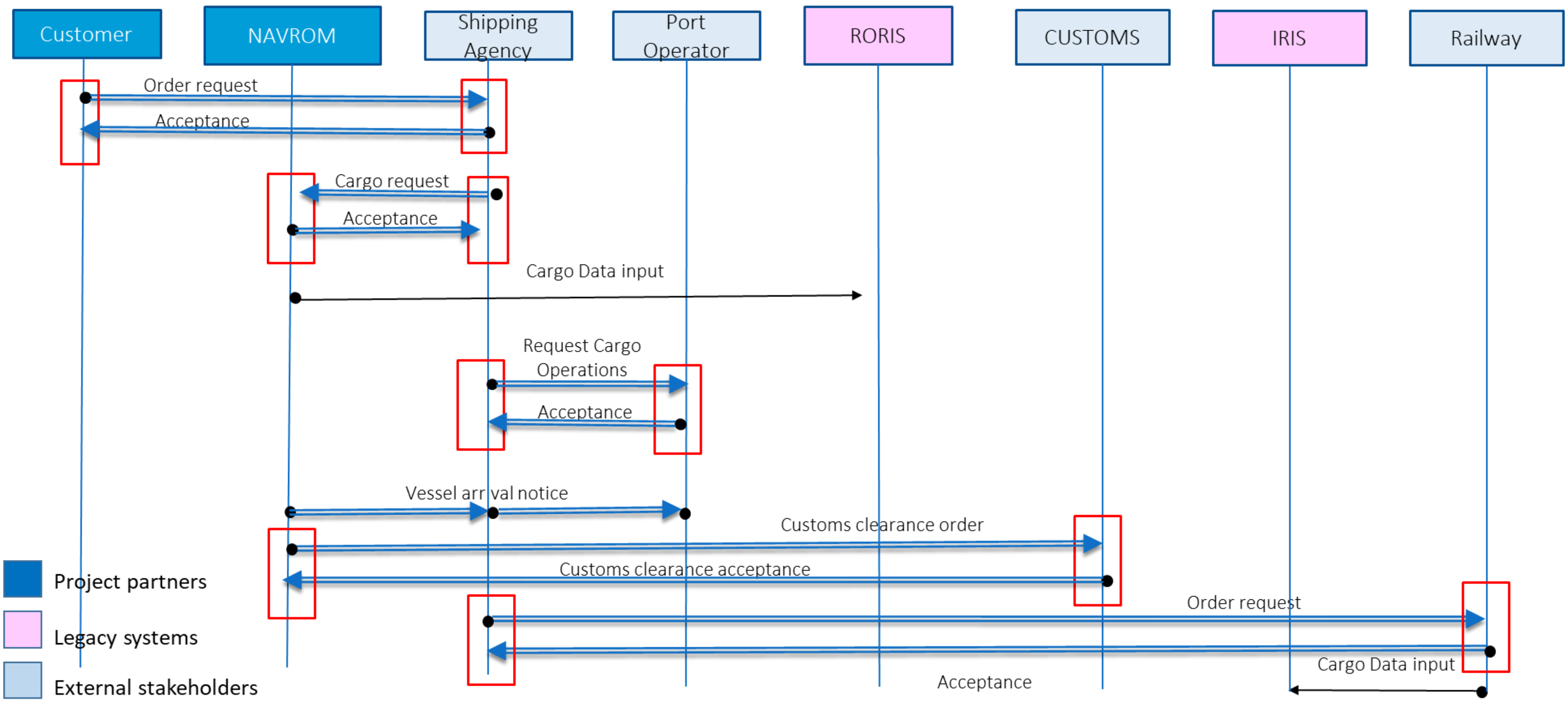

Figure 4-15: Romanian UC information flow (scenario A)

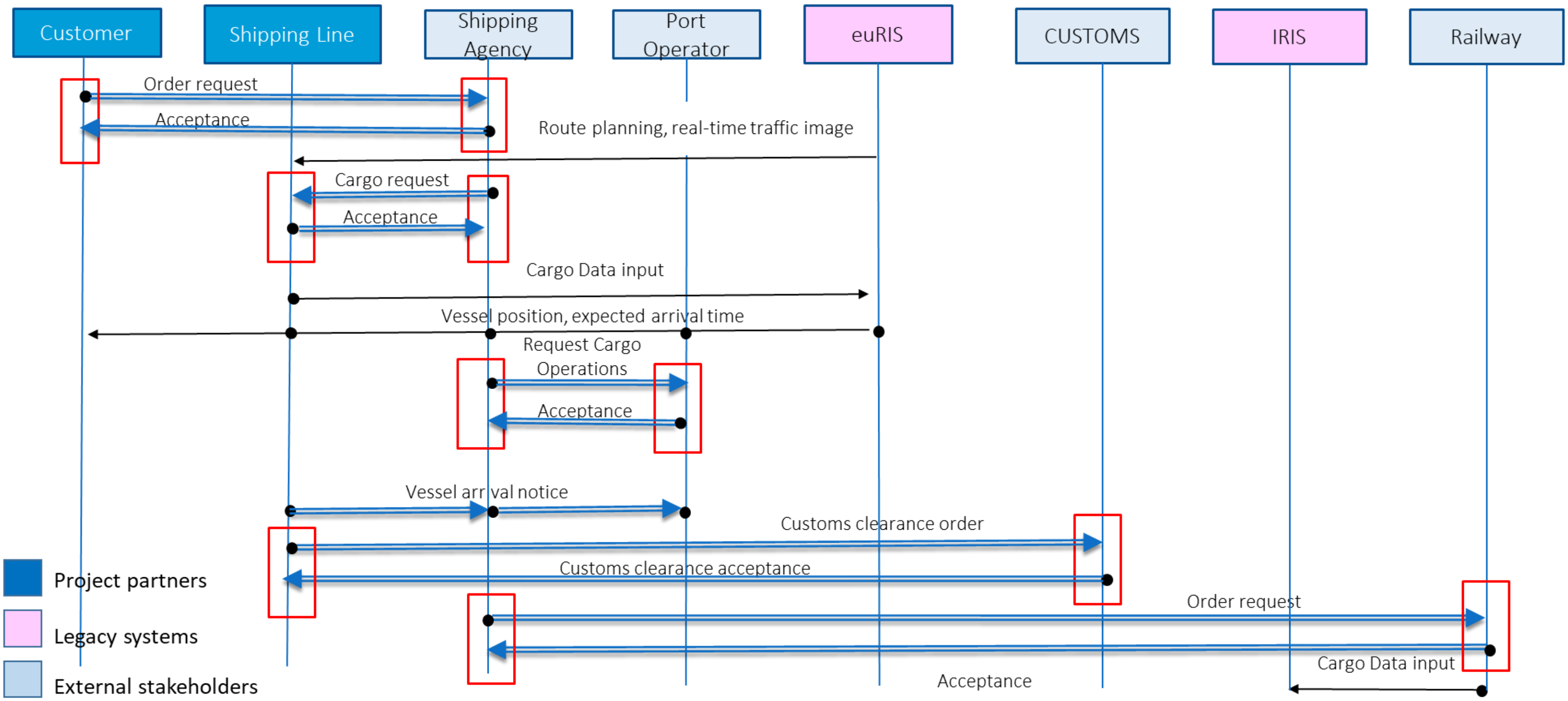

Figure 4-16: Romanian UC information flow (scenario B)

The TO-BE scenario, with FOR-FREIGHT in place will:

1. Integrate in a single place, with a common language the information that currently is not shared by different systems and stakeholder. This includes available historical data.
2. Integrate the real-time data generated by sensors, IoT gateways, GNSS trackers for freight tracking.

As a result of those integrations, FOR-FREIGHT will:

3. Allow real-time door-to-door tracking of the whole process.
4. Provide notification and advice from DSS to the port authorities and rail operators.
5. Automate several tasks such as ETA updating and reservation of railway using a unique cargo ID, based on ETA.

4.3.1.3 Functional requirements

As in the rest of the UCs, the first functional requirement identified for the Romanian UC are connected with data transmission. It is necessary to develop a translator to unify the formats of the different data input that will be fed into FOR-FREIGHT: RORIS system with XML format, IRIS system with E1 format, historical data, IoT sensors and GNSS trackers data. Another common functional requirement will be the different levels of security and accessibility of that data for the actors interacting with FOR-FREIGHT. With automated data exchange achieved, these are the rest of the functionalities expected in the Romanian UC:

- Automatic ETA update of the ship in the port of Galati.
- Full view of the end-to-end process to users, including real-time door-to-door tracking.
- 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.
- Automatic reservation to railway companies, using a cargo ID, based on precise 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.

Table 4-17 summarizes functional requirements (FR) that FOR-FREIGHT will allow in the Romanian UC and their connection with the project KPIs.

Table 4-17: Romanian UC Functional Requirements and project KPIs associated

FR ID	Data format unification	Project KPIs associated
RO-FR1	Translation of data to a common format.	-
RO-FR2	Real-time and historical data integration.	
	Accessibility management	
RO-FR3	Integrate different UI for different actors.	-
RO-FR4	Allow different levels of accessibility/authorization.	
	Automation of information exchange	
RO-FR5	Automated ETA update of the ship in the Port of Galati.	**RO3:** 20% reduction of routing errors. **RO4:** 30% reduction of accidents. **RO7:** 80% document digitalization.
RO-FR6	Real-time monitoring of freight locations and conditions.	
RO-FR7	Automated railway booking.	
	Planning and management resources	
RO-FR8	Container arrival prediction at Port.	**RO1**: 20% increased end-to-end capacity due to optimization of resource utilization.
RO-FR9	Suggestions on resource planning provided to the port authorities, the logistics operator and customs agencies.	

RO-FR10	Notifications and advice to the rail freight operators on storage space and resources forecast.	**RO2:** 20% decrease loading/unloading time. RO5: 25% reduction of the container idle time. **RO6:** 15% reduction GHG emissions.

Romanian first FR follow the same pattern as the Greek and Spanish UCs: RO-FR1 to RO-FR4 are directly connected with the need of different types of data integration and format unification as well as the security levels. Achieving these FR is essential to reach of the FR defined in table 4-17. RO-FR5 to RO-FR7 concern automation of information exchange and are will be mostly based on ETA update automation and the real-time data provided by sensors. The project KPIs they are connected with are RO2, RO3, RO4 and RO7, related to errors and accidents reduction and increase digitalisation. RO-FR8 to RO-FR10 refer to forecasting capacity based on DSS and as a result of the data integration. These FR are connected with the achievement of the RO1, RO2, RO5 and RO6 KPIs which refer to the overall end-to-end capacity and GHG emissions. During the analysis and refinement of the Romanian UC, we have made sure that all these FR here defined are not only connected with the proposed project KPIs, but also meet all the mid-term expected outcomes (EO1-EO6) and long-term expected impacts (EI1-EI4) defined in Annex 2.

As a conclusion from the above, the Romanian UC refinement carried out in the present deliverable will be able to solve the specific trial pains defined in D1.1 and allow the optimisation of river port-train multimodal and multi-stakeholder freight transport.

4.3.1.4 Technologies selected

The Romanian UC also requires the integration of technologies and equipment into FOR-FREIGHT platform to allow the functionalities defined in the previous section. The integration of equipment will allow monitoring and tracking critical areas that now are uncovered such as the cargo real-time and location in the port. The integration of the different technologies will make that data visible and, along with the historical data integrated, provide advice through a DSS to the necessary actors involved. The general categories of the selected technologies and their functions in the Romanian UC are:

- IoT sensors and video cameras: for real time tracking.
- AI/ML: 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, resource utilization.
- Digital Twins: to increase efficiency of present operational through real-time data availability and shipment visibility.
- 4G/5G/WiFi: end-to-end communication and interconnection of the diverse systems participating in the overall operations.
- Blockchain: for supply chain governance.

The following components will also be integrated to gather data currently unattended:

- Telemetry systems on railway wagons.
- Telemetry systems on barges/pushers.
- IoT sensors for container tracking (cargo status, freight integrity, location).

All these technologies will be incorporated to FOR-FREIGHT solution using previous developments from EC-Horizon projects (TRL>6) or commercially available components. BEIA will provide IoT sensors and video cameras developed in VITAL-5G project. NAVR and TCCFR will bring the 5G commercial coverage from VITSAL-5G and iNGENIOUS projects. ML models for demand and lead time forecasting are available from the Greek partner CERTH in case they are required.

Table 4-18 summarizes the technologies and components that will be integrated for the development of FOR-FREIGHT in the Romanian trial site. Their availability, current state of development (TRL) and connection with the Functional Requirements is also defined.

Table 4-18: Romanian UC SotA technologies and systems connected to Functional Requirements

Technology	Partner	Systems/Devices/Infrastructure	Link with Other Projects	Status	TRL	FR
IoT	BEIA	Monitoring Sensors (OBU sensors)	VITAL-5G	Available	7	RO-FR2 RO-FR3 RO-FR6
5G	NAVR, TCCFR	5G commercial coverage	VITAL-5G, iNGENIOUS	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

The incorporation of these technologies will enable the development of the functionalities defined for the Romanian UC. This will allow the integration of historical data, real-time tracking data, and legacy systems into FOR-FREIGHT solution, allowing interoperability of rail and port processes and the optimization of resources.

Table 4-19summarizes the connections among specific Romanian UC FR, project KPIs, technologies applied, mid-term expected outcomes (EO) and long-term impacts (EI). The detailed list containing the definition of EO, EI and their associated eoKPI and eiKPI can be found in Annex II: KPIs and Objectives.

Table 4-19: Romanian UC project KPIs and technologies applied connected with mid-term EO-long-term EI

Project KPIs				Mid-term- expected outcomes			Long-term expected impacts	
KPI ID	KPI target	KPI description	Technology applied	Expected Outcome-EO	eoKPI ID	General EO	Expected Impact-EI	eiKPI
RO1	20%	Increased end-to-end capacity due to optimization of resource utilization	Digital Twin IoT 5G AI/ML	EO1 EO2 EO4	eoKPI.1.1 eoKPI.4.5 eoKPI.7.1	EO6	EI1 EI2 EI3 EI4	eiKPI.11.1 eiKPI.12.1 eiKPI.12.2 eiKPI.13.1 eiKPI.14.1 eiKPI.15.1
RO2	20%	Decrease loading/unloading time	IoT AI/ML	EO1 EO3	eoKPI.1.4 eoKPI.5.1			
RO3	20%	Reduction of routing errors	Digital Twin IoT 5G AI/ML	EO1	eoKPI.2.2			
RO4	300%	Reduction of accidents	Digital Twin IoT 5G AI/ML	EO3 EO5	eoKPI.2.2			

RO5	25%	Reduction of container idle time	AI/ML IoT Digital Twin 5G	EO2 EO5	eoKPI.4.1 eoKPI.9.2 eoKPI.9.4			
RO6	15%	Reduction of GHG emission	Digital Twin IoT 5G AI/ML	EO1	eoKPI.3.1			
RO7	80%	Document digitalization	Digital Twin AI/ML	EO3 EO5	eoKPI.6.1 eoKPI.9.4			

4.3.2 Preparatory activities

A set of preparatory activities that will enable the start of the Romanian UC have been defined. These activities are presented in Table 4-20 and classified as blocking/no blocking for the trial to begin as well as the partners involved in them and the month of completion.

Table 4-20: Romanian UC preparatory activities

Preparatory activity	Blocker (Y/N)	Month	Partners involved
Meetings to: 1. Detail Romanian stakeholders' mode of operation of Galati port and the railway. 2. Study the feasibility of euRIS integration.	Yes	M9	All partners from Romanian UC
Checking the data infrastructure that will support the FOR-FREIGHT platform	Yes	M9	
Definition of technologies from third parties, external to the Romanian UC.	Yes	M9	
Definition of the different levels of security	Yes	M9	
Definition of the historical data to be fed into FOR-FREIGHT (type, time range, format)	Yes	M9	
Definition of the specific administrative manual tasks that will be digitalized/automated.	Yes	M9	

4.3.3 Use Case business scenario

By Month 12, the Romanian UC trial site will be able to offer a "quick win" level of implementation of FOR-FREIGHT solution. The development of a common platform and infrastructure foe enabling data sharing from

NAVR to railway operator will be achieved as well as real-time freight/cargo data sharing from river port to the railway operator. The specific services provided by this "quick win" solution will be:

- Provide an infrastructure and services that allows all stakeholders to check and access the relevant data, to monitor their processes and ensure the transparency between T&L chain.
- AI models that could estimate and offer forecasts through different inputs.
- Implement IoT sensors/devices to monitor status/location of freight containers and trains in real time.

Functionalities expected are:

- Increase a document data system will deliver a decentralized way of sharing data and documents between stakeholders.
- Use forecasts and predictions to anticipate potential issues or disruptions.
- Real-time situation of the port and railway, allowing a more accurate view of the processes and improving decision-making.

4.3.4 Expected challenges

The main challenges identified for the implementation of the Romanian UC are shown in Table 4-21:

Table 4-21: Romanian UC challenges

Challenge	Measures to overcome it	Partner (s) responsible	Date expected
Partners feeding all the required historical data when available.	Define the specific data required to be fed by each partner and the level of security required	All partners involved in Romanian UC	M9
Lack of historical data from some partners	Collecting data during the project. Data obtained from commercial data bases	All partners involved in Romanian UC	M12
Legacy systems inaccessible to other stakeholders.	Development of a new system/dashboard integrated into FOR-FREIGHT.	All partners involved in Romanian UC	M12

4.3.5 Implementation Plan

An implementation plan for the Romanian UC has been defined. This is fully aligned with the overall project implementation plan. Preparatory activities will correspond with *T1.4 FOR-FREIGHT solution architecture & design* (M4-M12) and *T2.3 River Port – Rail solution development, integration & testing* (M8-M28). The execution phase of the trial corresponds to *T3.3 River port - Rail trials (M17-M37).*

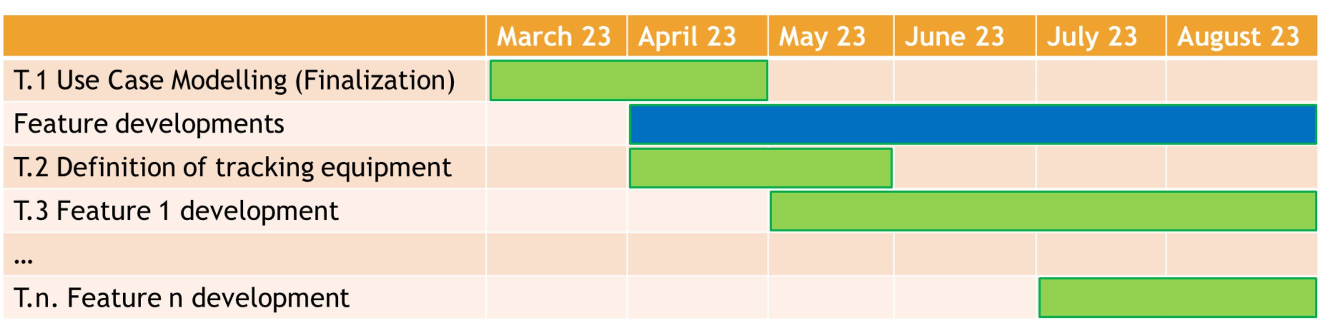

Figure 4-17: Romanian UC Implementation Plan

5 Societal and environmental impact and EU standards compatibility

In order to build an understanding of the framework conditions for a social and sustainable transition in the freight transport sector and how the innovations of FOR-FREIGHT correspond, we first dive deeper into the European and national regulatory framework relevant to the use case with Policy Scan section. Subsequently, in section Impact Scan, we outline the possible areas of impact from the innovations developed in FOR-FREIGHT, which will be further developed and refined in WP4.

5.1 Policy Scan

5.1.1 Use Case 1: Spanish trial

Along with innovating a digitalization process, the Spanish Use Case will develop an innovative last mile delivery service using a Subway-Based Network last-mile, shifting from urban road transport.

EU Regulations

There have been many new developments on the EU level to push forward economic and ecological sustainability in freight and logistics, most notably for this use case, the Combined Transport (CT) Directive (Council Directive 92/106/EEC) [1] and Trans-European Transport Network (TEN-T) (Regulation (EU) 1315/2013) [2]. The CT Directive aims to foster a shift from road transport to lower-emission transport modes thereby liberalising regulations on cabotage as well as utilizing fiscal incentives for specific CT operations. The TEN-T Programme was established by the European Commission to support the construction and upgrade of transport infrastructure across the EU. In 2021, a legislative proposal (COM/2022/384) [3] was adopted to amend the original TEN-T programme to align better with policy objectives in the European Green Deal and Sustainable and Smart Mobility Strategy, comprising four main aims:

1) Facilitate an increase in the share of rail, short sea shipping and inland waterways in view of a more sustainable modal composition of the transport system through infrastructure improvement
2) Foster multimodality and interoperability between the TEN-T transport modes and better integrating the urban nodes into the network.
3) Increase the resilience of TEN-T to climate change and other natural hazards or human-made disasters and support climate-neutrality by integrating the costs of greenhouse gas emissions in the cost-benefit analysis
4) Improving the efficiency of the TEN-T governance tools

The legislative proposal was again under review in 2022 in order to strengthen transport lines between the EU and Ukraine, thereby also extending TEN-T projects in neighboring EU countries, and is currently awaiting a decision.

Spanish National Regulations

In Spain, the Land Transport Planning Law (LOTT, "Ley Organica del Transporte Terrestre") and the accompanying regulatory framework (ROTT) largely regulate land transportation including, road freight transport (RFT). RFT has long dominated the Spanish inland freight transport industry, most recently accounting for 95% of inland freight transport in 2019, followed by rail at nearly 5%, and fluvial transport almost non-existent (CNR, 2020a). RFT transport in Spain is also made up most of the increase in emissions of freight transport since the 90s, thus it is also of particular relevance in the context of the Green transition [4].

Over the last few years, big reforms and modernizations in the land transport regulation have been underway. The reforms encompassed measures to modernize the Spanish road freight transport and make it more competitive. Modifications accepted in 2020 included requirements for (1) digitalizing authorization procedures in order to streamline inspection services, (2) stricter requirements for education and professional certification to work in the industry, (3) reduction of restrictions on age of new fleets, (4) stricter employment requirements and legal responsibilities for the Transport Manager, and (5) stronger penalties for excess weight and violations in driving/resting time ratios. Most recently, the Royal Decree Law 3/2022 (BOE-A-2022-3290) [5] stipulated mandatory changes in price of road transport contract in line with variations in the price of fuel, in light of volatile energy prices. It also stipulates that truck drivers are no longer allowed to participate in loading/unloading operations, with a few exceptions, and that this responsibility lies with the shipper and the consignee [6].

5.1.2 Use Case 2: Greek trial

The Greek Trial seeks to align all stakeholders involved in the end-to-end process in order to optimize the transportation and shipping process. Currently, one cargo is identified by a multitude of IDs because every stakeholder uses different proprietary management systems. Specifically, in the Greek Trial, the solution is to digitalize the data and provide a real-time position of the cargo, as well as automated booking of airline reservations and the calculation of estimated arrival times, thus a full view of the end-to-end process.

EU Regulation

Especially important for digitalizing the multi-model freight transportation sector, is the EU regulation eFTI (2022/1065) [7] which should be implemented by 2024. Its aim is the digitalization of transport documents, harmonising access procedures, rules and technical specifications and third-party certification EU-wide. This includes port to airport freight transportation and the regulation is currently implemented in Greece. Electronic freight transportation will not only reduce administrative costs and enhance the efficiency of transport, but it is also aimed at increasing the sustainability of transport. In Greece specifically, there are different projects in place aiming at implementing the regulation. Beyond the eFTI regulation per se, there are others EU regulations who play a role in the implementation of digitalizing and optimizing freight transportation.

Greek National Regulations

The Transport & Logistics Industry in Greece is one of the most important sectors for the national economy according to the International Freight Centre. The income it generates reaches 10.85% of the GDP, especially maritime transport plays an important role with the Greek-owned merchant fleet being the largest in the world, accounting for 15,6% of the global fleet in deadweight tonnage (DWT), in 2018 nearly 5,65m TEU were handled at Piraeus. Piraeus is the largest sea port in Greece and has the capacity to handle over 7,5m TEUs. The port is located in a crucial geographical position - in the southeast of Europe, thus being the central port in connecting Europe, Asia and Africa. The shipping and maritime logistics alone contribute 6,6% to the country’s GDP. Especially Piraeus has seen a lot of growth in the recent years and aims to be a state-of-the-art logistics hub and the south gate of Europe. More than 3.3million TEUs (twenty-foot-equivalent unit) were handled at the port’s container terminal. The increased maritime freight transport impacted the air and road freight transport in a positive way [8].

Greece provides a full range of supply chain services and distributing freight per trucks and airplanes. Road freight transportation is one of the most developed networks in Southeast Europa, consisting of more than 2,145km of highways and motorways, and had a share of 26% of the total road freight transportation in terms of tonnes-kilometer and is thus significantly below European average. Nevertheless, Greece ranked 11th among the EU countries with 354m tonnes being transported [8].

Air freight transport in Greece has a share of 35% of international trade in terms of value but it is rapidly expanding – with 45 airports, the most important one being “Eleftherios Venizelos” Athens International Airport (AIA), there is the potential for its emergence as a passenger and logistics hub for Southeast Europe. 88.3% of the total air freight passes through AIA [8].

5.1.3 Use Case 3: Romanian trial

According to **The Romanian road freight transport in 2020**, Romanian sector is one of the most active sectors in the European Union when it comes to long-distance international transport [9]. It operates mainly in Western Europe and transports more than 30% of goods between third countries, with cabotage representing 7% of the total volume. In 2004, the **Ministry of Transport** (main actor in regard to transport in Romania) estimated that 30% of the network had only 2% tkm and 8% pkm.

EU Regulation

In Romania, 1,000 stations generate fewer than 50 trips per day and 533 stations have fewer than 10 passengers per day [10]. In 2020, the mileage of vehicles decreased compared to 2017. This is mainly due to the fact that drivers returned to their location more frequently due to road controls and the pressure exerted by Western European countries under the EU Mobility Package. Gross wages of Romanian drivers increased also from less than €400 to €565 in three years, a direct result of the doubling of the minimum wage between 2016 and 2020 [9] under the EU's Mobility Package. With the EU mobility package, there are in general expensive changes in international transport across Europe as a result of political decisions to introduce new, stricter conditions for road transport.

However, the 2019-2020 **Strategic Transport Plan** published by the **Ministry of Transport and Infrastructure** covers the period 2014-2020 (member states are required to prepare a "General Transport Master Plan") and focuses on improving the connectivity of trans-European transport networks through the development of the TEN-T transport infrastructure network (the network covers 20% of the Romanian rail routes length). The establishment of a comprehensive and efficient transport system (cost-effective, sustainable, safe and with a reduced impact on the environment), the modernisation of existing infrastructures and the 45.45€ billion investments in all-mode and intermodal transport projects [11].

Romanian National Regulations

The Ministry is working on a number of projects, especially highways, to connect the main economic centers of the country. The priority areas are Sibiu-Pitesti, Sibiu-Brasov, Brasov-Bacau, Targu Neamt-Pascani-Iasi-Ungheni, Brasov-Comarnic, Pitesti-Craiova and Suplacu de Barcau-Bors. These highway projects involve the construction of almost 1,095 km of new roads, 118 km of which are in mountainous areas, with a budget of almost 10 billion euro [9].

The network is mainly maintained by the state-owned infrastructure company CFR-SA (Compania Naţională de Căi Ferate). The rail freight market has been open to private undertakings since 2001. In 2012, the (then 19) private operators had a market share of 55 %. The incumbent public operator (CFR Marfă) is to be privatised by 2016 at the request of the International Monetary Fund. The main challenge facing the sector, which is the eighth largest in the EU, is the modernisation of the existing network to improve speed and punctuality in order to restore the attractiveness of rail transport for both passengers and freight. **The National Rail Package** includes the construction of certain missing sections of the network and the electrification of most of the existing network by 2029 [9]. In 2015, **The Romanian General Transport Master Plan and Rail System** states that the state is disrepair is advanced and maintaining the existing rail network would not be affordable (European Parliament 2015). The Romanian Ministry of Transport claims that the deterioration is due to lack of money. Further, the situation is also due to poor management and operating practices. However, The Master Plan therefore suggests channelling the available resources towards the main lines.

The development of maritime transport is an important part of the strategic plan, which aims to modernize the maritime infrastructure at the country's main ports (Constanta, Galati, Giurgiu, etc.) and to improve links between the Danube river network and the Black Sea. The plan also provides for the establishment of multimodal services in the country's main airports and the development of regional airports to ensure improved accessibility to rural areas [9].

5.2 Impact Scan

Transparency, Monitoring & Evaluation of freight movement

Obtaining good-quality data on the combined transport sector has been a long-standing issue, inhibiting both business and policy stakeholders from conducting in-depth analyses and making evidence-informed decisions or policies [12].

The cloud-based platform that is to be developed in FOR-FREIGHT will essentially function as a coordination system among the different data systems of businesses and organizations at each multi-module freight hub. A key element to be integrated into the platform is the use of real-time data ranging from freight operation movements to external factors influencing freight movement (e.g. weather). Moreover, the three Use Cases provide solid testing grounds for the implementation of the platform in multiple contexts. Thus, the platform has a high potential to improve data collection and management on freight movement at micro scale, thereby providing a possible solution to this issue.

Labour/Worker conditions

The innovations in FOR FREIGHT also have potential for affecting labour and working conditions of workers in multi-modal freight transport. On the one hand, digitalisation offers potential to reduce human error and increase efficiency as well as workplace safety through the surveillance of workers by electronic devices, or get rid of them altogether by replacing drivers with new technologies. This will be monitored through certain KPIs in the project (e.g. reduction in accidents on multi-modal freight transport hubs). On the other hand, the work of some employees will change or even become obsolete. Low-educated workers are most susceptible to experience changes in their job through digitalisation processes in this sector, and they would require occupational re-training and upskilling, which has a higher potential for leading to job loss [13].

Thus, careful attention should be paid to the impact on employment through the development and implementation of these new digitalisation processes, to ensure fair working conditions are maintained and that workers are not left behind. This is especially important in an industry known for precarious working conditions - often times they have low wages and are seasonally employed, depending on the economic needs [14].

Urban sustainability

As transport and logistic operators look for alternative ways to deliver freight in urban areas, trams or metros are being considered as a useful transport system - as the use of existing infrastructure in cities can be a useful and efficient way to improve efficiency of distribution [15].

In the Spanish use case, the shift from road transport to subway-based network transport for the last-mile freight transportation in Madrid will likely have big implications. This offers many potential positive impacts, namely reduction in local environmental burden (e.g. noise, emissions, and traffic), reduced energy use, as well as an increase in available space and traffic safety. This transportation model is also more sensitive to changes in passenger flows [16].

Due to the complexity of changing this system, it is recommended to involve many of the stakeholders in the process. A study by Kramarz and Przybylska (2021) found that the city exerts a significant influence on the development of freight transport through its actions. According to them, there is a large gap in the perception of the logistics problem related to freight transport by the city authorities. This indicates the need to adopt measures aimed at incorporating the logistics aspects in the design or modification of urban strategies. However, implementing this process comes with difficulties: in a similar project in Barcelona and Valencia (e-tri-scooters instead of a subway-network), the biggest challenge facing this transportation transformation was getting all the correct parties to collaborate [17].

6 Conclusions

Deliverable D1.2 provides a detailed definition of the FOR-FREIGHT three UCs, based on the Legacy Systems and SotA technologies analyzed in D1.1. The results of this deliverable are closely linked and will serve as inputs for tasks T1.3, T1.4 and T3.5 as well as to subsequent FOR-FREIGHT Work Packages. This deliverable has presented a detailed analysis and definition of the three UCs where FOR-FREIGHT solution will be implemented. The methodology followed has allowed us to present a structured analysis of existing scenarios (AS-IS) regarding physical processes and information flows. By connecting the pains and challenges with the existing SotA technologies and Legacy Systems in the different UCs, we have reached a clear definition of the functionalities that FOR-FREIGHT solution will enable in each of them.

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. This has been the base upon which information exchange and Legacy Systems in the UCs have been analysed and optimised scenarios defined. A key finding in this respect has been that there is a set of general technical requirements that needs 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.

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.

KPIs originally defined, have been carefully reviewed for each of the UCs and connected to the mid-term expected outcomes (EO) and long-term expected impacts (EI). This has 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. This deliverable is the result of a co-design process that has involved all project partners who have provided their unique perspective and requirements based on their background (technology developer, vertical, SMEs).

7 References

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Annex I: Stakeholders´ Templates

Common Tool_T1.2_T1.3_T3.5

KPI Contribution

PROJECT KPIs													MID-TERM Expected Outcome			Long-term Expected Impacts	
Use case involved	Scenario (if applicable)	KPI ID (T1.2)	KPI target (T1.2)	KPI Description (T1.2)	Baseline description (T1.2)	Baseline value (T1.3)	ex-post measurement (T3.5)	Comparison baseline/expost measurement (T3.5)	Technology applied (T1.2)	Logistics process measured (T1.2)	Partner responsible for the calculation (T1.2)	Means of verification (T1.3)	Expected Outcome-EO (mid-term)	eoKPI ID	General EO	Expected Impact-EI (long-term)	eiKPI

Use Case Definition Tool

Legacy Systems

Testbed	Partner	Legacy System (as defined in D1.1)	Open questions	Answers
USE CASE 1				

Technologies

Technology	Partne	Systems/Devices/Infrastructur	Link with Other Project	Testbed	Status	TRL

Quick win & initial demo

	PREPARATORY ACTIVITIES				"QUICK WIN" solution by M12					EARLY DROP by M16				FINAL			
	What is missing to enable the start of your Use Case?	Is it already available? Y/N	From whom?	How to integrate it to enable start?	Solutions	Interfaces	Specifications of the services	Functionalities		Solutions	Interfaces	Specifications of the services	Functionalities	Solutions	Interfaces	Specifications of the services	Functionalities
UC1																	

Annex II: KPIs and Objectives

Mid-term expected outcomes (EO)	Description	General impact	eoKPI ID	eoKPI
EO1	More efficient, effective and sustainable management of goods and freight flows in (air) ports and inland terminals, taking into account all costs (economic, social and environmental) of the proposed solutions/innovations, including externalities and possible rebound effects.	1: Economic	eoKPI.1.1	Improve existing capacity utilisation by 20% Increase by 20% the Truck load factor.
			eoKPI.1.2	Increase by 20% the truck load factor.
			eoKPI.1.3	Improve by 10% the Train load factor.
			eoKPI.1.4	Increase by 20% the loading /unloading time in the terminals
			eoKPI.1.5	Increase by 15% the efficiency of the storage area, and equivalently reduce the number of empty running wagons.
		2: Social	eoKPI.2.1	Improved prediction of ETAs and delivery reliability (>15%).
			eoKPI.2.2	Reduction of errors, accidents and error caused delays by 20-30%;
		3: Energy consumption and Environmental	eoKPI.3.1	Reduced GHG emissions by15% due to more effective and sustainable management of goods and freight flows, and the use of public transport for last-mile delivery.
			eoKPI.3.2	Improve energy consumption by 20% using flexible use of last mile resources and routing optimisation.
			eoKPI.3.3	Reduce by >20% the aggregate environmental footprint of the multimodal supply chain, via effective loading and reduced idle/waiting times.

EO2	Expanded throughput of the nodes thanks to increased operational efficiency and optimised use of assets and infrastructures, without expanding the physical facilities.	4: Efficiency	eoKPI.4.1	Improved coordination efficiency, measured through reduction of the ITU Dwell time in port and airport terminals, by 25%.
			eoKPI.4.2	Improve coordination efficiency, with an over 80% load factor for the shuttle services (# of loaded units per shuttle, max # of units per shuttle).
			eoKPI.4.3	Improve collaboration efficiency, by raising the number of combined multimodal transports by more than 10%.
			eoKPI.4.4	Increased efficiency of the storage space by 15%
			eoKPI.4.5	Improved efficiency through increased accuracy of forecast planning by 15%.
			eoKPI.4.6	Improved efficiency through the reduction of the customs clearance process time by 20%.
EO3	Improved access to transhipment services at reduced costs.	5: Loading and storage Times	eoKPI.5.1	20% loading/unloading time reduction and 25% less transit storage time compared to the use of legacy systems/processes
		6. Admin & OPEX Costs	eoKPI.6.1	20% increase of document digitalization
			eoKPI.6.2	15% OPEX reduction due to the use of more efficient transport modes compared to the use of legacy systems/processes
EO4	More visible and standardised services provided within the multimodal freight transport nodes, seamlessly accessible by end users to maintain continuous door-to-door tracking of freight locations and boost shifting cargo to more	7. Accessibility	eoKPI.7.1	Single point of entry for T&L customers & end-users via the FOR-FREIGHT platform. Reduction of time to set-up an end-to-end multimodal freight transport with multiple stakeholders by 25% Real-time, door-to-door cargo tracking & conditions monitoring 24/7

	efficient and sustainable transport modes.	8: Delivery Times	eoKPI.8.1	Improve current on-time delivery ranges (from 30% - 70%) to top levels up to 85% and average by >20% compared to legacy systems and processes.
			eoKPI.8.2	Reduction by 50% the Trucks arriving at the terminal after cut-off time (10% of the Trucks) and reduction by 30% of Trucks' waiting time at the Terminals.
			eoKPI.8.3	Reduction of delivery times in urban areas 15%.
			eoKPI.8.4	Reduction of the container idle time at the port and airport by >25%.
EO5	Increased automation, digitalisation, standardisation and interoperability of processes, technologies and equipment, particularly intermodal transport units (ITUs) and cargo transport/transhipment procedures in multimodal freight transport nodes	9: Throughput	eoKPI9.1	Increased end-to-end throughput due to optimization of combined resource utilization by 20%.
			eoKPI9.2	Increased throughput rates due to the reduction of ITU idle times by 25%.
			eoKPI9.3	Increased throughput due to reduction of the customs clearance time by 20%.
			eoKPI9.4	Increased throughput due to reduction of errors/mistakes by 20% thanks to increased digitalization and standardized, interoperable procedures.
EO6	Better integration of the various freight transport nodes into overall logistic chains	10: TRL	eoKPI10.1	End-to-end integrated multimodal platform from TRL5 -> TRL7 by M28.

LONG-TERM EXPECTED IMPACT (EI)	Description	General impact	eiKPI ID	eiKPI
EI1	Upgraded and resilient physical and digital infrastructure for clean, accessible, affordable, connected and automated multimodal mobility.	11: Clean mobility	eiKPI11.1	Reduction of GHG emissions by >25% due to more effective and sustainable management of goods and freight flows and/or thousands of containers per year taken off the road.
		12: Connected and automated mobility	eiKPI12.1	>30% of T&L operational vehicles to be connected and automated in EU.
			eiKPI12.2	25% increase in offerings of integrated/combined T&L services by different stakeholders.
EI2	Sustainable and smart long-haul, regional and urban freight transport and logistics, through increased efficiency, improved interconnectivity and smart enforcement	13: Operational efficiency	eiKPI13.1	Improved operational efficiency by >30% through the optimized utilization of assets offered by the FOR-FREIGHT solution.
EI3	Reduced external costs (e.g., congestion, traffic jams, emissions, air and noise pollution, road collisions) of urban, peri-urban (regional) and long-distance freight transport as well as optimised system-wide network efficiency and resilience	14: Supply chain optimisation	eiKPI14.1	Overall supply chain optimization by >50% based on the DSS and real-time information.
EI4	Enhanced local and/or regional capacity for governance and innovation in urban mobility and logistics.	15: Connected logistics services	eiKPI15.1	>30% increase in connected logistics services by traditional and non-traditional logistics stakeholders (e.g., SMEs) with the use of heterogeneous multimodal data.