Flexible, multi-mOdal and Robust FREIGHt Transport

D1.1 Report on Current Multimodal T&L Practices & Recommendations for Improvement

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

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Glossary of terms and abbreviations

Abbreviation / Term	Description
3PL	Third Party Logistics
4PL	Fourth Party Logistics
ABS	ALLBESMART LDA
ACCC	Airport Cargo Community Committee
AEO	Authorized Economic Operator
AEOC	Authorized Economic Operator Customs Simplificatoin
AEOS	Authorized Economic Operator Security and Safety
AI	Artificial Intelligence
AIA	ATHENS INTERNATIONAL AIRPORT S.A.
ANSI	American National Standards Institute
AODB	Airport Operational Database
API	Application Programming Interfaces
ATG	ASOCIATIA TEHNOPOL – GALATI
BEIA	BEIA CONSULT INTERNATIONAL SRL
BMS	Building Management Systems
CERTH	CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CESNI	Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure
C-ITS	Cooperative Intelligent Transport Systems
COEL	COSCO SHIPPING LINES (GREECE) ANONYMI ETAIREIA
CPS	Cyber-Physical Systems
CSLS	COSCO SHIPPING LINES SPAIN SA
D	Deliverable
DCSA	Digital Container Shipping Association
DHL	DHL EXEL SUPPLY CHAIN SPAIN SL
DLT	Distributed Ledger Technology
DSS	Decision Support System
DTLF	Digital Transport and Logistics Forum
DUT	Unified Transport Document
EBOS	EBOS TECHNOLOGIES LIMITED
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
eFTI	Electronic freight transport information

eMBB	Enhanced Mobile Broadband
EMS	Environmental Management System
ERP	Enterprise Resource Planning
ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels
EU	European Union
FVP	FUNDACIÓN DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCIÓN Y ESTUDIOS COMERCIALES DE VALENCIAPORT
GA	Grant Agreement
GHG	Greenhouse Gas
GLN	Global Location Number
GOLD	GOLDAIR EXYPIRETISEIS EDAFOUS ANONIMI ETAIREIA
IATA	International Air Transport Association
ICT	Information and Communication Technology
IIoT	Industrial Internet of Things
IMEC	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM
IoT	Internet of Things
IPCOTF	International Port Call Optimisation TaskForce
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LSP	Logistics Service Provider
MdM	Master Data Management
MDM	METRO DE MADRID SA
MEAO	MEC Application Orchestrator
MEC	Multi-Access Edge Computing
ML	Machine Learning
mMTC	Massive Machine Type Communications
MSc	Master of Science
NAVR	COMPANIA DE NAVIGATIE FLUVIALA ROMANA NAVROM SA
OBUs	Onboard Units
PCS	Port Community System
PCT	Pireaus Container Terminal
PhD	Doctorate
PoC	Proof of Concept

PRM	Passengers With Reduced Mobility
QMS	Quality Management System
R&D&I	Research, Development and Innovation
RFID	Radio Frequency
RSUs	Roadside Units
SCADA	Supervisory Control And ata Acquisition
SDG	Sustainable Development Goals
SFTP	Secure File Transfer Protocol
SME	Subject Matter Expert
SotA	State-of-the-Art
T&L	Transport and Logistics
TCCFR	TELECOMUNICATII CFR SA
TEN-T	Trans-European Transport Network
TIC 4.0	Terminal Industry Committee 4.0
TMS	Transport Management System
TOS	Terminal Operating System
UC	Use Case
URLLC	Ultra-Reliable Low-Latency Communications
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything
VAT	Value-Added Tax
WCO	World Customs Organization
WINGS	WINGS ICT SOLUTIONS INFORMATION & COMMUNICATION TECHNOLOGIES IKE
WMS	Warehouse Management System
WP	Work Package
XML	eXtensible Markup Language
ZSI	ZENTRUM FUR SOZIALE INNOVATION GMBH

1 Executive Summary

This deliverable has the threefold purpose of (1) providing a State-of-The Art (SotA) analysis of the latest trends and ways of working of the different dimensions that explain the current situation in the transport and logistics (T&L) sector, focusing on the analysis of current practices, technologies, systems and standards used and especially among T&L stakeholders, (2) identifying current T&L sector general and specific weak points, barriers and potential improvements from a technical standpoint to increase and improve multimodal and transshipment T&L services (3) and studying the potential integration points of existing solutions with a first approach to the Use Cases (UC). As a result, this deliverable makes a first approximation or definition of how the project's outcomes will satisfy the identified gaps and needs in the T&L sector.

Thus, based on on SotA's analysis of the current logistics and intermodal transport modes, a detailed identification of the current problems (pains) and potential and expected benefits (gains) in the involved T&L stakeholders has been conducted, helping them to restructure their operations and implement new technologies, as well as to improve interoperable T&L solutions, increasing the efficiency and sustainability of the entire supply logistics.

Subsequently, building on the analyses of T&L weaknesses, problems and possible areas for improvement, it is indicated which technologies provided by the FOR-FREIGHT partners can interact in each of the UCs of the FOR-FREIGHT project (Spain, Greece and Romania), explaining how the requirements and demands of involved T&L stakeholders could be solved/overcome. The findings of this analysis will serve, therefore, as a baseline for the work that will be performed in *D1.2 FOR-FREIGHT multimodal transport Use Case definition*, report that will contain the requirements analysis results of the internal FOR-FREIGHT use cases and their detailed definition.

2 Introduction

This deliverable's goal is to detail a SotA report, containing the analysis of the current practices, technologies, systems and standards utilized including pain-point analysis and recommendations for improvements. In addition to this general context, the document provides a specific framework of the different project partners and their role within the sector, which will serve to lay the groundwork for the project.

The document has been prepared by analysing various sources, knowledge and know-how of the partners to establish this general context, and through collaboration with them, information has also been collected to identify their roles in the different domains of the sector. On the basis of this information, weaknesses and possible solutions to mitigate them have been identified.

The results of this deliverable are closely linked and will serve as inputs for Tasks T1.2, T1.3 and T1.4, as well as to subsequent FOR-FREIGHT Work Packages (WPs).

Initially, through the in-depth analysis of the current situation of the transport and logistics sector followed by its subsequent diagnosis for the detection of general and specific problems and barriers, the deliverable is aligned to the initial objective of WP1 of providing a detailed analysis of the current situation in the T&L sector on the domains of Business and Operational models, technology and with a particular focus on the current lack of standardisations both at operational and informational exchange levels.

This deliverable also refers to the Implementation Objectives 1 and 5. The Objective 1 involves the design and development of novel and interoperable T&L solutions that will deliver increased T&L node operational capacity and increased efficiency and sustainability of multimodal and transhipment T&L services in multi-stakeholder environments, with reduced freight transport costs and reduced environmental footprint. Whereas with regard to Objective 5, it mainly pursues to contribute to the standardisation of multimodal, multi-stakeholder end-to-end freight management solutions ensuring compatibility with existing EU/global standards and supporting a T&L ecosystem that brings together key stakeholders such as port, airport, rail or road operators. Through the output produced, D1.1 will deliver measurable results via the integration of various T&L systems and existing solutions, that are extracted as outputs from the SotA carried out in Chapters 5, including their potential integration points that will be suitable for FOR-FREIGHT solution.

The FOR-FREIGHT project brings a range of added value to the field of freight transport, focusing on maximizing the utilization of multimodal capacity, achieving competitive sustainability through increased efficiency, and reducing the average cost of freight transport through the development of novel solutions and their integration with legacy logistics systems, whose first steps and current SotA are set out throughout this deliverable together with the analysis of weaknesses and potential improvements that have been found both in the T&L sector and in the context of the stakeholders.

Hence, the main focus of FOR-FREIGHT brings significant added value to the field of freight T&L through its focus on end-to-end optimisation of logistics processes, the use of disruptive technologies, such as advanced Artificial Intelligence (AI)/Machine Learning (ML) techniques, to optimise the use of resources, increased resilience to disruptions, increased security through the use of blockchain technology and increased sustainability through the reduction of Greenhouse Gas (GHG) emissions.

2.1 Mapping FOR-FREIGHT Outputs

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

Table 2-1: Adherence to FOR-FREIGHT's GA Deliverable & Tasks Descriptions

FOR-FREIGHT GA Component Title	FOR-FREIGHT GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D1.1 Report on Current Multimodal T&L Practices & Recommendations for Improvement	"SotA Report containing the analysis of the current practices, standards and systems utilized in multimodal logistics, including pain-point analysis and recommendations for improvements. It is the output of Task 1.1."	Chapter 4	Chapter 4 describes an overview of the T&L sector.
		Chapter 5	Chapter 5 identifies current AS-IS situation of practices, standards and systems of the T&L sector.
		Chapter 6	Chapter 6 analyses weaknesses and barriers and identifies recommendations and solutions.
		Chapter 7	Chapter 7 links how the SotA relates to the different pains and gains identified among the partners, establishing the technologies, legacy systems that could be used among all those analysed in order to cover the potential solutions/improvements that FOR-FREIGHT will offer.

<table>
<tr><th colspan="4">TASKS</th></tr>
<tr><td rowspan="3">Task 1.1 Legacy system, State-of-the-Art and logistics standards analysis</td><td rowspan="3">“This task will perform a comprehensive assessment of “the current way of working”, focused on the various dimensions that explain the current situation of the Transport and Logistics sectors. In this manner, Task 1.1 will consider, i) Transport and Logistics Operational models assessment in order to characterise the performance and existing interrelation among key intermodal transport and logistics agents (shipping lines, port authorities, port terminals, customs, rail and road operators, etc.), ii) Business models addressing the value chain under which the transport and logistic agents are engaged along transport routes and logistic corridors, iii) Technological and legacy systems analysis to identify current platforms architectures and information exchange protocols and formats, with focus on the existing and non-existing standardised data exchange and iv) Current T&L data standardisation initiatives, thus aligning the current efforts in the field with the FOR-FREIGHT Use Cases (e.g. ship-port interface information exchange, port terminals standards, etc.).”</td><td>Chapter 5</td><td>Chapter 5 identifies current way of working in T&L sector and further elaborates the domains of Business & Operational Models, Technology & Legacy Systems and Data Standardisation.</td></tr>
<tr><td>Chapter 6</td><td>Chapter 6 identifies possible weaknesses, problems and areas for improvement that have been identified based on the sector analysis of the previous chapter and proposes solutions and improvements to them.</td></tr>
<tr><td>Chapter 7</td><td>Chapter 7 expains how the SotA of the T&L sector has been related to the different pains and gains identified among the FOR-FREIGHT partners, offering an overview of the identified legacy systems, technology and standardisation assets, which can potentially support the FOR-FREIGHT’s Use Cases.</td></tr>
</table>

2.2 Linkage to Other Project Outputs

The Table 2-2 shows the relationship between this deliverable and other project outputs which provides this direct linkage.

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

WP Number	Task Number	Deliverable Number related	Content
WP1	**T1.2, T1.3, T1.4**	**D1.2, D1.3, D1.4**	T1.2 will be responsible for the detailed description of the requirements analysis and Use case refinement. The SotA analysis conducted in D1.1 will be used to design multimodal use cases addressing the current industry gaps and inefficient processes. In addition, T1.2 will be used to define the limits for the benchmarking of the results per target KPI and also act as a driver for the necessary supported functionality of the FOR-FREIGHT end-to-end solution design and architecture, hence as input to T1.3 and 1.4 respectively.
WP2	**T2.2, T2.3, T2.4**	**D2.1, D2.2, D2.3**	WP2's main focus is to implement the solutions (SW, HW and integration) designed in WP1 and to deliver the E2E functional FOR-FREIGHT platform/solution. T2.1, T2.2 and T2.3 will perform the T&L use case implementation based on technical, business and deployment considerations and targeting specific KPIs defined in T1.2-T1.3, based on the potential integration points initially set in this deliverable (D1.1).
WP3	**T3.2, T3.3, T3.4**	**D3.2, D3.3**	The T&L stakeholders-partners will provide continuous feedback to the technology developers during the extensive multimodal freight transport trials in T3.2-3.4, for bug fixes, upgrades and extensions for the incremental improvements of the software platforms' functionalities and related management tools including the upgrade and extension (where needed) of the network and vertical infrastructures (port, airport, warehouse, vehicles) as part of the work to be carried out by WP2 that has been based on the information and SotA provided by T1.1.
WP4	**T4.1**	**D4.2, D4.5**	Co-design process of the FOR-FREIGHT solutions with the findings of the market analysis study and the insights/inputs received by external stakeholders (from the partner-network of the project partners), thus ensuring that the FOR-FREIGHT solutions will address commonly and widely agreed multimodal transport challenges.

2.3 Deliverable Overview and Report Structure

In this section, a description of the rest of the Deliverable's structure is provided, outlining each of its chapters and a summary of their content.

Chapter 3 explains the methodology followed in the next chapters of the deliverable, defining the methodology applied for the literature review, for obtaining and analysing information from the relevant FOR-FREIGHT partners on the sector and for covering the pains and gains.

Chapter 4 describes a general overview of the current situation of the T&L sector to highlight its relevance as well as the main challenges it has been dealing with in recent years and a review of the literature for each of the domains.

Chapter 5 establishes the SotA of the T&L sector. It provides a detailed overview of each of the different domains (T&L Business and Operational Models, Technology and Legacy Systems, Data Standardisation) and afterwards establishes the framework and the specific context in FOR-FREIGHT of the different partners, through the collection of information from all of them by means of various tools in order to establish their role.

Chapter 6 identifies possible weaknesses, problems and areas for improvement that have been identified based on the sector analysis of the previous chapter and proposes solutions and improvements to them.

In **Chapter 7** an overview of the identified legacy systems, technology and standardisation assets, which can potentially support the FOR-FREIGHT's Use Cases. This chapter will serve as an introduction to the Deliverable 1.2.

Finally, **Chapter 8** summarises the results of the deliverable and its contributions to the project objectives.

3 Methodology

This chapter introduces the methodology used to collect the information for each domain. Specifically, it covers how the templates have been drawn up and on the basis of which criteria, as well as the way in which the Pains and Gains analysis will be established.

This is aligned with the objectives of the deliverable to establish this SotA, for which in addition to conducting a general study of the sector, the different partners within the project will be properly identified and information and feedback will be collected from them, through information exchanges in the form of templates, surveys and discussions.

3.1 Literature Review

The gathering of the literature research has been conducted using mainly the scientific databases Google Scholar, IEEE Xplore, Scopus and ScienceDirect. Thereby, most of the results obtained are included in the fields of Transport and Logistics, Management of Technology and Innovation and Management Science and Operations Research. By using this variety of initial sources to conduct the research, it has been possible to get broader scope of literature.

Based on the conceptual framework, the starting premise of the search consists of the keywords that bring the bulk of FOR-FREIGHT's information together, "Transport and Logistics". These initial keywords have been complemented with secondary keywords reflecting the main domains covered in this deliverable, namely, "business models", "operational models", "processes", "technology", "industry 4.0", "legacy systems", "standards", "data standardisation", "State of the Art". Although additional searches have been carried out, these have been the core searches and the closest to the project needs. Results have been focusing on published literature since 2012. This relatively recent starting point has been established in this analysis due to the pace of research that the field of T&L has experienced in the last decade. However, sources from previous years have also been consulted to establish the basis, trends and developments.

In order to guarantee that the results obtained for the study are consistent and related to the subject matter, certain exclusion criteria have been selected to filter out initial results. Since the logistics sector covers a wide range of fields, the articles and papers found have been reviewed to ensure that their title and abstract can be related to the multimodal logistics context of the project. Those entries that do not comply with academic quality standards and haven't provide real and reliable data regarding T&L sector and its domains have been discarded. The number of citations has also been used as a confidence criterion to select the most prominent studies.

3.2 Domain Analysis

Initially, the methodology followed to address the main subject of the deliverable, i.e., the SotA of the T&L sector, will be presented. In order to accurately map the sector and the role of the different project partners, certain approaches have been considered for classifying them into broad groups and to be able to gather their understanding and know-how. Therefore, the methodology applied for the identification of the partners is set out below together with that followed in the development of the templates.

Ensuring effective participation of the stakeholders, clearly identifying the role of each member within the sector, is fundamental to the proper flow of information in the project. For the analysis and correct identification of FOR-FREIGHT's stakeholders, the established basis on the Grant Agreement have been taken as a starting point. In this document, an identification of each of the FOR-FREIGHT members has been carried out, properly classifying each one with their respective role, and differentiating mainly between T&L stakeholders and operators, technology developers and Subject Matter Experts (SMEs) and horizontal partners.

This stakeholder analysis is a form of technological intelligence which leads to a proper identification of the partners within the project. As stated above, the FOR-FREIGHT project will focus on finding out what role they play within the T&L chain, where they will be classified into these categories according to the work processes they perform and how the organisation is defined.

The methodology used for this classification of partners is based primarily on the identification of those areas and activities that they perform, mapping their competencies and expertise. Thus, the partners involved in the project will be grouped mainly into three categories:

- **Transport & Logistic Stakeholders and Operators**: those who can contribute to the definition of the respective needs in multimodal transport (shipping lines, port authorities, port terminals, customs, rail and road operators, etc.), who will bring knowledge of the transport sector and provide feedback on the design process of the FOR-FREIGHT platform solution.
- **Technology developers and SMEs**: those partners specialised in the technological part who will lead the design of an efficient and interoperable multimodal platform and will be in charge of the corresponding testing and validation process of the solution.
- **Horizontal partners**: academic, technologic or innovation research organizations, whose knowledge of the sector will ensure that the FOR-FREIGHT platform and its use cases are able to locate and reference real problems and needs, as well as measure their social, economic and environmental impact, guaranteeing some common standards among the partners.

In order to identify each of the partners according with the abovementioned groups, Table 3-1**Error! Reference source not found.** has been produced to classify which role(s) has each partner within the context of FOR-FREIGHT. Therefore, an overview of how the partners are organised within the project in general and this deliverable in particular can be obtained.

Table 3-1: FOR-FREIGHT Partners' classification.

Partner	Transport & Logistic Stakeholders and Operators	Technology developers and SMEs	Horizontal partners
CERTH		**x**	**x**
ABS		**x**	
ATG		**x**	
AIA	**x**		
BEIA		**x**	
NAVR	**x**		
COEL	**x**		
CSLS	**x**		
DHL	**x**		
EBOS		**x**	
FVP	**x**	**x**	
GOLD	**x**		
IMEC		**x**	
MDM	**x**		
TCCFR	**x**		
TIC4.0			**x**
WINGS		**x**	
ZSI			**x**

The gathering of information provided by FOR-FREIGHT's stakeholders is a further crucial and most relevant point of the deliverable which allows to get a realistic representation of the current way of working when it comes to their operations in multimodal, multi-stakeholder freight transports, carried out in different areas such as ports, warehouses, subway networks or airports; the challenges and "pain-points" that each of the stakeholders faces

during their operations; the technology, devices and legacy systems used by the personnel and to find out which are the most widespread and appropriate standards, at both operationally and technologically levels, that are in place and govern the current processes.

Through this collection of information, this representation of how the sector currently operates has been established and for this purpose, a set of tables have been designed with the aim of covering all the aspects abovementioned. The methodology applied in the design of these tables is based on a series of criteria and input research which have been extracted from the know-how of the partners as well as from approaches made by academia focused on establishing the SotA of the sector.

The central axis for constructing the table of T&L Business and Operational models focuses on the business canvas approach from Osterwalder and Pigneurb [7]. This approach aims on how companies perform its business and describes how they create value through their competitiveness, identifying their key activities, partners, customers, their relationship with them, their value proposition or their revenue stream [8].

However, some relevant domains for FOR-FREIGHT cannot be solely addressed with the Osterwalder and Pigneur approach. Therefore, a revision of this model has been carried out, adding domains that allow to identify critical challenges, concerns and needs of the stakeholders, the key role of the organizations inside the FOR-FREIGHT project as well as the expected benefits from the expected project's solutions in their operations.

The methodology followed through these T&L Business and Operational models tables will permit to draw a SotA of the current interrelation among key intermodal T&L agents, addressing their value chain of their operational strategy.

Given the relevance of technology and legacy systems in the project, a template has been designed to collect information separately for each of them. With the methodology applied in the technology table, the different types of technologies utilised by the partners can be identified. For this purpose, an AS-IS process approach is used, whereby the description of the current situation and existing assets is reported thus making it possible to reflect the present technologies. This AS-IS model is complemented by the future and expected development (if applicable) and situation of these technologies, which will be captured by means of a TO-BE approach. This will help to determine the current maturity of the technology in the different organisations that will be used for the development of FOR-FREIGHT solutions. Furthermore, the technologies' template seeks to identify the relation of the assets with the WPs and possible trial sites where they could be implemented inside the project.

A further key part of this deliverable is the proper identification of the current legacy systems of T&L stakeholders, on which the FOR-FREIGHT's solutions environment will later be built around. The legacy systems' tables capture essential information on the type of each respective legacy system, along with the architecture, technology and protocols it follows. It will also collect information on inputs and outputs, and the level of openness and interoperability with external/3rd party systems, services, databases, etc. In a similar way to the technology template, it addresses the existing linkage of the legacy systems with the different trial sites.

To conclude with the templates, the data standardisation tables have been designated to gather all relevant data standards of the multiple stakeholders, locating the scope they cover and identifying, in which parts of the supply chain the various standards are used. In this context, it is thus possible to gather a background of what the most common standards are and identify if there is a certain common information flow between the various stakeholders involved in the multimodal transport chain. The methodology applied in this table seeks to identify the standards, which are used in the sector, the respective stakeholders, and to identify potential interoperability overlaps between them.

All the templates used are available in Annex I: Stakeholders' Templates, with the tables referring to the T&L Business and Operational Models, Technology, Legacy Systems and Data Standardisation.

3.3 Pains and Gains

The methodology followed in the identification of the pains and gains is based on the collection and unification of the information provided by the partners.

In order to carry out the analysis of the pains, a process of identification of the pains presented by the different stakeholders, which had been collected using the templates for the domain analysis, was carried out. Once identified, the results obtained have been presented in table format (see Chapter 6).

In the analysis of the pains, a series of general categories have been established in which each of the potential drawbacks can be framed.

For the analysis associated with **business and operational models**, a classification has been made according to the trial sites proposed by the FOR-FREIGHT project (Sea port - last mile trials (SP) - FVP, DHL, CSLS, MDM; River port - Rail trials (RO) - ATG, NAVR, TCCFR; Airport - Sea port trials (GR) - AIA, COEL, GOLD). For each of the trial sites, a table has been developed and different categories have been established. The tables used are available in Annex II: Pains and Gains Templates. On the basis of this approach, gains and pains have been categorised on a different basis. The categories used, as well as the criteria for inclusion in each of them, are detailed in the table Table 3-2.

Finally, a distinction has also been made between pains/gains that are shared by the T&L agents in the trial sites and those that are exclusive to a specific T&L agent in order to have a more complete vision of the needs and improvements required by the T&L agents involved in the trial sites considered. Likewise, within each pain/gain category, each of the particular pains/gains of every identified trial site partners has been identified, indicating to whom it belongs.

For **technology**, it has been categorised according to the type of technology, where the pains and gains associated with each partner have been identified.

The same pattern has been followed for **legacy systems**, identifying with each partner each of the legacy systems used and the pains and gains of each of these systems.

Finally, the methodology followed to analyse the pains and gains of the **standards** identified has been carried out by associating the different standards with the partners that use them, and identifying the pains and gains of each standard.

Table 3-2: Pains and Gains categories – Business and Operational Models' Analysis

Category	Type	Description
Information silos across different domains.	Pains	Lack of overall picture of the end-to-end freight transport from its origin to its final destination, due to limitations while exchanging information among involved stakeholders and their management systems (information silos).
Lack of standardisation.		No consensus among T&L stakeholders on the adoption of common interfaces and standards to facilitate storing and exchange of information, decreasing the level of interoperability.
Low digitalisation and automation of processes.		Low penetration of technology in multiple logistics processes and devices and the low automation of such processes, which lead to intensive manual labour, which is more time consuming and prone to errors (inneficient equipment, vehicles, no live-tracking of the cargo, non-automated load/unload operations…).
Suboptimal resource planning of the processes.		Inefficient planning and utilization of personnel, materials and resources can occur when information is outdated or inaccurate. The lack of accurate information, information silosor not learning from historical data lead to suboptimal processes.
Rules, policies and regulatory instruments.		Risks associated with uncertaintly and lack of rules, policies and regulations, leading to scepticism to invest in new solutions and technologies. They could involve compliance costs, administrative burden, limit the flexibility of T&L companies' processes or can create barriers for competitiveness.
Fiscal instruments and incentives, investment and funding.		Complex fiscal instruments could lead to time-consuming and confusing bureaucratic procedures, as well as the limited or inadequately targeted investments. Difficulties in accessing funds and lack of incentives are also considered, i.e., the implementation and development of innovations should be encouraged by policy makers throught ther policies and fiscal instruments.
Operational efficiency.	Gains	Both operational and process efficiency are targeted. Increased efficiency mainly refers to the objective of reaching optimal planning of schedules, assets and operations, leading to cost and time savings.
Digitalisation.		Digitalisation comprises the use of new ICT tools/solutions that can help T&L companies to properly stramline their operations, improving their efficiency, reducing costs, achieving a greater transparency and interoperability among T&L agents and enhanced competitiveness. Highly-relevant examples are wireless communications (5G, beyond 5G), Internet of Things, AI/ML (Deep Learning, Federated Learning, etc.), Blockchain technology and others.
Operational sustainability and environmental impact.		The reduction of environmental impact has been mainly associated to the optimisation of the flow of goods along the entire logistics chain.
Governance and network.		The main focus has been on collaboration, management and governance opportunities to increase transparency, improve interoperability and intermodality and strengthen cooperation and communication between stakeholders.
Adaptation of/Transition to new lines of business (models) or deployment of new commercial solutions		New lines of business models and the adaptation of some existing ones that can increase the revenue of their operations, providing greater flexibility and agility to adapt to the T&L changing market conditions.

4 Background: Sector and Literature Overview

In this chapter, a general context of the T&L sector will be offered in order to highlight its relevance as well as the main challenges it has been dealing with in recent years.

Finally, a review of the literature for each of the domains will be included to illustrate in which areas the research has been focused on over the past years and whether there is a relationship between the areas on which research has been focusing and the trends and challenges affecting the sector.

4.1 Introductory T&L Sector Overview

Multimodal transportation is a critical piece of infrastructure in successfully linking global supply chains and is becoming increasingly important – but also complex - in the face of growing economic globalization. As such, it cannot be overlooked during the green and social transformations. In the EU, there are regulations set in place to foster a social and environmental transformation in the T&L Sector, that have specific relevance for Multimodal Transport.

The European Green Deal underlines the importance of transitioning to cleaner, greener, and smarter mobility and has spurred multiple policy initiatives in the T&L and multimodal industries. Revisions of the Trans-European Transport Network (TEN-T) Regulation (Regulation (EU) 1315/2013) [1] and the Combined Transport Directive (Council Directive 92/106/EEC) [2] have recently been undertaken to incentivize a shift to sustainable forms of transport, i.e., shifting away from road transport and towards inland waterways, maritime transport, and, especially, rail, and ensuring multimodal transport hubs are correctly equipped. Additionally, the revision of the Combined Transport Directive also entails a simplification of regulations to allow for easier implementation in operation [3]. Smart mobility is also a key focus of EU Green Deal regulations, and accordingly the Commission will likely revisit the 2010 ITS Directive and propose adaptations for mobility apps, intelligent services, and connected and automated mobility, for example. An initiative to propose a directive on “Commercial vehicles – weights and dimensions” has also been re-evaluated for its ability to contribute to a harmonious market across the EU [4]. Based on the evaluation, specific changes were undertaken to foster the uptake of clean vehicles in transport. Adoption by the commission is planned for Q2 2023.

However, EU regulation is only the tip of the iceberg when it comes to realizing improvements in social and environmental impacts of transport. A study by Kramarz and Przybylska [5] found that the city exerts a significant influence on the development of freight transport through its actions. According to them, there is a large gap in the perception of the logistics problem related to freight transport by the city authorities. This indicates the need to adopt measures aimed at incorporating the logistics aspects in the design or modification of urban strategies.

From a social point of view, it is important to take measures related to the quality of life of the citizens, which should be expanded, in particular, to include factors related to the separation of passenger and freight transport infrastructure, as well as the degree of satisfaction of logistics needs in the field of e-commerce. From the point of view of environmental protection, they propose to develop a system for evaluating the external costs of transport regions [5]. Another frame of reference in which to understand social and environmental sustainability is resilience. Hayes and colleagues [6], suggest a socio-ecological interpretation of resilience, i.e., that successful approaches result not from a single, permanent design change, but from the continuous use of feedback loops to detect environmental conditions and make minor adjustments, often including the ability to successfully switch between multiple operating states. For this type of adaptive resilience to take hold in transportation, they say it will require a change in approach to planning, design, and operation. Peer-reviewed case studies of existing projects testing these approaches, including a robust examination of outcomes, benefits, challenges, and lessons learned, would help provide a foundation for further development. For transportation infrastructure, this could include infrastructure sustainability assessment systems, key international standards and specifications, and research and practice in areas closely related to biomimicry, including industrial ecology, regenerative design, biophilia, ecosystem services, and materials science [6].

Thus, the players involved in the T&L sector have been forced to adapt to global trends and conditioning factors such as the advance of Information and Communication Technologies (ICTs), disruptive technologies, tightened environmental regulations and policies, commercial tensions, etc. The evolution of the industry has been conditioned by all of these factors, translating not only into opportunities but also into challenges and threats to overcome.

The growing concern of governments and economic operators about climate urgency has resulted, among others in: energy efficiency plans in the T&L sector; investment in green equipment and assets as well as in refuelling and recharging infrastructures; a commitment to modal shift in freight transport towards ship and rail; and a concern for integrated management of multimodal and transhipment transports to increase interoperability, performance and efficiency. And indeed, the EU's transport target of a 60% reduction in emissions by 2050 compared to 1990 has accelerated these efforts and initiatives.

The green transition has therefore become evident in the transport sector as well and has generated the need to adopt more sustainable systems and strategies in all the actors comprising the logistics chain. In this sense, just as transport has become a key part for reducing the carbon footprint of the logistics chain, logistics nodes, port, rail and air terminal operators and suppliers of technologies and solutions in the sector constitute other important players.

Digitalisation and automation have also become a priority for all logistics chain players, and it is crucial to make all of them resilient, as well as to increase their competitiveness and reach full decarbonization. As a result, new business, technologies and solutions are being developed and implemented in the sector, addressing operational and process inefficiencies and supporting sustainable development. This is complemented by new forms of business models relating to the application of technologies in transportation settings, such as data exchange federation, data spaces in transportation, etc. Some of the most relevant technologies highlighted in the T&L sector are identified hereunder:

- **Blockchain**: this technology is a distributed peer-to-peer system that follows the properties of immutability, order, security, consistency and transparency of data. It is being used in the industry to improve the security, traceability and integrity of the data and transactions carried out by the different actors in the logistics chain and is also related with the concept of smart contracts that help to improve and automate business operations.
- **5G (and beyond)**: the 5th generation technology standard (officially, 3GPP Release 15, and the follow-up releases 16 and forthcoming 17) for broadband cellular networks provides higher network throughput, reduced end-to-end latency, ultra-high reliability, etc. 5G wireless devices are connected through macro, micro, femto and pico cells, depending on the respective application requirements, coverage extent and outdoor/indoor contexts. Supported by other technologies such as IoT, cloud/edge computing, AI/ML, big data, etc., 5G offers faster and reliable data flows that enable real-time monitoring, actuation capabilities and advanced applications and frameworks.
- **IoT**: Internet of the Things, also known as IoT, describes the network of intuitive, scalable technologies, such as sensors, actuators, wireless technologies and software, which allow connecting and exchanging data with other systems and devices in real time.
- **AI/ML:** the field of study of machine learning deals with the processing, training and development of mathematical models from data that are used in the sector for tasks such as route optimisation, ETA predictions, dynamic resource allocation/scheduling operations, etc.
- **Robotics and Facility Automation**: self-driving processes where vehicles and tools move safely and autonomously with little or no direct human intervention. These autonomous driving techniques and the use of autonomous machines in the processes are refocusing manual, repetitive, tedious ways of working towards new business and operational models that reduce time and labour costs and improve accuracy and effectiveness.

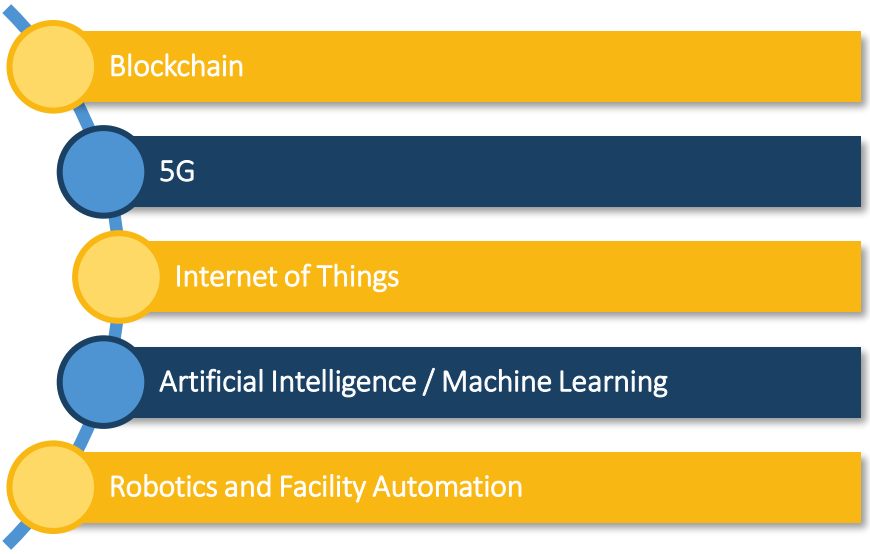

Figure 4-1: Current technological trends (Source: Own elaboration)

Nevertheless, the path towards the digitalisation and automation of the entire logistics chain involves the interconnection of several systems, equipment and agents. Furthermore, key logistics nodes such as ports and airports also need to be integrated more efficiently with logistics chains in their role as intermodal platforms and connecting maritime/air transport with land transport and vice versa.

Finally, other major challenge facing the T&L sector is the development and consolidation of standards in the sector. In response to these needs and to meet these challenges, several initiatives have emerged recently (e.g., European Maritime Single Window environment for maritime transport, the Digital Container Shipping Association which aims to establish shipping industry standards for the exchange of digital information between shipping lines and ports, the International Port Call Optimisation Task Force - Digital Transport and Logistics Forum, GS1, IMO GIA Industry Group, etc.), but there is still much to be done. A more detailed description of the current standards of the T&L sectors will be provided in the Chapter 5.

4.2 Literature Review

To further illustrate this SotA on the issues FOR-FREIGHT focuses on, the deliverable undertakes a review of the empirical literature on the subject. For this purpose, the main sources of information have been the analysis of various technical and specialised literature together with the knowledge and know-how provided by the partners, which have been collected throughout the development of the deliverable. Secondary data sources were also utilised to analyse the SotA of Business and Operational Models, technologies and legacy systems and paradigms of data standardisation; e.g., scientific papers, academic research, scientific journals, white paper articles, business reports.

Thus, the present literature review attempts to focus on the development and current trends of multiple related fields of study and concepts related to the current situation of business and operational models, the latest technologies and new emerging technologies in the sector, as well as the development and proliferation of different standards.

The trends that could be found in the first iteration of the literature review show an overall increase in relevance that this sector has been experiencing in recent years. Recent technological, operational changes and the manner in which the processes themselves are organized inside T&L sector are rapidly growing and changing the way the supply chain works.

Previous trends can be observed in Figure 4-2. This data has been obtained by applying "Transport and Logistics" and the additional keywords in the ScienceDirect platform. It can be noted that discussions and research on different topics in the sector have progressively increased overall in recent years, with a notable growth in the number of publications related to technology and standardisation, which have quadruplicated and tripled respectively in just a decade.

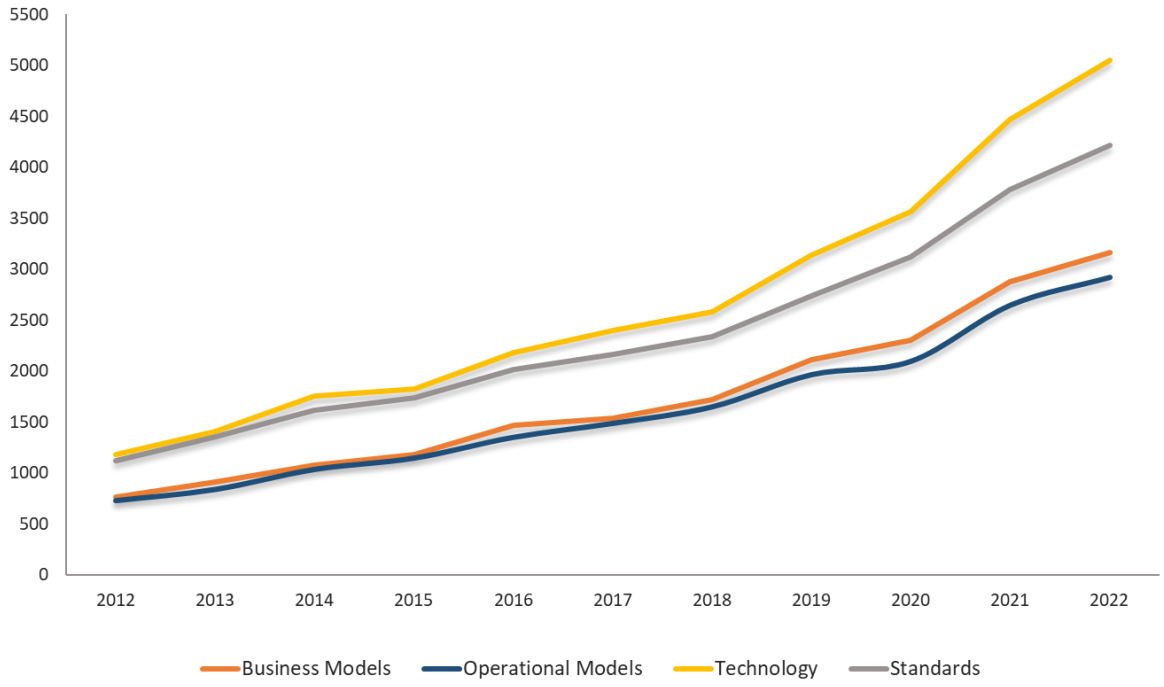

Figure 4-2: Number of published articles per year related with T&L sector (Source: Own elaboration)

The refined results after the process of applying these selection criteria have reported some 120 articles related to the topics and issues addressed in this deliverable and have helped to outline the SotA that will be defined in the following chapters. Much of these papers focus on the technology side, related on issues concerning Industry 4.0 and rising technologies such as 5G, Big Data or IoT, having these direct implications for the way business models have changed over the last decade as a result of their development and implementation. Similar paths are followed by standards, which point towards the search for common standards to improve the flow of information and enhance the interoperability of the sector.

5 State-of-the-Art T&L Sectors

A detailed SotA of the current logistics and intermodal transport modes (in terms of operational frameworks and their ecosystems) will be conducted based on the literature review, knowledge and information obtained through the templates explained in Chapter 3.2.

Before this analysis, a brief introduction of the key actors in the logistics chain will be carried out. Accordingly, a description of the role of each actor within the T&L sector and their relevance within this industry will be provided. Considering that the actors involved in the logistics chain are numerous and that one of the main objectives of the project is to optimize the multimodal logistics chain, the aforementioned description and analysis will be carried out from this approach.

In multimodal freight transport, goods are moved from point A (origin) to point B (destination) using two or more modes of transport, being one of its great challenges to eliminate segmentation in the logistics chain and thereby achieve greater integration of the different transport networks involved.

The different modes of transport along the supply chain identified are six: container ships, planes, trucks, railways, barges and last mile distribution vehicles. However, optimising intermodal freight transport along the value chain involves many other players.

The key actors actively involved in the logistics chain have been grouped into six different categories to facilitate the analysis and include both technology providers and technology users: fleet owner, hubs and ports, infrastructure service provider, technology provider/developer, shipping company, and logistics service provider. Each of these groups represents a specific segment of the T&L chain, being included all the stakeholders involved in the FOR-FREIGHT project.

This relationship has been described in Table 5-1, showing that FOR-FREIGHT comprises key partners of the multimodal T&L, who cover the entire ecosystem and enable a detailed mapping of current multimodal/transhipment freight operations, both from a technical and business perspective.

As a result, in the FOR-FREIGHT project multiple solutions, addressing different domains of the multimodal logistics chain, will be deployed. The analysis conducted in this deliverable follows this differentiating approach according to the three trial sites of the project:

- In the **Spanish (ES)** trial site the multimodal transport of freight from the Valencia port (fifth busiest port in Europe in terms of cargo) to a major logistics hub/warehouse via road (trucks). From there, its further dissemination to the end-users via “last-mile” operations within the city of Madrid, using the already available public subway network, will be addressed. The partners that are part of this trial site are: FVP, ABS, CSLS, DHL, IMEC and MDM.
- In the **Romanian (RO)** trial site, the unloading and reloading of cargo from the Danube Galati port (one of the biggest river ports in Europe) on to trains and its further transport towards central Europe via rail will be addressed. The partners that are part of this trial site are: ATG, BEIA, NAVR and TCCFR.
- Finally, in the **Greek (GR)** trial site, the multimodal freight transport from the Piraeus port (biggest port in Mediterranean in terms of cargo traffic) to the Athens International Airport (AIA) will be addressed, including the transport to and from the airport, the cargo handling, storing, processing and customs clearance at the airport, and its further dispatch to the rest of Europe via Air-freight. The partners that are part of this trial site are: AIA, COEL, GOLD and WINGS.

Table 5-1: T&L Value Chain: Involved actors.

FOR-FREIGHT T&L PARTNER		Fleet owner	Hubs and Ports	Infrast. Service Provider	Technology P/D	Shipping company	Logistics service provider
Name	**Main competencies and interests**						
CERTH	CERTH addresses issues related to transport policy, planning, management, operations and infrastructure for all modes, and covering technology, social, economic and environmental aspects				**x**		
ABS	ABS is an innovative SME, founded in 2015, specialized in software development, wireless connectivity and IoT solutions.				**x**		
ATG	ATG (Asociatia Tehnopol – Galati) expertise consists in elaboration of strategies for innovative development and public administration by stimulating the creation, support and coordination of companies, universities, and production centres in the Danube area.				**x**		
AIA	AIA is the Athens International Airport. Its role is to maintain and further develop the existing cargo business at the Airport, while at the same time creating and exploiting new cargo business opportunities. Specifically, AIA oversees all freight and mail handling activities at the airport, acts as the coordinator and facilitator of the airport's cargo community and spearheads the development and marketing activities of any new cargo relevant project.		**x**	**x**			
BEIA	BEIA has extensive experience with telemetry systems and network management and monitoring systems.				**x**		
NAVR	NAVR is the largest inland fleet in Europe, has a tradition of over 100 years, being an important European inland shipowner.	**x**				**x**	
COEL	COEL provides shipping agency services to develop brokerage, shipping, transport and commercial activities and undertakes to transport goods in containers by any means such as sea, land, rail and air transport. COEL also provides customs clearance, import, export, storage and cargo transshipments services					**x**	**x**
CSLS	COSCO Spain is Logistics Service Provider (LSP) specialising in end-to-end supply chain optimisation with commitment to research and innovation particularly for hinterland multimodal operations.					**x**	**x**
DHL	DHL offers logistics services along the entire supply chain in many industry sectors– from planning, sourcing, production, storage and delivery to returns logistics and value-added services.		**x**	**x**		**x**	**x**

EBOS	IT company providing technologically-advanced e-business software solutions and intelligent dashboards				x		
FVP	FVP is the research, innovation and training centre of the Valenciaport cluster (Port of Valencia community) and has in-depth knowledge in the field of port-logistics and maritime transport: competences in digital transformation, port sustainability, energy transition, safety and security.		x		x		
GOLD	GOLD is the leading Ground Handling Agent in the Athens International Airport.				x		x
IMEC	IMEC is a research hub for advanced CMOS scaling. Over the years, IMEC spearheaded several technologies that grew into full-fledged, market-ready solutions and technologies across a multitude of industries such data and telecommunication and Industry 4.0.				x		
MDM	MDM is the operator of the Madrid subway/metro network.			x			x
TCCFR	TCCFR is the national company that administers the digital network belonging to Romanian railway (CFR) and offers a large portfolio of services for all the companies that operate the railway infrastructure with over 500 sites (testing and commissioning).			x			
WINGS	WINGS develops software for various vertical sectors.				x		

5.1 Transport & Logistics Business and Operational Models

This sub-section will analyse the different business models and operational models currently used by partners, based on the templates collected and the information provided. After having established this general context of how business models and processes work today, the focus will now turn to the FOR-FREIGHT stakeholders who are directly part of the supply chain and who have been previously identified in Table 5-1.

Transport and logistics operational processes are the systems and procedures that enable the smooth and efficient movement of goods and materials from one location to another. These processes involve a wide range of actors, including manufacturers, retailers, transportation providers, and logistics companies, who all work together to ensure that goods are produced, stored, and transported in a way that meets the needs of customers and end-users.

At the heart of transport and logistics operational processes are the logistics networks that connect different locations and facilitate the flow of goods. These networks may include a combination of transportation modes, such as ships, trucks, trains and airplanes, as well as various locations where different stages in the supply chain take place like warehouses, distribution centers, and other facilities that are used to store and handle goods and offer a range of logistic services. In order to coordinate the movement of goods across these networks, logistics companies use a variety of tools and technologies, such as transportation management systems, routing software or tracking systems, to plan and execute efficient transportation operations.

One key aspect of transport and logistics operational processes is the coordination and collaboration among different actors in the supply chain. For example, manufacturers and retailers may work together to plan production and inventory levels, while transportation providers and logistics companies may coordinate the

movement of goods from one location to another. In order for these different actors to interoperate effectively, they must have a shared understanding of the processes and systems that are used to move goods, and they must be able to communicate and exchange information in a timely and accurate manner.

Overall, these operational models are essential for ensuring that goods are produced, stored, and transported in a way that meets the needs of customers and end-users. By enabling the smooth and efficient flow of goods across networks of transportation and logistics providers, these processes help businesses and organizations reduce costs, improve efficiency, and provide high-quality products and services to their customers.

These processes have undergone significant changes and developments in recent years, driven by a range of factors including advances in technology, shifts in consumer behavior, and changes in the global economy. One important aspect of these processes is the increasing use of vertical collaboration, where different actors in the supply chain work together to optimize the flow of goods and materials. As shows Figure 5-1 , this can take the form of second-party logistics (2PL), third-party logistics (3PL) providers, who handle a range of logistics functions on behalf of other businesses, or fourth-party logistics (4PL) providers, who coordinate and manage the activities of multiple 3PLs.

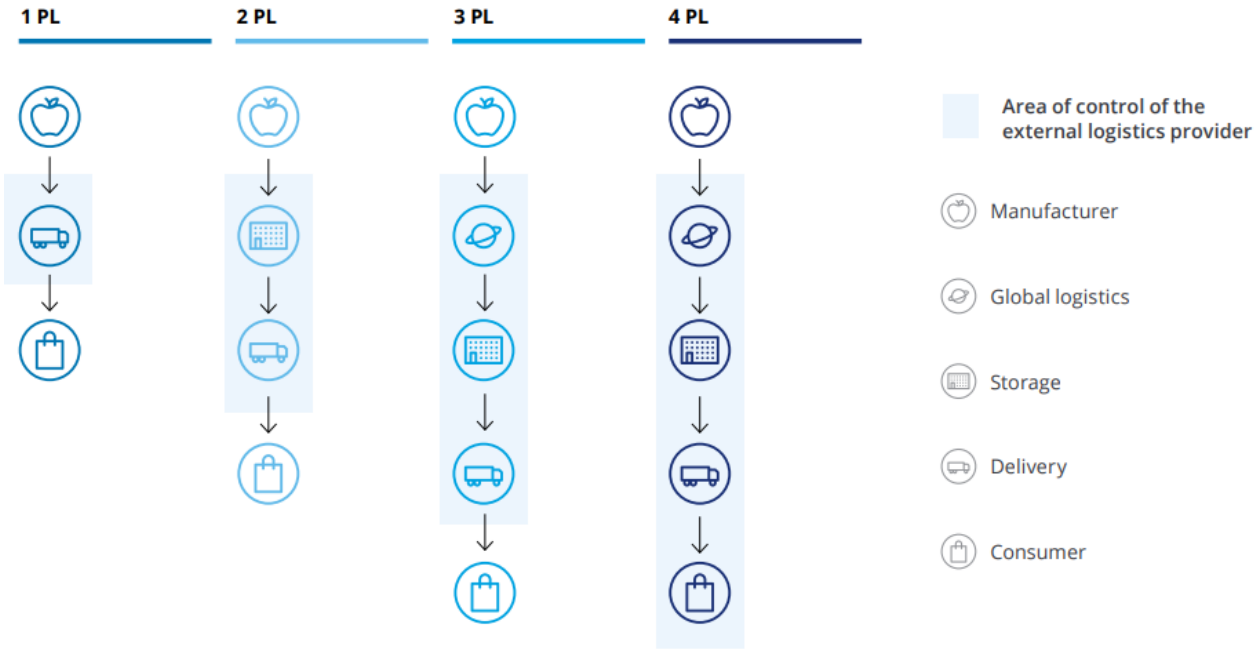

Figure 5-1: Degree of externalisation of the logistics function (Source: Deloitte)

Another trend in these processes is the growing use of asset-based strategies, where organizations focus on using their own transportation assets and infrastructure to move goods, rather than relying on external providers. This can help businesses to reduce costs and improve the efficiency of their supply chain operations, but it also requires significant investment in transportation assets and infrastructure.

The COVID19 pandemic has also had a significant impact on transport and logistics processes, with many businesses shifting to ebusiness models in response to changes in consumer behavior and restrictions on physical movement. This has led to a rapid growth in ecommerce and online shopping, and has highlighted the importance of efficient and reliable logistics networks for supporting these activities.

Despite these developments, there are still challenges and limitations in transport and logistics processes. One key issue is the low degree of technology adoption in the sector, with many organizations still relying on manual

processes and paper-based systems. This can lead to inefficiencies and difficulties in tracking and tracing goods, and can also make it difficult to implement new technologies such as the IoT and cargo traceability systems.

Another challenge is the lack of unified standardization in transport and logistics processes, with many different standards and protocols in use across the sector. This can make it difficult for different actors in the supply chain to interoperate effectively, and can also create barriers to entry for new participants.

This evolution in the procceses of operations on the T&L sector has resulted in new business models strongly influenced by technological trends and a new way of working, interacting and sharing information. In order to establish a definition of what is meant by business models, an initial set of terms is established with the aim of defining and sharing a common concept. In essence, a **business model** is a conceptual model of doing business. It represents the mechanism through which a company performs its business [8] and is one of the methods of implementing the strategic objective of an organisation.

Technological changes and the digitalisation of the current business models of the different organisations in the industry are leading to a scenario where the ability of these actors to adapt those new, and sometimes disrupting, new ways of working to their current operations are the key factor that will result in the effective adoption of these new approaches. The process of adopting new ways of operating and a progressive and appropriate adaptation of these changes to the way of working has modelled how they work and how they approach their business processes, as well as how they operate and interact with the other components within the T&L chain.

These digitalisation processes have delivered changes that focus the new business operations towards i) optimization of the currently used business models that have led to optimisation of costs and process efficiency, ii) extension and enhancement of services through the transformation of the business model and iii) development of new and disruptive business models [9].

The intensity with which these new digitalisation processes, as it's presented in the

Figure 5-2, covers the main business model components covering the provided services, the business processes performed for this purpose, and the non-current assets used for this purpose. High intensity of new technologies implementation, as a rule, contributes to expansion of the range of provided services, integration with a large number of participants in supply chains, the use of both own and leased assets (with favourable market conditions) [10].

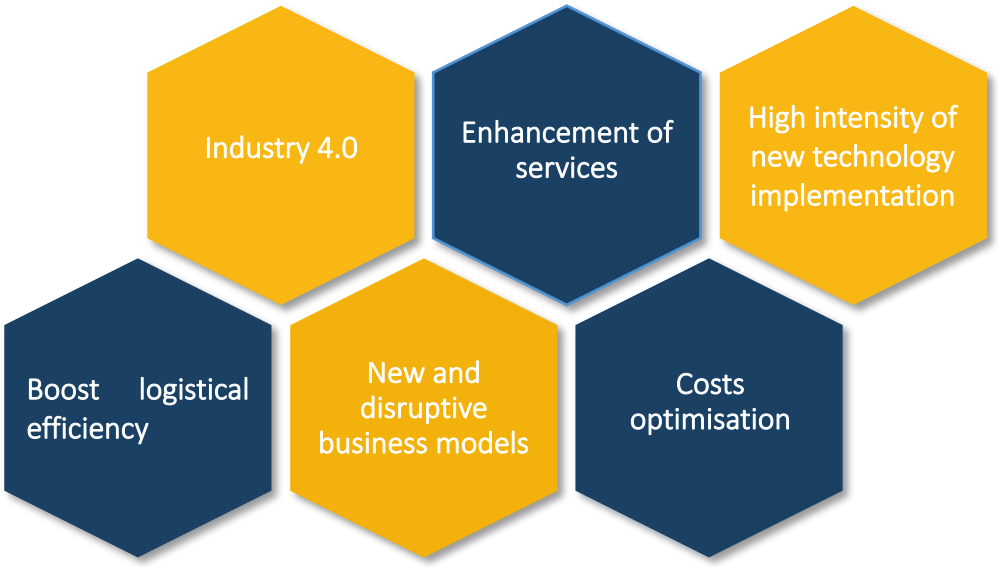

Figure 5-2: Principles of the business trend of digitalisation (Source: Own elaboration).

These new business models are supported by technological advances such as IoT, Industry 4.0 and automation helps to maximize the effectiveness of operations within the organization as well as across the whole supply chain partners [11]. These technologies will be covered in the following chapter 5.2.

To understand the scope of these concepts, the main factors affecting the usual processes and business models in this context of digitalisation have been identified. This will be key to understanding the direction in which stakeholders are heading current market conditions, the intensity with which they are applying and implementing new technologies in their processes, the level of development of their infrastructures, the qualification and training of their personnel [6], the degree of transition and the approach to their new ways of working.

A detailed analysis of the business and operational processes of the identified FOR-FREIGHT T&L stakeholders, namely AIA, COEL, CSLS, DHL, FVP, GOLD, MDM, and NAVR. These partners represent a diverse range of roles and activities within the sector, including transportation, warehousing, and logistics management (see Figure 5-3).

Figure 5-3: FOR-FREIGHT T&L Ecosystem (Source: Own elaboration).

Using information provided by these partners, including their role in the supply chain, key partners, key activities, value propositions, and customer segments, we will provide a detailed overview and gain a comprehensive understanding of their operations. This will be used for the subsequent identification of the pains and possible areas for improvement in the following chapter.

5.1.1 Spanish Trial Site

- ***CSLS:***

Actor type in the T&L value chain.

COSCO Spain is LSP specialising in end-to-end supply chain optimisation with commitment to research and innovation, particularly for hinterland multimodal operations. Thus, the main roles played by CSLS in the T&L value chain are as follows:

- Shipping agency.
- Logistics service provider.

Key partners.

The network of suppliers and partners that make the business model work is as follows:

- Shipping agencies.
- ICT solution providers.
- Port authorities, port and rail terminals and container depots.
- Rail/Truck operators.
- Research organizations.

Key activities.

The Company is one of COSCO Shipping Group's core business segments. The Company is mainly engaged in domestic and international container shipping services and related businesses. CSLS's main activities are linked to its role as:

- Shipping agent, providing data for transport of containerized cargo and related business.
- Solution end-user, providing requirements and assisting solution validation.

Value proposition.

The value proposition of CSLS's processes consists of:

- Know-how and expertise in container transport, sea, rail and truck.
- Support solution exploitation through own and public logistics network.

Customer segments and relationships.

The main customer segments link to CSLS are shippers, consignees and freight forwarders, while the main customer relationship consists mainly of data exchange with actors along the supply chain for transport optimisation.

Key resources.

To accomplish its services and activities, CSLS has the following key resources at its disposal:

- Shipping, Logistics and Transportation services.
- Aggregated knowledge in T&L enabling technologies (e.g., blockchain, IoT, AI/ML) from previous reference projects
- Data for feeding AI/ML and Digital Twins.

Revenue streams.

CSLS's main sources of revenue are container shipping and related businesses.

- ***DHL:***

Actor type in the T&L value chain.

DHL offers logistics services along the entire supply chain in many industry sectors– from planning, sourcing, production, storage and delivery to returns logistics and value-added services. The main roles played by DHL in the T&L value chain are as follows:

- Logistics Hubs/Nodes: warehousing solution for customers.
- Infrastructure service provider: Real State services for customers.
- Logistics service provider: DHL as logistics service provider for customers.
- Shipper: DHL as shipper for customers.
- E-commerce fulfilment: this part of the supply chain entails receiving and storing inventory, processing orders, picking items, packing boxes, and transporting the items to the customer's shipping destination.

Key partners.

The network of suppliers and partners that make the business model work is as follows:

- European heavyweight T&L operators: competitors and collaborators of DHL.
- National T&L association/clusters: T&L association, clusters where DHL is part.
- Academic & technology research partners: studies/research enhancing economic growth and business competitiveness through innovation.
- Innovative SMEs: to develop solutions for logistics companies boosting digitalization and innovation.
- ICT solution providers: fundamental to digitalize operations in the T&L sector.
- Technological partners: key partners for supply chain companies.
- Producers: as starting point of the supply chain process.
- Distributors/wholesalers: intermediate point on the supply chain (or starting).
- Retailers: intermediate point on the supply chain (or starting).
- Governments as they set policies, rules, law, etc. that logistics customers need to accomplish, follow.
- Customers/consumers: final point of the supply chain.
- Subcontractors (trucks/vehicle providers): collaborator needed as DHL does not own trucks.
- Other innovative transport modes (drones, subway as alternative transport mode, e-bikes, walkers, etc).

Key activities.

DHL's main activities are listed below:

- Service management. The service supply chain is the part of the supply chain dedicated to providing service on products. It addresses the supply of parts, materials, personnel and services needed to provide timely and effective product service, such as repair and maintenance.
- Data management and storage. It helps to centralise and synchronise data across supply chain networks and distributors. Master Data Management (MdM) encourages transparency and homogeneity of data, which results in cost-cutting and delivers revenue generation opportunities

- Integration of new technologies. It helps to provide visibility and control across the entire supply chain ecosystem to make data-driven, real-time decisions around everything from inventory status, manufacturing slowdowns and supply shortages to logistics, transportation, delivery schedules, pricing changes and more
- Development of new solutions. New last mile business model (combine with metro network), Blockchain & Digital Twins for real data exchange to support Decision making process in multimodal transport.
- Cloud and ICT management. Cloud-based experimentation platform for the provision of multimodal logistics services.
- Last mile logistics. Subway-Based Network as sustainable alternative for last mile distribution.
- Supplier: increase visibility of material and reduce logistics costs/delivery times.
- Customer/consumer. The main objective is to increase service level and customer satisfaction.
- Society. Last mile delivery is affecting traffic and environmental conditions, thus reducing the external cost it is also an important activity (Environmental impact + Social Cost).
- Competitors. In addition, DHL focus on finding new business models considering competitors' activities in order to create added value to DHL's operations compare to them. In some case competitors can also be considered for collaboration purposes.

Value proposition.

The value proposition of DHL's business consists of:

- Real-time monitoring to track material.
- Saving time and cost in handling processes and problems.
- Saving space (truck utilization/spared capacity in warehouses).
- Consolidation of data stream for a better data management and to inform all the involved parties (supplier, customer, etc.).
- Reducing reaction time and time of incoming information to decrease uncertainty and delays in deliveries.
- Enhance collaboration with different stakeholders to create win-win situations, reduce costs, increase delivery times, etc.
- Improvement of reliability and service quality level to increase customer satisfaction.
- Reduction of the environmental impact with new technologies and business models.
- Resources efficiency to reduce operational cost.
- Demand forecasting for a better operational planning.
- Digitalization to increase resilience, reduce operational costs, reduce errors, etc.
- Tracking and tracing of material to face unforeseen problems, for a better service level, etc.
- Security in operations, in data exchange, etc.

Customer segments and relationships.

The main customer segments link to DHL are T&L operators, cargo and shipping companies and enterprises who can develop innovative T&L applications, while the main customer relationships consist mainly of activities such as:

- Warehousing and transportation services.
- Data exchange, management and storage.

Key resources.

To accomplish its services and activities, DHL has the following key resources at its disposal:

- Warehousing solutions: 14 million m² warehousing and operational space for different sectors: e-commerce, retail, consumer, life sciences, technology, engineering and manufacturing as well as automotive. DHL warehouses are supported with digital technology solutions including Assisted Picking Robots, Indoor Robotic Transport, Intelligent Process Automation, Wearable Devices, Voice Picking, Inventory Management Robots and Algorithmic Optimizations. Shared or Dedicated Warehousing & Goods Distribution:
    - Dedicated and shared operations.
    - Ambient and temperature-controlled facilities.
    - Storage, pick, pack and dispatch.
    - Delivery and returns management.

- Transport Solutions:
    - Transport of raw materials and finished products.
    - Domestic distribution and international transport (cross-border logistics).
    - Transport Management System (TMS).
    - Temperature-assured transport.

- Management services: Strategic Guidance on Optimizing Supply Chain Design & Performance:
    - Network flow and supply chain process analysis.
    - Re-engineering and developing optimized supply chains.
    - Supply chain health checks and benchmarking.
    - Supply chain strategy, set-up and governance.

- Integrated solutions: all necessary services (transport, warehousing and management) together into a complete, optimized package, for the supply chain operations are simplified and business becomes stronger and more efficient.
    - Benefit from expert supply chain knowledge and innovative analysis tools.
    - Streamline logistics service sourcing, supplier oversight and customer touch point management.
    - Gain operational visibility and minimize operational risks.
    - Drive end-to-end continuous improvement.
- Additional Services:
    - Packaging Solutions: Packaging design, procurement and assembly, pre-retailing services and production of point-of-sale displays and primary packaging or co-manufacturing.
    - In-plant Logistics (Logistical Services for Inside the Manufacturing Plant): Kanban replenishment and line readiness, transportation scheduling, dispatch and yard management, sequencing and line feed and production engineering and labour productivity.
    - Pre-sales Services (Pre-sales and Pre-market Customization and Product Assembly): Postponement, customization and configuration, assembly and kitting.

- DHL Supply Chain has/owns:
    - 177.000 employees.
    - Around 10.000 vehicles.
    - Active in more than 50 countries.
    - Most innovative 3PL offering (according to Gartner ranking).

Revenue streams.

DHL's main sources of revenue comes from warehousing and transportation services.

- ***FVP:***

Actor type in the T&L value chain.

FVP is the research, innovation and training centre of the Valenciaport cluster (Port of Valencia community) and has in-depth knowledge in the field of port-logistics and maritime transport: competences in digital transformation, port sustainability, energy transition, safety and security. Thus, the main roles played by FVP in the T&L value chain are as follows:

- Part of the Logistics hub/node of the Port Authority of Valencia.
- Research and centre for knowledge and innovation in logistics, transport and ports of the maritime cluster.

Key partners.

The crucial partners for FVP are as follows:

- Port authorities and port terminals.
- Shipping agencies.
- Technology providers.
- Research organizations and academia.
- Other port community stakeholders (freight-forwarders, consignees, etc.).

Key activities.

FVP's main activities are linked to its role as:

- Innovation promoter by: 1) fostering the design, implementation and execution of R&D&I projects in the port logistics sector, aimed at enhancing the competitiveness of companies and institutions in the sector; 2) developing an acceleration and incubation programme specialized in the T&L sector, dedicated to transform, help and potentiate the companies within Valenciaport cluster through open innovation.
- Knowledge manager, offering specialized and high value-added training for the continuous professional development of the port-logistics community's human capital.
- Strategic partner of port communities around the world by providing technical assistance and support to Spanish logistics operators undergoing a process of internationalization as well as showing internationally the Port of Valencia’s know-how.
- Strategic partner of Valenciaport cluster, structuring the port logistics community, fostering cooperation within the sector, while reaching out to and engaging in dialogue with the general public, all within the framework of a collective social responsibility strategy.

Value proposition.

The value proposition of FVP’s business consists of:

- Increase the value of the port cluster and society.
- Support the process of digital transformation and adoption of new technologies.
- Assist the process of energy transition and environmental sustainability.
- Promote the transformation of business models towards collaborative ports.
- Enhance collaboration with different stakeholders.
- Increasing international visibility and promoting the Valenciaport brand.
- Improve the transfer and exploitation of project results (patents, spin-offs, start-ups, etc.).
- Continuous updating and development through educational and training programmes.
- Development and promotion of new cluster services and tools.
- Consolidate international activity and search for new markets.

Customer segments and relationships.

The main customer segments link to FVP are listed below:

- T&L operators and services, cargo handlers, shipping companies.
- Maritime and port authorities.
- SMEs who can develop innovative T&L applications.
- Consultancy firms for T&L applications.
- Training institutions.
- Academia offering MSc and PhD schools.
- Government and government institutions.

On the other hand, the main customer relationship consists mainly of the following activities:

- Lead and support the development of R&D projects for improving the competitiveness of Valencia Port Authority.
- Promote innovation actions with port community stakeholders, e.g., shipping agencies, port terminals, freight-forwarders, etc.
- Support the integration of external applications and services developed by external partners related to SMEs, academia, etc.

Key resources.

To accomplish its services and activities, FVP has the following key resources at its disposal:

- T&L know-how.
- Aggregated knowledge in T&L enabling technologies (e.g., AI/ML, blockchain, 5G, IoT) from previous reference projects.
- Technological infrastructure.

Revenue streams.

FVP's main sources of revenue are listed below:

- European and National R&D initiatives.
- Consultancy services in the T&L sector.
- Market intelligence service to develop indexes, databases and reports of strategic interest to the sector.
- Trainings and knowledge management initiatives.

- ***MDM:***

Actor type in the T&L value chain.

MDM is the operator of the Madrid subway/metro network, being the main roles it plays in the T&L value chain as follows:

- Infrastructure service provider.
- Logistics service provider.
- Public transport company.

Key partners.

The key partners identified by MDM are as follows:

- Public administrations.

- Service provider companies.
- Spare parts and materials supplier companies.
- Madrid Regional Transport Consortium.
- Technological partners.

Key activities.

MDM's main activities are listed below:

- Employees: identification and prioritization of the strategic Sustainable Development Goals (SDGs) of the business.
- Clients: mobility in Madrid city.
- Suppliers: to provide the necessary equipment/services to carry out the activity of passenger transportation.
- Shareholders: defining the company's strategic actions in the medium and long term.
- Society and public administrations.

Value proposition.

The value proposition of MDM's business consists of:

- Improve the infrastructure of the Metro network.
- Reduce waiting times between trains.
- Improve accessibility to stations.
- Increase operational efficiency: decrease €/km performed.
- Increase efficiency at stations: decrease cost per station open.
- Improvement of reliability and service quality level.
- Reduction of the environmental impact.
- Facilitating transparency in management.

Customer segments and relationships.

The main customer segments link to MDM are residents of the city of Madrid, retailers selling their products in the metro network, consultancy firms for public transport applications, training institutions and academia offering MSc and universities.

On the other hand, the main customer relationship consists mainly of the following activities:

- To have a train schedule with a frequency and occupancy that allows it to be the most cost-effective mobility option in the city of Madrid.
- Maintain station infrastructures and minimize downtime.
- Make Metro stations accessible to all citizens.
- Promote innovation actions with passenger transport stakeholders, e.g. public authorities, transport consortium, suppliers, etc.
- Encourage the use of sustainable sustainable public transport.

Key resources.

The key resources of MDM's company are mainly Madrid subway network, new technologies for a closer approach and better knowledge of travellers and the technological platform.

Revenue streams.

MDM's main sources of revenue come from payment for use the metro network and from the contributions of the Community of Madrid.

5.1.2 Romanian Trial Site

- ***TCCFR:***

Actor type in the T&L value chain.

TCCFR is the national company that administers the digital telecommunications network belonging to Romanian railway (CFR) and offers a large portfolio of services for all the companies that operate the railway infrastructure. The main role it plays in the T&L value chain is to be a telecommunications infrastructure service provider.

Key partners.

The main partners for TCCFR are the ICT solutions providers as well as railway companies.

Key activities.

TCCFR's main activities are linked to its role as:

- Innovation and integration of new technologies into the logistic processes.
- Operations carried out in last-mile logistics.
- Providing logistic support for railway safety communications.

Value proposition.

The value proposition of TCCFR's business consists of:

- Real-time monitoring
- Saving time and cost in handling processes and problems.
- Consolidation of common data stream of information.
- Reducing the reaction time and time of incoming information.
- Enhance the collaboration with different stakeholders.
- Improvement of reliability and service quality level of the services and operations.

Customer segments and relationships.

The main customer segments link to TCCFR are mainly classified as:

- T&L operators and services
- Cargo handlers
- Shipping and railway companies.
- Network operation and optimization stakeholders.

The relationships with these customer segments focus on maintaining a strategic partner group and an active network with other industry stakeholders.

Key resources.

To accomplish its services and activities, TCCFR has the following key resources at its disposal:

- Data and multimodal railway telecommunications maps.
- Railway telecommunications technological platform.

Revenue streams.

TCCFR's main sources of revenue are based on telecommunications services, operational support and consultancy services.

- ***NAVR:***

Actor type in the T&L value chain.

NAVR is the largest inland fleet in Europe, has a tradition of over 100 years, being an important European inland shipowner. Thus, the main roles played by NAVR in the T&L value chain are as follows:

- Shipping company.
- Fleet owner.

Key partners.

The crucial partners for NAVR are mainly the European heavyweight T&L operators and the shipping handlers.

Key activities.

NAVR'S main activities are linked to its role as:

- Innovation and integration of new technologies into the logistic processes.
- Operations carried out in last-mile logistics.
- Achieving efficiency in operation.
- Facilitate the smooth delevery IWT freight shipments and accommodate export on IWT freight shipments on bord, transshipment and transit cargoes.

Value proposition.

The value proposition of NAVR's business consists of:

- Real-time monitoring
- Saving time and cost in handling processes and problems.
- Consolidation of common data stream of information.
- Reducing the reaction time and time of incoming information.
- Enhance the collaboration with different stakeholders.
- Improvement of reliability and service quality level of the services and operations.

Customer segments and relationships.

The main customer segments link to NAVR are mainly classified as:

- T&L operators and services
- Cargo handlers
- Shipping companies.
- Network operation and optimization stakeholders.

The relationships with these customer segments focus on maintaining a strategic partner group and an active network with other industry stakeholders.

Key resources.

To accomplish its services and activities, NAVR has the following key resources at its disposal:

- Data and multimodal maps.
- Technological platform.

Revenue streams.

NAVR's main sources of revenue are based on operational support and consultancy services.

5.1.3 Greek Trial Site

- ***AIA:***

Actor type in the T&L value chain.

AIA role is to maintain and further develop the existing cargo business at the Airport, while at the same time creating and exploiting new cargo business opportunities. Specifically, AIA oversees all freight and mail handling activities at the airport, acts as the coordinator and facilitator of the airport's cargo community and spearheads the development and marketing activities of any new cargo relevant project.

The main roles played by AIA in the T&L value chain are as follows:

- Developer and provider of Airport's Infrastructure.
- Supervisor of the Ground / Cargo Handling Services and airline operations at the Airport.
- Facilitator of new projects and cargo flows.
- Coordinator and integrator of the airport community.

Key partners.

The network of suppliers and partners that make the business model work is as follows:

- Cargo & Ground Handlers.
- Airlines and international Courier Companies (Integrators).
- State Authorities (Customs, Veterinary and Phytosanitary Control Authorities).
- Freight Forwarders and Customs Brokers.
- Internal and external ICT service providers.

Key activities.

- Supervising & facilitating cargo handling operations at the Airport.
- Chairing and managing the Airport Cargo Community Committee (ACCC).
- Enhancing current and developing new cargo flows.
- Facilitating the streamlining and further simplification of Customs procedures.
- Promoting the international profile of AIA Cargo Community.
- Coordinating cargo-relevant marketing activities.

The ACCC comprises senior representatives from all airport cargo stakeholders, such as the freight and mail handlers, the airlines and the integrators, the forwarders and customs brokers, the Customs, the Greek Postal Authority, and the Veterinary and Phytosanitary inspectors. Through the ACCC all members of the cargo community meet and discuss both operational as well as developmental issues and decide jointly on the next steps. Through the ACCC, AIA communicates, integrates, and facilitates flows.

Value proposition.

The main value proposition that AIA offers is the development of a communication platform that integrates information from various sources providing an end-to-end view of the entire multimodal logistics process by standardizing the flows, providing real-time position and monitoring of the cargo resulting in a one-stop-shop point for sea-air cargo traffic development. Other key elements are as follows:

- Support digital transformation and adoption of new technologies.
- Improve processes and interoperability between various stakeholders in the local transport chain.
- Support the standardization and simplification of cargo flows between Seaport and Airport.
- Improve real-time visibility and transparency throughout the multimodal transport chain.

Customer segments and relationships.

The main customer segments link to AIA are T&L operators, cargo handlers, airlines, shippers, consignees and enterprises who can develop innovative T&L applications, while the main customer relationships consist mainly of activities such as:

- Liaison with AIA Cargo and Piraeus Port Community members.
- Liaison with Customs Authorities.
- Strategic partners (port operators).

Key resources.

To accomplish its services and activities, AIA has the following key assets at its disposal:

- Aeronautical Services & Air Cargo flows know-how.
- Established Cargo Clusters.
- Airport Infrastructures (Cargo Terminals Including).

Revenue streams.

The main revenue streams identified by AIA are as follows:

- Operational support & consultancy, focusing on the exploitation of the current Greek Origin-Destination Market.
- Maximization of the existing cargo business, increasing the transit flows via AIA.
- New cargo business development, supported by the development and further expansion of cargo flights at AIA.

- ***COEL:***

Actor type in the T&L value chain.

COEL provides shipping agency services to develop brokerage, shipping, transport and commercial activities and undertakes to transport goods in containers by any means such as sea, land, rail and air transport. COEL also provides customs clearance, import, export, storage and cargo transshipments services

Thus, the main roles played by COEL in the T&L value chain are as follows:

- Shipping agency.
- Logistics service provider.

Key partners.

The network of suppliers and partners that make the business model work is as follows:

- Port and regulatory authorities (Customs Authorities).
- Port Container Terminal Operator.
- Warehouse Operator.
- Custom's Broker.
- Trucker.
- Shipping agencies.
- Freight Forwarders & Consignees.
- Airlines.

Key activities.

- Facilitate the smooth delivery of inbound sea freight shipments, accommodate export sea freight shipments on board, transshipment and transit cargoes.

- Provide logistics services.
- Developing port to inland connectivity.
- Achieving efficiency in operation.
- Striving for the social and economic growth of the region.

Value proposition.

- Reduction of the shipment idle time at the port.
- Reduction of the custom's clearance process time.
- Increased efficiency of the storage space.
- Development of streamlined services and tracking systems for effectively monitoring the shipments.
- Adoption of digital transformation and new technologies.
- Strengthen partnership between the involved stakeholders.

Customer segments and relationships.

The main customer segments link to COEL are shipping agencies, shipping companies, rail and truck companies, agents focused on logistics operation and optimization and innovative custom's broker services, being the following the main customers:

- Piraeus Container Terminal - Piraeus port.
- Piraeus Consolidation & Distribution Centre (warehouse located in Piraeus).
- Container Terminal - Free Zone.
- Customs Authorities.

Key resources.

To accomplish its services and activities, COEL has the following key resources at its disposal:

- Shipping, Logistics and Transportation services.
- Share knowledge, data and experience from daily port to airport operation (including transportation and Custom's activities).

Revenue streams.

The main revenue streams identified by COEL are as follows:

- Operational support.
- Transportation, customs and logistics services.
- Owner of Custom's Simplified licenses based on Authorised Economic Operation certification.

- ***GOLD:***

Actor type in the T&L value chain.

GOLD is the leading Ground Handling Agent in the Athens International Airport and offers an extensive variety of transportation combined services all directly related to air transport. Thus, the main roles played by GOLD in the T&L value chain are as follows:

- Ground handling services provider for Airlines at airports.
- Logistics Hubs/Nodes Airport Warehouse operator.

Key partners.

The key partners identified by GOLD are as follows:

- Airlines and airline authorities/representatives (Customs Authorities, Health Authorities and Civil Aviation Authorities).
- Freight forwarders and cargo community.
- ICT solution providers.
- Airport operators.
- Airport & Cargo Ground Handlers.

Key activities.

GOLD among other provided services is the airport handling provider for the freight carried on board aircrafts of customer airlines. Key activities on this project are the physical and documental acceptance/delivery of sea to air freight or air to sea freight, temporary storage, preparation for dispatch to flight, report on hand on tracing processes, transport and load into the aircraft, and report the completion of the transportation process.

Value proposition.

The value proposition of GOLD's business consists of:

- Real-time monitoring.
- Saving time and cost in handling processes and problems.
- Consolidation of data stream.
- Reducing reaction time and time of incoming information.
- Enhance collaboration with different stakeholders.
- Improvement of reliability and service quality level.
- Reduction of the environmental impact.
- Resources efficiency.

Customer segments and relationships.

The main customer segments link to GOLD are airlines and freight forwarders, while the main customer relationship consists mainly of further enhancing the services provided outside the AIA, offering more alternatives to any possible AIA user for transiting shipments and providing a solid path for any new operator into this airport.

Key resources.

The key resources of GOLD's business are mainly cargo operations processes, EU customs processes and airport operations processes.

Revenue streams.

The main revenue stream of Goldair Handling SA is aircraft handling services including commercial passenger aircraft, cargo aircraft and executive aviation aircraft. These services can be outlined as per bellow:

- Passenger handling & Ticket Office services.
- Passengers With Reduced Mobility (PRM) services.
- CIP Lounge services.
- Flight administration & representation services.
- Ramp handling services.
- Baggage handling services.
- Cargo handling services.
- Cargo terminal handling operations & warehousing services.
- Consulting services.

5.2 Technology and Legacy Systems

The **technological** revolution of recent years has pushed companies to embrace ever more advanced technologies at an accelerated rate of adoption. These new technologies have the potential to help management and coordination of logistics and transport operational models move beyond complexity to satisfy volatile demand in a fast and efficient manner, offering the potential for logistics flexibility and supply chain management.

A wide range of different technologies has been developed and implemented in the "logistical transformation" that is taking place to align logistical processes with the requirements of the new production context underpinning the Industry 4.0 [12] (see Figure 5-4), a paradigm that describes the trend toward automation and data exchange in manufacturing technologies and processes which include among others Cyber-Physical Systems (CPS), Industrial Internet of Things (IIoT), cloud computing and AI [13] and summarises the direction that the industry has been following in recent years in order to move towards this digital transformation.

Figure 5-4: Main features of Industry 4.0 (Source: Own elaboration).

Many of these technological advances towards the Industry 4.0 paradigm will be present in the FOR-FREIGHT project, where the weight of technologies such as Blockchain, AI/ML, 5G, etc., will be significant and will offer clear opportunities to streamline and synchronise operations, increase efficiency, and improve productivity toward the establishment of Industry 4.0 [14]. The adoption of these new technologies and ways of working that lead organisations towards a digitalisation of their operations will enable the transition to this Industry 4.0 paradigm. Once on track in the direction of Industry 4.0, traditional supply chains have a great potential to transform a highly efficient digital supply chain by smartly connecting right from product development, procurement, manufacturing, logistics, suppliers, customers and service [15] while making cutting-edge technology cost-effective and reinforcing real-time, interoperable relationships between actors in the chain.

Through this technological transformation approach under the name Industry 4.0, it is intended to address the problems of digitalization and low penetration of cutting-edge technologies currently present in the T&L sector which leads to possible under-utilisation of technology and systems available along the entire supply chain.

The pace of adoption on those new technologies and systems is critical to the proper performance of an organization, as mentioned in the T&L Business and Operational models' section. In some cases, having cutting-edge technologies does not directly translate into better performance without a proper plan for deploying, adopting and adapting them to their needs and requirements. This is where the relevance of identifying and knowing the systems and technologies currently in use can be understood.

The replacement rate of technology, known as technological substitution, is not a question of new technology versus old technology, but rather as a question of interplay between new and old technology ecosystems' [16]. It is therefore essential to keep in mind what the current configuration of technology is and what legacy systems are available, in order to see how the adoption of innovations can be appropriately approached.

All these emerging technologies are complemented and counterbalanced by what are known as legacy systems. The T&L sector comprised a complex spectrum of different data types and usages that involved disparate **legacy**

systems that over the years had matured independently and differentially across the EU Supply Chain actors, resulting in different user requirements, different business models, different deployment trajectories and incompatible systems that could not share data or intelligence in ICT-driven ways [17]. In order to clearly identify the meaning this concept takes on in the project, legacy systems is defined as the existing HW/SW System/Application used by the different project partners and that could later be used/integrated in FOR-FREIGHT for the development of intermodal transportartion use cases.

To make processes more flexible and productive, it is necessary to realize certain customizations to the systems that are currently in operation in organizations [18]. These customisations or adjustments from more generic platforms and systems to a more personalised way of working, tailored to the individual needs of each stakeholder and usually without following industry standards beyond those common to their most direct customers, constitute the bulk of present-day legacy systems.

These legacy systems, tailored and adapted to the specific need of each member is one of the major obstacles for achieving a proper technical interoperability. Historically, applications and information systems along the T&L sector (and in the vast majority of industrial sectors) were developed in a bottom-up fashion, trying to solve domain-specific and local problems. This resulted in fragmented ICT islands which are difficult to interoperate [19].

This sub-section will identify the most representative technologies, as well as the legacy systems used by the partners indicated. As explained before, this section will be key to identify a common framework for the development of the technological solution to be offered by FOR-FREIGHT.

5.2.1 Technology

As part of FOR-FREIGHT project strategy, the use of technologies 4.0 is considered as a key component to support the end-to-end digitalization of the supply chain ecosystem for maximizing the use of multimodal freight transport capacity. Considering this approach, the SotA of technologies 4.0 for the different project partners is described as the following.

5.2.1.1 Internet of Things

IoT technology encompasses all the sensors, actuators, processing ability, software and other technologies that allow the connection and exchange of data with other devices and systems over the Internet and other communications networks. In supply chain scenarios such as ports, airports, and other logistics hubs, IoT can be used to address different use cases in operational, security and environmental domains.

As part of Greece testbed in FOR-FREIGHT, **AIA** will bring a large set of sensors, controllers and concentrators that could be used to: (i) monitor the security of buildings through the Building Management Systems (BMS), (ii) control safety and security in Athens Airport, (iii) monitor environmental aspects, (iv) perform shipping route optimizations through the use of analytics, and (v) automate the processing of orders. These IoT devices will be available for testing and explore digital twin environments in conditions where production systems are not affected. Additionally, **WINGS** could support the execution of different use cases related to: (i) inventory tracking & tracing systems, (ii) predictive analytics, (iii) fleet management, (iv) monitoring cargo integrity and (v) end-to-end delivery tracking, through its IoT management system in WINGS Chariot Platform, which integrates sensors, OBU, wireless connectivity gateways and data analytics applications. Complementing this contribution, **WINGS** will investigate the relevance of the use of robotics for performing automated or tele-operated loading and unloading of goods from vessels to trucks and vice versa at different logistics hubs. WINGS robotic platform for industry 4.0 and logistics has already been tested in various scenarios/features, including the use of Locobots px100, wx200, wx250, Clearpath Jackals, Clearpath Boxer and Custom UAV platform. Complementing the previous use cases, **GOLD** will also support the execution of a use case focused on temperature monitoring by using some IoT sensors that are installed in temperature-controlled chambers and connected to control and monitoring systems. As an additional asset, **CERTH and WINGS** could also support the real-time monitoring of perishable goods in last mile shipments for obtaining through the use of IoT sensors.

In Galati Port, **BEIA** offers the possibility of validating location-based service tracking, data-assisted navigation, predictive maintenance and sanity checks use cases, through the use of IoT sensors and video cameras relying on different connectivity technologies such as 3G/4G/5G, LoraWAN, Wi-Fi or low-power Bluetooth. These systems are already available in Galati Port in small-scale conditions and would support the execution of pilots focused on demonstrating communications between the infrastructure and vehicles or between vehicles. On the other hand, at the Port of Valencia, **CSLS** is interested in the exploitation of IoT sensors for real time information regarding container location and status. Additionally, **MDM** is open to explore the development of a PoC for enabling fast container loading/unloading.

Table 5-2: FOR-FREIGHT SotA – Internet of Things

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
AIA	Building Management Systems - SCADA	CHARIOT, SATIE, FORESIGHT	Greece	Available
WINGS	WINGS Chariot	VITAL-5G	Greece	Available
GOLD	Temperature Sensors	N/A	Greece	Available
CERTH, WINGS	Monitoring Sensors	ORION	Greece	Available
BEIA	IoT sensors and video cameras	VITAL-5G	Romania	Available
CSLS	IoT sensors for real-time tracking	N/A	Spain	Interested in using
MDM	Robotics for container loading/unloading	N/A	Spain	Interested in using

5.2.1.2 5G

5G technology is the fifth-generation technology standard for broadband cellular communications. It offers unprecedented capabilities for enabling enhanced mobile broadband (eMBB) communications, massive machine type communications (mMTC), and ultra-reliable low-latency communications (URLLC). Thanks to the use of new spectrum bands and the possibility of deploying 5G private networks, 5G technology offers an unlocked potential in supply chain scenarios for enabling different use cases such as remote control of robotics, vehicle to everything communications (V2X), real-time asset tracking, etc.

In Athens Airport scenario, **AIA** offers data and enhanced mobile broadband connectivity at the apron and cargo areas of the airport through the existing WIFI access points and routers, and the 4G/5G commercial coverage available in this location. Additionally, **WINGS** ensures the availability of 5G commercial coverage in all possible routes between the airport and Piraeus port for providing different services such as: instantaneous communication between assets (vehicles, sensors, IoT devices), broadband-like mobile services, and connectivity for edge computing. In cases, 5G coverage is not available for supporting specific, limited locations of all possible end-to-end operations, 4G technology will be considered as an alternative.

At the port of Galati and the port of Valencia**, NAVR, TCCFR** and **FVP** also confirm the existence of 5G commercial coverage for the execution of any use case where 5G connectivity is required.

Complementing the existence of 5G connectivity, FOR-FREIGHT technology providers such as **ABS** and **IMEC** could provide specific 5G-based solutions for enabling V2X communications and a better management and orchestration of 5G resources. In particular, **ABS** could contribute to the implementation of Cooperative Intelligent Transport Systems (C-ITS) use cases for enhancing safety and transport efficiency (fuel consumption and travel times) thanks to the use of its C-ITS Platform and a C-V2X test network, which includes the use of 10 Roadside Units (RSUs) and 5 Onboard Units (OBUs) for enabling vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications. On the other hand, **IMEC** offers a large set of 5G functionalities and

modules such as: (i) 5G Slice Inventory for storing the information, provisioning, managing and selecting 5G slices; (ii) 5G Monitoring module for collecting and exposing metrics and KPIs related to the network and services performance through a Grafana user interface; (iii) CAMINO, a framework for enabling a flexible management of vehicular communication technologies and services and, (iv) a wide set of 5G Edge Network Applications (EdgeApps) designed for covering specific vehicular and T&L use cases such as the resolution of emergency situations on the roads or the execution of assisted vessel transportation control services through the emission of warnings and control commands.

Table 5-3: FOR-FREIGHT SotA – 5G Technology

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
AIA	WiFi and 4G commercial coverage	STARGATE, 5G-TOURS	Greece	Available
WINGS	5G commercial coverage	5G-MOBIX, 5G-ROUTES, 5G-CARMEN, VITAL-5G, Hexa-X	Greece	Available
NAVR, TCCFR, FVP	5G commercial coverage	VITAL-5G, iNGENIOUS	Romania, Spain	Available
ABS	C-ITS Platform and C-V2X test network	C-ROADS.EU	Spain	Available
IMEC	5G Slice Inventory, 5G Monitoring Module, CAMINO, 5G Edge Apps	VITAL-5G, 5G-CARMEN	Any	Available

5.2.1.3 Cloud and Edge Computing

Cloud computing is the term used to describe the provision of computing services like infrastructures (servers and storage), platforms (databases and programs), and applications and other resources over the internet. Thanks to its flexibility and scalability, Cloud Computing has gained widespread use in port and logistics, allowing companies and entities to use low-latency services and applications without investing in infrastructure.

Additionally, higher traffic in the core segments of the network has led most industrial and port entities to adopt an edge computing approach, which is based on computing and storing part of the data close to the end user. **Edge computing** provides a distributed model that makes it easier to access and process the information generated in logistics hubs in real time. This reduces congestion in central nodes, thus lowering latency in operations, bandwidth needs, and energy consumption. Cloud computing and edge computing can be used simultaneously, giving both the core and local segment of the network flexibility and accessibility.

In FOR-FREIGHT, the use of Cloud Computing techniques will be available in the Greece testbed through the availability of **WINGS** cloud-based platforms: WINGS Chariot and WINGSPARK, which have been previously used for dealing with problems in logistics scheduling and autonomous parking. These platforms will be used in the project to host: (i) Transportation Management Systems, (ii) Inventory Management Systems, (iii) Warehouse Management Systems, (iv) Automated order processing, (v) Shipping routes optimization, (vi) Connection with third-parties, and (vii) Risk Management Analytics.

Additionally, **CERTH** offers several cloud-based modules available for deploying specific applications like a virtual freight centre, smart supply chain and intelligent intermodal corridor management system and a terminal operating system. The Virtual freight centre is a cloud solution that can be used for matching the supply and demand of storage space for logistics service providers and users. The intermodal corridor management system allows to monitor the status of containers through Bill of Lading and Container ID queries. Finally, the Terminal Operating System is able to provide gate control, yard management, vessel loading and unloading preannouncements, straddle management and monitoring. These services are available for implementation in any trial sites after defining the specific use case scenario.

Regarding, edge computing capabilities, **IMEC** could provide access to edge computing platforms acting as Multi-Access Edge Computing (MEC) systems for low-latency service and application deployments. These MEC service/application deployments are not use-case specific, and as such can be used as NFV infrastructure for various use cases that require low-latency and high-reliable connectivity between users and MEC services (e.g., V2X application scenarios). Among the existing platforms two types of edge infrastructure platforms are available: distributed edge computing nodes and a centralized edge computing platform available at IMEC premises. Complementing this platform, IMEC could also provide a MEC Application Orchestrator (MEAO), an the edge orchestration component that can perform flexible and smart placement of MEC applications on edge nodes (applications for V2X or other use case scenarios), in which it implements a placement mechanism to select the optimal node to serve the application. The aforementioned edge computing infrastructure could be easily combined with 5G deployments and is available for any FOR-FREIGHT scenario.

Table 5-4: FOR-FREIGHT SotA – Cloud and Edge Computing

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
WINGS	WINGS Chariot and WINGSPARK	VITAL-5G, 5G-MOBIX, 5G-CARMEN, 5G-ROUTES	Greece	Available
CERTH	Virtual Freight Center	WareM&O	Any	Available
CERTH	Smart Supply Chain and Intelligent Intermodal Corridor Management system	SmartCorridors	Any	Available
CERTH	Terminal Operating System	CloudYMS	Any	Available
IMEC	Multi-Access Edge Computing (MEC) system, MEC Application Orchestrator (MEAO)	5G-CARMEN, VITAL-5G	Any	Available

5.2.1.4 Big Data and Digital Twins

Big Data is the branch of technology focused on designing and running the set of computer architectures and technologies used to store and process data and information in quantities that exceed conventional systems' processing capabilities. In industry, the information recorded by sensors and devices can be processed in real time and on a massive scale using big data technology, allowing all kinds of data and statistics to be stored, shared and monitored. One industrial application of big data is the concept of **digital twins**, which are digital replicas or representations of a physical asset, typically composed of a set of variables that when combined and processed can describe and predict the behaviour of the industrial assets to be monitored.

When applied to logistics, big data and digital twin technology is poised to transform a wide range of operations. This technology can store different streams of information from logistics, sensorization, and positioning networks, and process that information in real time, which allows ports to create multi-dimensional models that then help optimize port supply chains, reducing delays and congestion and increasing the efficiency of the different players and facilities.

In FOR-FREIGHT, **WINGS** as a technology provider brings WINGS Chariot as a potential platform where non-real time and real-time data could be managed for monitoring different data sets related to warehouses' status, arrivals prediction, truck/vessel/cargo position and cargo status/condition. Through the exploitation of this platform, different use cases like route optimization, cargo status monitoring, warehouse management, arrivals forecasting, and transport network analysis could be addressed. Additionally, this platform could be the engine for the development of digital twin applications. Currently, this platform does not host any UC-relevant databases or datasets owned by WINGS. Nevertheless, through this platform, WINGS offers the possibility of hosting data for the execution of pilots in Greece testbed.

Additionally, **CERTH** could also bring the use of FENIX federated network of platforms, which allows to perform interoperable, decentralized data exchange between systems and platforms across Europe. CERTH FENIX connector, which is attached to the Greek Transport & Logistics Observatory, could be used for performing data exchange and communication between legacy systems and the FOR-FREIGHT platform. In addition to seamless data exchange, FENIX could also act as service broker and authorization tool for certifying service providers and users. To enable the integration with FOR-FREIGHT, specific FENIX connectors should be developed according to set specifications.

On the other hand, at the Spain testbed, **CSLS** requests the development of a digital twin application able to support flexible and dynamic end-to-end transport planning. The use of a digital twin application is intended for simulating optimal situations based on real time data exchange that support decision making process in order to improve truck planning and truck staying at the port and terminal and reduce traffic congestion at the port, therefore improve environmental impact, in terms of pollutant emission reduction. Additionally, **DHL** and **MDM** are also willing to involve digital twin applications as part of a blockchain environment where operational simulations based on real-time data exchange could be exploited for supporting decision-making processes.

Table 5-5: FOR-FREIGHT SotA – Big Data and Digital Twins

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
WINGS	WINGS Chariot	VITAL-5G, 5G-MOBIX, 5G-CARMEN	Greece	Available
CERTH	FENIX Connector attached to the Greek Transport & Logistics Observatory	FENIX, FENIX2.0	Any	Available
CSLS, DHL, MDM	Digital Twin Application for decision support	N/A	Spain	Interested in using

5.2.1.5 Blockchain

Blockchain is a kind of distributed ledger technology (DLT). It is used to perform digital transactions in real time and in a secure and distributed manner. Blockchain's concept of decentralized and digital value sharing (tangible and intangible assets) gives multiple applications in different industrial and commercial sectors. For logistics scenarios, blockchain gives different entities in the supply and logistics chains reliable information on the rest of the players for making decisions, performing operations, or undertaking activities. The goal is boosting productivity, cutting costs, increasing reliability, and fostering agreement among customers and providers. For ports and logistics hubs, one of its most notable applications is to container tracing and tracking services. Additionally, blockchain is able to enable greater visibility of the flow of container import and export operations taking place all along the logistics chain.

In FOR-FREIGHT, **FVP** provides a Hyperledger Fabric blockchain platform where information related to portcalls, discharges, storages and terrestrial shipment information can be visualized, created, updated or deleted, with the possibility to trace historical changes thanks to blockchain capabilities. Through this platform, FVP is able to allow different port of Valencia stakeholders to secure business-to-business data exchange, facilitate collaboration and test the traceability of container management information. Among the existing FOR-FREIGHT partners, **CSLS** is already integrating different documents like BAPLIES, lists of discharge, summary declarations and terrestrial transportation documents (DUTs). During the project lifetime, this platform could be enhanced by defining new user profiles and integrating new data sources as part of the Port of Valencia ecosystem, with the main objective of improving information flow between all agents by exchanging real time data in a more secure way and achieving document digitalization with the consequent reduction of paper-based processes. In addition to **CSLS**, at the Spanish testbed **DHL** and **MDM** are also interested in exploiting blockchain technology for the development of Smart Contracts able to support their decision-making process.

Table 5-6: FOR-FREIGHT SotA – Blockchain

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
FVP	Hyperledger Fabric blockchain platform	PLANET	Spain	Available
CSLS	Hyperledger Fabric blockchain platform	PLANET	Spain	Available
DHL, MDM	Blockchain application for time reduction in administrative and operational processes	N/A	Spain	Interested in using

5.2.1.6 Artificial Intelligence

AI is the branch of computer science focused on developing and combining algorithms created in computers and programs in order to learn and make connections and observations normally done by human reasoning. A subset of AI is ML, which is designed to develop algorithms that can automatically detect patterns in example data sets and information to then extrapolate these behaviours and perform classifications, predictions or decisions about future situations. In the port and logistics space, ML is set to greatly enhance the different systems for managing and mass processing information used in the land and maritime domains.

In logistics hubs domain, ML can use the information gathered by sensors, actuators, and mobile technology to understand, coordinate and optimize traffic flows. In the maritime domain, ML can also be used both in the dock area and terminals to calculate how long containers remain in the terminal, predict the date and time of ships' arrival, or shed light on vessel loading and unloading patterns. The use of ML in logistics could significantly reduce the number of operations to be performed in the different hubs, thus increasing efficiency, and reducing emissions and costs.

As part of FOR-FREIGHT ecosystem, technology providers are especially active in the development of AI-based solutions.

CERTH could contribute to the execution of use cases related to: (i) traffic analytics, (ii) warehouse capacity optimization, (iii) management of dynamic inventory, and (iv) dynamic vehicle routing models. Regarding traffic analytics, CERTH has developed a ML algorithm able to provide forecasts of speeds at selected road networks and nodes. The algorithm triggers traffic management strategies (for example, buffer management) and traffic information services to professional drivers through C-ITS technology. With respect to warehouse capacity optimization, ML algorithms are able to cover several aspects related to demand forecasting including predictive analytics, dynamic routing, demand forecasting, lead time forecasting and transport capacity optimization. Finally, regarding dynamic inventory management models and dynamic vehicle routing models, specific models could be developed for any trial sites if needed.

WINGS could also contribute to the execution of specific use cases related to: (i) warehouse capacity optimization, (ii) predictive analytics/forecasting, (iii) dynamic routing, and (iv) Intelligent resource management. For the execution of these use cases, WINGS will leverage existing AI/ML assets for the aforementioned applications, as part of the WINGSChariot platform. The development of domain-specific models tailored to the FOR-FREIGHT scenarios, their integration and finetuning will be part of the optimisation tools of the final solution(s) designed in FOR-FREIGHT, namely (i) advice from DSSs to logistics operators (concerning space necessary); (ii) cargo arrival prognosis and (iii) optimized resource allocation and routing (e.g., personnel, trucks, robot manipulators etc.). These algorithms are available for testing use cases as part of the Greece testbed.

In Valencia port testbed, **FVP** is able to provide specific optimization algorithms for enhancing maritime and terrestrial routing. These specific AI-based algorithms are able to recommend the best routing options in terms of best port call option for maritime transportation and best transportation way in the terrestrial domain

depending on operational, environmental and economic aspects. In FOR-FREIGHT, these algorithms could be further fine-tuned for supporting **CSLS** DSS on use of resources and end-to-end multimodal transport planning optimization (AI/ML), providing real-time recommendations for the selection of the best means of transport according to timetable, capacity…, while process is automated with the use of smart contracts. On the other hand, **DHL** is also interested in the development of predictive analytics for optimizing the use of resources of the end-to-end process. In particular, **DHL** aims at having access to the DSS for the optimization of resource utilization (labour, vehicles, equipment) and end-to-end multimodal transport planning optimization using advanced AI/ML techniques.

IMEC can contribute to the simulation tools, AI/ML models and optimization algorithms for end-to-end optimization of the multi-modal transport. Their solutions allow to predict the time, cost and emission of a given route of the logistics chain. They also predict the demand, capacity or dwelling time at the transloading points or distribution centres over future horizon. These predictions will be dynamically updated through time taking into account the last-minute situational changes. Next, IMEC can leverage these predictive indicators to build their optimizers which recommend the end-to-end logistic planning that minimizes the cost function computed based on the defined KPI aspects (resource utilization, time, cost and GHG emissions). While the solutions will be mainly applied within the scope of seaport – last-mile multimodal transport UC in Spain –, they can be highly adaptive with the extension of the chain in the future, e.g., with more transporters or distribution centres involved or removed.

Table 5-7: FOR-FREIGHT SotA – Artificial Intelligence

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
CERTH	ML models for demand and lead time forecasting	WareM&O, DeliNet, Development	Any	Available
WINGS	AI/ML models for route optimisation, ETA prediction, resource management (e.g., warehouse management system DSS)	VITAL-5G	Greece	Available
FVP	AI-based algorithms for maritime and terrestrial routing	PLANET	Spain	Available
CSLS	DSS on use of resources and end-to-end multimodal transport planning optimization	N/A	Spain	Interested in using
DHL	DSS for the optimization of resource utilization and E2E multimodal transport planning	N/A	Spain	Interested in using
IMEC	Simulation, AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport	N/A	Spain	Available

5.2.1.7 Legacy Technologies

In addition to the aforementioned technologies 4.0, many supply chain stakeholders still rely on legacy technologies like email and phone communications for managing a large part of their daily operational activities. In FOR-FREIGHT the use of these legacy technologies is observed in the following partners.

COEL manages communication and coordination with different stakeholders (import team, customs team, PCT free zone, warehouse) through e-mail and phone calls. Usually, customs team receive instructions for new

shipments from the airfreight team. For all next steps and procedures (monitor cargo status, perform customs clearance and arrange transportation to the airport, customs formalities before airfreight), instructions and information is exchanged via e-mail and phone.

GOLD also exploits the use of emails and phone calls for managing different operations such as bookings, AWB Amendments, pre alerts, irregularities, dock slot, special services, communication regarding bookings, AirWaybill amendments, pre alerts, irregularities, etc. Similar procedures are followed Same applies for coordinating the applications for slots on dock of the cargo terminal or special services (i.e., truck unload).

NAVR currently exploits RORIS and DAVID platforms for exploiting time reduction in administrative processes. RORIS is used for Danube traffic management and the exchange of information with systems for inland waterway transport. On the other hand, DAVID is used for managing standard forms for navigation on the Danube.

Table 5-8: FOR-FREIGHT SotA – Legacy Technologies

Partner	Systems/Devices/Infrastructure	Link with Other Projects	Testbed	Status
COEL, GOLD	Email and Phone Calls	N/A	Greece	Available
NAVR	RORIS, DAVID	N/A	Romania	Available

5.2.2 Legacy Systems

Complementing the analysis of the technology state-of-the-art, this subsection describes the list of legacy systems used by the project partners and that could be integrated in FOR-FREIGHT solution. These legacy systems could perform different roles when integrated, e.g. data providers, service providers, integrators, data consumers, service consumer, etc.

The Table 5-9 gathers the legacy systems, giving an overview of all systems that have been identified on the basis of the current FOR-FREIGHT partners inputs and are going to be discussed along this chapter.

Table 5-9: FOR-FREIGHT SotA – Current legacy systems overview

Partner	Legacy System	Testbed
AIA	AODB	Greece
	BMS	
CERTH	The Greek Observatory of Transport and Logistics	Greece
	FRETIS	
	Smart Corridors Data exchange & collaboration platform	
COEL	COSCO ERP	Greece
	HPCS	
	ICISnet	
CSLS	Global and local internal COSCO systems	Spain
DHL	TMS	Spain
	WMS	
FVP	ValenciaportPCS	Spain
	EDI/XML to JSON translator	
GOLD	GoldFreight	Greece
	ICISnet	
	Varied airline systems	

NAVR	RORIS	Romania
TCCFR	IRIS	Romania

5.2.2.1 AIA

Airport Operational Database (AODB) is a software application designed to provision operational flight data and resource allocation of airport's resources regarding cargo flights to all AIA internal and external customers. In particular, this platform provides information about flight schedules and realtime updates on arrivals and departures of flights as well as parking positions and aircraft types. The system is deployed on-premise and is based on a information broker architecture for performing data sharing. Data can be shared by SFTP or through the development of an API during the project lifetime. The use of AODB information is limited for the partners involved in the development of Greece tesbed and the integration of FOR-FREIGHT digital twin.

Building Management System (BMS) is the SCADA system responsible for the access control, security doors, electromechanical equipment and fire control in the airport buildings, cargo areas and the apron of Athens Airport. The system is deployed on-premise and is able to share data in different formats (XML, JSON, SFTP) in near real-time conditions through an SFTP scheduler. The use of the BMS information is limited for the partners involved in the development of Greece testbed and the integration of FOR-FREIGHT digital twin.

5.2.2.2 CERTH

The Greek Observatory of Transport and Logistics is a web application system designed to serve the transport and logistics sector. The Observatory provides different services like digital services inventory, infrastructure index – map and performance dashboard. The Observatory is equipped with a FENIX Connector for seamless data exchange in the FENIX Federated Network. The system is deployed in a cloud-based environment and is able to share data in different formats (JSON, XML) through REST API mechanisms. The system will be accessed through a royalty-free basis and will be mainly available for the Greece testbed (it can be extended to cover other sites too if required).

FRETIS is a terminal operating system (TOS) designed for performing specific yard and cargo management activities at any type of container terminal in maritime ports. The system is a cloud-based application able to exchange different types of historic data (XML, JSON, EXCEL, EDIFACT) through API connectivity services. The terms for deployment and use within the project need to be discussed for the application in any trial site.

Smart Corridors Data exchange & collaboration platform is a Smart Supply Chain and Intelligent Intermodal Corridor Management system designed to manage operational information for different stakeholders like port authorities, terminals, rail operators, public authorities, etc. This web platform is able to exchange data in different formats (JSON, EXCEL) through the use of API connectivity services. This system is available for use in FOR-FREIGHT.

5.2.2.3 COEL

COSCO ERP is the ERP software used to manage business information at COEL. The system is deployed on premise and the information can be provided in SQL, .NET and EDI format. The access to this system is limited to COEL users and depending on the business case of any use case in FOR-FREIGHT.

HPCS is the Port Community System (PCS) used to manage information from Port of Piraeus stakeholders including Pireaus Container Terminal (PCT), COEL users, port authority, terminals, customers, agencies, custom brokers, forwarders, etc. The information is provided in XML format and the access is managed by PCT.

ICISnet is a web based software used to manage business user information based on the VAT number. The information of the system is provided in XML format.

5.2.2.4 CSLS

Global and local internal COSCO systems used for managing information related to shipping operations involving different port community actors. The interoperability with internal system cannot be tested, due to the relevance of information, data cannot be shared with external. Therefore, the information will be anonymized and only available for project consortium and analysis. This information will be only made available for partners involved in the trials performed at Valencia Port.

5.2.2.5 DHL

Transport Management System (TMS): The TMS is a logistics platform that uses technology to help businesses plan, execute, and optimize the physical movement of goods, both incoming and outgoing, and making sure the shipment is compliant, proper documentation is available. The system is deployed in a cloud-based environment and the information is provided in XML format. This system will only provide historic data that could be accessed under specific access requests.

Warehouse Management System (WMS): The WMS is a software solution that offers visibility into a business' entire inventory and manages supply chain fulfillment operations. WMS optimizes the six fundamental warehouse operations that include receiving, putaway, storage, picking, packing, and shipping. The system is deployed in a cloud-based environment and the information is provided in XML format. This system will only provide historic data that could be accessed under specific access requests.

5.2.2.6 FV

Valenciaport Port Community System (PCS): ValenciaportPCS is an open and neutral electronic platform that allows a safe and smart information exchange between public and private agents in order to improve the Port of Valencia competitive position as a Port Community. Valenciaport PCS is a cloud-based application based on microservices architecture. The information is stored in XML, EDIFACT and JSON formats. For FOR-FREIGHT purposes, information related to historical portcall information and cargo flows could be provided. Since the PCS is a system owned by Valencia Port Authority and due to the relevance of the information stored in Valenciaport PCS, information cannot be shared with external parties. Information will be only made available for FVP internal developments in FOR-FREIGHT.

EDI/XML to JSON translator: EDI/XML to JSON translator is a software application designed to translate maritime and terrestrial shipping documents from EDIFACT and XML formats to JSON format to allow an easiest structuring and ingestion of relevant data. This software application is deployed in a cloud-based environment and is able to provide information stored in JSON format. An API could be developed for the exchange of information with external stakeholders after previous discussions with FVP and COSCO por accessing the information related to terrestrial and maritime shipping documents.

5.2.2.7 GOLD

GoldFreight is a WMS software web application designed to be compatible with aviation standards and is responsible for exchanging accounting, shipping and freight status documents like flight manifests, e-AirWaybills, housewaybills, freight status updates, customs declarations, invoicing documents, etc. The WMS application, which is deployed on-premise, is SQL based and stores information coming from different sources like XML, Cargo iQ, EDI, EMAIL, TELEX, etc. The access to the information stored in this system will be provided on a royalty free basis for partners involved in Greece testbed.

ICISnet is a software web application used as Customs Portal for the exchange of customs documents. The information is structured in XML format and is exchanged with different stakeholders such as customs authorities, ground handling agents, shippers, consignees, forwarders, etc. The use of the system in FOR-FREIGHT project will be made according to specific user rights for partners involved in Greece testbed.

Various airline systems like cargo handling and sales systems are used by airlines for booking, sales, operations and tracking of air cargo. These software applications are three-tier platforms or web applications integrating

information coming in EDI format, email and telex. In these systems, flight manifests, e-AirWaybills, Housewaybills, Freight Status Updates, Customs Declarations, Invoicing documents, accounting information can be exchanged with multiple stakeholders in Athens Airport like airlines, ground handling agents, forwarders, etc.

5.2.2.8 NAVR

RORIS is a software application used for tracking the river transport. The information is provided in XLS format as historic data for FOR-FREIGHT purposes. Partners receiving this information will be mainly Port Authorities, Customs and Border Police involved in Galati Port.

5.2.2.9 TCCFR

IRIS is a software application used for tracking freight trains on the railway. The position of the train is transmitted by radio communication between the engineer and signalman at the station and through the IRIS system - between the signalman and the Traffic Command Center, by entering data into the system from each station, after the train has passed. This system will provide the information in E1 format and historic data will be used by railway operators in Romania testbed.

5.3 T&L Data Standardisation

In recent years, interest and relevance of issues related with **standardisation of formatting and data involved in supply chain activities** have carried out a wide range of research and application discussions on logistics informatization and data standardization. This has promoted the process of logistics informatization in the pursuit of setting common standards among logistics stakeholders. The benefits of standards are many and include fostering of a harmonized way of understanding processes and measures, a reduction of the costs involved in aligning different proprietary systems and connectivity to other modules, ease of sharing information and speeding up transactions across different organizational domains and perhaps most importantly a common understanding of elements involved in T&L for a common language and communication enhancement.

The lack of common standards and frameworks is a relevant problem at all operational processes within the field of T&L that leads to ineffective operations at each stage of the supply chain and significantly limits the possibility of establishing interoperability between actors. There are currently many **different standards that are not globally adopted and accepted across the board**.

Data integration is the first step toward transforming data into meaningful and valuable information which provides different logistics actors with a unified real-time view of their business performance. Therefore, it could help improve the execution of the underlying processes and increase the utilization of logistics assets such as trains, trucks, terminals or warehouses [20]. This **integration of data goes first through this process of data standardisation** to be analysed and to unify the way they operate and communicate.

On this basis, the Implementation Objective 5 of the project dictates that FOR-FREIGHT must ensure compatibility with existing and emerging EU logistics standards as well as promote and contribute to the standardisation of multimodal, multi-stakeholder end-to-end freight management solutions and to ensure compatibility with existing EU/global standards, while advancing and supporting a T&L cantered ecosystem bringing together key stakeholders (port/airport/rail/road operators) and to maximise the project's impact through wide dissemination, communication, clustering and exploitation activities.

In order to define the current framework of the sector's standards and for the developed solutions to be applicable and suitable for real operational environments, the **input and requirements of key T&L stakeholders** will be taken into account (as part of the internal co-design process) and the **architecture of the solutions will be aligned with ongoing activities of multiple key logistics standardization bodies, committees and organizations** (e.g., European Maritime Single Window environment for maritime transport, the Digital Container Shipping Association, the International Port Call Optimisation Task Force - Digital Transport and Logistics Forum, GS1, IMO GIA Industry Group, etc.).

The common factors met across the different standards discussed in this section with an emphasis on T&L elements are:

I. The need of interoperability to support joint processes and facilitate information exchange, and by extension, developments.
II. The importance of data formats and ability to understand what is exchanged. Data exchange protocols and interfacing services between networks is important as well as database models.
III. Transparency, security and Governance. Data ownership still hinders open free data exchange and this aspect remains a challenge to interoperable networks. Standards may have a role to play (i.e., data models, semantics and structures).

It should be remembered that the purpose of this deliverable is not to create a common standard for all members, but to carry out a study of all those standards that are currently being used in the processes of the different parts of the T&L chain and technology partners. Thus, it is possible to outline a general SotA of the current situation of standards.

Therefore, although no standards are developed, this deliverable will analyse the current ones and identify **potential overlaps** and **similar ways of operating** that may exist between the different stakeholders, recommending and reinforcing the use of these standards. With this identification of certain commonalities in the standards, it is aimed to make a positive contribution improving interoperability through common, standardised processes, which will also serve to approach FOR-FREIGHT's technological solutions. Furthermore, the project will attempt to **map the different standardization activities to the different areas targets,** especially the Trials, and where possible make sure of those results, outputs and assets developed reinforce existing standards' work by common vocabularies, data re-usalibility, scalability and open access to the community. In this way the importance and weight of standards will be emphasized.

Accodrlingly, this sub-section will set out **which standards are currently used by the partners or are suggested as best practices** from relevant experiences, from logistics standards to data exchange standards, also serving as a starting point for establishing a common point towards interoperability improvement and breaking down the information silos that currently exist between the different actors.

5.3.1 T&L Reference Groups and Committees

There are different standardisation bodies, committees and organisations, as well as related associations and industry consortia, pursuing the same objective, i.e., to create a uniform way of representing processes, products, services and management to support interoperability). Nevertheless, as will be addressed in the following pages within this chapter, these actors do so in a "different" way and sometimes with a different focus depending on the area they are investigating.

The purpose of the project is to provide linkage to these initiatives and keep note of the work being done in an effort to align set up conditions in use cases and design parameters with developments towards a digitized logistics industry.

5.3.1.1 Digital Transport and Logistics Forum (DTLF)

The Digital Transport and Logistics Forum (DTLF), is an expert group of the European Commission bringing together public and private stakeholders from various transport and logistics communities to support the European Commission in promoting the digital transformation of the transport and logistics sector [21].

The DTLF's main areas of work include the provision of technical assistance for the implementation of Regulation (EU) 2020/1056 on Electronic Freight Transport Information (EFTI) and the development of Corridor Freight Information Systems for interoperable data sharing between all types of actors in multimodal freight transport and logistics chains.

The DTLF's overall objective is full-scale digital interoperability and data exchange in a shared, secured and trusted transport and logistics dataspace. The DTLF also contributes to the development of the Mobility Data

Space, being one of the sectoral initiatives in the framework of the European Common Data Spaces proposed in the European data strategy [22].

The DTLF recommends that, since the logistic sector is highly fragmented and composed by a wide range of SMEs, public institutions should take the initiative in boosting the creation of a logistic federative platform. The DTLF establishes the objective of using data sharing as a commodity, based on the following principles shown also in Figure 5-5.

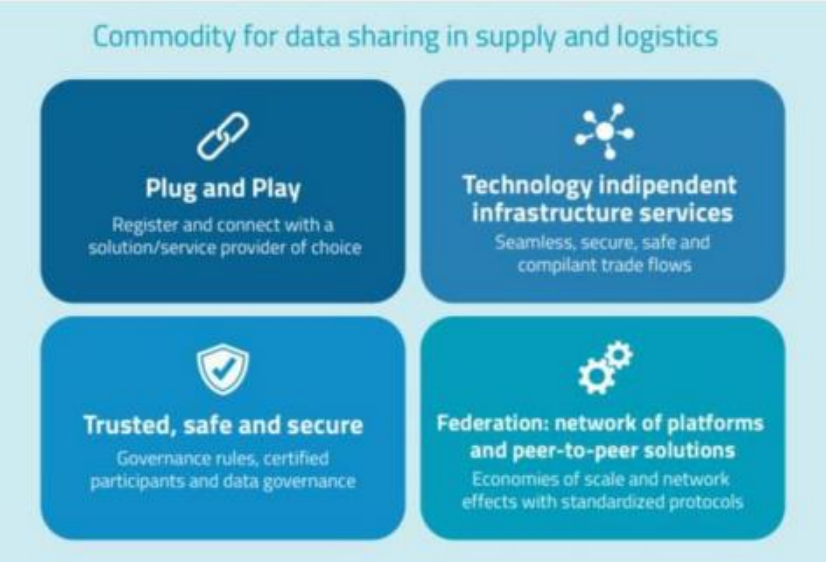

Figure 5-5: Commodity for data sharing in Supply and Logistics (Source: DTLF)

5.3.1.2 Digital Container Shipping Association (DCSA)

Digital Container Shipping Association (DCSA) [23] is a nonprofit, independent organisation established in 2019 by several of the largest container shipping companies. DCSA's mission is to be the de facto standards body for the industry, setting the technological foundation for interoperable IT solutions. Together with their member carriers, DCSA creates vendor-neutral, technology-agnostic, standards for IT and non-competitive business practices. By working towards the widespread adoption of these standards, their aim is to move the industry forward in terms of customer experience, efficiency, collaboration, innovation and respect for the environment.

The creation of standards remain at the heart of DCSA in relation to the areas of Electronic Bill of Lading, cybersecurity, booking, IoT Gateway Connectivity Interface & Remote Reefer Container on board monitoring, JIT port calls, Loadlist and Bay plan, Operational Vessel schedules or the Track and Trace.

DCSA standards-based API definitions are also key to making data accessible and actionable for all stakeholders in international trade. As early adopters of DCSA standards, carrier members like Shippers and Freight Forwarders and Solution providers are working to roll out their DCSA-defined API implementations.

5.3.1.3 International Port Call Optimisation TaskForce (IPCOTF)

The International Port Call Optimisation TaskForce (IPCOTF) [24] is an independent, neutral coalition of maritime organizations dedicated to reducing and optimising vessel berth time at ports. As shipowners, ports, terminals and ships agents supported by key global maritime players aim is to improve and standardize wherever feasible the exchange of nautical, administrative and operational data between ship and shore, ensuring all relevant parties are able to facilitate an efficiently complete vessel port call, be it for containers, bulk, liquid bulk or general cargo, passengers or crew.

This is done pooling resources and expertise in order to make the process of a vessel call anywhere in the world as efficient as possible from the moment a ship departs from its previous port of call right through until it arrives

at its destination port, completes operations and then leaves the berth. By navigating to the same waypoint of ship-shore data exchange, and by using the same standards, shipping, terminals and port interests all stand to benefit. Ultimately, it will reduce ship emissions en route, in and around ports, terminals and port cities, whilst at the same time ensuring greater safety, compliance, a cleaner environment and lower costs for Shipping Lines, Shippers, Terminals and Ports.

5.3.1.4 European Committee for Drawing up Standards in the field of Inland Navigation (CESNI)

At its plenary session in June 2015, the Central Commission for the Navigation of the Rhine (CCNR) adopted a Resolution creating a European committee for drawing up standards in the field of inland navigation (Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure – CESNI). This resolution promotes the development of uniform, modern, user-friendly requirements and takes into account the CCNR's "Vision 2018" for the sustainable development of inland navigation [25].

The creation of this new working body is in line with the desire of the CCNR, shared by the European Union, to reinforce governance at the European level, particularly in the field of regulations governing inland navigation.

The purpose of the committee is to bring together experts from the Member States of the EU and the CCNR and representatives of international organisations with an interest in inland navigation. The various stakeholders and professions in navigation in Europe will be well represented. In creating the committee, the EC – as well as the CCNR – is looking to simplify procedures in the field of regulating inland navigation, so that the experience acquired by the CCNR can be made fully available to all the institutional partners and stakeholders concerned.

5.3.1.5 European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN)

This standard lays down the uniform technical requirements necessary to ensure the safety of inland navigation vessels. It contains provisions on inland navigation vessel construction and equipment, special provisions for certain categories of vessels such as passenger and container vessels, provisions on the model of inland navigation vessel certificate as well as instructions on how to apply the technical standard. It is available in four languages (German, English, French, Dutch). The ES-TRIN 2015 brought together in a standardised way the requirements previously contained in directive 2006/87/EC and in the Rhine vessel inspection regulations. Subsequent editions of the ES-TRIN have enabled this standard to develop to take account of technical developments and feedback on its application [25].

References to ES-TRIN are now included in the legal frameworks of the EU and the CCNR (respectively directive (EU) 2016/1629 and Rhine vessel inspection regulations). The Danube Commission also decided in 2017 to recommend the standard in its international instruments. In 2023, all the riparian states of the Danube should have implemented the ES-TRIN in their national law. Moreover, the International Sava River Basin Commission intends to create a reference to the standard in its legal framework. In other words, ES-TRIN has been established, with great effort, as the centrepiece and baseline for the technical requirements for inland navigation vessels in Europe and has contributed to the reinforcement of governance and harmonisation at the European level.

5.3.2 FOR-FREIGHT T&L Standards

Continuing the analysis of the standards state-of-the-art, this subsection lists and describes the standards used by the project partners and that could be integrated in FOR-FREIGHT solution. The Table 5-10 gathers all standards identified on the basis of the current FOR-FREIGHT partners inputs and are going to be discussed along this chapter.

Table 5-10: FOR-FREIGHT SotA – Current and expected T&L Standards

Type of Standard	Standards	Testbed
	ETSI ITS	All

Technology for vehicular communications	3GPP C-V2X	Spain
	ISO/IEC 30141	All
	IEEE	Romania
Supply Chain – Data Management	GS1 (GS1 GS, EPCIS, GLN, GS1 XML)	All
	UN/EDIFACT	All
	CMR	All
	eCMR	All
	IATA	Greece
	eFTI	All
	XML	All
	DAVID	Romania
	ANSI X.12	All
	ICISnet	Greece
	Cargo IQ	Greece
	DATEX2	All
Supply Chain – General Aspects	ISO 14064	Spain
	ISO 28000	Spain, Greece
	AEO	Spain, Greece

5.3.2.1 Technology for vehicular communications

5.3.2.1.1 ETSI ITS

ETSI Technical Commitees for Intelligent Transport Systems [26] is responsible for standardization to support the development and implementation of Intelligent Transport Systems (ITS) service provision across the network, for transport networks, vehicles and transport users, including interface aspects, multiple modes of transport and interoperability between systems and helps to accelerate the introduction of ITS services and applications and to maximize their benefits by developing common European standards and technical specifications to enable interoperability. As part of this committee, ETSI ITS-G5 is a European standard for vehicular communications based on the IEEE-1609.x and IEEE-802.11p standards. IEEE-802.11p operates at 5.850 GHz to 5.9250 GHz with data rate support between 3 and 27 Mbps in a 10 MHz channel bandwidth, and between 6 and 54 Mbps in a 20 MHz channel bandwidth. This standard will be considered by **ABS**, **EBOS** and **IMEC** for its **application** in **Valencia Port**, **Metro Madrid**, **Athens International Airport** and **Galati Port**.

5.3.2.1.2 3GPP C-V2X

3GPP C-V2X is a vehicular communications standard defined by 3GPP standard and based on cellular modem technology that uses PC5 interface in the 5.9 Ghz band to send and receive messages to and from vehicles, motorcycles, and RSU [27]. This standard will be considered by **ABS** and **IMEC** for its potential **application** in **Valencia Port**.

5.3.2.1.3 ISO/IEC 30141

International Organization for Standardization (ISO) defines a wide set of standards for unifying the exchange of information between multiple stakeholders for many different domains. In this case, ISO/IEC 30141 is applied and can be defined as a technology standard defining reference architecture (IoT RA) and introducing common

vocabulary, reusable designs and industry best practices [28]. The use of this standard is proposed by **IMEC** and **NAVROM** for its **application** in **Valencia Port**, **Metro Madrid** and **Athens International Airport**.

5.3.2.1.4 IEEE

The IEEE 1451-99 standard is focused on developing a standard for harmonization of IoT devices and systems. This standard defines a method for data sharing, interoperability, and security of messages over a network, where sensors, actuators and other devices can interoperate, regardless of underlying communication technology [29]. The use of this standard is proposed by **BEIA** for **use cases developed in Galati Port**.

5.3.2.2 Supply Chain – Data Management

5.3.2.2.1 GS1

GS1 standards are the set of data standards designed to create a common foundation for business by uniquely identifying, accurately capturing and automatically sharing vital information about products, locations, assets and more [30]. Among the existing standards, the following are considered in FOR-FREIGHT:

- **GS1 GS**

  The GS1 General Specifications is the core standards document of the GS1 system describing how GS1 barcodes and identification keys should be used. GS1 handles the standardization of data in logistics by issuing the various identifiers (for products and goods, palettes and containers, locations and organizations, etc), organizing the allocation of identifiers (barcodes and RFIDs), defining product classifications and creating data models for events in supply chains, and for describing products. This standard will be considered by **IMEC** and **NAVROM** for its **potential application** in **Valencia Port**.

- **EPCIS**

  Retailer EPCIS is a GS1 standard that defines supply chain events, enabling disparate applications to create and share visibility event data, both within and across enterprises. This standard will be considered by **IMEC** and **NAVROM** for its **application** in **Metro Madrid scenario**.

- **GLN**

  Global Location Number (GLN) is a GS1 standard that provides businesses the ability to know where things are located throughout the supply chain. GLN provides a unique identifier of locations. The use of this standard is proposed by **CERTH** for its **application** in the **different trial sites**.

- **GS1 XML**

  GS1 Extensible Markup Language (XML) uses XML messages for structuring documents needed to describe the despatch or delivery of goods and services in real-time conditions. GS1 XML messages can be exchanged using any technical solution or internet transport protocol. The use of this standard is proposed by **CERTH** for its **application** in the **different trial sites**.

5.3.2.2.2 UN/EDIFACT

UN/EDIFACT (the United Nations rules for Elec-tronic Data Interchange for Administration, Commerce and Transport) comprise a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data, between independent computerized information systems. EDIFACT standards cover transaction sets (the business documents that you wish to transmit), data element directories and syntax rules which cover delimiter characters, etc [31]. The use of this standard is proposed by **CERTH**, **CSLS** and **FVP** for its **application** in **all use cases where supply chain documents are exchanged**, e.g., Valencia Port.

5.3.2.2.3 CMR

CMR is a standard focused on defining the regulation of road freight transport, serving as an international agreement [32]. The document has been adopted by most of the European states with the purpose to regulate legal issues concerning road freight transportation. In particular, CMR consignment note, constitutes a proof of the contract of carriage by road, determines the scope and responsibility for the operation performed and identifies the parties involved and the goods being transported. Its use implies adherence to the CMR ("*Contrat de Transport International de Marchandises par Route*") that governs this document. It includes the instructions that the exporter or the importer gives to the carrier, so it necessarily has to accompany the goods in road shipments.

The issue of this document should be made by the carrier (the driver of the truck) with all the necessary information to formalize the collection of the goods; however, it will normally be the exporter (sender), who completes the document on the arrival of the truck to his store, always in case of full loads; in case of groupage this document is normally handled by the forwarding agent because there is an internal transport to collect the goods grouped with other goods from different exporters to send them jointly to the final destination in a foreign country. The use of this standard is required by **DHL** for its **application** in **all trials where terrestrial shipping documents are expected to be exchanged**.

5.3.2.2.4 eCMR

The electronic version of CMR, the eCMR Protocol follows the same principles but it connects all stakeholders in the supply chain usually through a digital version platform [33]. The eCMR platform updates each stage as well as the delivery status. This version is set to be considered as a complete transport document where a credible electronic signature is required (usually blockchain). eCMR is not universally applied across EU countries but it is expected to be mandatory in the following years. The use of this document is proposed by **CERTH** for its **application** in **all trials where terrestrial shipping documents are expected to be exchanged**.

5.3.2.2.5 IATA

The International Air Transport Association (IATA) supports aviation with global standards for airline safety, security, efficiency and sustainability [34]. IATA defines standards for air cargo network services. **AIA** and **COEL** propose the use of the **IATA cargo Agent certified** for its **application** at **Athens International Airport**.

5.3.2.2.6 eFTI

Electronic freight transport information (eFTI) regulation establishes a legal framework that allows economic operators to share with enforcement authorities information in an electronic format concerning the transport of goods by road, rail, inland waterways and air in the European Union (EU) [35]. Its application will be mandatory in the forthcoming years. The use of this regulation is proposed by CERTH for its consideration in **all trials where supply chain documents are expected to be exchanged**.

5.3.2.2.7 XML

Extensible Markup Language (XML) is a standard designed for enabling the exchange of information in a standardized structure in the context of HTML and SGML (Standard Generalized Markup Language) [36]. XML schemas define custom markup tags that can contain attributes to describe the content that is enclosed by these tags. XML is widely used in logistics legacy systems for the exchange of information between different stakeholders. The use of this standard is requested by **FVP** and **CSLS** for its **application** in **use cases where an electronic exchange of data related to supply chain transportation is required** (e.g. Port of Valencia).

5.3.2.2.8 DAVID

Danube Navigation Standard (DAVID) is the standard used to exchange shipping and logistics information in Danube River port. The forms used in this standard can be found in the annexes of OMT nr. 187 of 2015 updated

[37]. From 01 January 2023 with the introduction of the CEERIS system, they will be made available as templates. The use of this standard is requested by **NAVROM** for its **application** in **Danube River trials**.

5.3.2.2.9 ANSI X.12

American National Standards Institute (ANSI) X.12 is a message formatting standard used with Electronic Data Interchange (EDI) documents for trading partners to share electronic business documents in an agreed-upon and standard format [38]. ANSI X.12 can be used for configuring and customizing message processing for new trading partners or updating configurations for established ones might be challenging. The use of this standard is proposed by **FVP** for its **application** in **all use cases where supply chain documents are exchanged**, e.g. Valencia Port.

5.3.2.2.10 ICISnet

ICISnet is a customs comunications standard used for managing information of all customs procedures performed in Greece [39]. This standard is used by **GOLD** for the **exchange of customs information in Athens Airport** and **Piraeus Port**.

5.3.2.2.11 Cargo IQ

Cargo iQ is an Electronic Data Interchange standard for air cargo used for performing shipment planning and performance monitoring activities based on common business processes and milestones [40]. **GOLD** proposes the use of this standard in **trials related to the Greek testbed**.

5.3.2.2.12 DATEX2

Datex2 is a data exchange standard for exchanging traffic information between traffic management centres, traffic service providers, traffic operators and media partners [41]. It contains for example traffic incidents, current road works and other special traffic-related events. The use of this standard is proposed by **CERTH** for **all trial cases related to traffic** (long haul or last mile).

5.3.2.3 Supply Chain – General Aspects

5.3.2.3.1 ISO 14064

ISO 14064-1:2018 is an environmental management standard used measure the greenhouse gases/carbon footprint emitted by direct or indirect effect in an organization [43]. This standard is proposed by **FVP** for its application in **Valencia Port**.

5.3.2.3.2 ISO 28000

ISO 28000 is a supply chain security management standard focused on reducing risks for people and cargo within the supply chain [44]. It helps to manage and mitigate potential security within the logistics area, targeting threats such as terrorism, fraud and piracy. From increased supply chain visibility and decreased supply chain disruption, ISO 28000 can help any organization mitigating effects of security incidents. This standard is proposed by **MDM** for its application in **Valencia Port**, **Metro Madrid** and **Athens International Airport**.

5.3.2.3.3 AEO

According to the World Customs Organization (WCO), an authorized economic operator (AEO) is a party involved in the international movement of goods in whatever function that has been approved by or on behalf of a national customs administration as complying with WCO or equivalent supply chain security standards [45].

The AEO concept is based on the partnership of customs with the economic operators and aims to enhance international supply chain security and to facilitate legitimate trade. The EU AEO programme, which is open to all supply chain actors, covers economic operators authorised for customs simplifications (AEOC), security and

safety (AEOS) or a combination of the two. Customs expect the AEO to act in line with customs legislation and to inform customs about any difficulties to comply with the legislation. In return, customs provide the authorised economic operators with certain benefits. The use of this certification is proposed by **AIA**, **COEL**, **CSLS** and **GOLD** for its **application** in **Piraeus Port**, **Warehouse**, **Athens International Airport** and **Valencia Port**.

6 Pains and Gains

On the basis of the analysis carried out in the previous chapter, a detailed breakdown has been made of the possible pains identified in the sector and in the different stakeholders, as well as the gains with which to reinforce these pain-points.

Properly identifying those pains and gains, barriers and improvement opportunities within this industry, can help companies and basically the whole T&L sector to streamline their operations and increase efficiency, leading to improved customer satisfaction and increased profits. Additionally, understanding the various business models, technologies, and legacy systems currently used can help companies to make informed decisions about the direction of their operations and the implementation of new technologies. Furthermore, the proper identification of data standardization is essential for ensuring that information can be easily shared and understood by all parties involved in the processes, which can facilitate collaboration and improve decision-making.

Finally, the impact of this pains and gains analysis is to properly identify the gaps along the expected FOR-FREIGHT improvements and how these requirements and demands could be covered with the resources, technologies and legacy systems provided by the stakeholders.

6.1 Transport & Logistics Business and Operational Models

This section will identify the pains related to business models and operational processes in the FOR-FREIGHT project is highly relevant in order to understand the challenges and difficulties that not only the project but the T&L sector aims to address. The pains represent the problems or issues that the project aims to solve, and by clearly identifying these pains, it is possible to focus on finding new business models, adjustments to current operations and processes or changes in the way of operating that will effectively address these challenges.

By separating the pains and gains according to trial sites (i.e, the Spanish, Greek and Romanian trial sites), it is possible to identify any variations in the results and understand the specific factors that may be contributing to them.

Additionally, separating the pains and gains according to trial sites can help to identify any potential biases or confounding factors that may be influencing the results. This categorisation by trial site will lead to ensure the validity and reliability of the trial results and will give both an overview of the general current weak points found in the FOR-FREIGHT context as well as to drill down to more specific relevant problems in the different trial sites.

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

Table 6-1: Identified Pains of the Spanish Trial Site

Pain Category	Pains
Information silos across different domains	- Delays in original documentation/paper-based documents. - Access to external systems and data streams owned by Port Community stakeholders (**FVP**). - Interconnecting networks and transport modes (**MDM**).
Lack of standardisation	- Lack of uniformity in standards for interoperability between different logistics actors. - Data governance/data security as information along a multimodal transport is shared between diverse actors (customer, consumer, logistics company, metro, maritime company. - Lack of common vocabulary/terminology between different transport modes (ships, truck, subway, etc). - No interaction between (legacy or other) systems (planning, routing, business, traffic systems) between different companies from different sectors (ships, truck, subway, etc). - Very limited interoperability among the involved stakeholders leading to delays and time-wastes and non-automated transfer of goods (**CSLS**).
Low digitalisation / automation of processes	- Lack of well-established infrastructures in the case of a new business model that need to be implemented (i.e., lockers in metro stations, cages for metro wagons, etc). - Technical feasibility of the proposed solution and technical difficulty in implementing the solution in certain stations (**MDM**). - To ensure the safety chain of the transported goods (**MDM**). - Lack of infrastructure foundation (**MDM**). - Digitalisation trends (**MDM**). - Multiple manual tasks leading to intensive manual labour and increased probability of errors (**CSLS**). - Absence of track and trace system on real-time for cargo visibility (**CSLS**). - High emissions related to the conventional transport modes (trucks) (**CSLS**). - Solutions for KPI calculation and monitoring (**CSLS**).
Suboptimal resource planning of the processes	- Lack of visibility of the goods along the supply chain process. - Longer delivery times based on non-real time information. - Congestions in cities due to growth of the e-commerce (**DHL**). - Congestions in ports/hubs and lack of visibility (**CSLS**). - Sub-optimal planning of resources (e.g., human resource, HW, vehicles, equipment, human labour) (**DHL**). - No simulation of potential scenarios/situations applied along the supply chain process supporting decision-making process (**CSLS**).
Rules, policies, and regulatory instruments	- Legal limitations related to city policies or data protection. - Complexity of regulations in cities due to sustainability reasons, environmental problems, protection of historical parts of the city,… (**DHL**).
Fiscal instruments and incentives, investment and funding	- Investment restrictions. - Financial cost. - Digitalisation will require investments to develop new solutions (**DHL**).

Table 6-2: Identified Pains of the Romanian Trial Site

Pain Category	Pains
Information silos across different domains	- The transfer of goods from seagoing vessels to railways is not a continuous, logically integrated process, but a fragmented one. - Delays in original documentation/paper-based documents. - The transfer between river vessels and railways is ordered by the beneficiaries of the goods. - Lack of data transfer between stakeholders.
Lack of standardisation	- Lack of common vocabulary/terminology. - No interaction between legacy (or other) systems related with planning, routing, business, traffic, etc. - Aspects regarding data governance and data security.
Low digitalisation / automation of processes	- Intensive manua labour is still needed for transshipment which results in inefficient use of resources. - Low digitalization and historical data available, so there is no real-time common operational picture possible. - Lack of investments in new technologies (i.e., no possibility of tracking goods in real time) (**TCCFR**).
Suboptimal resource planning of the processes	- Congestions in ports/hubs and lack of visibility due to the non-synchronizations between unloading/loading and handling activities with significant loss of time and uneconomical use of resources. - Congestions in cities due to the military conflict at the Ucranian border.
Rules, policies, and regulatory instruments	- Lack of infrastructure foundation. - Multiple manual tasks leading to intensive manual labour and increased probability of errors.
Fiscal instruments and incentives, investment, and funding	- Financial costs. - Local administration require investments for digitalisation and development.

Table 6-3: Identified Pains of the Greek Trial Site

Pain Category	Pains
Information silos across different domains	- Keeping up with the information flow: No a-priori knowledge on what type of container arrives at the port, when, at what quantity, and ETA at the airport warehouses **(ALL).** - Delays in original documentation/paper-based documents (**ALL**). - No interaction intra-domain and inter-domain between various systems (Customs, airlines, forwarders, airport) interconnecting networks and transport modes (**ALL**).
Lack of standardisation	- Lack of uniformity in standards for interoperability between different logistics actors. - Non-standardized processes.
Low digitalisation / automation of processes	- Delays during Customs clearance processes (**AIA**). - Lack of shipment visibility and difficulties for real time data (**COEL**). - Communication between stakeholders mainly via phone and e-mail (**COEL**).
Suboptimal resource planning of the processes	- Unpreparedness when a container arrives at the airport due to lack of freight monitoring data (e.g. ETA at the airport) **(ALL)**. - Congestions in AIA's landside Cargo Area and lack of visibility (**AIA**). - Need for just-in-time arrival of sea-cargo at AIA and advance planning of flight bookings (**AIA**). - Making sure that the information is received at the proper time and not neglected (**GOLD**). - Congestion within the infrastructure and bottlenecks outside of it (**GOLD**). - Heavy delays with respect to the current operation (**GOLD**).
Rules, policies, and regulatory instruments	- Changes of Governmental law and practices (**GOLD**).
Fiscal instruments and incentives, investment, and funding	- Financial cost of necessary investment to digitize and integrate individual stakeholders' systems (**AIA**).

Once the identification of the main problems found in relation to the T&L Business and Operational models has been presented, the same exercise is carried out to identify the main gains they present, giving answers to the possible improvements that could be solved, covered or promoted to improve the business models and processes with the support of the FOR-FREIGHT project. The tables below set out the identified gains for the three trial sites.

Table 6-4: Identified Gains of the Spanish Trial Site

Gain Category	Gains
Operational Efficiency	- Real-time data exchange and monitoring. - Saving time and cost in handling processes and problems. - Amplify innovation in T&L services by blending FOR-FREIGHT outcomes with in-house artefacts. - Improvement of reliability and service quality level (**CSLS**).
Digitalisation	- Integrate innovative AI/ML and blockchain solutions to enhance port community operations and enhance process traceability, contributing to reduce fragmentation (**FVP**). - Reduction of transport times from DHL warehouse to destination (**DHL**). - Overall supply chain optimization based on the Decision Support System (DSS) and real-time information (**DHL**). - Supply chain governance based on blockchain technology (**DHL**). - Integrate innovative T&L and other enabling technologies for transport planning and data exchange optimisation (**CSLS**).
Operational sustainability and environmental impact	- Reduction of external costs (Environmental impact + Social cost). - Flexible user friendly FOR-FREIGHT Solutions to promote 3rd party adoption (**DHL**). - Door-to-door tracking over multimodal transport (**DHL**).
Governance and network	- Enhance knowledge and foster collaboration. - Facilitate information exchange among last-mile distribution systems and the other systems in the chain. - Collaboration with different stakeholders. - Flexible user friendly FOR-FREIGHT Solutions to promote 3rd party adoption (**DHL**). - Door-to-door tracking over multimodal transport (**DHL**).
Adaptation of/Transition to new lines of business (models) or deployment of new commercial solutions	- Development of a new business model to face competitors (**CSLS**). - Develop an innovative last mile delivery service to increase DHL's portfolio (**CSLS**). - Accelerate the development of T&L applications towards commercial deployment (**CSLS**).

Table 6-5: Identified Gains of the Romanian Trial Site

Gain Category	Gains
Operational Efficiency	- Increase efficiency of present operation through real time data availability and shipment visibility (**NAVR**).
Digitalisation	- Integrate innovative T&L and other enabling technologies to reduce fragmentation. - Standardise and digitise multimodal flows (NAVR).
Operational sustainability and environmental impact	- Reduction of transport times from DHL warehouse to destination. - Overall supply chain optimization based on the Decision Support System and real-time information (**ATG**).
Governance and network	- Enhance knowledge and foster collaboration.
Adaptation of/Transition to new lines of business (models) or deployment of new commercial solutions	- Accelerate the development of T&L applications towards commercial deployment. - Attract additional volumes and cargo by offering a new service to shippers and consignees (**NAVR**). - Amplify innovation by integration FOR-FREIGHT outcomes to NAVR cargo flow concept (**NAVR**).

Table 6-6: Identified Gains of the Greek Trial Site

Gain Category	Gains
Operational Efficiency	- Amplify innovation by integrating FOR-FREIGHT outcomes to AIA's cargo flow concept (**AIA**). - Increase efficiency of present operation through real time data availability and shipment visibility (**COEL**). - Development of streamlined services and tracking systems for effectively monitoring the shipments (**COEL**). - Introduction of new intermodal connectivity process (**GOLD**). - Introducing new methods on resources optimisation (**GOLD**).
Digitalisation	- Integrate innovative T&L and other enabling technologies to reduce fragmentation (**AIA**). - Standardise and digitise multimodal flows (**AIA**). - Adoption of digital transformation and new technologies (**COEL**).
Operational sustainability and environmental impact	- Reduction of transport time (and as a result both energy and emissions) from Piraeus Port to the Athens Airport.
Governance and network	- Enhance visibility throughout the supply chain. - Enhance knowledge and foster collaboration. - Strengthen partnership and achieve synergies between the involved stakeholders. - T&L chain optimisation (**GOLD**). - Receiving new partners, new stakeholders, new customers in this specific chain (**GOLD**). - Having new lean governmental policies which will enable more chain simplifications (**GOLD**).
Adaptation of/Transition to new lines of business (models) or deployment of new commercial solutions	- Accelerate the development of T&L applications towards commercial deployment (**AIA**). - Attract additional volumes and cargo flights by offering a new service to shippers and consignees (**AIA**).

In conclusion, after analysing the identified gains of the business and operational models, there is a certain set of gains that sums up the path and trends of these gains. The operational efficiency aims to improve through the use of real-time data systems. The digitalization of processes also leads to more accurate and faster processes, supported by the use and integration of new technologies. In terms of operational sustainability, the reduction

of externalities from last-mile stands out. The trial sites also demonstrated benefits in terms of governance and network, by enabling better coordination and collaboration among different stakeholders in the supply chain. Finally, this analysis also finds new opportunities by allowing the transition to new lines of business and the deployment of new commercial solutions, accelerating this development of T&L applications towards this commercial deployment.

6.2 Technology and Legacy Systems

This subsection identifies the pains and gains related with the technological component of the project and the use of existing legacy systems in each trial site. First, pains and gains related to technology are analysed considering the different technological trends identified within the SotA provided in Section 5.2. In this context, pains like the existence of information silos, lack of interoperability, data unavailability, technology unavailability or a sub-optimal use of resources are considered and analysed. Additionally, gains like technology readiness, data availability and the existence of previous work in these fields are also identified. According to this approach, the set of pains and gains per technology trend and parners is described as follows:

Table 6-7: Identified Pains and Gains of the technology

Technology	Partners	Pains	Gains
IoT	**WINGS, AIA, GOLD, COEL**	**Information silos and potential lack of interoperability:** WINGS needs to have access/specifications to existing legacy systems in Piraeus Port and Athens Airport	**Wide availability of existing IoT systems for Greek testbed for different use cases:** WINGS can provide a mature IoT management system able to cover multiple use cases in Athens Airport. AIA can integrate SCADA, BMS, Environmental system, etc. GOLD could contribute with sensors and temperature-controlled system.
	WINGS, MDM	**Potential Limitation for collaboration: WINGS** robotics system to be investigated as potential feature for Athens Airport testbed. **Information silos and potential lack of interoperability:** Need of integration with MDM warehouse management system.	**Technology Readiness:** WINGS could investigate the application of robotic platforms to test MDM container loading use case.
	CSLS	**Technology Availability:** Lack of IoT tracking technology provider at the Port of Valencia	**Know-how:** CSLS has already tested the use of other IoT tracking solutions as part of the execution of several research initiatives.-
5G	**ABS, IMEC**	**Technology Availability:** Lack of private 5G networks where innovations can be applied	**Back-up solution to existing limitation:** Availability of 5G coverage in all testbeds
Cloud and Edge Computing	**WINGS, CERTH**	**Data Availability:** CERTH needs to feed their systems with specific information from end-users. **Information silos and potential lack of interoperability:** WINGS needs to have access/specifications to existing legacy systems in Piraeus Port and Athens Airport	**Technology Availability:** WINGS and CERTH could provide existing cloud computing platforms for demonstrating a wide variety of use cases in different scenarios. IMEC could provide edge computing solution for 5G-related scenarios.
	IMEC	**Technology Availability:** Lack of private 5G networks where IMEC edge computing solution can be integrated	

Big Data and Digital Twins	**WINGS**	**Data Availability:** WINGS Chariot platform does not host any UC-relevant databases or datasets owned by WINGS. Data needs to be provided by partners interested in exploiting this platform.	**Technology Readiness:** WINGS Chariot and Greek T&L Observatory Data Platform capabilities have already been tested in previous projects (VITAL-5G, 5G-MOBIX, 5G-CARMEN, FENIX) and are available for the execution of further use cases in FOR-FREIGHT.
	CERTH	**Lack of unified management systems via common (standardized) interfaces (low interoperability):** To integrate the Greek T&L observatory data platform in FOR-FREIGHT specific FENIX connectors should be developed.	
	CSLS, DHL, MDM	**Sub-optimal resource planning based on outdated information: CSLS, DHL** and **MDM** systems need to be able to provide real-time data for the development of a digital twin application.	**Data availability and Know-how:** CSLS, DHL and MDM systems can provide the data needed for feeding a digital twin application in FOR-FREIGHT. These stakeholders could also contribute to develop the business logic running behind the digital twin application thanks to the know-how they could offer in different logistics segments.
Blockchain	**FVP, CSLS**	**Information silos across different domains:** The information to be registered in blockchain is stored in different CSLS systems and in different data formats (EDI, XML). **Lack of unified management systems via common (standardized) interfaces (low interoperability):** CSLS systems do not include APIs to exchange information with external systems.	**Previous work available:** To mitigate the existing pains, FVP already designed an ETL pipeline and performed some initial integrations with CSLS systems as part of the work performed in PLANET project.
Artificial Intelligence	**FVP, CSLS**	**Information silos across different domains and lack of unified management systems via interfaces:** The information registered in CSLS systems and relevant for the design of AI algorithms is stored across different silos and there is a lack of common interfaces for extracting information.	**Previous work available:** To mitigate the existing pains, FVP already designed an ETL pipeline and performed some initial integrations with CSLS systems as part of the work performed in PLANET project.
	DHL, MDM, WINGS, CERTH	**Information silos across different domains and lack of unified management systems via interfaces:** The information registered in DHL and MDM systems is stored across different silos. These systems do not have interfaces for extracting information.	**Technology Available:** CERTH and WINGS could contribute to the development of AI algorithms for DHL and MDM use cases since they have existing solutions for warehouse optimization and DSS in logistics.
Legacy Technologies	**COEL, GOLD**	**Low digitalization/automation of the logistics processes:** Calls and emails are the only data source available.	**Data Availability:** Large number of potential data sources if integration and interoperability can be addressed.
	NAVR	**Lack of unified management systems via common (standardized) interfaces (low interoperability):** RORIS and DAVID need to be open to interoperability.	

As it can be extracted from Table 6-7, the main pains observed for the analysed technologies are related to the absence of interoperability with external systems for enabling the exchange of information, contributing to create information silos. In most cases, the absence of interoperability is directly theresult of the lack of interfaces to create unified management systems. Complementing this main aspect, other pains related to the existing low levels of digitalization and data unavailability can also be identified in several stakeholders, thus limiting the potential exploitation of specific technology solutions. Nevertheless, as shown in the table, these limitations are already being mitigated by the consortium thanks to the experience and know-how of different partners in the application of the aforementioned technologies. This mitigation shows that the project can also offer specific gains related to the availability of technology and the know-how obtained from previous research initiatives.

Complementing the previous work, the analysis of pains and gains of the existing legacy systems is also considered a crucial step to understand the existing limitations of the systems to be used in FOR-FREIGHT project. Pains like data privacy restrictions, lack of interoperability, system unavailability, and technology restrictions are considered as relevant limitations for the integration of existing systems in FOR-FREIGHT architecture. Additionally, positive aspects like the existence of interoperability mechanisms, data availability or technology readiness will help to leverage the capabilities of existing systems as part of the project execution. The set of pains and gains identified for the existing legacy systems provided by the different partners is analysed in Table 6-8.

Table 6-8: Identified Pains and Gains of the legacy systems

Partners	Legacy System	Pains	Gains
AIA	**AODB**	**Data Privacy:** AODB information is only available for its use in Airport Athens trials. No sharing of information is allowed with other parties.	**Interoperability:** The system has a moderate interoperability using SFTP or APIs. A specific API could be developed for the project.
	BMS	**Lack of Interoperability:** Data exchange is only available through an intermediate SFTP server.	**Data Availability:** Datasets in XML, JSON and SFTP format can be exchanged in near real-time conditions
CERTH	**Greek Observatory of T&L**	**Not identified**	**Interoperability:** The system has a high degree of interoperability using APIs, OAuth and OpenID solutions. **Readiness Level:** The system is already fully developed.
	FRETIS	**Technical Limitation:** The system has a high degree of complexity.	**Interoperability:** The system has a high degree of interoperability using APIs. Data can be exchanged in JSON, XML, EDI formats.
	SmarCorridor	**System Availability:** The system is highly dependent on the end user participation	**Interoperability:** The system has a high degree of interoperability using APIs. Data can be exchanged in JSON and EXCEL formats.
COEL	**COSCO ERP**	**System Availability:** The access to this system is only allowed for CSLS users	**Not identified since it may not be available**
	HPCS	**System Availability:** The access to this system is managed by PCT	**Not identified since it may not be available**
	ICISnet	**Technical Limitation:** The system has a high degree of complexity.	**Not identified since it may not be available**
CSLS	**Global and local internal COSCO systems**	**Data Privacy:** Interoperability with internal system cannot be tested, due to the	**Data Availability:** Relevant data related to maritime and terrestrial shipments can be

		relevance of information, data cannot be shared with external.	provided after previous anonymization techniques
DHL	**TMS**	**Technical Limitation:** Lack of track and trace system. Lack of real time information. Complex to execute simple and daily tasks.	**Data Availability:** Historical data related to terrestrial shipments can be provided after specific requests
	WMS	**Technical Limitation:** The system has a high degree of complexity.	**Data Availability:** Historical data related to terrestrial shipments can be provided after specific requests
FVP	**PCS**	**Data Privacy:** Valenciaport PCS is a system owned by Valencia Port Authority. Due to the relevance of the information stored in Valenciaport PCS, information cannot be shared with external parties.	**Data Availability:** Historical data related to terrestrial shipments can be provided after specific requests. **Interoperability:** The system has a moderate degree of interoperability using APIs. Data can be exchanged in JSON and XML and EDI formats.
	EDI/XML to JSON Translator	**Exploitation Rights/Data Privacy:** The translator is a software developed by FVP and therefore the use/exploitation of the service needs to be discussed with FV.	**Data Availability:** The system is able to provide JSON datasets after ingesting EDI and XML files. **Interoperability:** An API could be developed for interacting with external systems.
GOLD	**GoldFreight**	**Technical Limitation:** Not compatible to multimodal transportation	**Accessibility:** Access can be given on a royalty free basis
	ICISnet	**Technical Limitation:** Poor intervention on the development	**Not identified**
	Airline Systems	**Technical Limitation:** Not compatible to multimodal transportation	**Not identified**
NAVR	**RORIS**	**Technical Limitation:** Obsolete support/hardware	**Data Availability:** Historical data can be shared in XLS format.
TCCFR	**IRIS**	**Technical Limitation:** Obsolete support/hardware & software	**Data Availability:** The system is able to provide real information about train positioning in non-real time conditions.

According to the analysis shown in Table 6-8, the main pains observed with respect to the existing legacy systems are related to technical limitations (obsolescence, low compatibility) and the lack of accessibility to these systems within the project due to the sensitivity of the information managed. On the other hand, the analysed systems show some gains since they already offer a wide availability for exploiting historical data and some of them have available external interfaces that enable their potential interaction with other external systems.

6.3 T&L Data Standardisation

Data standards define a set of guidelines to structure and regulate the exchange information among different systems and/or stakeholders through a common and unified framework. Nevertheless, in some occasions the application of these standards to specific scenarios may result too generic, specially in scenarios where systems and applications are tailored for the execution of specific use cases in domains that are not directly related to the nature of the standard. Under this paradigm, the set of data standards to be considered in FOR-FREIGHT (Section **Error! Reference source not found.**) are analysed in this subsection, highlighting the main limitations and particular strengths for its potential application in the project use cases. The pains and gains identified per standard and partner are the following:

Table 6-9: Identified Pains and Gains of standardisation

Data Standards	Partners	Pains	Gains
ETSI-ITS	**ABS, EBOS, IMEC**	Not identifiedETSI ITSG5 communication standard targets narrow band V2X communications and safety applications. It has been challenged on the market by the new standard 3GPP C-V2X based on cellular communications.	Improve safety in freight transport on roads.
3GPP C-V2X	**ABS, IMEC**	3GPP C-V2X Competes compete on the market with the legacy and more mature ITS G5 standard.	Improve safety in freight transport on roads.
GS1 – GS	**IMEC, NAVR**	Subject to commercial use restrictions.	Not identified
GS1 - EPCIS	**CERTH, IMEC, NAVR**	Subject to commercial use restrictions.	Gain a shared view of physical or digital objects within a relevant business context both within and across enterprises.
GS1 - GLN	**CERTH**	Subject to commercial use restrictions.	Unambiguous identification of locations.
ISO/IEC 30141	**IMEC, NAVR**	Subject to commercial use restrictions.	A standardized IoT Reference Architecture using a common vocabulary, reusable designs and industry best practices.
ISO 14064	**FVP**	Too generic, not specified to the T&L sector. Outdated and has to be up to date to a newer version.	Not identified
ISO 28000	**MDM**	Not identified	Provides the ability to control and manage threats coming from logistical operations.
AEO	**AIA, COEL, CSLS, GOLD**	Cross-site movement of goods is not in scope for the FOR-FREIGHT project.	Framework for moving goods in temporary storage between different member states, recognized status across the EU.
IATA	**AIA, COEL**	Not identified	Framework for the reduction in errors, fines related to air cargo shipments, custom delays due to incorrect labelling or documentation, risk of aircraft damages, sped up shipment processing.
IEEE	**BEIA**	Not identified	To build sensor networks with devices, such as sensors and actuators, and can facilitate device and data interoperability in the realm of the Internet of Things (IoT), Industrial Internet of Things (IIoT), and Cyber Physical Systems.
UN/EDIFACT	**CERTH, CSLS, FVP**	Need for interoperability between the different existing EDI formats in order not to create gaps and losses of information and efficiency in information exchanges.	EDI formats provide semi-structured data easing the understanding and ingestion of supply chain information.
DATEX2	**CERTH**	Interoperable data exchange between operators is not necessarily guaranteed, as different data providers create DATEX II profiles independently of each other and	Concerns applications where information exchange between management systems for different modes is crucial, like multi-

		use them according to their national frameworks and specifications.	modal information systems and where the exchange of measured data is important. DATEX2 is a reference for all applications requiring access to dynamic traffic and travel related information in Europe.
CMR	**DHL**	A CMR note does not necessarily guarantee its bearer and/or the carrier's rights of ownership or custody of the goods.	Allows trucking companies to operate more confidently and efficiently across borders
eCMR	**CERTH**	The electronic version of CMR. Not universally applied across EU countries (e.g., Greece has not ratified it yet).	The electronic version of CMR. eCMR is expected to be mandatory in the following years.
eFTI	**CERTH**	Not universally applied.	Mandatory application in the forthcoming years.
XML	**FVP, CSLS**	XML format is not easy to parse and store in non-relational databases. Translation to JSON format is required.	XML format provides semi-structured data easing the understanding and ingestion of the information.
DAVID	**NAVR**	Not widely adopted	Provides guidelines for structuring data used in Danube Navigation Systems.
ANSI X.12	**FVP**	Configuring and customizing message processing for new trading partners or updating configurations for established ones might be challenging. Solutions based on that standard can be expensive for small-to-midsized business.	Standard allowing the exchange of electronic business documents between trading partners.
ICISnet	**GOLD**	Air freight does not have as a key reference of the shipment the Air waybill like in the rest air cargo chain.	Provides guidelines for all customs procedures performed in Greece.
CargoIQ	**GOLD**	Detailed warehouse tracking is not included on the standard.	Includes the main milestones of acceptance, prepared for dispatch etc.

On the basis of this analysis, the key points that summarise the current SotA standards have been gathered. The use of these "tailor-made" standards can be noted, with little or no interaction between the different system due to representing different information. The fact that the list above contains a double digit number of standardization sources supports the argument of the plethora of information out there, but at the same time how easy the T&L actor might get confused on what is applicable and what is not, specially across different lines of work. The following points outline the conclusions that should be kept in mind for dealing with standards across the T&L sector:

- Lack of technology awareness by operators.
- Standarisation process aiming for less paperwork and improve digital platforms' interoperability.
- The need to establish a common set of language, data ownership, governance and framework of rules.
- Maintaining formats that are outdated or whose new versions are already being applied is a step backwards towards a proper standardisation.
- The associated cost and ease of implement some new standards over the current ones suppose a barrier to accessing to a common framework for some agents like SMEs.
- Greater transparency, as there are instances where users are not aware of the standards that exist.
- Lack of standards in sectors like rail creates costraint and lack of visibility.
- Standards must be able to reflect end-to-end data connectivity and information on all elements (goods in all states, location, cargo condition, transport means, routes, categories, etc.).

- Security must be incorporated to standards' structure. Digital privacy remains crucial to interoperability and must be ensured by standards that meet the criteria and requirements.
- Technological providers could include standards in the form of connectivity schemas and data structures with embedded coding systems like GS1 reference numbers, making it easy for the user to engage with other modules. Even the backbone of ICT infrastructures could be based on a common platform designed to be able to connect with other modules in an open and trusted way.
- Standards must overcome old, inflexible processes or even stand-alone systems' models. In addition, they should be adopted before they become mandatory in order to allow sufficient time for adaptation.
- Adoption and acceptance of standards by industry leaders will act as a catalyst for further industry usage for both vertical and horizontal collaborations.

7 FOR-FREIGHT Potential Integration Points

This chapter establishes an initial definition of each of the trial sites considering all the lessons learnt from the current analysis performed in this deliverable, a first approach that will lead to a more detailed and in-depth description through deliverable D1.2 *FOR-FREIGHT multimodal transport Use Case definition*.

Nevertheless, the main objective of Chapter 7 is to explain how the SotA of the T&L sector has been related to the different pains and gains identified among the partners, establishing the technologies, legacy systems that could be available and interested in being used among all those analysed in order to cover the potential solutions that FOR-FREIGHT will offer.

Through these potential integration points, it is expected to bring significant improvements that can satisfy the needs through this initial approach to the FOR-FREIGHT solution, giving an overview of all the aspects that have been analysed throughout the deliverable while providing the connections and links between the different points and being able to establish a first overview of how the different use cases are going to be defined.

This link between the solution and the localised problems in the SotA reinforces and strengthens the added value that this FOR-FREIGHT project resulting solution will be able to offer to the T&L sector, having the potential to provide solutions along the lines of improving operational efficiency, digitalisation and adoption of new business models in the T&L field.

This chapter also seeks to identify the common points between project partners, establishing a communication network between the different stakeholders, keeping them informed and involved in the development and implementation process of the FOR-FREIGHT use cases and being able to locate among the SotA analysis what solutions they are looking for and with which partners they can collaborate in that direction.

7.1 Spanish Trial Site

The Spanish trial site combines Sea Port-road (truck) and subway (last-mile). Its main goal is to aggregate information form individual management systems and use of resources involved in the supply chain process to a DSS. As a result, end-to-end multi-modal transport planning optimization from ship to port, to central warehouse, to last-mile will be achieved. For this optimization, the use of smart contracts will be incorporated and IoT devices (supported by 5G) will track each container (ITU) based on Galileo/EGNOS GNSS along the complete transport process. Two scenarios are defined within the Spanish UC:

1) Activities carried out in Valencia Port in connection with the warehouse (DHL). Containers will be unloaded from the vessel and loaded either on a truck or on train plus truck for DHL's warehouse destination. Truck or train plus truck legs to DHL's warehouse are managed by CSLS. The goal of this scenario is to optimize the connection vessel/truck or train of containerized import traffics managed by CSLS by improving port operations and transport to DHL facilities. Blockchain and Digital Twins will be developed to simulate optimal situations by using historical data to demonstrate real-time data exchange that support the DSS. This will improve the efficiency between the Port of Valencia and its connection with the terrestrial side.
2) Activities carried out from the warehouse to final customer (last-mile distribution). This scenario will use the existing Metro de Madrid network to prove that a reduced emissions (>80% less) and transport costs (>12% less) are possible compared to current urban vehicle distribution mode.

So far, the key refinements compared to the Grant Agreement definition of this UC refer to the use of historical data to build the platform and the specific definition of that data (e.g. vessels schedules and latest updates on time of arrival, resources for unloading containers, destination of containers, truck/train assignation, etc.).

To link the identified pains of the Spanish trial site with the potential solutions, Table 7-1 summarises and connects the previous chapters of this deliverable, providing, as a result, the first recommendations for improving the processes and operations of the Spanish actors involved in this trial site.

Table 7-1: Spanish Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential solution	End-users	Technical partners
Information silos across different domains	- Delays in original documentation/paper-based documents (**ALL**). - Access to external systems and data streams owned by Port Community stakeholders (**FVP**). - Interconnecting networks and transport modes (**MDM**).	Bird's eye view of the end-to-end multi-modal transport process based on integrated information from multiple related platforms.	**AI/ML**	DSS on use of resources and end-to-end multimodal transport planning optimization.	**CSLS interested in**.	**IMEC -** Simulation, **AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport** **FVP - AI-based algorithms for maritime and terrestrial routing**
				DSS for the optimization of resource utilization and E2E multimodal transport planning.	**DHL interested in; MDM potential beneficiary.**	**IMEC -** Simulation, **AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport**
			Blockchain	Blockchain for time reduction in administrative and operational processes.	**DHL and MDM interested in.**	**FVP and CSLS** - Supply chain governance based on Blockchain technology: **provided by a Hyperledger Fabric blockchain platform.**
Lack of standardisation	- Lack of uniformity in standards for interoperability between different logistics actors (**ALL**). - Data governance/data security as information along a multimodal transport is shared between diverse actors (customer, consumer, logistics company, metro, maritime company (**ALL**).	- Improve data flow between T&L stakeholders by common standarisation criteria, increasing the interoperrablility among the different utilised systems and enhacing multimodal transport. - Regulated access to different levels of information based on each user's access rights.	**Blockchain**	Blockchain for time reduction in administrative and operational processes.	**DHL and MDM interested in.**	**FVP and CSLS** - Supply chain governance based on Blockchain technology: **provided by a Hyperledger Fabric blockchain platform.**

	- Lack of common vocabulary/terminology between different transport modes (ships, truck, subway, etc) (**ALL**). - No interaction between (legacy or other) systems (planning, routing, business, traffic systems) between different companies from different sectors (ships, truck, subway, etc) (**ALL**). - Very limited interoperability among the involved stakeholders leading to delays and time-wastes and non-automated transfer of goods (**CSLS**).					
Low digitalisation / automation of processes	- Lack of well-established infrastructures in the case of a new business model that need to be implemented (i.e., lockers in metro stations, cages for metro wagons, etc) (**ALL**). - Technical feasibility of the proposed solution and technical difficulty in implementing the solution in certain stations (**MDM**). - To ensure the safety chain of the transported goods (**MDM**). - Lack of infrastructure foundation (**MDM**). - Digitalisation trends (**MDM**). - Multiple manual tasks leading to intensive manual labour and increased probability of errors (**CSLS**). - Absence of track and trace system on real-time for cargo visibility (**CSLS**). - High emissions related to the conventional transport modes (trucks) (**CSLS**). - Solutions for KPI calculation and monitoring (**CSLS**).	- Door-to-door tracking of the entire process and full awareness of the cargo's location, status and current custodian. - Automated processes, reducing errors and guaranteeing up-to-date information (Blockchain/smart contracts).	**IoT**	IoT sensors for real time tracking.	**CSLS interested in.**	Technical partners still need to confirm IoT availability.
			Blockchain	Blockchain for time reduction in administrative and operational processes.	**DHL and MDM interested in.**	**FVP and CSLS** - Supply chain governance based on Blockchain technology: **provided by a Hyperledger Fabric blockchain platform.**
			AI/ML	Traffic analytics and dynamic vehicle routing models.	**DHL and MDM interested in.**	**CERTH - ML models for demand and lead time forecasting.**
				DSS on use of resources and end-to-end multimodal transport planning optimization.	**CSLS and DHL potential beneficiaries.**	**FVP - AI-based algorithms for maritime and terrestrial routing**

Suboptimal resource planning of the processes	- Lack of visibility of the goods along the supply chain process (**ALL**). - Longer delivery times based on non-real time information (**ALL**). - Congestions in cities due to growth of the e-commerce (**DHL**). - Congestions in ports/hubs and lack of visibility (**CSLS**). - Sub-optimal planning of resources (e.g., human resource, HW, vehicles, equipment, human labour) (**DHL**). - No simulation of potential scenarios/situations applied along the supply chain process supporting decision-making process (**CSLS**).	- Door-to-door tracking of the entire process and full awareness of the cargo's location, status and current custodian. - Improved decision-making process and inefficiencies reduction (Digital Twins) for optimization of transport routes based on multiple real-time and historical factors. - Sustainable process management and reduced GHG emissions based on transport optimization and time-wastes reduction. - Innovative transport mode (subway) to execute the last mile delivery decreasing traffic congestions and emissions and increasing safety and speed. Distribution with vans/small trucks in urban areas will be switched by existing subway network.	**AI/ML**	DSS on use of resources and end-to-end multimodal transport planning optimization, providing real-time door-to-door tracking, forecast of optimal routing and ETA for the entire process.	**CSLS, DHL, MDM interested in**.	**IMEC -** Simulation, **AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport** **FVP - AI-based algorithms for maritime and terrestrial routing**
				DSS for the optimization of resource utilization and E2E multimodal transport planning.	**DHL interested in; MDM potential beneficiary.**	**IMEC -** Simulation, **AI-based prediction and Optimization algorithms for route planning optimization of multi-modal freight transport**
			Digital Twin	Digital Twin application for DSS.	**CSLS, DHL, MDM interested in.**	Technical partners still need to confirm Digital Twins availability.
			IoT	IoT sensors for real time tracking.	**CSLS interested in; DHL potential beneficiary.**	Technical partners still need to confirm IoT availability.
				Robotics for container loading/unloading.	**MDM interested in.**	Technical partners still need to confirm Robotics availability.
			5G	5G based solution for enhacing safety and road transport efficiency (fuel consumption and travel times).	**DHL potential beneficiary.**	**ABS - C-ITS Platform and C-V2X test network** .

7.2 Romanian Trial Site

The Romanian trial site combines river Port and rail transport. The target is to combine information from all individual management systems to allow access to fluent and accessible information on transport flow. For this, state-of-the-art IoT and data processing solutions (e.g., 5G, Internet of Containers) will be used.

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

Table 7-2 summarises and connects the previous chapters and findings of this deliverable in order to draw the initial conclusions that will feed into the D1.2.

Table 7-2: Romanian Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential Solution	End-users	Technical partners
Information silos across different domains	- The transfer of goods from seagoing vessels to railways is not a continuous, logically integrated process, but a fragmented one (**ALL**). - Delays in original documentation/paper-based documents (**ALL**). - The transfer between river vessels and railways is ordered by the beneficiaries of the goods (**ALL**). - Lack of data transfer between stakeholders (**ALL**).	Full view of the end-to-end process to users, including real-time door-to-door tracking information.	**Digital Twins**	Digital Twins solution for Galati port.	**NAVROM, TcCFR, Port Galati**	Technical partners still need to confirm Digital Twins availability.
			Blockchain	Supply chain governance based on Blockchain technology.	**NAVROM, TcCFR, Port Galati**	Technical partners still need to confirm Blockchain availability.
Lack of standardisation	- Lack of uniformity in standards (**ALL**). - Lack of common vocabulary/terminology (**ALL**). - No interaction between legacy (or other) systems related with planning, routing, business, traffic, etc. (**ALL**). - Aspects regarding data governance and data security (**ALL**).	Providing functionalities for efficient multimodal logistics, ensuring compatibility with existing and emerging EU logistics standards, including 3rd party applications.	**Blockchain**	Supply chain governance based on Blockchain technology.	**NAVROM, TcCFR, Port Galati**	Technical partners still need to confirm Blockchain availability.
Low digitalisation / automation of processes	- Intensive manual labour is still needed for transshipment which results in inefficient use of resources (**ALL**). - Low digitalization and historical data available, so there is no real-time common operational picture possible (**ALL**). - Lack of investments in new technologies (i.e., no possibility of tracking goods in real time) (**TCCFR**).	- Provide an accurate real-time position of the cargo / container, and provide complete remote monitoring capabilities for logistics operators and users. - Automatic ETA update of the ship in the port of Galati, based on historical and real-time tracking data.	**IoT**	IoT sensors for tracking.	**NAVROM, TcCFR, Port Galati**	**BEIA - IoT sensors and video cameras.**
			5G	4G/5G network coverage.	**NAVROM**	**TCCFR - 5G commercial coverage.**
			AI/ML	AI/ML solutions for Galati port.	**NAVROM, TcCFR**	**CERTH - ML models for demand and lead time forecasting.**

Suboptimal resource planning of the processes	- Congestions in ports/hubs and lack of visibility due to the non-synchronizations between unloading/loading and handling activities with significant loss of time and uneconomical use of resources (**ALL**). - Congestions in cities due to the military conflict at the Ucranian border (**ALL**).	- Reduced GHG emissions based on carbon footprint analysis. - Automatic reservation to railway companies, using a unique cargo ID, based on precise ETA. - Suggestions from the decision support system (DSS) to the port authorities, the logistics operator and the customs agencies, regarding the necessary resources to be reserved (staff, vehicles, etc.), depending on the size of the goods, the type and the exact ETA. - Notification and advice from DSS to rail freight operators on the required storage space and resources to be available at the exact time of arrival of the goods.	**AI/ML**	AI/ML solutions for Galati port.	Port Galati	**CERTH - ML models for demand and lead time forecasting.**

7.3 Greek Trial Site

The Greek Trial Site combines Sea Port, Airport (air-freight) and road transport (truck) for an end-to-end optimization with DSS and real-time monitoring and control capabilities. The target is to create a solution that integrates 1) information form the legacy individual management systems of all involved stakeholders, the field equipment and devices of their personnel and additional information with 2) intelligence provided by newly deployed sensors, devices and Machine Learning and data analytics functions. Historical data will be used as well as real-time data to build the platform and achieve the automation of the processes that are now executed manually.

The demo scenario comprises a container loaded in Ukraine heading to Piraeus. All information will be automatically updated in the FOR-FREIGHT platform, allowing monitoring the cargo and arranging further steps of the process such as automatic reservation of air-freight ticket, advice on resources allocation at port terminal or storage location at the airport cargo handler.

At the time of submission of this deliverable the key refinements compared to the Grant Agreement definition of this UC refer to the live update of the entire process based on port, road and air traffic data fed directly into FOR-FREIGHT platform. This will always allow to provide the most accurate ETA for all intermediate points (port, custom, airport storage, airplane loading).

As in the previous cases, in order to connect the problems identified in the Greek test site with possible solutions, Table 7-3 summarises and relates the previous chapters of this deliverable, drawing also the initial conclusions that will serve as a basis for D1.2 and the whole project.

Table 7-3: Greek Trial Site Potential Integration Points

Pain Category	Pains	Expected improvements	Technology	Potential solution	End-user	Technical partners
Information silos across different domains	- Keeping up with the information flow: No a-priori knowledge on what type of container arrives at the port, when, at what quantity, and ETA at the airport warehouses **(ALL)**. - Delays in original documentation/paper-based documents (**ALL**). - No interaction intra-domain and inter-domain between various systems (Customs, airlines, forwarders, airport) Interconnecting networks and transport modes (**ALL**).	Full view of the end-to-end process towards users including the cargo's real-time location, status (temperature, humidity, vibrations, luminosity, etc.).	**IoT**	IoT sensors for real-time and status tracking.	**GOLD, COEL, AIA potential beneficiaries.**	**AIA - Building Management Systems** – SCADA. **WINGS - WINGS Chariot** and **WINGSPARK**. **GOLD, CERTH and WINGS - Temperature and Monitoring Sensors.**
			5G	4G/5G network coverage .	**GOLD, COEL, AIA potential beneficiaries.**	**AIA - WiFi and 4G** commercial coverage (only Wifi needed). **WINGS - 4G and 5G** commercial coverage.
Lack of standardisation	- Lack of uniformity in standards for interoperability between different logistics actors (**ALL**). - Non-standardized processes (**ALL**).	- Improve data flow between T&L stakeholders by common standarisation criteria, increasing the interoperrablility among the different utilised systems and enhacing multimodal transport. - Different levels of access to information for different platform users based on their level of authorization/clearance.	**Big Data & Cloud Computing**	Platform for monitoring different datasets related to warehouses' status, arrivals prediction, truck/vessel/cargo position and cargo status/condition	**GOLD, COEL, AIA potential beneficiaries.**	**WINGS - WINGS Chariot** and **WINGSPARK**.
				Seamless data exchange and auhtorizsation tool for certifying service providers and users.	**GOLD, COEL, AIA potential beneficiaries.**	**CERTH - FENIX Connector attached to the Greek Transport & Logistics Observatory**.
				Cloud solution for matching the supply and demand of storage space for logistics service providers and users.	**GOLD, COEL, AIA potential beneficiaries.**	**CERTH - Virtual Freight Center**.

Low digitalisation / automation of processes	- Delays during Customs clearance processes (**ALL**). - Lack of shipment visibility and difficulties for real time data (**COEL**). - Communication between stakeholders mainly via phone and e-mail (**COEL**). - Delays in original documentation/paper-based documents (**ALL**). - No interaction between various systems (Customs, airlines, forwarders, airport) interconnecting networks and transport modes (**AIA, GOLD**). - Keeping up with the information flow (**GOLD**).	- Tracking of a specific container/ITU onboard a ship heading for Piraeus Port, using a unique Identification code/ Bill of Lading number (ID). - Automated update of tuck's and ship's ETA at the port of Piraeus based on historical and real-time door-to-door tracking data (available to all stakeholders, via commonly agreed APIs).	**IoT**	IoT sensors for real-time tracking.	**GOLD, COEL, AIA potential beneficiaries.**	**CERTH and WINGS - Monitoring Sensors.**
			5G	4G/5G Network coverage for real-time updates.	**GOLD, COEL, AIA potential beneficiaries.**	**AIA - WiFi and 5G 4G** commercial coverage (only Wifi needed). **WINGS - 4G and 5G** commercial coverage.
			AI/ML	Traffic analytics and dynamic vehicle routing models.	**GOLD and COEL potential beneficiaries.**	**CERTH - ML models for demand and lead time forecasting**.
				DSSs on logistics operators concerning space necessary, cargo arrival forecasting and optimized resource allocation and routing.	**GOLD and COEL potential beneficiaries.**	**WINGS - WINGS Chariot.**
			Big Data & Cloud Computing	Databases and the monitoring different data sets related with containers, arrival predictions of truck and ships amd forecasting.	**GOLD, COEL, AIA potential beneficiaries.**	**WINGS - WINGS Chariot.**
Suboptimal resource planning of the processes	- Unpreparedness when a container arrives at the airport due to lack of freight monitoring data (e.g. ETA at the airport). **(ALL)** - Lack of uniformity in standards for interoperability between different logistics actors (**ALL**). - Non-standardized processes (**ALL**).	- Advice from the Decision Support System (DSS) towards the port and airport authorities and customs agencies, regarding the necessary resources to be reserved (personnel, vehicles, etc.), based on the cargo size, type and accurate ETA. - Advice from the DSS to the logistics operator regarding the resources to be reserved for the unloading,	**AI/ML**	Traffic analytics and dynamic vehicle routing models.	**GOLD, COEL, AIA potential beneficiaries.**	**CERTH - ML models for demand and lead time forecasting**.

		reloading and transport of the cargo from the port to the AIA. - Automated booking of airline reservation using a unique cargo ID, based on accurate ETA. - Notification and advice from the DSS to the airport cargo handlers regarding the necessary storage space, and resource to be available at the exact arrival time of the cargo.		DSSs on logistics operators concerning space necessary, cargo arrival forecasting and optimized resource allocation and routing.	**AIA, COEL potential beneficiaries.**	**WINGS – Wings Chariot**

8 Conclusions

In the shape of SotA report, this deliverable defines the project framework and the potential role of different partners, mapping out the existing business models, legacy systems and technologies to identify potential integration points for the FOR-FREIGHT platform.

This SotA analysis of the T&L sector covered each of the aforementioned fields in-depth towards a proper definition of the current SotA, detailing business and operational models not only in the T&L sector but also among all FOR-FREIGHT T&L stakeholders. Following these tendencies, a wide range of technologies was detailed, focusing on cutting-edge technologies such as 5G, IoT sensorisation, blockchain, digital twins or AI/ML algorithms, mapping them to the current stakeholders framework. To bring this SotA to a closure, the standards that are currently used in operations or have potential relevance were also mapped.

As a result of this analysis, the relationship between the pains and gains identified by the FOR-FREIGHT partners and recommendations for further improvements towards FOR-FREIGHT implementation in the different trial sites was established.

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

These problems and concerns together with the existing solutions gave a first definition of how the project's outcomes can meet specific pains and gaps identified for the different T&L stakeholders involved in the project, for example, providing access to real-time data, enabling the interaction with external systems, automatise procedures or improve coordination and collaboration between the different stakeholders in the supply chain and, therefore, operational efficiency and sustainability.

Overall, the added value of D1.1 is that it provides a comprehensive analysis of the T&L sector, identifies areas for improvement and a basis for the final definition of the FOR-FREIGHT use cases, helping to ensure that the project is focused on addressing the most pressing needs of the T&L sector, providing maximum value to stakeholders involved in the project, and serving as an input for the work to be performed in Task 1.2. Additionally, the document also reflects the potential added value of FOR-FREIGHT solution, influencing the work to be done in Tasks 1.3 and 1.4, where the testing and validation methodology and FOR-FREIGHT architecture solution is expected to be defined.

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Annex I: Stakeholders' Templates

T&L Business and Operational Models template

T&L Business and Operational Models		
<Partners Name>		
Type	**Description**	**Additional notes**
Actor type in the T&L value chain (some stakeholders could play multiple roles/groups)		
Key Partners (network of suppliers and partners that make the business model work)		
Stakeholder's Key Activities		
Stakeholder's Value Proposition		
Customer Relationships		
Customer Segments		
Key Resources		
Revenue Streams		
Critical challenges, concerns and needs the stakeholder faces		
Key Role in FOR-FREIGHT		
Expected benefits from FOR-FREIGHT		

Technology template

Technology										
<Partners Name>										
Type	**Use Cases /Applications**	**AS-IS (description of current situation)**	**Existing Assets**	**Degree of maturity (Theoretical Demonstration, PoC, Implemented Small, Medium or Large Scale)**	**Availability in FOR-FREIGHT (Y/N)**	**TO BE (expected development in the project, ONLY if available)**	**Inputs required from other partners (ONLY if available)**	**Related WP (ONLY if available)**	**Relation with other projects**	**Trial Site (ONLY if available)**

Legacy Systems template

Legacy Systems													
<Partner's Name>													
System Name	**System Type**	**Description**	**Architecture**	**Technology**	**Protocols/ Formats/ Standards**	**Exchanged information, Inputs and Outputs**	**Openness and Interoperability**	**Limitations and Potential Risks**	**End user**	**Availability in FOR-FREIGHT (Y/N)**	**Conditions of Use (ONLY if available)**	**Expected Development (ONLY if available)**	**Trial Sites (ONLY if available)**

Standardisation template

Standardisation					
<Partners Name>					
Standard	**Framework (Scope)**	**Supply Chain Segment**	**Description**	**Limitations or Gaps**	**FOR-FREIGHT Domain Application**

Annex II: Pains and Gains Templates

T&L Business and Operational Models Pains

Pain Category	Pains
Information silos across different domains	
Lack of standardisation	
Low digitalisation / automation of processes	
Suboptimal resource planning of the processes	
Rules, policies, and regulatory instruments	
Fiscal instruments and incentives, investment, and funding	

T&L Business and Operational Models Gains

Gain Category	Gains
Operational Efficiency	
Digitalisation	
Operational sustainability and environmental impact	
Governance and network	
Adaptation of/Transition to new lines of business (models) or deployment of new commercial solutions	

Technology Pains and Gains

Technology	Partners	Pains	Gains
XXX	A, B, C		
	B, D		
	A		

Legacy systems Pains and Gains

Partner	Legacy Systems	Pains	Gains
A	XXX		
	YYY		
	ZZZ		

Standardisation Pains and Gains

Data Standards	Partners	Pains	Gains
XXX	A, B, C		