Flexible, multi-mOdal and Robust FREIGHt Transport

D1.4 FOR-FREIGHT System Architecture & Technology Specifications (Revised Version)

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[1] According to FOR-FREIGHT's Quality Assurance Process for reports:
4 months before Deliverable's Due Date: Table of Contents ready to be reviewed by WP leader/ Technical Manager/ Quality Manager
3 months before Deliverable's Due Date: 50% should be complete. Review by the Quality Manager (& Technical Manager for software).
2 months before Deliverable's Due Date: 80% should be complete. Review by the Quality Manager. (& Technical Manager for software).
1 month before Deliverable's Due Date:100% should be complete. Review by the Quality Manager and Peer Reviewers.
M: Sent to PC for Submission to the EC after addressing all comments by Quality Manager and Peer Reviewers

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Glossary of terms and abbreviations

Abbreviation / Term	Description
ABS	ALLBESMART LDA
AI	Artificial Intelligence
AIA	Athens International Airport
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
AODB	Airport Operational Data Base

API	Application Programming Interface
ATG	ASOCIATIA TEHNOPOL – GALATI
AWS	Amazon Web Services
BEIA	BEIA CONSULT INTERNATIONAL SRL
CERTH	CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CI/CD	Continuous Integration/Continuous Development
CSLS	COSCO SHIPPING LINES SPAIN SA
D	Deliverable
DHL	DHL EXEL SUPPLY CHAIN SPAIN SL
DMP	Data Management Plan
E2E	End-to-End
EAB	External Advisory Board
eBOS	eBOS TECHNOLOGIES LIMITED
EI	Expected Impact
ELK	Elasticsearch, Logstash, Kibana
EO	Expected Outcome
ES	Spanish
ETA	Estimated Time of Arrival
FFW	Freight Forwarder
FV	Fundación Valenciaport
GA	Grant Agreement
GDPR	General Data Protection Regulation
GR	Greek
GraphQL	Graph Query Language
HPCS	Hellenic Port Community System
IoT	Internet of Things
ISO	International Organization for Standardization
JV	Joint Venture
KPI	Key Performance Indicator
MDM	METRO DE MADRID SA
ML	Machine Learning

MVP	Minimum Viable Product
NoSQL	Non-relational Structured Query Language
PC	Project Coordinator
PESTLE	Political, Economic, Socio-Cultural, Technical, Legal, and Environmental
PCS	Port Community Systems
PoC	Proof of Concept
PortCDM	Port Collaborative Decision-Making
RBAC	Role-Based Access Control
REST	REpresentational State Transfer
RO	Romanian
SaaS	System as a Service
SQL	Structured Query Language
SWOT	Strengths, Weaknesses, Opportunities, and Threats
T&L	Transport and Logistics
TCCFR	TELECOMUNICATII CFR SA
TM	Technical Manager
TIC4.0	Terminal Industry Committee 4.0
TMS	Transport Management System
TRL	Technology Readiness Level
T	Task
UAT	User Acceptance Testing
UC	Use Case
UI	User Interface
WINGS	WINGS ICT SOLUTIONS INFORMATION & COMMUNICATION TECHNOLOGIES IKE
WMS	Warehouse Management System
WP	Work Package

1 Executive Summary

This deliverable provides an in-depth overview of the FOR-FREIGHT platform's updated architecture and the implementation status of its use cases across Spain, Greece, and Romania. The primary objective of the FOR-FREIGHT project is to enhance the efficiency, transparency, and reliability of logistics and freight operations through innovative digital solutions and advanced predictive models. This document highlights the significant progress made in developing key components and solvers tailored to address the unique challenges faced by each use case.

The FOR-FREIGHT platform's updated architecture and the iterative development process adopted for the solvers underscore the project's commitment to leveraging innovative technologies to address logistics challenges. Active engagement with stakeholders has ensured that the solutions developed are practical and aligned with real-world needs. As the project moves forward, continued refinement and incorporation of feedback will be crucial in achieving the overarching goals of enhancing efficiency, reducing costs, and minimising environmental impact in the logistics and freight transport industry.

In the **Spanish Use Case**, efforts have concentrated on addressing inefficiencies in port operations and logistics networks. Key solvers, such as ES_01 for predicting vessel ETA at the Port of Valencia and ES_05 for CO2 emissions predictions, are under development and refinement based on stakeholder feedback. Workshops with companies like COSCO SHIPPING LINES SPAIN SA (CSLS), DHL EXEL SUPPLY CHAIN SPAIN SL (DHL), and METRO DE MADRID SA (MDM) have played a critical role in validating these tools, ensuring they enhance operational efficiency despite some delays due to the adaptation challenges. The **Greek Use Case** has focused on integrating logistics processes to optimize transport times, fuel costs, and greenhouse gas emissions. Central solvers like GR_01, GR_05, and GR_12 provide comprehensive predictions to support better decision-making and resource allocation, with development largely on track. In the **Romanian Use Case**, the emphasis is on enhancing digital integration and coordination in water-to-railway transportation. Solvers like RO_01 for container ship ETA prediction and RO_10 for tracking container positions are being developed to improve real-time data exchange and operational efficiency. While some delays have occurred due to re-evaluations and legislative changes, these adjustments have resulted in more tailored and effective solutions.

This deliverable highlights the progress and challenges encountered thus far in developing the platform, providing a clear roadmap for future developments and emphasising the potential of the FOR-FREIGHT platform to revolutionise logistics and freight operations through advanced digital solutions.

2 Introduction

Deliverable (D) 1.4, titled "FOR-FREIGHT System Architecture & Technology Specifications (Revised Version)," is the fourth document listed under Work Package (WP) 1 "State of the Art Analysis, Use Case Definition, and Solution Design." This report outlines the architecture and specifications for the revised End-to-End (E2E) FOR-FREIGHT system, including the testing and validation methodology, and the risk assessment for solution design and development. It is based on the outcomes of Tasks (Ts) 1.3 and 1.4, with inputs from Tasks 1.1 and 1.2.

This deliverable also refers to the Implementation Objectives 1 and 3. Implementation Objective 1 involves the creation and implementation of innovative and interoperable transport and logistics (T&L) solutions that will enhance operational capacity at T&L nodes, improve the efficiency and sustainability of multimodal and transhipment services in multi-stakeholder settings while simultaneously lowering freight transport costs and minimising the environmental impact. On the other hand, Implementation Objective 3, aims to validate the FOR-FREIGHT solutions in real-world multimodal and multi-stakeholder environments using real end-user data, through meticulously designed use cases that will demonstrate the maturity and business-readiness of the solutions (TRL≥7). This validation will highlight the superior performance of FOR-FREIGHT's integrated logistics chain management—measured in terms of capacity, resource efficiency, sustainability, reduced emissions, and cost—compared to the existing fragmented logistics operations. D1.4 outlines the architecture and the technological specifications of the FOR-FREIGHT platform, which are foundational to achieving the goal of creating innovative and interoperable T&L solutions. By detailing the system architecture and describing the integration of various solvers and components, the deliverable demonstrates how the platform is being designed to enhance operational capacity, efficiency, and sustainability in multimodal and transhipment logistics environments. The updates and improvements in system architecture, as detailed in the deliverable, directly contribute to achieving reduced transport costs and a minimised environmental footprint, aligning with the first objective. The deliverable also addresses the objective of validating the FOR-FREIGHT solutions by providing a framework for testing these solutions in real-life, multi-stakeholder environments. By documenting the progress and implementation status across the Spanish, Greek, and Romanian Use Cases, D1.4 illustrates how the solutions are being adapted, refined, and tested using real end-user data. This approach is designed to showcase the maturity and readiness of the solutions, demonstrating their superior performance in terms of capacity, resource efficiency, sustainability, reduced emissions, and cost—key metrics that align with Implementation Objective 2.

This report emphasises three primary areas:

1. **Refinement of the FOR-FREIGHT End-to-End System Architecture (T1.4):**
    - The design will be based on the requirements and specifications collected from T1.2 and will outline the integration of various logistics systems and components. An overview of the initial system architecture will be provided, describing the platform's scope, high-level system architecture, components, subsystems, and integration points. This design will serve as a reference for WP2 software and testbed development/upgrades.
2. **Testing and Validation Methodology (Task 1.3):**

This section details the acceptance test procedures for the technological and business validation of the FOR-FREIGHT platform and solutions:

- **Technological Validation:** Procedures are specified for collecting data feeds from logistics nodes, systems, sensors, and other equipment, including how these feeds will be used and analysed by the FOR-FREIGHT Platform to present data in a user-friendly manner. Benchmarking thresholds for each Key Performance Indicator (KPI) will be defined based on use case requirements;
- **Business Validation:** Adopting the Lean Startup methodology [1], this section focuses on business motivations and includes end-user feedback from trials of the Transport and Logistics (T&L) use cases. A structured questionnaire and guidelines for organising focused group

workshops are provided to facilitate iterative cycles of business solution validation. The outputs will identify use cases with the highest commercialisation potential for developing a service product portfolio.

3. **Risk Analysis for Design/Development of the Central FOR-FREIGHT Platform:**
   - This section identifies and analyses the risks associated with the platform's development, along with mitigation strategies. The findings will inform the development and assessment processes in WP2 and WP3.

This report establishes the holistic platform architecture and evaluation framework of the FOR-FREIGHT platform based on the requirements of the project stakeholders and Use Cases. It integrates with T1.2 “Requirements Analysis and Use Case Refinement” and T3.5 “Evaluation, lessons learned, and best practices” to define and validate results with corresponding KPIs (before-after) and generate insights per testing case and utilised multimodal solution.

2.1 Mapping FOR-FREIGHT Outputs

This section presents 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. The purpose is to aid the reviewer in finding the specific sections of the document where the respective tasks’ requirements are addressed, guide the author through the process, and serve as a checklist to address everything that needs 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			
D1.4 FOR-FREIGHT system architecture & technology specifications (Revised version)	“Report on the final architecture and component description of the system. It is the output of Tasks 1.3 and 1.4.”	Chapter 3	Chapter 3 is an overview of the revised FOR-FREIGHT platform architecture describing the scope of the platform, the components and subsystems, and the integration points.
		Chapter 4	Chapter 4 outlines the technological validation methodology, detailing the KPI baseline definition and the data collection process for the baseline scenario. This chapter compiles activities from the FOR-FREIGHT's use cases, describing the KPI

			baseline values and the data collection procedures from logistics nodes, systems, sensors, and other relevant equipment that will serve as inputs to the solutions. It also elaborates on the methods for verifying the KPIs.
		Chapter 5	Chapter 5 details the business validation methodology, elaborating on the application of the Lean Start-up methodology. It outlines the specific tasks involved in this approach and how they will be executed. The resulting validations will identify the use cases with the highest commercialisation potential, enabling their advancement to the next phase of creating a service product portfolio.
		Chapter 6	Chapter 6 describes a comprehensive risk analysis conducted on the design of the solutions and the FOR-FREIGHT central platform, as well as for the three Use Cases. Additionally, it outlines the mitigation actions that have been defined to address these risks.
TASKS			

T1.3	"The testing and validation methodology to be elaborated in this task entails the acceptance test procedures for conducting both the technological and business validation of the FOR-FREIGHT platform and solutions. In particular, as far as the technological validation is concerned, procedures will be defined for collecting the data feeds from the logistics nodes, systems and sensors and other relevant equipment, stating also how these feeds will be used and analysed by the FOR-FREIGHT Platform to produce and present the necessary data in a user-friendly form. Threshold limits for the benchmarking of the results will also be defined per target KPI based on the requirements stemming from each use case. For the business validation, we will use the lean start-up methodology that centres around the main motivations of a business. The inputs will include apart from the business case itself, end-user feedback from their direct engagement in the trials of the T&L use cases. The corresponding outputs will be validations that will allow identifying use cases with the highest commercialisation potential progress to the next step of creating a service product portfolio. For this purpose, we will use a set of questionnaires, surveys, and focused group workshops directly engaging other T&L actors. Output: D1.3, D1.4."	Chapter 4	Chapter 4 outlines the technological validation methodology, detailing the KPI baseline definition and the data collection process for the baseline scenario. This chapter compiles activities from FOR-FREIGHT's use cases, describing the KPI baseline values and the data collection procedures from logistics nodes, systems, sensors, and other relevant equipment that will serve as inputs to the solutions. It also elaborates on the methods for verifying the KPIs.
		Chapter 5	Chapter 5 details the business validation methodology, elaborating on the application of the Lean Start-up methodology. It outlines the specific tasks involved in this approach and how they will be executed. The resulting validations will identify the use cases with the highest commercialisation potential, enabling their advancement to the next phase of creating a service product portfolio.
Task 1.4	This task is responsible for designing the FOR-FREIGHT end-to-end system architecture for the central platform. The design of such platform will be based on the requirements and specifications analysed and established on T1.2, as well as the integration approach of the various logistics systems and components. The high-level architecture will be used as the starting point in order to elaborate a fine-	Chapter 6	Chapter 6 describes a comprehensive risk analysis conducted on the design of the solutions and the FOR-FREIGHT central platform, as well as for all three Use Cases. Additionally, it outlines

	grained architecture description, containing the description of all the functional and communication blocks and the high-level interfaces among them. The outcome of this task will be used by WP2 as the reference for the software and testbed development/upgrades. From the architectural perspective, the focus will be on defining the functional components of the platform, the data type that will be exchanged, and the high-level interfaces that will enable the interaction/exchange between components. The outcome architecture design will be implemented in Task 2.5 and evaluated via the different use cases in WP3. The FOR-FREIGHT solution design will be constantly monitored to timely react and eliminate risks by activating the proper mitigation strategies at an early stage where possible, supporting the project management risk analysis developed in WP6. The risk analysis of the developments and their evaluation, together with the mitigation strategies will be identified and analysed in Task 1.4 and this output will feed into the project solutions development and assessment (of WP2 and 3 respectively). Output: D1.3, D1.4.”		the mitigation actions that have been defined to address these risks.

2.2 Linkage to other project outputs

This section gives details of the respective deliverables' interdependencies with other WPs, project outputs, etc., as provided in the table below.

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

WP Number	Task Number	Deliverable Number related	Content
WP1	T1.1 T1.2	D1.1 D1.2 D1.3	The legacy systems, state-of-the-art and logistics standards analysis performed in T1.1, together with the definition and requirements from the Use Cases in T1.2, is the baseline for the work carried out in T1.3. The risk analysis of the developments and their evaluation, together with the mitigation strategies, will be identified and analysed in T1.4 and this output will feed into the project solutions

			development and assessment (of WP2 and 3 respectively).
WP2	T2.1 T2.2 T2.3 T2.4 T2.5	D2.1 D2.2 D2.3	WP2's main focus is to implement the solutions (software, hardware, and integration) designed considering the requirements defined in WP1 tasks, and to deliver the E2E functional FOR-FREIGHT platform/solution. T2.1 will monitor and keep the pace of developments across the different trial sites following the internal co-design process from WP1. T2.2, T2.3 and T2.4 will perform the T&L use case implementation based on technical, business and deployment considerations and targeting specific KPIs defined in T1.2-T1.3. Finally, T2.5 will be responsible for developing the central FOR-FREIGHT platform functionalities and components as well as ensure that the trial site solutions are fully implemented and integrated, as well as guarantee E2E access to all trial sites. All WP2 tasks will contribute to the development of the business validation methodology through the onboarding, testing, and validation of the solvers developed by the Use Cases (UCs) to the FOR-FREIGHT platform. This will complement the effort of the onboarding of stakeholders which is a vital component of the business validation methodology development.
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 trials in the three UC locations. Based on the analysis and definition performed in WP1, a detailed planning and set-up will be carried out in T3.1. Each of the trials will be performed in T3.2, T3.3 and T3.4. In addition, T3.5 will evaluate the results of the trials. All WP3 tasks will be an important part of the development of the business validation methodology through the testing of the solving solutions developed for the FOR-FREIGHT platform and correlating them to internal and external stakeholder's interests based on external and internal focus groups.
WP4	T4.1	D4.2 D4.5	The findings in T1.1 and T1.2, together with the market opportunity analysis and feasibility study developed in T4.2, set a base for T1.3 and T1.4 in terms of commercial opportunities and needs to be addressed by the FOR-FREIGHT solutions.
WP6	T6.3	D6.1 D6.2	Initial version of project's Quality Handbook, including a risk management overview that is applied in Chapter 7.

2.3 Deliverable Overview and Report Structure

The structure of D1.4 follows a detailed format aimed at presenting the development and implementation of the FOR-FREIGHT platform. The Introduction section outlines how the deliverable fits within the broader objectives of the FOR-FREIGHT project. It maps specific outputs to project goals, demonstrating their contribution to the overall vision. Additionally, it explains the connections between this deliverable and other project outputs, emphasising integration and coherence. A brief overview of the report's content and structure is also provided, preparing the reader for the detailed discussions in the following chapters.

The third section, “Revised System Architecture Overview”, details the updates and improvements made to the system architecture since the last version described in D1.3. This includes design modifications, enhancements in system capabilities and adjustments based on previous feedback. The section defines the overall scope and objectives of the platform, outlining its main functions and services. It also describes the main components and subsystems, including their roles and interactions, providing an in-depth look at how each part contributes to the platform's functionality. The role of the Workflow Engine within the system is discussed, as well as the design and functionality of the User Interface, focusing on user experience considerations. Key integration points within the system architecture are identified, detailing how different components and external systems communicate and work together. These architectural updates are directly applied across the three project use cases—Spain, Greece, and Romania—where the revised architecture supports the specific needs and challenges of each use case. For the Spanish UC, for example, the architecture is refined to enhance the prediction of CO_2 emissions within complex port operations, integrating seamlessly with the systems used by stakeholders like COSCO, DHL, and MDM. In the Greek UC, the focus on optimising logistics processes through integrated solvers is underpinned by the platform’s updated architecture, which ensures efficient data processing and decision-making tools are well-aligned with real-time operational needs. Similarly, the Romanian Use Case benefits from these architectural improvements, particularly in enhancing digital integration and real-time coordination between water-to-railway transportation systems. The overall system architecture thus serves as the backbone that enables the FOR-FREIGHT platform to meet the unique requirements of each use case, driving improvements in operational capacity, efficiency, and sustainability across the board.

In the “Technological Validation Methodology and Implementation” section, the scope and methodology used for technological validation are outlined, including the approaches and techniques employed to ensure the platform meets its technical requirements. The section defines the baseline Key Performance Indicators (KPIs) used for assessment and explains the data collection baseline process. It provides updates on KPIs and data collection for the Spanish, Greek, and Romanian use cases, including specific results and insights gained from ongoing trials. The framework and results of the implementation and verification process are detailed, covering the deployment, testing, and outcomes of the platform.

The “Business Validation Methodology Updates” section explains how the Lean Start-up methodology has been applied in the project, focusing on iterative development and user feedback to refine solutions. Updates and results from the Spanish, Greek, and Romanian use cases are provided, detailing progress, challenges, and successes in implementing solutions in these countries. The section also includes a commercialisation analysis, examining market opportunities, competitive advantages, and strategies for bringing the solutions to market.

Risk Assessment is covered in the sixth section, with updates on risk identification and analysis. It includes the challenges identified and tackled, as well as the reassessment of previously identified risks. Actions taken to mitigate identified risks are described, outlining strategies and measures implemented to reduce or manage risks effectively. The section provides a detailed risk assessment and mitigation strategies for solution design and development, ensuring potential issues are addressed early in the process. Specific risk assessments and mitigations for the Spanish, Greek, and Romanian trials are discussed, covering unique challenges and risk factors encountered in each use case. The section concludes by summarising the challenges faced and lessons learned during the project, offering valuable insights into what worked well and what could be improved in future efforts.

Finally, the “Conclusions” section wraps up the document by summarising the key findings, outcomes, and implications of the deliverable. It provides a holistic view of the project’s progress and suggests directions for future work, ending the report with final thoughts and recommendations.

3 Revised System Architecture Overview

In the dynamic realm of logistics and freight management, the FOR-FREIGHT platform stands out with its cloud-based, objective-customised, and role-based design, crafted to deliver operational benefits across all project participants. As we embrace the latest advancements, this chapter provides a detailed look into the revised system architecture of FOR-FREIGHT, reflecting our commitment to addressing the complexities identified through three key trial sites in Spain, Greece, and Romania.

3.1 Redesigning the FOR-FREIGHT Platform Architecture

The updated FOR-FREIGHT platform architecture is demonstrated in Figure 3-1. The updated architecture results from the work coming primarily from WPs 1, 2 and 3.

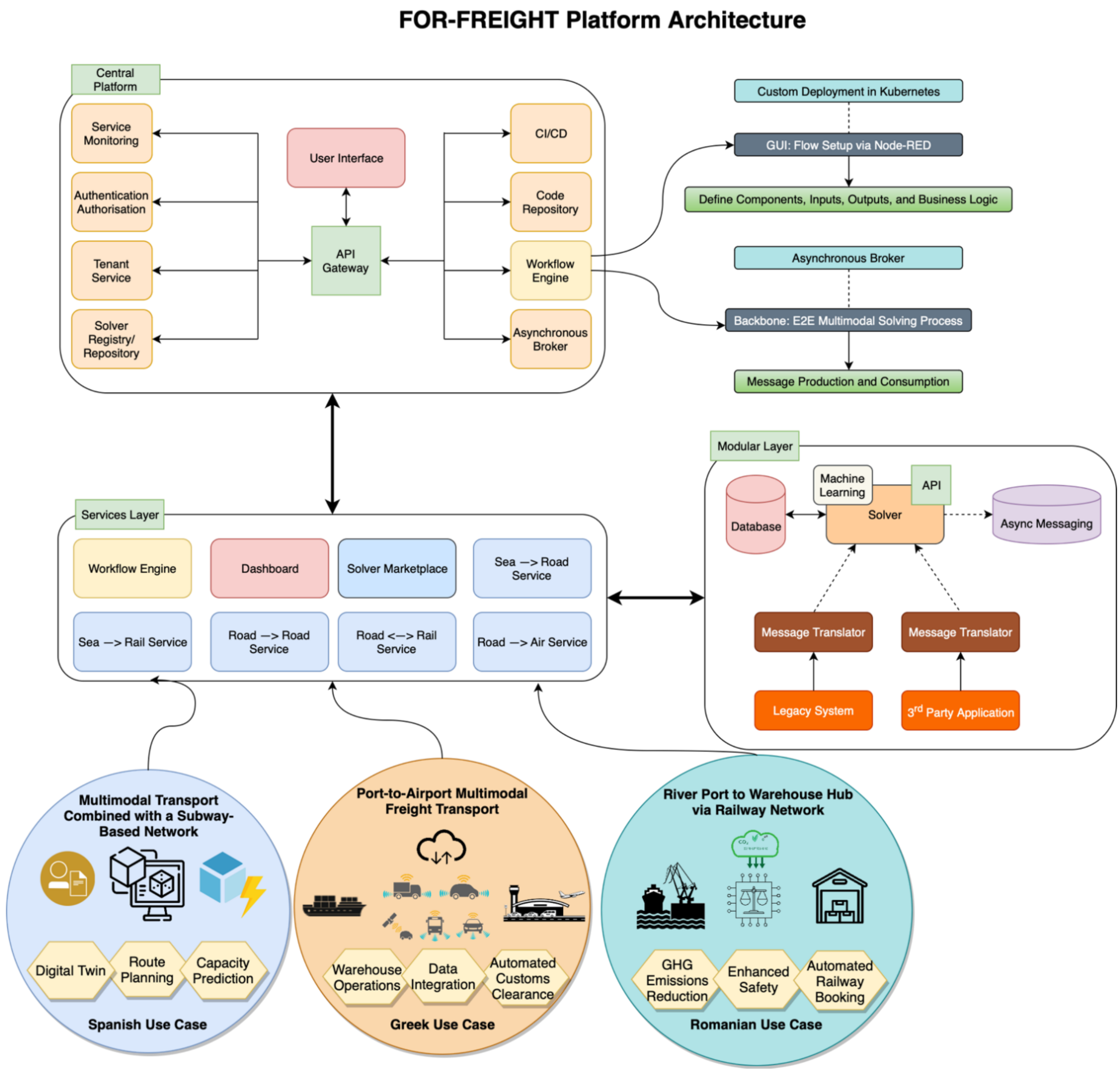


Figure 3-1 The Updated FOR-FREIGHT Platform Architecture and its relation to the Use Cases of the project

The FOR-FREIGHT platform integrates a broad spectrum of technical solutions, including Internet of Things (IoT), Artificial Intelligence (AI)/Machine Learning (ML), and Big Data Management to confront and resolve the unique challenges encountered in each use case. This updated architecture is designed to model logistics networks according to specific operational requirements, transforming KPIs and operational expectations into actionable technical challenges such as prediction, simulation, optimisation, and decision support.

Central to our revised architecture is the strategic integration of technical modules that propel the multi-modal logistics service towards achieving its goals. By synergising with existing assets, leveraging built-in solvers, and incorporating external third-party applications, the platform minimises redundant efforts and maximises the utility of current resources.

Additionally, the updated design orchestrates the operation of these integrated solutions, encompassing aspects such as monitoring, lifecycle management, and data exchange. It ensures comprehensive support for tracking, visualisation, output viewing, and exportation, tailored to different user roles.

The design approach remains lightweight, starting with a foundational prototype that intersects broadly with all three use cases, followed by the addition of tailored components to address specific needs. This strategic design philosophy aims to enhance flexibility and efficiency, ensuring that the FOR-FREIGHT platform evolves to meet the demands of modern logistics and freight management with precision.

The layers and subcomponents of the FOR-FREIGHT platform are described in the following sections of the chapter.

3.2 Scope of the Platform

The FOR-FREIGHT platform is a sophisticated, cloud-based system designed with customized objectives and role-specific features to provide operational benefits to all participants involved in the project. This comprehensive platform incorporates a range of advanced technical solutions, including IoT, AI/ML, and Big Data Management, to address the challenges identified in the three trial sites: Spanish, Greek, and Romanian Use Cases.

Within the scope of FOR-FREIGHT, the architecture design emphasizes several key functionalities that are directly applied across these use cases. For instance, in the Spanish Use Case, the platform supports the complex logistics network of the Port of Valencia by integrating predictive and optimization tools that enhance the efficiency of port operations. The use of built-in solvers and legacy systems ensures that the platform meets specific operational expectations, such as optimizing CO_2 emissions, which are crucial for stakeholders like COSCO and DHL.

In the Greek Use Case, the platform's ability to convert KPIs into technical challenges, such as simulation and decision support, directly contributes to optimising logistics processes across multiple stakeholders. The platform’s lightweight design and focus on commonalities allow for the seamless integration of multi-modal logistics services, ensuring that the solutions developed are both efficient and scalable.

The Romanian Use Case benefits from the platform's robust data management and coordination capabilities, which are critical for improving digital integration in water-to-railway transportation. By leveraging existing assets and coordinating the operation of integrated solutions, the platform enhances the real-time tracking and visualization of logistics operations, ensuring that the specific needs of Romanian stakeholders are met.

The platform's design intentionally keeps it lightweight, with an initial focus on maximizing commonalities across all use cases, followed by the addition of customized components tailored to the unique needs of each trial site. This approach ensures flexibility and scalability while addressing the distinct challenges and requirements of the Spanish, Greek, and Romanian Use Cases.

3.3 Components and Subsystems

The **Central Platform Layer** is essential for the operation and management of the FOR-FREIGHT platform, providing core services that ensure its functionality and security. It includes several key subcomponents crucial to the smooth operation of the platform. Service Monitoring plays a pivotal role by continuously observing and tracking the health, performance, and availability of all services within the platform. This involves collecting various metrics, logs, and traces, which are essential for real-time diagnostics and troubleshooting. In case of any failures or performance issues, alerts are generated to ensure prompt responses, thereby maintaining the high availability and reliability of the platform. The Authentication and Authorisation subcomponents are equally critical, managing user identities and access controls to ensure that only authorised personnel can access sensitive services and data. This includes secure user login processes, token management, and Role-Based Access Control (RBAC), all designed to maintain the integrity and security of the platform's resources. The Tenant Service supports the multi-tenancy feature of the platform, which allows multiple organisations to use the platform securely. It ensures that each tenant's data is isolated and provides tenant-specific configurations and customisations to meet their unique needs. The Solver Registry/Repository manages the storage and lifecycle of solvers—optimisation algorithms that are central to the platform's logistics capabilities. This repository provides a catalogue of available solvers, complete with metadata for easy discovery and selection, and handles versioning and updates to keep the solvers current and effective.

The **Application Programming Interface (API) Gateway** acts as the single-entry point for all API requests, routing them to the appropriate microservices. It handles request validation, rate limiting, authentication, and logging, simplifying integration and ensuring secure and efficient communication between clients and services.

External Components include the Continuous Integration/Continuous Development (CI/CD) system, Code Repository, Workflow Engine, and Asynchronous Broker. The CI/CD system automates the build, test, and deployment processes, ensuring rapid and reliable delivery of new features and updates, and supports version control and collaboration through integration with the code repository. The Workflow Engine orchestrates business workflows, managing task execution orders, dependencies, and states, supporting both synchronous and asynchronous workflows. The Asynchronous Broker facilitates asynchronous communication between services by managing message queues and topics, ensuring reliable message delivery and processing.

The **Modular Layer** includes components that provide essential functionalities across the platform, designed to be reusable and modular. The Database stores structured data required by the platform, supporting various database technologies such as Structured Query Language (SQL) and Non-relational Structured Query Language (NoSQL) to meet different use cases. It ensures data integrity, security, and high availability, providing a reliable backbone for data storage and retrieval. The ML component offers advanced predictive analytics and decision-making capabilities, incorporating models for demand forecasting, route optimisation, and anomaly detection. These models continuously learn and improve from new data, enhancing their accuracy and effectiveness over time. The Solver is an optimisation engine that solves logistical and operational problems, providing algorithms for tasks such as route planning, load balancing, and resource allocation. It integrates with the Solver Marketplace to deploy different solvers as needed. The API component provides programmatic access to the platform's features and data, supporting various standards such as REpresentational State Transfer (REST) and Graph Query Language (GraphQL). This allows external applications and services to interact with the platform, enabling seamless integration and automation. The Asynchronous Messaging component manages asynchronous communication and message passing between services, ensuring reliable delivery, ordering, and processing of messages. It supports various messaging patterns, including publish/subscribe and point-to-point, to facilitate effective communication in a distributed architecture.

The **Integration Layer** facilitates interaction with external systems. The Message Translator ensures compatibility and interoperability with legacy systems and third-party applications by translating messages between different formats, handling data transformation, validation, and enrichment. Legacy Systems represent older systems integrated with the platform, ensuring backward compatibility and data synchronisation, and managing the transition and coexistence of old and new systems. Third-Party Applications include external applications from partners, suppliers, and customers that interact with the platform via APIs and message translators, enabling seamless data exchange and enhancing the platform's ecosystem. The Integration Layer facilitates the platform's interaction with external systems and applications. The Message Translator translates messages between different systems and formats, ensuring compatibility and interoperability with legacy systems and third-party applications. This involves data transformation, validation, and enrichment to ensure that information is correctly interpreted and processed by the receiving systems. Legacy Systems represent older systems that need to be integrated with the platform, ensuring backward compatibility and data synchronisation. This component manages the transition and coexistence of old and new systems, allowing organisations to modernise their operations without disrupting existing processes. Third-party Applications include external applications from partners, suppliers, and customers who interact with the platform. These applications integrate via APIs and message translators, enabling seamless data exchange and enhancing the platform's ecosystem. This integration layer ensures that the FOR-FREIGHT platform can connect with a wide range of external systems, providing flexibility, and extending its capabilities.

The **Services Layer** is composed of several business-specific services that handle the core logistics operations of the platform. The Workflow Engine within this layer manages and executes complex business workflows, integrating with various services to ensure that tasks are completed efficiently. It includes mechanisms for error handling, retries, and compensations, ensuring robust and reliable process execution. The User Interface will allow users to monitor operations in real-time and make informed decisions based on up-to-date information. The Solver Marketplace acts as a repository for optimisation algorithms (solvers) that can be used to solve logistical problems. Users can browse, select, and deploy these solvers based on their specific needs, with detailed information available on each solver's capabilities and performance. Transportation services such as Sea to Road, Sea to Rail, Road to Road, Road to Rail, and Road to Air manage the logistics and transitions of freight across different transport modes. Each service coordinates with relevant operators, ensuring seamless transfer and tracking of cargo. These services optimise routing, scheduling, and load management to enhance efficiency and reduce costs.

The **User Interface** component is the primary touchpoint for users interacting with the FOR-FREIGHT platform. It is designed to be highly user-friendly, providing a comprehensive front-end application that includes user interfaces, management consoles, and various operational tools. These tools allow users to easily monitor platform activities, manage logistics operations, and utilise the platform's capabilities to their fullest extent. The interface is built to ensure that users can navigate the platform with ease, access necessary information quickly, and perform their tasks efficiently.

The **External Components** integrated into the FOR-FREIGHT platform enhance its capabilities and streamline development and operational processes. The CI/CD system automates the entire lifecycle of software development, from building and testing to deployment. This ensures that new features and updates are delivered rapidly and reliably, reducing downtime and improving the overall user experience. The Code Repository stores the platform's source code, providing a robust system for version control, branching, and collaboration among developers. This integration allows for efficient management of the development process and ensures that the codebase remains consistent and up-to-date. The Workflow Engine orchestrates the execution of business workflows, managing the dependencies, state, and order of various tasks. This engine supports both synchronous and asynchronous workflows, enabling complex processes to be executed seamlessly.

In subsections 3.4 and 3.5, we focus on further detailing the development and functionalities of two of the most crucial components for the FOR-FREIGHT platform, namely the Workflow Engine, which is the "backbone" of the platform responsible for stringing together the solvers selected by the user allowing the customisation of solving solutions and the User Interface which is the "face" of the platform, where users can access and control the features of the platform, designed to facilitate users from different backgrounds.

3.4 Workflow Engine

The Workflow Engine for the FOR-FREIGHT platform operates as a flexible and scalable tool to orchestrate and automate complex logistics processes across its various use cases. The Workflow Engine leverages Node-RED[1] logic, an open-source flow-based visual programming tool that allows developers to wire together flows of data and logic using a web-based flow editor. This engine facilitates the automation of tasks and decision-making processes within the logistics chain, ensuring that operations are streamlined and responsive to real-time data inputs.

To this end, FOR-FREIGHT Workflow Engine is capable of integrating seamlessly with diverse data sources critical to logistics operations, including legacy systems, IoT sensors, and external APIs. This capability ensures that real-time data from different stakeholders and operational nodes within the logistics network can be accessed and processed efficiently. The platform leverages data processing capabilities to handle tasks such as data transformation, validation, and enrichment, ensuring that data is standardised and prepared for further analysis and decision-making.

In terms of workflow orchestration, FOR-FREIGHT Workflow Engine's visual flow design allows logistics operators and developers to create and modify workflows intuitively. Flows are constructed by dragging and dropping nodes onto a canvas, connecting them to define the sequence of operations and decision points. This visual approach enhances transparency and simplifies the development and maintenance of complex workflows in dynamic logistics environments.

Decision support is enabled through conditional logic nodes, which allow the platform to make real-time decisions based on incoming data and predefined rules. For example, it can dynamically adjust transport routes based on traffic conditions detected by IoT sensors or reroute shipments to optimise delivery schedules. The platform also incorporates error handling and alert mechanisms, triggering notifications when anomalies like delays or inventory shortages are detected, enabling timely corrective actions.

The modular architecture of the tool also supports scalability and extensibility, accommodating the integration of new technologies and the customisation of workflows to meet evolving logistics requirements. It facilitates parallel processing of tasks across different parts of the logistics network, enhancing operational efficiency and responsiveness. Security measures such as data encryption and access controls ensure secure data handling, protecting sensitive information throughout its lifecycle within the platform.

In application to the Spanish, Greek, and Romanian use cases of FOR-FREIGHT, the Workflow Engine is tailored to specific requirements. For instance, in Spain, it automates decision-making processes for optimal last-mile transport using metro networks. In Greece, it facilitates real-time monitoring and management of cargo positions across multimodal transport routes. In Romania, it orchestrates efficient transport information flow using IoT and 5G technologies to prevent congestion and meet operational timelines. Overall, the Workflow Engine component empowers the FOR-FREIGHT platform with agile, automated, and data-driven logistics operations, driving efficiency and competitiveness in logistics management.

3.5 User Interface

In the FOR-FREIGHT platform, the User Interface (UI) will act as the primary gateway for users to access and manage the platform's robust functionalities. It is designed specifically to expose the capabilities of the platform, ensuring that users can interact with its various components seamlessly. The UI will not perform any processing or operations itself but serve as a conduit through which users engage with the platform's core functions, providing a user-friendly and intuitive experience.

A standout feature of the UI will be its Wizard-like functionality, which will guide users through the selection process. After users choose their desired transportation service—such as Maritime, Road, Railway, or Subway—the intuitive Wizard will present them with their respective intermodal interface (such as Maritime-to-Road), as

[1] https://nodered.org/

well as their real-world transport and logistics problems related to their selection. Once a specific problem is chosen, the Wizard will direct users to solving processes tailored to address the issue. These processes will be clearly labeled with detailed descriptions, helping users understand their purpose and select the most appropriate solution. For instance, users will see options like " ETA Predictions" or " Optimal route planning based on cost, GHG emissions and time predictions," each leading to specialised solving processes designed to tackle specific logistics challenges effectively.

The UI's integration with the Workflow Engine is another key feature, managing and executing complex logistics workflows. Users will be able to initiate and manage these workflows through the UI, directly interacting with the Workflow Engine to orchestrate various solving processes and develop E2E solutions for logistics tasks. This integration will also allow users to monitor the status of ongoing processes, with real-time insights into solver performance and workflow progress. The UI will thus be the central point for effective logistics management.

Moreover, the UI will be able to aggregate data from a variety of integrated systems, including IoT devices, legacy systems, and cloud services, presenting this data in a clear and organised manner in the form of dashboards. This comprehensive data aggregation will allow users to gain a holistic view of the entire logistics process, making informed decisions based on accurate, real-time information. The UI will be equipped with interactive tools such as customisable views, charts, and real-time alerts, enabling users to manage and monitor logistics operations effectively. These features will ensure that users can quickly interpret data, take informed actions, and optimise their logistics operations.

Additionally, user authentication is a critical feature of the UI, ensuring secure access to the platform. Upon logging in, users will be authenticated through a robust security system that verifies their credentials and permissions. This authentication process will not only protect sensitive data but also personalise the user experience by tailoring the available features and information according to the user's role and access level. By implementing secure authentication methods, the UI will ensure that only authorised users can interact with the platform's functionalities and access its various components, maintaining the integrity and confidentiality of the logistics operations managed through the system.

In conclusion, the UI of the FOR-FREIGHT platform is a critical component that will centralise access to the platform's key tools, data, and workflows. By providing an intuitive and user-friendly interface, it will enhance operational efficiency, reduce complexity, and support sustainable growth in logistics management. The UI will ensure that users can fully utilise the platform's capabilities, empowering them to make informed decisions and optimise their logistics operations across various contexts.

3.6 Integration Points

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

TIC4.0 (Terminal Industry Committee 4.0) plays a crucial role in the integration points of the FOR-FREIGHT platform by providing standardized protocols and frameworks that facilitate seamless communication and interoperability between different components and systems within the logistics and freight operations. By adopting TIC4.0 standards, the platform ensures that various technical modules, legacy systems, and external applications can effectively communicate and work together, thus enhancing the overall efficiency and reducing the complexity of integration.

Data Standards Definition: Establishing data standards is crucial for ensuring smooth information exchange between systems. These standards should include common formats, transmission protocols, and schemas to increase compatibility. By defining these standards, the platform can facilitate seamless data interchange, thereby enhancing interoperability across the different systems involved in the logistics process.

Data Extraction: Collaboration among stakeholders involved in legacy systems and third-party applications is fundamental for achieving technical alignment between various information sources. This involves defining standards, addressing technical limitations, and modernising systems where necessary. Identifying the legacy systems and third-party applications that need to be integrated is the first step. Determining the data sources and formats they provide allows for the development of a collection of connectors. These connectors interact with the systems, enabling the extraction and transformation of data into a unified format.

Data Transformation: The integration of diverse systems often leads to redundancies and inconsistencies in data structures. To avoid duplication and ensure consistency, data is consolidated using mapping techniques that recognise differences in data structures across legacy systems. This step ensures that the data is transformed into a cohesive, unified format that can be effectively utilised by the FOR-FREIGHT platform.

Data Security: Ensuring data security is a critical factor during data manipulation and transfer. Robust measures must be implemented to protect sensitive information. Anonymisation techniques are employed to safeguard data by replacing identifiable information with anonymised equivalents. To facilitate secure data transformation, message translators need to be implemented as middleware integrated into the central platform. These translators act as intermediaries between the legacy systems or third-party applications and the platform, handling data transformation based on the established standards. By accessing these translators through APIs, the systems can interact using standardised communication protocols in a controlled and secure manner.

Integration with Specific Use Cases:

In the Spanish Use Case, the integration focuses on aggregating information from individual management systems to support decision-making in resource use and transport planning. The use of Blockchain for real-time data exchange and AI/ML predictive analytics requires robust APIs and standardised data formats to ensure seamless integration. Dynamic transport planning based on Digital Twins also demands precise data transformation and security protocols to manage and protect the real-time data flow. Interoperability between solvers and their connection to certain legacy systems is another relevant integration point in the Spanish case. The connection of Port Community Systems (PCS) of the port of Valencia and other systems used within the port, such as PAULA, communicate and send information to its related solvers, allowing them to obtain data on the current situation of the port and details of port calls. Communication between solvers is also another remarkable interoperability factor, thanks to the representation of solver outputs in a common TIC4.0 data model, allowing an agile and seamless exchange of information between solvers, with the information clearly documented.

For the Greek Use Case, integrating information from legacy management systems and new sensors is essential. The platform must automate manual processes, provide real-time cargo/container positions, and offer full remote monitoring capabilities. This requires standardised data formats and secure APIs to ensure accurate data aggregation and real-time monitoring across the logistics process. The message translators play a crucial role in converting diverse data inputs into a unified, actionable format.

In the Romanian Use Case, leveraging IoT and advanced data processing solutions like 5G and the Internet of Containers is key. The platform must enable fluent and accessible information on transport flow, prior planning, and resource optimisation to avoid congestion and meet operational targets. Standardised interfaces and APIs are necessary to integrate data from various stakeholders, while data security measures ensure the integrity and confidentiality of the information exchanged.

By implementing these integration strategies, the FOR-FREIGHT platform can overcome interoperability challenges, ensure secure and efficient data handling, and provide a comprehensive, real-time logistics solution tailored to the needs of various stakeholders in different use cases.

4 Technological Validation Methodology and Implementation

The technological validation and implementation of the FOR-FREIGHT platform follow a comprehensive methodology to ensure that it meets all functional and non-functional requirements. This process begins with a thorough requirement analysis and specifications phase, where detailed sessions with stakeholders help to define clear and measurable specifications for each component and service within the platform. This foundational step ensures that the platform's architecture and components are aligned with the business needs and technical requirements. Following this, a feasibility study evaluates the technical aspects of the platform, identifying potential risks, constraints, and challenges associated with the technology stack and integration points.

To further validate the platform's key functionalities and technologies, a Proof of Concept (PoC) is developed. This small-scale prototype focuses on critical components such as the API Gateway, Authentication and Authorisation, and the Solver Registry/Repository, testing their integration with external components like CI/CD systems and legacy systems. An architecture review with experienced architects and domain experts coming from academia and industry (e.g., ports, airports, T&L companies, etc.) follows, ensuring that the architecture supports scalability, reliability, security, and performance requirements. Performance and load testing simulate various load scenarios to measure response times, throughput, and resource utilisation under different conditions, using tools such as Apache JMeter[2] or Gatling[3].

Security testing is a crucial aspect of the validation process, involving comprehensive assessments to identify vulnerabilities and ensure robust security measures. This includes penetration testing, vulnerability scanning, and security code reviews. Additionally, compliance and standards validation ensure the platform adheres to industry standards and regulatory requirements relevant to freight and logistics, such as the standard from the International Organisation for Standardisation (ISO), ISO 27001 for information security and the General Data Protection Regulation (GDPR) for data protection. User Acceptance Testing (UAT) involves end-users in the testing phase to validate that the platform meets their expectations and business requirements, with feedback collected and iterations made based on user insights and suggestions.

The CI/CD validation ensures that automated, reliable, and repeatable build, test, and deployment processes are in place, integrating seamlessly with version control systems, code repositories, and testing frameworks. Comprehensive documentation and knowledge transfer sessions ensure that all components, including design documents, API specifications, user manuals, and operational guides, are well-documented. Training sessions and support for development, operations, and support teams are also provided to ensure smooth adoption and usage.

Implementation begins with setting up the necessary infrastructure for development, testing, and production environments, utilising cloud services like AWS, Azure, or Google Cloud for scalable and flexible provisioning. Each component of the platform is developed according to defined specifications and architecture, with iterative integration starting with core services such as Authentication and Authorisation, API Gateway, and Service Monitoring. An automated testing framework is implemented to facilitate continuous testing, developing unit tests, integration tests, and end-to-end tests for all components and services.

Performance optimisation is a continuous process, with regular monitoring and enhancements to ensure efficient algorithms, caching strategies, and database optimisation techniques are in place. Security enhancements are also ongoing, with regular security audits and the implementation of best practices such as encryption and secure coding standards. The CI/CD pipeline is configured and integrated with tools like Jenkins, GitLab CI, or CircleCI, automating the build, test, and deployment processes to ensure rapid and reliable delivery of updates.

[2] https://jmeter.apache.org/

[3] https://gatling.io/

User training and support are provided to ensure smooth adoption, with training materials, video tutorials, and helpdesk support available to assist users. Deployment to the production environment follows a well-defined plan, with monitoring and logging solutions implemented to track the platform's health and performance. Feedback loops with users and stakeholders are established to gather insights and drive continuous improvement, ensuring the platform evolves with user needs and technological advancements.

By following this technological validation methodology and implementation plan, the FOR-FREIGHT platform meets its functional and non-functional requirements, delivering a robust, secure, and high-performing solution for logistics and freight management.

4.1 Scope and Methodology

The testing and validation methodology outlined in this task aims to ensure rigorous technological validation of the FOR-FREIGHT platform and its solutions. This process includes defining acceptance test procedures that will validate the functionality and performance of the platform against predefined benchmarks. These procedures are crucial for collecting data feeds from logistics nodes, systems, sensors, and other relevant equipment. The methodology specifies how these data feeds will be utilised and analysed within the FOR-FREIGHT platform to generate and present necessary data in a user-friendly format.

Key to this methodology is the establishment of threshold limits for benchmarking results against target KPIs. These KPIs are directly derived from the requirements of each use case, defining specific target values that represent operational goals. This ensures that the technological validation process is aligned with the strategic objectives of the project, focusing on measurable outcomes that indicate successful implementation and functionality of the platform solutions.

The validation process involves measuring these KPIs to track progress and verify that the solutions meet expected performance levels. Digital KPIs serve as critical metrics for assessing technology validation, guiding the project team in understanding the effectiveness and impact of the implemented solutions. It is essential that each KPI is clearly defined to correspond with specific logistics processes and their associated expected thresholds.

In Task 1.2 of the project, detailed descriptions of KPIs, their target objectives, and the logistics processes they measure were established. These KPIs were further connected to mid-term Expected Outcomes (EO) and long-term Expected Impacts (EI), linking functional requirements of the use cases to specific project goals. This alignment ensures that the validation process not only verifies technical functionalities but also contributes to evaluating the broader impacts and benefits of the FOR-FREIGHT solutions.

To streamline data collection and KPI calculation across project tasks, a collaborative effort stemming from WP3 produced a common Excel tool that will be reported in future deliverables. This tool facilitates the organised gathering of information from T1.2, T 1.3, and T3.5 across all three use cases. By preventing overlaps between tasks and compiling comprehensive input data sets, this tool provides a unified summary of requirements and expected outputs. It enables technical partners to outline essential elements of the solutions and central platform development effectively, setting the stage for subsequent tasks such as solution design and implementation in WP2.

In essence, this methodology ensures that the technological validation of FOR-FREIGHT is methodical and comprehensive, leveraging precise KPIs and streamlined data management to validate performance and assess the real-world impact of the platform's solutions across diverse logistics scenarios.

4.1.1 KPI Baseline Definition

In Task 1.3, each use case established its KPI baseline by either providing the actual measured values where available or estimating the values when direct measurement was not possible. Additionally, the verification methods for each KPI were outlined, meaning the conceptual framework for calculating the KPIs after implementing the solutions developed under the FOR-FREIGHT project was defined.

Validating the baseline KPIs for the FOR-FREIGHT platform involves several steps to ensure that the initial measurements are accurate, reliable, and representative of the current logistics processes. Here is a detailed approach to validating these baseline KPIs:

Define Clear KPI Metrics and Standards (Completed)

First, it is essential to clearly define each KPI metric and establish the standards or benchmarks for what constitutes acceptable performance. This involves specifying the units of measurement, the data sources, and the calculation methods for each KPI. Clear definitions prevent ambiguity and ensure consistency in data collection and interpretation.

Data Collection Plan (Completed)

Develop a comprehensive data collection plan outlining the sources of data, the frequency of data collection, and the tools and methods to be used. This plan should detail how data will be gathered from various logistics processes and systems, ensuring that all relevant aspects of the operation are covered.

Initial Data Gathering (Completed)

Collect initial data for each KPI according to the data collection plan. This involves retrieving historical data from existing logistics systems, databases, and manual records. Ensuring data is collected over a significant period is crucial to account for variability and provide a robust baseline.

Data Validation (Ongoing)

Validate the collected data for accuracy and completeness. This step involves cross-checking data against other sources, performing sanity checks, and looking for anomalies or inconsistencies. Techniques such as data triangulation (comparing data from multiple sources) and statistical analysis can be employed to ensure the reliability of the data.

Data Cleaning (Ongoing)

Clean the collected data to remove errors, outliers, or irrelevant information. This involves identifying and addressing missing values, correcting inaccuracies, and normalising data to ensure consistency. Data cleaning ensures that the baseline data accurately reflects the current state of logistics processes.

Stakeholder Review (Ongoing)

Engage stakeholders, including business partners and technical teams, in reviewing the baseline data. This collaborative review helps ensure that the data accurately represents the current operations and that any discrepancies or issues are identified and addressed. Stakeholders can provide valuable insights and validate the relevance and accuracy of the data, helping with their expertise in reviews, as well as discussions or periodic validation workshops in the data produced in solvers. The project partners have been using their networks to promote the project results, and the project itself has connected with sister projects (e.g., MultiRELOAD, AWARD, etc.), relevant associations in the European Ecosystem (e.g., the European Technology Platform ALICE – Alliance for Logistics Innovation through Collaboration in Europe) and policymakers through the participation of partners to large events and expos. FOR-FREIGHT is committed to keeping up-to-date with all the ongoing evolutions in the European and International Transport and Logistics Ecosystem, positioning itself as a flagship project, and promoting the FOR-FREIGHT platform to onboard as many external users as possible.

Baseline KPI Calculation (Completed)

Calculate the baseline values for each KPI using the validated and cleaned data. Ensure that the calculations follow the defined methods and standards established in the initial step. Document these baseline values comprehensively, including the context and conditions under which the data was collected.

Documentation and Reporting (Ongoing)

Document the baseline KPI values and the data collection and validation process thoroughly. This documentation should include detailed explanations of the data sources, collection methods, validation steps, and any assumptions or limitations. Providing this context is essential for transparency and future reference.

Verification Against Objectives (Ongoing)

Verify the baseline KPI values against the project objectives and benchmarks. This step involves comparing the baseline values with industry standards, historical performance data, and the expected outcomes of the FOR-FREIGHT platform. This comparison helps in setting realistic targets and identifying areas for improvement.

Continuous Monitoring (Ongoing)

Establish a system for continuous monitoring of the KPIs to ensure that the baseline remains relevant over time. As the project progresses, periodically reassess the baseline KPIs to account for any changes in the logistics processes or external factors. Continuous monitoring through processes of validation and integrity of results and developments helps maintain the accuracy and relevance of the baseline data. Calibrations of results and comparisons with project stakeholders involved in the different solutions will ensure that continuous monitoring adjusts and validates the results obtained in FOR-FREIGHT.

Continuous monitoring in the FOR-FREIGHT project is an essential process to ensure that baseline KPIs remain relevant and accurate throughout the project's lifecycle. This system involves the regular collection and analysis of data to track performance, identify deviations, and implement corrective actions promptly. The primary goal of continuous monitoring is to maintain a high level of operational efficiency and effectiveness, ensuring that the project's objectives are consistently met.

To achieve this, a dedicated continuous monitoring system will be established, leveraging advanced data analytics and real-time reporting tools. This system will integrate with various components of the FOR-FREIGHT platform, collecting data from logistics nodes, sensors, and other relevant sources. The data collected will be processed and analysed to provide insights into the performance of different aspects of the platform. This real-time data collection allows for the timely detection of any deviations from the expected baseline KPIs, enabling prompt corrective actions.

The continuous monitoring system will be designed to be both comprehensive and flexible, capable of adapting to changing conditions and requirements. It will include dashboards and visualisation tools that provide stakeholders with easy access to performance metrics and trends. These dashboards will be customisable, allowing users to focus on specific KPIs or areas of interest. Additionally, automated alerts and notifications will be set up to inform stakeholders of any significant deviations or issues that require immediate attention.

Regular audits and reviews will be conducted as part of the continuous monitoring process. These audits will involve a thorough examination of the collected data, ensuring its accuracy and reliability. The results of these audits will be used to update the baseline KPIs as necessary, reflecting any changes in operational conditions or requirements. This iterative approach ensures that the KPIs remain relevant and aligned with the project's goals.

Furthermore, continuous monitoring will involve regular feedback loops with stakeholders. This feedback will be crucial in identifying any gaps or areas for improvement in the monitoring system. By incorporating stakeholder feedback, the system can be continuously refined and enhanced, ensuring it meets the needs of all users. This collaborative approach fosters a sense of shared ownership and responsibility, enhancing the overall effectiveness of the monitoring process.

In conclusion, continuous monitoring in the FOR-FREIGHT project involves the implementation of a robust system that integrates data collection, real-time analysis, and regular audits. This system ensures the ongoing relevance and accuracy of baseline KPIs, enabling prompt corrective actions and continuous improvement. By leveraging advanced analytics and fostering collaboration with stakeholders, the continuous monitoring system enhances the project's ability to achieve its objectives efficiently and effectively.

Stakeholder Sign-Off (Ongoing)

Obtain formal sign-off from stakeholders on the validated baseline KPIs. This step ensures that all parties agree on the initial measurements and are aligned on the starting point for evaluating the impact of the FOR-FREIGHT platform. Stakeholders' buy-in is crucial for the credibility and acceptance of the baseline data, and sign-off is a critical milestone in the validation and deployment process of the FOR-FREIGHT platform. It involves obtaining formal approval from key stakeholders and ensuring that all parties agree on the initial measurements, KPIs, and project deliverables. This step is essential for maintaining transparency, accountability, and alignment among all involved parties.

The importance of stakeholders' sign-off cannot be overstated. It ensures alignment and agreement among all stakeholders, including technical partners, business users, and external collaborators, with the project's objectives, baseline measurements, and expected outcomes. This fosters a shared understanding and consensus on the project's direction and KPIs. Before moving forward with the implementation and further development, it is crucial to validate that the baseline KPIs accurately reflect the current state of logistics processes. Stakeholder sign-off confirms that these initial measurements are correct and agreed upon, providing a reliable foundation for future comparisons and assessments. Moreover, formal approval from stakeholders enhances accountability and transparency in the project. It ensures that all decisions, data, and methodologies have been reviewed and endorsed by relevant parties, reducing the risk of misunderstandings or disputes later in the project.

The stakeholder sign-off process involves several key steps. Comprehensive documentation is prepared detailing the baseline KPIs, data collection methods, initial findings, and any assumptions or limitations. This documentation provides stakeholders with a clear and detailed understanding of the current project status. Organised review meetings are then conducted with stakeholders to present the documentation, explain the methodologies used, and discuss the findings. These meetings provide an opportunity for stakeholders to ask questions, seek clarifications, and provide feedback. Any feedback or concerns raised by stakeholders during the review meetings are addressed, which may involve revising the baseline KPIs, adjusting data collection methods, or providing additional information to ensure all stakeholder concerns are satisfactorily resolved. Once all feedback has been incorporated and stakeholders are satisfied with the documentation, a formal approval process is initiated, typically involving obtaining signatures or written confirmations from key stakeholders, indicating their agreement and approval of the baseline KPIs and project documentation.

By involving stakeholders in the validation process and obtaining their formal approval, confidence and trust in the project's methodologies and findings are significantly enhanced. This collaborative approach builds strong relationships and fosters a sense of shared ownership and responsibility. Additionally, stakeholder sign-off helps to mitigate risks associated with misalignment or misunderstandings. By ensuring all parties agree on the baseline KPIs and project objectives, the likelihood of disputes or issues arising later in the project is reduced. With baseline KPIs and methodologies formally approved by stakeholders, the project has a solid foundation for future evaluations.

By following these steps, the baseline KPIs can be validated effectively, providing a reliable foundation for measuring the impact of the FOR-FREIGHT platform and guiding future improvements in logistics processes.

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

- Use case involved;
- Scenario, if applicable, in which the use case is developed (covered by T1.2);
- Target ID (covered by T1.2);
- Target description (covered by T1.2);
- Target expected value (covered by T1.2);
- KPI ID;
- KPI description;
- KPI baseline value;

- KPI ex-post value (will be covered by T3.5);
- Comparison baseline/ex-post measurement (this will be covered by T3.5);
- Technology applied to calculate the KPI (covered by T1.2);
- Logistic process measured by the KPI (covered by T1.2);
- Partner/s responsible to provide the calculation supported by the developed solution/s within the project (covered by 1.2);
- Means of verification, details on how the KPI must be calculated (covered by T2.5);
- Relation between KPIs to mid-term EOs that the project contributes to (covered by T1.2);
- Long-term EIs, in relation to each KPI defined, to long-term expected impacts that the project contributes to (covered by T1.2).

4.1.2 Data Collection Baseline Definition

In Task T1.3, with the collaboration of all involved partners, a comprehensive analysis was conducted on the data to be collected from various logistics nodes, systems, sensors, and other relevant equipment necessary to support the FOR-FREIGHT platform and solutions. This data collection effort was organized and facilitated using a common Excel tool file (FOR FREIGHT_T1.2_T1.3_T3.5_Common tool.xlsx) developed under Tasks T1.2, T1.3, and T3.5, and shared with all partners participating in the three use cases.

The baseline for data collection encompasses specific data points for each KPI that could be provided to the FOR-FREIGHT project, taking into account the operational environments (EOs) and technologies that will be utilized in developing the final solutions. This data has been systematically listed and detailed for each use case and scenario, where applicable, and for each associated KPI.

The definition and details of the data collection baseline are the following:

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

4.2 Use Case KPI and Data Collection Updates

The collection and analysis of KPIs and data ex-post will be addressed by T3.5 once the project progresses and the final solutions will be implemented and validated. Since the final solutions will be derived after three iterative cycles (detailed business validation methodology can be found in Section 6 below), it is possible that the final version of the data collected from different partners may slightly vary from what is specified in this deliverable. This document outlines the data for each KPI that could be made available to the FOR-FREIGHT project, taking into account the expected outcomes and technologies to be used in developing the final solutions. However, at this stage, no solutions have been developed yet. Currently, technical partners are still refining requirements and expected outputs defined by business partners and will continue collaborating on the design of preliminary solutions.

Additionally, the information gathering on KPIs and data collection ex-post are documented in the common Excel tool generated by Tasks 1.2, 1.3, and 3.5, as mentioned above. This will facilitate the final analysis and comparison between pre-FOR-FREIGHT KPI measurements and ex-post KPI measurements.

4.2.1 Spanish Use Case and Trials

The Spanish Use Case has focused on addressing inefficiencies and fragmented logistics networks from port to last-mile delivery. Key solvers have been developed to enhance the efficiency, transparency, and reliability of the logistics processes. The development process continues for the final drop and refinement of the second drop of the solvers so that the solutions are ready for use in the trials to be held in both scenarios, Valencia and Madrid.

One of the primary solvers, ES_01, is designed to predict the ETA of vessels at the port of Valencia. This solver is crucial for optimising port operations by providing accurate predictions of vessel berthing times, enabling better resource planning and allocation. The solver takes inputs from various legacy systems, such as the Valenciaport Port Community System (PCS), the Port Collaborative Decision-Making (PortCDM) system, and meteorological prediction services. Although the model is still undergoing hyper-parameter tuning, it has shown promising preliminary results. Moreover, ES_03 predicts the total stay duration of cargo at the Port of Valencia, considering factors such as dwelling time and service operations.

In addition, ES_04 is a key solver that predicts transport costs from point A to B, covering different transportation modes like trucks, trains, and metros. It forms part of an E2E group of solutions, working alongside ES_05 to estimate costs, time, and emissions. ES_05 specifically predicts CO_2 emissions for transportation routes, enabling stakeholders to assess the environmental impact of their choices and select more sustainable options. They work in conjunction with solvers ES_12 and ES_13 which cover the time-related predictions to form an E2E group of solutions for estimating costs, time, and emissions.

Solvers for real-time localisers ES_14 and ES_15 development started, with tests carried out to validate the proper functioning of the IoT sensors installed in the trucks as well as the 5G connectivity phones that will be used for the Madrid scenario. ES_14 provides real-time tracking of the truck carrying the freight, and ES_15 extends the tracking to the packages delivered throughout the Metro de Madrid network to the final lockers.

For the first workshop and end-users survey related with the first drop of solutions, solver ES_05 (CO_2 emissions predictor), and ES_08, which predicts demand at MDM, have also been presented and refined based on this feedback.

These solvers are connected to KPIs developed through the work done in WP3 and are part of the deliverable D3.1. In the case of the Spanish Use Case, the solving solutions developed amongst other KPIs, aim to improve forecast planning by >15%, reduce container staying at the port and GHG emissions by >15% as well as increase transport orders digitalisation by 20%.

4.2.2 Greek Use Case and Trials

The GR Use Case has developed several solvers to optimise the E2E logistics process, focusing on integrating information from various systems to improve transport time, fuel costs, and greenhouse gas emissions predictions. The solvers GR_01, GR_05, and GR_12 generate predictions for optimal transport times, fuel costs, and GHG emissions, respectively. These solvers are integrated with outputs from other solvers like GR_09, GR_10, GR_11, and GR_12 to provide comprehensive details on available flights and warehouse operations. The Greek solvers GR_13, GR_14, and GR_15 ensure efficient coordination between various entities involved in the logistics process, aiming to minimise delivery time, cost, and CO_2 footprint. Some solvers like GR_04 are still in progress but are expected to be completed within the planned timeframe.

Likewise to the Spanish UC, some of the KPIs that the Greek UC is trying to achieve are reduction of the container idle time by 25% and, a reduction of the customs idle time by more than 2.5 hours.

4.2.3 Romanian Use Case and Trials

The Romanian Use Case addresses challenges in water-to-railway transportation, focusing on enhancing digitalisation, coordination, and proactive strategies for unforeseen events. Solver RO_01 predicts the ETA of container ships at the Port of Galati, using classical calculations and ML techniques to refine predictions based on various factors like weather conditions and river traffic. This solver is integrated with other solvers for continuous data exchange via RabbitMQ[4] for asynchronous messaging. Solver RO_10 tracks container positions and updates ETAs based on real-time data from ships and trains. These solvers help optimise the logistics process from river transport to the final railway destination, ensuring efficient coordination and improved operational efficiency. Development has seen some deviations due to re-evaluations and changes in legislation, but these adjustments have provided opportunities for enhanced collaboration and more tailored solutions. Some KPIs that will lead to validating the Romanian UC success are the decrease of loading/unloading time by 20%, document digitalisation by 80% and reduction of the container idle time by 25%.

4.3 Implementation and Verification Framework and Results

The technology validation concluded with the verification of tests conducted in each use case to demonstrate potential improvements achieved through the implementation of FOR-FREIGHT solutions. Task 1.3 provides procedures for contacting the verification framework, which will be executed in T3.5, responsible for analysing and evaluating trial results carried out in the use cases. The verification framework involves comparing baseline and ex-post measurements for each KPI defined in T1.2. Baseline KPI values collected in T1.3 will be reported in the common Excel tool described above, as well as in Section 5.2 of this deliverable. These baseline values reflect the current logistics processes in each use case, while the ex-post values will measure the future situation considering the use of FOR-FREIGHT solutions. Once both values are collected, comparisons will be made for each KPI using the following formula:

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

This result will be benchmarked against the target KPI to verify if the target has been achieved and to demonstrate potential improvements attainable with the use of FOR-FREIGHT solutions.

The implementation and verification framework for the FOR-FREIGHT platform and Use Cases is as follows:

Requirement Analysis and Specifications

To initiate the implementation of the FOR-FREIGHT project, comprehensive requirement analysis sessions will be conducted with stakeholders from each use case to gather business needs and technical requirements. This process will involve detailed discussions to outline the specific functionalities required for the platform and use cases, ensuring that all aspects of the logistics processes are covered. Clear and measurable specifications for each component and service will be defined, aligning them with the business objectives and expected outcomes.

Feasibility Study

A feasibility study will be performed to evaluate the technical aspects of the platform and its components. This will involve assessing the chosen technology stack, identifying potential risks and constraints, and determining the viability of integrating the platform with existing logistics systems. The feasibility study will provide insights into any challenges that might arise and propose mitigation strategies.

Proof of Concept (PoC)

A PoC will be developed to validate the key functionalities and technologies of the platform. This PoC will focus on critical components such as the API Gateway, Authentication and Authorization, and the Solver Registry/Repository. The PoC will also test integration with external components like CI/CD systems and legacy logistics systems, ensuring that the core features work as intended in a controlled environment.

Architecture Review

An architecture review will be conducted with experienced architects and domain experts to ensure the proposed architecture supports scalability, reliability, security, and performance requirements. This review will

[4] https://www.rabbitmq.com/

involve scrutinising the design of each component, ensuring that the architecture can handle the anticipated load and integration complexities.

Performance and Load Testing

Performance and load testing will simulate various load scenarios to assess the platform's ability to handle real-world usage. Tools like Apache JMeter or Gatling will be used to measure response times, throughput, and resource utilisation under different conditions. This testing phase will identify any performance bottlenecks and guide optimisations to enhance the platform's efficiency.

Security Testing

Comprehensive security assessments will be carried out to identify and address vulnerabilities within the platform. This includes penetration testing, vulnerability scanning, and security code reviews. Ensuring robust security measures are in place is critical to protect sensitive logistics data and maintain the integrity of the platform.

Compliance and Standards Validation

The platform will undergo validation to ensure it meets industry standards and regulatory requirements pertinent to logistics and freight management. This process involves confirming alignment with standards like ISO 27001 for information security and GDPR for data protection. Achieving compliance is crucial for sustaining trust and meeting legal obligations across various regions and among different stakeholders.

User Acceptance Testing (UAT)

The UAT will involve key stakeholders and end-users in validating that the platform meets their business requirements and expectations. Feedback from these sessions will be collected to refine and improve the platform. Iterations based on user insights ensure the final solution is user-friendly and aligned with business needs.

CI/CD Pipeline Implementation

The CI/CD pipeline will be established and configured to automate the processes of building, testing, and deploying the platform. Integration of tools such as Jenkins, GitLab CI, or CircleCI will facilitate the rapid and dependable delivery of updates. This automation will facilitate continuous integration and deployment, maintaining the platform's stability and enabling quick releases of new features and bug fixes.

Component Development and Integration

Development of each platform component will be carried out according to the defined specifications. An iterative integration process will begin with core services such as Authentication and Authorization, API Gateway, and Service Monitoring. This modular approach will ensure that each component is developed and tested thoroughly before integration.

Automated Testing Framework

An automated testing framework will be implemented to ensure continuous testing throughout the development lifecycle. This framework will include unit tests, integration tests, and E2E tests for all components and services. Tools like Selenium for UI testing, Postman for API testing, and JUnit for unit testing will be used to maintain high test coverage and reliability.

Performance Optimization

Continuous monitoring and optimisation of the platform's performance will be a priority. Techniques such as caching strategies, database optimisations, and efficient algorithm implementations will be applied to enhance performance. Monitoring tools like Prometheus and Grafana will provide real-time insights into performance metrics, guiding ongoing optimisations.

User Training and Support

Comprehensive training sessions and support will be provided to ensure smooth adoption of the platform. Training materials, video tutorials, and helpdesk support will assist users in navigating and utilising the platform effectively. This will empower users to maximise the platform's capabilities and achieve their logistics goals.

Deployment and Monitoring

The platform will be deployed to the production environment following a detailed deployment plan. Monitoring and logging solutions will be implemented to track the health and performance of the platform in real-time. Tools like the ELK stack (Elasticsearch, Logstash, Kibana) will be used for centralised logging and monitoring, ensuring quick identification and resolution of any issues.

Feedback and Continuous Improvement

Establishing a feedback loop with users and stakeholders will be crucial for the continuous improvement of the platform. Regular updates and enhancements based on user feedback, performance data, and emerging technological advancements will ensure that the platform evolves to meet changing needs and maintains its competitive edge in the logistics industry.

By meticulously following this implementation plan, the FOR-FREIGHT platform will be validated and deployed effectively, ensuring it meets its functional and non-functional requirements and delivers a robust, secure, and high-performing solution for logistics and freight management.

5 Business Validation Methodology Updates

This section outlines the methodology for conducting the business validation of the solutions developed within the FOR-FREIGHT project. Implementing a structured ideation process is crucial for mitigating risks, minimising implementation costs, accelerating market entry, and preventing both unnecessary losses and the development of products that lack consumer value. Business validation helps ascertain whether the timing for launching and developing the idea is optimal and if the solution meets market efficiency standards.

Business idea validation involves gathering pertinent information to assess the relevance and potential return on investment of a new product or solution. This process also identifies the resources necessary for its development. The primary objective is to gauge the viability and market demand for the service, thereby confirming the potential for success. The approach is tailored to the specific qualities of the Spanish, Greek, and Romanian markets, ensuring relevance and effectiveness across different contexts. Each use case includes an individualised market analysis to address unique logistical challenges and opportunities in these specific use case regions.

The validation process includes explaining the solution's suitability to stakeholders and managing test plans. It also involves evaluating the results of these tests to ensure that the solution meets the required criteria and expectations. In the context of the FOR-FREIGHT project, Business Validation and Technological Validation methodologies serve distinct but complementary purposes in ensuring the success of the developed solutions. Business Validation focuses on assessing the market feasibility and economic viability of the FOR-FREIGHT solutions. This process involves gathering and analysing information to evaluate whether the developed solutions meet market needs and offer a worthwhile return on investment. Key aspects of business validation include understanding the market demand, determining the target customer base, and verifying the commercial potential of the solutions. This involves validating the timing of the product's market entry, the alignment of the solution with customer requirements, and the overall value proposition. The goal is to ensure that the solutions not only address real-world logistics challenges but also have a strong potential for success in the market. This involves conducting a comprehensive market analysis, building on the previous efforts in the project like the Political, Economic, Socio-Cultural, Technical, Legal, and Environmental (PESTLE) and Strengths, Weaknesses, Opportunities, and Threats (SWOT) analyses, which identify strengths such as high market demand for efficient logistics solutions and opportunities in digital transformation, alongside weaknesses like reliance on existing infrastructure and threats from competitive technologies.

Technological Validation, on the other hand, is concerned with the performance and functionality of the solutions from a technical perspective. This methodology involves rigorous testing to ensure that the FOR-FREIGHT platform and its components function correctly and efficiently. It includes evaluating how well the technology integrates with existing systems, how it handles real-time data processing, and its ability to meet predefined technical requirements and KPIs. Technological validation assesses aspects such as system reliability, data accuracy, scalability, and the effectiveness of the technology in solving specific logistical problems. It involves measuring performance against benchmarks and ensuring that the technology performs as intended under various conditions. Moreover, stakeholder engagement and continuous feedback mechanisms are integral to both business and technological validation processes, ensuring that the solutions are refined and adapted based on real-world input and performance by building a feedback loop between the stakeholders and the development of the project. These efforts have already resulted in tailored impact maximisation strategies and risk mitigation plans, continuing to improve developments via feedback from the engagement activities.

5.1 Lean Startup Methodology Application

Applying the Lean Startup Methodology to the FOR-FREIGHT platform involves iterative development, continuous feedback, and validated learning to ensure the platform meets user needs effectively and efficiently.

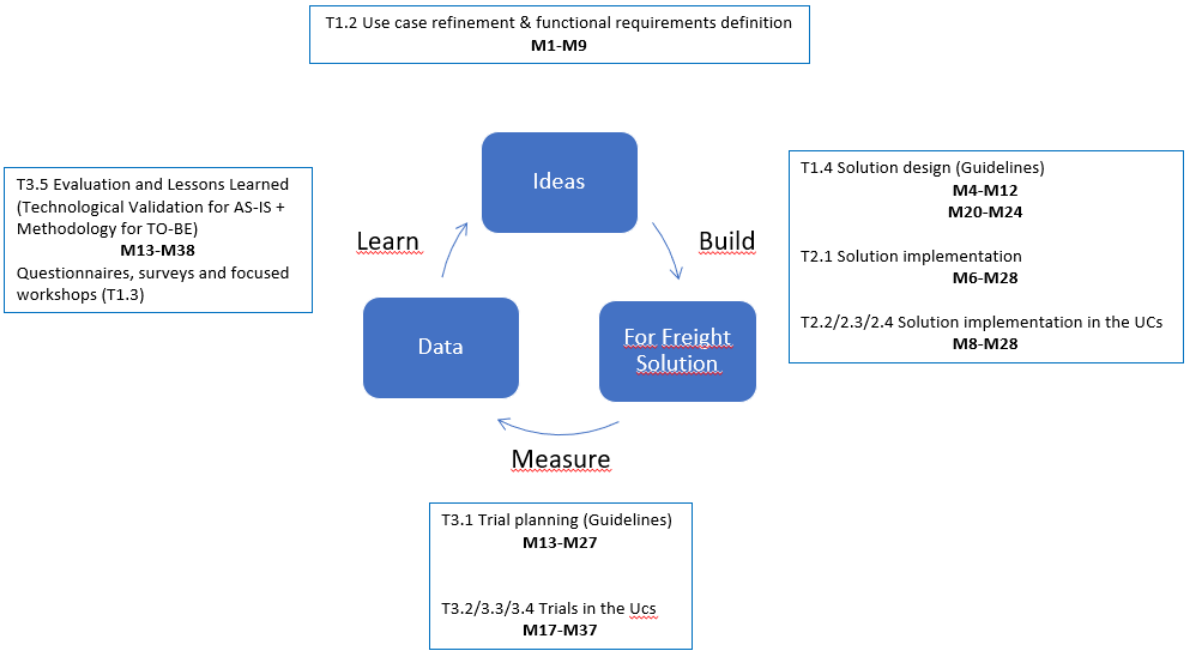


Figure 5-1 Scheme of Lean Startup Methodology adapted to FOR-FREIGHT Project.

This approach starts with building a Minimum Viable Product (MVP), a basic version of the FOR-FREIGHT platform that includes core functionalities necessary to address the primary needs of the Spanish, Greek, and Romanian trial sites. The MVP should be lightweight and include essential features for modeling logistics networks, integrating technical modules, and supporting user-role-based functionality.

After developing the MVP, it is deployed to a limited group of users within the trial sites to gather initial feedback. The interactions of these end-users with the platform are monitored, noting any challenges they face and areas for improvement. Various feedback mechanisms, such as surveys, interviews, and usage analytics, are employed to collect this information.

Applying the Lean Startup methodology to the FOR-FREIGHT project, a minimum of three iteratives cycles will be performed in each use case in order to find the best solution to satisfy the requirements set by business partners in T1.2 and T1.3. See the following Table regarding “Schedule proposal for Business Validation Methodology of the FOR-FREIGHT Project” set in D1.3.

Table 5-1 Schedule proposal for Business Validation Methodology of the FOR-FREIGHT Project

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

The feedback gathered is then analysed to identify patterns and insights about the platform's performance and user satisfaction. This analysis focuses on understanding which features are mostly valuable, the ones that are not yet used, and additional functionalities users may need. Assumptions about user needs and operational challenges are validated through this process.

Based on the insights gained, incremental improvements are made to the platform. These improvements may involve enhancing existing features, fixing bugs, and adding new functionalities that address user needs more effectively. Changes that deliver the most value to users and address critical pain points are prioritised. Throughout this process, the approach is continuously assessed to determine whether it meets the project's goals. If feedback indicates that certain assumptions were incorrect or if new opportunities emerge, the strategy or focus of the platform is adjusted accordingly—a process known as pivoting. If the approach is validated, the platform is further refined and expanded.

Once the MVP is stable and well-received, the scope of the platform is gradually expanded by adding more complex features and addressing additional use cases. Each new addition is tested and validated before full-scale implementation. This staged approach reduces risks and ensures that the platform evolves in alignment with user needs and operational goals. Implementing a continuous deployment process allows for frequent updates and improvements. This enables rapid iteration and ensures that users always have access to the latest features and fixes. Maintaining an agile development environment where feedback loops are short and responsive is crucial. Ongoing communication with users is maintained to gather continuous feedback and ensure the platform evolves to meet their changing needs. Forums, user groups, and regular updates keep the user community engaged and informed about new developments and improvements.

By following the Lean Startup Methodology, the FOR-FREIGHT platform can be developed to be responsive to user needs, minimise waste, and deliver value efficiently. This iterative and feedback-driven approach ensures the platform evolves in a user-centric manner, increasing its chances of success and adoption. We will use all relevant stakeholders to apply our feedback-driven approach and make sure our platform grabs the pulse of the T&L ecosystem.

Firstly, **logistics operators** are key users who will validate the platform's practical functionality in real-world scenarios. These professionals are responsible for managing and coordinating the movement of goods across the supply chain. Their involvement will be crucial in assessing whether the FOR-FREIGHT platform effectively supports end-to-end logistics processes, including transport planning, resource allocation, and real-time tracking. By using the platform to manage their operations, logistics operators will provide valuable feedback on its usability, efficiency, and integration with existing systems.

Supply chain managers are another group of essential users who will validate the platform's impact on overall supply chain management. They oversee the flow of goods from suppliers to end customers, making their insights critical for understanding how well the platform enhances visibility, optimises processes, and improves decision-making. Their evaluation will focus on how the FOR-FREIGHT platform helps streamline operations, reduce lead times, and manage inventory levels more effectively.

Technology developers and IT specialists involved in the project will also be key users in the validation process. They will assess the platform's technical performance, including its integration with other systems, data processing capabilities, and adherence to technical specifications. Their feedback will be essential for identifying and addressing any technical issues, ensuring that the platform operates reliably and efficiently.

End-users, such as **warehouse staff and transportation coordinators**, will provide direct input on the platform's user interface and functionality. Their day-to-day interactions with the platform will offer insights into its ease of use, the clarity of its data presentation, and its overall effectiveness in supporting operational tasks. Their feedback will be critical in refining the platform to better meet the needs of those who use it on the ground.

Finally, **business analysts and consultants** will play a role in evaluating the platform's alignment with industry standards and business objectives. They will assess whether the platform delivers on its promises, meets the established KPIs, and contributes to the strategic goals of the FOR-FREIGHT project. Their analysis will help in understanding the broader business impact of the platform and ensuring that it aligns with market expectations and competitive standards.

Together, these users will provide comprehensive feedback that covers both the technological and business aspects of the FOR-FREIGHT platform, ensuring that it meets the needs of all stakeholders and performs effectively in real-world logistics scenarios.

Workshops play a pivotal role in the business validation process for the FOR-FREIGHT platform and its solutions across all use cases. These workshops provide an interactive and collaborative environment where end-users, stakeholders, and technical partners can engage directly, facilitating a comprehensive understanding of the current implementation and its impact. By incorporating the Lean Startup methodology, these workshops emphasise the importance of continuous iteration and adaptation based on real user feedback, ensuring that the solutions developed are closely aligned with user needs and business objectives.

The structure of workshops should cover the following points:

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

Planned date periods for the workshops were defined in D1.3 as below:

Table 5-2 Planned date periods for the development of the internal focused workshops proposed

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

The primary objective of these workshops is to validate the solutions developed within each use case by gathering detailed feedback and insights from the end-users who will be utilising these solutions. This direct engagement helps identify any gaps or areas of improvement early in the development cycle, allowing for timely adjustments and refinements. By involving stakeholders such as logistics companies, supply chain managers, and technical experts, the workshops ensure that the solutions are not only technically sound but also practical and effective in addressing the specific challenges faced by the industry.

During these workshops, various activities are set to be conducted, including demonstrations of the developed solutions, interactive discussions, and hands-on exercises. Participants are encouraged to evaluate the solutions based on predefined KPIs, usability, and overall effectiveness. This structured approach ensures that the feedback collected is both qualitative and quantitative, providing a holistic view of the solution's performance. Furthermore, the workshops serve as a platform for end-users to express their expectations, preferences, and any additional features they might require, which are crucial for the iterative improvement process.

The business validation workshops are instrumental in ensuring that the FOR-FREIGHT platform delivers value to its users. By continually incorporating user feedback into the development process, the platform can evolve to meet the dynamic needs of the logistics and freight industry. This user-centric approach not only enhances the relevance and adoption of the solutions but also drives innovation and efficiency in logistics operations.

Using workshops for business validation in the FOR-FREIGHT platform fosters a collaborative environment that bridges the gap between technical development and real-world application. It ensures that the solutions are rigorously tested, validated, and refined based on actual user experiences, ultimately leading to a robust, user-friendly, and impactful platform for the logistics and freight industry.

5.1.1 Spanish Use Case

Applying the Lean Startup Methodology to the Spanish Use Case of the FOR-FREIGHT platform involves a focused and iterative approach to developing a solution that meets the specific needs of aggregating information across the supply chain, supporting decision-making, and optimising transport modes. Initially, the process begins with the creation of a MVP that includes the fundamental functionalities necessary to aggregate data from various management systems involved in the supply chain process. This MVP would support decision-making on resource use and transport planning from the ship to the port, central warehouse, and last-mile delivery.

Once the MVP is developed, it is deployed to the trial sites in Valencia Port and the associated warehouses. This initial deployment allows for real-time feedback from users involved in these operations. Their interactions with the platform are closely monitored to identify any challenges and areas needing improvement. The feedback is collected through various mechanisms such as surveys, interviews, and usage analytics, ensuring a comprehensive understanding of the platform's performance and user experience.

The feedback is then analysed to draw insights into which features are most valuable and which aspects require enhancement. For instance, the use of blockchain for real-time data exchange, digital twins, and AI/ML predictive analytics can be tested for their effectiveness in supporting flexible and dynamic transport planning. Insights from this analysis guide the iterative improvement of the platform. Features that deliver significant value, such as reduced emissions and cost savings, are prioritised for further development and refinement.

Throughout this process, the Lean Startup Methodology emphasises the importance of continuous learning and adjustment. If the feedback reveals that certain assumptions about the use of the metro network for last-mile delivery or other logistical elements were incorrect, the approach can be pivoted. Conversely, validated assumptions will be further developed and scaled. This iterative process ensures that the platform evolves based on actual user needs and operational challenges.

The methodology also supports a phased expansion of the platform's scope. After stabilising the MVP and addressing initial feedback, the platform's capabilities can be gradually extended to include more complex functionalities and address additional scenarios, such as the second scenario covering last-mile distribution from the warehouse to the final customer. Each new addition is carefully tested and validated before full implementation, reducing risks and ensuring that the platform remains aligned with user requirements and project goals.

By leveraging continuous deployment, the platform can roll out updates and improvements frequently, ensuring that users have access to the latest features and fixes. This agile approach maintains short feedback loops and allows for rapid iteration. Additionally, continuous engagement with users through forums, user groups, and regular updates keeps the user community informed and involved, fostering a collaborative development environment.

In essence, the Lean Startup Methodology ensures that the FOR-FREIGHT platform for the Spanish Use Case evolves in a user-centric manner. By focusing on validated learning, iterative development, and continuous feedback, the platform is designed to effectively aggregate supply chain information, support decision-making, and optimise transport planning, ultimately leading to more efficient, sustainable, and cost-effective logistics operations.

The Spanish Internal UC Workshop has been an essential tool for validating the current implementation and results with the end users of the Spanish UC, specifically CSLS, DHL, and MDM. This workshop served as a critical validation step, enabling the collection of feedback and insights directly from stakeholders. It aligns with the project's Lean Startup methodology, which emphasises continuous iteration and adaptation based on user feedback. This approach allows technical partners to refine and improve their solutions following each iteration, guided by the suggestions and needs of end-users.

End-user engagement in the validation process is crucial for ensuring that FOR-FREIGHT solutions address real user needs and problems effectively. Through this involvement, the Spanish UC validated the relevance and effectiveness of the solutions, identified potential areas for improvement, and updated and enhanced the solvers for subsequent iterations. FVP conducted this workshop with end-users and technical partners, focusing on the solvers ES_05 (CO_2 prediction of a trip A-B) and ES_08 (Demand prediction on MDM) developed in the first drop of solutions. The primary goal was to gather stakeholders' opinions and feedback on the functionality, usability, and effectiveness of the solvers.

The workshop agenda included demonstrations of how the two solvers worked, quantitative evaluations based on KPIs associated with the solvers, interactive discussions, and exercises/questionnaires to facilitate active participation and engagement from participants in evaluating and validating the solvers. During the workshop, and as a first step in the qualitative analysis of solvers ES_05 and ES_08, participants (CSLS, DHL, and MDM) were asked questions to collect specific feedback on various aspects of both solvers. These questions included inquiries on how to proceed with the KPI calculations of solver ES_05, whether the current state of solvers ES_05 and ES_08 met their initial expectations, and if solvers ES_05 and ES_08 provided the expected CO_2 emissions information for the respective routes and demand predictions. Additionally, participants were asked about the value the solvers brought, their desired outputs from the solvers, the potential impact on their operations, preferred user interface features, and areas for improvement for future refinements of the solvers. The specific results of the workshops connected to the solvers presented are as detailed below:

Solver ES_05:

User Input and Usability: Participants valued the ability of the solver to allow users to select different modes of transportation, services, and input detailed information relevant to their specific needs. The feature that enables the calculation of the CO_2 footprint based on the selected transportation mode was considered particularly beneficial for making informed decisions regarding route selection. The tool's interface was user-friendly, although some participants suggested the inclusion of additional variables to enhance the accuracy of the CO2 calculations.

Business Impact: Participants identified that solver ES_05 could significantly improve their operations by providing critical data on emissions that would otherwise be difficult to calculate manually. Departments focused on sustainability and environmental impact within organisations expressed the highest interest in integrating this solver into their daily operations. While the tool was seen as a positive addition, some concerns were raised about the potential complexity of integrating the solver with existing systems and the need for additional staff training.

Commercial Viability: There was a consensus that the solver could be a valuable commercial tool, particularly if offered as part of a broader suite of logistics solutions. Participants were willing to pay for access to the solver, especially if it could be seamlessly integrated into a fully operational platform with other end-to-end (E2E) solvers.

Solver ES_08:

User Input and Predictive Capabilities: Participants appreciated solver ES_08's ability to handle predictive modelling based on historical data and simulations for non-existent processes. This capability was crucial for optimising logistics, particularly in planning for parcel demand and depot management. The user interface was generally well-received as a concept, but there were suggestions for improving the real-time data presentation and enhancing the clarity of certain outputs.

Operational and Environmental Benefits: The solver's ability to predict CO_2 emissions for different transportation options was noted as a vital feature that could aid in achieving sustainability goals. The tool was expected to facilitate a shift in transportation modes, promoting more environmentally friendly options. Participants also highlighted the solver's potential to reduce operational costs by optimising route planning and resource allocation. However, they stressed the importance of accurate data input for these benefits to be fully realised.

Challenges and Recommendations: The main challenges identified were related to the integration of the solver with existing business processes and the need for staff to develop new skills to fully utilise the tool. Participants recommended further refinement of the solver to include more detailed customisation options and suggested regular updates to the predictive algorithms based on real-time data.

The workshop provided valuable feedback to guide the technical partners in making necessary adjustments to solvers ES_05 and ES_08. The feedback emphasised the importance of usability, integration with existing systems, and the potential for these tools to impact business processes and sustainability efforts significantly. Participants were generally optimistic about the solvers' potential and were willing to adopt them as part of their long-term logistics strategies, provided that their suggestions for improvements were addressed.

A sample of the questions of the survey used to gauge internal stakeholder needs can be found in Annex I: Execution of the Use Cases Workshops.

5.1.2 Greek Use Case

Applying the Lean Startup Methodology to the Greek Use Case of the FOR-FREIGHT platform involves a structured, iterative approach to developing a solution that effectively integrates information from diverse management systems and field equipment to support multimodal logistics. Initially, the process begins with developing a MVP that includes core functionalities necessary to integrate information from legacy management systems, field devices, newly deployed sensors, and ML and data analytics functions. This MVP aims to provide logistics operators and end-users a real-time, comprehensive view of the logistics process.

After the MVP is developed, it is deployed to a limited group of users involved in the Greek Use Case. This deployment allows for real-time feedback from logistics operators and end-users interacting with the platform. Their experiences and challenges are closely monitored through various feedback mechanisms such as surveys, interviews, and usage analytics. This feedback collection is essential for understanding the platform's performance and identifying areas for improvement.

The collected feedback is then analysed to gain insights into which features are mostly valuable and which aspects need enhancement. For example, the platform's ability to automate processes currently executed manually, minimise human error, provide accurate real-time cargo/container positions, and offer full remote monitoring capabilities can be thoroughly evaluated. These insights guide the iterative improvement of the platform, with a focus on enhancing features that deliver significant value and address critical pain points.

Throughout this process, the Lean Startup Methodology emphasises continuous learning and adjustment. If feedback indicates that certain assumptions about integrating information or the utility of newly deployed sensors and ML functions were incorrect, the strategy can be adjusted accordingly. This process of pivoting ensures that the platform evolves based on actual user needs and operational realities. Conversely, validated assumptions and successful functionalities are further refined and scaled up.

The methodology also supports a phased expansion of the platform’s capabilities. Once the MVP is stable and receives positive feedback, the platform’s scope can be gradually expanded to include more complex functionalities and additional scenarios. Each new feature or capability is carefully tested and validated before full-scale implementation, reducing risks and ensuring alignment with user requirements and project objectives.

Implementing continuous deployment allows for frequent updates and improvements, ensuring that users have access to the latest features and fixes. This agile approach maintains short feedback loops, enabling rapid iteration and adaptation. Continuous engagement with users through forums, user groups, and regular updates keeps the user community informed and involved, fostering a collaborative development environment.

In summary, the Lean Startup Methodology ensures that the FOR-FREIGHT platform for the Greek Use Case evolves in a user-centric manner. By focusing on validated learning, iterative development, and continuous feedback, the platform is designed to effectively integrate information from diverse sources, support multimodal logistics, and enhance operational efficiency. This approach ultimately leads to a robust solution that minimises human error, automates manual processes, and provides real-time monitoring and accurate cargo positioning, thereby meeting the needs of logistics operators and end-users effectively.

The Greek Internal UC Workshop has been a critical process for validating the current implementation and results with the end users of the Greek UC, namely COEL, GOLD, and AIA. WINGS presented the key technical enablers of the 1st drop of solutions. The workshop comprised four main parts: i) the presentation of the Greek UC challenges and implemented list of solvers and E2E solving processes (GR_01, GR_02, GR_04, GR_09, GR_10, GR_11, as well as the “master solvers”/E2E solving processes GR_13, GR_14 and GR_15); ii) the presentation of the capabilities and features of the local, Greek UC FOR-FREIGHT platform; iii) the presentation of the capabilities and Workflow Engine features of the central FOR-FREIGHT platform; iv) the discussion between the Greek UC stakeholders and WINGS in relation to the provided questionnaire and the collection of initial feedback. Then, the Greek UC stakeholders worked offline on the questionnaires and provided their detailed feedback. The questionnaire comprised five sections: Section 1 “Technological Evaluation”, Section 2 “Environmental Impact”, Section 3 “Economic Impact”, Section 4 “Business Process Improvement”, and Section 5 “Commercialisation and Market Fit.”

For AIA, the workshop results were particularly significant in terms of improving operational efficiency within the airport's cargo area. Participants from AIA noted that the solutions helped in facilitating and developing cargo flows while alleviating traffic congestion. The solvers enhanced cargo handling efficiency and capacity without compromising service quality. Technologically, AIA fully agreed that the solutions met all requirements, integrated well with existing systems, and performed efficiently even under multiple queries. Environmentally, the solutions contributed to reducing GHG emissions, particularly through better route optimisation and predictive analytics. Economically, AIA recognised the solutions' role in reducing operational costs, particularly in labour, and in improving resource allocation. The enhanced decision-making capabilities, along with the user-friendly interface, were also highlighted as key factors for successful adoption. Moving forward, AIA expressed interest in continuing to use these solutions, contingent on broader adoption by other Cargo Community members.

GOLD's feedback was equally positive, with participants expressing complete agreement on the technological performance and integration of the solutions. The usability of the platform, particularly the interface's intuitiveness and the clarity of result visualisation, was also rated highly. From an environmental perspective, GOLD acknowledged the solutions' effectiveness in reducing GHG emissions and meeting sustainability KPIs. Economically, the solutions led to significant cost efficiencies, particularly through the reduction of the labour costs and the optimisation of processes. The improvements in operational efficiency, especially in terms of delivery times and inventory management, were also noted. GOLD valued the competitive advantage provided by these solutions, particularly in enhancing supply chain visibility and automation capabilities. The organisation indicated a substantial likelihood of continuing to use the solutions, especially if they could be seamlessly integrated into broader logistics operations.

For COEL, the workshop results reinforced the solutions' alignment with their operational goals. Technologically, COEL agreed that the solutions met the set requirements with robust performance and integration. The usability and user-friendly nature of the platform were appreciated, particularly in how the interface facilitated quick adoption and minimal disruption to daily routines. Environmentally, COEL recognised the solutions' contribution to reducing GHG emissions and optimising resource allocation. Economically, the solutions were found to improve operational cost efficiency, with notable benefits in labour cost reduction and process optimisation. COEL also emphasised the importance of reduced cargo idle time, improved customer service experience, and enhanced supply chain visibility. The organisation expressed a willingness to adopt these solutions on a larger scale, contingent on the involvement and alignment of other stakeholders within the logistics community.

Overall, the workshop successfully tailored the solutions to the specific needs of each participant, demonstrating their practical applicability and benefits across different aspects of logistics and freight management. The positive feedback across all participants underscores the solutions' potential for broader adoption and long-term sustainability.

A summary of the responses received by the internal Use Case partners can be found in Annex I: Execution of the Use Cases Workshops.

5.1.3 Romanian Use Case

Applying the Lean Startup Methodology to the Romanian Use Case of the FOR-FREIGHT platform involves a systematic, iterative approach to developing a solution that effectively integrates information across various stakeholders using advanced IoT and data processing solutions. Initially, the process begins with creating a MVP that includes the essential functionalities needed to combine information from individual management systems of suppliers, shipping agents, port authorities, terminal operators, warehouse operators, railway operators, and beneficiaries. This MVP should leverage state-of-the-art technologies such as 5G and the Internet of Containers to provide fluent and accessible information on the transport flow.

Once the MVP is developed, it is deployed to a selected group of users involved in the Romanian Use Case. This deployment phase allows for real-time feedback from these users, whose interactions with the platform are carefully monitored. Feedback is collected through various methods, including surveys, interviews, and usage analytics, to capture a comprehensive understanding of the platform's performance and user experience.

The feedback is then analysed to extract insights into the platform's most valuable features and areas requiring improvement. For instance, the platform's capability to facilitate prior planning and resource use throughout the transport chain, optimise resources to avoid congestion, and ensure the operational time target can be thoroughly evaluated. These insights guide iterative enhancements, focusing on refining features that deliver significant value and address critical operational challenges.

Throughout this process, the Lean Startup Methodology emphasises continuous learning and adaptability. If the feedback reveals that certain assumptions about the integration of information or the utility of IoT infrastructure were incorrect, the strategy can be adjusted accordingly. This pivoting process ensures that the platform evolves based on actual user needs and operational realities. Conversely, validated assumptions and successful functionalities are further developed and expanded.

The methodology also supports a phased approach to expanding the platform's capabilities. After stabilising the MVP and addressing initial feedback, the platform's scope can be gradually expanded to include more complex functionalities and additional use cases. Each new feature or enhancement is thoroughly tested and validated before full-scale implementation, reducing risks and ensuring that the platform remains aligned with user requirements and project goals.

Implementing continuous deployment allows for frequent updates and improvements, ensuring that users have access to the latest features and fixes. This agile approach maintains short feedback loops, enabling rapid iteration and adaptation. Continuous engagement with users through forums, user groups, and regular updates keeps the user community informed and involved, fostering a collaborative development environment.

The Lean Startup Methodology ensures that the FOR-FREIGHT platform for the Romanian Use Case evolves in a user-centric manner. By focusing on validated learning, iterative development, and continuous feedback, the platform is designed to effectively integrate information from diverse stakeholders, support prior planning and resource optimisation, and enhance operational efficiency. This approach ultimately leads to a robust solution that leverages advanced IoT and data processing technologies to provide real-time monitoring, avoid congestion, and meet operational targets, thereby addressing the needs of all stakeholders involved in the transport flow.

BEIA organised the Romanian Internal UC Workshop, a key event for engaging end users from TcCFR, INLS, and ATG. This workshop was one of the tools used to validate the current implementation and results, ensuring that FOR-FREIGHT solutions effectively address real-world problems. The event aimed to foster collaboration and gather valuable insights from end users.

The workshop began with a presentation on the RO_10 (ETA) and RO_01 (Tracking) solvers, covering their business logic, architecture, practical examples, APIs, and KPIs. These presentations were crucial for gathering feedback on the functionality, usability, and overall effectiveness of the solvers. Participants were given comprehensive overviews, which helped them understand the intricate workings and potential applications of the solvers in their respective domains.

After the presentations, a short explanation about how the solvers can enhance each other was provided. This explanation highlighted the synergies between the solvers, demonstrating how their combined use could yield better results and more robust solutions.

Following this, participants engaged in a discussion about potential future improvements and areas that should be developed, such as information security and exploitation possibilities. This discussion was vital for refining and enhancing the solutions based on user input, which in line with the project's Lean Start-up methodology, which emphasises continuous iteration and adaptation. The collaborative environment encouraged participants to share their unique perspectives and propose innovative ideas for future developments.

A questionnaire was sent out after the workshop to gather additional insights from stakeholders (e.g, the port of Galati). This follow-up was designed to capture detailed feedback and ensure that all voices were heard, contributing to the continuous improvement of the FOR-FREIGHT solutions.

5.2 Commercialisation Analysis

The commercialisation of the FOR-FREIGHT platform hinges on its ability to provide comprehensive, real-time logistics solutions tailored to diverse use cases across multiple geographies. The platform's cloud-based, objective-customized, and role-based design ensures it can adapt to the specific needs of various stakeholders in the logistics chain, from suppliers and shipping agents to port authorities and end-users. By integrating advanced technologies such as IoT, AI/ML, and Big Data Management, FOR-FREIGHT offers a sophisticated solution capable of addressing complex logistical challenges and improving operational efficiency.

In the Spanish Use Case, the platform's value proposition centres on its ability to aggregate information from individual management systems, enhancing decision support for resource use and transport planning. The emphasis on utilising the existing Metro network for last-mile delivery, facilitated by real-time data exchange through Blockchain and dynamic transport planning via Digital Twins and AI/ML predictive analytics, positions the platform as a transformative tool for reducing emissions and costs. The platform's ability to address critical pain points in logistics and provide significant environmental and financial benefits will be key selling points in this market.

The Greek Use Case highlights the platform's capability to integrate information from legacy management systems and new sensors, supporting the end-to-end multimodal logistics process. Through the GR UC FOR-FREIGHT demonstrates its potential to revolutionise logistics operations. The platform's ability to provide a comprehensive real-time picture of logistics processes and improve operational accuracy and efficiency will attract logistics operators seeking to modernise their systems.

In the Romanian Use Case, the platform leverages state-of-the-art IoT and data processing solutions to combine information from various stakeholders, enabling seamless access to transport flow data. The focus on prior planning and resource optimisation through IoT infrastructure ensures that the platform can effectively monitor activities, avoid congestion, and achieve operational time targets. This use case showcases the platform's strength in integrating cutting-edge technologies to deliver real-time monitoring and resource management, making it a compelling solution for logistics operators aiming to enhance efficiency and reduce operational bottlenecks.

The Lean Startup Methodology employed in the development of the FOR-FREIGHT platform ensures that it evolves based on validated user needs and feedback, minimising waste and maximising value. This iterative approach allows for rapid adaptation to market demands and continuous improvement, making the platform highly responsive and user-centric. The ability to deploy and refine the platform in real-world scenarios across different regions demonstrates its versatility and scalability, further strengthening its market appeal.

The FOR-FREIGHT project, as outlined in the D4.2 “FOR-FREIGHT Business Plan”, aims to address multimodal freight transport issues by developing a cloud-based platform that enhances collaboration, interoperability, and optimises freight flows. This initiative promotes a comprehensive multimodal logistics ecosystem with sustainable and innovative solutions. The business plan includes tailored commercialisation strategies for Spain, Greece, and Romania, focusing on AI, ML, blockchain, route optimisation, and advanced tracking technologies to improve efficiency and reduce costs, despite initial investment and legal challenges.

The project sees substantial commercial potential in the T&L sector through licensing, a subscription-based SaaS model, customisation, system integration, white labeling, and API licensing. Future steps include implementing a detailed commercialisation strategy, forming strategic partnerships, conducting pilot projects, protecting intellectual property, ensuring customer support, and scaling efforts for global expansion while adhering to regulatory standards. Continuous innovation will be essential to stay competitive and relevant, focusing on sustainability and adapting the business model to dynamic market conditions and customer needs.

The complete commercialisation plan will be detailed in D4.5. The preliminary strategy emphasises a joint approach with key partners to establish a commercial framework for the FOR-FREIGHT platform as a service. This involves a subscription-based revenue model for cloud services, complemented by operational services such as support and consultancy. Before forming a Joint Venture (JV), a cross-licensing agreement will enhance the platform's Technology Readiness Level (TRL) and ensure sustained innovation. The JV will include roles for technical support, innovation, market analysis, and business strategy to commercialise the project’s results within two years post-completion, ensuring sustainability and market relevance.

The FOR-FREIGHT project will collaborate with key consortium partners, including CERTH, eBOS, DHL, and WINGS, led by BEIA, to develop and implement a joint commercialisation strategy. These partners will form the commercialisation team responsible for establishing the appropriate commercial framework. The framework will support the provision of the FOR-FREIGHT platform and its solutions as a service, enabling third parties to deploy their transport and logistics applications efficiently. Revenue will be generated from subscription-based cloud services, determined by usage time, features, and the number of concurrent users. Additionally, the strategy leverages the FOR-FREIGHT platform's capabilities to deliver other operational services, such as support and consultancy on a subscription model. These partners, with their expertise and proven track records in industry-oriented research and technology development at TRL 7-9, will ensure the successful commercialisation of the project’s solutions.

Ultimately, the FOR-FREIGHT platform's commercialisation strategy will benefit from its demonstrated capability to integrate diverse data sources, support advanced analytics and decision-making, and enhance operational efficiency across various logistics environments. By addressing the unique challenges of different use cases and leveraging advanced technologies, the platform is well-positioned to attract a wide range of customers in the logistics industry, from small operators to large-scale enterprises. Its emphasis on real-time data integration, process automation, and resource optimisation will be crucial in differentiating it from competitors and driving its adoption in the market.

6 Risk Assessment

Risk assessment is a critical component of the FOR-FREIGHT platform's development and implementation process. Given the complex and dynamic nature of logistics and freight operations, the platform must be robust, reliable, and capable of addressing various potential risks that could impact its performance and effectiveness. The primary goal of this risk assessment is to identify, analyse, and mitigate risks that could hinder the successful deployment and operation of the FOR-FREIGHT platform across different use cases.

The FOR-FREIGHT platform integrates advanced digital technologies, predictive models, and real-time data analytics to enhance logistics operations. However, the reliance on cutting-edge technology also introduces various risks, including technical, operational, strategic, and external risks. Technical risks pertain to potential issues with system architecture, software development, data accuracy, and cybersecurity. Operational risks involve challenges related to system integration, user adoption, and maintenance. Strategic risks encompass the alignment of the platform with business objectives and stakeholder expectations, while external risks cover factors such as regulatory changes, market fluctuations, and environmental impacts.

In this risk assessment, we systematically evaluate these potential risks to ensure proactive measures are in place to mitigate them. The assessment process involves identifying risk factors, evaluating their likelihood and potential impact, and developing strategies to minimise or manage these risks. By doing so, we aim to enhance the resilience and reliability of the FOR-FREIGHT platform, ensuring it can effectively support the logistics and freight industry in achieving greater efficiency, transparency, and sustainability.

The assessment is structured to cover all aspects of the platform, from initial development and deployment to long-term operational stability. This comprehensive approach ensures that all potential vulnerabilities are addressed, and that the platform can handle both anticipated and unforeseen challenges. Through continuous monitoring and iterative improvements, the risk assessment will evolve alongside the platform, adapting to new developments and emerging threats.

The risk assessment of the FOR-FREIGHT platform is essential for safeguarding its success and ensuring it delivers the intended benefits to all stakeholders involved. By identifying and addressing risks proactively, we can ensure the platform's robust performance, secure operation, and long-term viability in the highly competitive and ever-changing logistics and freight sector. The risk identification and inventorying methodology has been documented in deliverable D1.3.

6.1 Solution design/development Risk Assessment and Mitigation

Risk assessment on the solution design and development of the general platform of FOR-FREIGHT and the corresponding UC’s solvers has been updated from deliverable D1.3 in Table 6-1 following the risk methodology defined above.

Table 6-1 below reports the Risk analysis on the solution design and development of FOR-FREIGHT's general platform and the corresponding UC solvers. It is essential to mention that some of the following risks were reported in the project’s Technical Report for the reporting period M01-M22, and some were defined by the project consortium after M22.

Table 6-1 Risk analysis on the solution design and development of the general platform of FOR-FREIGHT and the corresponding UC's solvers.

Description of the risk	Likelihood (R-U-P-L-AC)[5]	Impact (I-Mi -Mo-Ma-Cr)[6]	Risk	Risk-Mitigation measures
Proposed solvers are redundant, unrealistic, or do not meet UC's needs or expectations.	U	Ma	High	Thoroughly study D1.2 and have the system design reviewed by UC stakeholders, periodical and per-request feedback requests on functionalities.
Cost overruns: The platform development effort exceeds the project budget.	U	Mo	Moderate	Relevance sorting of modules, identification of must-have and nice-to-have solutions.
Lack of historical/real-time data to ensure models' performance and freshness	U	Mo	Moderate	Scope the model in accordance with data possibility and use Simulation to generate part of the missing data.
The proposed platform brings unequal benefit to involved partners during implementation, resulting in degradation of trust or commitment.	U	Mo	Moderate	Platform design must allow UC partners to customise the system towards multivariate benefit objectives, and assessment of benefit over time during implementation and via feedback to ensure timely adaptation towards harmonised benefit.
Solvers are excessively used case specific and hard to extend or upscale if needed.	R	Mo	Moderate	Ensure generalisation and extensibility in model design, exchange/collaboration across use cases for inheritance of overlap features.
Unauthorised access to sensitive logistics data, leading to insufficiency of collected data and as a consequence, inefficiency of built models.	P	Ma	High	Implement strong data encryption, access controls, user authentication, and regular security audits.
Difficulty on integration of different components (legacy systems, solvers and third-party applications) due to incompatibility of protocol, data format and deployment environment.	U	Ma	High	Compatibility testing, standardised data formats, clear communication channels among stakeholders, robust data governance.

[5] R = Rare, U = Unlikely, P = Possible, L = Likely, AC = Almost Certain

[6] I = Insignificant, Mi = Minor, Mo = Moderate, Ma = Major, Cr = Catastrophic - Critical

Insufficient involvement of key stakeholders, leading to misalignment and poor adoption.	R	Ma	Moderate	Involve stakeholders early and consistently, gather feedback, and ensure their needs are considered throughout the design process.
Political instability, regulatory changes, and environmental factors impacting logistics chains (e.g., war, extreme weather conditions, etc.)	P	Mo	Moderate	Stay informed about geopolitical situations, diversify supply chain sources, and consider environmental sustainability in planning.
Third-party vendors for technology and services delivery disruption, affecting solution's full-fledged features.	U	Mo	Moderate	Maintain regular and transparent communication with third-party providers.
High expectations for software capabilities: All system components must be finely tuned, reliable and scalable to achieve the required KPIs that exceed usual TRL 7 solutions.	P	Ma	Moderate	The System/Platform modules and the testbed infrastructure will be configurable, performant and scalable. Security and privacy will be considered and enforced all the way through design and implementation. The consortium includes partners with sound experience in setting up such solutions.
Less than expected performance: The risk is that the System/Platform fails to match required performance indicators, stakeholders' acceptance and solution usefulness.	U	Ma	High	FOR-FREIGHT includes solid industrial partners with a worldwide reputation, implying a strong user interaction that minimises this risk. For this reason, periodical exchanges between stakeholders will be conducted during the entire course of the project. Any potential problems will be detected and addressed in the early stages. The project management structure also includes an External Advisory Board (EAB) of independent experts that will steer project activities.
There is a risk that requirements are not well defined, therefore, there is no reference to track requirements and validate KPIs.	P	Ma	High	The requirements are methodologically captured in WP1 and in the trials with use case stakeholders playing a key role. The project evolution process is agile, and the solution adapts to changing

				use case partner requirements during the lifetime of the project.
Solution components maturity: Risk that the developed components are below the required level of maturity to sustain the application requirements, requiring specialised customised development to achieve their target TRL levels.	P	Ma	High	Many system components are project assets or belong to partners' existing solutions. The risk is minimised as the project will perform incremental development, configuration, integration, and extension of such components. For all solutions, there will be alternatives and options, producing less risky implementations properly tested before deployment. Risk is monitored by TM.
Data and information security: The risk concerns the security and privacy of data and information, as security is of utmost importance.	R	Ma	High	The platform design & architecture comprises of services for encryption, authorisation, pseudo-anonymisation and secure information flows. These will be protected behind a secured access environment with appropriate security policies, as also defined in the project's Data Management Plan (DMP). Risk monitored by the Technical Manager (TM).
Proper Testing issues: The risk is that testing on the deployed System/platform was not done properly thus finding defects while performing Facility validations through use cases.	P	Mo	Moderate	Testing of the performance of the platform and solutions will be initially conducted in a dry-run environment (local, integration and system) before their validation in realistic use cases in field trials. Testing is a part of the quality assurance function and is monitored by the PC, the TM, and Quality Manager (QM).
Complexity of integration procedures: Risk that integration procedures among components developed/belonging to different stakeholders are too hard.	P	Mo	Moderate	The integration of diverse and novel system modules, legacy systems and APIs is a challenging and demanding process. A separate task has been dedicated to integration activities (T2.5) and consortium partners that are responsible for the integration are in a position to demonstrate a vast experience in successful

				integration from previous H2020 actions. The careful planning of all actions and the close interaction between WP2 and WP3 will also help to avoid this risk.
Complexity of code: The risk is that the complexity of developing the code for the platform and trial site solutions is high.	L	Ma	High	The high expertise and experience of the technological partners involved in the development of the trial site solutions and of the FOR-FREIGHT platform, together with the careful design and selection of the requirements at the design phase reduce the probability of this risk. Risk monitored by the TM.
There is a risk that the central platform developed will not be compatible and not be able to be packaged together with trial site multimodal solutions.	P	Ma	High	The risk is addressed by careful co-design principles in WP1 (UCs and platform architecture are designed in tandem) and the common testing and validation framework where data representations and APIs will be designed. Utilisation of technology, with common standards will also be favoured. Both the probability and the impact of such a risk will be monitored and controlled by the TM.
Lack of coordination: In large projects there is a risk related to ad hoc and uncoordinated development, resulting in diverging results and components.	U	Ma	High	FOR-FREIGHT will use an agile methodology. All developments are incremental with end-users directly collaborating to the development of the system components. The development approach and progress are constantly monitored by the TM and managed by the QM.
Technology Management, Late Identification of Issues: The risk is about technology issues and defects, or possibly wrong options are only discovered at a very late stage of the project creating high risks to execution or inability to perform.	U	Mo	Moderate	The project plan is agile and adaptive, leaving sufficient space for adaptation and rework if necessary. Project planning allows controlling such risks, through a separate planning process and dedicated roles for the project and for the validation of the platform and solutions through the use cases. However, as impact is high, it will be constantly

				monitored and mitigated by the PC/QM.
A use case is not completed: The risk is not to have a use case executed because of lack of resources and/or personnel changes from a project partner.	P	Ma	Major	The PC will raise the issue urgently with the management of the partner organisation, as losing one of the use cases may decrease the quality of the outcome of the project. If no alternative UC can be found within the consortium, in consultation with the EC, the consortium will consider a replacement UC (and maybe partner).
Risks to innovation: Project outcomes are constrained in the 'closed world' of researchers, thereby delivering solutions of limited scope/applicability.	L	Mo	Moderate	There will be a strong innovation, capacity building and commercialisation drive in the project. There is strong industrial, research and SME participation in the project. The TM and Innovation Manager (IM) constantly monitor this risk.

6.1.1 Spanish Trial

Risk assessment on the Use Case 1 – Spanish Trial has been performed and updated in Table 6-2 following the risk methodology defined above.

Table 6-2 Risk analysis on the Use Case 1 – Spanish Trial

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

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

6.1.2 Romanian Trial

Risk assessment on the Use Case 2 – Romanian Trial has been performed and updated in Table 6-3 following the risk methodology defined above.

Table 6-3 Risk analysis on the Use Case 2 – Romanian Trial

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi -Mo-Ma-Cr)	Risk	Risk-Mitigation measures
Lack of communication between different operators, and local authorities.	U	Mi	Low	Regular meetings, AGILE methodology.
Overcrowding of the T&L Chain with the risk of blocking the river ports due to the Ukrainian conflict.	P	Ma	High	Functional maintenance of the port activity.

Lack of implementation infrastructure.	U	Mi	Low	Ensuring E2E coverage of internet services.
Change of consortium partners.	P	I	Low	Backup solution for replacement.
The migration of the population from the conflict zone and the blocking of port activities.	U	Mo	Moderate	Involvement of local authorities.
Adaptation of the infrastructure to the new volumes of operations.	P	Mi	Moderate	Government investments in infrastructure.

6.1.3 Greek Trial

Risk assessment on the Use Case 3 – Greek Trial has been performed and collected in Table 6-4 following the risk methodology defined above.

Table 6-4 Risk analysis on the Use Case 3 – Greek Trial

Description of the risk	Likelihood (R-U-P-L-AC)	Impact (I-Mi -Mo-Ma-Cr)	Risk	Risk-Mitigation measures
A single platform module does not achieve the expected TRL.	U	Mo	Moderate	Preliminary testing will be conducted (either physically or virtually) during each development step/version of each individually developed component to ensure its functionality.
Integration among systems (e.g., HPCS, Goldfreight, AODB) that belong to different stakeholders (COEL, GOLD, AIA) may be hindered as certain interfaces may not be accessed due to authorisation conflicts or complexity.	L	Mi	Moderate	The close interaction between WP2 and WP3 will reduce the probability of this risk. Moreover, potential authorisation restrictions may be tackled by the implementation of synthetic interfaces/emulated systems.
The improvements expected in KPIs are not adequately achieved during the trial phase.	U	Mi	Low	Periodical meetings/calls between stakeholders are conducted during the entire flow of the project. Any problems will probably be detected & addressed in early stages or at least in a timely manner.

Snowball effects in case of delays due to unforeseen factors (e.g., potential Covid-19 re-outbreak).	U	Mo	Moderate	All partners have experienced the recent pandemic, and some of them were working in relevant R&D projects during that period. There is recent experience on how to handle critical issues on such projects via teleworking, thus minimising the impact of the risk.

6.2 Challenges and Lessons Learned

Performing risk analysis on the FOR-FREIGHT platform and its use cases—Romanian, Greek, and Spanish—has yielded several valuable lessons that can enhance the project's effectiveness and preparedness for future challenges.

Firstly, the risk analysis process highlighted the importance of early and thorough identification of potential risks across all components of the platform. In the Romanian use case, where the focus is on integrating diverse data sources and IoT technologies, risks related to data interoperability and system integration emerged as significant concerns. This experience underscored the necessity of establishing robust data standards and developing flexible interfaces to ensure seamless integration. Addressing these risks early in the project helps in avoiding costly rework and delays during later stages of development.

In the Greek use case, which involves managing complex multimodal logistics processes and real-time data, the risk analysis revealed the criticality of reliable data accuracy and system performance. Risks associated with data quality and system reliability were prominent, emphasising the need for rigorous validation and continuous monitoring of data inputs and system operations. This experience reinforced the importance of implementing comprehensive testing procedures and robust error-handling mechanisms to maintain operational efficiency and reliability.

The Spanish use case, with its focus on optimising last-mile delivery and integrating blockchain for real-time data exchange, highlighted the potential risks related to technology adoption and user acceptance. The risk analysis identified challenges in adapting existing workflows to new technologies. This revealed the need for proactive internal end-user engagement and training to facilitate smooth transitions and maximise the benefits of new technologies. It also emphasised the importance of clear communication with stakeholders to address concerns and adjust solutions based on feedback.

Across all use cases, a common lesson learned was the value of a dynamic and iterative approach to risk management. As the project progresses and new information becomes available, challenges need to be addressed to reflect changing conditions. This iterative approach ensures that the risk management strategies remain relevant and effective throughout the project lifecycle.

Additionally, the analysis reinforced the importance of collaboration and communication among project partners. Effective risk management requires input from various stakeholders, including technical experts, end-users, and project managers. Collaborative risk assessment processes enable a more comprehensive understanding of potential risks and foster the development of more effective mitigation strategies.

Overall, these lessons underscore the need for a proactive, flexible, and collaborative approach to risk management in complex projects like FOR-FREIGHT. By addressing risks early, continuously monitoring and adapting strategies, and engaging with stakeholders, the project can enhance its resilience and better achieve its objectives.

7 Conclusions

Deliverable D1.4 encapsulates the progress and significant outcomes achieved throughout the development and implementation phases of the FOR-FREIGHT platform. The detailed examination of the revised system architecture has highlighted the critical updates and enhancements made since the previous version, reflecting the project's adaptive and responsive approach to technological advancements and stakeholder feedback. Through a thorough validation process, both technologically and within business contexts, the platform has demonstrated its capability to meet the project's goals while aligning with the broader objectives set out from the inception of FOR-FREIGHT.

The FOR-FREIGHT project has made significant strides in updating the platform architecture and implementing use case-specific solutions. The multi-layered architecture of the FOR-FREIGHT platform, comprising the Central Platform Layer, User Interface, API Gateway, External Components, Services Layer, Modular Layer, and Integration Layer, has been designed to ensure modularity, scalability, and flexibility. This architecture facilitates efficient management and optimisation of logistics operations across various transportation modes.

The Spanish Use Case has focused on enhancing efficiency and reliability in logistics processes from the Port of Valencia to Madrid. Key solvers such as ES_01 for ETA prediction, ES_04 for cost prediction, and ES_05 for CO_2 emissions prediction have been developed and validated through stakeholder workshops. These solvers have shown promising results in optimising port operations, transport costs, and environmental impact, although continuous refinement is necessary based on user feedback.

The Greek Use Case has addressed the integration challenges within the sea-air transport and logistics chain. Solvers like GR_01 for transport time prediction, GR_05 for fuel cost prediction, and GR_12 for GHG emissions prediction have been integrated to provide comprehensive details on available flights and warehouse operations. The focus on minimising delivery time, cost, and CO_2 footprint through efficient coordination between entities has been a significant achievement. Some solvers are still under development but are expected to be completed within the planned timeframe.

The Romanian Use Case has targeted the optimisation of water-to-railway transportation. Solvers such as RO_01 for ETA prediction at the Port of Galati and RO_10 for real-time container tracking have been developed to enhance digitalisation, coordination, and proactive strategies for handling unforeseen events. These solutions have improved operational efficiency and coordination despite some deviations in development due to re-evaluations and legislative changes.

Overall, the FOR-FREIGHT project has successfully developed a robust and adaptable platform architecture and implemented use case-specific solutions that address the unique challenges of logistics and freight management. The iterative development and validation approach, involving continuous feedback from end-users and stakeholders, has been crucial in refining the solutions and ensuring they meet real-world needs. Moving forward, the focus will be on further refining the solvers, enhancing integration capabilities, and ensuring the solutions are scalable and adaptable to evolving logistics requirements. The project's success so far underscores the importance of collaboration, continuous iteration, and the integration of advanced technologies in transforming logistics and freight operations.

As the project moves forward, the focus will be on leveraging the lessons learned and the data collected to enhance the platform further, ensuring it meets the dynamic needs of the freight industry. The commercialisation potential identified during the business validation phase opens up new avenues for deployment, promising a significant impact on the market. Overall, this deliverable has successfully set the stage for the continued evolution and eventual market readiness of the FOR-FREIGHT platform, marking a pivotal step in the project's lifecycle.

8 References

[1] Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Publishing Group.

[2] International Organization for Standardization, «ISO 31000:2018, Risk management - Guidelines», February 2018.

9 Annex I: Execution of the Use Cases Workshops

This Annex provides a complementary visual and descriptive account of the workshops conducted as part of the FOR-FREIGHT project. The following sections include screenshots and comprehensive information about each workshop, illustrating the collaborative efforts and key discussions. These workshops played a crucial role in gathering stakeholder input, refining project components, and ensuring that the solutions developed are both practical and aligned with industry needs. By including this Annex, we aim to offer a transparent and thorough overview of the interactive processes that have contributed to the platform's evolution, showcasing the collective expertise and engagement that have driven the project forward.

Spanish Use Case Workshop

Workshop Agenda for Spanish Use Case: Gathering End-User Feedback for Solvers ES_05 and ES_08

Date: 26/02/2024

Time: 11:30 – 13:00

Location: Online

1. Welcome and Introduction (10 minutes)

- Brief introduction of workshop objectives and agenda
- Quick overview of the FOR-FREIGHT project and its relevance to the Spanish Use Case

2. Overview of Solvers ES_05 and ES_08 (20 minutes)

- Presentation on Solver ES_05: Key features and current status
- Presentation on Solver ES_08: Key features and current status

3. User Experience and Feedback Session (40 minutes)

- Interactive session for end-users to share experiences with the solvers
- Discussion on any challenges, usability issues, and suggestions for improvement

4. Prioritization of Feedback and Next Steps (10 minutes)

- Group discussion to prioritise the most critical feedback points
- Outline of the action plan for implementing changes to Solvers ES_05 and ES_08

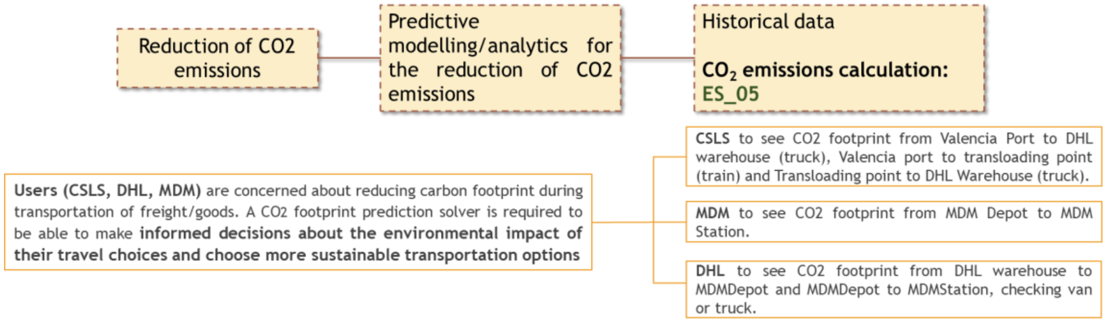
5. Closing Remarks (10 minutes)

- Summary of key takeaways
- Explanation of the next steps and follow-up actions

Questionnaire Spanish Use Case Workshop – Solver ES_05

This questionnaire, together with the discussions at the Spanish Use Case Workshop, will serve to gather end-users' feedback and valuable information in helping technical partners to better meet the needs and adjust the solver.

As a recap, here is the **ES_05 overview**:



1. User Input: Users should be able to **select the mode of transportation (e.g., truck, train, metro**) they plan to use. The solver should allow users to input the **journey's starting point (Point A) and destination (Point B)**. Depending on the mode of transportation and the A-B route, they will need to provide **extra details** associated with the selected option **(container cargo weight, truck/van cargo, roller cage weight, number of roller cages, emission factor if available…).**

2. **Calculation of CO2 Footprint**: After entering the relevant information, the solver should calculate and display the estimated CO2 footprint of the journey based on the chosen transportation mode.

3**. Output of ES_05**: The initial output of this solver will provide the CO2 footprint information that will help users make informed decisions about transportation options based on their emissions. Hence, the solver will provide **the value of kg of CO2 per kg of load that would be emitted using that particular route**.

<u>**Sections of the ES_05 survey**</u>**:**

User role and Integration

1. What is your user role in the T&L supply chain? (Multiple choice?)
2. What is your user role in this solver? (Multiple choice?)

Business Section: Value and Impact

1. How do you assess the current level of the following aspects?
2. What is the value this solver brings to you?
3. Which department in your company would use this solver?
4. How would this department integrate the solver into their functions or way of working?
5. What repercussions would it have on their way of conducting operations/tasks/activities?
6. Due to this solver, what aspects do you think would be improved in your operations/business?
7. Due to this solver, what aspects do you think would be negatively affected in your operations/business?
8. What obstacles can you see in using or applying this solver in your business?
9. How would the utilisation of this solver impact your business?
10. Rate the perceived benefits of knowing the CO2 emissions generated in freight transport:

Technological Section

1. Do you think the solver should take into account other variables (inputs)?
2. Order from the most valuable to least valuable format and units in which the solver output is provided:
3. When would it be most useful for you to receive the information from the solver for decision-making?

4. How often would you use this solver?
5. Which areas could be improved for the following refinement of the solver?

Commercialisation/Future Usage Section

1. Do you think the solution would be easy to implement in your business (considering your role in the T&L supply chain)? (1-5)
2. How would the utilisation of this solution impact the T&L industry? 1-5
    a. It will require the modification of the current transport mode planning process.
    b. It will contribute to the transportation modal shift.
    c. It will require the development of new user skills and knowledge.
3. Would you pay to have this tool to predict kg of CO_2 emissions per kg of cargo? (Yes/No/Other)
4. If yes, how much would you be willing to pay?
5. Would you use this solver in the future, along with the before and during E2E solvers, if they would be deployed on a fully operational and functional platform? (1-5)

Questions (brainstorming):

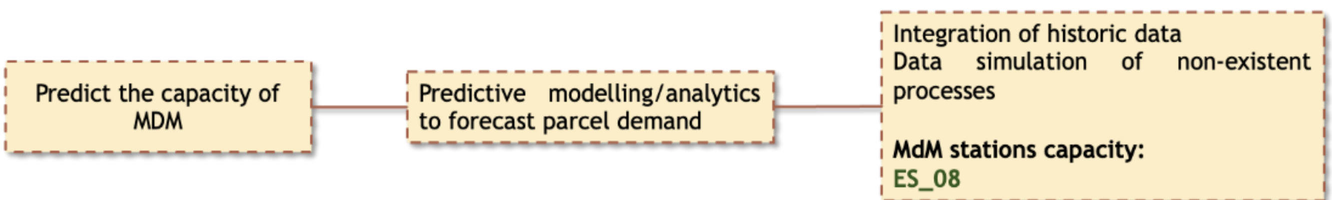
1. What is your user role in this solver?
2. How do you assess the current level of CO_2 measurement in the T&L chain?
3. What is the value this solver brings to you?
4. Due to this solver, what aspects do you think would be improved in your operations, and what impact would it have on your business?
5. How would you incorporate these/this tools/solution in your activity/business?
6. Which department in your company would use this solver? How would this department integrate the solver into their functions or way of working? What repercussions would it have on their way of conducting operations/tasks/activities?
7. What benefits and obstacles can you see in using or applying this solver in your business?
8. Do you think the solver should take into account other variables (inputs)?
9. What are the benefits of knowing the CO_2 emissions generated in the freight transport?
10. When would it be most useful for you to receive the information from the solver for decision-making?
11. How useful will it be for you to have the opportunity to follow in ‘real-time’ (after logging into the platform) CO_2 emissions data? What and how would it affect you?
12. How useful will it be for you to have the opportunity to follow in ‘real-time’ (through automatic email notifications) CO_2 emissions data? What and how would it affect you?
13. Does the solver provide you with the expected CO_2 emissions information for the route A to B?
14. Does the output help you make informed decisions about transportation options?
15. Would you change the way of transportation based on the solver’s emission predictions, in case some alternative transport mean will emit less CO_2 for the given route?
16. What would you like to see on the user interface of the solver?
17. Is there anything that seems confusing regarding how the solver works?

18. How important do you think it is to include emission factors for the different modes of transport? Should it be appropriate to work with the average emission factor values of the transport mode?
19. Do you have any suggestions for improving the solver's performance?
20. What would you like to see as the output of the solver?
21. Does the current state of the solver meet your initial expectations?
22. Which areas could be improved for the following refinement of the solver?
23. Would you use this solver in the future, together with the before and during E2E solvers, if they would be deployed on a platform that is fully operational and functional?
24. How often would you use this solver? Daily? Just when you want to make punctual consultations?
25. Would you pay for a tool that predicts the CO2 emissions? How much would you be willing to pay?
26. Are you saving time by using the services compared to before?
27. Is the solution easy to implement, does it need new knowledge and skills?
28. How do you measure the current level of planning and re-planning of inland transport for route optimisation?
29. OUTPUT UNITS (DISCUSS DURING THE WORKSHOP)

<u>**Questionnaire Spanish Use Case Workshop – Solver ES 08**</u>

This questionnaire, together with the discussions at the Spanish Use Case Workshop, will serve to gather end-users' feedback and valuable information in helping technical partners to better meet the needs and adjust the solver.

As a recap, here is the **ES_08 overview**:



1. User Input: Users should be able to **select the mode of transportation (e.g., line of metro**) they plan to use. The solver should allow users to input the **starting point (Point A)** and the **destination (Point B)** of the journey. Depending on the mode of transportation and the A-B route, they will need to provide **extra details** associated with the selected option **(container cargo weight, time of dispatch, roller cage weight, number of roller cages, …).**

3**. Output of ES_08**: The initial output of this solver will provide the CO2 footprint information that will help users make informed decisions about transportation options of rollers to the depots of MDM based on the integration of historical data and data simulation of non-existent processes **using predictive modelling to forecast parcel demand**.

<u>**Sections of the ES_08 survey**</u>**:**

User role and Integration

1. What is your user role in the T&L supply chain? (Multiple choice?)

2. What is your user role in this solver? (Multiple choice?)

Business Section: Value and Impact

1. How do you assess the current level of the following aspects?
2. What is the value this solver brings to you?
3. Which department in your company would use this solver?
4. How would this department integrate the solver into their functions or way of working?
5. What repercussions would it have on their way of conducting operations/tasks/activities?
6. Due to this solver, what aspects do you think would be improved in your operations/business?
7. Due to this solver, what aspects do you think would be negatively affected in your operations/business?
8. What obstacles can you see in using or applying this solver in your business?
9. How would the utilisation of this solver impact your business?
10. Rate the perceived benefits of knowing the CO2 emissions generated in freight transport:

Technological Section

1. Do you think the solver should take into account other variables (inputs)?
2. Order from the most valuable to least valuable the format and units in which the solver output is provided
3. When would it be most useful for you to receive the information from the solver for decision-making?
4. How often would you use this solver?
5. Which areas could be improved for the following refinement of the solver?

Commercialisation/Future Usage Section

1. Do you think the solution would be easy to implement in your business (considering your role in the T&L supply chain)? (1-5)
2. How would the utilisation of this solution impact the T&L industry? 1-5
    a. It will require the modification of the current transport mode planning process.
    b. It will contribute to the transportation modal shift.
    c. It will require the development of new user skills and knowledge.
3. Would you pay to have this tool to predict kg of CO2 emissions per kg of cargo? (Yes/No/Other)
4. If yes, how much would you be willing to pay?
5. Would you use this solver in the future, along with the before and during E2E solvers, if they would be deployed on a fully operational and functional platform? (1-5)

Questions (brainstorming):

1. What is your user role in this solver?
2. What is the value this solver brings to you?
3. Due to this solver, what aspects do you think would be improved in your operations and what impact would it have on your business?

4. How would you incorporate these/this tools/solution in your activity/business?
5. Which department in your company would use this solver? How would this department integrate the solver into their functions or way of working? What repercussions would it have on their way of conducting operations/tasks/activities?
6. What benefits and obstacles can you see in using or applying this solver in your business?
7. Do you think the solver should take into account other variables (inputs)?
8. When would it be most useful for you to receive the information from the solver for decision-making?
9. Does the output help you make informed decisions about transportation options?
10. What would you like to see on the user interface of the solver?
11. Is there anything that seems confusing regarding how the solver works?
12. Do you have any suggestions for improving the solver's performance?
13. What would you like to see as the output of the solver?
14. Does the current state of the solver meet your initial expectations?
15. Which areas could be improved for the following refinement of the solver?
16. Would you use this solver in the future, together with the before and during E2E solvers, if they would be deployed on a platform that is fully operational and functional?
17. How often would you use this solver? Daily? Just when you want to make punctual consultations?
18. Are you saving time by using the services compared to before?
19. Is the solution easy to implement, does it need new knowledge and skills?
20. How do you measure the current level of planning and re-planning of inland transport for route optimisation?
21. Is it meaningful to look at rollers?
22. Do the seasonality and tendencies observed in the 3-month sample data reflect the real situation?
23. How much in advance would you like to predict the capacity? (1 day, 1 week, etc.)?
24. Will it be more meaningful to view the total number of parcels/rollers at one MDM depot, or should we break down the figures based on origin (e.g., DHL warehouse), transport mode (van/truck), or even further to the destination station?
25. Is there a user's feedback mechanism to evaluate the effectiveness of the prediction algorithm? (via scoring, satisfaction voting, etc.)
26. How often can the algorithm be adapted or updated based on changing requirements or cargo demand? (e.g., 3 months, 6 months, 1 year, etc.)

Romanian Use Case Workshop

Agenda for FOR-FREIGHT - RO UC Workshop

- 13:00 - 13:05: Workshop Introduction
- 13:05 - 13:10: RO_10 Business Logic and Impact
- 13:10 - 13:15: RO_10 Architecture
- 13:15 - 13:20: RO_10 Example
- 13:20 - 13:25: RO_10 API
- 13:25 - 13:30: RO_10 KPIs
- 13:30 - 13:35: RO_01 Business Logic and Impact
- 13:35 - 13:40: RO_01 Architecture
- 13:40 - 13:45: RO_01 Example
- 13:45 - 13:50: RO_01 API
- 13:50 - 13:55: RO_01 KPIs
- 13:55 - 14:00: Next Steps
- 14:00 - 14:10: Q&A

During the workshop, the following questions were posed:

For solver RO_10: Real-Time Tracking of Container Coordinates

1. **Business Logic and Impact:**
   - How does the current real-time tracking solution impact your daily operations?
   - What specific business outcomes do you expect from the implementation of RO_10 in terms of operational efficiency and customer satisfaction?
2. **Architecture:**
   - Does the proposed architecture of RO_10 align with your current systems?
   - Are there any architectural challenges or limitations you foresee with integrating RO_10 into your existing logistics infrastructure?
3. **Example:**
   - How do you envision using the RO_10 solver in a typical logistics scenario within your operations?
   - Can you identify any potential gaps in the example provided that might require additional features or customization to meet your needs?
4. **API:**
   - Is the RO_10 API designed in a way that it can be easily integrated with your current systems?
   - What additional functionalities or data points would you require from the RO_10 API to enhance its usefulness?
5. **KPIs:**

- Are the KPIs associated with RO_10 relevant and comprehensive in measuring its impact on your operations?
- What additional KPIs, if any, should be considered to better reflect the performance and value of the RO_10 solver?

For solver RO_01 Prediction of Container Ship Arrival Time

1. **Business Logic and Impact:**
    - How critical is the accurate prediction of container ship arrival times to your operational planning and scheduling?
    - What business benefits do you anticipate from implementing RO_01 in terms of reducing downtime and optimizing resource allocation?
2. **Architecture:**
    - Does the architecture of RO_01 provide the flexibility needed to integrate with your current port management systems?
    - Are there any specific technical or operational constraints that you believe need to be addressed within the RO_01 architecture?
3. **Example:**
    - Based on the example provided, do you feel that RO_01 sufficiently addresses the variability and uncertainties in predicting ship arrival times?
    - What additional use cases or scenarios would you like to see covered by RO_01 to ensure its applicability across different operational contexts?
4. **API:**
    - How do you plan to integrate the RO_01 API with your existing systems?
    - Are there specific data integration needs or customization requirements that should be considered for the RO_01 API?
5. **KPIs:**
    - Do the KPIs for RO_01 adequately measure its effectiveness in improving the accuracy of ship arrival predictions?
    - What additional metrics could help in evaluating the success and business impact of RO_01?

Next Steps

- What are your key concerns or suggestions as we move forward with the implementation of RO_10 and RO_01?
- How can we ensure that the transition to using these solvers is smooth and meets your operational expectations?
- What further support or information do you need to fully leverage these solvers in your daily operations?

Q&A

- Are there any aspects of the solvers' functionality or integration that remain unclear or need further explanation?
- How do you foresee these tools evolving in the future to better serve your business needs?

These questions aim to elicit detailed feedback from stakeholders, helping to align the solvers more closely with their operational requirements and business objectives.

Greek Use Case Workshop

This subsection includes the responses of the internal stakeholders who were part of the dedicated Greek UC workshop, where the partners involved in the UC were informed about the solver development progress and functionalities. A discussion followed with the partners concerning the potential of the solvers to be adapted to their facilities and business development aspects. The partners were then asked to fill out a questionnaire concerning the future technological and business validation as a steppingstone for the future development of the Greek UC innovations.

Workshop Agenda:

1. Welcome and Introduction (10 minutes)

- Brief introduction of workshop objectives and agenda
- Quick overview of the FOR-FREIGHT project and its relevance to the Greek Use Case

2. Greek Solutions Implementation (20 minutes)

- Identified problem root causes of the Greek UC
- Solving approach to the problems identified

3. E2E Solvers, Business Flow and Feedback Session (40 minutes)

- Presentation of the demonstrated solvers and business process considerations
- Interactive session for end-users to share experiences with the solutions developed
- Discussion on any challenges, usability issues, and suggestions for improvement

4. Prioritization of Feedback and Next Steps (10 minutes)

- Group discussion to prioritise the most critical feedback points
- Outline of the action plan for implementing changes to the Greek UC Solvers

5. Closing Remarks (10 minutes)

- Summary of key takeaways
- Explanation of the next steps and follow-up actions including completing the Greek UC Survey

Responses from AIA

Table 9-1 Responses from AIA to Section 1: Technological Evaluation

Question	Response (1 to 5)
Performance and Integration:	
Do the developed solutions (e.g., solvers, workflow engine) meet the technological requirements initially set?	5 Fully agree

Are the system functions well integrated (e.g., between warehouse management systems, port legacy systems, etc.)?	5 Fully agree
Is the speed of calculations and data processing sufficient for real-time operations?	5 Fully agree
Can the system handle multiple queries and requests simultaneously without performance degradation?	5 Fully agree
Usability:	
How intuitive and user-friendly is the platform's interface (including the WE's interface)?	5 Fully agree
Is the visualisation of results (e.g., route recommendations, ETA predictions) clear and actionable?	5 Fully agree

Table 9-2 Responses from AIA to Section 2: Environmental Impact

Question	Response (1 to 5)
Sustainability	
Have the implemented solutions contributed to the reduction of GHG emissions in the transport and logistics operations?	5 Fully agree
Are the predictive analytics tools effective in minimising environmental impact (e.g., recommending routes that reduce emissions)?	5 Fully agree
Environmental Goals	
Are the environmental KPIs, such as reducing container idle times and optimising resource allocation, being met?	5 Fully agree
Do the solutions help achieve your company's overall sustainability goals?	4 Agree/High

Table 9-3 Responses from AIA to Section 3: Economic Impact

Question	Response (1 to 5)
Cost Efficiency:	
Have the solutions led to a measurable reduction in operational costs (e.g., fuel consumption, labor costs)?	5 Fully agree
Is the cost-benefit ratio of the solutions favourable when considering the investment required for implementation?	5 Fully agree
Economic KPIs	
Are the economic KPIs, such as reducing logistics costs and improving resource utilisation, being achieved?	4 Agree
How do these improvements impact your organisation's bottom line? **Detailed response:** Our primary goal as AIA is the facilitation and development of cargo flows while alleviating traffic congestion within the airport's cargo area. These objectives are largely achieved by enabling Cargo Handlers to enhance their cargo handling efficiency and capacity without compromising the quality of their services.	4 Agree

Table 9-4 Responses from AIA to Section 4: Business Process Improvement

Question	Response (1 to 5)
Operational Efficiency:	
Have the solutions improved business processes, such as reducing delivery times, optimising inventory management, and enhancing customer service?	5 Fully agree
Is the decision-making process (e.g., route selection, resource allocation) now more efficient and informed?	5 Fully agree
User Experience	

How easy is it for your team to adopt and use the new solutions? Detailed response: The user-friendly environment and the automations that are achieved are key factors for the adaptation of the solutions	4 Agree
Is there a clear understanding of access rights and security within the system?	4 Agree
Have the solutions reduced the need for manual intervention in logistics operations?	4 Agree

Table 9-5 Responses from AIA to Section 5: Commercialisation and Market Fit

Question	Response (1 to 5)
Market Readiness:	
How easy is it to implement these solutions in other similar logistics environments?	4 Agree
Do you believe the solutions align with the needs of other potential adopters in the logistics industry?	4 Agree
Competitive Advantage:	
Do you perceive the solutions to outperform existing alternatives in the market?	4 Agree
In what ways are the solutions better than your current processes or systems?	4 – The solutions have successfully enhanced supply chain visibility and introduced automation capabilities that were previously nonexistent.

Future Adoption:	
Would you consider continuing to use these solutions after the project ends?	4 Agree
What factors would influence your decision to adopt these solutions on a larger scale? **Detailed response:** The involvement of other members of the Cargo Community, particularly the Cargo Terminal operators, will be a critical determining factor.	Agree

Responses from GOLD

Table 9-6 Responses from GOLD for Section 1: Technological Evaluation

Question	Response (1 to 5)
Performance and Integration:	
Do the developed solutions (e.g., solvers, workflow engine) meet the technological requirements initially set?	5 Fully agree
Are the system functions well integrated (e.g., between warehouse management systems, port legacy systems, etc.)?	5 Fully agree
Is the speed of calculations and data processing sufficient for real-time operations?	5 Fully agree
Can the system handle multiple queries and requests simultaneously without performance degradation?	5 Fully agree
Usability:	
How intuitive and user-friendly is the platform's interface (including the WE's interface)? Detailed response: Designed according to current flow/needs	5 Fully agree

Is the visualisation of results (e.g., route recommendations, ETA predictions) clear and actionable?	5 Fully agree

Table 9-7 Responses from GOLD for Section 2: Environmental Impact

Question	Response (1 to 5)
Sustainability	
Have the implemented solutions contributed to the reduction of GHG emissions in the transport and logistics operations?	5 Fully agree
Are the predictive analytics tools effective in minimising environmental impact (e.g., recommending routes that reduce emissions)?	5 Fully agree
Environmental Goals	
Are the environmental KPIs, such as reducing container idle times and optimising resource allocation, being met?	5 Fully agree
Do the solutions help achieve the overall sustainability goals of your company?	5 Fully agree

Table 9-8 Responses from GOLD to Section 3: Economic Impact

Question	Response (1 to 5)
Cost Efficiency:	
Have the solutions led to a measurable reduction in operational costs (e.g., fuel consumption, labor costs)? **Detailed response:** The solutions have led to a reduction in operational costs, particularly in areas such as labour costs and process efficiency. By optimising workflows and introducing automation where applicable, we've managed to streamline operations, which has significantly reduced the need for overtime and	5 Fully agree

minimised redundancy. This reallocation of human resources has not only lowered labour costs but also enhanced overall productivity.	
Is the cost-benefit ratio of the solutions favourable when considering the investment required for implementation? **Detailed response:** The solutions quickly demonstrated their value by streamlining processes and reducing labour costs, making the investment worthwhile even in the short term.	5 Fully agree
Economic KPIs	
Are the economic KPIs, such as reducing logistics costs and improving resource utilisation, being achieved? **Detailed response:** We've seen better allocation of human resources and more effective use of materials and time, resulting in reduced waste and higher productivity. These improvements have directly contributed to the economic goals of the project, validating the effectiveness of the solutions in driving resource efficiency.	4 Agree
How do these improvements impact your organisation's bottom line? **Detailed response:** The enhancements in productivity and efficiency mean that we can achieve more with the same or fewer resources, which boosts overall output without a corresponding increase in costs. This improved efficiency not only contributes to immediate cost savings but also positions the organisation for better financial performance in the long run, making the bottom line more robust and sustainable.	4 Agree

Table 9-9 Responses from GOLD to Section 4: Business Process Improvement

Question	Response (1 to 5)
Operational Efficiency:	
Have the solutions improved business processes, such as reducing delivery times, optimising inventory management, and enhancing customer service? **Detailed response:** The solutions have significantly improved operational	5 Fully agree

efficiency across several key business processes. Delivery times have been reduced through better scheduling and streamlined logistics, allowing us to meet customer demands more quickly and reliably. This improvement not only enhances our ability to deliver on time but also boosts customer satisfaction.	
Is the decision-making process (e.g., route selection, resource allocation) now more efficient and informed? **Detailed response:** Data-driven tools and enhanced visibility into operations have enabled quicker and more accurate decisions, ensuring that resources are allocated where they are most needed. This has minimised waste, optimised productivity, and allowed for more strategic planning.	5 Fully agree
User Experience	
How easy is it for your team to adopt and use the new solutions? **Detailed response:** The user-friendly design of the solutions has facilitated quick adoption, allowing the team to integrate them into their daily routines with minimal disruption. The automation of routine tasks has also freed up time for the team to focus on more strategic activities, further improving efficiency and job satisfaction.	5 Fully agree
Is there a clear understanding of access rights and security within the system?	5 Fully agree
Have the solutions reduced the need for manual intervention in logistics operations?	5 Fully agree

Table 9-10 Responses from GOLD to Section 5: Commercialisation and Market Fit

Question	Response (1 to 5)
Market Readiness:	
How easy is it to implement these solutions in other similar logistics environments? **Detailed response:** The core principles and technologies used are applicable across various logistics settings, making it easier to replicate the success seen in the pilot project. Key factors such as user-friendly interfaces, modular components, and	4 Agree

comprehensive support documentation further facilitate the implementation process.	
Do you believe the solutions align with the needs of other potential adopters in the logistics industry? **Detailed response:** We believe the solutions align well with the needs of other potential adopters in the logistics industry. The solutions were designed with common industry challenges in mind, such as improving operational efficiency, optimising resource allocation, and enhancing overall productivity. These are universal needs across the logistics sector, making the solutions relevant and valuable to a broad range of organisations.	4 Agree
Competitive Advantage:	
Do you perceive the solutions to outperform existing alternatives in the market? **Detailed response:** The solutions have demonstrated clear advantages over traditional methods and competing products through several key aspects	4 Agree
In what ways are the solutions better than your current processes or systems? **Detailed response:** Enhanced efficiency, Advanced Technology, User Experience, Customisation, Automation	4 Agree
Future Adoption:	
Would you consider continuing to use these solutions after the project ends? **Detailed response:** Continued use would be especially beneficial if stakeholders' broader adoption of these methods supports a more integrated and cohesive approach across the organisation or industry. This alignment would maximise the solutions' impact and ensure that their benefits are fully realised and sustained over time.	4 Agree
What factors would influence your decision to adopt these solutions on a larger scale? **Detailed response:** The potential for scaling and integrating these solutions into ongoing operations, combined with the support from other stakeholders, reinforces the case for their continued use beyond the project's conclusion.	4 Agree

Responses from COEL

Table 9-11 Responses from COEL to Section 1: Technological Evaluation

Question	Response (1 to 5)
Performance and Integration:	
Do the developed solutions (e.g., solvers, workflow engine) meet the technological requirements initially set?	5 Fully agree
Are the system functions well integrated (e.g., between warehouse management systems, port legacy systems, etc.)?	5 Fully agree
Is the speed of calculations and data processing sufficient for real-time operations?	5 Fully agree
Can the system handle multiple queries and requests simultaneously without performance degradation?	5 Fully agree
Usability:	
How intuitive and user-friendly is the platform's interface (including the WE's interface)?	5 Fully agree
Is the visualisation of results (e.g., route recommendations, ETA predictions) clear and actionable?	5 Fully agree

Table 9-12: Responses from COEL to Section 2: Environmental Impact

Question	Response (1 to 5)
Sustainability	
Have the implemented solutions contributed to the reduction of GHG emissions in the transport and logistics operations?	5 Fully agree

Are the predictive analytics tools effective in minimising environmental impact (e.g., recommending routes that reduce emissions)?	5 Fully agree
Environmental Goals	
Are the environmental KPIs, such as reducing container idle times and optimising resource allocation, being met?	4 Agree/High
Do the solutions help achieve the overall sustainability goals of your company?	4 Agree/High

Table 9-13 Responses from COEL to Section 3: Economic Impact

Question	**Response (1 to 5)**
Cost Efficiency:	
Have the solutions led to a measurable reduction in operational costs (e.g., fuel consumption, labor costs)?	4 Agree/High
Is the cost-benefit ratio of the solutions favorable when considering the investment required for implementation?	4 Agree/High
Economic KPIs	
Are the economic KPIs, such as reducing logistics costs and improving resource utilisation, being achieved?	4 Agree/High
How do these improvements impact your organisation's bottom line? Detailed response: Potentially an important and valuable tool for Shipping Lines and Freight Forwarders (FFWs), for prioritising cargo gate-out from terminal and efficiency in truck planning, minimising cargo idle time in terminal and related costs.	4 Agree/High

Table 9-14 Responses from COEL to Section 4: Business Process Improvement

Question	Response (1 to 5)
Operational Efficiency:	
Have the solutions improved business processes, such as reducing delivery times, optimising inventory management, and enhancing customer service?	4 Agree/High
Is the decision-making process (e.g., route selection, resource allocation) now more efficient and informed?	4 Agree/High
User Experience	
How easy is it for your team to adopt and use the new solutions?	4 Agree/High
Is there a clear understanding of access rights and security within the system?	4 Agree/High
Have the solutions reduced the need for manual intervention in logistics operations?	5 Fully agree

Table 9-15 Responses from COEL to Section 5: Commercialisation and Market Fit

Question	Response (1 to 5)
Market Readiness:	
How easy is it to implement these solutions in other similar logistics environments?	4 Agree/High
Do you believe the solutions align with the needs of other potential adopters in the logistics industry?	4 Agree/High
Competitive Advantage:	

Do you perceive the solutions to outperform existing alternatives in the market?	4 Agree/High
In what ways are the solutions better than your current processes or systems? Detailed response: Apart from operational & capacity efficiency, and optimised inventory, the solution also enhances the Customer Service experience through reduced cargo idle time, supply chain visibility and reduction of errors (electronic data exchange vs manual process)	4 Agree/High
Future Adoption:	
Would you consider continuing to use these solutions after the project ends?	4 Agree/High
What factors would influence your decision to adopt these solutions on a larger scale? Detailed response: Involved stakeholders/“Community” members such as airport cargo handlers, airlines, FFW, Custom’s Brokers etc., would be important to adopt a similar solution in order to share and exchange data. The mechanisms and structures of these solutions could be further developed and potentially play the role of a community system.	4 Agree/High