



Flexible, multi-mOdal and Robust FREIGHt Transport

D5.5 Report on standardisation activities

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Glossary of terms and abbreviations

Abbreviation / Term	Description
AC	Accept
AD	Application Documents
AE	Aligned Elements
AIA	Athens International Airport
ANSI	American National Standards Institute
API	Application Programming Interface
AT	Actual Time
ATC	Actual Time of Completion
ATS	Actual Time Start
B/L / eBL	Bill of Lading / Electronic Bill of Lading
BP	Pilot's Bulletin
CAB	Conformity Assessment Body
CATOS	Computer Automated Terminal Operating System
CEERIS	Central & Eastern European Reporting Information System
CCS	Cargo Community System
CHE	Cargo Handling Equipment

CMR	Convention relative au Contrat de Transport International de Marchandises par Route
COGA	Customs and Other Government Agencies
DCSA	Digital Container Shipping Association
DTLF	Digital Transport and Logistics Forum
DTTF	Digital Transport & Trade Facilitation
D	Deliverable
e-AWB	e-Airwaybill
EDI	Electronic Data Interchange
EDIFACT (UN/EDIFACT)	Electronic Data Interchange for Administration, Commerce and Transport of the United Nations
eFTI	Electronic Freight Transport Information
EMSWe	European Maritime Single Window environment
EOSP	End Of Sea Passage
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
EU	European Union
IMO FAL	Facilitation Committee of the International Maritime Organisation and its associated Convention on Facilitation of International Maritime Traffic
FCL	Full Container Load
FEPOR	Federation of European Private Port Operators
FFW	Freight Forwarder
GA	Grant Agreement
HPCS	Hellenic Port Community System
HTTP/HTTPS	Hypertext Transfer Protocol/Hypertext Transfer Protocol Secure
HW	Hardware
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICT	Information and Communications Technology
IHO	International Hydrographic Organization

IHO GI registry	International Hydrographic Organization Geospatial Information registry
IPCOTF/ITPCO	International Port Call Optimisation Task Force/International Taskforce Port Call Optimisation
IoT	Internet of Things
IMO	International Maritime Organisation
IMO SIP	IMO Strategy Implementation Plan
ISO	International Organisation for Standardization
IT	Information Technology(ies)
JSON	JavaScript Object Notation
KPI(s)	Key Performance Indicator(s)
LCL	Less than Container Load
MQ	IBM MQ Series
MQTT	MQ Telemetry Transfer
MSW	Maritime Single Window
NMEA 0183	National Marine Electronics Association Electrical and Data Specification number 0183
OT	Operational Technology
OVS	Operational Vessel Schedules
PAULA	Platform for Automatically Linking Agents
PBP	Pilot Boarding Place
PCDC	Piraeus Consolidation and Distribution Centre
PCT	Piraeus Container Terminal
PCS	Port Community System
PEMA	Port Equipment Manufacturers Association
PIN	Personal Identification Number
PortCDM	Port Collaborative Decision Making System
PTA	Planned Time of Arrival

PTC	Planned Time of Completion
PTD	Planned Time of Departure
PTS	Planned Time Start
REST	Representational State Transfer
RTS	Requested Time Start
SDO	Standards Development Organisation
SMDG	Ship Message Design Group
SOAP	Simple Object Access Protocol
SOLAS	Safety of Life at Sea
SOSP	Start Of Sea Passage
SW	Software
T&L	Transportation and Logistics
TCP/IP	Transmission Control Protocol/Internet Protocol
TIACA	The International Air Cargo Association
TIC4.0	Terminal Industry Committee 4.0
TOS	Terminal Operating System
UDP	User Datagram Protocol
UN	United Nations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UNECE	United Nations Economic Commission for Europe
UN ECOSOC	United Nations Economic and Social Council
VSA	Vessel Sharing Agreement
WCO	World Customs Organisation
WMS	Warehouse Management System
XML	eXtensible Markup Language

1 Executive Summary

The world of transportation and logistics has varying degrees of standardisation in the digital field, even registering significant differences between transportation modes and locations. With the advent of telecommunications and Information Technologies (IT), multiple standardisation initiatives were started to improve competitiveness, track and trace and collect useful data on the transportation process. Later on, international standards such as Electronic Data Interchange for Administration, Commerce and Transport of the United Nations (EDIFACT) were created to harmonise international trade documents. While some efforts have been made by the administrations and international institutions, especially concerning administrative processes like customs or documentation, process modelling still lags behind. Furthermore, digitalisation efforts are mainly products of local initiatives and thus are designed with local needs in mind: for example, Port Community Systems (PCS) are promoted by port authorities to communicate with the local logistics community. In addition, each transportation mode normally has its own initiative. Consequently, a “patchwork” of systems coexists nowadays. Since they are often not interoperable, this acts as a hurdle for the adoption of harmonized systems and solutions.

To circumvent this, supranational institutions, standardisation bodies, and industrial associations have been promoting the development of standards and the creation of expert groups that oversee them. At the worldwide level, the United Nations’ United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and International Air Transport Association (IATA), which are responsible for the EDIFACT and CargoXML standards, among others, are successful examples. Meanwhile, the European institutions have endorsed the formation of expert groups such as the Digital Transport and Logistics Forum (DTLF) and enacted regulations such as the European Maritime Single Window environment (EMSWe). From the industry’s side, sectorial organisations have been formed covering diverse aspects and steps of the logistics chain: for example, in the maritime sector: TIC4.0 in the terminal industry, Digital Container Shipping Association (DCSA) from the container transport’s side, International Association of Maritime Aids to Navigation and Lighthouse Authorities (IALA) S-211 for the port call, and so on. However, as mentioned before, these usually work independently from each other, which makes interoperability a challenge. A summary and analysis of these have been incorporated into this document to provide a complete overview of them.

From the FOR-FREIGHT project’s perspective, the presence of three Use Cases (UCs) at different Member States where multiple transport modes are involved and with multiple degrees of digitalisation serves as an excellent opportunity to assess the status of standardisation. After the initial analysis and cross-check of other FOR-FREIGHT databases of standards, a deep review of the systems used by all use cases was performed. The findings are in line with the preliminary analysis, showing that digitalisation varies greatly depending on the location, transportation mode, and intermodal levels. Three UCs where a port using PCS is present have a clear advantage, since using these software suites usually drive forward the adoption of digital solutions in the rest of the supply chain, as both Valenciaport and Piraeus show. However, these initiatives can meet resistance and reluctance of other port actors and have barriers to entry due to the financial and technical cost of digitalisation and scepticism of its benefits. Once leaving the port area, difficulties arise from the fact that the various legacy systems of hinterland actors are often not interoperable, even still rely on paper documents, phone calls, and e-mails for communications in some areas. Lastly the Spanish use case adds the novelty of using the Metro de Madrid network for the transportation of goods, thereby requiring new developments to embed tracking and tracing and cargo information into the previous systems.

Due to its universality and openness to embrace other transportation modes, the Terminal Industry Committee (TIC4.0) organisation could play a central role in developing common standards for hinterland processes. Its semantics, which have already been proven in real-world applications at port terminals, are flexible enough to be adapted to the realities and needs of other transportation modes. The FOR-FREIGHT project will serve as a testbed for the feasibility of the adaptation of TIC4.0’s data model. Moreover, the gap analysis has shown that the standardisation needs could be addressed or overcome using uniform data models. On the plus side, TIC4.0 is compatible with established data presentation models such as JavaScript Object Notation (JSON), MQ

Telemetry Transfer (MQTT), or eXtensible Markup Language (XML), which are used by legacy systems and other organisations.

To build upon FOR-FREIGHT and other projects and initiatives' results, policy recommendations and a recommendation on standardisation road mapping have been defined to achieve maximum success in disseminating the results and potential, while establishing coordinated actions for collaboration. Taking advantage of the favourable momentum that exists today in digitalisation matters, institutions, Standards Development Organisations (SDOs) and industry should aim for the creation of common discussion spaces where new standards are developed considering all points of view. Thereby, a favourable environment for the development of "interoperable-from-design" solutions would be achieved. Actions for this could be organised via workshops, formal committees and other instruments where all stakeholders could take part. Parallel to this, governments and regulators should be regularly informed to encourage its transformation into formal laws and requirements once the standards are mature enough. It should be noted, however, that the low degree of digitalisation of the logistics industry, coupled with the atomisation and financial weakness of some agents such as self-employed drivers, call for the use of European or national funding programs to foster it. This is especially true for laggard Member States or logistics chain agents. Otherwise, the risk of low market acceptance and uptake remains high, given that many organisations still rely on traditional means of communication (paper, phone, e-mail) for some processes.

In conclusion, the standardisation of the digitalisation of the logistics sector, while experiencing a good momentum, should be coordinated by higher instances and other means to achieve common ground for interoperability and harmonisation. Institutions and building upon initiatives such as the DTLF, EMSWe and Electronic Freight Transport Information (eFTI), coupled with the standards made by international SDOs and industry associations, shall take the opportunity to build upon this and contribute to the creation of a better, interoperable, connected transport. This Deliverable D5.5 "Report on standardisation activities" (D5.5 from this point onwards) emphasises on the opportunities that this ecosystem may bring for the entire transportation sector, starting with the international initiatives and a state-of-the-art description, continuing with the analysis of the Use Cases and concluding with a full set of conclusions and policy recommendations. The revised version of D5.5, D5.6 "Report on standardisation activities (Revised version)", which is due on FOR-FREIGHT's Month 38, will include a revision based on both the progress made by external institutions and the progress made by the project FOR-FREIGHT itself. It is expected that a more mature version of the Solvers and the Use Cases will be available by the conclusion of D5.6, further enriching the findings of this Deliverable.

2 Introduction

This report, Deliverable (D) D5.5 “Report on standardisation activities” presents an analysis of the worldwide standardisation environment, coupled with a complete gap analysis based on the FOR-FREIGHT project’s output. The document has been divided into three main sections, the first one dealing with state-of-the-art analysis, the second one is the full analysis of standardisation gaps at the Use Cases and the last one making policy and standardisation recommendations. The document fulfils the requirements of Task (T) 5.2, “Standardisation contributions & policy recommendations” of the Grant Agreement (GA). Since it is foreseen that the architecture of the FOR-FREIGHT’s solutions will be aligned with ongoing activities of multiple European and international key logistics standardisation bodies, an analysis on these has been performed in the document. Namely, Objective 5 of the project “To ensure compatibility with existing and emerging EU logistics standards as well as promote and contribute to the standardisation of multimodal, multi-stakeholder end-to-end freight management solutions and to ensure compatibility with existing EU/global standards, while advancing and supporting a T&L centered 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” is specially addressed with this document. The contributions here will be relevant for the development of revised version of the TIC4.0 Data Model and will be discussed with other stakeholders.

A revised version of this document D5.6 “Report on standardisation activities (revised version)” is expected for Month (M) 38 of the project. Consequently, the main findings of this document will be expanded with a further analysis of the advancements of the following months, together with the findings of the deployment of FOR-FREIGHT’s solvers.

2.1 Mapping FOR-FREIGHT Outputs

This section presents the FOR-FREIGHT ‘s 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			
D5.5 “Report on standardisation activities”	“Initial report on the standardization activities and policy recommendations, based on output of the project. It is the outcome of Task 5.2.”	Chapter 3 “Standardisation Landscape”, Chapter 4 “Use Case application of standards: the case of FOR-FREIGHT”, Chapter 5 “Development of roadmaps for standards development”	Analysis of the standardisation gaps based on FOR-FREIGHT’s Use Cases’ outcomes, current state of the art, and previous reports. Policy recommendations and conclusions section based on the external findings, own work and FOR-FREIGHT’s results (e.g., Use Cases, Solvers, legacy systems, previous experiences).

TASKS			
<p>T5.2 “Standardisation contributions & policy recommendations”</p>	<p>“Task 5.2 will be focused on establishing the appropriate link between FOR-FREIGHT and the main European and international standardisation groups on the transport and logistics fields. In this respect, FOR-FREIGHT is completely aligned as one of the project partners (Terminal Industry Committee 4.0, TIC4.0) is the international reference in port terminal operations and information exchange standardisation. TIC4.0 integrates most of the key players in the maritime port industry (global port container operators, port equipment manufacturers and port software developers). Moreover, FOR-FREIGHT will establish appropriate links with other reference groups like the Digital Transport and Logistics Forum (DTLF), the Digital Container Shipping Association (DCSA), the International Port Call Optimisation Task Force (IPCOTF) and GS1, among others. In this manner, FOR-FREIGHT guarantees that its development will be guided towards producing reusable, scalable and standardised solutions based on the guidelines and standards provided by these organisations.</p> <p>Aspects addressed by Task 5.2 will include ship-port data sharing harmonisation, cargo handling process standardisation at port terminals, including communication protocols and process harmonisation, port-hinterland communication exchange, involving intermodal transport and associated data formats. Moreover, Task 5.2 will address standardisation needs in the last-mile distribution leg taking into account logistic warehouse process and interaction with last-mile distribution channels. Task 5.2 will identify standardisation gaps during the Use Cases definition and development, thus contributing to fulfil existing needs among the involved stakeholders. Based on this work, FOR-FREIGHT will provide</p>	<p>Chapter 3 “Standardisation landscape”, Chapter 4 “Use Case application of standards: the case of FOR-FREIGHT”, Chapter 5 “Development of roadmaps for standards development”, Chapter 6 “Conclusions”</p>	<p>Analysis on current standardisation initiatives and mapping.</p> <p>Integration of TIC4.0’s standards and description on how these can help the FOR-FREIGHT project. Analysis of ship-port data sharing harmonisation, cargo handling process standardisation at port terminals including communication protocols and process harmonisation, port-hinterland communication exchange involving intermodal transport and associated data formats at all three Use Cases (Spain, Greece, Romania).</p> <p>Identification of standardisation gaps based on the Use Cases’ experience.</p> <p>Provision of standardisation and policy recommendations.</p>

	validated standardisation and policy recommendations in line with the abovementioned organisations' guidelines. Output: D5.5, D5.6.”		
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2.2 Linkage to other project outputs

The report on standardisation is a core part of the FOR-FREIGHT project because it details the various standards which can be of use during the course of the project to strengthen and promote interoperability across the involved transport media. In previous deliverables, the project partners already have described the standards they are using (see Table 2-2). While comprehensive, this list clearly shows the disparity between the digitalisation levels and standards used by the partners. It is expected that the standards and results described in this Report will flow into the solvers that are currently being developed as part of Work Package 2. Furthermore, the adoption of a common standard can be a driver for the further commercialisation and adoption of the FOR-FREIGHT solution (WP4). Lastly, the revised version of Deliverable D5.5, D5.6, will further expand and describe the progress made by both the consortium and external agents in the field of standardisation, further refining the results and helping to achieve a more mature solution for the FOR-FREIGHT platform.

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

WP Number	Task Number	Deliverable Number related	Content
WP1 “State of the Art analysis, Use Case Definition and Solution Design”	T1.1	D1.1	Standards used by the project organisations and its mapping. D1.1 contains a list of legacy systems and standards already in use by the project consortium partners. These have been incorporated into this document.
WP2 “FOR-FREIGHT solution implementation, Integration & testing”	T2.2	D2.1, D2.2, D2.3	Solvers and FOR-FREIGHT platform: FOR-FREIGHT’s solvers are designed to consider the current situation at the Use Cases. The software is connected to the legacy systems and will make use of the TIC4.0 standard for inputs and outputs.
WP4 “Commercialisation & Innovation	T4.3	D4.3, D4.5	Impact maximisation. Commercialisation and innovation activities will take into account the standardisation activities that exist across Europe and that are described in this document.
WP5 “Dissemination, Communication & capacity building”	T5.2	D5.6	Report on standardisation activities (revision) ¹ : A revised version of D5.5, D5.6, is due on Month 38. The document will build upon this report’s findings and conclusions while also taking into account the FOR-FREIGHT project’s conclusions.

¹ Due Month 38
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2.3 Deliverable Overview and Report Structure

This Deliverable has been structured as follows:

Chapter 2 (Introduction) provides an overview of the Deliverable, describing the situation, its structure, role in the FOR-FREIGHT project and mapping the outputs and results to other project's results.

Chapter 3 (Standardisation Landscape) is an analysis of the worldwide standardisation landscape has been performed with specific focus on transportation-related organisations of all transportation modes. Institutions, SDOs, industry associations, and other initiatives have been screened. A thorough analysis of the nature of the standards and their applications has been performed to assess its applicability and compatibility. Standards have been classified according to the transportation leg where they apply, namely ship-port, cargo handling, and port-hinterland for ports, air transport, and rail standards. The potential central role of TIC4.0 has been highlighted in the cargo handling chapter, showing its semantics and data model, and how it helps to harmonize processes.

Chapter 4 (Use Case Application of standards: the case of FOR-FREIGHT) is a full report on the standardisation gaps of FOR-FREIGHT's Use Cases (Spain ([Section 4.1](#)), Greece ([Section 4.2](#)) and Romania ([Section 4.3](#))) has been made with the contribution of the relevant partners. The main aim of this section is to reflect the reality of the logistics chain's digitalisation at the three locations and in the different transportation modes that are involved. A deep dive into the particularities of each sector showcases the gaps and strengths and is the basis of the analysis for the policy recommendations.

Chapters 5 (Development and Roadmaps for standards development) and 6 (Conclusions) focus on the policy and standardisation roadmap recommendations. Building upon the previous sections' analysis, they highlight the various available possibilities for cooperation that the current situation creates, hinting at its strengths and weaknesses while also highlighting both opportunities and possible hurdles standardisation and digitalisation initiatives could face. Finally, the report provides additional advice on how these could be fostered and overcome.

3 Standardisation landscape

The complexity of the supply chain has meant that efforts related to standardisation have not been properly coordinated. This reality has resulted in individual efforts whose objective is to promote standardisation within their field of activity. Back in 2011, the European Union already called for a “more efficient use of transport and infrastructure through the use of improved traffic management and information systems, advanced logistic and market measures such as the integration of markets and removal of distortions and restrictions” in its White Paper “Roadmap to a Single European transport area – Towards a competitive and resource efficient transport systems” [1]. Besides the obvious technological challenges arising from the fragmentation, diversity and lack of digitalisation of the supply chain systems and documents, public and private institutions and enterprises have to deal with the unique requirements and administrative processes of the globalised world. Despite the efforts made to achieve a common framework, especially in the latter topic, there is significant room for improvement in the monitorisation of processes and the way information is collected, processed, and exchanged.

As stated in FOR-FREIGHT D1.1 “Deliverable D1.1 "Report on Current Multimodal T&L Practices & Recommendations for Improvement" [2], “the Transportation and Logistics (T&L) sector comprises 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, business models, deployment trajectories, and incompatible systems that could not share data or intelligence in Information and Communications Technology (ICT)-driven ways. To identify the meaning this concept takes on in the project, legacy systems are defined as the existing HW (hardware)/SW (software) System/Application used by each project partner and that could later be used/integrated with the FOR-FREIGHT platform for the development of intermodal transportation use cases”.

In this way, a myriad of initiatives has taken up the task of resolving these issues, such as those that are presented in this chapter. These partially cover the activities related to the maritime sector, namely DCSA (Digital Container Shipping Association) and IPCOTF (International Port Call Optimisation Task Force), the container terminal sector (Terminal Industry Committee 4.0, TIC4.0), the logistics and transport sector (IPCOTF). Furthermore, other organisations that have developed standardisation activities with application in other fields of logistics and transportation means, especially those involved in our project (air and inland maritime transport) are described as well. Thanks to this extensive analysis, the deliverable will present the problems and challenges of the logistics chain from all points of view, identifying both possible overlaps and spaces where standards are far from being adopted.

3.1 Ship-Port Related Standards

The first phase of the processes within the established logistics chain in FOR-FREIGHT, for which it is important to know the existence of different standards harmonising processes, communications, and technologies, encompasses all activities related to the linkage between the vessel, ports, and terminals. In this regard, various organisations and initiatives are seeking to put forth different standards at both international and European levels. Through this review, the aim is to understand the functions of the involved organisations, in order to identify the nature of their activities and consequently determine if there are overlaps between organisations.

3.1.1 International Port Call Optimisation Task Force (IPCOTF)

The International Port Call Optimisation Task Force (IPCOTF)² is a non-affiliated, impartial coalition of maritime entities committed to minimising and streamlining the time vessels spend at ports. Comprising shipowners, ports, terminals, and ship agents, along with significant global maritime contributors. The primary objective is to enhance and, when possible, standardise the exchange of nautical, administrative, and operational data between ships and shore [3].

² <https://portcalloptimization.org/>
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This collective effort aims to enable all relevant stakeholders to efficiently facilitate a comprehensive port call for various cargo types, including containers, bulk, liquid bulk, general cargo, passengers, or crew. Through the pooling of resources and expertise, the goal is to optimise the vessel calling process worldwide, ensuring efficiency from the departure of a ship from its prior port of call to its arrival, completion of operations, and departure from the berth. Harmonising ship-shore data exchange and adopting uniform standards offer benefits to shipping, terminals, and port interests, leading to reduced emissions during transit and around ports, enhanced safety, compliance, a cleaner environment, and lowered costs for shipping lines, shippers, terminals, and ports.

The contribution of IPCOTF in this matter has been materialised in a “Guide for Nautical Data” [4] to showcase the collaborative efforts of Hydrographic Offices and Port Authorities in fulfilling their joint SOLAS (Safety of Life at Sea) responsibilities outlined in Chapter V Regulation.

Furthermore, the aforementioned document has played a key role in shaping the “Guidelines For Harmonized Communication And Electronic Exchange Of Operational Data For Port Calls” [5], a document crafted by the International Maritime Organisation (IMO). These guidelines aim to provide comprehensive guidance for the seamless implementation of electronic and automated exchange of operational data between ships and ports. In addition to facilitating this exchange, the guidelines include precise definitions of the various stakeholders involved in port and ship-related activities.

3.1.2 Digital Container Shipping Association (DCSA)

One of the strongest digitalisation organisations of the world, DCSA³, was established in 2019 by the shipping companies MSC⁴, Maersk⁵, CMA CGM⁶, Hapag-Lloyd⁷, ONE⁸, Evergreen⁹, Yang Ming¹⁰, HMM¹¹ and ZIM¹². According to the association, the goal of DCSA is to “establish IT standards that enable interoperability of technology solutions across the industry, facilitate digital interconnectivity and seamless data communications that anyone involved in the industry can leverage” [6]. Moreover, DCSA’s main aim is to achieve paperless international trade, starting with a secure, standardised Electronic Bill of Lading (eBL) by the year 2030.

As previously mentioned, DCSA originates within the container shipping sector, specifically addressing aspects related to ship logistics, encompassing both documentary and procedural elements. The standards developed by DCSA are designed to meet the requirements of logistics stages occurring in close proximity to the ship’s environment. They do not address processes or definitions related, for example to ports, unless there is a direct connection with the vessel, such as the Port-Ship interface. Apart from the eBL, DCSA currently has standards for the following processes, with varying degrees of maturity:

Establishing a standardised method for the booking process, applicable to both shippers and carriers, can bring mutual advantages. Beyond the evident operational efficiencies, a seamless digital procedure holds the potential to elevate transparency and compliance in the sphere of international trade. This, in turn, may lead to cost savings for shippers and consignees through reduced banking fees, while carriers stand to benefit from streamlined communication automation with downstream stakeholders like authorities and service providers.

³ <https://www.dcsa.org/>

⁴ <https://www.msc.com/es>

⁵ <https://www.maersk.com/>

⁶ <https://www.cma-cgm.com/>

⁷ <https://www.hapag-lloyd.com/es/home.html>

⁸ <https://www.one-line.com/en>

⁹ <https://www.evergreen-marine.com/>

¹⁰ <https://www.yangming.com/>

¹¹ <https://www.hmm21.com/company.do>

¹² <https://www.zim.com/>

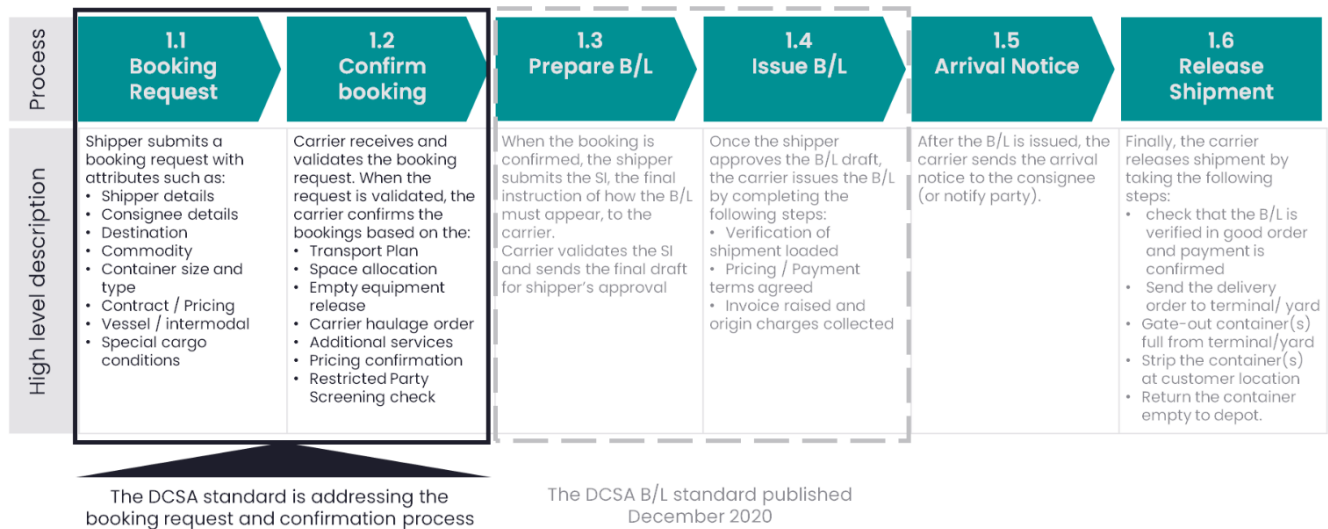


Figure 3-1: End-to-end documentation process – Booking. Source: [6]

The first publication related to booking processes includes digital standards and regulatory reforms. The objective is a comprehensive automation of documentation processes and the promotion of paperless trade in container transportation. It is also important to highlight that this first set of standards only focuses on the standard load, and in terms of the process stages, the “Reservation Request” stage, and the Reservation Confirmation stage. The following describes what is included:

- Achieving full digitisation of shipment documentation;
- Establishing regulatory acceptance of digitised documents;
- Implementing security standards to enable the digital transfer of title documents;
- Digitising supporting documents and certificates.

This publication reflects DCSA’s commitment to establishing standards for booking process data definitions and outlining an industry blueprint for requesting and confirming bookings. Aligned with DCSA’s ambition to digitally map the end-to-end standardised documentation process, the document encompasses:

- An overview of the end-to-end documentation process;
- Process maps for requesting and confirming bookings, including amendments;
- Details on mandatory, conditional, and optional booking process data fields;
- Definitions for booking process data fields, both semantic, and data-specific fields.

In addition, the DCSA standard for the booking process encompasses several supplementary documents, addressed separately:

- Updated Information Model (2022.1), incorporating all data entities and attributes related to booking requests and confirmations;
- Booking process interface standards 1.0;
- Booking process Application Programming Interface (API) specifications 1.0.

- **Cybersecurity**

In collaboration with its member carriers, DCSA has published the “DCSA Implementation Guide for Cyber Security on Vessels” [7] for the global container shipping industry. The guide aims to assist vessels in preparing

for the implementation of IMO Resolution MSC.428¹³(98) on Maritime Cyber Risk Management in Safety Management Systems, scheduled to come into effect in January 2021.

The DCSA guide outlines best practices, providing all shipping companies with a unified language and a practical, task-oriented approach to meet the IMO's implementation deadline in January 2021. The primary audience for this guide includes cyber security leads responsible for ensuring cyber security across vessel fleets. It is designed to complement existing ship Safety Management Systems (SMS) by offering additional guidance on cyber-related aspects, encompassing:

- IT such as computers, electronic manuals, networks, and applications;
 - Operational Technology (OT) including engine control, Electronic Chart Display and Information System (ECDIS), on-board measurement and control systems, Programmable Logic Controllers (PLCs), and remote support for engines.
- ***Electronic Bill of Lading***

This publication represents a pivotal first step in the journey toward digitising the Bill of Lading (B/L) within the realm of container shipping. Developed by the DCSA, this standard not only addresses the B/L, but also extends its reach to the Sea Waybill. This essay explores the comprehensive standards set forth by DCSA, encompassing both physical and digital channels in the preparation and issuance of the B/L. For a more detailed explanation, please check Figure 3-1 above.

The document includes definitions, references and guidelines to correctly prepare an eBL document, stating the standards and processes of the documentation process and providing a reference framework for the adoption of digital B/L documents by the industry:

- Scope of the Standard:
 - Definition of the B/L, including its digital counterpart, the eBL;
 - Uniform usage of the term B/L throughout the document;
- Processes of Preparing and Issuing the B/L:
 - Standards applicable regardless of the channel used, whether physical or digital;
 - In-depth examination of the Sea Waybill within the standard.
- Setting Standards for B/L Data Definitions:
 - Industry blueprint for preparing and issuing both physical and digital B/Ls;
 - Initial step in mapping an end-to-end, standardised documentation process for digitisation.

▪ ***Components of the Document***

- Overview of the end-to-end documentation process;
- Process maps related to the preparation and issuance of a B/L, including amendments;
- General definitions of terms related to the B/L;
- Overview of mandatory, conditional, and optional B/L data fields;
- B/L data field definitions, both semantic and data-specific, aligned with the United Nations Trade Facilitation and E-business Centre UN/CEFACT.

In conclusion, DCSA's standard for the Bill of Lading stands as a foundational document, paving the way for the digitisation of a critical component within container shipping. By establishing comprehensive standards for both physical and digital channels, DCSA aims to streamline processes, enhance industry efficiency, and set the stage for further advancements in standardised documentation.

¹³ "MSC" stands here for "Maritime Cyber Risk"
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In addition to the above, the DCSA standard for the B/L includes the following technical elements, each addressed in separate documentation:

- Updated Information Model (2022.1), containing all data entities and attributes pertinent to preparing and issuing a B/L.:
- B/L Interface Standards 2.0;
- B/L API Specifications 2.0.

This multi-faceted approach ensures a holistic and well-rounded standard that addresses the intricacies of both traditional and digital channels within the container shipping industry.

- ***Internet of Things (IoT) events***

DCSA and its member carriers have released IoT events standards with the objective of enhancing end-to-end cargo visibility within the global container shipping industry. The standards are designed to facilitate industry-wide standardised data sharing pertaining to the tracking and tracing of containers equipped with IoT devices, including “smart containers”. This establishes the groundwork for an interoperable framework of cargo visibility solutions.

By implementing these standards, carriers and participants in the supply chain move one step closer to furnishing customers with a continuous flow of pertinent information regarding the location of containers and the status of their contents at any given point during the container journey. This can be seamlessly achieved using the IoT Events 1.0 Beta API either as a standalone solution, or in conjunction with DCSA’s Track & Trace 3.0 Beta and Reefer Events 1.0 Beta 1 APIs.

- ***IoT – Gateway Connectivity Interface***

The goal of the IoT – Gateway Connectivity Interface is to promote efficiency, transparency, and innovation in global trade through smart containers that leverage IoT connectivity standards. Interoperable solutions for smart containers aim to furnish relevant information on container status and whereabouts to customers and operational teams of carriers worldwide, whether at sea or on land.

As to what concerns the container shipping industry, the concept of IoT involves connecting sensors and electronic devices mounted on containers to the internet and/or local systems. This facilitates the exchange of data for various supply chain purposes and applications. However, the historical lack of interoperability among different IoT solutions has hindered the seamless provision of information throughout the container journey. Addressing this challenge, the DCSA Gateway Connectivity Interfaces standard has been developed as the initial step towards resolving the interoperability issue.

This standard specifically targets the supporting network infrastructure, focusing on IoT gateways, deployed to enable connectivity for IoT container devices. In this context, gateways serve as intermediaries for connectivity between multiple IoT container devices, IoT cloud platforms, and/or local systems. Through the implementation of this standard, industry stakeholders, including carriers, vessel owners, ports, terminals, container yards, and other infrastructure owners, move one step closer to:

- Designing a uniform network infrastructure supporting all IoT container solutions developed by various carriers and/or IoT providers;
- Mitigating the risk associated with investment in IoT devices without imposing restrictions on individual strategies and priorities;
- Generating a demand volume that industry stakeholders, market suppliers, and service providers can capitalise on.

- ***IoT – Remote Reefer Container Monitoring on Board***

This comprehensive exploration delves into the recent release from the DCSA IoT Program, focusing on standardising data for remote Reefer container monitoring on vessels. The primary goal is to establish a robust

framework for the exchange of critical information captured from smart Reefer containers. This standardisation ensures a uniform sharing of data among pertinent stakeholders, particularly the vessel crew, to enable effective remote monitoring aboard vessels. The overarching objective is to foster interoperability and collaboration, ultimately delivering more efficient services to end users.

- ***Significance of Defined Data Elements***

A crucial cornerstone in achieving interoperability and promoting collaboration among stakeholders is the definition of the minimum set of required data elements for Reefer containers. This standardisation provides a common language for communication, ensuring that all involved parties interpret and utilise the data in a consistent manner. By outlining essential data elements, this standard lays the groundwork for a cohesive and integrated system, allowing stakeholders to work together seamlessly. This collaborative effort is geared towards providing enhanced services to end users in a more streamlined manner.

- ***Supplementary Support by DCSA***

To complement and enhance the understanding of the DCSA IoT Data Standard, two supplementary resources have been introduced:

- DCSA Glossary of Terms 2.0:
 - The DCSA Glossary of Terms 2.0 serves as an indispensable companion, providing definitions and explanations of business terms utilised in DCSA documents. This glossary ensures a consistent interpretation of terms across all readers, fostering a shared understanding within the community. By offering clarity on the terminology, stakeholders can communicate effectively, minimising misunderstandings and facilitating the seamless implementation of the DCSA IoT Data Standard.
- DCSA IoT Release 1: Standard for Gateway Connectivity Interfaces:
 - The inaugural release under the DCSA IoT Program, titled “DCSA IoT Release 1: Standard for Gateway Connectivity Interfaces,” is specifically designed to ensure interoperability at the gateway radio interface level. This release outlines the standardisation of interfaces between various IoT solutions deployed by different entities. By establishing a common framework at the gateway level, this release complements the overarching DCSA IoT Data Standard, guaranteeing a smooth flow of data between different IoT solutions employed by stakeholders.

- ***Just-in-time Port Call***

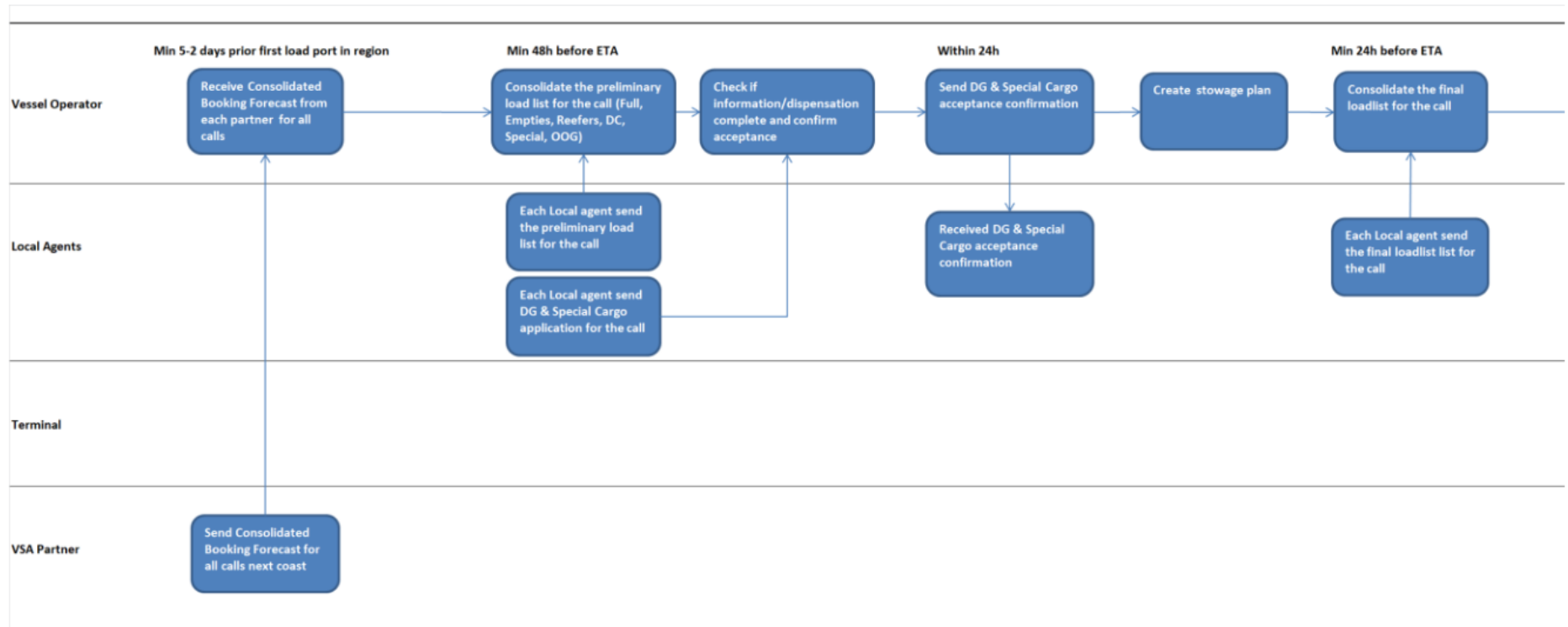
Within the extensive framework of the DCSA Just-in-Time Port Call Initiative, collaborative efforts between DCSA and its affiliated carriers have yielded the release of all-encompassing standards. These cover port call data definitions, interface standards, and messaging API specifications tailored for 100 event timestamps. These standards, which intricately address the six key facets of a port call, are designed to support digital port call planning, elevate operational efficiency, and optimise the allocation of resources. By promoting a Just-in-Time port call process, DCSA’s standards enable container ships to optimise steaming speed, reducing fuel consumption and greenhouse gas emissions. Aligned with existing standards from ITPCO and IMO, DCSA ensures a global industry framework that safeguards investments. The integration of DCSA Just-in-Time port call standards and DCSA operational vessel schedules (OVS) standards fosters transparency in the vessel voyage ecosystem. API definitions for Just-in-Time Port Call are available on SwaggerHub¹⁴, facilitating rapid implementation of DCSA standard-compliant APIs. Detailed documentation, including versioning guidance, is accessible on GitHub.

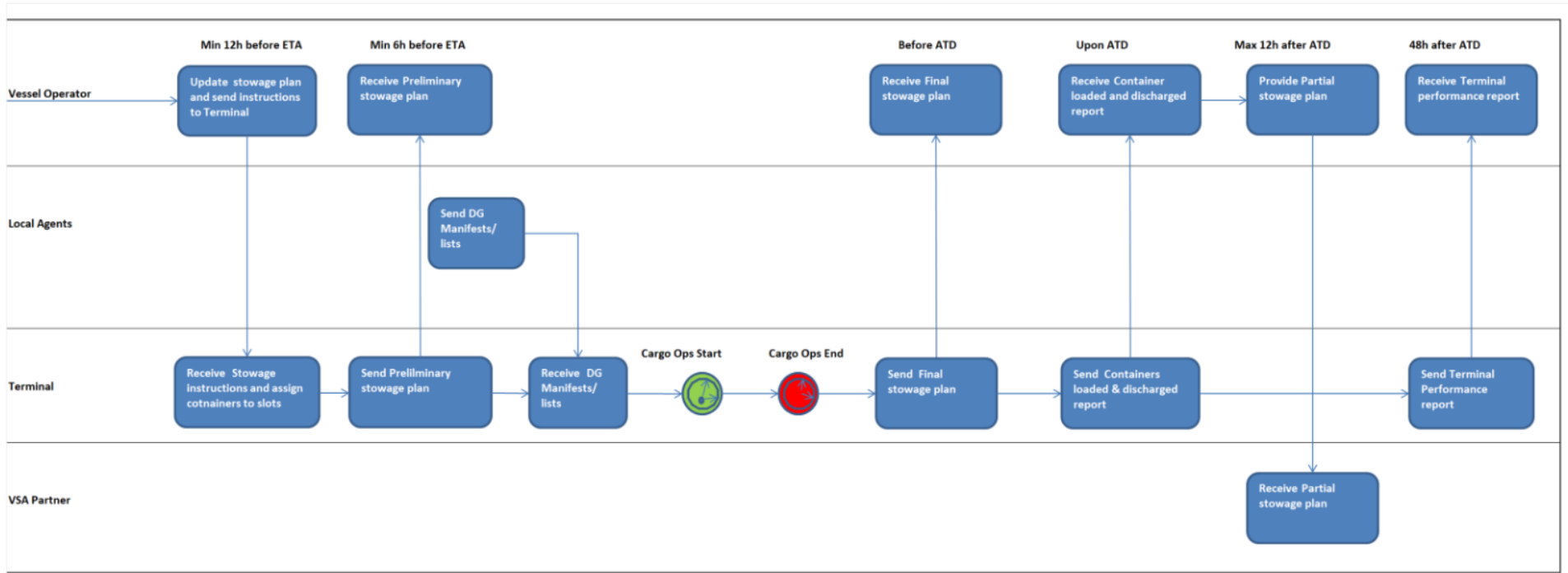
¹⁴ <https://app.swaggerhub.com/organizations/dcsaorg>
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For those wanting to establish a digital, global, and transparent just-in-time port call ecosystem, the DCSA Standard for Just-in-Time Port Call publication provides downloadable data definitions and interface standard documents, allowing a streamlined approach to port call optimisation.

- ***Load List and Bay Plan***

This release establishes a set of standards and communication timelines for the exchange of information regarding container load volumes and stowage details among vessel sharing agreement (VSA) partners, terminals, and ports. These definitions integrate existing event standards with recommended submission timelines developed by DCSA, with collaborative input from four of the world's largest terminal operators. The adoption of these standards is anticipated to optimise the efficiency of cargo operations and enhance the planning of associated shipping activities. This marks the inaugural instalment in a series of standards releases from DCSA that specifically address cargo operations. Future standards within these series will expand to cover topics such as empty handling and dangerous goods. To access the Load List and Bay Plan Definitions and review the recommended standards for digital communication of cargo information, thereby fostering more efficient and predictable port calls, interested parties can download the documents presented in the Figures 3-2 and 3-3 below.





Figures 3-2 and 3-3: End-to-end documentation process

- **Operational Vessel Schedules**

These standards have been designed to facilitate the automatic exchange of vessel schedule data between carriers and operational service providers. Implemented within this framework, carriers gain the capability to digitally disseminate their schedules. Subsequently, their VSA partners and operational service providers can seamlessly subscribe to their feed, receiving updates automatically or retrieving them as necessary. This implementation ensures comprehensive inter-regional vessel schedule transparency, fostering heightened efficiency and improved planning and optimisation of shipping activities. The DCSA OVS standard publication encompasses updates to the DCSA Industry Blueprint and Information Model, featuring OVS schedule definitions, process maps, and terms. Additionally, it provides OVS data interface standards along with associated reading guides.

- **OVS OpenAPI Specifications**

As an integral component of the Operational Vessel Schedules standard, DCSA has also released OVS OpenAPI definitions on SwaggerHub, an open-source API development platform. These OpenAPI definitions for Operational Vessel Schedules align with the DCSA API design principles, offering carriers a tool for swift implementation of DCSA standard-compliant APIs. Documentation for the Operational Vessel Schedules standard, including versioning guidance, is available on GitHub.

- **OVS Publication**

The OVS standards publication is available for download from its website to learn about the process of digitising their OVS, which is based on a shared understanding of the data and processes used in scheduling. This approach ensures consistency, simplicity, timeliness, and interoperability in operational vessel schedule solutions across the industry.

- **Reefer Events**

Reefer events standards have been established to enhance end-to-end cargo visibility within the global container shipping industry, aiming to facilitate industry-wide standardised sharing of data pertaining to the tracking and tracing of Reefers. They thus lay the groundwork for an interoperable framework of cargo visibility solutions. By implementing these standards, carriers and participants in the supply chain move one step closer to delivering an uninterrupted flow of pertinent information to their customers. This information includes details about the location of Reefer containers and the status of their contents at any given point throughout the container journey. DCSA has successfully developed the capability to achieve seamless communication through the implementation of the Reefer Events 1.0 Beta 1 API, whether utilised as a standalone solution or integrated in conjunction with DCSA's Track & Trace 3.0 Beta and IoT Events 1.0 Beta 1 APIs.

- **Track and Trace**

Track and Trace (T&T) standards encompass common processes, data, and interface standards that can be implemented by carriers, shippers, and third parties. The objective is to facilitate cross-carrier shipment tracking, enabling customers and supply chain participants to engage in unified digital communication with all carriers. The data model, a crucial element within these standards, ensures uniform track and trace data definitions for users across different systems. These definitions are based on the Industry Blueprint, a publication jointly developed by DCSA and its carrier members in 2019. The Industry Blueprint introduced a standardised vocabulary¹⁵ and proposed current state standards for industry processes.

Furthermore, the T&T container tracking standards are strategically aligned with UN/CEFACT standards. This alignment aims to preserve existing investments while promoting efficient communication among all participants in the supply chain.

¹⁵ https://dcsa-website.cdn.prismic.io/dcsa-website/65bceec39615e73009ec43c0f_20231215_DCSA_Industry-Blueprint-2023.4-Process-Maps.pdf

As part of the broader logistics ecosystem, DCSA's standards contribute to a cohesive and integrated system within the maritime segment of the supply chain. By focusing on the container shipping industry and aligning with UN/CEFACT standards, DCSA ensures the preservation of existing investments while facilitating efficient communication among all stakeholders. In conclusion, DCSA's standards play a vital role in shaping the future of maritime logistics, providing a foundation for standardised, streamlined, and technologically advanced processes that benefit the entire logistics industry.

3.1.3 IALA/S-211

IALA has published the "S-211 Port Call Message" [8], which covers the ship-to-port, port-to-ship, port-to-port, as well as port actor-to-port communication. The S-211 arises from the need to standardise and precisely define these communications to contribute to an efficient coordination of port calls, and is based on business logic explained as the understanding of how to conceive a port call. Development is based on multiple instances of Port Collaborative Decision Making (PortCDM), as a sub concept of Sea Traffic Management (STM), validated in different ports. Furthermore, collaboration with other developments (such as the UKHO_IHMA 2017 timestamp standard, GS1's EPCIS, PCS and National Single Windows) ensures compatibility of S-211, which originates from the MONALISA 2.0 and the STM validation projects and is maintained by the International PortCDM Council. It was converted to an S-200 style product specification in January 2018.

The port call message standard S-211 has the following features:

1. It is compliant with the international standard format for route exchange.
2. It is compliant with the IMO e-Navigation concept and specifically, the Common Maritime Data Structure (CMDS).
3. It will be included in the International Hydrographic Organisation Geospatial Information (IHO GI) Registry as the centre point of CMDS.
4. It supports the relevant Maritime Service Portfolios (MSP) as defined in the IMO Strategy Implementation Plan (SIP) and as described by documents under construction by IALA.
5. It has a granularity that matches general needs in logistics and could be transferred to hinterland transportation to further improve the maritime transport chain.

3.1.4 International Organisation for Standardisation, ISO 28005

ISO standards, especially within port logistics, refer to a number of internationally recognised guidelines and criteria established by the International Organisation for Standardisation (ISO). These standards are designed to ensure quality, efficiency, safety, and sustainability in various processes and operations within port logistics. They provide a framework for organisations involved in port activities to adhere to best practices, streamline operations, and enhance overall performance. ISO 28005 is an international standard for the electronic exchange of security and safety information between different actors involved in the maritime supply chain. It is designed to facilitate the secure and efficient flow of goods and information, while also reducing the risk of fraud and other illegal activities.

The standard consists of two parts:

- **ISO 28005-1:2013: Message structures. Implementation of a maritime single window system**

This part of the standard defines the structure and content of the messages that are used to exchange security and safety information. It also specifies the technical requirements for implementing a maritime single window system, which is a single electronic platform that allows all the different actors involved in the maritime supply chain to exchange information with each other [9].

- **ISO 28005-2:2021: Core data elements**

The “Core Data Elements” section of the standards specifies the core data elements that must be included in the messages that are exchanged between different actors in the maritime supply chain. These data elements include information such as the name of the vessel, the voyage number, the cargo on board, and the port of destination [10].

3.1.5 UN/EDIFACT

The UN/EDIFACT standard is a set of internationally agreed standards, directories and guidelines for the electronic interchange of structured data between computerised information systems [11]. United Nations Economic Commission for Europe (UNECE) and United Nations Trade Data Interchange Directory (UNTDID) are in charge of maintaining, approving, and publishing the rules and standards.

Its usage is recommended within the framework of the United Nations. Although it was initially conceived for retail, today the standard has been adapted to other industries such as healthcare, construction, logistics and transportation, and other services (e.g., banking, insurance, etc.).

In logistics, the standard provides information about multiple stages of the administrative and physical process. As explained before, EDIFACT’s messages cover the following areas:

- Port call information: call info, bayplan/stowage plan, container arrival, container discharge/loading, gate in/out report, dangerous cargo list, cargo status, handling and movement, etc.;
- Contract and financial information: banking status, bank transactions, balance of payment, documentary credits, insurance, etc.;
- Customs and legal requirements information: Sanitary/phytosanitary certificates, customs declaration and responses;
- Other information: medical information, payroll, safety and hazard, etc.

3.1.6 IPCSA

IPCSA is an international association that aims to support and facilitate systems and innovations for its members and their users, promoting the use of international data standards in sea and airports, at border crossings and via Single Window systems around the world. Comprised by private and public members including governmental organisations, and recognised by UN’s Economic and Social Council (ECOSOC) and IMO, IPCSA provides practical advice and guidance (instead of policy) [12].

The areas of interest covered by IPCSA are the following:

1. Airport Community Systems (AirPCS) /Cargo Community System (CCS): This area of interest encourages the development of AirPCSs and CCS in airports worldwide, and promotes air freight digitalisation. To achieve this, the Task Force coordinating with Single Window developments, collaborates with key international organisations related to the movement of goods in the air industry (including IATA, International Civil Aviation Organisation (ICAO) and The International Air Cargo Association (TIACA), sharing and exchanging experiences across different modes of transport and encouraging the use of the e-Airwaybill (eAWB) and other global initiatives.
2. Business Applications: This area coordinates, reviews, and provides advice on all aspects related to the setting up of Business Applications. Among other tasks, the aim is to define, coordinate, and keep under review proposals from members of the logistics sector, both national and international, that can impact their development. In turn, the area also prepares dissemination documents and defines targets for the development process.
3. Customs: The Customs and Other Government Agencies (COGA) deal with all matters pertaining to these organisations that are related to the business and activities of Port Community System Operators, Sea and Airport Authorities and Single Window Operators. This task force has the role of examining and

reviewing EU and other international policies which might impact the association and prepare papers for submission to the relevant authorities.

4. PCS and Software Development: This group encourages and supports the development and implementation of Port Community Systems for seaports, airports, and land border crossing points, as well as Single Windows across Europe.
5. PROTECT: Dealing with the electronic reporting requirements by authorities for vessels entering or leaving a port or port area, PROTECT maintains and develops Electronic Data Interchange (EDI) through the PROTECT Guide. It also designs and now maintains the IFTDGN (Dangerous Goods), BERMAN (Berth Management), and WASDIS (Waste Disposal) Messages of the EDIFACT standard.
6. Research: This area monitors the multidisciplinary initiatives in the fields of PCS, Single Windows and other related topics promoted by organisations and academic institutions. More precisely, its goal is to inform IPCSA members about its findings, areas of interest, trends, future innovations and technology transferability of the projects into business applications and development based on their research activities. Furthermore, it also closely follows initiatives coordinated by international and regional organisations and other public bodies.
7. Standards: Of special interest to FOR-FREIGHT, this area aims to provide information and advice related to standards to be used, as well harmonisation, and technology. This includes:
 1. Inventorisation between IPCSA members: used standards.
 2. Standards related to maritime, inland, and air transport logistics.
 3. Standards in a multinational environment (National Single Window network).
 4. New standards and areas to be explored.
 5. Development of new standards.
 6. Stakeholder management with international standard organisations – including, but not limited to: GS1/WCO/SMDG/UN/IMO/DCSA.
 7. Harmonisation of the use of standardised messages between IPCSA members, and with stakeholders.
 8. Inventorisation of code lists used.
 9. Inventorisation of local laws compared with EU and International Legislations.
 10. Technology and innovation improvements.
 11. New technologies, areas to be explored.
 12. Vision on development of new technologies and trends.

3.1.6.1 Port Community Systems (PCS)

Port Community Systems were developed by seaports to act as a “communications hub” for the entire logistics community of the seaport. They usually consist of a software that centralises the messages generated by customs, logistics companies, terminals, shipping lines, etc. which cover exports, imports, transshipments, consolidations, hazardous cargo, and maritime statistics reporting. The first systems appeared in the late 1970s and early 1980s in Germany, France, and the UK, with other countries such as the Netherlands and Spain developing them in the 1990s and the turn of the 20th century. A PCS is conceived as a modular system with functions designed to cater to the needs of all the various sectors and players with tools specific to them, creating an integrated system. Improved reliability, processes, costs and punctuality, and the need of standardised communication platforms are cited as the drivers for the creation of PCSs.

According to IPCSA (International Port Community Systems Association), the services provided by PCS can be summarised as follows:

- Easy, fast and efficient EDI-based information exchange, re-use and centralisation, available all year round;
- Customs declarations;
- Electronic handling of all information regarding import and export of containerised, general, and bulk cargo;

- Status information and control, tracking and tracing through the whole logistics chain;
- Processing of dangerous goods;
- Processing of maritime and other statistics.

Facilities with a PCS in place benefit from higher efficiency and speed regarding port processes, particularly through automation and the reduction of paperwork, therefore enhancing the sustainability of transport and contributing to global carbon reduction targets. Ports that do not have PCS in place have an average of 150 contact moments for each container discharged.

International efforts to standardise PCS communications are coordinated by IPCSA. However, PCS are mostly developed “in-house”: while the overall “look and feel” is the same, most PCS worldwide are ad-hoc solutions designed to cater the local needs of a specific port. Furthermore, while the sea and administrative parts are mostly mature, the integration with hinterland services and transport companies has room for improvement and should be tackled to ensure compatibility and foster market uptake of digitalisation services.

3.1.7 European Maritime Single Window environment (EMSWe)

An initiative promoted by the European Commission and with legislative force, EMSWe strives to achieve a “common digital interface” at all European Union ports. By adopting it, the entire port community will benefit from a streamlined bureaucratic process in the interactions with the administration. Another advantage is also the reduced need for training in the formalities of the different Member States. Although the data model and structure have been outlined since 2010, the system is expected to come into force in August 2025.

At the core of EMSWe lies a set of common messages that is similar to the current EDIFACT¹⁶ messaging system. These exchange the relevant information of the vessel and its cargo between the port actors (i.e., port authority, port master, carrier, customs, pilot and tug services, etc.).

The EMSWe should be ready and implemented by 2025 at the latest. Adding to the European Directive establishing EMSWe, procedures are set in the eFTI regulations to ensure data interoperability with the EMSWe environment and facilitate re-use and the exchange of cargo information along the entire logistics chain within the hinterland. Below can be seen a schema on how EMSWe works, along with a reference to “SafeSeaNet”, a vessel traffic monitoring and information system developed by the European Maritime Safety Agency to enhance maritime safety, port and maritime security, marine environment protection, and the efficiency of maritime traffic and maritime transport [13].

¹⁶ For more information on the EDIFACT standard, please visit Section 3.1.4
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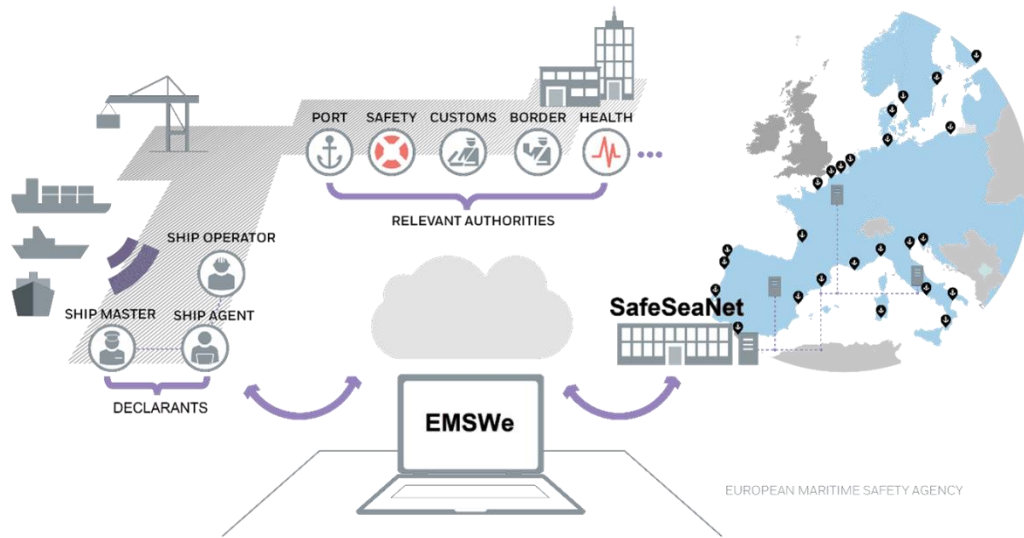


Figure 3-4: EMSWe schema and SafeSeaNet Source: [13]

The Delegated Regulation (EU) 2023/205 [14] detailed the data set about the information required by the national authorities for administrative and operational purposes. The following are the elements that must be presented:

1. Reporting obligations stemming from legal acts of the Union:
 - Notification for ships arriving in and departing from ports of the Member States
 - Border checks on persons
 - Notification of dangerous or polluting goods carried on board
 - Advance waste notification
 - Waste delivery receipt
 - Ship pre-arrival security information
 - Number of persons sailing on board passenger ships
 - Information on persons sailing on board passenger ships
 - Customs formalities
 - Notification of arrival
 - Presentation of goods to customs
 - Temporary storage declaration of goods
 - Customs status of goods
 - Electronic transport documents used for transit
 - Exit notification
 - Exit summary declaration
 - Re-export notification
 - Safe loading and unloading of bulk carriers
 - Notification of arrival of ships eligible for an expanded inspection
 - Maritime transport statistics
2. International Maritime Organisation Facilitation Committee (FAL) documents and reporting obligations stemming from international legal instruments:
 - General Declaration
 - Cargo Declaration
 - Ship's Stores Declarations
 - Crew's Effects Declaration
 - Crew List

- Passenger List
- Dangerous Goods
- Maritime Declaration of Health

All these formalities address the information requirements for proper and harmonious facilitation, promoting coexistence and interaction among the involved parties. As it is applicable within the European context, it harmonises diverse realities, significantly reducing process duplication, and enhancing the efficiency levels of logistic chains. According to the regulation, the process shall be overseen by conformity assessment bodies accredited by European regulations.

3.2 Cargo Handling Processes

The next stage to consider in the logistic process established in FOR-FREIGHT is cargo handling. These are the activities that occur in ports, where container terminals in this case are responsible for carrying out loading, unloading, storage, and dispatch processes of cargo towards the hinterland. At this point, efforts will be made to identify standards that harmonise terminal operations processes, as well as the communications and technologies used to carry out these processes.

3.2.1 Terminal Industry Committee's Role in FOR-FREIGHT

The international association TIC4.0¹⁷ was established in the year 2018 as a response to the lack of standardisation of digitalisation activities in the port industry. With a broad representation encompassing from terminal operators and port equipment manufacturers to Terminal Operating System suppliers and media partners, the initiative aims to bring together the port industry community to develop a common standard that will allow objective comparisons of equipment/systems and define the format for electronic data exchange.

As of the time of writing (April 2024), the organisation was composed of 58 worldwide members that are actively involved in the development of the industry standard. A total of ten publications (two per year)¹⁸ of the TIC4.0 standard, which covers the common language, have been published to date, and are available in TIC4.0's website for download. Furthermore, TIC4.0 has established contact with recognised standardisation bodies with the long-term goal to turn its work into an international standard. Lastly, the initiative has been endorsed by the Federation of European Private Port Companies and Terminals (FEPORT), and the Port Equipment Manufacturers Association (PEMA).

The following paragraphs will provide a detailed description of the technical development of the standards and the process for obtaining and reaching an agreement among the participating parties in the association for the validation of the standards before publication. Subsequently, the current scope of the standards will be presented, detailing which aspects of the reality within port terminals have been successfully published and outlining future developments. The discussion will conclude with the possibility of applying TIC4.0 standards and their logic beyond the port terminal environment, exploring the potential role they could play in the FOR-FREIGHT project. In order to understand the TIC4.0 standards and the value they bring, it is necessary to explain, on the one hand, in detail the technical possibilities the TIC4.0 standard offers and, on the other, how TIC4.0 designs to model all activities related to port terminals. Firstly, it is important to understand how TIC4.0 achieves the necessary consensus to grant standard status to its definitions. The process by which this is accomplished is as follows.

3.2.1.1 TIC4.0 standard definition workflow

TIC4.0 is divided into two fundamental decision-making bodies. On the one hand, there is the Executive Council, responsible for establishing and ensuring the direction and goals of the association. On the other hand, there is the Operations Council, which plays a fundamental role in creating the technical development strategy and

¹⁷ www.tic40.org

¹⁸ <https://tic40.org/standards/>

ensuring its proper control. The process of developing a standard begins with the interest, whether internal or from a partner's need, to explore a specific topic for standardisation. The proposal is shared and analysed within the Operations Council to determine the relevance of the proposal. If it is deemed satisfactory and sufficiently significant to dedicate resources to its development, a Task Force is created. This Task Force is assigned a Leader and a group of collaborators responsible for discussing the proposal, establishing the steps to apply the methodology. Once the agreed-upon definitions are made, they undergo a review by the Review Board, and if they meet expectations, they are published in the next immediate version.

As mentioned earlier, TIC4.0 aims to enhance the level of digitisation in the sector. Therefore, the standards developed by the Association serve to harmonise the digital exchange of data based on a specific data language using common semantics and ontology. These semantics are capable of representing any reality in a digital format that may emerge within logistics activities through the creation of a sentence that combines a set of specific elements, which will be explained below.

3.2.1.2 Semantic

The data language underlying the semantics of Industry 4.0 is the main innovation and contribution in the quest to provide new tools to the industry for achieving better data capture, processing, and analysis to enhance operational processes through a deeper understanding of reality. Being able to represent any reality in digital format is key to achieve better decision-making and observations of a terminal. The language of Industry 4.0 can represent any reality by combining five main elements: Subject, Concept, Observed Property, Measurement Point, and Value.

The semantics define the way TIC4.0's messages are structured, and the information they contain. It is divided in five basic elements, header, subject, concept, observed property, point of measurement, and value. Below is a description of these concepts:

- **Header:** It identifies the message in origin (destination), time of reference for the message, and unique reference;
- **Subject:** Who or which entity is executing an object (as per the TIC4.0 semantics) or embodying a concept;
- **Concept:** Refers always to a particular subject (or subject-subsystem) specifying what the subject is (status), or does (action-event);
- **Observed Property:** How much is the magnitude of the concept (status, pieces, length, volume weight, energy, time, speed, power, duration, acceleration, etc.) represented in the value;
- **Point of Measurement:** Defines where in place and time (past, present and future) the value representing the concept of observed property of the subject is measured and represented;
- **Value:** A "value" in TIC4.0 is defined as "the actual measured result for a specific combination of the TIC4.0 semantic items "time of measurement", "subject, concept and observed property", and "point of measurement". The same value can be represented in several units.

TIC4.0 language has a specific grammar (semantic):
it allows to create a sentence to express any “reality” in a digital format

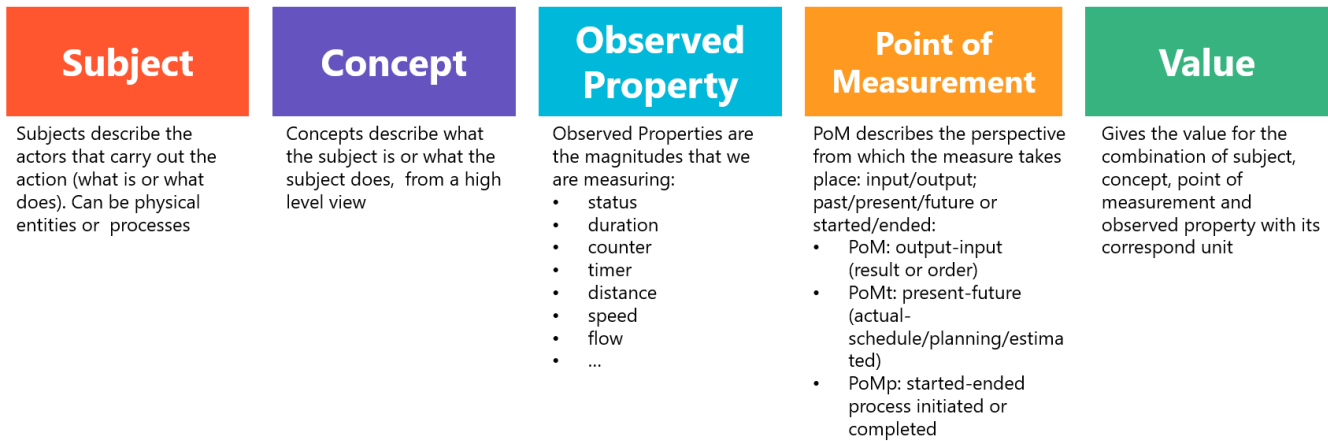


Figure 3-5: TIC4.0’s semantics. Source: [15]

The combination of a **SUBJECT** with multiple combinations of **CONCEPTS**, **OBSERVED PROPERTIES** and **POINT OF MEASUREMENTS** give us a unique meaning of a **VALUE**.

Email 2345345 From Jason Martial at 2020-06-04T09:37:08.000Z the subject with id **STS8765745346** and subject name **MFT-STS01** has the **working status (output actual)** on **TRUE** and the **drive speed (output actual)** is **25 km/h**.

```
msg.id: D6wZ6ngBBIsOzhTbxvHy; msg.sender: TOSMFT; msg.timestamp 2020-06-04T20:55:08.000Z;
msg.start_timestamp: 2019-06-04T20:55:08.000Z; terminal.id CLT_ES; terminal.name: “Curro Local Terminal”;
terminal.type: “terminal”; terminal.quay.cycle.move_and_unloading.counter.actual.output.box : 265.568;
terminal.quay.cycle.move_and_loading.counter.actual.output.box : 265.544 ;
terminal.quay.cycle.move.actual.output.box : 531.112 ;
terminal.quay.cycle.move_and_unloading.counter.actual.output.teu : 458.548;
terminal.gate.cycle.move_and_unloading.counter.actual.output.box : 258;
terminal.quay.cycle.move_and_loading.counter.actual.output.teu : 458.548 ;
terminal.gate.cycle.move_and_loading.counter.actual.output.box : 244;
terminal.cycle.move.counter.actual.output.box : 531.614 ; terminal.move.cost.actual.iinput.€ : 50.444.333;
```

Figure 3-6: Message expressed in TIC4.0 format. The colours represent the type of element as described in the previous figure. Source: [15]

- **Dataset**

The dataset is defined as the database that contains the list of data defined by TIC4.0 (a piece of reality). This is a combination of subject, concept, observed property, plus valid points of measurements, and units:

- **Data:** represented in a flat format;
- **Subject:** including subject and sub-subjects;
- **Concept:** represented by the concept ID;
- **Observed Property;**
- **Point of Measurement;**
- **Value:** defined as the possible units to be used for data representation;
- **Link to the definition:** hyperlink to the definition template for each component of the data;

- **Workflow status (status):** the status within the TIC4.0 workflow;
- **Version;**
- **Release;**
- **Short Description:** aiming to provide a high-level understanding of the data.

3.2.1.3 Data Model

To digitally represent and define TIC4.0's dataset and semantics, a Data Model has been developed. The Data Model follows an RDF (Resource Description Framework) schema to define the details of the content such as the validity of the format or the type of data (Boolean, integer, real, etc.), mandatory or optional fields, etc. More specifically:

- The subject creates the hierarchy tree structure (we have sub-subjects) that helps to identify the boundary of the value. This hierarchy is fixed by TIC4.0 for each kind of subject (CHE, TOS, Terminal) and can mix any type. An array defined by the concept metadata structures the data in a way that multiple identical subjects with different metadata (e.g., ID, name, location) can be sent in the same message;
- The concept's metadata defines "what it is", while the concept itself is a definition of what the subject "is doing". Both are expressed in a "flat" way and can be combined to express multiple actions: for example, registering a crane that simultaneously hoists and trolleys a cargo;
- Observed properties define the magnitudes of the concept and are expressed in a "flat". As with concepts, they can be used multiple times per concept;
- Values are created as arrays that mix observed properties and point of measurements in time and units. The length of the array depends on the relation between the data frequency, message frequency and the amount of different point of measurements that need to be represented.

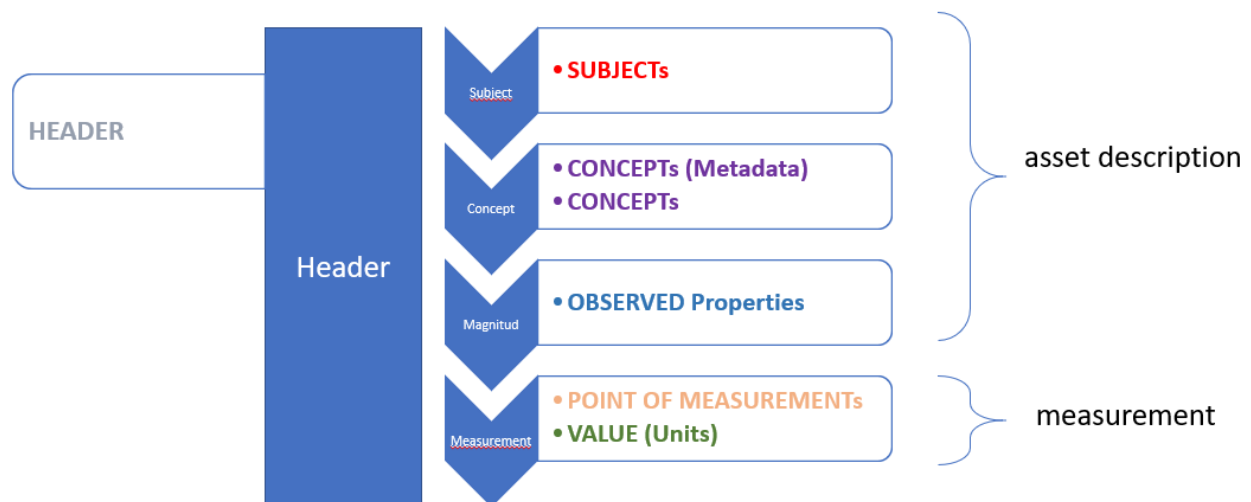


Figure 3-7: TIC4.0's message structure and components. Source: [16]

The data models created by TIC4.0 are capable of adapting to multiple data exchange protocols and can also be transmitted using different communication technologies. While there are multiple alternatives, providing the possibility of being implemented in a broader range of circumstances, the digital text format recommended by TIC4.0 for achieving the best results is through JSON. The main advantage that JSON offers over other alternatives is the ability to encapsulate multiple subjects in a single message, enabling an enriched representation of reality

and simplifying data exchange. The following list includes the rest of the text formats and technologies that can utilise the TIC4.0 standard:

- MQTT;
- JSON;
- OPC-UA;
- CanBUS;
- ModBus;
- Profinet (DB fix);
- Plain text (email, handwritten, document, etc).

3.2.1.4 Publications

Quarterly, TIC4.0 publishes an updated version of the standard, semantics, and data model. These publications are the product of the discussions of the various expert groups, which form the core of the organisation and are divided in expertise fields according to the scope of work of the task forces.

Interface: Due to how the TIC4.0 standard and common language works, any system or machine using the TIC language is able to create a standardised database that can be accessed by terminal managers. The interface and API shall be designed ad-hoc depending on the legacy system.

TIC4.0's standards are published on an open basis for everyone to use. Any interested actor can download them for their own intent and purpose to integrate them into their software.

As for the Data Model, the organisation, as mentioned before, has conceived it to flexibly represent and model in a computer model the "realities" of the port processes. They are classified according to their nature, associated event and information regarding geographical position, time events, duration and status, "fusing" data collected from port machinery, TOS, and other pieces of equipment. This "fusion" allows to extract useful information on the process performance, ranging from pure operational efficiency to environmental performance.

3.2.2 Technical features of the TIC4.0 Standard

From the collaboration of TIC4.0 members, a set of standards has emerged aimed at harmonising the ways in which the reality of what happens within port terminals is understood. In this section, we will detail the current scope of the Association's standards publications, highlight the areas where effort has been concentrated so far, and outline the next steps. There will also be a mention of the possibility of adapting TIC4.0 standards to other realities within the logistics industry, mainly defining the role it can play in the FOR-FREIGHT project.

In general terms, there are two main dimensions in which activities at port terminals could be categorised. On one hand, there are processes, ranging from a simple assignment of a work order to a specific team or person, to a complex process such as the arrival of a vessel at a terminal and the sub-processes that must be executed. However, this is only one part of the reality; the other part concerns the execution of these processes. This part of the activities is primarily carried out by equipment. Therefore, to understand the behaviour of an equipment, what it did, does, and primarily what it intends to do, it is necessary to digitally represent these realities. Once both dimensions are standardised in a digital format, it is possible to establish relationships between them through the intercommunication among systems (representing processes) and equipment (representing execution).

On this aspect, TIC4.0 has three main data models in which all the realities related to processes and machines are condensed. Firstly, there is the TOS data model, which functions to capture the operational processes of the terminals. Secondly, the Health data model is responsible for representing processes related to maintenance

actions. Lastly, the Cargo Handling Equipment data model allows representing the realities of machines in a terminal.

3.2.2.1 Process harmonisation

Currently, the complexity of container port operations, regardless of their size, requires a computer system to manage or assist in managing them to achieve efficiency and effectiveness. The most widespread systems in the industry are Terminal Operating Systems, which are responsible for managing terminal processes, including planning, execution, and reporting, considering internal resources and external service demands.

Due to this scenario, one of the most direct paths to standardise and harmonise terminal processes is to apply this logic to industry Terminal Operating Systems (TOS), achieving a “generalisation” effect in the sector and the adoption of common semantics combined with a common definition of the forms and sequences from which processes are composed. Considering that there is no standardised framework widely adopted within the industry that can be considered for the project, the developments carried out by TIC4.0 will be taken as a reference, as they are closely related to this issue.

Together with the TOS data model, the other group of processes necessary to achieve interoperability aimed at ensuring the proper functioning of equipment. This would allow obtaining the necessary information to optimally utilise the technical resources within a terminal. These processes, within terminals, fall under the area of maintenance and repair. In TIC4.0, the focus is on developing the digital representation of all these realities. In this regard, recent publications have introduced the Health data model, which has been designed to transmit as much information as possible about the capability of equipment to perform the tasks for which it has been manufactured.

- **Operational processes (TOS data model)**

The TOS data model addresses the standardisation of terminal processes, unifying the necessary definitions under the logic of TIC4.0 semantics. These definitions, as mentioned earlier, are developed in working groups composed of experts from significant companies in the sector. To explain how TIC4.0 has approached the development of the TOS data model, we begin by presenting TIC4.0's definition of a TOS:

The TOS manages all terminal operational processes from data entry to planning, execution and reporting. Usually, the process starts with orders and schedules to be followed by the planning. During execution the TOS manages the allocations on the terminals and the Container Handling Equipment (CHE) to execute certain moves. Typically, a TOS also supplies optimisation rules, configurations and algorithms. After execution the TOS also handles the reporting and provides the data to further processes such as billing. A TOS today also often comes with BI and KPI modules as well as first approaches to AI. In the context of TIC TOS will also be more and more connected to the equipment's data and vice versa [15].

The following are the groups of processes already published by TIC4.0:

So far, there are three major process groups defined in the TOS data model that can represent the majority of past, present, and future scenarios, encompassing events that occur within the terminal itself, as well as those that take place externally with a present and future relationship to the terminal. These three sets of processes are Carrier Visit, Cargo Visit, and Job Instruction, and are reported in Table 3-1 below.

Table 3-1: Terminal processes in TIC4.0.

Name	Type	Description
CarrierVisit	Process	CarrierVisit describes the process of a carrier (vessel, truck, barge, train) passing through a terminal (visiting the terminal) to load or unload cargo, or utilise other 3rd party-services (e.g., bunkering, garbage disposal, etc).
CargoVisit	Process	Lifecycle of cargo at a terminal from arrival until departure (both included).

JobInstruction	Process	A job instruction is a collection of orders (something) that a source (system/someone) tells subjects (system/someone/something/equipment) to do to an object (system/someone/something/equipment) in a coordinated way.
-----------------------	---------	--

As can be observed, both Carrier Visit and Cargo Visit encompass processes that occur both while the subject (e.g., vessel or cargo) is outside the terminal premises and those that happen while the subject is inside the terminal, directly interacting with operations. These two processes, combined with JobInstruction, make it possible to interconnect different subjects for the completion of a specific operational process that relies on various participants for its development, and is composed of different phases.

Seeking to enhance the level of representation of reality proposed by TIC4.0, elements of the previously mentioned processes have been defined, which can be sub-processes, events, status, actions, or devices. A table can be found in Annex I summarizing the definitions published up to this point.

- **CHE Health processes (Health data model)**

Most of the operational processes, as we have seen, are carried out by the equipment. Therefore, it is necessary to have a current and future understanding of their availability to efficiently plan operations. This involves detailed knowledge of the resource status during both the planning phase and the execution of operations. Continuous information about the health status of the equipment is crucial to act promptly upon detecting any deviation from the planned activities.

As mentioned earlier, the maintenance department is responsible for ensuring the health of the equipment. Similar to the TOS handling operations, where the system manages the terminal's operational processes, in the case of maintenance, processes are managed and controlled through the Maintenance Management System (MMS). TIC4.0 has applied the same logic as with the TOS data model to represent the reality of maintenance processes in port terminals. By digitally representing the MMS with TIC4.0 standards, it becomes possible to depict the various aspects related to maintenance processes in terminals.

The progress of this topic so far includes the publication of the White Paper, outlining the intentions behind this work. Consensus has been reached on the necessary process to achieve standardisation in this regard. The first version of the main maintenance processes has been captured in a data model using the language of TIC4.0. What remains to be defined is the set of definitions that give meaning to the data model and unambiguously explain the industry significance of each element comprising the standard.

3.2.2.2 Cargo Handling Equipment

An important pillar in terms of port terminal operations is the CHE, which is responsible for executing work orders based on their current state. In this context, TIC4.0 has published the CHE Data Model, which aims to represent all possible scenarios within the necessary time periods for each CHE in the terminal. It should also possess sufficient complexity for people, systems, and other equipment to understand the information and, thus, be able to interact with complex processes. Similar to the TOS, it is important to know the definition that the industry represented in TIC4.0 has established. In TIC4.0 language, a CHE is defined as *“any machine designed to move (transport or lift) any cargo (including containers) from one location to another”* [17].

- **Sub-Group of CHE Data Model**

The CHE Data Model can be divided into two sections. On one hand, there are sub-subjects that are part of a CHE and therefore, must be considered. As per the TIC4.0 language, a “subject” is an entity, object or any other concept, with the capability of doing something of consideration for the proper functioning of operations. On the other hand, the second section consists of concepts that apply to subjects, more precisely, concepts that describe what a subject is or what it is doing.

So far, there are four sub-subjects considering a CHE as the main subject. They are Health, Driver, Spreader, and Power Source. Each of these subjects, in turn, may have subordinate subjects, as well as specific concepts that

describe what these subjects are or what they do. The following list (Table 3-2) describes the definitions of each subject. As in all cases, these definitions are consensus reached in the development of the task forces responsible for defining them, having been reviewed by a review board, and published for the general public.

Table 3-2 : Subject definitions in TIC4.0.

Name	Subject Type	Description
Drive	System	System in charge of the displacement of the main body of the subject.
Health	Process, logic, control	The term health represents the array of systems which are used to monitor and manage the proper functioning of the subject within its working environment as designed.
Power Source	CHE	A machine designed to convert energy into useful mechanical motion.
Spreader	Device	Various configurations of the spreader exist such as fixed, telescoping length, or telescoping width. Configurations currently include the following possibilities of lifting: one (single), two containers (one next to each other at the short side: twin), two containers (one next to each other at the long side: tandem). Further configurations do exist but are yet not established in the market.

The set of concepts mentioned in Annex I is applicable to any subject that can be or is doing what the concept represents. This distinction is important to make, as there are concepts that will not apply to all CHE due to the level of specificity of the concept in question. For example, concepts related to the lifting system of a CHE will not apply to terminal tractors, which do not have a lifting system as part of their features.

3.2.2.3 General Definitions

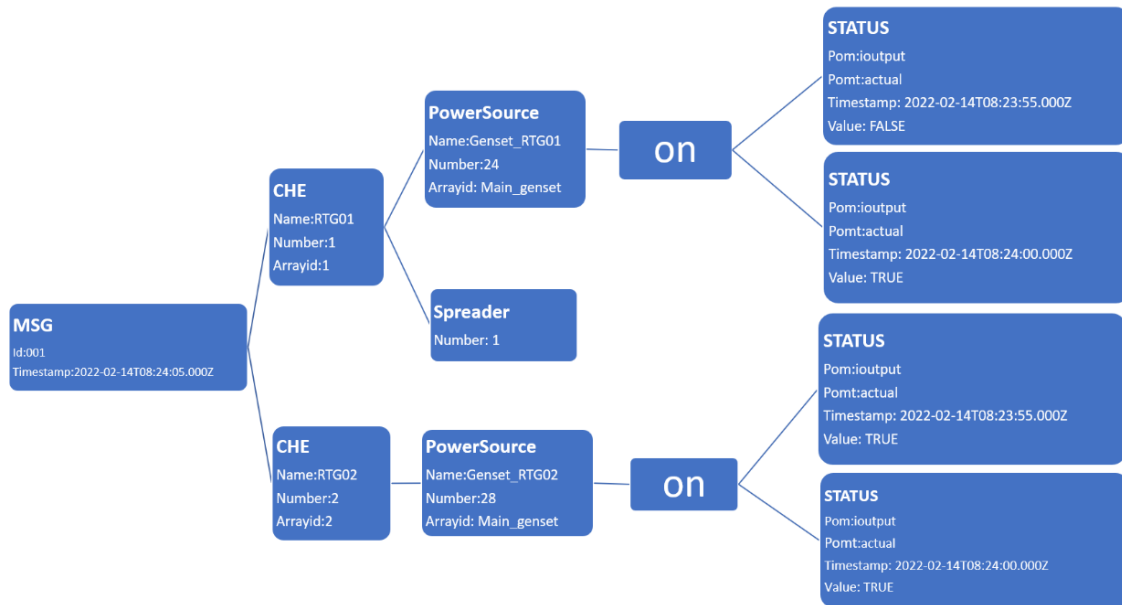
Finally, to get a complete picture on how the TIC4.0 standards work, those definitions that do not fall within the category of TOS or CHE, but are both concepts and definitions that are part of general processes, are presented. Therefore, it is necessary to express them according to the TIC4.0 semantics. Annex I shows those which have been defined to date.

In conclusion, given the absence of a standardised process in port terminals, the consensus reached by TIC4.0 definitions is considered the closest to an industrial standard. The combination of strictly process-oriented definitions represented in the TOS, specific definitions of CHEs that provide states for carrying out processes as planned, and general definitions aiming to broaden the spectrum of standardised reality, represent a comprehensive tool. This tool ensures the correct understanding of reality on a global scale, accessible by machines, individuals, and systems. It spans from simple spreadsheets and email reports to the utilisation of big data in digital developments, such as digital twin and business intelligence, among others.

3.2.2.4 Communication protocols

The information protocols used within the port industry are common to most industries, so the necessary communication structures for the deployment of solutions, such as those proposed by TIC4.0, already exist. Furthermore, the TIC4.0 proposal is not exclusive to large terminals; it is possible that it could be applied in terminals and ports lacking advanced communication systems.

Figure 3-8: TIC4.0's communication protocols. Source: [18]



TIC4.0 uses the JSON format by default because it allows to express an array of subjects (for several sub-subjects), or observed properties (for different combinations of timestamps, pom, pomt, names, etc). JSON is also the default file format for many protocols such as REST and MQ¹⁹ Telemetry Transport (MQTT), extensively used to share data or publish IoT data. These arrays give us a high flexibility thanks to the hierarchical structure. Although the use of other hierarchical structures, such as XML, is possible in TIC4.0, TIC4.0 recommends using JSON as a default.

Table 3-3: TIC4.0 to FLAT format table. Source: [18]

TimeStamp	2022-02-14T08:24:00.000Z	TimeStamp	2022-02-14T08:23:55.000Z
Che @1 name	RTG01	Che @1 name	RTG01
Che @1 number	1	Che @1 number	1
Che @1 powersource @ name	Genset_RTG01	Che @1 powersource @ name	Genset_RTG01
Che @1 powersource @ number	24	Che @1 powersource @ number	24
Che @1 powersource @ on status ioutput actual value	TRUE	Che @1 powersource @ on status ioutput actual value	FALSE
Che @2 spreader.number	1	Che @2 spreader number	1
Che @2 name	RTG02	Che @2 name	RTG02
Che @2 number	2	Che @2 number	2
Che @2 powersource @ name	Genset_RTG02	Che @2 powersource @ name	Genset_RTG02
Che @2 powersource @ number	28	Che @2 powersource @ number	28
Che @2 powersource @ on status ioutput actual value	TRUE	Che @2 powersource @ on status ioutput actual value	TRUE

¹⁹ "MQ" refers to the IBM MQ series and has no specific meaning
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By using the flat format, TIC4.0 is limited to include only one timestamp per message and add in the name of the critical information to identify which subject, concept, observed property, and point of measurement is related to it.

- **Message Validation**

It is a process to check if the message complies with the TIC4.0 schema. The validations are made based on a JSON Schema. The schema doesn't limit the content to TIC4.0, but if the attribute is classified as a TIC4.0 attribute, the Schema will check if the format is TIC4.0.

- **JSON Schema**

Basic rules:

1. All subjects are arrays.
2. All concepts are not arrays.
3. All observed properties are arrays and contain at least the timestamp.

The JSON schema validates the type of the “key” (objects and values). Shall it exist in the registered sample and in the schema, then it will check the variable type²⁰ for coincidence. A non-existent variable will simply be ignored, producing no error message in the process. The JSON TIC4.0 schema can be extended with proprietary extra information as TIC4.0 does not set any limit to the content of the message, nor limitations for external proprietary content.

3.2.3 Potential Role of TIC4.0 in FOR-FREIGHT

In summary, we have observed that TIC4.0 standards represent reality through two different dimensions: processes and Collaborative Human Entities. We can consider this as a binary system whose interaction enables interoperability through intercommunication among the involved parties via information exchange based on a common data format and language. By establishing the definitions of both dimensions, we ensure their comprehensibility for everyone participating in the industry in an unambiguous manner. It is pertinent to consider, at this point, how TIC4.0 can contribute within FOR-FREIGHT and what potential role it should play, independently of the analysis of the state of standardisation in the UCs considered in the project.

To address this inquiry effectively, our initial analysis should focus on identifying potential similarities between the operations within a container terminal and the processes occurring in both the preceding and subsequent legs of the broader logistics chain involving port terminals. This comprehensive examination aims to determine the adaptability of the TIC4.0 standard to interact with its environment, delineate the potential modes of interaction, and identify any conceivable barriers to implementation beyond the confines of the port environment.

It is crucial to underscore that, echoing through both the backward and forward segments of the logistics chain, the processes closely mirror those conducted within a terminal or a significant subset of them. The primary objective of a port terminal is to seamlessly transfer cargo between different transportation modes, whether identical or distinct. Given the occasional impracticability of achieving synchronisation and coordination between various modes of transportation, the imperative of storage arises to accommodate the time lapse between one mode of transportation and the subsequent one. This multifaceted activity entails the orchestration of three principal process categories: unloading/loading, cargo transportation, and storage. As elucidated earlier, these intricate tasks are efficiently managed by a systematic process planning framework alongside a dedicated cohort of equipment and personnel entrusted with their execution.

These three fundamental processes (loading/unloading, transportation, and storage) are either entirely or at least partially present in the remaining legs of the logistics chain. For instance, in a warehouse or an intermodal platform in the hinterland, we observe the necessity for loading and unloading activities to or from a mode of

²⁰ Variable type: boolean, string, real, etc.

transportation. Once the cargo is unloaded, it needs to be moved from point A to point B, and if required, the detachment of delivery from reception must be orchestrated. Warehouses play a pivotal role by storing the cargo until the transport medium arrives to convey it to its designated destination. However, the manifestation of terminal processes extends beyond this stage. Even when the intended representation is as simple as transporting a container from a container terminal to an inland port for loading onto another mode of transportation or delivering it to a warehouse for cargo deconsolidation into smaller units, the process mirrors that of unloading a container from a ship onto a truck. The truck then transports it from the dock to the yard, where it is stored until further transportation is needed.

Not only do the processes closely resemble those of a terminal, but the synergy between processes and equipment is also evident in these activities beyond the ports. Wherever there are systems orchestrating and overseeing processes, coupled with machinery or personnel responsible for their execution, the TIC4.0 standard can effectively represent the realities emerging from these scenarios. A compelling example is once again found in the case of a warehouse, where a Warehouse Management System (WMS) functions similar to a Terminal Operating System (TOS) in a terminal. It oversees process management, and there are machines and personnel, whether automated or manual, responsible for handling the ingress and egress of goods, transporting them, and storing them for subsequent delivery.

This dynamic is also mirrored in land transportation with Fleet Management Systems and trucks, or in maritime transport with Fleet Management Systems for ships and the vessels themselves. The commonality lies in the synchronised interaction between systems governing processes and the machinery or personnel executing them, demonstrating the applicability of the TIC4.0 standards beyond the realm of ports.

The feasibility of implementing TIC4.0 in these emerging scenarios hinges on conducting a detailed analysis of the unique characteristics of the processes occurring at each stage of the logistics chain and adapting existing data models to these new realities. While acknowledging that this is not a straightforward task, it is indeed achievable with the requisite effort. Conceptualising a unified data model for logistical processes and another model that encapsulates the realities of the diverse equipment involved in these processes is not only feasible but also essential for the successful integration of TIC4.0.

3.3 Port-Hinterland Connection & Last Mile Distribution

This phase of the logistic process encompasses the activities and processes that occur from the moment the cargo is authorised to leave the port area by the involved administrations, until the cargo is delivered to the final customer. This includes activities such as container delivery from the terminal, haulage transportation, warehousing, and last-mile distribution, or urban logistics. It is important to determine at this stage whether there is any standardisation regarding how the parties share information, whether the industry has adopted any standardised forms of processes, technology, communication protocols, or common semantics.

3.3.1 Digital Transport and Logistics Forum (DTLF)

DTLF is a forum made up of more than one hundred experts²¹, established in 2015, whose purpose is to create a platform to promote dialogue in a structured and systematised way, as well as to provide technical knowledge in coordination between the Member States of the European Union, the European Commission, and the transport and logistics community. It brings 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. Since 2015, it has been serving as a platform for structural dialogue, provision of technical expertise, cooperation and coordination between the Commission, Member States, and the transport and logistics sector.

The goal of DTLF is to support the European Commission in the design and deployment of different activities and programmes, especially those in regard to digital implementation and development aiming to enhance

²¹ As of the time of writing, the full list of experts is unavailable because its mandate has expired.

interoperability and data exchange. The main technical assistance is dedicated to the implementation of Regulation (EU) 2020/1056 [19] on Electronic Freight Transport Information (eFTI), the Corridor Freight Information Systems dedicated to developing interoperability data sharing, and Paperless Transport.

3.3.1.1 Organisational Structure

The above-mentioned topics are addressed by the forum through three different subgroups to properly tackle the challenges and peculiarities posed by these issues. These subgroups are of a high level of complexity and, at the same time, multidisciplinary, and are structured as follows [20]:

- **Subgroup 1: Paperless Transport**

This subgroup's main objective is to contribute to the transition from an activity that currently remains highly dependent on paper as a means for the transfer and storage of information to one in which processes, procedures, and documentation are entirely digital, maintaining the level of security and transparency while increasing efficiency and sustainability.

This group has had different levels of contribution and objectives. In the first period (2015-2018), its main activity was focused on identifying the most significant legal and technological challenges and their relationship between transport operators and authorities, more specifically, the existing legal fragmentation across Member States in digitalisation matters and the technical challenges of ensuring interoperability among the supply chain and international electronic data exchange (customs, e-documents, e-transport documents, etc.). Since the creation of Regulation (EU) 2020/1056 [19] on electronic freight transport information, four working teams have been established to assist the EU in the implementation of this regulation. The following are the four groups:

- "Data" Team: Contributes to defining eFTI data sets per EU and national legal acts;
- "Functional" Team: Shapes specifications for the eFTI environment, covering rules, procedures, and platforms;
- "Technical" Team: Advises on technical aspects of eFTI environment architecture;
- "Implementation and Certification" Team: Assists in creating certification rules for eFTI platforms and service providers.

- **Subgroup 2: Corridor Freight Information System**

Continuing in the pursuit of seamless and efficient logistics, a critical need is addressing interoperability that enhances multimodality. In a scenario like the one experienced in the past with the collapse of transportation infrastructure, reducing dependence on certain modes is crucial to ensure the proper performance of supply chains and overall productivity. The dataspace is designed to unify current or upcoming platforms within a federated network, facilitating seamless connectivity and data sharing among all private and public stakeholders within a neutral and trustworthy environment.

Similarly to what reflects Subgroup 1, on this occasion, four working teams have been established with the aim of developing technical specifications for data exchange, as well as a guide for both, the public, and private sectors. The four working teams are the following:

- Plug and Play: Facilitating individual stakeholder connection and data sharing with joint agreements;
- Technology-Independent Services: Developing platform services for universal processes, business interoperability, and legal compliance;
- Federation of Platforms: Enabling interoperability between diverse platforms, even with varying technologies;
- Trusted, Safe, and Secure: Establishing neutral governance for secure data sharing across multiple platform providers, including peer-to-peer solutions.

- **Subgroup 3: Electronic Freight Transport Information (eFTI) Delegated Acts**

The enactment of Regulation (EU) No 2020/1056 [19] on electronic freight transport information (eFTI), effective since August 20, 2020, stands as a key measure in the digital transformation of transport and logistics. The Commission, prioritising smart mobility, aims for paperless freight transport by 2030, aligning with the Sustainable and Smart Mobility Strategy.

The eFTI Regulation empowers the European Commission to adopt delegated acts, and Sub-group 3, "eFTI delegated acts", was established to consult experts of each Member State on the development of the regulation. In addition to this, the Commission decided to hold consultation meetings within the DTLF on the eFTI's draft delegated acts.

To address this, DTLF formed a special sub-group comprising experts designated by Member States and observers from a limited number of stakeholders. As of DTLF's last mandate, sixteen independent observers²² were appointed to it. Shall it be deemed necessary, experts from the European Parliament and the Council may also attend meetings in accordance with the Interinstitutional Agreement on Better Law-Making.²³

Regarding the project itself, the existence of such initiatives facilitates innovation by lowering technical, documentary, and procedural barriers, thereby reducing costs and enhancing efficiency throughout the entire chain. Since these three subgroups are continually evolving, it's important to monitor the outcomes to prevent any non-compliance and, directly, gain benefits from the milestones achieved.

3.3.2 Electronic Freight Transport Information (eFTI)

Electronic Freight Transport Information (eFTI) is a European regulation that aims to govern electronic information in the freight transport sector. Its goal is to tackle the issue of establishing and clarifying procedures across Member States to achieve greater interoperability and operational guarantees, lower costs, increased efficiency in information, and better communication among the parties involved in the sector. This, in turn, will act as a driver for the improvement and market uptake of digitisation in this industry.

To promote the digitisation of freight transport and logistics to reduce inefficiencies, as well as to enhance the execution capabilities of competent authorities, and increase the efficiency and sustainability of transportation, the European Commission approved in 2020, the Electronic Freight Transport Information Regulation (eFTI 2020/1056) [19]. This regulation encourages the use of digital technologies to:

- Meet regulatory requirements associated with the necessary documentation for freight transport;
- Reduce administrative costs for operators;
- Attain acceptance by competent authorities of electronically provided information on freight transport;
- Ensure the consistent implementation of the acceptance obligation by such authorities;
- Guarantee the interoperability of the systems and computer solutions used.

The eFTI employs three pathways of work to define these regulations. Apart from DTLF, which was mentioned in the previous chapter, these groups are DTLF SG3, responsible for developing Application Documents (AD) to define basic standards, and the Digital Transport & Trade Facilitation (DTTF) which develops Alignment Elements (AE), aiming to achieve consistent implementation conditions within the EU. The exchange of documents will be carried out through the eFTI platforms based on ICT systems and databases designed to store document information. The Commission possesses a high-level infrastructure that mandates authorities to connect to a national interface, which subsequently redirects their requests to the appropriate eFTI platform. Both platforms and providers must obtain certification from a Conformity Assessment Body (CAB) in order to ensure secure

²² As of DTLF's last mandate, the group of observers was composed of experts of different Member States of the transportation and IT fields.

²³ The Interinstitutional Agreement on Better Law-Making is an instrument aimed to improve cooperation between the Parliament, Council and Commission to enhance transparency. Furthermore, the agreement sets rules for public and stakeholder consultations, which is the case here.

exchange of information. The data model, which includes all information requirements in accordance with each legislation, was adopted in June/July 2023. Member States must adopt the eFTI Regulation by December 2025, although they may choose to do so earlier if they are prepared, and certified eFTI platforms and service providers are available.

3.3.2.1 European Regulation on Transport Information (eFTI): Regulation (EU) 2020/1056 of the European Parliament and of the Council of 15 July 2020 on electronic freight transport information (eFTI)

The European Regulation on Transport Information (Regulation (EU) 2020/1056 of the European Parliament and of the Council, of 15 July 2020 on electronic freight transport information) aims to “encourage the digitalisation of freight transport and logistics to reduce administrative costs, improve enforcement capabilities of competent authorities and enhance the efficiency and sustainability of transport. This legal text was developed to create a uniform legal framework at the Union level, since it is considered to be the main reason for the lack of progress towards the simplification and greater efficiency of information exchanges made possible by available electronic means. Thanks to the eFTI developments, logistics actors shall make information available in a machine-readable or human-readable format for the authorities on the spot. Regulation 2020/1056 eFTI platforms used for processing regulatory information shall provide functionalities that ensure that:

1. Personal data can be processed in accordance with Regulation 2016/679 (General Data Protection regulation).
2. Commercial data can be processed in accordance with Article 6.
3. Competent authorities can access and process data in accordance with the specifications adopted by means of delegated and implementing acts referred to in Articles 7 and 8.
4. The economic operators involved in the process can make information available to competent authorities in accordance with Article 4.
5. A unique electronic identifying link can be established between a shipment and the related data elements, including a structured reference to the eFTI platform where the data is made available, such as a unique reference identifier.
6. Data can be processed solely based on authorised and authenticated access.
7. Data processing shall be duly recorded in operation logs to allow, as a minimum, the identification of each distinct processing operation, the natural or legal person having made the operation, and the sequencing of the operations on each individual data element.
8. Data shall be archived and remaining accessible for competent authorities in accordance with the relevant Union legal acts and national law laying down the respective regulatory information requirements.

Standardisation is a key element of the industrial policies of countries, regions and economic areas. Industry associations, regulators and Standards Development Organisations (“SDOs” for short) create standardisation documents to foster competitiveness, compatibility, and interoperability, and ensure that a level playing field is present in the market. In the field of logistics and transportation, diverse efforts have been promoted by all of the above-mentioned entities with the aim of enhancing communications between all actors of the logistics chain. Apart from international organisations such as the International Standards Organisation (ISO) or European Committee for Standardisation (CEN), the industry has also taken the initiative.

With the advent of digitalisation and new technologies for electronic data exchange, the industry increasingly invested in these to improve its processes and information exchange with customers, authorities, and other means of transportation. Prime examples are IATA’s Cargo XML Standards, the United Nations’ EDIFACT suite of messages or EMSWe. However, these efforts have usually been conceived with the needs of a specific area of the transport sector. To further add to this problem, local logistics communities such as seaports have developed their own ad-hoc systems that cater to their specific local problems, preventing interoperability.

The goal of the standardisation committees described in this document is to achieve interoperability and the interlinking of multiple systems, each with its own unique features and targets. Multiple initiatives, expert forums, SDOs, and other organisations from across the world with special relevance are analysed, placing specific attention on TIC4.0 and its initiative to promote standardisation.

3.3.3 Global System of Standards (GS1)

GS1, the global standardisation organisation known mainly for the development of the barcode, is an association comprised of retailers, manufacturers, material suppliers, and other companies that strive to develop common T&T systems. Since the inception of the original barcode for retail applications, it has ventured into the healthcare and logistics sectors to provide traceability and scanning solutions. The GS1 system of standards works by identifying, capturing, and sharing information about objects throughout their lifecycle in an interoperable way. Its principles are described below [21]:

1. Supply chain partners identify business objects and locations using standardised identifiers.
2. The second fundamental aspect of GS1 is information capturing. All partners have the ability to capture the object's identity and other attributes (e.g., the expiry date), encoded in a standard manner in a data carrier (barcodes, RFID). Thanks to this, the object may be read automatically and consistently across the supply chain. Time, location, and other useful data for tracing are recorded.
3. Once supply chain partners use a common language for identification and data capture, the gathered data is refined and enhanced with business context to transform it into data that can be shared using standardised semantics, in a standardised format, as well as using exchange protocols.

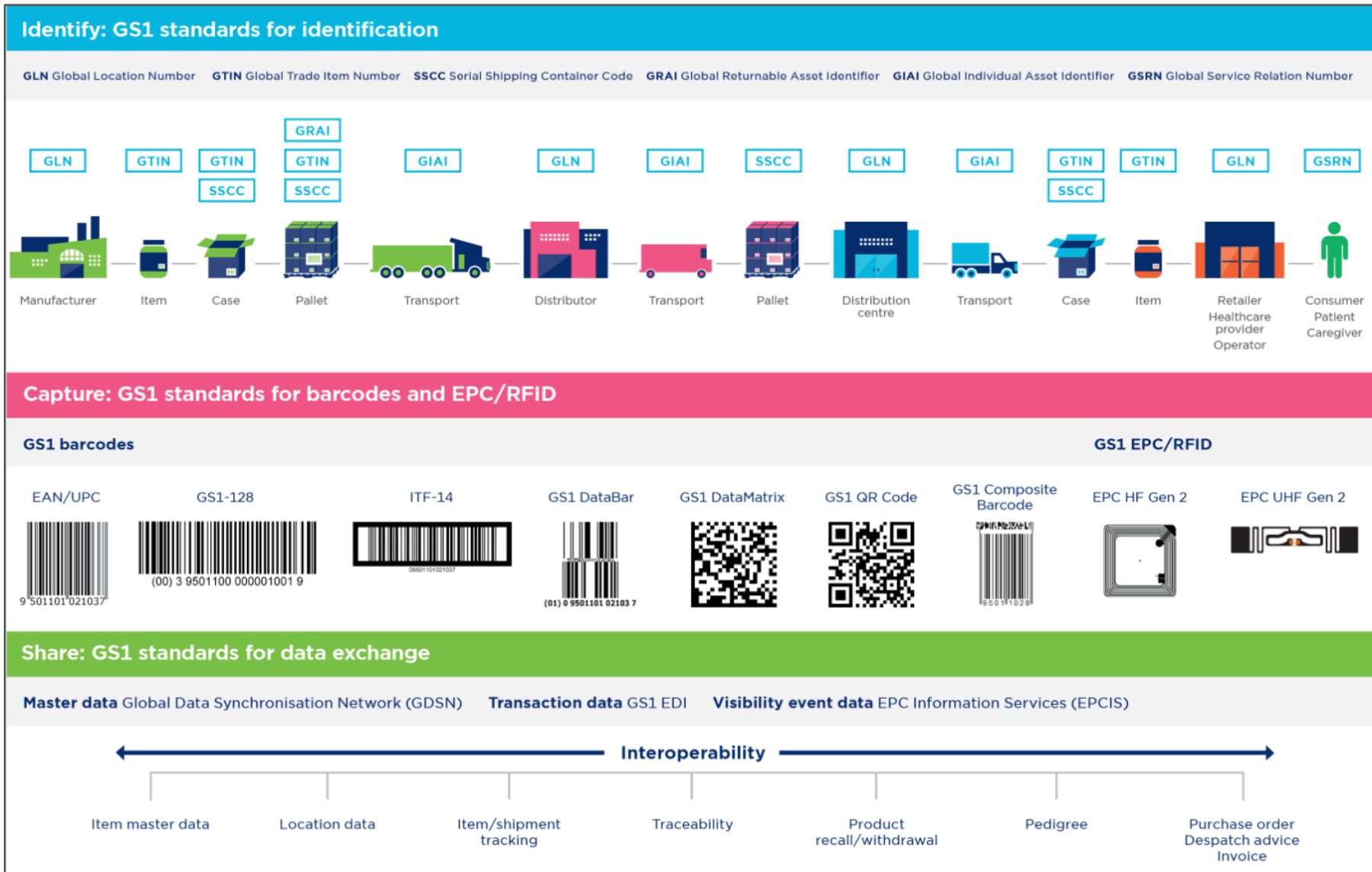


Figure 3-9: GS1 standards procedure. Source: [21]

Logistics standards are developed by GS1's "Transport and Logistics" community. Its flagship publication is the Logistics Interoperability Model (LIM), a framework of common business processes supported by the exchange of related information that ranges from master data alignment to financial settlements. According to the document, the LIM covers the following scenarios, limited to a Business to Business (B2B) environment:

- Procurement;
- Planning;
- Warehousing;
- Financial settlement.

Further processes presented in the logistics chain are out of scope and may be described at the next stage of the LIM development (LIM 2.0).

3.3.4 Advanced Shipping Notices (ASN)

Advanced Shipping Notices (ASN) were created to reduce errors and communication losses in shipment deliveries, especially at the B2B level. The document contains detailed information on the shipment's content and enables digital exchange between supplier and customer, allowing faster shipping deliveries.

Documents are automatically issued by the supplier's software to the company or warehouse as soon as the cargo is shipped, serving as a notification and confirmation. Thanks to this, once it is received at the destination, the receiver can obtain all relevant data (e.g., product, quantity, supplier, shipment data, etc.) by only reading a barcode. Significant time savings are achieved because no paper documents and, thus, manual analysis and processing are needed.

The following data is part of an ASN:

- Shipment number and date;
- Delivery date and delivery conditions;
- Shipment-related information (e.g., addresses, transport conditions, etc.);
- Order data (e.g., cargo type, product, quantity, product batch and serial numbers, etc.);
- Cargo unit used (parcel or packaging type);
- Serial Shipping Container Code²⁴ (SSCC) or GS1 128 code.

ASN is based on internationally accepted standards: the US uses the EDI 856 standard (defined by ANSI X.12), and the rest of the world employs the DESADV (Dispatch Advice Message) of the EDIFACT messaging system.

3.3.5 Convention relative au Contrat de Transport International de Marchandises par Route (CMR)

Conventional CMR

Mentioned in D1.1, "CMR" ("Contrat de Transport International de Marchandises par Route") stands as a standard dedicated to delineating the regulation of road freight transport, functioning as an international agreement. This document has been embraced by many European states with the aim of overseeing legal matters related to road freight transportation. Specifically, the CMR consignment note serves as evidence of the contract of carriage by road, outlining the extent and responsibilities of the operation and identifying the involved parties and transported goods. Its utilisation implies adherence to the CMR, which governs this document. It contains the instructions provided by the exporter or importer to the carrier, making it imperative for it to accompany goods in road shipments.

The issuance of this document is typically the responsibility of the carrier (the truck driver), who must include all necessary information for formalising the collection of the goods. However, in the case of Full Container Load (FCL), the exporter (sender) completes the document upon the truck's arrival at their facility. In Less than

²⁴ 18-digit GS1 identification key used to identify a logistic unit
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Container Load (LCL) situations, the forwarding agent typically handles this document since there is internal transport involved in collecting goods grouped with others from various exporters, sending them collectively to the final destination in a foreign country. For example, the FOR-FREIGHT partner, DHL, mandates the use of this standard in all cases where terrestrial shipping documents are expected to be exchanged.

- **eCMR**

The electronic counterpart of CMR, known as the eCMR Protocol, adheres to the same principles but integrates all stakeholders in the supply chain through a digital platform [22]. The eCMR platform updates each stage and delivery status digitally. This version is recognized as a comprehensive transport document, requiring a credible electronic signature, often implemented through blockchain technology. While eCMR is not universally adopted across EU countries, it is anticipated to become mandatory in the coming years.

3.4 Air Transport Related Standards

Since the Greek UC considers air transport as the final stage of the chain, it is necessary to determine if there is any initiative harmonising activities and serving as a reference to simplify communications between this mode of transport and the preceding stages in the established sequence for this use case. Standards aimed at disciplining operational and communication processes would facilitate the coordination of activities in a transport medium like air, which depends on agility to meet committed schedules.

3.4.1 IATA

The IATA is a globally recognised trade association representing the interests of airlines across the world. Established in 1945, IATA serves as a unifying force within the aviation industry, aiming to promote safe, secure, efficient, and sustainable air transportation.

One of the key roles of IATA is to establish and uphold standards related to various aspects of airline operations, particularly concerning cargo handling and logistics. IATA develops and maintains standards and best practices that govern the handling, transportation, and documentation of air cargo shipments. In the realm of cargo operations, IATA's contributions are manifold. It formulates standards and guidelines for packaging, labelling, and handling procedures to ensure the safe and secure transportation of goods by air. These standards cover a wide range of areas, including the classification of hazardous materials, temperature-sensitive shipments, and perishable goods.

Furthermore, IATA plays a crucial role in streamlining processes and procedures related to cargo operations. It develops industry-wide standards for electronic documentation, such as electronic air waybills (e-AWB), which facilitate paperless transactions and enhance efficiency throughout the supply chain.

3.4.1.1 IATA Resolution 672 E-air Waybill

IATA passed Resolution 672 “E-air Waybill” to create a digital equivalent of the paper Air-Waybill, the contract between the airline and the “shipper”. Airlines and other interested parties developed the multilateral e-AWB agreement to ease paperwork burdens. Once a party signs, it gains the ability to exchange e-AWB with other parties, both airlines or freight forwarders.

The agreement includes the legal framework for signatories to conclude cargo contracts by electronic means and provisions for [23]:

- The consent to do e-AWB;
- High level operational aspects of e-AWB;
- Confidentiality and security of data;
- Rights and obligations of parties.

All of these can be achieved while not modifying the conditions of the contract and carriage. Thus, the benefits of adopting e-AWB are numerous. Firstly, airlines have a single agreement with IATA that enables them to accept

e-AWBs from all participating freight forwarders. In turn, freight forwarders have a one-stop shop agreement which allows them to tender e-AWB shipments to multiple airlines in airports worldwide. Lastly, all parties remain in control of where and when e-AWB should start based on their technical and operational readiness.

Below (Figure 3-10) is a chart of the e-AWB describing how the process works [24]. Firstly, the shipper sends a booking request with the shipment information and security details. Afterwards, it is the duty of the shipper and freight forwarder to plan the shipment and confirm the booking. Freight Forwarders are in charge of picking up the freight and preparing the cargo for export and transmitting the AWB data to the carrier. Finally, the airline processes the information received from the Freight Forwarder, performs the shipment acceptance checks, signals it as “Ready for Carriage” once preparations have ended, transmits the AWB data to GHA and authorities where applicable, operates the flight, checks the shipment in, and hands over the shipment once the trip has finished:

The below chart presents a simplified view of a paperless air cargo process using the main e-AWB messages

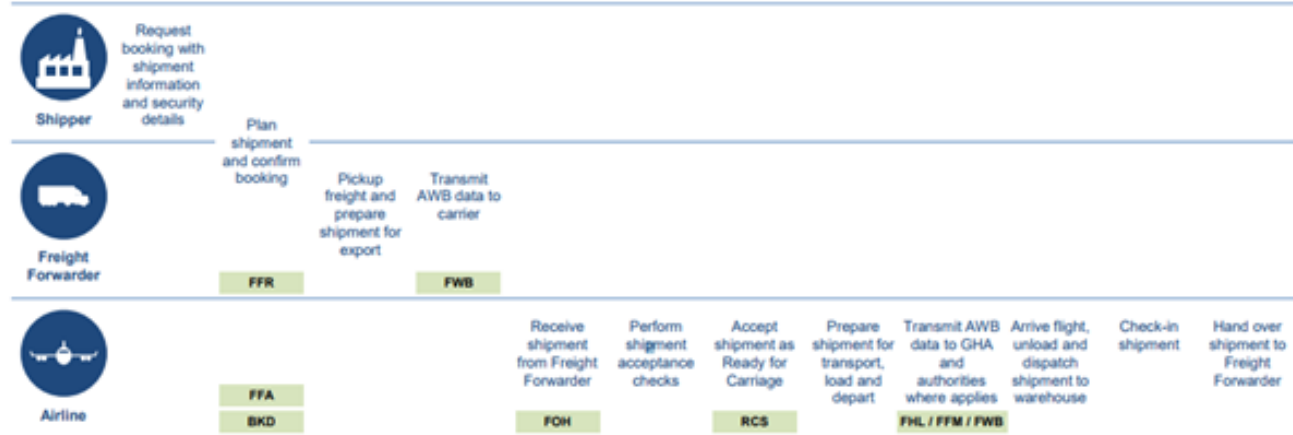


Figure 3-10: Paperless e-AWB process. Source: [24]

3.4.1.2 IATA Cargo XML

Developed by IATA, Cargo XML is an emerging standard for the electronic communication between airlines and other stakeholders such as shippers, freight forwarders, ground-handling agents, regulators, customs, and security agencies. For the messages, the standard has looked at multimodal and cross-border messaging, aiming to [25]:

- Facilitate cargo business processes;
- Fulfil customs’ requirements for Advanced Cargo Information (ACI) filing;
- Comply with security regulations like e-CSD.

The organisation has laid down the requirements and methods in a “White Paper”, dated from 2016, which serves as a guide for the industry to adopt digital information exchange across the supply chain. Furthermore, a Manual and toolkit are available to the public. Lastly, the messages are developed by an in-house Working Group, who, in turn, uses the United Nations Center for Trade Facilitation and Electronic Business component library as a guide. Cargo XML is more focused on administrative processes than on operations, the focus being the manifest, waybill, and booking. No provisions on terminal handling equipment, cargo or aircraft movements are made.

3.4.1.3 ONE Record Standard

In recent years, IATA has developed the ONE Record data-sharing standard with the goal of improving efficiency, transparency and collaboration in the air cargo industry [26]. The work builds on the association's previous standardisation program (e-freight program), which was started in 2005 and led to the creation and implementation of the e-AWB, the current standard for most shipments. ONE Record is "a data sharing standard that provides a single record view of shipments, facilitating data integration, system connectivity, and security among airlines and their partners. This standard promotes digital innovation and expands the use and role of data in the industry" [26]. By adopting the ONE-Record standards, the entire airline industry would benefit from "increased transparency and traceability, reduced paperwork and manual processes, improved data accuracy and consistency, real-time data access and enhanced data sharing and collaboration" [26]. ONE Record will serve as a starting point for achieving true digitalisation for air cargo operations. Airlines, partners and service providers would cooperate via collaborative, digital services while helping to create digital experts in the air freight industry. IATA governance programs foresee that airlines will have developed ONE Record capability by 1 January 2026 [26].

The standard is comprised of [26]:

- A common data model for air cargo that enables data integration with existing and new data services
- API specification detailing how airlines and their partners can connect their existing systems with each other
- Security specification that ensures data privacy and confidentiality for everyone involved

More than 200 companies around the world are currently testing and implementing more than 25 ONE Record Use Cases comprising topics ranging from the exchange of air waybill data, freight tracking, customs processes and multimodal transport integration. According to IATA, these pilots are being transformed into real operational systems and capabilities [26].

3.4.1.4 Cargo Community Systems (CCS)

CCS, also called "messaging service providers" is a system commonly used in the air cargo industry. According to IATA "White Paper for Digital Connectivity", CCS gives air cargo stakeholders an integrated platform for data sharing and reuse. These adhere to IATA messaging standards and provide solutions for regulatory compliance and support a wide range of heterogeneous protocols ranging from proprietary to modern web-based communications. Most of air cargo data today is exchanged using CCS, with connecting intermediary software a popular choice for air cargo communications. Stakeholders connected to a particular CCS much like PCS, constitute its community. For them to communicate with it, a single communication channel is established with the software.

To collaborate and interconnect with each other, CCS providers collaborate and interconnect with each other to enable information exchange with the communities of other systems. Airlines and Freight Forwarders are connected to common CCS for commercial and operational reasons, and they can join multiple communities directly. However, challenges arise when using CCS systems. The IATA White Paper names the following:

- Lack of a standardised registration process;
- No prerequisites defined for customers;
- Lack of standard business processes between airlines, freight forwarders and CCSs for issuing and sharing IDs;
- Complex problem-solving when multiple CCSs are involved;
- Switching from one CCS to another complicated;
- Lack of end-to-end visibility (track and trace) on the customer end;
- Lack of transparency on the customer end;
- Technical details (i.e., communication protocol) of a customer remain with its CCS partner;
- Lack of a central repository for who is using certain communication protocol.

Some challenges are of a severity that can prevent significant technological advancements in the air cargo industry, requiring from action to achieve improvements.

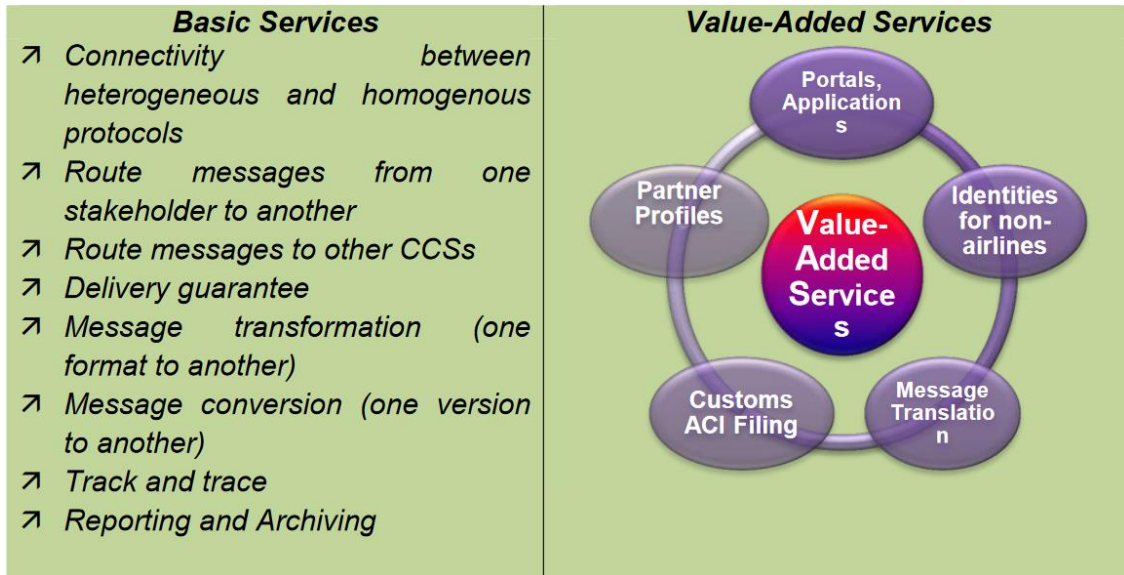


Figure 3-11: Basic services provided by an airport CCS. Source: [27]

The evolution of CCS has seen it expanding their scope to non-traditional players in the cargo supply chain. Customs authorities and regulators can access them to allow for filings and reporting. In parallel to this, they now offer other value-added services and products (e.g., portals and applications).

3.5 Railway Related Standards

Similarly to the Greek use case, where air transport is considered, in the Romanian use case, the train is the chosen means of transportation to connect the port and the hinterland. This particularity creates the need to consider the standards currently in use, as well as those being developed that may have some application in the near future, affecting the project's development in some way.

3.5.1 Convention concerning International Carriage by Rail (COTIF) and International Rail Transport Committee (CIT)

The Convention on International Carriage by Rail (COTIF), which applies to Europe, the Maghreb and the Middle East. OTIF Member States apply most of the appendices to COTIF (the CIV, CIM, RID, CUV, CUI, APTU and ATMF Uniform Rules). The regulations cover everything from the Contract of International Carriage of Goods by Rail (CIM), and Contracts for the Use of Infrastructure. Furthermore, its regulations draw on the TAF TSI and TAP TSI Standards of the European Union for the telematic exchange of freight-related data [28]. CIT Rail also has a Multimodality Committee, whose mission is to improve the framework conditions for the signature of multimodal contracts of carriage, particularly for shipping firms, road hauliers, and railways. However, it focuses on administrative processes.

4 Use Case application of standards: the case of FOR-FREIGHT

In Deliverable D1.1, a series of standards used by all project partners was identified to gather insights on the available technologies and standards of interest for the FOR-FREIGHT solution. The following table, also available in D1.1, represents all current standards in use by the partners, as of the time of writing.

Table 4-1: FOR-FREIGHT SotA – Current and expected T&L Standards. Source: FOR-FREIGHT D1.1

Type of Standard	Standards	Testbed
Technology for vehicular communications	ETSI ITS	All
	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

Considering the parts of the logistics chain and the means of transport the partners cover, it can be seen that a significant fragmentation exists. Therefore, one of the main challenges of the project will be the uniformisation and unification of information exchange to ensure that it runs smoothly and seamlessly.

4.1 Spanish Use Case

This section is a deep dive and analysis on the existing standards and its usage within the Spanish use case. The analysis is divided into three main areas covering the entire logistics chain from the creation of a port call to the delivery of the goods to the designated locker at a specific metro station. The Spanish use case begins with the unloading of an import container from a ship to a port terminal. Subsequently, the container is transported by train or truck from the terminal to a warehouse where it is deconsolidated. Once at the warehouse, the parcels are sorted and placed in roller cages, then transported by vans to the metro depot located in the Madrid Metro's garages. The roller cages are loaded onto train cars and unloaded at stations where lockers will be located to finally deposit the parcels for the end customer to retrieve.

4.1.1 Ship-port data sharing harmonisation

The majority of processes related to information exchange at the Port of Valencia are centralised on the platform created by the Port Authority of Valencia called ValenciaportPCS. This platform acts as a central hub for the communication of all transportation and logistics agents linked to operations at the port.

4.1.1.1 Port Call Request

The initial communication related to ships and ports in Valencia starts with the call request for a berth at the port. This process involves the exchange of multiple documents, which are directed towards the entities that need the information. Streamlining the authorisation process for vessel docking and berthing, this system interfaces with both the Port Authority of Valencia and the Maritime Captainty, handling authorisation requests efficiently. To agilise the service and meet electronic documentation submission requirements to the Port Authority of Valencia (APV), ValenciaportPCS offers the Client Application. Through an extensive form, this application expedites the completion of requests, automatically transmitting them in a singular submission to the Port Authority, Maritime Captainty, and Customs.

The Berth Management Service facilitates the submission of:

- Detailed vessel notifications, encompassing technical specifications;
 - Berth requests for efficient scheduling;
 - Notifications concerning passengers, crew members, and waste management.
- **Operational procedures:**

The Maritime Agent submits essential data to the Port Authority, including the arrival port, vessel particulars, shipping company details, and prior and subsequent discharge ports. Upon berth acceptance, comprehensive information on passengers, crew, waste, and other pertinent details is promptly transmitted. Beyond assigning a berth number, the submission of the berth request initiates the customs folder automatically, streamlining the clearance process for goods to be loaded or unloaded from the vessel. The exchanged messages are as follows [29]:

Table 4-2 : EDIFACT messages exchanged during operational procedures. Source: own work

Name	Description	Standard
BERMAN	The Berth Request message is sent by the Ship's Agent or Consignee to the Port Authority. Typically transmitted at least 24 hours prior to the vessel's arrival, it includes identifying information about the vessel, shipping line, transported goods, and planned operations.	EDIFACT
PAXLST	The Crew List message is sent by the Ship's Agent or Consignee to the Port Authority. Typically dispatched at least 24 hours prior to the vessel's arrival and, in any case, it is necessary to send it to obtain confirmation for a Berth Request. It provides details about the crew upon entry and exit of the vessel, including their rank and identification.	EDIFACT
WASDIS	The Waste Notification message is sent by the Ship's Agent or Consignee to the Port Authority. Typically dispatched at least 24 hours prior to the vessel's arrival, and in any case, it is necessary to send it to obtain confirmation for a Berth Request. It includes details about the type and quantities of waste stored, as well as references to the latest deliveries made.	EDIFACT

The communication protocols used for sending and receiving the messages are as follows:

- SOAP (Simple Object Access Protocol);
- API REST (Representational State Transfer).

4.1.1.2 Vessel Arrival and Port Communication

- **Arrival**

The arrival of a vessel at the Port of Valencia triggers various processes that require different exchanges of data and information. Currently, the Port of Valencia does not have a formally implemented standard regarding this aspect.

However, one of the most crucial communications is the announcement of the Estimated Time of Arrival and Estimated Time of Departure. In this instance, within the ValenciaportPCS platform, maritime agencies are required to declare and update this information to facilitate the planning and coordination of activities. This information is included in the previously explained original BERMAN, and it is necessary to update it in case of any existing modifications.

- **Port Communication and Services Provider**

Regarding communications among the port, terminals, and port services, there are no homogeneous standards for the communication protocols and message formats. These activities are carried out in a traditional manner, relying on emails, phone calls, and radio frequency communications for the exchange of necessary information between the involved parties.

- **PortCDM – PAULA (Platform for Automatically Linking Agents)**

It is important to emphasise at this point the existence of initiatives at the Port of Valencia for the implementation of the PortCDM concept through the PAULA platform, which would serve as a SmartPort and that is currently in the implementation stage [30] [31].

PortCDM represents an organisational framework designed to enhance predictability in sea transport operations through the establishment of unified and standardised data exchange protocols. It focuses on maintaining a consistent flow of information regarding intentions, outcomes, and potential disruptions related to movements and service provisions across all stakeholders involved in the entire berth-to-berth maritime transport process.

The implementation of a SmartPort under the PortCDM concept would involve standardising both processes and communication protocols at a comprehensive level, consequently leading to the harmonisation of transmitted information.

- **Process Standardisation**

At the process level, the PAULA platform is designed following the standardised processes outlined by DCSA in the Just-In-Time Arrival section. This procedural framework is grounded in the principles outlined by the IMO FAL Convention (IMO FAL), as detailed in the Just-In-Time arrival guide and can be readily applied across various sectors within the shipping industry.

DCSA has categorised the port call process into six key stages:

1. Planning for Berth Arrival.
2. Planning for Pilot Boarding Place Arrival and Services.
3. Execution of Pilot Boarding Place and Berth Arrival.
4. Commencement of Cargo Operations and Services.
5. Planning for Services and Port Departure.
6. Execution of Port Departure.

In addition to establishing a framework of standard processes, DCSA has also harmonised a set of definitions (see Annex II for more details) concerning the most crucial timestamps in the arrival processes at terminals. Additionally, it has outlined in a general manner the four key-points in port call negotiations.

Table 4-3 : Definitions of the timestamps according to DCSA. Source: [31]

Name	Description	Phase
Estimated	When an entity expects to arrive, depart, commence, or complete a service or operation. For example: a carrier provides the terminal operator with an estimate of when it will arrive at berth.	Planning
Requested	When the receiving party requests a service to take place at a specific time. For example: a terminal operator requests a carrier to change its Time of Arrival due to a delay at berth of a previous vessel.	Planning
Planned	The confirmation of the requested time by the sending entity. For example: when a carrier confirms the Requested Time of Arrival at berth from the terminal	Planning
Actual	The actual execution of the planned event. For example: arrival Pilot Boarding Place.	Operational

4.1.1.3 Vessel – Terminal Communications

Finally, in this section we address the communication and processes that exist between the terminals and the ships, mainly focusing on information regarding cargo and operations concerning planning and execution. The standardisation of these operations depends on having a standard in communications through the harmonisation of information with a common semantics. This is essential to achieve proper planning of loading and unloading operations, as well as subsequent yard operations planning. A correct performance in these areas result in a significant improvement in productivity, both in terms of resource allocation and their optimal utilization, greatly enhancing operational efficiency and its impact on productivity.

- **Definitions of messages according to UN/EDIFACT:**

Table 4-4 : Messages exchanged during Vessel-Terminal Communications. Source: UN/EDIFACT

Message	Description
BAPLIE	A message to transmit information about equipment (mostly containers) and goods on a means of transport (typically a container vessel), including their location on the means of transport [28].
MOVINS	A Stowage instruction message contains details of one means of transport vehicle, giving instructions regarding the loading, discharging, and restorage of equipment and/or cargoes and the location on the means of transport where the operation must take place [29].
COPRAR	A message to order to the container terminal that the containers specified must be discharged from a seagoing vessel or must be loaded into a seagoing vessel.
	This message is part of a total set of container-related messages. These messages serve to facilitate the intermodal handling of containers by streamlining the information exchange. The business scenario for the container messages is clarified in a separate document, called: 'Guide to the scenario of EDIFACT container messages' [30].

	A message by which the container terminal reports that the containers specified have been discharged from a seagoing vessel (discharged as ordered, overlanded or short landed), or have been loaded into a seagoing vessel.
COARRI	This message is part of a total set of container-related messages. These messages serve to facilitate the intermodal handling of containers by streamlining the information exchange. The business scenario for the container messages is clarified in a separate document, called: 'Guide to the scenario of EDIFACT container messages' [31].

These universally used messages contain all the necessary information about the cargo and its arrangement on the ship. Both BAPLIE and MOVINS are crucial for terminal Vessel Planners when planning vessel operations. Once this planning is established, Yard Planners are tasked with organising operations according to the above-mentioned plan. The COARRI and COPRAR messages are associated with reporting. In the case of COPRAR, it is the list specifying to the terminal which containers should be unloaded. Meanwhile, COARRI is the confirmation of compliance with the request for loading or unloading of the container.

4.1.2 Cargo handling process standardisation at port terminals

This stage considers whether any of the terminals at the Port of Valencia have implemented the standards presented earlier. Any initiative aimed at harmonising terminal processes, as well as their communications, contributes to increasing efficiency levels and allows for a higher level of interoperability, which helps better coordinate operations that occur before and after the terminal in the logistics chain.

4.1.2.1 Process harmonisation

Unlike the situation within the Port of Valencia, which has invested heavily in the management of calls and taken the initiative to digitise and standardise port services, the development in terms of port terminals does not exhibit the same degree of progress. The implementation of a specific operational standard has not been identified.

It is important to note that, except for the TIC4.0 initiative, no international standard for processes or communications can be considered a benchmark. For this reason, it is considered that the reality of the terminals at the Port of Valencia is reflective of that of other terminals globally.

4.1.2.2 Communication protocols

To analyse the communication protocols used by port terminals, it is necessary to first mention that the Terminal Operating Systems (TOS) are the operational, administrative, and management cores of a terminal. Therefore, interaction with external agents primarily occurs through these computer systems. The widely used Terminal Operating Systems (TOS) in the industry, such as those offered by companies like Navis, RBS, TBS, among others, are equipped with the technical capabilities to interact with the environment by using the primary communication protocols in the port logistics industry.

Table 4-5 : Communication protocols used in the Spanish Use Case. Source: own work

Related to	Communication Protocol
System to System	TCP/IP REST API Web services
System to CHE & CHE to CHE	CAN BUS 4G / 5G TCP/IP UDP/IP

In general terms, a TOS communicates both with other systems and with Container Handling Equipment (CHE). In the case of communications between systems, the communication protocols typically include TCP/IP, REST API, and Web services. These three types of protocols are generally industry standards, so there should be no difficulties in enhancing interoperability. As for communications between the system and CHE, as well as between different CHEs, 4G/5G networks and CAN bus are also widely utilised solutions.

4.1.3 Port-hinterland communication exchange

Successful port-hinterland communication relies on the harmonisation across the different companies and actors which manage the flow of information across the logistics chain. As in port operations, information can be related to the shipment, the vehicles, cargo, customs and others such as financial status and billing.

As of the time of writing, coordination of information varies on a case-by-case basis, depending on the maturity of deployment and development of PCS and similar systems. Even today, some documents are still printed on paper and physically exchanged, scanned or shown at the pick-up or delivery point. At locations where a PCS is present, information regarding delivery and acceptance documents, bill of lading, origin and destination, cargo-related data, vehicle and time is exchanged between land and sea transport seamlessly. However, once the cargo has left the PCS environment, there is no platform that centralizes either the information or the communications between the parties involved in the process. This impedes the flow of operations and increases the likelihood of process breakdowns.

International efforts such as the IPCSA strive to uniformise communication standards for the entire process. Airports, ports, and other actors are present in the IPCSA. Furthermore, messaging systems such as EDI or TIC4.0 provide insight and information on the different activities. However, these initiatives have room for improvement. As for TIC4.0, the FOR-FREIGHT project shows the potential of the common language to achieve mutual understanding and interoperability.

4.1.3.1 Intermodal transportation and associated data formats

As explained before, the Port of Valencia centralises its data exchange and communications via its own PCS. This complex platform gathers the relevant information from all actors involved in a shipment to ensure it flows seamlessly between them. Transport orders, customs status, EDI messages involving trucks, rail loading and discharge lists, Bill of Lading are among the info processed by it.

However, the system still has its gaps. For example, only the transportation companies that possess a compatible API with the PCS can make use of its systems, the ones that are not being obliged to rely on traditional communications such as e-mails. Information on transshipment points is limited, such as shipment and vehicle

status, position, and other useful data. Warehouses and their internal processes, such as picking processes, are not covered by the PCS, since they are not relevant for the port.

For land transportation, the ValenciaportPCS makes use of the “Single Transport Document”, a document comprising the transport orders, transport instructions, and delivery/release orders. It complies with the IFTMIN message of the EDI standard.

In the specific case of railway transport:

- COSCO Shipping Lines creates a Unified Transport Document (DUT), including a rail transport order, an acceptance, on its own local system and sends it to Valenciaport’s PCS;
- The PCS sends an acknowledgement EDI message to COSCO, APERAK, confirming it has received the DUT;
- The PCS splits the DUT into three documents and sends release order to the port terminal, the transport orders to CSP Rail and the acceptance order to Conte-Rail, the dry port;
- CSP Rail sends the Inland Transport Details Confirmation to the PCS which forwards it to COSCO; and also sends the partial Loading List RAIL (COPLIS) to the PCS, which in turn sends it to CSP Logitren, the railway undertaking;
- CSP Logitren completes the loading list and sends the COPORD in the PCS. The latter sends it to the terminal;
- Once the terminal has the confirmation, a confirmation message is sent to the PCS, triggering the messages containing the final loading list (to the railway undertaking), the equipment list (to CSP Rail) and the release confirmation (to COSCO);
- For the discharge list, CSP Rail sends a message (COPLIS) via the PCS to CSP Logitren containing their discharge list of the railway transport. CSP Logitren via PCS sends the Complete Discharge List (COPORD) to the dry port (Conte-Rail);
- Conte-Rail send the final confirmation (COPORD) via PCS, which sends confirmations to every other actor involved (COPORD confirmation to CSP Logitren, COPLIS confirmation to CSP Rail and Acceptance confirmation to Cosco Shipping Lines).

A description of the exchanged messages can be found on the following table:

Table 4-6 : Exchanged messages between all parties in the Spanish Use Case. Source: own work

Name	Description	Standard
DUT (Documento Único de Transporte/Unified Document)	Document comprising the transport instructions, release and acceptance orders of the Valenciaport PCS [32]. The rail transport order is the message in which the Shipping Agent assigns the rail transport to the Logistics Operator. Release order and Acceptance order are sent by the container provider (normally the Shipping Agent) to authorise the release and acceptance of the container in the depots as well as the port and rail terminals.	EDIFACT-based
APERAK	Inform and acknowledge the message issuer that its message has been correctly received or rejected due to issues in the processing of his application [33].	EDIFACT
COPRAR (COPLIS)	Message containing the equipment list of a railway transport [34].	EDIFACT

COPRAR (COPORD)	Message containing the discharge/charge list of a railway transport [34].	EDIFACT
RELEASE confirmation	Release document for each container of a shipment issued by the terminal [35].	XML
ACCEPTANCE confirmation	Acceptance confirmation document for each container of a shipments issued by the dry port [35].	XML
Inland Transport Details	The Transport Assignment message aims to organise road transport between contracting parties, transport providers, container providers, and release and acceptance companies. It enables the transport provider to provide certain information concerning the transport (the vehicles assigned, for example) or the specific operation (actual loading/unloading dates, the plate number of an empty container which has been collected, etc.) [35].	XML
Transport Order request	Request form client to COSCO for the transport of their containers to final destination [35].	NO (e-mail)

When it comes to railway transportation, the European TAF TSI standard of mandatory adoption by railway undertakings in the European Union, has provisions for cargo information, estimated times of arrival, equipment, and other relevant train information. While it is designed to achieve interoperability across infrastructure managers, port authorities, logistics operators and railway undertakings, the documents do not foresee compatibility with advanced PCS or other logistics systems: its sole purpose is to exchange train-related data relevant to the transportation process. It is, therefore, limited to that mode of transport.

Road transport in Spain is a highly atomised business: the vast majority of trucks are owned by self-employed persons. As a consequence, the market uptake of innovative IT technologies is difficult and is done at varying pace depending on the economic possibilities and digitalisation strategies of companies and individuals. In the Spanish Use Case, for example, the truck fleet is not owned by COSCO Shipping, which contracts different transport companies and self-employed truckers depending on the situation.

In a cargo operation using the PCS, the messages are exchanged as described below:

- COSCO Shipping Lines creates a DUT, including truck transport order, acceptance order, and release order, on its own local system and sends it to Valenciaport's PCS;
- The PCS sends an acknowledgement EDI message to COSCO, APERAK, confirming it has received the DUT;
- The PCS splits the DUT into three documents and sends the acceptance order for the empty container addressed to the depot, the release order of the entire container to the terminal, and a transport order for the trucker to collect the container;
- The trucker sends the Inland Transport Details message to COSCO via the PCS;
- Once the container is released, the terminal sends the Release Confirmation Message to the PCS. In turn, the PCS sends it to COSCO;
- When the empty container is accepted by the depot, it sends a message to the PCS (Acceptance Confirmation). The PCS then relays this message to COSCO.

A description of the exchanged messages can be found on the following table:

Table 4-7 : Exchanged messages between all parties in the Spanish Use Case when using the PCS. Source: own work

Name	Description	Standard
DUT (<i>Documento Único de Transporte</i> /Unified Transport Document)	Document comprising the transport instructions, release and acceptance orders of the Valenciaport PCS [32]. The truck transport order is the message in which the Shipping Agent assigns the road transport to the Logistics Operator. Release order and Acceptance order are sent by the container provider (normally the Shipping Agent) to authorise the release and acceptance of the container in the depots as well as the port and rail terminals.	EDIFACT-based
APERAK	Inform and acknowledge the message issuer that its message has been correctly received or rejected due to issues in the processing of his application [33].	EDIFACT
RELEASE confirmation	Release confirmation document for each container of a shipment issued by the terminal [35].	XML
ACCEPTANCE confirmation	Acceptance confirmation document for each container of a shipment issued by the depot [35].	XML
Inland Transport Details (Delivery or Acceptance Orders)	The Transport Assignment message aims to organise road transport between contracting parties, transport providers, container providers, and release and acceptance companies. It enables the transport provider to provide certain information concerning the transport (the vehicles assigned, for example) or the specific operation (actual loading/unloading dates, the plate number of an empty container which has been collected, etc.) [35].	XML
Transport Order request	Request form client to COSCO for the transport of their containers to final destination [35].	NO (e-mail)

The communication protocols used for the sending and receiving of messages are:

- SOAP (Simple Object Access Protocol);
- API REST (Representational State Transfer);
- E-mail.

4.1.4 Last-mile: Subway System

The Spanish UC brings a major innovation by using the subway system for last mile distribution to transport cargo across the city of Madrid. Since this is a novelty, no subway operator in the world has a cargo management system in place nor has developed interfaces to communicate with logistics operators, shippers or end customers. This significant gap shall be addressed if such a solution is adopted in the future. The latest version of TIC4.0's data model, released in November 2023, includes data sections to make it compatible with EDI messages and represent their information in the TIC4.0 language. Therefore, it has potential to be used in future hinterland message exchanges. The advancements on this will be included in the revised version of the Deliverable (D5.6).

4.2 Greek Use Case

The Greek UC describes an entire logistics chain scenario as follows: container discharge from vessel, move container to port warehouse, truck delivery from Piraeus port to Athens International Airport (AIA) (Goldair warehouse) for further loading on aircraft - connecting to proper flight. The following diagram, extracted from Baltazar et al., shows a process diagram for a standard export via air transport:

Export Firm → Insurance → Freight Forwarder A → Handling → Customs → Airline → Handling → Freight Forwarder B → Import Firm

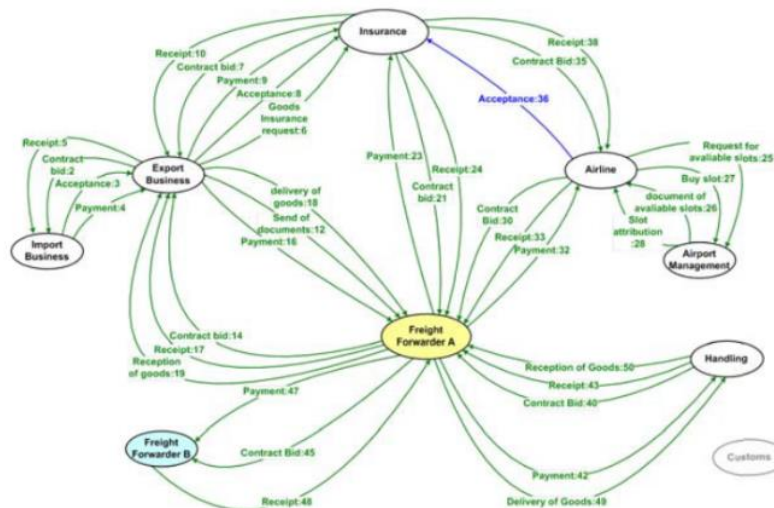


Figure 4: Cargo Contracting Scenario Map

Figure 4-1: Export process in an air transport

As displayed on the diagram, a complex flow of information is required to export a cargo via air transport, set in motion by the export order. The Freight Forwarder centralises the process, by receiving a bid from the airline and processing the payment, contracting the insurance, and managing the process with the export business. It also receives the order of the handling company for the reception of goods. The airline, in turn, asks the airport for available slots for the flight and books them, and receiving confirmation from the airport management. However, no mention is made of other means of transportation required to bring the cargo to the airport.

4.2.1 Ship-port data sharing harmonisation

Piraeus Container Terminal (PCT) maintains and manages the container terminal facilities and operations of all types of containers with the aid of modern equipment and advanced technologies. PCT has launched the “Hellenic Port Community System (HPCS)”, an online platform which connects multiple systems and provides standardised communication [36]. Although the platform provides a variety of tools aiming to offer an integrated system for all stakeholders, most users are still reluctant to use and register (the use of HPCS and registration for several function/operations is not mandatory). Thus, the use and data maintained in HPCS are very limited.

4.2.2 Cargo handling process standardisation at port terminals

The activities of the Port of Piraeus are carried out by the company Cosco, one of the leading operators of port terminals worldwide, operating in the largest ports around the globe. The expertise and technical capabilities of the company ensure the use of top-tier technologies and processes.

4.2.2.1 Process harmonisation

Cargo handling within PCT terminal is done at the PCDC (Piraeus Consolidation and Distribution Centre) warehouse. PCDC is the only warehouse inside the Free Zone area, having major advantage in handling imported containers as no custom procedures are required for container transfer between PCT container terminal gate and PCDC. As to what concerns the land transportation leg, there is no standard procedure for information exchange. Most of the communications still rely on traditional pen-and-paper hardcopies, e-mails and telephone calls, therefore making process harmonisation a difficult endeavour.

4.2.2.2 Communication protocols

PCT has selected Computer Automated Terminal Operating System (CATOS) software as the vessel and yard planning software for its Terminal Operating System. Similar to the Spanish Use Case, the use of CATOS allows PCT to exchange various EDIFACT messages, essential for vessel operations planning, with its customers such as:

Table 4-8 : Exchanged messages in the Greek Use Case when using the PCS. Source: own work

Name	Description	Standard
BAPLIE	A message to transmit information about equipment (mostly containers) and goods on a means of transport (typically a container vessel), including their location on the means of transport [37].	EDIFACT
CODECO	A message by which a terminal, depot, etc. confirms that the containers specified have been delivered or picked up by the inland carrier (road, rail, or barge) [38].	EDIFACT
COARRI	A message by which the container terminal reports that the containers specified have been discharged from a seagoing vessel (discharged as ordered, overlanded or shortlanded), or have been loaded into a seagoing vessel [39].	EDIFACT

In addition, any interested party is able to receive the immediate information about container discharge event through Container Discharging Info System (WEB IP) – however, registration in the PCT website is necessary to get access [40]. Cargo handling at PCDC warehouse is managed through WMS system. PCDC information exchange with external users is done mainly via simple e-mail. However, system-to-system connections and customised solutions with modern simplified customs procedures are feasible for special projects (concerns mainly solutions to VIP Customers/ Multinational companies). PCDC warehouse e-services portal are also available with following services:

1. **Customs:** Access to warehouse real-time stock, customs' hold instruction to warehouse, access to all archived files and warehouse books related to Customs'.
2. **Customer:** Place work order (Stuffing-Unstuffing-Cross-docking), real-time tracking for outbound cargo (arrivals and documentation completion), track and trace per container or cargo, auto-notification for task completion, retrieve details of the work or documents (i.e., photos, comments, other useful information for customs' formalities), access to real-time stock; Issue PIN for truck gate-in, and access to KPI's for specific projects such as performance per pallet, truck waiting time, etc.
3. **Custom's broker:** Auto-notification for custom's clearance order, Receive Free Zone custom's status certificate online (necessary for customs' formalities), auto-notification for cargo release, electronic payment.

4.2.3 Port-hinterland communication exchange

The delivery of the cargo to the hinterland occurs once the cargo has been deconsolidated at the warehouse in the Port of Piraeus and loaded onto a truck directly bound for Athens International Airport for subsequent loading onto the airplane. This is a critical point in the logistics chain of the use case, as operations at airports must be

highly coordinated to avoid delays in operations that ensure compliance with the deadlines demanded by the airport terminal.

4.2.3.1 Air-to-hinterland, warehouse process and interaction with last-mile distribution channels

This is the most critical leg of the Greek use case, where the actors have the need to intervene and introduce some communication platform and other technology to enhance communication between different stakeholders (port warehouse, truck, freight handler/forwarder, airport warehouse, connect to aircraft/flight) and provide supply chain visibility and transparency.

Seamless communication through proactive status updates aims to limit disruptions and risk mitigation, while at the same time achieving better warehouse planning/performance and, of course, enhancing customer experience.

- **Involved Parties - Stakeholders:**

Table 4-9 : Involved parties and stakeholders of the Greek Use Case. Source: own work

Freight Forwarder	Customs agent	Sea transport warehouse	Land transport	Air transport (warehouse)
Shipping Line Freight Forwarder (in this case, COSCO Shipping Lines)	Customs Broker	PCDC warehouse	Trucker	AIA warehouse

Unlike sea transport, communication between all above parties is done via phone, e-mail and even physical presence with hardcopies where required. In the specific flow between PCDC port warehouse to Goldair airport warehouse (located in Athens International Airport (AIA)):

- COSCO Shipping Lines (acting as FFW) books the flight and sends the work order to PCDC port warehouse via e-mail;
- COSCO Shipping Lines sends work order to Customs’ Broker via e-mail;
- PCDC will provide availability/slot and PIN for truck gate-in via e-mail;
- PCDC will provide required information for Customs’ formalities procedure to Custom’s Broker;
- Customs’ Broker will prepare customs’ formalities and will deliver hardcopies to truck driver before truck will gate-out the port warehouse;
- Upon truck arrival at Goldair airport warehouse all co-ordination between truck driver – COSCO Shipping Lines office at the airport – Goldair warehouse - Custom’s Broker for airfreight and Custom’s Authorities located in the airport require hard copies and physical presence. Communication is achieved via phone and e-mail.

As described above, the flows of information of the supply chain do not follow a structured standard. Each leg uses non-standardised procedures, even relying on “manual” communications such as e-mail, phone, and paper hard copies for the land transport between the port and the airport. However, despite their potential to improve the current situation, international standards for data exchange like IATA Cargo XML, EDIFACT, and others cannot be implemented due to challenges in communication methods and variations in procedures that are present in the leg between the port and the airport.

4.3 Romanian Use Case

The Romanian use case is the last of the three. This use case is located at the Port of Galati on the Danube River. The process encompasses the navigation of the vessel carrying the cargo, the unloading of the container at the Port of Galati, and the delivery by train to the hinterland where it will be handed over to the final customer.

4.3.1 Ship-port data sharing harmonisation

The Galati Port in Romania has made considerable strides in digitalisation and improving communication, especially in facilitating information exchange between vessels and port authorities. A crucial element of this digital overhaul is the implementation of advanced communication standards, specifically HTTP (Hypertext Transfer Protocol) and HTTPS (HTTP Secure). These protocols facilitate the secure transmission of data across the internet, guaranteeing that the information exchanged between ships visiting the port and the port's administration is done so both efficiently and securely.

The Galati Port's digitalisation efforts, such as adopting HTTP and HTTPS protocols for sharing information, showcase a progressive stance towards port administration. This strategy promotes efficient communication and boosts the port's capacity to manage growing amounts of cargo without compromising on security, safety, or environmental conservation.

The website of the Romanian Naval Authority displays details about a platform provided by agents representing the shipowners of vessels arriving at the Port of Galati. This encompasses both maritime ships and those meant for inland navigation.

Permissions and information management are regulated depending on the type of information exchanged, the companies and authorities involved and other factors.

4.3.1.1 Port Call Request

An example of Ship-port data-sharing harmonisation is represented by The Romanian National Single Window (NMSW). It collects information from reporting formalities required at ship's arrival or departure, distributes the information to the relevant national and local authorities, and records decisions and comments from Authorities and communicates them to the ship representative. In addition, the MSW is interconnected with the European SafeSeaNet system in order to retrieve information from previous port calls from other Member States. Ship data providers can submit notifications via the XML interface (based on ISO 28005 standard) and the Web User Interface, which includes the possibility to upload XLS files. Relevant information is made available to authorities using the web interface.

The Figure 4-2 below represents the submission of notifications by the Ship Data Provider to Authorities. It describes how decisions and comments from authorities are provided to ship data providers via the XML interface (based on ISO 28005 standard) and the Web User Interface. Email notifications are sent to authorities and ship data providers to warn them of new and updated notifications or decisions.

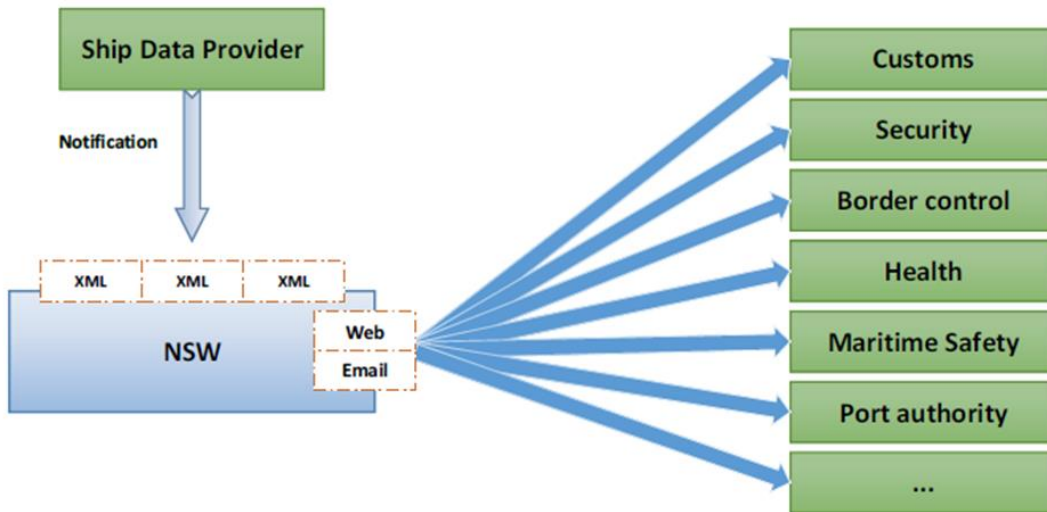


Figure 4-2: Distribution of information from the MSW platform to the authorities: Source [41]

The Figure 4-3 below represents the report of Authorities' decisions and comments to the ship data providers:

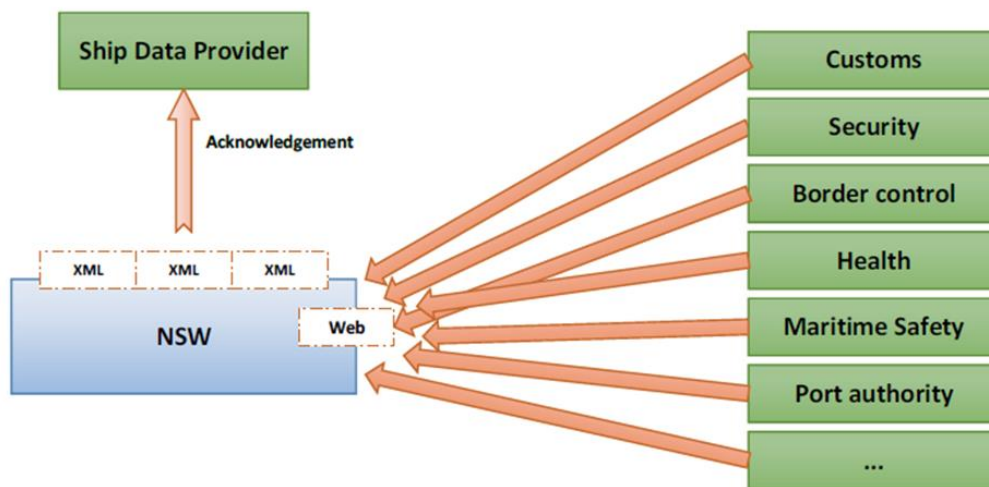


Figure 4-3: Distribution of information from the authorities from the MSW platform. [41]

Information is reported to The Romanian Maritime Single Window (NMSW) in notifications, sent before arrival ("arrival notifications") before departure ("departure notifications") and at arrival/departure (included in "arrival"/ "departure notifications"). Notifications may be reported through a web interface or a system interface. Data elements can be reported in distinct notifications by one or several ship data providers. Updates of previously provided information are accepted (in order to update or correct parts of the information).

The Figure 4-4: Information flow in MSW platform. Source below represents the information flow in the MSW:

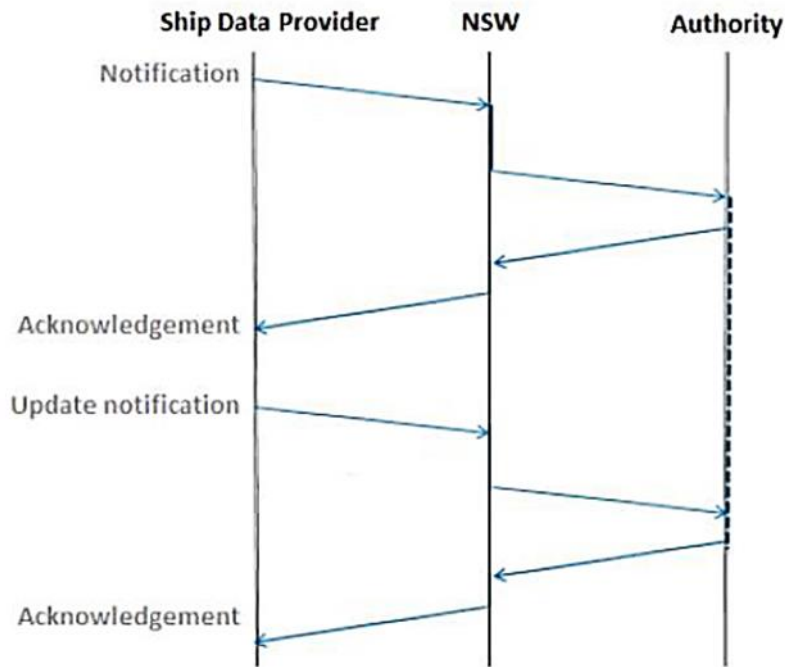


Figure 4-4: Information flow in MSW platform. Source [41]

On the other hand, ship-port data-sharing harmonisation for inland vessels is also made using HTTPS, namely Central & Eastern European Reporting Information System (CEERIS): which is included in the EuRIS platform. The EuRIS platform is a collaborative effort between thirteen European countries, established as part of the RIS COMEX project from 2016-2021. It functions as a comprehensive system for skippers, vessel owners, and logistics operators, providing vital information for navigation on major European waterways. Importantly, the platform allows users to customise the information they receive and ensures privacy by allowing the information owner to control access. EuRIS presents all waterway and traffic-related information of thirteen European countries on handy maps or in tables, with:

- A real-time traffic image;
- Position information of authorised vessels;
- Notices to Skippers;
- Actual water levels, discharges, bridge clearance, water depth;
- Information about the fairways, bridges, locks, berths, terminals;
- The operating times of locks and bridges;
- A Route and Voyage Planner;
- travel duration and expected arrival times.

An example can be illustrated through the reporting obligations for a convoy journeying from the Port of Constanta to the Port of Reni in Ukraine, which includes specific requirements from both the Port of Constanta and the Port of Galati, as follows:

<input type="checkbox"/>	Reporting requirements	The country	Tip	Authority
<input type="checkbox"/>	Passing 3	Romania	Pass	Multiple
<input type="checkbox"/>	Passing 4	Romania	Pass	Multiple
<input type="checkbox"/>	RO Galati Maritime Danube Ports Administration Arrival	Romania	Arrival	CN APDM Galati
<input type="checkbox"/>	RO Constanta Administration of the Navigable Canals Departure Agigea	Romania	Departure	Navigable Canal Administration
<input type="checkbox"/>	RO Constanta Administration of the Navigable Canals Arrival Agigea	Romania	Arrival	Navigable Canal Administration
<input type="checkbox"/>	RO Constanta Maritime Ports Administration (APC) Arrival	Romania	Arrival	Constanta Maritime Ports Administration
<input type="checkbox"/>	RO Galati Maritime Danube Ports Administration Departure	Romania	Departure	CN APDM Galati
<input type="checkbox"/>	RO Constanta Maritime Ports Administration (APC) Departure	Romania	Departure	Constanta Maritime Ports Administration
<input type="checkbox"/>	RO Constanta DAVID Departure International Report	Romania	Departure	Multiple
<input type="checkbox"/>	RO Constanta DAVID Arrival International Report	Romania	Arrival	Multiple

Figure 4-5: Reporting obligations in CEERIS/EURIS platform. Source: own work

More thoroughly, for example, for Romanian Galati Maritime Danube Ports Administration Arrival, following information must be provided in XML version (WASDIS 1.0, ERIMAN 1.0, INVRPT 1.0, MHDS 1.2, ERINOT 1.4, ERIVYOY 1.4, PAXLST 1.4):

Route	General	Transport	Single ship/Convoy
	Departure		Convoy dimensions
	Destination		Main ship
	Border points		Barge
Operator Details	Vessel Operator	Shipment	Dispatch
	Ship's Agent		Dangerous goods
			Non-dangerous goods
			Particularities

Figure 4-6: Information provided in CEERIS/EURIS platform. Source: own work

4.3.1.2 Vessel – Terminal Communications

In port of Constanta, the MOVINS and BAPLIE files are integral parts of the shipping and logistics industry, specifically used in the context of container handling and stowage planning.

BAPLIE files are a standard EDI format used in the shipping industry to detail the stowage positions of cargo onboard ocean vessels. They provide comprehensive information about where each container is located on a ship, which is crucial for efficient loading, unloading, and planning of cargo handling at ports. After every port call, a BAPLIE file is typically updated, and a final version is usually shared with the next port of call.

MOVINS files, on the other hand, are used for sending modifications to the planned stowage of a vessel. They are particularly useful for terminal operators as they allow for the efficient communication of changes in stowage plans to carriers and ship captains. The ability to convert a BAPLIE file into a MOVINS file is a significant feature that aids in streamlining operations and improving the handling process at terminals.

These files play a critical role in modern shipping and port operations, where efficiency and accuracy in cargo handling are paramount. The utilisation of such standardised file formats allows for better coordination, planning, and execution of container movements, thus enhancing the overall efficiency of maritime logistics.

4.3.2 Cargo handling process standardisation at port terminals

In the case of loading and unloading processes at the ports of Galati and Constanta, there are variations due to the different levels of digitalisation between the two ports. While the Port of Constanta benefits from an operator like DP World, one of the leading operators worldwide, the Port of Galati lacks a container terminal with the equipment and facilities present in Constanta. It is for this reason that it is difficult to find adequate levels of standardisation in this stage of the logistics chain. Similarly, as we have seen in the previous use cases, port operations currently do not have widely adopted levels of standardisation. However, the progress made at Constanta, together with the FOR-FREIGHT's project findings, can represent a starting point for the digitalisation. The shared administration of both Galati and Constanta could act as a driver for this, given its experience and the presence of a major worldwide operator such as DP World.

4.3.2.1 Process harmonisation

Process harmonisation in cargo handling at Romanian port terminals, such as the Port of Galati and Port of Constanta, typically involves integrating and standardising various operational procedures. This includes the use of specific communication protocols and technologies to coordinate cargo handling activities efficiently. For example, the ports might employ digital platforms for real-time communication between the port authorities, shipping companies, and terminal operators. This can involve sharing information about vessel arrivals, cargo specifications, and handling schedules. Additionally, standardised safety and operational protocols are usually in place to ensure smooth cargo handling processes. These standardised processes and communication methods, as briefly also shown in the following Figure 4-7, help to improve the efficiency, safety, and overall management of cargo operations in the port terminals.

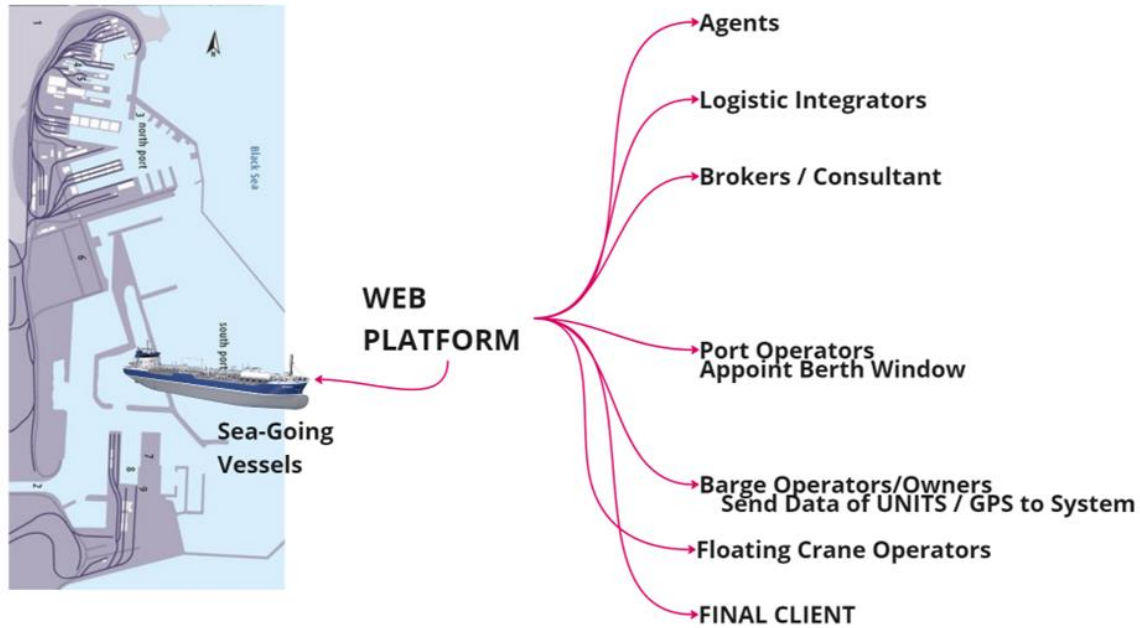


Figure 4-7: Standardisation of operational flows through the web platform

4.3.2.2 Communication protocols

In this section, key-communication protocols are presented and analysed:

NMEA 0183 Protocol: Primarily used in marine navigation systems, this protocol is employed for communication between different marine electronic devices like GPS receivers, auto pilots, and sonar systems. It's a standard for transmitting data over serial connections in the maritime industry.

AIS: AIS is a vital protocol in maritime navigation safety. It allows ships to broadcast their position and other data to other ships and AIS base stations on the shore via VHF radio. This protocol is crucial for collision avoidance and vessel traffic management in ports.

PCS Protocols: These are specialised protocols used within port community systems to facilitate the exchange of information among various stakeholders in the port community, including shipping lines, port authorities, customs, and terminal operators. These protocols help in streamlining port operations and reducing turnaround times.

Transmission Control Protocol/Internet Protocol (TCP/IP) Protocol Suite: Widely used in port IT systems for internal communications and data transfer over the internet. It facilitates the exchange of information between port operation systems, administrative systems, and external entities.

Radio Frequency Identification (RFID): Employed for tracking containers and equipment within the port. This protocol allows for automatic identification and data capture, enhancing the efficiency of cargo handling and logistics operations.

4.3.3 Port-hinterland communication exchange

The expedition of cargo to the hinterland in the Romanian use case is carried out through rail transport. To conduct these operations safely and efficiently, it is advisable to have clear, unambiguous communications. Having communication standards for information exchange and possible protocols, helps reduce eventualities and increases certainty in operations.

4.3.3.1 Last-mile distribution, warehouse process and interaction with last-mile distribution channels

"Last-mile distribution," "warehouse processes," and their interaction with "last-mile distribution channels" are key components in the logistics and supply chain management that ensure products reach their final destination efficiently. The interaction between warehouse processes and last-mile distribution channels is crucial for maintaining the efficiency of port operations. Technologies like RFID tagging and GPS tracking are used to monitor cargo movements in real-time, facilitating seamless transitions between different stages of the distribution process. This system exemplifies the integration of modern technology and logistical strategies in maritime port operations, ensuring goods are moved quickly, safely, and efficiently from ships to their final destination.

4.4 Gaps and inefficiencies of the current situation

Once the analysis of the standardisation status for each specific use case is completed, we can, in turn, understand the developments that exist among the use cases themselves. The next section will analyse in greater detail the status along the logistics chain of each country, identifying gaps internally as well as across levels in each country.

To represent the current situation in a more visual way, the following table has been created. The different levels of standardisation in each stage of the logistics chain are depicted in various colours. Three levels of standardisation have been defined; the red colour represents the absence of any standardisation, including the absence of initiatives in development without application in the theoretical field. The "yellow" colour identifies those parts of the chain where initiatives are currently being developed nowadays to address the gap created by the absence of an established, widespread standard. Finally, in green, those parts where there is a standard that has been widely adopted by the parties involved in the logistics chain.

Table 4-10 : Evaluation of the Use Case’s standardisation degrees. Source: Own work

	Ship-Port			Cargo Handling standardisation		Port-Hinterland		
	Port Call Request	Vessel arrival and port comm.	Vessel-Terminal Comm.	Processes	Comm. Protocols	Haulage transport	Warehouse	Last-mile
Spanish UC	Green	Yellow	Green	Yellow	Green	Yellow	Red	Red
Greek UC	Yellow	Red	Green	Yellow	Green	Yellow	Red	Red
Romanian UC	Yellow	Red	Green	Yellow	Yellow	Yellow	Red	Red

At first glance, different degrees of standard adoption can be observed within the use cases. This is observed and is a common occurrence in all the three use cases, with some particular exceptions. While stages with less development in this regard will be further analysed later in this section, the endpoints of the chain, specifically concerning storage and last-mile distribution, are the areas with lower advancement in standardisation. This situation is observed to be repeated across all three use cases.

4.4.1 Spanish Use Case

The situation of the logistics chain in Spain appears to have the highest level of general standardisation, at least in terms of the processes surrounding the port area. At this point, the main reason contributing to this is the existence and effective functioning of the ValenciaportPCS platform. As we have seen, this tool enables all agents involved in port processes to share information through the platform, thanks to various communication

technologies it offers. It allows companies of any size to utilise the tool for planning their operations, contributing to a well-established level of standardisation.

- ***Ship-Port stage***

Regarding the standardisation of the ship-port stage in Spain, the current the situation can be deemed as “generally correct” in terms of standards adoption and usage. The process of Port Call Request in a port, which is complex due to various administrative procedures that must be complied with, has been simplified through the use of ValenciaportPCS. The existence of the EMSWe, as well as having a platform that incorporates its requirements and centralises them, allow for the standardisation of criteria, aiming to streamline operations.

As for the ship arrival stage at the port and terminal, an intermediate level of standardisation has been considered due to the initiative of the Port Authority of Valencia to continue developing a PortCDM platform. This would automatically standardise both processes and communications by complying with standards such as DCSA and TIC4.0 aimed at regulating these activities. However, currently, and in a widespread manner, there are no standards either at the process, administrative, or communication levels that simplify or serve as a reference. This is why this point was defined as an area for improvement.

Finally, in the stage regarding communications between the ship and terminals, at least in terms of information and data, the level of standardisation is correct since all terminals are equipped with technologies for the exchange of EDIFACT files, which is (EDIFACT) a widely extended standard across major ports worldwide. In conclusion, the current situation at the Port of Valencia is satisfactory, but it is necessary to promote measures that address the lack of harmonisation in the arrival processes at the terminals, as this is one of the points where inefficiencies are most observed when studying the entire chain.

- ***Cargo Handling Standardisation***

After analysing the situation between the ship and the port, it is time to observe and analyse the situation within the port terminals. Out of the two stages, we have divided the analysis into the standardisation of processes, which is mainly the one lacking of a reference standard. Although, as mentioned earlier, terminal processes do not vary significantly due to their similarity, and they also lack a widely extended standard. This is the case in all the three terminals in Valencia, as well as globally. The presence of an initiative of TIC4.0 was the main factor in assigning the “yellow” colour, which will be detailed shortly. While it has not been formally implemented within the terminals, there are initiatives aimed at gradually introducing the solutions developed by the Association. Additionally, although the existence of such solutions would drive a significant improvement in the management and productivity of the chain, enabling better interaction between the parties, the current state of the situation does not show potential complex risks that could jeopardise the proper development of operations.

Concerning the communications between the terminals and the environment, whether in transport or administration, the actual situation does use the necessary technologies that comply with the most commonly used communication protocol standards at an industrial level. Having three operators of first-rate international terminals such as Cosco Shipping Ports, MSC Terminals, and APM Terminals enables the deployment of cutting-edge communication and operations management systems capable of supporting all types of standards in the port sector. Therefore, it is considered that the level of standardisation at this stage is appropriate. In conclusion, while the cargo handling stage in the port could still benefit and improve from standards aimed at harmonising processes, the overall result is positive.

- ***Port-Hinterland***

The last phase in the Spanish use case involves the connection between the port and the hinterland, storage, and last-mile distribution. This stage is perhaps the most sensitive in the project because the majority of users of the future platform will be concentrated in the processes that occur after the departure of the merchandise from the port. In comparison with the previous stages within the Spanish use case, this phase has a lower overall

level of standardisation. As the process moves away from the sphere of the port, standardisation becomes more diffuse and scarcer.

The only stage that, although insufficient, has an acceptable level of standardisation and harmonisation, is the connection between the hinterland and the port. Similar to previous processes, this part of the logistics chain has managed to gain efficiency through the possibilities offered by the ValenciaportPCS platform. Likewise, in the maritime phase, the platform enables significant interaction between the port and transportation to the hinterland, allowing the exchange of information in various standard formats through which necessary notifications are made. Therefore, we consider that this point still lacks further deployment to be considered mature in standardisation, partly due to the challenges that rail transport faces in digitising its processes and improving communications through ValenciaportPCS.

Based on the analysis of the Spanish UC, the following conclusions can be drawn:

- There is significant progress in the administrative part of the logistics process, mainly thanks to the use of internationally recognised standards such as the EDI messaging suite, IALA S/211 and DCSA port call standards, or Maritime Single Windows. In the strictly maritime part, vessels can communicate with customers, services and authorities by using these standards. However, there still are gaps on how some events are defined (Estimated Time of Arrival, for example) or on small details of the definitions. Radio and phone messaging are still used between vessels, pilots, and mooring personnel, due to their reliability and immediacy, with no standardised messages like the ones used by Air Traffic Control in air transport, or Central Traffic Control in railways;
- All the three Valencia terminals do have a TOS. However, they are from different manufacturers. Since communication protocols and interfaces are very similar among them, TIC4.0's solutions could be used to standardise their communications and achieve interoperable results;
- The Port Community System acts as the central "data exchanging platform" of the port. All actors participating in the transport exchange information via the system, which relies on EDI messaging and protocols to structure its data. Some local improvements, such as the Unified Transport Document, have been developed based on them. However, the influence of the PCS decreases the farther you go from the port. Warehouses, dry ports, and other hinterland actors do not report their actions into the system;
- In contrast to the administrative process, the physical process part shows significant gaps in standardisation. Data collection from sensor-equipped machinery, vessels, vehicles is done in heterogeneous ways, with no collective standard to represent the data in a digital format. For example, there is no link between the Terminal Operating Systems of the terminals and the PCS. TIC4.0's common language could bring significant advantages to this: its universal dataset is oriented to achieve interoperability and common ways of structuring, representing and storing the data. Standards such as the TAF TSI are more oriented to share information about the equipment, schedules, and transportation details for a single transportation mode;
- To achieve the goal of the FOR-FREIGHT platform, a representation of the arrival forecasts and other transportation information shall be created based on data provided by each player of the logistics chain. As of today, data provided by the legacy systems of the project's partners does not follow a standardised format. By using TIC4.0's solution and language at strategic parts of the software, the system's output data can be re-structured to achieve an interoperable format for the FOR-FREIGHT platform and its internal solvers to use. Conversely, the end user can benefit from easily interpretable and comparable results;
- The FOR-FREIGHT project uses Metro de Madrid's subway network to transport freight in an urban environment. Since Metro's service is passenger-oriented, its legacy systems are not designed to register and process freight movements and thus, no information exchange systems are in place.

4.4.2 Greek Use Case

The reality of standardisation for the Greek use case, while not ideal, can be considered sufficient and slightly inferior to what is shown in the Spanish use case. The main difference lies in the functionality and maturity of the PCS. In the port of Valencia, this platform is highly institutionalised, operating extensively and involving all actors in the logistics chain. In the case of the port of Piraeus, the PCS is not widely used, so different methods still coexist to coordinate operations, making the implementation of standards difficult.

- ***Ship-Port stage***

Similar to the Spanish situation, the Piraeus Port's efforts in establishing a Port Community System have shown its rewards. Nowadays, all adhered actors' operations related with the information exchange of ship calls can be reliably exchanged with the port authority and others. Despite this, as mentioned above, some reservations exist among the port community that are limiting and slowing down the adoption of the PCS, creating gaps in its technological advancement and data collection. On the other hand, well-established communication protocols such as EDIFACT and other message information technologies are in use at Piraeus. To enhance communication protocols between the actors, Piraeus should centre its efforts in expanding the adoption of the PCS to more port communities. By fostering this, the entire port community could benefit from a standardised platform to centralise data exchange and information, as shown in the Spanish Use Case. Based on the analysis, we can deem the standardisation stage at the port of Piraeus as "intermediate", due to the reluctance of adoption of the Hellenic PCS. TIC4.0's standardisation efforts could assist in the creation of more complex systems like a PortCDM or others. Furthermore, its terminals are equipped with state-of-the art handling equipment and are EDIFACT-compliant.

Summing up the previous information, it can be concluded that the situation at the port of Piraeus has definite room for improvement. Measures to encourage the adoption of standards shall be taken to close the observed gaps in standardisation, and enhance the port's processes.

- ***Cargo Handling Standardisation***

The PCDC makes use of the CATOS, an advanced software for yard and vessel planning, for its operations. Its message exchange is mainly done via EDIFACT messages, while the warehouse has a WMS in place to manage its contents and cargo movements. However, there is no standard procedure for information exchange between the hinterland, as the system relies on specific ad-hoc programs is created based on the needs of VIP customers or multinational companies specifically requesting it. Although an e-services program has been developed for some procedures such as customs notifications and payments, customer tracking, auto-PIN procedures for truckers and others, no notifications are made to agents of the hinterland. Both the CATOS and the e-services portal could serve as the basis for the development of more complex notification and communication methods: for example, the tracking and tracing services could be integrated with the airport's legacy systems to ensure a seamless information flow.

As mentioned before, the presence of the Hellenic PCS has been received with reluctance by the port community. The experiences of other major ports in Europe and worldwide show that PCS act as major drivers for the standardisation and digitalisation of logistics. Further improvements in this field would also benefit the hinterland exchange processes, possibly removing the need for a specific e-services platform. Therefore, further improvements shall be made in the digitalisation area to improve the situation.

- ***Port-hinterland Standardisation***

This is the area where the Greek Use Case shall make definite efforts for digitalisation and harmonisation, since the involved parties (air, road, and sea transport) mainly communicate via e-mail, paper documents, and phone calls. Before any standardisation can take place, the actors should try to develop a unified process for communication and explore the possibility of connecting its legacy systems, for example, via the FOR-FREIGHT platform that is being developed in this project.

The possibility of harmonising TIC4.0 with similar initiatives of air transport such as the ONE Record suite, endorsed by the air transport industry, could open the possibility to harmonise process definitions and the representation of significant events and information of both transportation means. Land transport, on the other hand, could benefit from the experience of other ports that have implemented Port Community Systems for the exchange of transport orders and the registration of important events inside the port. This approach, however, should be made in accordance with the respective actors to maximise acceptance for the adoption of new solutions.

4.4.3 Romanian Use Case

Due to the analysis of the standardisation status in the Romanian use case at the Port of Galati revealing a very low level due to insufficient development in digitalisation, we could conclude that the gaps are very wide in all phases of the logistics chain. Similarly, we will conduct the study based on the analysis of the Port of Constanta, as a framework for future development of digitalisation, standardisation, and interoperability of the Port of Galati.

- ***Ship-Port stage***

The communications, processes, and protocols developed at this stage in the Port of Constanta show moderate standardisation. Segregating the analysis, in the phase related to the Port Call Request, the absence of a PCS with functionalities as seen in the cases of Valencia and Piraeus is key to not considering this phase standardised. The lack of centralised communications on a single platform, through which information is made accessible at a technical level, hinders interoperability. However, the fact of being members of IPCSA, and having an active project for developing a PCS platform is a point that allows us to think that in the future these processes will follow general sector standards.

A positive point is the existence of a National Single Window (NSW) which complies with European regulations regarding the declaration and announcement of the formalities necessary for the arrival and departure of a ship at a port. It is important to note that there is expected to be an interconnection between the future PCS and the NSW, ensuring that information is shared between the parties in a standard way, without duplicating administrative processes. Once this point is developed, it could be considered that there is an important level of standardisation even among the three use cases when carrying out a Port Call Request process, which would be replicable in any of the ports.

Regarding standardisation related to Port Call and Just in Time Arrival processes, the application of a specific standard is also not observed. Romanian ports do not have a standardised methodology for vessel entry nor for the planning and execution of arrival operations such as piloting, towing, and mooring. These communications, as mentioned earlier, continue to be conducted through radio frequency, telephone, and email communications. This same deficiency is present in all the three use cases, making it one of the most immature points in terms of standardisation development.

Finally, regarding communications involving the ship and the terminal for the planning of loading and unloading operations, terminals at the Port of Constanta use standards such as EDIFACT (BALIE, MOVINS, and COPRAR), which are also present in the use cases of Spain and Greece. This is where the greatest alignment between the three use cases is observed, making it possible to consider this stage as standard in terms of data exchange format, semantics, and technologies used.

- ***Cargo Handling Standardisation***

The section concerning loading and unloading operations lacks development related to standardisation due to the absence of validated and adopted standardised processes in the industry itself. However, it is worth considering that within the container terminal operators at the port are companies like DP World, one of the global leaders. It is understandable that they have high-level operations management systems capable of handling operational processes following best practices achievable by global companies. They also have the most

advanced communication technologies to ensure internal interoperability among teams, as well as with external agents.

- ***Port-hinterland Standardisation***

The final stage which involves dispatching the goods to the hinterland in the Romanian use case via train to the customer, focuses on standardisation regarding authorisation information for both delivery and receipt to and from the terminals. As we have seen, this part is carried out at the Port of Constanta through the use of CODECO. However, not having a PCS that consolidates and distributes this information hinders interoperability, as efforts must be duplicated to share the information.

5 Development of roadmaps for standards development and contributions to new standardisation activities to SDOs

As part of the standardisation strategy, TIC4.0 could use both the expertise of current associates who operate land or intermodal transport operations and seek collaboration or expansion to new members from these areas. Since TIC4.0's main advantage is its flexibility and adaptability, it is feasible to continue adapting, expanding, and fine-tuning the data model to represent the "realities" of intermodal transportation. Furthermore, the standard could be promoted at specialised forums that were previously mentioned in this document such as the DTLF, ISO, and other standardisation forums. The adoption of unified standards, an area where the three Use Cases have shown clear gaps and inefficiencies, could be central to achieve better interoperability, enhance the competitiveness of intermodal solutions, and promote the use of synchronised, multi-modal logistics chains. The 'rejection' of intermodal solutions is not solely attributable to physical barriers; rather, it is also hindered by prolonged, time-consuming, and outdated processes of exchanging business data, thereby diminishing its efficiency and appeal.

Based, on the one hand, on the analysis of the standardisation landscape, and, on the other hand, the analysis of standardisation gaps in the three Use Cases, the FOR-FREIGHT consortium has created a set of policy recommendations and roadmaps to pave the way for future standardisation. This has been divided into five "needs" directly targeted to the main areas of improvement and describing future possible advancements and initiatives. Concerning the situation at the port of Valencia, the continuous efforts made by the Port Authority to implement its Port Community System have reaped its rewards. Customs and other formalities can be made via the PCS, while transport orders are seamlessly shared between the actors, thanks to the usage of well-established interfaces and messaging systems such as EDIFACT, API REST, and other market-recognised applications. However, once the cargo leaves the "port sphere", procedures start to get more complicated. Companies rely on third-party, proprietary applications to manage the administrative procedures of warehouses and trucking. Moreover, since the use of the Metro de Madrid network for freight transportation is a completely novel initiative, the subway company has no established legacy system to communicate with logistics operators apart from the spare part management systems. Thus, new policies and systems must be developed to address the advent of novel solutions to transport cargo, as well as rules and regulations. Finally, the situation at the Greek Use Case shows that the bureaucratic processes of the port-air transport supply chain still rely on the traditional e-mail and phone communications. The FOR-FREIGHT platform could serve as an impulse to improve the situation, paving the way for the adoption of common interoperable solutions.

For the sake of clarity, a series of "needs" have been identified based on the report's findings:

- ***"Need 01" - Harmonisation of the port-hinterland communication process – administrative***

Thanks to the multiple initiatives promoted by international (IMO, UN, etc.) and European institutions, the port-hinterland administrative processes enjoy some degree of standardisation. The promotion of MSW and single customs procedures, among others, have eased the burden of international trade. However, significant gaps remain to be addressed, especially in communities where Port Community Systems are absent or are still partially implemented. The presence of a Port Community System accelerates the unification of administrative processes due to its "single window" nature, the usage of internationally recognised standards (EDIFACT, API REST, etc.) for data information exchange, and a design concept targeting the integration of all port actors. Despite this, due to the varied levels of uptake of significant IT technologies by the transportation sector, reluctance to adopt cooperative solutions because of "competition fear" have led to dissimilar levels of adaptation. Lastly, an additional factor is the complexity and lengthiness of legislative procedures and adaptations and changes, which requires institutions and companies to change their systems.

Hinterland terminals are one of the areas where IT implementation diverges between facilities. Even in 2024, phone, paper, and e-mail are still prevalent for information exchange. Customs' procedures, at least in Spain²⁵

²⁵ Spanish Customs Authority "Ventanilla Única Aduanera" (Customs Single Window)

and Greece, benefit from single windows. The European Union Customs Single Window Certificates²⁶, whose regulation was approved in 2022, is a legal framework striving to improve information sharing and digital cooperation between customs administrations and other government authorities in charge of enforcing non-customs formalities at the EU border in areas such as health and safety, environmental protection, food and product safety, agriculture, etc. This will enable easier customs clearance procedures for economic operators, ensuring interoperability between the customs and non-customs domains to streamline the electronic exchange of documents.

- ***“Need 02” - Harmonisation of the port-hinterland communications for physical process monitoring***

Port-hinterland communication is the area where the most significant improvements can be made. Based on the experiences of all three Use Cases, multiple legacy systems and information exchange processes exist, making standardisation a difficult task. Traditional means such as telephone communications and e-mail exchanges are still prevalent, especially in communications between hinterland actors.

In the case of the Greek Use Case, for example, the Port of Piraeus’ “Hellenic PCS” mainly handles the communications of the naval part of the transport. The airport, in turn, relies on proven standards such as IATA Cargo XML and other airport management systems for aircraft operations. However, key documents of the hinterland transportation process are still exchanged via phone, hardcopies, and e-mails between freight forwarders, customs brokers, the port’s warehouse, truckers, and the AIA warehouse. Such a situation, where digitalisation is compartmentalised and limited to single chain actors, completely prevents the use and implementation of standards.

The Romanian situation, in turn, depicts a scenario where the inland port processes have been digitalised via the use of proven standards such as EDIFACT and other web-based solutions. Information flows seamlessly to the customs brokers, agents, crane, barge and port operators and the end customer. As it was the case in the Greek scenario, information exchange becomes more difficult once the cargo leaves the port, relying on traditional means to monitor cargo going in and out of it. Due to the low level of digitalisation and interoperability of this Use Case, the logistics community around the port of Galati shall make efforts to improve its systems. However, the lack of established legacy systems represents a great opportunity to start from a standardised common ground.

- ***“Need 03” - Harmonisation of inland waterway – seaport processes. Extension of the EMSWe to inland waterways***

Represented in the FOR-FREIGHT consortium by the Romanian Use Case, inland waterways is an area where standardisation lags behind compared to its seaport counterpart. Rivers are usually administered by multi-country administrations of the countries the body of water is traversing. Since ships need to traverse canals or reach the sea to enter another river, these administrations have developed their own means for traffic controlling and other procedures. However, since sea-going vessels are capable of entering them, the coordination required between sea and inland waterways to ensure the continuity of the flow of information represents a good opportunity to take the best of both worlds.

The European Maritime Single Window environment was designed with the needs of the sea-going vessels and seaports in mind. Therefore, significant adaptations should be made before it can be used in inland waterways. The opportunity for harmonising and developing a common solution should be taken in a moment where the EMSWe will become mandatory in the next years. As a consequence, the European Union should strive to make a definite push to extend it to inland waterways, since the benefits of its adoption would be of significance and greatly improve the competitiveness of European ports.

²⁶ https://taxation-customs.ec.europa.eu/eu-single-window-environment-customs_en

- ***“Need 04” - Interoperability of mode-specific communications (e.g., Cargo XML, railway documents, etc.)***

As described before, initiatives to standardise process mapping and other operations of each have appeared for each specific transportation mode. However, these developments are usually made independently of each other. Each solution is tailored to tackle the specific problems of the transportation mode, usually ignoring the efforts of the other actors. This contributes to an atomisation of solutions and a lack of interoperability. Furthermore, the degree of digitalisation varies greatly across all modes and facilities: As in the Greek Use Case, paper documents and phone calls are still used for critical communications.

The lack of digitalisation can be seen as a double-edged sword: on the one hand, it acts as a barrier to the market uptake of solutions due to the absence of digital systems; conversely, on the other, it represents an opportunity to start from a “greenfield” situation and deploy truly interoperable solutions from the beginning. To achieve this, the various standardisation initiatives of different fields that are currently working on the creation of common, interoperable solutions shall try to establish a framework for collaboration. This would allow to tackle the interoperability issues from the beginning.

In addition to this, the possibility of interlinking current existing solutions should be explored, as is the case of the FOR-FREIGHT project. As Port Community Systems and Airport Cargo Community Systems show, the implementation of a common solution acts as a catalyst for the adoption of digital solutions by the local logistics communities. Despite this, as the implementation of the Hellenic Port Community System at Piraeus shows, these initiatives can be met with reluctance and resistance. Therefore, an effective communication and implementation strategy shall be designed to showcase the benefits of its deployment. As a positive example, described in the Spanish Use Case section, the adoption of ValenciaportPCS has improved the data exchange between port and hinterland actors. Consequently, all involved actors can seamlessly exchange data, improving waiting times and process development, minimising data losses, and guaranteeing that every company and authority receives the required information in a timely manner.

5.1 Standardisation monitoring

- ***Standardisation of administrative processes***

Administrative processes have benefited from significant developments in regulations and efforts to achieve unified single windows, customs clearance procedures, and other information exchanges. Due to the international “momentum”, these initiatives have generated, international and national institutions should push for the adoption and creation of systems that make use of them, streamlining the administrative procedures and achieving better competitiveness. In order to achieve this, the problem should be tackled from two main fronts:

1. Transposition of EU Directives and formal adoption of standards in national law, with realistic adoption calendars that take into account the subtleties of the national markets and its degree of digitalisation. This action plan shall establish EU-wide and national roadmaps stating clear goals, ideally divided into modes of transportation and interlinking areas for common development and the prevention of development “niches”. The multiple EU institutions and initiatives (e.g., DTLF, EMSWe, etc.) shall oversee the process and coordinate these institutions and initiative, including the collaboration with other international institutions such as DCSA, IATA, etc., to achieve maximum interoperability and acceptance.
2. Establishment of funding schemes and other instruments to foster the uptake of digital solutions in the logistics chain. Since one of the most significant hurdles for the digitalisation is the atomisation and the various degrees of market adoption of digital solutions in transportation companies, institutions should act as one of the main drivers of its promotion with these instruments, in conjunction with the legislative efforts.

As explained before, administrative standardisation is the area where the quickest achievements can be made thanks to the existing work. Further work shall gather the needs and initiatives of different transportation modes together to achieve real seamless communications.

- ***Collaboration with other standardisation initiatives (DCSA, S-211, EDI)***

Ideally, the development of information exchange standards shall take into account the multiple initiatives that the logistics community and regulators are developing to prevent divergences. Apart from EDI and IATA standards, which have the endorsement of internationally recognised “umbrella institutions”, the industry has been organising itself to tackle the digitalisation issue in institutions such as DCSA, IALA, or TIC4.0. Albeit these cover different areas of the logistics chain and processes, these areas do often overlap and/or require from information present in other areas to properly work. Non-interoperability would create inefficiencies and gaps that would hinder the adoption of standards, thereby making “interoperability from design” desirable.

Currently, TIC4.0 maintains active channels of communication with DCSA and other initiatives to integrate DCSA’s language into the data model. Furthermore, a Task Force within the organisation has been created to interpret EDI messages into TIC4.0. Apart from this, the experience of FOR-FREIGHT will serve as the basis for the collaboration with air transport and inland waterways. Both the ONE Record standard and the TIC4.0 standard have been developed for utilization within digital messaging exchange formats, such as JSON or XML. These data models encapsulate process information for specific transportation operations. Considering FOR-FREIGHT's proposal to employ TIC4.0 as the standard for digital data communication to facilitate interoperability, the implementation of a message translator between ONE Record and TIC4.0 would harmonize data representation. To achieve this objective, the initial steps involve establishing equivalences between the definitions within both data models, adapting any ONE Record definitions not already encompassed by the TIC4.0 language. This analysis will pave the way for the development of a translation solution between the two standards, enabling solvers to employ a single, unified data model for information communication. The solution must exhibit sufficient versatility to address these variables comprehensively.

- ***Emphasise the importance of PCS and its potential to drive standardisation initiatives***

The two seaport use cases (Valencia and Greece) have shown how PCSs, when present, act as major factors for digitalisation in port areas. The sole presence of such a system stimulates the adoption of compatible digital solutions in the port community to keep up with progress, resulting in an enhanced competitiveness for all port actors. However, the Greek Use Case also shows that PCS can be met with resistance by established actors. Furthermore, it can act as a barrier for companies and self-employed drivers with less financial resources, thereby increasing the importance of establishing a realistic adoption calendar.

Despite this, the advantages of PCS significantly outpace its disadvantages, making them essential for the improvement of port operations. As a consequence, port authorities and regulators should encourage their adoption and ensure financing schemes that bolster its development of the solution while ensuring that no company is “left behind” in its compatibility.

- ***Standardisation of data collection***

As shown in FOR-FREIGHT's Use Cases, data collection still happens in a “disorganised” way, especially when combining multiple transportation modes. The use of pen and paper, e-mails, and phone calls is still widespread, while each legacy system collects information according to its needs and design. Furthermore, disparities may exist even between terminals and facilities of a single journey. Therefore, compatibility is not guaranteed and data losses due to miscommunications, transcription errors, and others are a very real possibility.

Along with the abovementioned initiatives, a strong focus on data collection and presentation shall be placed by all actors, since uniform data is the basis of a solid interoperability. The FOR-FREIGHT project has shown that uniform data presentation can bring significant benefits for everyone involved in a transport, since data is presented in an expected, structured form that saves development time and costly errors.

- ***Set the basis for the collaboration with standardisation organisations of other transportation means (e.g., air transport's ONE Record, TAF TSI in railways)***

The FOR-FREIGHT project consortium has organisations that encompass all transportation modes (road, rail, sea transport, air transport, and inland waterways). Thanks to this fact, its representatives have been able to compare the standardisation efforts that exist in these, finding common ground for standardisation and areas where from major developments are required before any standardisation can take place. The findings of this report, together with the discussions that have taken place in the project, can be used as the foundations for further collaboration.

At the time of writing (April 2024), the discussions for the harmonisation and adaptation of TIC4.0's data model to other transportation modes were still at their initial stages. Therefore, it is expected that the revised version of D5.5 (D5.6) will include the conclusions of the consortium work, which will revolve about the harmonisation efforts made in the course of the solver's developments and the Use Case's findings.

5.2 Desired Standardisation Impact

To present a complete picture of how standardisation activities can benefit from FOR-FREIGHT, a roadmap on how standardisation efforts can be further developed has been completed as part of this document. The roadmap details the steps that should be taken during and after the project to achieve maximum impact. Further developments and refinements shall be expected for the revised version (D5.6), due for M38 of the project.

5.2.1 Roadmap

- ***Gap analysis and needs for standardisation***

The various situations present at the three Use Cases have served as the basis for a gap analysis and needs for standardisation. While different, the three UCs have shown areas where standardisation is lacking, starting from data collection and communication channels, ending with software disparities and incompatibilities. Furthermore, a broad analysis on current standardisation initiatives was made in this document to present a complete picture of transport organisations. FOR-FREIGHT's methodology and results could be replicated in further projects and sites to gather information on the standardisation status across the EU. Furthermore, the results could be combined with the findings of other European and international projects to present a more complete view on the worldwide situation. The preliminary results show multiple areas where major efforts shall be undertaken to improve digitalisation, especially in the interface of two or more transportation modes (e.g., port-airport, warehouse-metro, etc.).

- ***Open discussions (workshops, sectoral association meetings, international forums) on the topic to address needs and present new solutions***

This activity can be performed during and/or after the FOR-FREIGHT project has concluded and would be a vital part to validate, refute and expand the findings of the consortium. Several workshops should be conducted with the presence of relevant stakeholders, namely:

- Port operators;
- Airports;
- Railway undertakings;
- Railway operators;
- Inland terminals;
- Inland ports;
- Inland waterways authorities;
- Warehousing/3PL operators;
- Road transport companies;
- Airlines;

- Shipping companies;
- Freight forwarders;
- European Commission (DG MOVE, DG DIGIT, DG RTD);
- International institutions (IMO, IATA, UIC, UNCTAD, etc.);
- International standardisation institutions (TIC4.0, DCSA, S-211, D).

During these workshops, the main findings of FOR-FREIGHT should be presented and create opportunities for the open discussion. External expert interventions on the topic should be encouraged to present realistic points of view on standardisation and real-world applications on other areas. The presence of European institutions, on the one hand, should act both as a driver for the adoption of common solutions and, on the other, serve as an opportunity to inform them about the standardisation activities' status and possibilities to encourage regulations. Furthermore, the participation of relevant supply chain actors would ensure that all points of view of the logistics chain are taken into account and discussed, paving the way for collaboration and sharing of results.

Along with these, international institutions could take the initiative and organise their own workshops on standardisation, with the target of bringing together similar organisations and SDOs whose areas overlap or complement. The main goal of these events would be the alignment of the various developments and finding common areas to develop "interoperable-from-design" solutions that cater the market needs, establish formal channels for the cooperation between them, and set the basis for further, coordinated standardisation developments. The involvement of formal, internationally recognised associations such as CEN, ISO, or national standardisation bodies would be of advantage, since their involvement would ensure maximum acceptance of both industry and regulators. Lastly, governments and regulators should be periodically made aware of the advancements made by these expert groups in order to keep them informed and encourage their transformation into formal laws and requirements once they are mature enough.

As a pivotal forum for European logistics, the DTLF could be used as a reference framework to develop and find out about the state-of-the-art of data initiatives in other Member States. The work of the institution should be used by European authorities as a reference to promote digitalisation and find out ways to steadily increase the level of digitalisation and harmonise the digital landscape of the Member States, with the main advantage coming from the fact that it would have the endorsement and acceptance of an officially EU-recognised group. Thanks to this, the acceptance of standards would be strongly increased. In parallel, the European Union should dispose of European funding and other instruments to fund and promote digitalisation, especially in those Member States or sectors lagging behind compared to its counterparts.

- ***Promote standardisation initiatives based on the workshops and current standardisation activities. Coordination of standardisation efforts***

As an organisation for standardisation, TIC4.0 could play a central role in the coordination of processes and operative transformation. The organisation can adapt its data models and procedures to represent hinterland and other transportation processes by collaborating with other SDOs, institutions, and organisations. Thanks to this, TIC4.0 could help to standardise areas that lie out of today's scope of work of current standardisation trends, and lay the groundwork for the development of universal standards: warehouse-hinterland Interfaces warehouse – hinterland, etc.

The main reasons to use TIC4.0 are the following:

1. Universally compatible: TIC4.0's data model and procedures can be expressed in most of today's preferred file formats (XML, JSON, MQTT, flat), even being able to be adapted to standard e-mails. Organisations such as DCSA, EDI, and IATA already use these file formats, easing the adaptation process.
2. Proven specific semantics: TIC4.0's solutions have been successfully implemented in various terminals and machinery around the world, showing its potential and feasibility. Pilot projects such as the implementation of TIC4.0 at Malta's container terminal or at Eurogate's Hamburg Terminal, show the real impact of a full-scale implementation and served as a benchmark to prove the correct functioning

of the semantics. In turn, the semantics and data model are carefully developed and curated by the groups of experts that comprise TIC4.0's Task Forces.

3. **Universality:** While developed for port terminals, the structure of TIC4.0's data model can be adapted to represent the processes and specifics of other parts of the logistics chain. To incorporate them to the data model, each of them shall be represented following the procedures of TIC4.0's semantics. Furthermore, the data model was designed to adapt itself to other standards specifics: for example, fields for DCSA's or S-211's specifics are currently embedded into it. Consequently, any adaptation to other transportation modes shall preferably follow the specifics of accepted standards (e.g., IATA, EDI, etc.)

6 Conclusions

Administrative procedures and processes enjoy from a greater degree of standardisation due to its promotion via recognised institutions such as the United Nations, IATA and the European Union, and the immediate impact on international trade. Initiatives like the EMSWe, EDIFACT or the IATA suite of messages for cargo are good examples of this. However, the modelling of physical processes is still lagging behind compared to the administrative procedures due to multiple factors: lack of digitalisation and uptake of new technologies, financial barriers and the atomisation of the logistics sector. At international level, the supranational institutions, national governments, industry associations and SDOs have been developing their own solutions, often catering to the needs of a specific sector or transportation mode. This has resulted in a “patchwork” of standards which are often not compatible with each other. On the flipside, these initiatives have created a “momentum” for digitalisation which can be capitalised on to improve its market uptake. The port terminal industry has started the initiative “Terminal Industry Committee 4.0” to foster the creation of common standards on this topic. Although the association’s initial focus was placed on terminals and its processes, the data model that was developed inside the association has potential to model the realities of other transportation modes and hinterland processes due to its universal semantics. Therefore, it could play a pivotal role in the development of common standards for the logistics chain.

Concerning FOR-FREIGHT, the project is divided into three Use Cases that cover multiple transportation modes and are focused on three different Member States. Consequently, they are good benchmarks for the standardisation and digitalisation status. Results show a great disparity between transportation modes and locations. In the case of Valenciaport, the presence of a PCS has greatly contributed to the digitalisation of other actors such as road and rail transport. EDIFACT and other types of messages are regularly exchanged between them to inform about important information and events happening in the logistics chain. However, once the cargo leaves the port’s “sphere of influence”, it becomes more difficult to properly track the information. In addition, the novelty of using Metro de Madrid’s subway network to transport cargo requires the integration and creation of new systems to monitor information created by the items moved across it. Concerning the Greek Use Case, as in Valencia, the Hellenic PCS of Piraeus’ port have had a positive influence on the digitalisation of the actors. However, according to the project partners’, it has met some resistance from some sectors to its implementation. When it comes to the port-airport connection, both agents still rely on traditional paper copies, e-mails, and phone calls to exchange information, hence making the resolution of this issue essential. Despite this, since no established system is in place, it represents a good opportunity to establish an “interoperable-from-design” solution. Lastly, the Romanian Use Case has focused on the digitalisation efforts of the port of Constanta, which has systems in place for the information exchange across the different actors, as a model of what Galati could do in the future. This decision was made because of the insufficient degree of digitalisation existing at the latter port and is a prime example of the difficulties the logistics sector is facing when adopting IT technologies. The FOR-FREIGHT’s project findings, coupled with future initiatives of the Constanta administration could act as a driver for the uptake of digital solutions at Galati. Furthermore, the presence of DP World, a major terminal operator at Constanta, could further help both administrations in their digitalisation.

Taking the advantage of the present “momentum” of digitalisation the logistics sector is experiencing, a series of actions could be taken to align current initiatives and develop common, universally-accepted standards. These workshops should be organised to both showcase the results and findings of the FOR-FREIGHT project and gather together relevant stakeholders to discuss on these topics. To ensure success, the presence of European institutions, top SDOs, and industry associations shall be strongly encouraged. These discussions shall, in turn, be centred on finding the gaps, areas for improvement, and overlaps. Furthermore, governments would be able to be regularly informed about the progresses, oversee them and encourage its transformation into law once the standard is mature enough to be published. Any progress made in standardisation and digitalisation activities would quickly translate into better competitiveness due to the current status of IT adoption in the logistics sector. Directives and initiatives such as the DTLF, eFTI and other European efforts such as the EMSWe are examples of

this. It should be noted, though, that any initiative to improve this shall consider the difficulties for the market uptake mentioned before (financial and other barriers).

In the next steps of the project, the updated iteration of this deliverable (D5.6) will encompass the latest advancements achieved by the FOR-FREIGHT consortium, alongside a revised edition of the worldwide standardisation review. It is advisable to initiate contact with relevant institutions during this interim period to commence dissemination efforts and facilitate preliminary collaboration on standardisation. This will also gauge the willingness of stakeholders to accommodate these initiatives. Additionally, the progression of the three Use Cases will act as a testing platform for the adoption of standardized practices, serving as an initial feasibility study for their implementation. The timeline of actions will consist of a deep dive on the standard's application, testing the usability of them in the UCs and addressing each one's particular capabilities and issues. The findings of this report, coupled with the experience of the project, will serve as the foundation for this part. In turn, further details on the adaptation of the TIC4.0's standards to hinterland activities and processes will be described, since it is expected that the project's solvers will be more advanced by the due date of D5.6. TIC4.0's role as an interoperability facilitator will be highlighted with the contributions of the Use Cases. The ONE Record and TIC4.0 standards aim to streamline digital messaging in transportation operations, promoting interoperability. Harmonizing data representation between these standards through a translator could facilitate the adoption of a unified data model for efficient information exchange. The translator could be developed in some form of middleware, software library or alternative system will be also explored to achieve interoperability with TIC4.0. How the solution will look like will depend on factors such as the technology used by the legacy systems, compatibility and others. Progress has been made in the Spanish Use Case, where the TIC4.0 language was successfully integrated into the FOR-FREIGHT's environmental and cost estimation solvers. Lastly, the possibility of integrating TIC4.0's data model into the Greek and Romanian Use Cases will be explored. More details on this will be described in D2.2, D2.3 and D5.6.

Furthermore, a thorough monitoring on the UCs and the platform's advancements, not only from TIC4.0's point of view, will be made. Further assist to the necessities regarding the necessities of common standards that enable intercommunication and interoperability will be provided. Conversely, the State-of-the-Art chapter will be updated with the latest advancements that may happen (adoption of EU-Directives, updated versions of new standards, adoption of official/mandatory status, etc.).

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Annex I: TIC4.0 definitions

Process table of TIC4.0. Source: TIC4.0's own work

Stage	Element	Name	Subject Type	Stage	Element	Name	Subject Type
Carrier Visit	SUBJECT	Arrival	Process	Carrier Visit	CONCEPT	FirstTimeTerminalReadyToWork	Event
Carrier Visit	SUBJECT	Anchorage	Process	Carrier Visit	CONCEPT	TerminalBerthReadyForDeparture	Status
Carrier Visit	SUBJECT	Drift	Process	Carrier Visit	CONCEPT	FirstTimeCarrierReadyForDeparture	Event
Carrier Visit	SUBJECT	Pilot	Process	Carrier Visit	CONCEPT	FirstTimeTerminalBerthReadyForDeparture	Event
Carrier Visit	SUBJECT	Towage	Process	Cargo Visit	CONCEPT	Inbound	Event
Carrier Visit	SUBJECT	Mooring	Process	Cargo Visit	CONCEPT	Check-InCheck-In	Event
Carrier Visit	SUBJECT	PortGate	Process	Cargo Visit	CONCEPT	Dwell	Status
Carrier Visit	SUBJECT	TerminalGate	Process	Cargo Visit	CONCEPT	Check-out	Event
Carrier Visit	SUBJECT	TerminalOperations	Process	Cargo Visit	CONCEPT	Outbound	Event
Carrier Visit	SUBJECT	PreparationAtArrival	Process	Job Instruction	SUBJECT	Order	Process
Carrier Visit	SUBJECT	CargoOperations	Process	Job Instruction	CONCEPT	Moving To Collect	Action
Carrier Visit	SUBJECT	Lashing	Process	Job Instruction	CONCEPT	Queuing To Collect	Action
Carrier Visit	SUBJECT	ClosingAtDeparture	Process	Job Instruction	CONCEPT	Ready to Collect	Action
Carrier Visit	SUBJECT	ShorePower	Process	Job Instruction	CONCEPT	Collect	Event
Carrier Visit	SUBJECT	Gearboxes	Process	Job Instruction	CONCEPT	Moving To Deliver	Action
Carrier Visit	SUBJECT	Departure	Process	Job Instruction	CONCEPT	Queuing to Deliver	Action
Carrier Visit	CONCEPT	Carriersafetyaccessible	Status	Job Instruction	CONCEPT	Ready To Deliver	Action
Carrier Visit	CONCEPT	FirstTimeCarrierSafety Accesible	Event	Job Instruction	CONCEPT	Deliver	Event
Carrier Visit	CONCEPT	CarrierReadyToWork	Status	Job Instruction	SUBJECT	Subject (Job Instruction)	Device
Carrier Visit	CONCEPT	FirstTimeCarrierReadyToWork	Event	Job Instruction	SUBJECT	Object (Job Instruction)	Device
Carrier Visit	CONCEPT	TerminalBerthReadyForArrival	Status	Job Instruction	CONCEPT	Assigned	Status
Carrier Visit	CONCEPT	FirstTimeTerminalBerth ReadyForArrival	Event	Job Instruction	CONCEPT	Not Dispatched	Status

Carrier Visit	CONCEPT	TerminalReadyToWork	Status		Job Instruction	CONCEPT	Dispatched	Status
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TIC4.0's concept list. Source: TIC4.0's own work

Element	Name	Subject Type
CONCEPT	Standby	Activity
CONCEPT	Not Standby	status
CONCEPT	Working	status
CONCEPT	Idle	status
CONCEPT	Stability	activity
CONCEPT	Retracting	Activity
CONCEPT	RetractingWidth	Activity
CONCEPT	Extending	Activity
CONCEPT	ExtendingWidth	Activity
CONCEPT	Energy	Status

General definitions table. Source: TIC4.0's own work

Element	Name	Subject Type	Description
SUBJECT	Cycle	Process	A Cycle is a discrete (individual, separate and distinct) process designed (designated) to move payloads from one location to another by a subject (che ²⁷ , tos, terminal, carrier, etc.)
CONCEPT	Move	move	<p>Move it is a concept within the TIC 4.0 semantic (ontology) which describes the action of a subject (usually the subject is the Cycle 2021.002 process).</p> <p>Move must refer to the subject which made the action (usually the subject that is performing the CYCLE process).</p> <p>Depending on the point of measurement of the process MOVE can refer to an active cycle (a cycle which has already "started") or a completed cycle (a cycle that has "ended"). This is very relevant in long processes like a terminal.cycle.move where there could be a lot of cycle.move that have started but have still not finished.</p> <p>Move can be associated with a continuous system-process (liquid bulk, gas, belt conveyor), or with a discrete system-process, being in such case necessary to consider cycles to describe the nature of the</p>

²⁷ This and subsequent terms left in lowercase because they are referring to TIC code elements which are in lowercase in the Data Model.

			<p>Move (single, multi, or simultaneous).</p> <p>For some cycle processes running in parallel, or serial like for terminal cycle, the “move” action might be conducted by more than one sub-subject (several CHEs).</p>
CONCEPT	Single	Status	Operational mode to perform one payload (box) in one cycle regardless of the size of the payload.
CONCEPT	Twin	Status	A spreader operational mode to perform two payloads (containers) in one cycle with one spreader connected to both containers. Both containers being 20ft long and positioned in such a way that the short sides of the containers are facing each other.
CONCEPT	Tandem	status	Operational mode to perform two payloads (containers) in one cycle with two spreaders, each spreader is connected to a single container. Both containers (typically being 40ft long) are positioned in such a way that the long sides of the containers are facing each other.
CONCEPT	Quad	status	Operational mode to perform four payloads (containers) in one cycle with two spreaders in Twin Mode, each spreader is connected to two containers. All four containers are 20ft long and positioned in such a way that the short sides of the containers are facing each other on each spreader.
CONCEPT	Location	Activity	Location defines where (what place) the subject is.
CONCEPT	On	Activity	If the main power supply and all subject systems can operate (do the job for which they have been designed for) the subject in less than five seconds, requiring no more (a maximum) than one (not a sequence) operator action, then TRUE. If not, then it returns a FALSE signal.
CONCEPT	Off	status	If the main power supply and all subject systems are not ready to operate (do the job for which they have been designed for) the subject in less than five seconds or requires more than one operation action (a sequence) then TRUE else FALSE
CONCEPT	Powered	Status	Defines the state of the referred subject (which must have a true plugged state value) - If it is receiving power from an external source.

Annex II: DCSA definitions

Timestamps defined by DCSA. Source: [31]

	Timestamp [Date/Time & Facility/Service]	Data Owner		Timestamp [Date/Time & Facility/Service]	Data Owner		Timestamp [Date/Time & Facility/Service]	Data Owner
1	Estimated Time of Arrival Berth (ETA Berth)	Carrier	18	Gangway Down and Safe	Carrier	35	Requested Time of Departure Berth (RTD Berth)	Port authority
2	Requested Time of Arrival Berth (RTA Berth)	Terminal operator	19	Estimated Time Start Cargo operations (ETS Cargo ops)	Terminal	36	Planned Time of Departure Berth (PTD Berth)	Carrier
3	Planned Time of Arrival Berth (PTA Berth)	Carrier	20	Requested Time Start Cargo operations (RTS Cargo ops)	Carrier	37	Requested Time Towage service (RTS Towage)	Port authority
4	Estimated Time of Arrival Pilot Boarding Place (ETA PBP)	Carrier	21	Planned Time Start Cargo operations (PTS Cargo ops)	Terminal	38	Planned Time Start Towage service (PTS Towage)	Tugs
5	Requested Time Towage service (RTS Towage)	Port Authority	22	Vessel Readiness for Cargo operations	Carrier	39	Requested Time Start Pilotage service (RTS Pilotage)	Port authority
6	Planned Time Start Towage service (PTS Towage)	Tugs	23	Actual Time of Start Cargo operations (ATS cargo ops)	Terminal	40	Planned Time Start Pilotage service (PTS Pilotage)	Pilot
7	Requested Time Start Pilotage service (RTS Pilotage)	Port Authority	24	Estimated Time of Cargo operations Completion (ETC cargo ops)	Terminal	41	Actual Time Completion Bunkering service (ATC Bunkering)	Service Provider/ Bunkering
8	Planned Time Start Pilotage service (PTS Pilotage)	Pilot	25	Requested Time of Cargo operations Completion (RTC cargo ops)	Carrier	42	Actual Time of Completion Cargo operations (ATC cargo ops)	Terminal
9	Requested Time of Arrival Pilot Boarding Place (RTA PBP)	Port authority	26	Planned Time of Cargo operations Completion (PTC cargo ops)	Terminal	43	Terminal ready for vessel departure	Terminal
10	Planned Time of Arrival Pilot Boarding Place (PTA PBP)	Carrier	27	Estimated Time Start Bunkering service (ETS Bunkering)	Service Provider/ Bunkering	44	Actual Time Completion Lashing service (ATC Lashing)	Service Provider/ Lashing

11	End Of Sea Passage EOSP	Carrier	28	Requested Time Start Bunkering service (RTS Bunkering)	Carrier	45	Vessel ready to sail	Carrier
12	Actual Time of Arrival Pilot Boarding Place (ATA PBP)	Carrier	29	Planned Time Start Bunkering service (PTS Bunkering)	Service Provider/ Bunkering	46	Actual Time Start Pilotage service (ATS Pilotage)	Pilot
13	Actual Time Start Pilotage service (ATS Pilotage)	Pilot	30	Estimated Time Completion Bunkering service (ETC Bunkering)	Service Provider/ Bunkering	47	Actual Time Start Towage service (ATS Towage)	Tugs
14	Actual Time Start Towage service (ATS Towage)	Tugs	31	Requested Time Completion Bunkering service (RTC Bunkering)	Carrier	48	Actual Time of Departure Berth (ATD berth)	Carrier
15	Actual Time Completion Towage service (ATC Towage)	Tugs	32	Planned Time Completion Bunkering service (PTC Bunkering)	Service Provider/ Bunkering	49	Actual Time Completion Pilotage service (ATC Pilotage)	Pilot
16	Actual Time of Arrival Berth (ATA Berth)	Carrier	33	Actual Time Start Bunkering service (ATS Bunkering)	Service Provider/ Bunkering	50	Start Of Sea Passage (SOSP)	Carrier
17	Actual Time All Fast (AT All fast)	Carrier	34	Estimated Time of Departure Berth (ETD Berth)	Carrier			