Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network

D4.5 Recommendations for PLANET Standardization

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[1] According to PLANET's Quality Assurance Process

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
API	Application Programming Interface
DCSA	Digital Container Shipping Association
EDI	Electronic Data Interchange
EPCIS	Traceability event messaging standard that enables supply chain visibility through sharing event data using a common language across, between and within enterprises.
AIOTI	Enterprise resource planning
BSP-RDM	UN/CEFACT Buy-Ship-Pay Reference Data Model
CCL	UN/Core Component Library
CEN	European Committee for Standardization
ebXML	ISO 15000 series, electronic business eXtensible Markup Language
ERP	Enterprise resource planning
ETSI	European Telecommunications Standards Institute
FIATA	International Federation of Freight Forwarders Associations
GDTI	Global Document Type Identifier
GIAI	Global Individual Asset Identifier
GINC	Global Identification Number for Consignment
GLN	Global Location Number
GOVCBR	A multi-functional UN/EDIFACT message
GPC	Global Product Classification
GRAI	Global Returnable Asset Identifier
GS1	Provides the most widely used system of standards in the world.
GS1 EANCOM®	Is a GS1 subset of the UN/EDIFACT standard (United Nations Electronic Data Interchange for Administration, Commerce and Transport)

Abbreviation / Term	Description
GS1 UN/CEFACT XML	Business message standards are developed within UN/CEFACT and hosted by the UNECE, a body of the UN.
GSIN	Global Shipment Identification Number
GTIN	Global Trade Item Number
HS Code	Harmonised Commodity Description and Coding System
IMO ship identification number scheme	Ship Identification Number
ISO	International Organization for Standardization
ISO 14533 series	Electronic signatures
ISO 9362	Business Identifier Code (BIC)
ISO/IEC 15459	Unique identification
ISO/IEC 15459-1 and ISO/IEC 15459-5	Unique Item Identifier (UII)
LEI ISO 17442	Legal Entity Identifier
MLETR	UNCITRAL Model Law on Electronic Transferable Records (2017)
RFID	Radio-frequency identification
SSCC	Serial Shipping Container Code
TIN	Trader Identification Number
UCC	The Union Customs Code
UCR	Unique Consignment Reference
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UN/EDIFACT	The United Nations Electronic Data Interchange for Administration, Commerce and Transport
UNSPSC	United Nations Standard Products and Services Code
W3C DID	Decentralised Identifier (DID)
WCO	World Customs Organization

Source: Own elaboration

1 Executive Summary

Main objective of T4.5 was to provide recommendations that can be inferred from ongoing/anticipated EGTN design and deployment in the various LL's with a focus on standardization of smart contracts in supply chains. The report focuses on the adoption of communication and identification standards in the logistics industry. It identifies various stakeholders, including trade optimization actors, service providers, academic institutions, and policy-making bodies, who have specific needs and expectations related to the development of technologies such as IoT, blockchain, and AI in logistics.

The lack of adoption of standards in logistics processes has led to inefficiencies and difficulties in achieving interoperability in the supply chain. GS1 is the only organization that comprehensively addresses standardization in both identification and communication throughout the supply chain. Recommended standards, such as EPCIS, EDI, and GS1 standards, are proposed to improve transport and logistics processes. The use of these standards can facilitate data flow, automation, and real-time monitoring in warehouse operations, last-mile delivery, transport control, and resource parameter management.

The report emphasizes that many partners in the surveyed Living Labs do not currently use identification and communication standards in their logistics processes. The aim is to show companies the existing standards and their utilization to enhance accessibility, accuracy, and understanding of important information. The implementation of GS1 standards is proposed for various logistics processes, including transport management, shipping and receiving, warehouse management, assets' management, and border procedure management (customs). Each process's benefits are highlighted, emphasizing improvements in efficiency, accuracy, traceability, and overall supply chain performance. The recommendation provides links to guidelines and documentation for the implementation of each standard, enabling companies to adopt the recommended standards effectively.

Referring to technology, blockchain can support international logistics processes by providing a decentralized and immutable ledger that records and verifies the movement of goods, ensuring transparency and trust among multiple parties involved in the supply chain. Smart contracts can automate and enforce contractual agreements in international logistics, ensuring that conditions such as delivery schedules, payment terms, and compliance requirements are met, thereby reducing manual errors, delays, and disputes. Through blockchain and smart contracts, stakeholders in international logistics can securely share and access critical information, such as shipping documentation, customs declarations, and quality certifications, improving efficiency and reducing administrative burdens. The use of blockchain and smart contracts in international logistics can enhance traceability and provenance of goods, enabling real-time tracking and verification of product origins, certifications, and compliance with regulatory standards, contributing to supply chain integrity and reducing the risk of counterfeit or substandard products.

The GS1 standards for identification, data carriers, electronic communication and process design create the conditions for transparency at all stages of the value chain. These standards enable the automation of processes through a uniform and unambiguous language. Only through the global uniqueness of objects with uniform semantics can the automatic recording of objects and the exchange of information be made available to participants in both horizontally and vertically integrated value chains. However, this can only work if organizations speak a common language, 'The language of uniform standards.'

Concluding, standards are indispensable for linking the physical world with the digital world. The real world can only be connected with the digital world if it can automatically identify the information along the value chain which can then be exchanged digitally. The standards to be used relate primarily to the identification of objects (Identify), the capture of data (Capture) and the exchange of data (Share) for objects along the supply chain. By means of these enabling technological standards, various business processes such as traceability can also be standardized.

2 Introduction

The purpose of the following report is to present recommendations that can be inferred from ongoing/anticipated EGTN design and deployment in the various LL's with a focus on standardisation of smart contracts in supply chains.

This report will focus on an analysis of the opportunities and benefits arising from using smart contracts in the supply chain and associated technologies, particularly blockchain. In the fast-paced world of logistics, where goods and information flow seamlessly across global supply chains, standardization plays a pivotal role in ensuring efficient operations, enhanced collaboration, and increased productivity. A chapter about standards delves into the importance and impact of standardization in the context of cutting-edge technologies that are revolutionizing the logistics industry. The report explores specific standardization initiatives and frameworks that have emerged to address the challenges and opportunities associated with modern logistics technologies. It delves into industry consortia, regulatory bodies, and international standards organizations that work collaboratively to define best practices, guidelines, and protocols for technology implementation in logistics. For the purpose of the report, a survey was conducted among participants from Living Lab 1, Living Lab 2, and Living Lab 3 which allowed gathering information about used logistics processes in international supply chains. Based on this knowledge, recommendations were prepared for using the most commonly used and helpful standards.

Implementation of the work was divided into 3 stages:

"Standardization preparation", which covers issues such as the territorial scope of research, and the investigated logistics processes. In October 2022, a survey was carried out in Poznan during the second General Assembly in the premises of Lukasiewicz Research Network - Poznań Institute of Technology. The conducted research allowed for the collection of information related to the use of identification and communication standards in individual Living Labs and their Business Cases. This chapter also identifies the stakeholders that may be interested in the report's results and contains Outputs data from other projects within PLANET. This became the basis for further considerations in the following chapters.

Chapter "Standardization Strategy" highlights the difference between the terms "standards" and "standardization." Standardization is the process of developing, defining, and establishing standards, while standards are the result of this process. In the context of the PLANET project, standards are essential, and the project aims to identify existing standards that could be useful. However, the lack of adoption of data standards and awareness of existing standards hinders the seamless flow of data along supply chains and diminishes efficiency gains.

This chapter provides information on GS1 and non-GS1 standards. It presents an analysis of the opportunities and benefits arising from using smart contract in the supply chain and associated technologies, particularly blockchain. It identifies and analyses existing standards for smart contract, with particular focus on solutions dedicated to the flows of goods in international supply chains. The analysis includes implementations and problems encountered.

Last chapter "Recommendations for PLANET standardization" discusses the preparation and recommendation of standards for transport and logistics processes including the use of smart contract and blockchain. It highlights the lack of use of identification and communication standards in Living Labs, which can hinder the seamless flow of data in the supply chain. The recommendation is based on the use of GS1 standards, which cover all identification and communication needs. GS1 standards provide a common language to identify and share product data, ensuring accuracy and accessibility. This chapter also touches on the European Union regulations which indicate which GS1 standards should or must be used, for example EU Medical Devices Regulation (2017/745), EU Tobacco Products Directive (2014/40/EU), and EU Falsified Medicines Directive (2011/62/EU).

2.1 Mapping PLANET Outputs

Purpose of this section is to map PLANET's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1: Adherence to PLANET's GA Deliverable & Tasks Descriptions

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D4.5 Recommendations for PLANET standardisation	Recommendations for PLANET standardisation including report on impact of standardisation and merits of different standardisation routes and organisations.	Chapter 4 and 5	Chapter 4 and 5 presents the standardisation landscape, including identified relevant standards and organizations as well as recommendations relevant to PLANET project output.
TASKS			
T4.5 Recommendations for PLANET standardisation	Main objective of T4.5 is to provide recommendations that can be inferred from ongoing/anticipated EGTN design and deployment in the various LL's with a focus on standardisation of smart contracts in supply chains.	Chapter 5 Recommendations for PLANET standardization	This chapter will provide recommendations for the use of selected standards within the Planet and EGTN project.
Subtask ST4.5.1	Standardisation preparation will provide an analysis of the opportunities and benefits arising from using smart contract in the supply chain and associated technologies, particularly blockchain. Will identify and analyse existing standards for smart contract, with particular focus on solutions dedicated to the flows of goods in international supply	Chapter 3 Standardization preparation	This chapter will provide definition of researched area and stakeholders; investigated logistic procesess in LL's also outputs from other Planet deliverables on standardization.

	chains. The analysis will include implementations and problems encountered. The subtask will also deliver an inventory of ongoing/anticipated EGTN design and deployment activities in the various LL's with focus on standardisation of smart contracts in supply chains.		
ST4.5.2	PLANET Standardization Strategy will address the following questions: who are the stakeholders? To which extent do their interests differ? would CERN, or GS1 be the appropriate standards body to develop these standards or would another one be better, or a combination? If standards' setting would be left to the market, what would happen then? How can benefits and costs be forecasted? Finally, as smart contract may serve as a case for many other standards that are needed as enablers of a global trade network, dependencies with those will also be specified.	Chapter 4 Standardization strategy	This chapter provides information about GS1 identification, communications and other standards in the supply chain and Standardization in the concept of the Physical Internet and EGTN.
ST4.5.3	Provide recommendations for PLANET standardization: Based on the results of the previous subtasks, smart contract standardization recommendations will be delivered.	Chapter 5 Recommendations for PLANET standardization	This chapter provides recommendations for the use of selected standards within the Planet and EGTN project.

Source: Own elaboration

2.2 Deliverable Overview and Report Structure

The document consists of seven chapters, structured as follows:

- Chapter 3 describes definition of researched area and stakeholders; all investigated logistic processes in LL's and also outputs from other Planet deliverables on standardization.
- Chapter 4 provides a description of identification and communication standards in the Supply Chain and describes standardization in the concept of the Physical Internet and EGTN.
- Chapter 5 provides recommendations for the use of selected standards within the Planet and EGTN project.
- Chapters 6 and 7 address conclusions and references, respectively.

3 Standardization preparation

3.1 Definition of the research area

This chapter is the basis for further considerations and, consequently, recommendations for standardisation. The subject of the research is the area covered by the work of all three Living Labs. Therefore, it defines the territorial scope of the research, the processes analysed, as well as the stakeholders of the research results. In addition, the work is also based on the outputs from other PLANET project deliverables on standardisation.

3.1.1 Territorial scope of research

The territorial scope of research refers to the geographical area or region in which a particular research study is conducted or applicable. It defines the boundaries within which data is collected, analyzed, and conclusions are drawn. The territorial scope of the PLANET project varied according to the implementation in each LL's, however it is clear that it transcends national boundaries and involves different countries and regions even including those outside of Europe. So the considerations within this paper touch on aspects of standardization in the international and even global scope:

LL1 evaluated how new technologies (IoT, AI and blockchain) and concepts (Physical Internet) could improve processes, operations and efficiency along the door-to-door transport chains linking the Maritime Silk Road with EU internal corridors.

LL2 focused on dynamic and Synchromodal management of TEN-T & intercontinental flows promoting rail transport and utilising the Port of Rotterdam (PoR) as the principal smart EGTN Node coordinating the rail focused transport chains linking China through Rotterdam to/from USA, and the Rhine-Alpine Corridor destinations.

LL3 focused on streamlining logistic processes in flows from China to Europe along the Silk Road by implementing IoT technologies (based on the EPCIS platform) and GS1 standards that facilitate transmission of data between the partners involved in the e-commerce operations.

3.1.2 Investigated logistics processes

Logistics processes encompass a wide range of activities involved in the movement, storage, and management of goods and resources from their origin to their final destination. These processes can vary depending on the industry, organization, and specific requirements. Within the PLANET project, we had 3 different Livestock Labs in different regions touching on different processes and related problems, which is important in terms of recommendations for standardization. During one of the General Assembly in Poznan we conducted the survey

aimed at examining using identification and communication standards in particular Living Labs and their Business Cases.

The study was based on the following logistics processes:

1. Transport Management
2. Shipping & Receiving
3. Warehouse Management
4. Returnable assets' management (such as pallets, cases, crates, totes..)
5. Individual assets' management (such as manufacturing, warehousing, handling equipment…)
6. Border Procedure Management (Customs)

Then we collected the answers, so that we could see which logistics processes are the subjects of particular LL's and what is the scale of use of standards in identified processes.

Below, we present the investigated processes in particular Living Labs with information of using identification or/and communication standards:

1. **Living Lab 1** aims at testing new solutions (IoT, AI, blockchain) and concepts (PI) to improve process, operations, and efficiency along D2D transport chains linking China with Spain.
    a. **Use case 1 on improving container cargo operations between China and Spanish hinterland.**

    Processes which are the subject of Use Case 1:

    1. Shipping & Receiving
    2. Transport Management
    3. Returnable assets' management
    4. Individual assets' management
    5. Border Procedure Management (Customs)

    Identification needs and identifiers which are used:

    1. Locations and parties (eg. VAT number)
    2. Logistic unit (container number, palet type)
    3. Returnable assets (container number)
    4. Individual assets (container number)
    5. Shipment (scac code)

    Usage of communication standards: NO

    b. **Use case 2 on optimizing warehouse operations and automation and last mile deliver efficiency and sustainability.**

    Processes which are the subject of Use Case 2:

    1. Shipping & Receiving
    2. Warehouse Management
    3. Transport Management

    Identification needs and identifiers which are used:

    1. Trade Items (GTIN and other internal)
    2. Location and Parties (RAILWAY LOCATION CODES - RNE reference files)
    3. Logistic unit (SSCC)
    4. Shipment (GSIN)
    5. Consignment (GINC)
    6. Individual assets (Container ID - BIC OR RLU CODE)

Usage of communication standards: EDI, EPCIS

2. **Living Lab 2** - Synchro modal dynamic management of TEN-T & intercontinental flows promoting rail transport: China – Rotterdam, USA/UK focusing on the role of rail transport.
    a. **Use case 1 focuses on synchromodality in a Blockchain enabled Platform utilising advanced IoT, supporting BlockLab customers & communities to create the best multi-modal alternatives for logistics solutions within LL2's corridors**

        Processes which are the subject of Use Case 1:

        1. Shipping & Receiving
        2. Border Procedure Management (Customs)

        Identification needs and identifiers which are used:

        1. Location and Parties (internal identifiers)
        2. Shipment (internal identifiers)

        Usage of communication standards: NO

    b. **Use case 2 focuses on investigating Eurasian rail freight expansion in the LL2 corridor by building on results from T1.2. Key issues for infrastructure development are explored, as well as the potential for expanding services in the corridor and implement (in a test environment) the use of Blockchain on rail freight transport between China and Europe. This will also utilize use case 1 tools to investigate freight flow synergies and Blockchain innovation to support integration with European RFCs;**

        Processes which are the subject of Use Case 2:

        1. Transport Management
        2. Border Procedure Management (Customs)

        Identification needs and identifiers which are used:

        1. Location and Parties (RAILWAY LOCATION CODES - RNE reference files)
        2. Individual assets (Container ID - BIC OR RLU CODE)

        Usage of communication standards: NO

    c. **Use case 3 analyses LL2 corridor flows and assess the implications for TEN-T infrastructure, extending T1.2 results with data from EGTC and use cases 1 and 2. This is directed at strategic corridor planning and its use for EGTC members (focusing on the EGTC Rhine-Alpine area);**

        Transport and logistics processes are not the subject of UC3.

        Usage of communication standards: NO

3. **Living Lab 3 focus on streamlining logistic processes in flows from China to Europe along the Silk Road Route by implementation of IoT technologies and EPCIS platform along with other GS1 standards that would facilitate transmission of data between the partners involved in the logistics operations within an e-commerce channel.**

a. **Use case 1 - Increased visibility of goods thanks to IoT along the Silk Road Development and sensors systems that help control resource parameters in real time and identify them while moving in the transport process, examining potential positive results in terms of broad implementation.**

   Processes which are the subject of Use Case 1:

   1. Shipping & Receiving
   2. Warehouse Management
   3. Transport Management

   Identification needs and identifiers which are used:

   1. Trade Items (clients' identifiers)
   2. Location and Parties (Internal numbers)
   3. Logistic unit (Internal numbers)
   4. Shipment (Internal numbers)
   5. Consignment ((Internal numbers)

   Usage of communication standards: EPCIS

b. **Use case 2 - Creation of a digital connection between actors in the transport network, enabling standardized data flow and access to information about cargoes coming from China to Poland in the whole supply chain in real time (implementation of the SSCC number and EPCIS test).**

   Processes which are the subject of Use Case 2:

   1. Shipping & Receiving
   2. Transport Management
   3. Border Procedure Management (Customs)

   Identification needs and identifiers which are used:

   1. Trade Items (GTIN or other internal)
   2. Logistic unit (SSCC, UPU number)
   3. Shipment (internal numbers)
   4. Consignment (UPU numbers)

   Usage of communication standards: EPCIS

All collected answers from PLANET partners are in the table below:

Table 2: Usage of GS1 standards in T&L processes

	LL1		LL2			LL3	
	UC 1	UC2	UC1	UC2	UC3	UC1	UC2
Which processes are the subject of your Use Case?							
Shipping & Receiving	x	x	x			x	x
Warehouse Management		x				x	
Transport Management	x	x		x		x	x
Returnable assets' management (such as pallets, cases, crates, totes..)	x						
Individual assets' management (such as manufacutring, warehousing, handling equipment...)	x						
Border Procedure Management (Customs)	x		x	x			x
What kind of objects do you identify in your processes?							
Trade items		x				x	x
Locations and parties	x	x	x	x		x	
Logistic unit	x	x				x	x
Returnable assets	x						
Individual assets	x	x		x			
Shipment	x	x	x			x	x
Consignment		x				x	x
other							
Which GS1 identification standards are used in your UC?							
Global Trade Item Number		x					x
Global Location Number							
Serial Shipping Container Code		x					x
Global Shipment Identification Number		x					
Global Identification Number for Consignment		x					
Other - NOT GS1	x		x	x		x	x
NONE	x		x	x	x	x	
Which GS1 communication standards are used in your UC?							
GS1 Standards for Data Exchange (GS1 eCom – Electronic Data Interface EDI)		x					
GS1 EPCIS Information Service		x				x	x
other							
NONE	x		x	x	x		

Source: Own elaboration

Results of the survey were used as a base for the further analysis in that document and for the creation of final recommendations (chapter 5.1) for the whole PLANET project.

3.1.3 Stakeholders interested in the results

Given the results of the Planet project, and in particular the indications and recommendations resulting from the application of the standards supporting the PI (IoT, BC, SC) the recipients of these results are certainly:

- Actors optimising global trade flows (EU Ten-T coordinators, Shippers, Ports, Rail, etc.)
- Industrial and SME provider of Trade flows modelling and Consulting services
- Open-source communities and Start-ups
- Academic and RTOs in Geo-Political, Global Trade Analysis
- RIA and CSA consortia from MG calls and others relevant projects
- Private & public funding institutions for research and innovation in global trade
- Policy-making institutions
- General public & media.

In general, the needs and expectations of stakeholders in relation to the project outcomes in the context of the solutions and standards considered in this document relate to:

- Multimodal transport flows model along global corridors and TEN-T and a comprehensive hybrid modelling and simulation capability tuned to represent TEN-T integrated Green EU-Global T&L networks
- End-to-end transport chain models including last mile and ocean shipping underpinned by IoT, Blockchain and AI technologies

- Synchromodality on Blockchain enabled Platforms integrated with predictive and optimisation analytics enabling individual actors to find and manage the best transport solutions
- Development of Ports/Hubs as Smart EGTN Principal Nodes making automated intelligent decisions required for a PI approach and associated smart warehousing nodes and smart city hubs
- Eurasian rail freight expansion and Integration with European RFCs
- E- commerce distribution through EGTN smart nodes underpinned by Postal operators' innovative collaboration model
- Multi criteria DSS specially to support strategic development of TEN-T corridors: Intelligent PI Nodes and PI Network services.

The above areas, by reason of their problematic nature, need to be developed, so support in the form of research and testing of PI operation using IoT, BC, SC and AI technologies is particularly important here.

3.1.4 Outputs from other PLANET deliverables on standardization

Taking into account the results of the work, mainly WP1 and WP2, the following outputs were relevant for the development of this deliverable:

- D1.9 Simulation-based analysis of T&L and ICT innovation technologies
- D2.5 EGTN Connectivity infrastructure
- D2.15 Integration and Interoperability of proprietary BlockchainSystems for Seamless Global Trade Workflows
- D2.18EGTN smart contracts and associated PI motivated workflows in the context of SLA management

Within the framework of D1.9, chapters on the following issues were key to the analysis and development of recommendations for standards in the IoT and PI areas:

- overview of the three different geographical settings used as modelling use-cases/scenarios, as well as the associated Transport and Logistics actors, stakeholders, technologies, and processes considered within each scenario – chapter 3.

Within the framework of D2.5, chapters on the following issues were key to the analysis and development of recommendations for standards in the IoT area:

- EGTN Connectivity Infrastructure, especially in the context of integration of Kafka platform and EPCIS – chapter 3.

Within the framework of D2.15, chapters on the following issues were key to the analysis and development of recommendations for standards in the BC area:

- the state-of-the-art frameworks, protocols, and platforms that are used in the process of applying Blockchain interoperability solutions – chapter 4
- the scenarios that will use the Blockchain interoperability service of the EGTN platform and will validate its architecture–as part of the EGTN blueprint architecture – chapter 5
- description of the software architecture of the EGTN Blockchain component, the deployment details, data structures as well as the integration points with the open cloud based EGTN platform – chapter 6.

Within the framework of D2.18, chapters on the following issues were key to the analysis and development of recommendations for standards in the PI area:

- the role of Smart Contracts in the EGTN Platforms and PI – chapter 3.2

- implementing EGTN Smart Contracts as a solution to meet the Alice roadmap objectives for PI -chapter 6.2

The following deliverables were examined in the context of standards analysis which are related to LL's works: D3.4, D3.5, D3.6.

- LL1 used the following standards for testing within the individual test cases (TC's):
  - EDIFACT
  - OpenAPI specification v3 for the REST API of the FF blockchain https://swagger.io/specification/
  - GS1 Transport Instruction (TI) & Response https://mocdn.gs1.org/standards/edi-xml/xml-transport-instruction-and-response/3-1
  - GS1 Transport Status Request & Notification, https://www.gs1.org/standards/edi-xml/xml-transport-status-request-and-notification/3-4
  - GS1 EPCIS events in the DHL blockchain

- LL2 did not use standard solutions as part of its research

- LL3 used the following standards for testing within the individual test cases (TC's):
  - Identification standards: UPU standards, GS1 standard (SSCC, GTIN, GLN), CN standards
  - IoT core architecture: GS1 EPCIS 1.1
  - IoT standards for transport monitoring: DASH7.

Outputs from other PLANET deliverables on standardization were used as a base for the further analysis in that document and for the creation of final recommendations (chapter 5.1) for the whole PLANET project.

4 Standardization strategy

Standardization strategy refers to an approach adopted by organizations to establish and implement consistent practices, processes, and specifications across various aspects of their operations. It involves developing and adhering to standardized procedures, protocols, and guidelines to achieve greater efficiency, quality, interoperability, and compatibility.

The term "standards" needs to be divided from the term "standardization". This is important to clarify it as colloquially those terms are sometimes mixed up or used as synonyms:

- Standardization is the process of developing, defining and establishing standards whereas
- Standards are the result of this process.

Standards are a form of materialized technical knowledge, available to any type of company, which enables the creation of better products, services, processes or management systems. Each standard is usually a detailed and accurate technical specification. This may benefit both companies and their customers, e.g. by enabling them to gather product information in a more cost-effective way, guarantee its reliability and ensure the compatibility of the IT solutions they implement.

In the PLANET context, it is the standards that are essential in the first place. PLANET looks into what standards exist that could be of use for this project purposes. As such, PLANET is about recommendations of adopting existing standards. By doing so, the popularization of standards being recommended by PLANET will help to strengthen the weight and importance of these standards.

4.1 Standardization in the Supply Chain

Identifying, capturing and sharing information about the movement of products — and the digitalisation of everyday business processes — not only enhances interoperability between stakeholders but creates a highly

efficient, sustainable and collaborative logistics environment. This is where the standards used in supply chains that support the above-mentioned processes come in.

Standards promote interoperability of supply chains and transparency in their operation. They allow an organization to focus on how to use information, rather than on how to obtain it. Properly developed standards are more important today than ever before in the context of the challenges posed by the current economic environment. They simplify the relationship between trading partners and within the organization.

The lack of adoption of data standards and on how trade data are exchanged, combined with an actual absence of standards, significantly hinder the seamless data flow from one end of the supply chain to the other. This has diminished efficiency gains along supply chains and has weighed heavily on companies, in particular small businesses.

Despite calls for more standardization, the real issue is the lack of alignment and awareness of existing standards. Although many organizations have been actively working on developing trade standards, adoption remains limited in large part due to the complexity and fragmentation of the standards landscape.

The lack of standards knowledge is not a new issue. The European Commission has tried to find a solution for this problem by creating a service whereby a range of standards, tools, open-source software, services, artefacts are made searchable through an aggregator portal called “Join-up" and can be found here. This is a search engine across various standards’ solution portals.

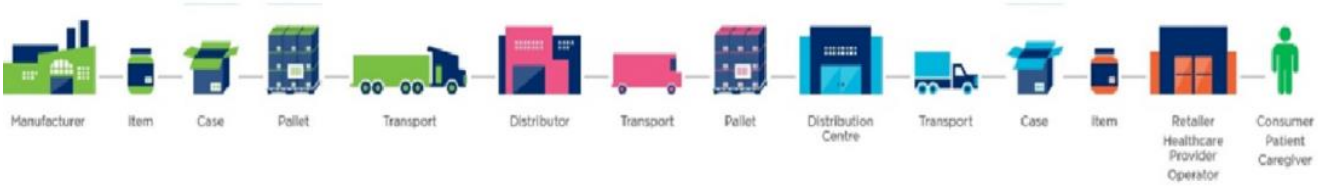

Figure 1. Supply Chain diagram
Source: Own elaboration

4.1.1 Standards organizations

Organizations involved in developing standards devote much time and effort in creating rules, guidelines and best practices to simplify and harmonize how trade and supply chain data are produced and exchanged machine-to-machine. The most important standardization organizations at the global level are the International Organization for Standardization ISO, the International Electrotechnical Commission IEC, and the International Telecommunication Union ITU. At the European level, the Comité Européen de Normalisation CEN cooperates with ISO by taking over many of their standards (EN-ISOs) and sometimes developing these together. Such cooperation is even more intense between the Comité Européen de Normalisation Electrotechnique and the IEC: most IEC standards are accepted as European standards (EN-IECs). All European standards are implemented in the national’ standardisation systems of all EU and EFTA member states and some other European countries. ISO and IEC standards are not automatically included in national standards systems but many countries implement a substantial portion of them. For telecommunications standardization in Europe, the European Telecommunications Standards institute ETSI is available. ETSI serves an international market and has little cooperation with the ITU.

Some users may not be aware of all the existing standards in Supply Chain. The objective is to drive adoption of existing standards and to facilitate trusted, real-time supply chain collaboration and real-time standard data exchange, while reducing costs and complexity.

Below you can find various standards development organisations, industry associations, public sector agencies and private sector organisations:

- Digital Container Shipping Association (DCSA) - is a nonprofit, independent organisation established in 2019 by several of the largest container shipping companies. DCSA's mission is to be the de facto standards body for the industry, setting the technological foundation for interoperable IT solutions.
- European Committee for Standardization (CEN) - CEN supports standardization activities in relation to a wide range of fields and sectors including: air and space, chemicals, construction, consumer products, defence and security, energy, the environment, food and feed, health and safety, healthcare, ICT, machinery, materials, pressure equipment, services, smart living, transport and packaging. CEN & CENELEC and ETSI have been working together on a basic set of standards for Cooperative Intelligence Transport Systems (C-ITS),
- European Telecommunications Standards Institute (ETSI) - is a European Standards Organization (ESO). It is the recognized regional standards body dealing with telecommunications, broadcasting and other electronic communications networks and services. This includes supporting European regulations and legislation through the creation of Harmonised European Standards.
- GS1 - (a NFP, NGO) provides the most widely used system of standards in the world and they offer a portfolio of services and tools to make adoption of GS1's royalty free standards easier and more impactful to businesses. GS1 organisations in more than 110 countries manage the barcode standard used by retailers, manufacturers and suppliers worldwide. Together with more than 2 million members, GS1 creates a common foundation for business by uniquely identifying, accurately recording and automatically sharing important information about, for example, products, locations, assets and businesses.
- International Federation of Freight Forwarders Associations (FIATA) - is a non-governmental, membership-based organisation representing freight forwarders in some 150 countries. FIATA is a reference source on international policies and regulations governing the freight forwarding and logistics industry. FIATA works at the international level to represent service providers who operate in trade logistics and supply chain management.
- International Organization for Standardization (ISO) - is an independent, non-governmental international organization with a membership of 167 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.
- United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) - is a global leader in electronic trade facilitation and electronic business and was first established by the United Nations in 1957. Its value in creating and maintaining electronic data interchange messaging solutions, guidelines and modelling core component libraries makes UN/CEFACT's inclusion in any study of this kind indispensable.
- World Customs Organization (WCO) is an independent intergovernmental body whose mission is to enhance the effectiveness and efficiency of Customs administrations.

All described organisations are involved in developing standards and devote much time and effort in creating rules, guidelines and best practices to simplify and harmonize how trade and supply chain data are produced and exchanged machine-to-machine.

The objective of different standards implementation is mainly to facilitate trusted, real-time supply chain collaboration and real-time standard data exchange, while reducing costs and complexity.

To reduce friction and to enable scale in digital exchanges, there is a need to standardise the digital language and medium of exchange when using standardised trade and transport-related documents and data formats.

Despite calls for more standardisation, the real issue is the lack of alignment and awareness of existing standards. Although many organisations have been actively working on developing trade standards, adoption remains

limited in large part due to the complexity and fragmentation of the standards landscape. Some of these organizations deal with standardization in a very limited way or for selected industries or groups of companies.

Nevertheless, GS1 is dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across sectors. The GS1 system of standards is the most widely used supply chain standards system in the world. The standards are designed for intersectoral and long-term use. They are regularly maintained and developed. Having been granted ARO (Approved Referencing Specification Originator) status by ISO/IEC Joint Technical Committee GS1 standards may be referenced by ISO, e.g. the technical standard ISO IEC 19987 Event Information Exchange Standard (EPCIS).

The organization that comprehensively addresses standardization in both - identification and communication context throughout the supply chain is GS1.

The GS1 standards provide a global harmonized and integrated framework to manage supply chain information making the global value chain more efficient. As distinct from other standards, GS1 standards ensure globally unique identification and enable cross-border compatibility of supply chain solutions, regardless of the industry.

The main idea behind GS1 standards is to “make it possible for companies to speak the common language and enable visibility in the supply chain”. And it is a fact that they successfully transform the exchange of data between different participants, developing an efficient supply chain. GS1 Barcodes are the leading actor in this process, enabling the encoding of information (key identifiers and attributes) and allowing the track and trace through the whole supply chain.

It`s crystal clear that the GS1 standards benefit the supply chain in various ways. Their significant impact comes from the great opportunities that unlock for the supply chain participants such as opening up to new markets, seamless product distribution, and enhancement of brand protection and consumer trust. It is essential to mark that the common standards help rationalize business processes, increase speed, reduce paperwork, and cut costs.

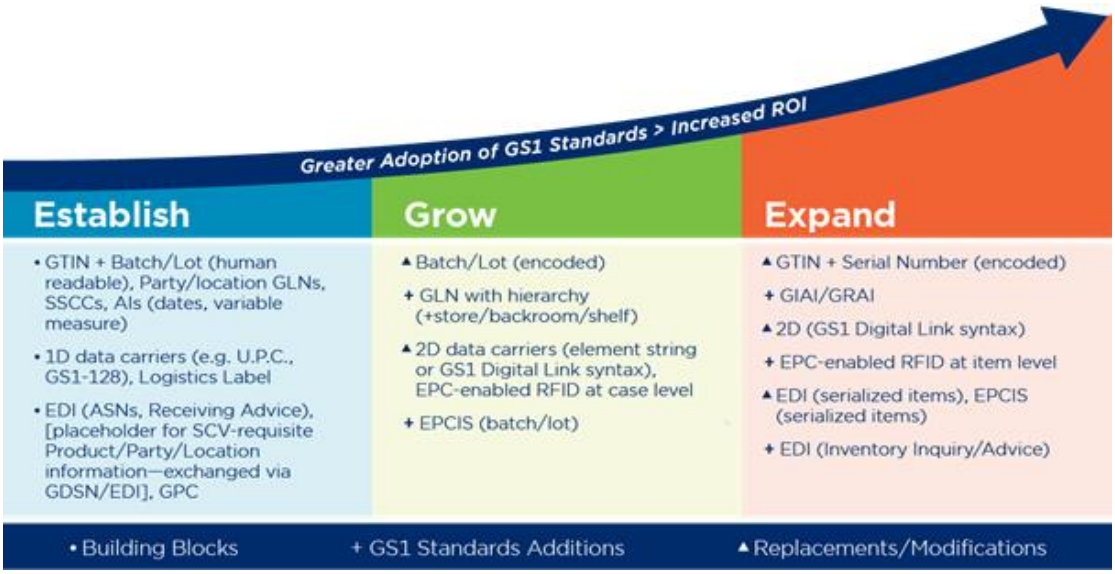

Figure 2. Adoption of GS1 standards
Source: Own elaboration

In the next part of the report, we will take a closer look at the role of GS1 organizations in the supply chain. Moreover, we will define existing identification and communication standards, and point out a number of benefits of using them.

4.1.2 Typology of standards

Standards enable more effective, automated information sharing and reuse within the supply chain by enabling all parties to speak the same language by leveraging the same set of the standard data description and standard data exchange structure which can then be interpreted in the same way, regardless of the tools chosen to create the machine-readable format.

Identifiers are the 'name' and/or 'ID' of 'elements' such as products, packages, persons, entities, carriers, containers, trade documents and any other physical/digital items in supply chain and related data exchanges. Identifiers are a key building block for integrating data within organisations, between business partners and across sectors and industries. From physical procedures to digital data interchanges and workflows, an identifier is the 'bridge' between a physical 'thing' and its data, a virtual entity or a digital twin in an information and digital environment—the latter is also referred to as an information system, the internet, the internet of things, the industrial internet and parts of the meta-universe. All supply chain actors would benefit from a consistent reference to established identifier standards which provide systematic identification of subjects (legal entities and natural persons with rights and obligations) and objects (entities without rights and obligations).

Anyone can create their own identifier and identification for their closed applications and systems. However, using globally accepted and standardised identifiers and code schemes can unlock great advantages for trade partners as they participate in the global economy and international trade. This would facilitate the creation and sharing of unique 'end-to-end' identification of subjects and objects, resulting in richer, high-quality data in the international supply chain. It would also increase the ability to track-and-trace, be it locations of particular objects or status/tracking events such as receiving, packing, shipping and transporting, which occur to the traceable object during its lifecycle across different supply chain actors' processes.

It is important to note that this chapter does not provide an exhaustive list of all standards available but does list some of the most notable and widely used standards as a starting point to facilitate interoperability among the most supply chain actors. This chapter is divided into GS1 standards and others used in the supply chain.

In this document, taking into account the characteristics of the PLANET project, we will focus on identifications (Trade Items, Logistics Units, Assets, Locations and parties), communications and business documents exchange standards.

4.1.2.1 Identifications standards (Trade Items, Logistics Units, Assets, Locations and parties)

GS1 Standards

GS1 standards provide a common way for businesses to uniquely identify, accurately capture and automatically share information about their products, locations, assets and much more. GS1 standards are the global language of business, supporting real-world supply chain business processes.

While GS1 standards may be used in any combination in a given business application, the "Identify, Capture, Share" paradigm is pervasive in situations where GS1 standards apply. Using the GS1 technical standards from the three groups can provide solutions for business applications like supply chain visibility, traceability, etc.

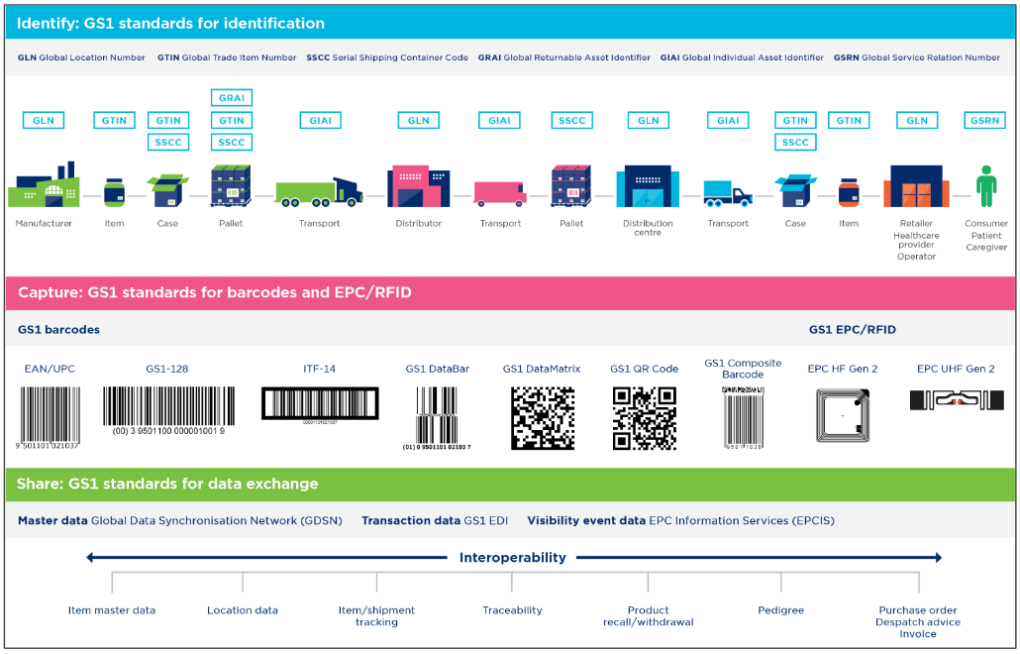

Figure 3. Structure of the GS1.
Source: www.gs1.org

GS1 ID Keys give companies efficient ways to access information about items in their supply chains and share this information with trading partners. ID Keys enable organisations to assign standard identifiers to products, documents, physical locations and more. Because GS1 ID keys are globally unique, they can be shared between organisations, increasing supply chain visibility for trading partners. There are 12 GS1 ID keys, allowing organisations to connect physical events and related information. For the purposes of the report, we will describe selected standards:

- Global Trade Item Number (GTIN) - can be used by a company to uniquely identify all of its trade items. GS1 defines trade items as products or services that are priced, ordered or invoiced at any point in the supply chain. The GTIN can be used to identify types of products at any packaging level (e.g., consumer unit, inner pack, case, pallet). Groups of trade items with similar production and usage characteristics such as production batches can be further identified with the help of the batch / lot number, expiry date, and similar data elements. Individual trade items can be uniquely identified using a GTIN plus serial number. Once a company has assigned a GTIN to a trade item, it provides a common language for all of its entities and trading partners worldwide to uniquely identify the item and easily communicate information about the item. The GTIN can be encoded in a barcode or an EPC/RFID tag. By scanning the barcode or EPC/RFID tag, companies can efficiently and accurately process products and related information; for example, at check out in a store, when receiving goods in a warehouse, and when administering medication in a hospital. GTINs can be used to unambiguously identify trade items online, for example in catalogues, in electronic messages such as purchase orders and invoices, and embedded in web pages to optimise use by search engines and other information consumers. **The GTIN is fully compatible with ISO/IEC 15459 – Part 4: Individual products and product packages**.

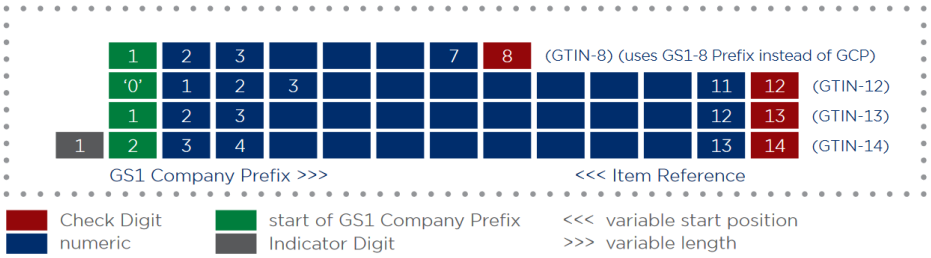

Figure 4. Structure of the GTINs.
Source: www.gs1.org

- Serial Shipping Container Code (SSCC) – can be used by companies to identify a logistic unit, which can be any combination of trade items packaged together for storage and/ or transport purposes; for example a case, pallet or parcel. The SSCC is a crucial key for traceability, since it uniquely identifies each distributed logistic unit and its content. The SSCC enables companies to track each logistic unit for efficient order and transport management. The SSCC can be encoded in a barcode or EPC/RFID tag, ensuring the logistic unit can be accurately and easily identified as it travels between trading partners, anywhere in the world. When SSCC data is shared electronically via EDI or EPCIS, this enables companies to share information about the status of logistic units in transit, and reliably link it to related transport information such as shipment details. The SSCC enables companies to link to additional information about the logistic unit. This information can be communicated via a Despatch Advice or Advanced Shipping Notice (ASN) prior to the logistic unit's arrival. Upon receipt the SSCC will be scanned, providing the required information to speed up the receipt of goods as well as the subsequent invoicing process. **The SSCC is fully compatible with ISO/IEC 15459 – Part 1: Unique identifiers for transport units**. This is often referred to as the ISO licence plate and is a prerequisite for tracking and tracing logistic units in many international supply chains.

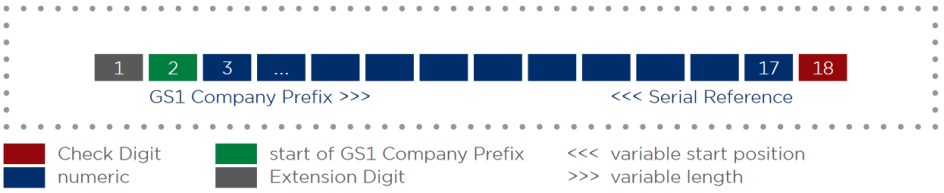

Figure 5. Structure of the SSCC.
Source: www.gs1.org

- Global Location Number (GLN) - can be used by companies to identify their locations, giving them complete flexibility to identify any type or level of location required. GLN provides a globally unique, standardised identifier that allows companies to answer the questions "who" and "where" within their own organisation and throughout the entire supply chain. GLNs can be used to identify different locations.
    - A GLN identifying a party answers the question of "**who**" is involved within the use case leveraging GS1 standards. This may be a legal entity or function that defines who is transacting in a scenario.
        - Legal entity - a legal entity is any business, government body, department, charity, individual, or institution that has standing in the eyes of the law and has the capacity to enter into agreements or contracts.
        - Function - a function is an organisational subdivision or department based on the specific tasks being performed, as defined by the organisation.
    - A GLN identifying a location answers the question of "**where**" something has been, is, or will be. GLN can be used to identify two types of locations: physical location and digital location.

- Physical location - a physical location is a tangible place that may be represented by an address, coordinates, or other means. A physical location within another physical location can be allocated its own GLN. Each sub-location is a specific space located on or within another physical location. Under certain circumstances, these sub-locations can be identified with a GLN extension component. Not all locations stay in a fixed spot. A mobile location refers to something that answers the question, "where?" and is expected to move and can also be allocated a GLN. (e.g., shipping vessels, mobile blood donation van).
- Digital location – a digital location is an electronic (non-physical) address that is used for communication between computer systems. Information associated with a digital location GLN will include the related legal entity and may include the development status (testing, production), network address of the location and the system administrator contact details (email address, phone number, etc.).

GLNs in barcodes can help to route products to their destination or capture where they came from. Use of EPC®/RFID and readers identified with GLNs can support automatically capturing the movement of goods without the need for line-of-sight scanning or other manual intervention. Sharing information relating to parties and locations using GLN within GS1 standards like EDI and EPCIS will enhance transitional data and physical event data. **GLN is fully compatible with ISO standard 6523. The International Code Designator (ICD) for GLN is '0088'.**

Figure 6. Structure of the GLN.
Source: www.gs1.org

- Global Returnable Asset Identifier (GRAI) - this GS1 Key is especially suitable for the management of reusable transport items, transport equipment, and tools and can identify these returnable assets by type and if needed also individually for tracking and sorting purposes. In distribution processes, returnable assets are used by companies to package, protect and transport physical products, and are reused for multiple deliveries. Examples include crates, bread trays, pallets and even beer kegs. Returnable assets can be owned by either trading partner or can be rented via a system where companies collaborate on the use of these assets. The GRAI can be encoded in a barcode or EPC/RFID tag that can be scanned to automatically register the returnable asset's movements, for example, when used to ship goods or when returned empty. The GRAI (with serial number) can also be used to manage regular maintenance and record repairs. When used electronically, the GRAI helps companies more easily track and manage their valuable returnable assets. The GRAI also provides companies with greater supply chain visibility; when a company knows which goods are contained in a particular returnable asset, it can track the asset and, at the same time, track the goods it contains.

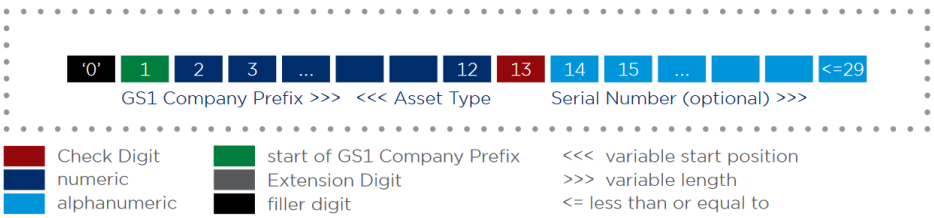

Figure 7. Structure of the GRAI.
Source: www.gs1.org

- Global Individual Asset Identifier (GIAI) - companies can apply a GIAI on any asset to uniquely identify and manage that asset. Companies assigning the GIAI can be either the asset owner or a leasing or rental company. The GIAI can be encoded in a barcode or EPC/RFID tag connected to the asset. Companies can quickly identify the individual asset and register relevant data such as its location as well as repair and maintenance activities. Applied electronically, the GIAI enables a company to record individual assets in asset management and accounting systems across company boundaries.

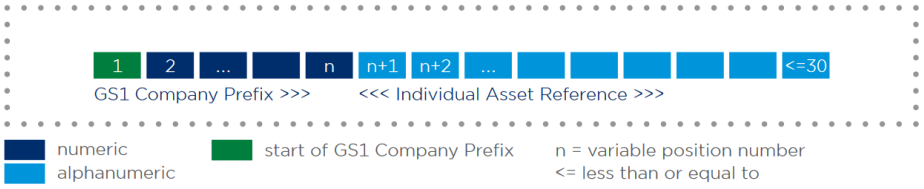

Figure 8. Structure of the GIAI.
Source: www.gs1.org

- Global Identification Number for Consignment (GINC) - can be used by companies to identify a consignment comprised of one or more logistic units that are intended to be transported together. Logistic units in a particular shipment may be associated with different GINCs during various transport stages; for example, when the shipment gets consolidated with other shipments during its journey, and deconsolidated again before it reaches the consignee. The GINC allows freight forwarders and transport providers to keep track of the logistic units being transported together. The GINC is typically used by freight forwarders to instruct transport providers; for example, on a Master Airway Bill (MAWB) or a Master Bill of Lading (MBL). The GINC can be encoded in a barcode or as text on a MAWB / MBL, or in addition to the Serial Shipping Container Code (SSCC), on a logistics label.

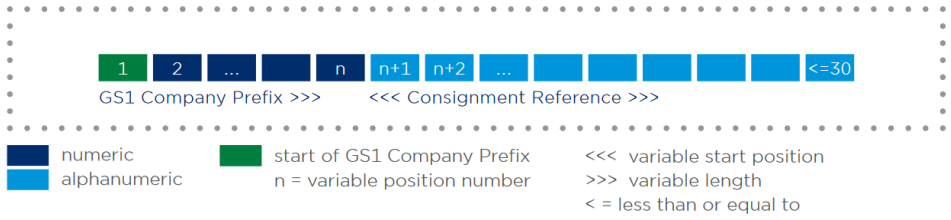

Figure 9. Structure of the GINC.
Source: www.gs1.org

- Global Shipment Identification Number (GSIN) - is a number assigned by a seller and shipper of goods to identify a shipment comprised of one or more logistic units that are intended to be delivered together. The logistic units keep the same GSIN during all transport stages, from origin to final destination. The GSIN identifies the logical grouping of one or several logistic units, each identified with a separate Serial Shipping Container Code (SSCC). The GSIN can be encoded by the shipper in a barcode or as text on a House Way Bill, or in addition to the SSCC, on a logistics label. The GSIN can be electronically used by a company in transport instruction and transport status messages between freight forwarder and transport provider, and also as a reference in the Despatch Advice. **The GSIN is fully compatible with ISO/IEC 15459 – Part 8: Grouping of transport units. The GSIN also meets the requirements for a unique consignment reference (UCR) according to the World Customs Organisation.**

Figure 10. Structure of the GSIN.
Source: www.gs1.org

- Global Document Type Identifier (GDTI) - can be used by companies to identify documents, including the class or type of each document. In cases where companies require identification of individual documents, an optional alphanumeric serial number can be included in the GDTI. The term "document" is applied broadly to cover any official or private paper that infers a right (a proof of ownership) or obligation (notification or call for military service) upon the bearer, or a diploma or certificate. Such documents typically require recording of the appropriate information contained on the document. Examples of the kind of documents that could benefit from a GDTI are physical documents such as certificates, invoices, driving licenses, and electronic documents such as digital images, EDI messages. The GDTI can be encoded in a barcode or printed directly on the document. Companies can use the GDTI as a method of identification and registration of documents and related events. They can also use the GDTI for information retrieval, document tracking, and electronic archiving. One specific application is the prevention of fraud and document falsification; for example, assigning a GDTI to each diploma or certificate that is then linked to a central registry.

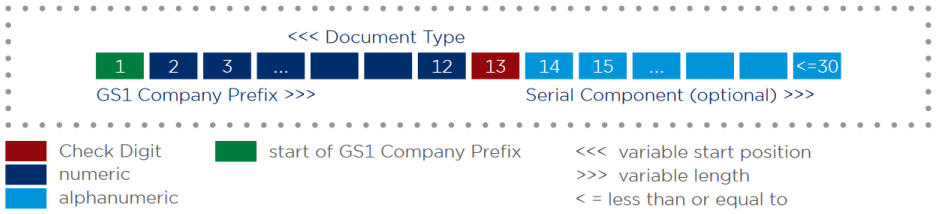

Figure 11. Structure of the GDTI.
Source: www.gs1.org

- Global Product Classification (GPC) - a GS1 standard that helps global trade partners to classify products by grouping them into categories based on their essential properties as well as their relationships to other products in GS1 related systems

Identification standards provided by other organisations:

Besides the identifier standards mentioned in 4.1.2.1.1, the transport and logistic sector benefits from a few additional identifier standards as listed below:

- LEI ISO 17442 - Legal Entity Identifier (LEI) - the LEI connects to key reference information that enables clear and unique identification of legal entities. LEI issuers—also referred to as Local Operating Units (LOUs)—provide registration, renewal and other services, and act as the primary interface for businesses to obtain2 an LEI. The LEI data are available for any user free of charge on www.gleif.org.
- W3C DID - Decentralised Identifier (DID) - a type of identifier that enables verifiable, decentralised digital identity. A DID refers to any subject (e.g., a person, organisation, thing, data model, abstract entity, etc.) as determined by the controller of the DID. In contrast to typical, federated identifiers, DIDs have been

designed so that they may be decoupled from centralised registries, identity providers and certificate authorities.

- ISO 9362 - Business Identifier Code (BIC) - the BIC is used for addressing messages, routing business transactions and identifying business parties within the financial services industry. SWIFT in its role of ISO registration authority issues BICs4. The BIC is used in financial transactions, client and counterparty databases, compliance documents and many others, although not all BICs are connected to the SWIFT network used by banks and other institutions for financial messaging.
- TIN - Trader Identification Number (TIN) - a globally unique identification number that can be used for retrieving underlying information relating to an economic operator involved in cross-border supply chain, to enable customs administrations to perform the appropriate actions, particularly in the context of mutual recognition arrangements/agreements of authorised economic operators.
- Harmonised Commodity Description and Coding System (HS code) - a multi-purpose international product nomenclature developed by the WCO, used in customs and trade procedures.
- United Nations Standard Products and Services Code (UNSPSC) - a global classification system of products and services in all industry sectors, managed by GS1 US for the UN Development Programme (UNDP)5. Enables procurement teams to conduct spend intelligence, improve strategic sourcing and monitor spending limits.
- Unique Consignment Reference (UCR) - a reference number for customs use and may be required to be reported to customs at any point during a customs procedure.
- ISO/IEC 15459 - unique Identification - this series of standards specifies the generation of unique identifiers for transport units, individual products, individual returnable transport items and groupings of items. It makes provision for a registration authority that recognises issuing agencies (e.g., GS1, FIATA, UPU) managing identification systems. Primarily used for automatic identification and data capture applications (barcodes and RFID).
- ISO 14533 series - electronic Signatures - ensure the interoperability of implementations with respect to long-term signatures that allow validation of the digital signature a long time after its generation.
- IMO ship identification number scheme - Ship Identification Number - The IMO number is a permanent number assigned to each ship for identification purposes, to enhance maritime safety, security and environmental protection, and to facilitate the prevention of maritime fraud. Inserted in the ship's certificate, it would remain unchanged upon transfer of the ship to other flag(s).
- ISO/IEC 15459-1 and ISO/IEC 15459-5 - Unique Item Identifier (UII) - Identifiers of individual transport units and returnable transport items based on ISO/IEC 15459 Unique Identification system.

4.1.2.2 Communications and business documents exchange standards

In today's interconnected business landscape, effective communication and seamless exchange of information between organizations and systems are vital for efficient operations and collaboration. The chapter on "Communications and Business Documents Exchange Standards" explores the frameworks and standards that play a crucial role in establishing a common language and structure for data exchange. These standards provide the foundation for interoperability, reliability, and security in various industries, enabling the smooth transmission of business documents and facilitating seamless integration between disparate systems.

This chapter delves into several widely adopted standards and protocols that have revolutionized the way organizations exchange information. It examines the purpose, features, and benefits of key standards such as Electronic Data Interchange EDI - EANCOM®, GS1 UN/CEFACT XML, GS1 XML, EPCIS etc.. By studying these standards, readers will gain insights into how they contribute to streamlined communication, improved efficiency, and enhanced collaboration across diverse sectors such as finance, procurement, logistics, and more.

Understanding and implementing these communication and document exchange standards is crucial for organizations aiming to optimize their operations, reduce manual efforts, minimize errors, and enhance data security. By adhering to these standards, businesses can unlock new opportunities for seamless integration, accelerate processes, and effectively communicate with partners, suppliers, and customers across borders.

By exploring the rich landscape of these standards, readers will acquire the knowledge necessary to make informed decisions about implementing the most appropriate standards for their organizations, thereby fostering improved communication, efficiency, and collaboration in today's interconnected business environment.

4.1.2.2.1 Electronic Data Interchange

Electronic Data Interchange (EDI) allows rapid, efficient and accurate automatic electronic transmission of agreed business data between trading partners. GS1 EDI provides global standards for electronic business messaging that allow automation of business transactions commonly occurring across the entire supply chain. It covers master data alignment, order and delivery and financial settlement management, as well as transport and warehouse management. The main business partners in scope for this are retailers, manufacturers, material suppliers and logistic service providers.

While, in the market, the need for digitisation of business data is increasing more and more, the technological evolution may require the players to extend and modify their EDI implementations with frequency, in response to new legal or business requirements.

In order to facilitate these implementations, reducing ambiguities in the content of transactional messages and in the use and definition of the business terms, GS1 has developed a new methodology, based on a semantic approach, aiming at facilitating the support of new syntaxes, technologies and requirements emerging from the market.

GS1 has currently three sets of EDI standards: EANCOM®, GS1 UN/CEFACT XML, GS1 XML.

GS1 EANCOM® is a GS1 subset of the UN/EDIFACT standard (United Nations Electronic Data Interchange for Administration, Commerce and Transport), which comprises a set of internationally agreed standards, directories and guidelines for the electronic interchange of data. It is fully compliant to UN/EDIFACT. It provides the collection of only those message elements which are needed by the business application and required by the syntax (mandatory elements). Omitted are optional elements covering specific business requirements not relevant for GS1 users.

EANCOM® incorporates into the electronic messages the GS1 Standards of physical identification of trade items, logistics units and the Global Location Numbers (GLN) identifying the trading partners. It allows integrating the physical flow of goods with related information sent by electronic means.

The EANCOM® messages are mostly equivalent to traditional paper business documents. Messages available in the EANCOM® standard cover the functions required to complete a trade transaction:

- Messages which enable the trade transaction to take place, e. g. price catalogue, purchase order.
- Messages used to instruct transport services to move the goods.
- Messages used in settlement of the trade transactions through the banking system.

All messages are implemented in parallel by different users. Although GS1 XML is a newer technology than EANCOM®, the latter has a large and constantly growing number of users. GS1 will continue supporting both syntaxes going forward.

The messages available in the GS1 XML standard cover the following areas of the supply chain:

- Data Synchronisation messages that enable sending information about trade item attributes and support its automated synchronisation between business partners, using the Global Data Synchronisation Network (GDSN).
- Messages used to order goods and respond to this order.
- Messages used to announce the despatch of goods and confirm their receipt.
- Messages requesting payment for the goods sold and informing about the payment being sent.
- Messages for planning and execution of transport.

- Messages supporting automated replenishment of goods.

GS1 UN/CEFACT XML business message standards are developed within UN/CEFACT and hosted by the UNECE, a body of the UN. This guarantees an international focus, openness in the development process and are free from fee usage (As specified by the mission of UN/CEFACT and policy of UNECE as a global forum). For all published specifications and standards, the Intellectual Property Rights (IPR) are owned by the UN and as such are open for free use by everyone.

GS1 UN/CEFACT, a subsidiary intergovernmental body of the UNECE Committee on Trade, is mandated to develop a programme of work of global relevance to achieve improved worldwide coordination and cooperation in the areas of trade facilitation and electronic business, covering both commercial and government business processes that can foster growth in international trade and related services. It encourages close collaboration between governments and private business to secure the interoperability for the exchange of information between the public and private sector. Example messages are: Cross Industry Despatch Advice and Cross Industry Invoice.

4.1.2.2.2 EPCIS

EPCIS is GS1's flagship data sharing standard for enabling visibility, within organisations as well as across an entire supply chain of trading partners and other stakeholders. It helps provide the "**what, when, where, why** and **how**" of products and other assets, enabling the capture and sharing of interoperable information about status, location, movement and chain of custody. EPCIS is a traceability event messaging standard that enables supply chain visibility through sharing event data using a common language across, between and within enterprises. EPCIS 2.0 supports existing and emerging industry use cases for traceability and supply chain visibility, providing such information as:

- Whereabouts of products produced at or shipped from a given facility, to support tracking and tracing.
- Aggregation of individual items packed into cases, cases loaded onto pallets, pallets into containers.
- Timestamped series of business-relevant sensor data (e.g., for critical mechanical components or in temperature-controlled transports).
- Details on measured concentrations of chemicals and microorganisms, for food safety applications.
- Accurate overview of product inventory or equipment availability across networks of distributed locations.
- Expiration of perishable assets (e.g., vaccines) to ensure timely use and first-in/first-out distribution.
- Certification details associated with harvest, production, shipments and locations, such as reduction of carbon emissions or efficient use of water and land.

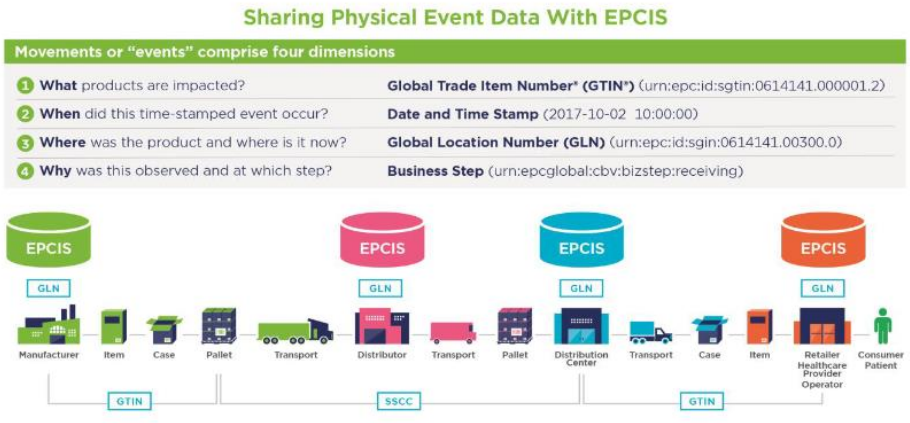

Figure 12: Sharing Physical Event Data With EPCIS.
Source: www.gs1.org

EPCIS or Electronic Product Code Information Services is a part of the EPCglobal network, which provides a secure environment for storing specific data about products and their exchange between partners. In other words, it is a standard used to track the progress of objects, in real time, during their flow in the supply chain. EPCIS stores information about when a particular facility was registered, where it was located and with what business step; for each registered facility.

EPCIS operates on event definitions. Each data in the system is stored as one of 5 types of events:

- ObjectEvent,
- AggregationEvent,
- TransactionEvent,
- TransformationEvent,
- SensorEvent.

Each event is defined as a file in XML format with a specific structure, compliant with GS1 EPCIS standard.

4.1.2.2.3 Master references for the cross-border supply chain

Those references have informed the basis of many currently available data standards and those in the works. Any supply chain actor that wants to integrate with the rest of the ecosystem would benefit from leveraging the same reference libraries:

- UN/Core Component Library (CCL) - Ensure consistency and interoperability. The Semantic base definitions are compatible with all other UN/CEFACT deliverables and mappable with many other organisations' data models such as WCO, IATA, GS1, etc.
- UN/CEFACT Buy-Ship-Pay Reference Data Model (BSP-RDM) - It can be applied by any country, region or industry community to provide the definitions of contextualised transport-related data exchange documents which can be integrated into software solutions for traders, carriers, freight forwarders, agents, banks, customs and other governmental authorities etc.
- UNCITRAL Model Law on Electronic Transferable Records (2017) - The MLETR builds on the principles of non-discrimination against the use of electronic means, functional equivalence and technology neutrality underpinning all UNCITRAL texts on electronic commerce. It may therefore accommodate the use of all technologies and of all models, such as registries, tokens and distributed ledgers.
- ISO 15000 series, Electronic business eXtensible Markup Language (ebXML) - It can provide an open infrastructure that enables the global use of electronic business information in an interoperable, secure, and consistent manner by all types of organisations (e.g., commercial enterprises, government agencies, not-for-profit organisations).

4.1.2.2.4 Standard types and data formats of documents in the supply chain

- Standards for Commercial Transactions Documents:

Table 3: List of standards for Commercial Transactions Documents

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
Catalogue	UN/CEFACT Cross Industry Catalogue	UN/CEFACT XML, UN/EDIFACT	ICC Incoterms latest version

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
		OASIS Universal Business Language (UBL) latest version	
Request for Quotation (RFQ) and Quotation	UN/CEFACT Cross Industry Quotation	UN/CEFACT XML, UN/EDIFACT OASIS Universal Business Language (UBL) latest version	ICC Incoterms latest version
Purchase Order (PO)	UN/CEFACT Cross Industry Ordering Process	UN/CEFACT XML, UN/EDIFACT OASIS UBL latest version ISO 20022	For companies involved in supply chain finance (SCF) programme (if any, such as pre-shipment finance), specific rules may apply as part of the programme.
Commercial Invoice **UN**	UN/CEFACT Cross Industry Invoice (CII) Peppol BIS Billing 3.07	UN/CEFACT XML, UN/EDIFACT OASIS UBL latest version ISO 20022	UN/CEFACT Executive Guide on e-Invoicing ICC Uniform Rules for Forfaiting (URF 800) where needed to obtain receivables financing
Packing List	UN/CEFACT Cross Industry Export Packing List	UN/CEFACT XML, UN/EDIFACT OASIS UBL latest version	
Despatch Advice	UN/CEFACT Cross Industry Delivery	UN/CEFACT XML, UN/EDIFACT OASIS UBL latest version	

Source: Own elaboration

- Standards for Transport, Forwarding and Cargo Handling Documents:

Table 4: List of standards for Transport, Forwarding and Cargo Handling Documents

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
Shipping/ Forwarding Instruction	UN/CEFACT Multimodal Shipping Instruction	UN/CEFACT XML, UN/EDIFACT	

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
		OASIS UBL latest version JSON, API	
	DCSA Shipping Instruction for multimodal container shipping		
Bill of Lading	DCSA electronic bills of lading (eBLs) for multimodal container shipping	JSON, API	ICC Uniform Customs and Practice for Documentary Credits Supplement for Electronic Presentation (eUCP) latest version ICC Uniform Rules for Collections Supplement for Electronic Presentation (eURC) latest version
	BIMCO electronic bills of lading (eBLs) for dry and wet bulk		
	Electronic FIATA Multimodal Transport Bills of Lading (eFBL)	JSON, API & PDF with QR code	
Air Waybill	IATA e-AWB	EDI messages (FWB/ XFWB, FSU/XFSU), IATA Cargo XML, EPIC Basic API, IATA ONE Record specifications (JSON, API)	IATA Resolution 672 on E-air Waybill, also known as "Multilateral e-AWB Agreement" ICC eUCP latest version ICC eURC latest version
CIM Consignment Note (Rail Transport Document)	CIM/SMGS Consignment Note	EDI, working towards XML/EDIFACT converter	ICC eUCP latest version ICC eURC latest version
CMR Consignment Note (Road Transport Document)	UN/CEFACT eCMR	XML	ICC eUCP latest version ICC eURC latest version

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
Verified Gross Mass (VGM) Report for Containerised Shipments8	Depends on shipping line	UN/EDIFACT Verified gross mass message (VERMAS)	SOLAS (International Convention for the Safety of Life at Sea)

Source: Own elaboration

- Standards for Official Control Documents:

Table 5: List of standards for Official Control Documents

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
Advance Electronic Information (AEI)	AEI Derived Information Package (DIP)	XML	
Pre-Loading Advance Cargo Information (PLACI)17	PLACI regime		WCO's SAFE Framework of Standards Joint WCO-ICAO Guiding Principles for Pre-Loading Advance Cargo Information (PLACI)
Transit Declaration, Export Declaration, Import Declaration, Cargo Report Export, Cargo Report Import	WCO Data Model and information packages	XML UN/EDIFACT Government Cross-Border Regulatory messages (GOVCBR)	WCO Revised Kyoto Convention - General Annex Guidelines - Chapter 3: Clearance and other Customs formalities WTO Trade Facilitation Agreement (TFA) The International Convention on the Harmonised System (HS Convention) WTO Customs Valuation Agreement

TYPE	DATA STANDARD	DATA FORMAT/ EXCHANGE STANDARD	ANY APPLICABLE RULES, REGULATIONS, GUIDELINES
			WCO Single Window Compendium
Postal Consignment Note, Postal Customs Clearance	CN22/CN23 customs declaration WCO DM – UPU Derived Information Package (DIP)	UPU–WCO standard EDI messaging (CUSITM/CUSRSP) and inter-postal standard messaging (ITMATT)	WCO Revised Kyoto Convention, Specific Annex J, Chapter 2 (Postal Traffic)
Consignment Security Declaration (CSD)	UN/CEFACT Air Consignment Security Declaration	UN/CEFACT XML, UN/EDIFACT	

Source: Own elaboration

4.1.3 Use of standards in customs and tax aspects

The Customs Union is one of the pillars of the European Union and is at the heart of the internal market. It has provided a stable foundation for economic integration and growth in Europe for nearly five decades. More and more countries are digitalizing their customs systems, both processes and procedures in equal measure.

Where forms were once filled in, submitted and stamped by hand, the process has now moved online and digitalization is at the heart of the Union Custom Code for all member states. The EU Customs Union is essential for the proper functioning of the single market. In practice, National customs services in all EU countries work together as one to manage the day-to-day operations of the Customs Union.

The Union Customs Code (UCC) adoption and application as of 1 May 2016 completes the shift by customs to a paperless and fully electronic and interoperable environment with core values of simplicity, service and speed. The UCC represents the new framework Regulation on the rules and procedures for customs throughout the EU and covers most of the projects that were previously introduced by the e-Customs decision. The main project remaining as being covered by the e-Customs decision is the EU Single Window environment for customs initiative.

With the current and ongoing Union Customs Code implementation that aims to bring more efficient customs handling, we're seeing the final steps towards a truly digital environment. Full digitalization will have an obvious impact on the software that businesses use to submit customs information and declarations – either their own or the software used by their customs broker. UCC also requires data sets that are wider than many current customs software can handle.

On 28 September 2020, the European Commission published a Communication entitled "**Taking Customs to the Next Level: a Plan for Action**". Political Guidelines published in July 2019 by Commission President Ursula von der Leyen called for "**a stronger framework that will allow us to better protect our citizens and our single market**" and "**an integrated European approach to reinforce customs risk management and support effective controls by the Member States**.The new Action Plan outlines concrete steps to try to achieve those objectives.

Thirty actions scheduled for 2020-2025 seek **to address the challenges faced by the EU Member States customs authorities**. This includes more efficient management of their ever-increasing roles, to ensure, for example, that import duties, excise duties, and VAT are paid correctly and that goods are checked at import/export at the EU border and unsafe/fake goods or controlled items are identified and handled appropriately, taking account of

the major increase in e-commerce and risks related to that. In addition, the expected Brexit-related increase of customs declarations and the COVID-19 crisis highlight the clear need for improved management of the EU customs union.

The Action Plan acknowledges that there are weak links in the system and that **greater availability and use of data and data analysis and more robust risk management tools are required**, as well as more EU financing for customs equipment and IT systems. By end 2025, the Commission wants to complete a modern, interconnected and fully paperless customs environment, covering the implementation of the Union Customs Code (which has been in place since 2016).

An additional important aspect is the regulation adopted by the European Commission (Council Directive (EU) 2017/2455 of 5.12.2017) regarding the e-commerce VAT package.

The entry into force of the EU e-commerce VAT package from 1 July 2021 has resulted in a number of changes related to the charging of VAT on low-value shipments. Currently, customs and tax declarations for all imported goods can be made through:

> **Special Arrangements:** The courier collects VAT is collected and pays Customs, or
> **Import One-Stop Shop (IOSS)**: Marketplace collects taxes from the buyer upon purchase and courier handles customs declaration.

As a result, there is a need for the systems that identify or track the consignment to include data to uniquely identify the product according to the harmonised HS and CN nomenclature of the commodity and its value, introduced by the World Customs Organisation. In addition, there is a need to identify the transaction on the sales platform (for the option of accounting for VAT via IOSS, which is likely to be mandatory from 2025).

Product identification systems provide the means through which goods can be identified uniquely. In global trade, different industry sectors are gradually supplementing or replacing plain language descriptions of products with product identification numbers. Several critical business functions are fulfilled when unique identifiers used to refer to commodities in trade documents.

The distinction between commodity classification (HS) and product identification is vital. Classification schemes are designed to assign commodities to specific categories that are significant for industrial or regulatory decision-making. Identification schemes, on the other hand, provide the means to uniquely and distinctly identify goods and trace them through the supply chain.

By using product identification systems, traders improve the level of trust, granularity of information and certainty in commercial transactions. Complete product traceability is achieved by including product identifiers in records of all materials used in the manufacture of finished goods.

Though not normally required, Customs and other government agencies may ask for product identification information for some commodities to identify shipments subject to import, export or transit processes. Industry operated schemes of product identification have proved to be useful to Customs and border authorities in a variety of ways in managing risks and ensuring compliance with cross-border regulations, apart from furthering simplification of regulatory information and documentation.

Product Identification Numbers are developed for commercial purposes, but they can be easily used by Customs and other government agencies for applying regulatory controls, risk assessment, and speeding up the release and clearance of goods. The ability of these numbers to provide access to predefined, unique and unambiguous information about the product, constitutes the value proposition for the use of these numbers. Although not all products have Product Identification Numbers, these numbers are being used increasingly by trade and industry. For example, the Global Trade Item Numbers (GTINs) issued by GS1 are applied to the majority of the goods encountered in trade. Additionally, Global Product Classification (GPC) is GS1 classification system for goods. It is a four tier system – Segment, Family, Class, and Brick. These roughly correlate to the Section, Chapter, Heading

and Sub-heading system in the Harmonized System (HS). There are approximately 4,000 bricks (8-digit) in the GPC.

The Harmonized System (HS) is the primary basis for tariff classification, trade negotiations and statistical reporting. However, various regulatory requirements and concerns can be effectively met with deeper level of details and better insights into product features. For some product lines (e.g., pharmaceuticals, chemicals and medical supplies), regulators need production batches to be identified as well, and therefore batch numbers and serial numbers could be added as additional requirements. These requirements can be met by numerous product identifications and categorizations.

The use of Product Identification Numbers can be of strategic value to Customs and other cross-border regulatory agencies in improving, inter alia, the effectiveness of risk management, combating of counterfeit goods and the control of strategic and regulated goods. Customs can benefit significantly from the use of product identification techniques that have been developed and are commonly relied upon by trade and industry.

Product Identification Numbers can help in accessing further information on products; verifying product compliance and product safety; establishing identity of goods; improving data quality for better risk assessment and more effective Customs controls; reducing the volume of data that need to be supplied by traders by relying more on a concise identifier instead of lengthy product description; bringing down errors in the provision of product description by traders; and enabling the use of automatic data capture devices, such as barcode reader or Radio-frequency identification (RFID); as well as opening up new opportunities on a more convenient use of mobile devices or mobile apps.

With Product Identification Numbers, there is a great potential for simplifying and reducing the regulatory information to be reported by trade. This is the primary benefit for both Customs and trade. If goods can be assigned unique identification codes, databases can store information about the classification of each good under different schemes of classification, allowing the trader to retrieve and readily use the information as and when required. When a Product Identification Number is present in data held in Customs databases, this will help to identify the goods and pinpoint their exact nature long after they have been released into general circulation.

Product Identification Numbers can be combined with the HS and “end-use codes”. This combination is of interest in general for several types of commodities, especially strategic goods, hazardous goods, food and pharmaceuticals. In addition, a mapping database between Product Identification Number and HS could help increase the accuracy of product classification based on HS.

What is valid for product is also valid for identifying the various roles of the stakeholders in an international transaction (shipper, manufacturer, custom representative, AEO, freight forwarder, importer, distributor etc…) This can be done with the use of the GLN (Global Location Numbers), also provided by GS1, amongts other usefull identification standards which allow to provide identification on business locations and their functions.

Therefore a more precise identification of product (GTIN/ISO15459-6), Location (GLN/ISO6523) and identification of transporting asset (SSCC/ISO15459-1 or GIAI/ISO15459-4&5 or GRAI/ISO15459-5 or GSIN/ISO15459-6) together with HS code could help achieving a better risk assesment for Customs.

Identifiers, the core activity of GS1, are the « name » and/or « ID » of « elements» such as products, packages, persons, entities, carriers, containers, trade documents and any other physical/digital items in supply chain and related data exchanges. Identifiers are a key building block for integrating data within organisations, between business partners and across sectors and industries. From physical procedures to digital data interchanges and workflows, an identifier is the ‘bridge’ between a physical ‘thing’ and its data, a virtual entity or a digital twin in an information and digital environment

GS1 has been working with many customs organization over the years focussing on GTIN and the associated master data, to improve the flow of goods in the international trade system:

Table 6: List of customs agencies with which GS1 Member Organizations cooperates

Economy / Region	Data Type and Identification	Product Category	Agency	Status
Argentina	GTIN used in the compliance declaration of import and export products, customs tax risk prevention and control.		Administración Federal de Ingresos Públicos (Tax revenue agency of Argentina)	In force, but low level of adoption. Non-mandatory / optional to use Resolution 3814/2015 AFIP, with effective date 11/24/2015
Azerbaijan	GTIN For international producers and the importing of construction products from abroad, it is proposed to add an additional column "GTIN" to the customs declaration.	Construction material For international producers / imported construction products	Customs (TBC)	Planning stage: It is being planned to create a catalog of construction products and equipment that are sold on the local market in Azerbaijan. The main identifier in this catalog will be GTİN
Canada	Global Trade Item Number, Unique Device Identification	Consumer products, health products, medical devices, pharmaceuticals, blood products	Canada Border Services Agency; Health Canada	Implemented
China	Global Trade Item Number, and associated master data elements	All product categories that carry GTIN General Trade	General Administration of Customs China	Implemented as of August 2019
China	Global Trade Item Number, and associated master data elements	Cross border e-Commerce trade	General Administration of Customs Chongqing, China	Piloting as of 15 December 2021
Egypt	International code of each item (the standard numbering system "GS1" or any	Not indicated. Cargo contents.	Ministry of Finance Egypt	Issued 8 April 2021 *(Decree of the Minister of Finance number 38:2021*

Economy / Region	Data Type and Identification	Product Category	Agency	Status
	other international standard numbering system)			*concerning Advance Cargo Information*
EU	E-commerce Parcel Identification keys SSCC, GSIN and GTIN (ISO equivalent referenced)	Goods imported into the EU valued at less than €22 by non-EU companies will stop being exempt from VAT	EU Customs Authorities	In force July 2021
Mongolia				
Russian Federation	GLN compulsory information in not available GLONASS geo coordinates should be entered ; GTIN is an optional element that the applicant may enter	Consumer products, cosmetics etc.	Submitted to Rosaccreditation *Unified Register of Certificates of Conformity*	Russian Government Decree 936 2021 in force as of September 2021
New Zealand	GTIN for imported / exported products *If the product carries product identifier it must be stated.*	Products carrying GTIN	New Zealand Customs	In force as of May 2021
USA	GLN; LEI; DUNS	Seafood, Toys, Alcoholic beverages, consumer goods, goods returned etc.	US Customs and Border Protection	POC 2022 participation by China, UK, Italy, France, Vietnam, Canada, Mexico, Australia, New Zealand
USA	SSCC	Boxed beef	USDA FSIS (Meat Imports)	New rules since 2021 moving to use of barcoding – from shipping mark stamp
Vietnam	GTIN verification for exported products	Products produced in Vietnam under	Vietnam Customs	In force as of 2019

Economy / Region	Data Type and Identification	Product Category	Agency	Status
		contract manufacturing		

Source: www.gs1.org

At the links provided, you can find Countries and Customs Agencies regulating and promoting GS1 standards: https://www.gs1au.org/for-your-industry/online-marketplaces/cross-border/countries-and-customs-agencies-regulating-and-prom

Business case: Making China's customs clearance processes more efficient and more accurate with Verified by GS1: https://www.gs1.org/docs/casestudies/verified-by-gs1-success-story-china-customs.pdf

4.1.4 Standardization in modern technologies used in logistics

In the fast-paced world of logistics, where goods and information flow seamlessly across global supply chains, standardization plays a pivotal role in ensuring efficient operations, enhanced collaboration, and increased productivity. The chapter on "Standardization in Modern Technologies Used in Logistics" delves into the importance and impact of standardization in the context of cutting-edge technologies that are revolutionizing the logistics industry.

This chapter explores the dynamic landscape of modern technologies that have reshaped the logistics sector, including Internet of Things (IoT), blockchain and smart contract. It examines how standardization efforts have facilitated the seamless integration and interoperability of these technologies, allowing logistics stakeholders to leverage their transformative potential.

The chapter delves into the fundamental principles and benefits of standardization in logistics technologies. It examines the role of standardization in establishing common protocols, interfaces, and data formats, enabling different technologies to communicate and exchange information seamlessly. By adhering to industry-wide standards, organizations can break down data silos, improve visibility, optimize processes, and create efficient end-to-end logistics networks. Furthermore, this chapter explores specific standardization initiatives and frameworks that have emerged to address the challenges and opportunities associated with modern logistics technologies. It delves into industry consortia, regulatory bodies, and international standards organizations that work collaboratively to define best practices, guidelines, and protocols for technology implementation in logistics.

By studying the standardization landscape, logistics professionals and stakeholders can gain insights into the advantages of adopting standardized technologies. They will understand how standardization helps mitigate compatibility issues, reduces implementation complexities, and facilitates seamless connectivity across supply chain networks. Additionally, the chapter highlights the role of standardization in promoting trust, security, and interoperability in the adoption of emerging technologies like blockchain for supply chain transparency and AI-driven optimization algorithms for route planning and demand forecasting. Overall, this chapter serves as a comprehensive guide to the significance of standardization in modern technologies used in logistics. By embracing standardized approaches, logistics stakeholders can harness the full potential of emerging technologies, drive innovation, and gain a competitive edge in the increasingly interconnected and dynamic global logistics landscape.

4.1.4.1 Blockchain and smart contracts

The use of blockchain technology allows for full transparency and integrity of the data stored in the data blocks. Each block holds information about the previous block creating an unbroken chain of consecutive information. The characteristics of blockchain complement well systems and databases storing data that are event-driven in

nature. The use of blockchain in which each block is a validated event fits into the current GS1 standards for logistics events:

[https://www.gs1.org/sites/default/files/docs/internet-of-things/gs1_blockchain_external_messaging_a4.pdf].

Blockchain technology, as presented, acts as a kind of repository of logistics events. In principle, each organisation and each actor in the supply chain may have its own internal register of events based on technological solutions derived from blockchain. The key, therefore, is to provide methods for communication between systems throughout the supply chain and, additionally, that the format of the information stored in the blocks is standardised.

The first condition is provided by the SOFIE Interledger Connector which allows communication between different blockchain systems, while ensuring that the entire system remains decentralised. The Connector, as a result of adding another event to the block, is able to propagate the event information to all involved, so that each of the connected blockchain systems will contain the same sequences of events, reflecting their physical and actual course.

It should be noted that blockchain technology does not define the formats and forms of events that are stored in blocks. In order to avoid implementation and standardisation issues, existing logistical event standards should be used. One of the existing and used standards is the GS1 EPCIS 2.0. It defines formats for both business and physical events. The contents of the standardised EPCIS 2.0 messages could be a component of the blocks in the individual blockchains of all actors in the supply chain. The blockchain would then also act as an EPCIS event repository. In this form, the repository would implicitly provide the event data integrity condition, i.e. it would explicitly allow the history of logistics units to be mapped.

Another enabling technology for the overall solution is Smart Contracts. It is often combined conceptually with Blockchain technology, although it is a separate concept. A Smart Contract is a contract that can perform an action depending on its content. In simple terms, a Smart Contract is code that is executed when certain conditions are met. The engine that monitors and supervises the execution of an action in a smart contract would take event data from the EGTN platform and individual blockchains. Depending on the implementation of the contract, an event would be emitted as a result of its execution, which would be published in the blockchain - or, more precisely, would be distributed by the blockchain connector. A blockchain diagram of the process is shown in Figure 12.

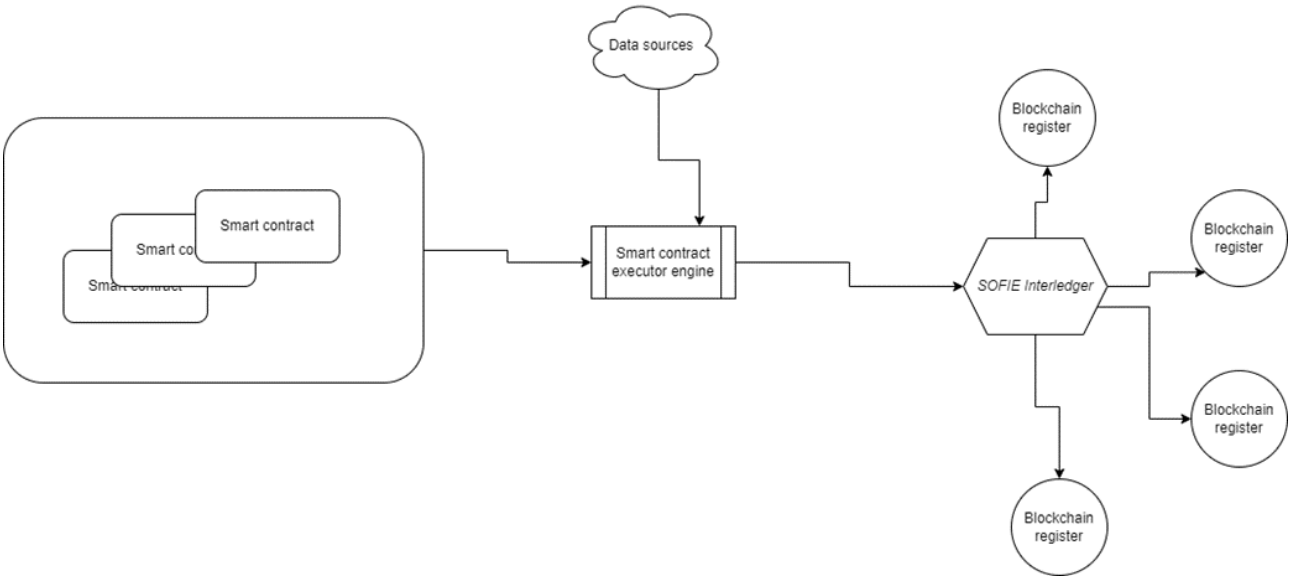

Figure 13. SOFIE Interconnector and smart contracts block diagram
Source: Own elaboration

In order for the concept of smart contracts to become a reality, it is necessary to ensure that these contracts have access to a common data source that will guarantee the integrity of the data between participants in the supply chain. At the same time, the common registry must guarantee and ensure the veracity of the data on the basis of which the smart contracts will perform certain actions.

Blockchain technologies solve several problems that currently exist in the data sources of supply chain participants. Despite the existence of track and trace standards, the databases in which information on the current status of shipments is stored are not interconnected. Each actor in the supply chain has its own unsynchronized records.

Blockchain-based technologies are inherently decentralized. Any user wishing to download or publish information on the blockchain has a full local copy. Its validity and integrity are ensured by built-in cryptographic functions, guaranteeing that every user of the system operates on the same data source. This property of the blockchain allows it to be used as a solution to the problem of uncommunicated actor database registers in the supply chain. In the case study [Deliverable Blocklab], a concept is presented whereby each actor operates on an internal blockchain that is communicated through the interconnector described above. In the scenarios presented, the decentralised blockchain has a complete history of tracking goods and the relevant data is transferred from the process actors' systems. The result of such a scenario is the creation of a decentralised register of tracked goods, which guarantees that the data stored in it is integral, accessible to each actor, and digitally signed.

The concept is that an interconnector allowing the transfer of data between the blockchains of the various process actors will be embedded in the EGTN system. This architecture allows the decentralised nature of the information to be maintained. As demonstrated in [Deliverable Blocklab], central registries in track and trace applications do not allow for transparent information transfer. In centralised systems, a certain hierarchy of ownership is encountered, which is related to the concern that the transmitted data will be used by the owner of the central system. A decentralised system guarantees that the registry will be an inviolable source of data as long as the majority of its users want to use it.

PLANET project deliverable D2.18 EGTN Smart Contracts presents a concept that allows the implementation of smart contracts. The use of decentralised blockchains means that track and trace processes will produce large amounts of data which must be validated and transferred to a decentralised common registry in a common format. Hence, the use of an interledger connector is essential. The Interledger Connector implemented inside the EGTN platform as proposed in [D2.E18] holds and validates data published in other blockchains of the system participants. As a central communication node, the Interledger Connector should at the same time have access to the full information published by the system participants. A consequence of this approach, is the implementation of a smart contracts engine inside the EGTN platform.

The concept presented is to use smart contracts logic to publish blocks to the blockchain registry to automate information processes. Smart Contracts will have logic based on 'if-then' rules and will perform specific operations - such as automatic acknowledgements of receipt or reacting to incoming data to the blockchain register. Smart Contracts will allow alerts to be defined so that system participants will receive notifications based on which they will automate certain actions in their internal systems. The use of this technology will reduce the human factor in the entire solution and maintain the transparency of the entire registry.

Blockchain-based technologies, combined with the concept of Smart Contracts, make it possible to solve problems concerning:

- **Data availability** - each of the system participants uses its own internal data sources and, through the interconnector available inside the EGTN platform, propagates the necessary information to other system participants.

- **Data centralisation** - blockchain technologies generally operate on a decentralised data storage system. Each participant in the system has a local copy of the repository - moreover, no central organisation is the operator of the global system or event register

- **Data integrity** - storing information in the form of related blocks maintains data integrity. Each block has information about the previous block - in this context an event. This ensures that the sequence and structure of events is intact

- **Data veracity** - each block of data is digitally signed by the publisher.

- **Process automation** - the use of smart contracts which, depending on the data provided, can perform specific actions, allows the automation of processes regarding any event stored in the blockchain.

The integration of blockchain technologies and smart contracts as described, as one method of communication on the EGTN platform should encourage data sharing among system participants. As blockchain technologies do not determine what content can be stored as blocks, system participants have full control over the content of the transmitted data. The interledger connectror solution allows for the standardisation of their formats.

As far as the choice of a specific algorithm and implementation is concerned, the following conclusions can be drawn from the analysis carried out in the document "D 2.15".

Public Connectors focus on public Blockchains and cryptocurrencies, therefore they cannot be considered as candidate technologies to achieve Blockchain interoperability in PLANET. Regarding the Blockchain of Blockchains category, while the provided features can be desirable for end-users, frameworks that fall under this category do not interoperate with each other. Taking this into account, end-users are forced to choose between existing solutions, leading to sub-optimal leveraging of available resources. Furthermore, the Blockchain of Blockchains category involves the cost of transaction fees to keep the network in operation and to sustain a business model across several Blockchains, thus rendering its applicability questionable given enterprise Blockchain systems.

At the time of writing this deliverable, the SOFIE Interledger component is the ideal candidate to support the requirements, as these were set out by the PLANET partners, and at the same time to fit the specification of the EGTN platform. It adopts the Hybrid Connectors approach that provides an abstraction layer to underlying Blockchain systems. Furthermore, it supports integration with several Blockchain systems, such as Hyperledger Fabric and Ethereum - which are the two Blockchain systems used by the LL stakeholders - but also provides integrations with several other Blockchain systems. SOFIE also features an extensible plugin-based architecture.

However, the recent arrival and progression of Hyperledger Cactus over the past few months as well as its great potential meant that it should also be included in the experimentation process. Preliminary deployments and hands-on experimentation using SOFIE have already been conducted to assess the framework in terms of usability and security. In parallel, Hyperleder Cactus is also under examination and is undergoing extensive investigation by the engineering team of PLANET to validate the stability, scalability, and security of its codebase, given its incubation status. The final decision (either continue using SOFIE or migrate to Cactus) will be taken in the coming months and presented in the final deliverable D2.16 (due month 30). The decision will depend on the following criteria:

- Stability and usability of Cactus
- Added value brought by Cactus compared to SOFIE
- Amount of effort required to migrate from SOFIE to Cactus.

This decision will not affect the high-level software architecture, interfaces and data exchanged as presented in section 6, given that the design and protocols in both frameworks follow similar approaches.

The table below summarises the characteristics of the Blockchain interoperability state-of-the-art frameworks, which were analyzed:

Table 7: Characteristics of the Blockchain interoperability state-of-the-art frameworks

Framework	Released	Category	Licence	Description and Use Cases	Link
SOFIE Interledger	December 2020	Hybrid Connector	Open source	Supports events-based synchronisation between multiple types of blockchains. Features standardised interfaces and a connectors-based architecture. Use cases include transferring data from one ledger to another, connecting public and private ledgers and HTLCs.	SOFIE
Hyperledger Cactus	March 2020	Hybrid Connector	Open source	A plugin-based framework which aims at providing developers with an abstraction layer over backend blockchain systems. It features a business logic plugin which coordinate cross-blockchain integration and connectors to multiple types of blockchains.	Cactus
Interledger	2015	Hybrid Connector	Open source	A web-based payments infrastructure that allows greater global financial inclusion. It is a protocol connecting consortium/private ledgers and public ledgers. Use cases: • Asset transfer or exchange • Synchronising two ledgers	Interledger
COSMOS	Mar 2019	Blockchain of Blockchains	Open source	Based on Tendermint protocol, with a main chain (COSMOS hub) to connect multiple other Tendermint-based (Zones) or other kind of Blockchains (Peg Zones). Each Zone maintains its own state.	COSMOS
Polkadot	Nov 2019	Blockchain of Blockchains	Open source	Primarily described as a scalable heterogeneous ‘‘multi-chain’’, it attempts to introduce a new, overarching relay-chain, upon which many so-called “parachains” can be built. It uses sharding to increase scalability. Concept very similar to COSMOS.	Polkadot
Baseline	March 2020	Hybrid Connector	Open source	Coordinating records between legally separated entities. Maintain data integrity between two different databases of two different Orgs • CRM, Customer relationship management • ERP, Enterprise Resource Planning	Baseline

4.1.4.2 Internet of Things

The Internet of Things (IoT) is the concept of many objects, smart devices, machines, consumers, patients and services being increasingly able to be connected to solve problems in new and more effective ways. The vision behind the concept is that increased connectivity will facilitate automation, visibility and access to services. The IoT promises to enable commercial companies and governmental organisations to increase their ability to tailor products and services to individual needs and to ensure they are delivered accurately and effectively.

The Internet of Things (IoT) refers to the network of physical objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. While IoT applications guide businesses for making decisions by providing actionable intelligence from real-time and old (pseudo or non-real time) data mashup.

In the context of the project objective of the EGTN IoT infrastructure is to envision an interoperable environment capable to accommodate different service and device providers, maintaining a security and privacy constraints. This problem must be afforded at two different layers of the IoT infrastructure: in the premises, where different device from different providers must cooperate, and the Cloud side where different users must interoperate in terms of information sharing.

The GS1 system of standards and services as a key enabler of IoT

The IoT is not any single, specific new technology. It is a framework for integrating digital technologies associated with identification, sensing and data management. IoT applied to manufacturing opens new opportunities for GS1, as illustrated by the initiatives that surrounds new business strategies such as Industry 4.0, also known as Smart Manufacturing, Digital Industry or Digital Manufacturing.

GS1's "Global Language of Business" connects the physical and digital worlds, laying the foundation for IoT. Unique identification of objects, assets, locations, etc. (things) and automatic data capture, powered by GS1 barcodes and EPC/RFID, enable interoperability and are key requirements for IoT.

Seamless, trusted sharing of "big data" is enabled by GS1 standards. IoT is driving increased connectivity of "things" – which leads to massive data collection. Data quality is more important than ever and GS1 standards provide the foundation for accurate, sharable, searchable and linkable data, starting with standardised attributes.

It is recommended that GS1 develop messaging to help users understand that GS1 identifiers are a foundational requirement for successful IoT applications and the associated GS1 "share" technologies (including EPCIS and GDSN) enable IoT capabilities. These messaging campaigns should be developed for both sector-specific and more general audiences. In addition, GS1 should consider proactively enriching its data capture, data discovery and data sharing standards portfolio. This will enable user companies to invest confidently in IoT applications making use of diverse technologies.

GS1 identification standards provide the means to identify real-world entities so that they may be the subject of electronic information that is stored and/or communicated by end users. The GS1 identification standards include unique identifiers (called GS1 identification keys), which may be used by an information system to refer unambiguously to a real-world entity such as a trade item, logistics unit, physical location, document, service relationship or other entity.

GS1 standards for data capture provide the means to automatically capture data that is carried directly on physical objects, bridging the world of physical things and the world of electronic information. The GS1 data capture standards include:

- Definitions of barcode and radio-frequency identification (RFID) data carriers, which allow GS1 identification keys and supplementary data to be affixed directly to a physical object.

- Standards that specify consistent interfaces to readers, printers, and other hardware and software components that connect the data carriers to business applications.

GS1 standards for data exchange provide the means to share information, both between trading partners and internally, providing the foundation for electronic business transactions, electronic visibility of the physical and digital world, and other information applications. GS1 standards for information sharing are:

- Definitions of master data, business transaction data and physical event data.
- Tools for optimising online product search
- Communication standards for sharing this data between applications and trading partners
- Discovery standards that help locate where relevant data resides across a supply chain and
- Trust standards that help establish the conditions for sharing data in a secure way.

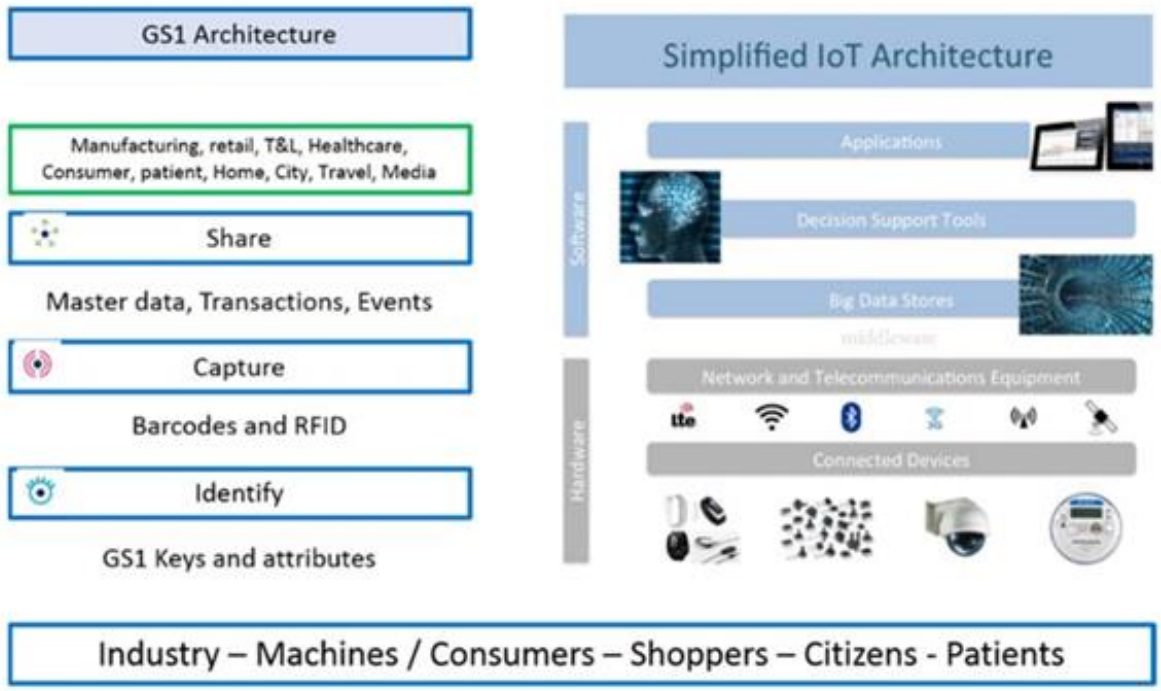

Figure 14. GS1 standards for data exchange
Source: www.gs1.org

The foundation layer to IoT is the Connected Devices. These devices include barcode, RFID readers and sensors that act as interfaces between uniquely identified objects and the next layers of the architecture where data are transferred, stored and analysed. The triggers are on the one hand the machines executing tasks in an industrial IoT context and on the other hand human beings seeking experiences or efficient ways to do things.

The Big Data Stores are the next important layer of the architecture. The advent of affordable big data solutions means that the large amounts of data collected can be captured, stored, analysed, curated, searched, shared, much beyond the capability of traditional relational database systems.

The next layer relates to Decision Support Tools. Without automation the sheer quantity of data is unmanageable and largely unusable.

The Application layer is where the business functionality lives.

This basic comparison between the GS1 architecture and the simplified IoT architecture shows that the GS1 standards meet the needs for IoT applications.

Standards for IoT

A critical factor in enabling the IoT will be the agreements on what standards to use for identifying things, for capturing data and for sharing information relevant to the IoT applications.

Standards like: 3GPP, ETSI and DCSA supports the coexistence in the premises of different IoT devices by different providers with the same network interface and data representation.

GS1 EPCIS 2.0 (and its old releases) can be seen a good opportunity since it provides a secure, ad-hoc and standardised approach to implementing data sharing to authorized users, identified by GS1 codes and also GS1 EPCIS data-models is the proper tool to communicate with the EGTN platform.

The Alliance for Internet of Things Innovation (www.aioti.eu) aims to create a dynamic European IoT ecosystem to unleash the potentials of the IoT. It identified the standard development organisations, industry alliances and open source software initiatives that contribute to the standards required for IoT.

Figure 15. IoT Standard Organizations and Alliances
Source: Alliance for Internet of Thinks Innovation

Many standards bodies have implemented plans to develop standards for IoT. Because IoT does by its own nature relate to multiple areas of applications, many existing and forthcoming standards can claim to address IoT requirements. For example, standards for bar codes, RFID, network and Internet technologies are all part of the IoT standardisation landscape.

GS1 enjoys partnerships with several bodies in the IoT context, including:

- AIOTI, the European Alliance for Internet of Things Innovation
- IIC, the Industrial Internet Consortium
- ISO/IEC JTC 1, Working Group 10 on the Internet of Things
- ITU-T, International Telecommunications Union Joint Co ordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SC&C)

- W3C, the World Wide Web consortium and their Web of Things interest group

4.1.5 Possibility of use of standards in the ICT systems

Nowadays, the synergy between available digital technologies is starting to unleash its potential much faster than in the past. Researchers at the Massachusetts Institute of Technology who analyse technology trends, point to the existence of five major trends in the digitalisation of processes, to which they give the acronym DANCE from the first letters of the English words:

- **Data** – as data resources are growing exponentially,
- **Algorithms** – because new computational methods, such as machine learning, enable the efficient use of large data sets,
- **Networks** – because the Internet is beginning to connect not only people but also machines in the form of the Internet of Things,
- **Cloud** – because computing power can be increased almost without limit, and cloud-based data solutions offer the possibility of simpler deployment of systems, faster integration and, importantly in the age of pandemics, the possibility of access from anywhere on earth,
- **Exponentially** rising computer power.

The digital revolution has greatly accelerated in recent years and the pandemic has further accelerated the transformation. The trend of overcoming existing barriers and building an organisation culture that is open to change and innovation is evident. Also not insignificant is the idea of Industry 4.0, which includes the integration of intelligent machines, systems, and the implementation of process changes to increase efficiency. Cloud infrastructure and applications, AI-supported data analysis and automation tools, or the development of e-commerce sales are creating entirely new opportunities for growth and efficiency improvements for both large and small businesses.

Nowadays, companies use a number of different IT tools in their operations to support them in the digitalisation of supply chain processes. These solutions are presented categorised by the types of processes (business areas) that are supported by each tool:

- ERP (Enterprise Resource Planning)
- SCM (Supply Chain Management)
- MES (Manufacturing Execution System)
- APS (Advanced Planning and Scheduling)
- WMS (Warehouse Management Systems)
- QMS (Quality Management System)
- CMMS (Computerised Maintenance Managment Systems)
- TMS (Transport Management System)
- transport platforms (including those enabling eCMR implementations)
- e-commerce platforms
- PIM (Product Management System)

In view of the increasing globalisation and intersection of systems, it is valuable that the ongoing changes towards the digitalisation of processes and systems, whether manufacturing, logistics or sales, are supported by the use of global standards and electronic document structures.

The digitalisation processes using global standards are supported by GS1's cooperation with IT solution providers. Nowadays, these are mainly systems that support companies in the area of warehouse management, the use of logistics labels and EDI message exchange. In face of the increasing digitalisation occurring in various areas of business logistics, it is therefore worth considering which other areas, in addition to those supported so far, should be of interest to GS1 in terms of the implementation of GS1 standards.

The table below summarises the GS1 standards and solutions that can be used in enterprise IT systems:

Table 8: Overview of GS1 solutions

Abbreviation	Description	Area
GTIN	Global Trade Item Number	Identification
GLN	Global Location Number	Identification
SSCC	Serial Shipping Container Code	Identification
GSRN	Global Service Relation Number	Identification
GRAI	Global Returnable Asset Identifier	Identification
GIAI	Global Individual Asset Identifier	Identification
GDTI	Global Document Type Identifier	Identification
GSIN	Global Shipment Identification Number	Identification
GINC	Global Identification Number for Consignment	Identification
GCN	Global Coupon Number	Identification
CPID	Component/Part Identifier	Identification
EAN/UPC	EAN/UPC bar codes	Data capture
EPC/RFID	Electronic Product Code / Radio-Frequency Identification tags	Data capture
GS1 EDI	Electronic Data Interchange, standards: GS1 EANCOM® and GS1 XML	Data sharing
GDSN	Global Data Synchronization Network	Data sharing
GS1 GDM	GS1 Global Data Model	Data sharing
GS1 SmartSearch	Internet standard to support e-commerce	Data sharing
EPCIS	Electronic Product Code Information Services	Solution
Traceability	GS1 identification numbers and barcodes, GS1 logistics label, GS1 EDI electronic messages, EPCIS	Solution
Upstream	GS1 identification numbers and barcodes, GS1 logistics label, GS1 EDI electronic messages	Solution
Order-to-Cash	EDI messages (order, delivery advice, delivery note, invoice. GS1 logistics label and the SSCC.	Solution

Source: www.gs1.org

By analysing the usability of each standard and solution in each class of IT systems, GS1 standards that are already being implemented and those that have the potential to be applied are identified.

I – standards and solutions GS1 already implemented in IT systems

P – standards and solutions GS1 with application potential

Table 9: Applicability of GS1 solutions across different classes of IT systems

		ERP	SCM	MES	APS	WMS	QMS	CMMS /EAM	TMS	transport platform	e-CMR	PIM	e-commerce
1	**GTIN**	I		I	I	I	I	I	P	P	P		P
2	**GLN**	I	I			I	I	P	P	P	P		
3	**SSCC**	I	I	I	I	I	I	P	I	P	P		
4	**GSRN**												
5	**GRAI**	P	P			P	P	P	P	P			
6	**GIAI**	P		P	P		P	P	P	P			
7	**GDTI**	P									P		
8	**GSIN**		P			P			P	P			
9	**GINC**		P			P			P	P			
10	**GCN**	P											
11	**CPID**	P											
12	**EAN/UPC**												
13	**EPC/RFID**	P		I	P	I							
14	**GS1 EDI**	P				P			I		P		
15	**GDSN**											P	P
16	**GS1 GDM**												P
17	**GS1 SmartSearch**											P	P
18	**EPCIS**	P											
19	**Traceability**	P	P	P	P		I						

		ERP	SCM	MES	APS	WMS	QMS	CMMS /EAM	TMS	transport platform	e-CMR	PIM	e-commerce
20	**Upstream**												
21	**Order-to-Cash**	I											

Source: Own elaboration

The use of GS1 identifiers is particularly widespread and popular in integrated business management systems and warehouse management systems. This is due to the extensive experience of ERP and WMS systems in implementing GS1 standards. At the same time, there is also potential for further development of these class systems with global standards.

In the area of ERP systems, GTIN, GLN and GIAI identifiers may be primary in nature, so it is important to require specific rules for the validation of identifier numbers generated in the system. It is important that the same identifier code numbers are used for items processed in ERP related systems: APS, MES, WMS and TMS. If the ERP system is integrated with the WMS, the use of the GLN number allows for the automation of customer billing. The use of GLN numbers in the ERP system makes it possible to unambiguously identify each entity working with the company.

In the area of WMS systems, there is great potential for the implementation of GTIN, GLN, SSCC, GRAI, GINC and GSIN standards. In particular, the GSIN number is mainly used in WMS class systems, where it allows for the improvement of the organisation of shipments consisting of many logistic units directed, for example, to the same recipient. Using the GSIN identifier, as with the GINC, it is possible to receive or issue multiple logistic units aggregated to one shipment, mainly in combination with the DESADV message. Other identifiers allow for the efficient execution of receipts/delivery to neighbouring links in the supply chain (GTIN), the automation of settlements with contractors in the ERP system if the WMS is integrated with it (GLN), and if the WMS is integrated with ERP. Using the GRAI identifier it is possible to automatically generate a package return order in the ERP system.

For transport platforms offering an e-CMR delivery list service, GS1 EDI and the GLN, SSCC, GSIN and GINC identifiers have particular potential for use. Nowadays, the UN/CEFACT EDI standard is not widely used and e-CMR solution providers operate on individual data exchange standards. The use of the global e-CMR standard in tools offering such a solution to their customers is highly recommended and represents a potential for cooperation between e-CMR solution providers and GS1.

In the area of logistics platforms, the GRAI number, used for bulk returnable packaging, was of particular interest to solution providers. IT solution providers indicate a high potential for customer interest and development of this area in their solutions. In addition, according to users of logistics platforms, there is a great need to implement a GLN identification standard, however, the prerequisite for it to function properly is a sufficiently broad database of available location numbers with attributes, which will be reliably updated by point owners.

In terms of market development potential on the basis of trends and demand for IT systems of selected classes, a special role is nowadays played by systems supporting the operation of the e-commerce industry, purchasing platforms and PIM systems. Nowadays, purchasing trends and the continuous development of the e-commerce industry give potential for further development of IT systems supporting online sales, and thus it is possible and advisable to use global standards for product identification.

Considering the dynamically developing market for transport services, and the progressive digitalization of the process, including the move towards paperless documents for users, the area of transport can be seen as particularly worthwhile from the point of view of implementing the GS1 Global Standards. The GS1 identification standards have broad potential for application in TMS systems, and logistics platforms. In the area of paperless and the use of the global e-CMR standard, an additional impulse for action is the European Union's requirement for the exclusive use of the e-CMR from 2026. This creates the potential for the development of logistics platforms and IT tools to support transport processes for the generation of delivery list. It will also be advisable to use the standardised global UN/CEFACT message standard, which provides potential for GS1 to collaborate with transport support system providers in this area.

Summary of applicability of GS1 solutions across of IT systems

The implementation of GS1 standards in IT systems supporting logistics processes should follow current trends in the digital development of companies. One of trends is the comprehensive and integrated management of supply chains. As noted in the introduction of this chapter, companies nowadays place great emphasis on:

- cloud – based IT solutions
- solutions supported by the Physical Internet (IoT)
- big data technologies
- e-commerce
- paperless

Thus, IT systems supporting the processes should enable the digital development of businesses in this area.

Blockchain and Smart Contracts

Blockchain is described as the core technology of Bitcoin and other cryptocurrencies - a shared digital ledger or constantly updated record of all transactions. Blockchain can be considered both an economic and technological breakthrough. It provides a solution to any problem that requires a trusted ledger in a decentralized environment where not all participants, both humans and computers, can be fully trusted. Blockchain is a set of cryptographic techniques and protocols used by a network of cooperating nodes to securely record data in a distributed database consisting of encrypted blocks of data. To date, there have been three major milestones in the development of blockchain technology: the use of digital money in Phase 1.0, the use of smart contracts in Phase 2.0, and the creation of programmable blockchains in Phase 3.0. At the current stage of development, blockchain is mainly used for small local applications; there are very few industry- or ecosystem-level applications for it. Nevertheless, the special features of blockchain have started to spread to several sectors.

Smart contracts are an important development in Blockchain. Smart contracts were first proposed in the 1990s as a digital transaction protocol to execute the terms of an agreement. Smart contracts are simply code containers that encapsulate and replicate the terms of real contracts in the digital realm. Contracts are essentially a legally binding agreement between two or more parties, with each party agreeing to fulfill its obligations. Importantly, the agreement must be legally enforceable, often through a central legal entity (organization). Nevertheless, smart contracts replace trusted third parties or intermediaries between the parties. They take advantage of this by executing code that is automatically disseminated and verified by network nodes in a decentralized blockchain. Moreover, they enable transactions between untrusted parties without the need for direct contact between the parties, dependence on third parties, and intermediation costs.

Compared to traditional contracts, smart contracts offer the advantage of reducing transaction risk, lowering administrative and service costs, and increasing the efficiency of business processes, as they are often placed on and secured by the blockchain. Smart contracts are predicted to be a superior solution to the current transaction mechanism in a wide range of businesses in this regard. Smart contracts have many potential applications in industries including healthcare, supply chains, energy, etc. The development of smart contracts may automate

procedures in many types of sectors. They offer the data accessibility necessary to provide a service when requested. Since smart contracts are implemented in the blockchain system, and the blockchain itself may be thought of as a distributed database, the blockchain has the added benefit of being a distributed system that can guarantee the integrity of any data stored in it. However, there are still several obstacles preventing smart contract technology from being widely used. These obstacles can be divided into several areas, like processing, acceptance, immutability, integrity, usability, security, privacy and last but not least the legal issues.

Mainstream blockchains like Hyperledger and Ethereum lack robust data processing and efficient smart contract execution. They function like distributed databases, where each node shares the entire blockchain data, limiting the platform's data processing power to that of a single node. Smart contract code is executed sequentially, further reducing the data processing capability. The blockchain's storage capacity cannot be increased, making it difficult to expand smart contract storage. Additionally, fixing mistakes in block data records requires appending the correct record to the end of the chain, restricting block storage's scalability. As blockchain data continues to grow with transactions, there's a need for truly scalable storage for smart contracts.

Despite the buzz around smart contracts and blockchains, there are still many myths surrounding the technology in both public and consortium spheres. Overblown expectations and exaggerated use cases have contributed to this. Convincing consumers and stakeholders to adopt new technology may be challenging, leading to increased development expenses and a poor return on investment. In reality, some use cases can be implemented more effectively using conventional databases. Therefore, those interested in creating smart contract solutions should consider the cost of development and the limitations of the technology.

Also the lack of a sophisticated contract development language and efficient vulnerability detection techniques poses a challenge. Once Ethereum smart contracts are implemented, they cannot be altered, making it difficult to address security issues. Fixing bugs in a smart contract after it's integrated into a blockchain is not straightforward. Updating and terminating contract status requires a new approach, which conflicts with Ethereum's "code is law" concept and faces acceptance challenges from every node in the network. Smart contracts pose security risks, and their implementation can lead to the creation of a new blockchain if certain nodes are not validated.

A In the field of integrity, although all nodes in a network execute predetermined software to carry out smart contract terms, the data used by these contracts is not entirely reliable because it's controlled by other parties. Access to information stored in smart contracts or blockchains is often restricted, requiring the use of third-party wallet applications that can put users' personal information at risk.

Considering usability of smart contracts it differs from conventional contracts in their adaptability. Except for bugs, they cannot be changed, as they are logic-based computer programs with limited interaction. Unlike conventional contracts, they do not allow for discussion and revision based on subsequent approvals. Directly handling data for common consumers is problematic due to the P2P nature of blockchains. Additionally, when using cryptocurrency, the exchange rate can be unpredictable.

Security is a primary issue with blockchain systems, and many vulnerabilities are caused by misunderstandings in scripting language. According to Wang et al., smart contract semantic vulnerabilities are transaction-ordering reliance, call stack depth, time-stamp dependence, re-entry attacks, and mishandled exceptions. Smart contract systems have low maintainability and several potential security flaws, posing significant risks as their code is difficult to maintain once implemented. Patching a security issue in a smart contract on the chain is almost impossible due to the immutable nature of the blockchain. To increase the security of smart contracts, creating new languages or upgrading current ones should be carefully considered. It's also important to be aware of mechanisms and weaknesses before using specific blockchain platforms since the types of attacks vary.

While most studies indicate that smart contracts may not replace the law entirely, they can function as legally enforceable contracts under certain conditions. It's crucial to determine if smart contract technology can substitute the law or not. Marino and Juels' research provides a basis for developing a smart contract system that aligns with contract law and enables parties to modify or cancel smart contracts in specific circumstances. The term "smart contract" doesn't imply that research should exclude contract law entirely.

the use of pseudonymous public smart contracts does not always guarantee privacy since it does not ensure unlinkability, which is important for both fungibility and privacy. To protect privacy, an additional data protection component can be integrated. However, the use of encryption methods can increase the processing load on the system. Therefore, future research will focus on developing lightweight privacy-preserving strategies.

Improving the security performance of smart contracts has been a priority, with various factors such as cryptography, consensus algorithms, and smart contracts affecting their security. Addressing smart contract security issues requires a comprehensive approach that considers multiple components. While progress has been made in blockchain security, there is still room for improvement, and a multi-level and multi-factor approach is essential to creating an ideal security protection system for the blockchain.

Large-scale smart contract verification and the standardization of verification methods and tools are still in their infancy, with few practical applications. Existing technologies can detect only specific vulnerabilities, and there is an overlap in the vulnerabilities detected by some technologies, making vulnerability identification complicated. To improve detection efficiency and reduce detection costs, smart contract verification must scale up and unify vulnerability security validation and monitoring technologies.

To counter the threat posed by quantum computing, cryptographic security technology has been developed. Blockchain technology relies on cryptography, and quantum computing poses a significant danger to encryption techniques, making it imperative to develop reliable cryptographic security technologies. The focus of future blockchain research and development will be on creating these technologies and harmonizing and interoperating conventional legal norms with digitally executed contracts.

Currently, smart contracts work alongside conventional contracts, but further work is required to improve their legal understanding, establish review criteria, reduce errors, and bring them up to legal review requirements. Enhancing current laws to specify different scenarios of smart contracts and the meaning communicated by parties to the transaction is also necessary to avoid accountability issues in the future. Coordination and integration of smart contracts and traditional regulations can be achieved through these two variables.

Below is a table with sample software solutions using blockchain and smart contracts:

Table 10: Sample software solutions using blockchain and smart contracts

Software Solution	Company	Description
VeChain	VeChain Foundation	A blockchain-based platform for supply chain management that uses smart contracts to track goods and verify their authenticity. The platform provides tools for inventory management, product tracing, and data sharing between stakeholders.
Modum	Modum.io AG	A blockchain-based platform for supply chain monitoring and data analysis. The platform uses smart sensors to monitor goods in transit, with data recorded on a private blockchain. Smart contracts ensure compliance with regulations and automate payments.
Provenance	Provenance Ltd.	A blockchain-based platform that enables companies to track the journey of their products from source to consumer. The platform uses smart

Software Solution	Company	Description
		contracts to verify the authenticity of products and ensure ethical sourcing and production practices.
Ambrosus	Ambrosus Technologies AG	A blockchain-based platform that provides end-to-end visibility and traceability for food and pharmaceutical supply chains. The platform uses smart sensors to monitor the condition of goods in transit, with data recorded on a public blockchain. Smart contracts ensure transparency and compliance with regulations.
Tallysticks	Tallysticks Ltd.	A blockchain-based platform for invoice financing and trade finance. The platform uses smart contracts to automate the invoicing and payment process, with payments settled in cryptocurrency. The platform also provides tools for risk assessment and credit scoring.

Source: Own elaboration

The use of blockchain and smart contracts in supply chain IT systems offers numerous possibilities to streamline operations, enhance data integrity, and improve collaboration among stakeholders. Let's explore the potential applications of these technologies in supply chain IT systems:

- Data Integrity and Traceability: Blockchain can serve as a tamper-proof ledger for storing and sharing critical supply chain data. By recording information such as product origins, manufacturing processes, quality control checks, and logistics movements on the blockchain, supply chain IT systems can ensure data integrity and provide a transparent audit trail for stakeholders. This traceability enables quick and accurate identification of bottlenecks, inefficiencies, and compliance issues within the supply chain.
- Supply Chain Visibility: Blockchain-based supply chain IT systems can provide real-time visibility into inventory levels, shipment status, and transaction history. By integrating data from multiple parties onto a shared blockchain platform, stakeholders can access up-to-date and synchronized information, enabling better decision-making, optimized inventory management, and improved customer service.
- Automated Smart Contracts: Smart contracts can automate various aspects of supply chain operations, such as purchase orders, invoices, and payments. By encoding contractual terms, conditions, and triggers into self-executing smart contracts, supply chain IT systems can automate payment settlements, trigger actions based on predefined conditions (e.g., delivery confirmation), and streamline administrative processes. This automation reduces human error, accelerates transaction processing, and enhances overall efficiency.
- Supplier Management and Audits: Blockchain can facilitate the secure storage and verification of supplier information, certifications, and compliance records. Supply chain IT systems can leverage blockchain to maintain an immutable record of supplier qualifications, performance history, and regulatory compliance. This transparent and auditable system enables efficient supplier management, simplifies audits, and ensures adherence to ethical and regulatory standards.
- Counterfeit Prevention: Blockchain-based solutions can help combat counterfeit products by creating a secure and transparent system for verifying product authenticity. By recording unique product identifiers (e.g., serial numbers, QR codes) on the blockchain, supply chain IT systems can enable customers and stakeholders to verify product origins and track its journey throughout the supply chain, reducing the risk of counterfeit goods entering the market.

- Supply Chain Financing and Insurance: Blockchain can facilitate supply chain financing and insurance by providing a transparent and immutable record of transaction history. Supply chain IT systems can leverage blockchain to enhance visibility and trust for financiers and insurers, enabling them to assess risk, streamline underwriting processes, and facilitate faster and more secure financing options for suppliers and buyers.
- Collaborative Networks and Interoperability: Blockchain-based supply chain IT systems can enable secure and efficient collaboration among diverse stakeholders, including manufacturers, suppliers, distributors, and logistics providers. By establishing a shared blockchain platform, supply chain IT systems can facilitate real-time data sharing, streamline communication, and enable interoperability between different systems, leading to improved coordination and faster response times.

While the adoption of blockchain and smart contracts in supply chain IT systems presents exciting possibilities, organizations need to carefully consider factors such as scalability, privacy, regulatory compliance, and integration challenges when implementing these technologies. Nonetheless, the potential benefits of increased transparency, streamlined operations, and enhanced trust make blockchain and smart contracts compelling solutions for transforming supply chain IT systems.

4.2 Standardization in the concept of the Physical Internet and EGTN

4.2.1 Physical Internet Standardization Guidelines and ALICE roadmap

If we consider the standardization aspect of ALICE's Physical Internet roadmap, we can point to several important elements:

- The Physical Internet envisions the development of the Logistics Nodes into Physical Internet nodes in which the operations are **standardised** and the usage of a **family of standard** and interoperable modular load units from maritime containers to smaller boxes is extensive. The Physical Internet envisions the usage of the PI-containers that are universal and can be easily combined. This issue has been addressed by the Modulushca project (FMCG and retailers' networks).
- In the context of System of Logistics Networks there should exist protocols, which should allow organisations to replace hard coded connections to internal partners with open, **standards-based** protocols and connectors including services, location, processes definitions.
- **Standardisation** of assets, protocols and procedures as well as practices and data communication in the 2030 – 2035 timeframe will be standardized, and eases network integration and flexible and agile logistics solutions can be realized.

The table below shows in summarized way indicated ALICE roadmap, the development areas of PI and the roles and impacts of digital technologies as enabling factors for the implementation.

Table 11: PI development and enabling factors by means of digital technologies

Development areas of PI	Implementation Objective	Digital technology roles and impacts
PI Nodes	Automated processes and standardized services	- IoT standardizes the data for sharing. - AI, ML provide efficient services and enable automation (e.g. picking, loading, unloading).
Physical Internet Networks	Seamless, flexible and resilient, door-to-door services for all shipments	- IoT enables data and information sharing.

Development areas of PI	Implementation Objective	Digital technology roles and impacts
		- AI and BDA provides efficient services (e.g. optimal routing, optimal asset utilization) - Computing platforms offer continuous services.
System of Logistics Networks	Source, efficient and extensible services for the flow of goods, information and finance across logistics networks.	- AI & BDA create the business intelligence for cooperation and inter-operation. - BC-based smart contracts synchronize the flows. - The ML integration ensures the correctness of data before shared in BC networks.
Access and Adoption	Accessible, non-discriminatory PI	- IoT and connectivity technologies (5G) optimizes coverage for PI service access. - Computing platforms offer pervasive & affordable services with the ease of access. - Digital Twins in creating the adoption plan, guidance and strategies types of business models.
Governance	Governance bodies, collaboration frameworks, competition rules and trust agreements.	- Digital Twins-based simulation models and adjust the governance bodies. - Trust and secure collaborative frameworks are enabled by BC.

Source: H. Tran-Dang, D.-S. Kim: Physical Internet in Era of Digital Transformation: Perspectives and Open Issues, DOI: 10.1109/ACCESS.2021.3131562

So how does the PLANET project fit into the implementation of the roadmap developed by ALICE?

The PLANET project aims at ensuring an effective integration of the European to the Global Network having a Geo-economics view and a technological view, implementing the EGTN infrastructure based on the PI paradigm and its enabling technologies as IoT, AI and Blockchain. In this scenario, the EGTN platform is thought to implement a sustainable, integrated, and multimodal freight transport that engages diverse stakeholders of the T&L supply chain and enables them to interoperate and exchange data through a secure ICT infrastructure.

The concept of applying the PI enablers technologies that have been tested within individual LL's fits into Alice's roadmap. In order to facilitate the concept shown in the figure below, the different technologies identified as PI enablers need to develop over different timeframes: current state and maturity levels, 2022-2030, 2030-2050 and beyond 2050.

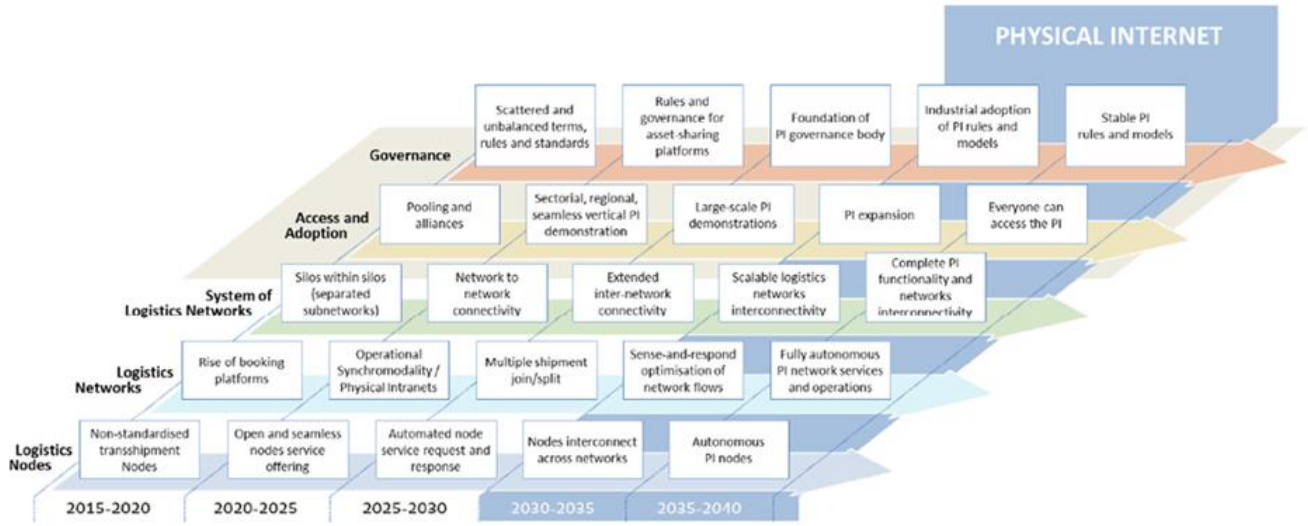

Figure 16. The Physical Internet Roadmap
Source: ALICE-ETP, 2020. Roadmap to the Physical Internet

PLANET's vision is supported by two key R&D pillars:

- Understanding and assimilating global, geopolitical, trade and economic imperatives
- Leveraging technological advancements and new logistics concepts

The objectives to achieve this vision are, which is illustrated below:

1. Provide a Simulation Capability for analysing the impact of new trade routes and emerging innovations for the TEN-T and f European logistics operations, and for designing a geo-economics aware and PI inspired Integrated EU Global Trade Logistics Network [EGTN]
2. Deliver the PLANET Cloud-based Open EGTN ICT Infrastructure, leveraging inter-organisational workflows and smart contracts linked with IoT and federated Blockchains, to support the development of EGTN solutions in the Living Labs
3. Set up and operate 3 global corridor-Living Labs, interconnected into a Digital Clone, to provide an experimentation/innovation environment and testbed for EGTN solutions involving major actors from the T&L industry
4. Provide an EU Roadmap and Capacity Building program to steer innovation towards EGTNs aligning with global T&L blockchain initiatives and the ALICE PI working groups.

4.2.2 Inventory of ongoing/anticipated EGTN design and deployment activities in the various LL's

In the context of the PLANET project and its Living Labs, multiple alternative technologies, infrastructures, and policies were considered. The aim of all alternatives was to drive operational efficiency in a Physical Internet enabled supply chain. The three PLANET Living Labs investigated three unique aspects of technological and infrastructural development. Focusing on the connectivity of the TEN-T network to global trade corridors:

- LL1 examined how new technologies (IoT, AI and blockchain) and concepts (such as Physical Internet) can improve processes, operations and efficiency along the door-to-door transport chains linking the Maritime Silk Road with EU internal corridors.
- LL2 examined how synchro-modal dynamic management of TEN-T & intercontinental flows promoting rail transport and utilizing the Port of Rotterdam (PoR) as the principal smart EGTN Node coordinating the rail focused transport chains linking China through Rotterdam to/from USA, and Rhine-Alpine Corridor destinations, and

- LL3 examined streamlining logistic processes in flows from China to Europe along the Silk Road by implementing IoT technologies (based on the EPCIS platform) and GS1 standards that facilitate transmission of data between the partners involved in the e-commerce operations.

In this chapter focus in inventory of ongoing/anticipated EGTN design and deployment activities in the various LL's.

In the context of using IoT and PI there are some conslusions and recommendations from the execution of the different test cases related to LL1. The availability of data sources is typically one of the main restrictions for the development of Physical Internet and Artificial Intelligence solutions where large amounts of data are needed for training and testing models. In most cases, shipping and logistics companies still work with legacy systems where data accessibility is restricted due to the lack of common application interfaces (APIs) for enabling the exchange of data with external sources. Consequently, data has been extracted in Excel files where information is available in proprietary data formats that need to be adapted to common data formats such as JSON. The parsing of Excel files and the translation of data formats is a time-consuming effort that needs to be made before starting data processing and cleansing period, resulting in delays for the development of innovative solutions. In addition, the lack of APIs limits the approach of the defined services, where only offline data can be used to develop the solution. This aspect impedes the development of applications where the ingestion of data is needed in real-time conditions.

The next area which are analysed during research and test conducted in LL1 was Data framework for blockchain interoperability. The definition of a common data model is a key aspect that needs to be addressed for enabling the exchange of events between different blockchain solutions. In PLANET LL1, interoperability between PoV and FF Community blockchain networks was successfully tested for the exchange of Interledger events. Nevertheless, to enable the exchange of real business information between both networks, a common data model was missing for both parts.

Another aspect of LL1 research is the area of Hardware shortage and limitations used in IoT solutions. Currently, IoT tracking solutions installed on shipping containers require non-lithium batteries for being shipped as regular containerized cargo. This aspect limits the duration of the battery, since non-lithium batteries typically offer lower duration than conventional lithium solutions. The solution provided in LL1 relies on a lithium battery, and as a consequence, still has room for improvement.

Regarding LL2 were integrated local platforms (Port of Valencia, Freight Forwards and Port of Rotterdam) with the overarching EGTN platform. Regional logistic events ware published in each platform specific blockchain network, for the Interledger solution to forward the event to the EGTN platform. The EGTN platform is therefore enabled to generate a real-time overview of logistics on EU level. This logistics overview could be validated and enriched with sensor data, and data from other platforms that could be connected.

Development of IoT solutions based on DASH7, RFID, LPWSN and sensors systems was used to control resource parameters in real time and identify them while moving in the transport process, examining potential positive results in terms of broad implementation tested in LL3. At the same time creation of a digital connection between actors in the transport network, enabled standardized data flow and access to information about cargoes coming from China to Poland in the whole supply chain in real time by the implementation of the EPCIS event based database and exchange of the gathered data with EGTN infrastructure.

Considering the area of integration with EGTN platform under study in LL3, several problematic issues were noted. From a programming point of view, integration with the EGTN platform is not very easy or intuitive. It requires the use of the Apache Kafka broker, does not offer other means of integration and does not support common data exchange protocols such as HTTP REST, MQTT, SOAP, etc. Many systems used by logistics companies do not have support for the Apache KAFKA client. In order to facilitate integration with this type of

platform, it would be necessary to provide developer documentation, integration instructions, examples of clients under an open source licence. An additional difficulty is the lack of a sandbox environment to validate the integration created by external developers.

For the corridor route optimization analytics service, Big data augmented by the detailed corridor transport models and real time IoT sensor information should be used to develop effective routing optimization that is based on accurate real-time information rather than static data. The development of the corridor route optimization-based analytics requires not only the Big data augmented by detailed corridor transport models and IoT sensor information, but also domain expert knowledge to be used as criterion to take the final decision on changing routes.

Conclusions from LL's regarded to used digital technologies and possibilities integration with EGTN

A strong recommendation from LL1 testing in the PI and IoT area is to identify the required data sources and their interoperability/accessibility before defining the use case approach where PI and AI capabilities are required.

Taking into account the tests and research carried out by LL2, the conclusion is that the application of blockchain technology enable a secure and trustworthy exchange between all relevant stakeholders.

The finding of LL3's work demonstrates that the integration of infrastructure, policy, technology and operational data available through the EGTN platform, can be used to assess infrastructure and rolling stock availability, and inform investment decisions for the improvement of the operational efficiency of the network - which will allow the development of the TEN-T network and idea of the Physical Internet on a large scale.

5 Recommendations for PLANET standardization

5.1 Standards identified for implementation within the PLANET project and EGTN

5.1.1 Recommended GS1 standards to support logistics processes

Based on the investigated processes (which are described in 3.1.2 chapter) we have prepared the general recommendation for standardization of particular logistics processes.

Considering the use of standards of individual LLs in the IoT area, it can be seen that one is particularly suitable and recommended, namely EPCIS. This applies in particular to:

- LL1 - Use case 2 on optimizing warehouse operations and automation and last mile deliver efficiency and sustainability using EDI and EPCIS
- LL3 – use case 1 i 2 – implementation of IoT technologies and EPCIS platform along with other GS1 standards that would facilitate transmission of data between the partners involved in the logistics operations within an e-commerce channel.

In the context of use case 2 implemented under LL1 the data access is implemented through a LL1 web GUI interface as well as sharing directly the data represented in an interoperable manner exploiting GS1 EPCIS data models.

Both the EGTN platform and the IoT architecture (defined in D2.3) are designed to be scalable, interoperable, and flexible in terms of the tracking, tracing, and monitoring needs at different granularity, reaching the organisational interoperability exploiting the GS1 codes and data-models (GS1 EPCIS 2.0). These features support the seamless integration of different IoT services for monitoring the supply chain but maintaining the peculiarities of each one of them.

In the context use case 1 implemented under LL3 IoT solutions based on DASH7, RFID, LPWSN and sensors systems was used to control resource parameters in real time and identify them while moving in the transport

process, examining potential positive results in terms of broad implementation. The data was exported from a sensory data aggregation platform and converted to EPCIS 2.0 compliant events. In use case 2 there were generating the corresponding SSCC numbers for the generated events in EPCIS 2.0 format.

LL3 proposed the following approach to IoT system architecture:

- The mobile operator IoT platform collects the data/parameters during the execution of logistics processes feeding the EPCIS repository, considering the standardized data-model.
- The EPCIS repository ingests the data from IoT platform and feeds the EGTN system. The EPCIS repository enables a secure and ad-hoc data sharing with the stakeholders involved in the logistic transactions.

The EGTN Platform receives data from EPCIS and exploits it to implement added value services toward greener and more optimized logistics networks.

According to the survey data collected from particular Living Labs, it can be concluded that **the vast majority of the partners do not use identification and communication standards during the processes** which are the subject in their use cases. The aim of the recommendation is to show the companies what kind of standards exist in the supply chain and how they can use them into their process. The recommendation also shows the benefits from using particular indentification or/and communication standards into particular transport and logistic process. The recommendation is based on using GS1 standards, which cover all standards needs when it comes to identification and communication aspects.

GS1 standards create a common language to identify, capture and share product data, ensuring important information is accessible, accurate and easy to understand. Identification and communication standards create a common foundation for business by uniquely identifying, accurately capturing and automatically sharing vital information about products, locations, assets—and more.

Through the power of GS1 Standards, organisations can use accurate, robust information that makes it possible for the right product to be in the right place at the right time, allowing consumers to find the products they are looking for. Businesses can also combine different GS1 standards to streamline business processes such as traceability.

The following is a proposed recommendation for the implementation of standards for logistics processes that are the object of PLANET project Living Lab activities:

Transport Management

Shippers and transport companies need to share capacity information with each other. They also rely increasingly on specialist logistics service providers, who themselves have to synchronise intricate transport operations. Effective transportation planning encompasses all the supply chain processes – from selecting the right supplier right through to invoice processing. A key function of any logistics company is to maximise profitability by optimising these Transport Management processes.

Companies can simplify this complex world of transport management by using GS1 standards – particularly: **GS1 identifiers:** logistic units (SSCC), pick-up and drop-off locations (GLN), shipments (GSIN), consignments (GINC) and **GS1 communication standards:** the LIM-based transport planning, transport instruction and transport status messages using GS1 XML or GS1 EANCOM messages, eCMR (UN/CEFAST message) and real-time event data using GS1 **EPCIS**.

Benefits of GS1 standards using in transport management:

1. Helps you to manage complex deliveries involving different modes of transport
2. Improves knowledge of where shipments are and when they will arrive
3. Increases the consignment control from container to pallet to individual carton
4. Enables you to deliver multiple shipments from various sources in a single drop

5. Allows you to split one inbound consignment into multiple separate deliveries
6. Boosts sustainability efforts thanks to packed trucks and reduced emissions

Moreover, companies can use prepared guidelines and documentation as part of the implementation of each standard:

- Logistic Interoperability Model (LIM):

  https://www.nweurope.eu/media/14879/gs1_logistics_interoperability_model_application_standard.pdf

Shipping & Receiving

Shipments come in from manufacturing plants or distribution centres. They depart toward other warehouses or directly to retail stores, hospitals, restaurants and other destinations. They need to be received, verified, logged, consolidated, stored, and more – sometimes even down to the serialized item level. It is vital to know what is expected to arrive and when; and to know where the outbound shipments are as they make their way downstream. Furthermore, the increasing frequency of "continuous replenishment" methods creates demands for expedited cross-docking, more frequent deliveries and smaller drop sizes.

Efficient and accurate shipping and receiving processes are absolutely necessary. Trading partners must have a shared and unambiguous way of identifying pallets, and cases and communicating related despatch and receipt information. That is why GS1 recommends using such standards as: **SSCC** to identify logistic units, **GTIN** for trade items and **GLN** to identify delivery locations. Moreover, in that processes companies can use **GS1 communication standards:** Share item and location master data via GDSN, despatch advice and receiving advice via GS1 XML or GS1 EANCOM messages, and real-time event data using **GS1 EPCIS.**

Benefits of GS1 standards using in Shipping and Receiving process:

1. More precise and timely information about incoming shipments
2. Smoother, quicker matching of deliveries against advance shipment information
3. Reduction of time-consuming and error-prone manual intervention
4. Reduction of incorrect shipments – an especially pertinent benefit for perishable and/or time-sensitive deliveries
5. Prompt and automated feedback on goods received and delivery discrepancies
6. Traceability at all levels along the entire supply chain

Warehouse Management

More manufacturers and retailers are outsourcing the management of their warehouses and distribution centres to Logistic Service Providers (LSPs). Furthermore, warehouses are no longer used just for storage. LSPs are offering warehouse-based value-added services including the consolidation of goods from multiple transport operators, management of cross-dock deliveries and additional services such as assembly of retail displays. Changing consumer behaviour also greatly impacts warehousing dynamics as consumers expect a large choice of products at the store. Retailers offer more choices to meet these expectations and avoid empty shelves. That means high frequency replenishment with short lead times. This is creating a real need for very close collaboration among all trading partners. For this sort of warehouse management to work successfully, all parties need to share accurate information in real time.

Recommended standards, which can be used to improve warehouse management: **GTIN** for trade items, **SSCC** for logistic units **SSCC** and GLN for warehouse locations. Moreover, in that processes companies can use **GS1 communication standards:** Share item and location master data via **GDSN,** inventory report, despatch instructions and status notifications via the LIM-based GS1 XML or GS1 EDI EANCOM messages, and real-time event data using GS1 EPCIS.

Benefits of GS1 standards using in Warehouse management:

1. Efficient management of inbound and outbound flows
2. Precise and timely exchange of inventory information
3. Reduction of safety stock levels and increased on-shelf availability
4. Improved consolidation and bundling of deliveries
5. Reduction of manual errors

Returnable and Indvidual Assets management

Many manufacturers, transporters and logistics service providers use wheeled trolleys, handcarts, plastic bins, pallets and production trays to move goods from one location to another within their own domains, or upstream and downstream in the supply chain. If these sorts of assets are not always where they are needed when they are needed, replacing them creates delivery delays and increases costs. And yet, they all too frequently go missing, because manually logging their comings and goings is perceived as too time-consuming and often omitted. All trading partners benefit when individual returnable assets can be identified, tracked and traced across different physical sites. No location ever needs to find itself short of necessary equipment, and inventory management of assets is significantly faster and more accurate.

Recommended standards, which can be used to improve assets management: **GRAI** to identify reusable transport items such as pallets and crates, **GIAI** to identify transport equipment such as intermodal containers, trailers, wagons, **GLN** to identify asset locations. GS1 communication standards: GS1 XML or GS1 EANCOM messages to exchange information on asset movement and GS1 EPCIS to achieve real-time event data.

Benefits of GS1 standards using in assets management:

1. Enhance capacity utilisation of available assets
2. Increase on-time delivery
3. Reduce costs associated with the loss of returnable assets
4. Reduce disputes between trading partners regarding assets whereabout

Border Procedure Management (Customs)

Managing the flow of goods across land and sea borders poses a major challenge and growing security concerns for govern - ment agencies and trading partners. Any given container or pallet imported from abroad could in fact pose a real threat to consumer safety because of counter - feiting, smuggling, infestation or terrorism. Economic realities are driving governments, importers, and brokers to look for new efficiencies in managing products at international borders. The search for solutions that effectively deliver product visibility has remained a frustrating goal for governments. It is because of this that government officials need help to make prompt and well-informed decisions to admit or deny entry. The situation calls for logical, efficient ways to know what shipments to target for screening, and what shipments do not need the time and attention of border management agents.

GS1 Standards can significantly improve product visibility at border crossings, improve consumer security, and deliver cost savings to industry, government, national regulators and customers alike. Existing product data in the supply chain can be leveraged for smarter cargo admission at international Borders by using B2B logistics data to solve B2G supply chain challenges. To improve custom processes, you can use GS1 standards such as: **GTIN** for trade items, **SSCC** for logistic units and **GSIN** for shipments. Moreover, companies can share item master data including product classification with GDSN and the GS1 Global Product Classification (GPC), shipment data with GS1 XML or GS1 EANCOM, and real-time event data on shipments underway using GS1 EPCIS.

Benefits of GS1 standards using in Border Procedure management:

1. Increasing visibility of products as they travel throughout the global supply chain to international borders.
2. Enabling customs to seamlessly interoperate by sharing electronic information with other government agencies, industry and each other.

3. Improving customs authentication procedures to verify products and players in the supply chain as genuine and legal.

5.1.2 Recommendations on modern technologies - Blockchain, smart contracts, EPCIS GS1, IoT and EGTN

The implementation of presented LLs' scenarios requires the creation of a communication medium that allows transparency and security of data exchange. Additionally, this medium should provide access to specific data for all actors involved in the transactions. These conditions are met by the EPCIS GS1 repository with elements of blockchain technology, which in this case will ensure transparency and data integrity by maintaining event continuity. Each EPCIS GS1 event can be included in the content of the blockchain.

The use of smart contracts technology will allow the automation of activities related to the publication and generation of events to the repository. The engine integrated into the EGTN platform will execute the actions implemented in smart contracts which will allow the automation of the information flow.

The Blockchain technology is used by several stakeholders of PLANET within specific LLs to enable trust in networks of untrusted participants. Smart contracts are also employed to automate, accelerate, and safeguard processes that require complex manual operations by multiple stakeholders of different organisations.

The Blockchain interoperability service deployed in the EGTN platform provides common interfaces to enable the exchange of data and events between existing backend Blockchain systems and to simplify, standardise and streamline interorganisational workflows. All these information will be presented on the EGTN dashboard to increase transparency and openness of the entire supply chain.

Taking into account the results of the work presented in all PLANET deliverables, the following outputs were relevant for the development of the recommendations:

1. **D1.9 Simulation-based analysis of T&L and ICT innovation technologies final version**

   a. **LL1 (Gateway to hinterland) - Technologies and innovations considered in the integrated PLANET modelling capability for UC1 (LL1) were as follows:**
      - Blockchain
      - PI
      - AI
      - Optimization for decision making - Linear programming

   LL1 used the following standards for testing within the individual test cases (TC's):

- EDIFACT
- OpenAPI specification v3 for the REST API of the FF blockchain https://swagger.io/specification/
- GS1 Transport Instruction (TI) & Response https://mocdn.gs1.org/standards/edi-xml/xml-transport-instruction-and-response/3-1
- GS1 Transport Status Request & Notification, https://www.gs1.org/standards/edi-xml/xml-transport-status-request-and-notification/3-4
- GS1 EPCIS events in the DHL blockchain

Blockchain

The focus was on the transport documents and the container as the main two assets that involve multiple information exchanges and transfers between different stakeholders along the transport chain with the aim to foster digital integration and secure monitoring transactions among actors in a win-win strategy.

- the Cloud IoT Platform was found as the instrument for ingesting the data collected from the premises, then store visualize, and process it. Finally, it will oversee feeding standardized repository capable to expose standardizes, secure and ad-hoc interfaces to all the stakeholders involved in transactions.
- The IoT environment must be interoperable with different set of IoT protocols (i.e., technical interoperability) and with the stakeholders' platforms (i.e., syntactic and semantic interoperability). For these reason, IoT environment must expose interoperable protocols and data-models capable to satisfy up to the semantic interoperability. Regarding this scenario, the DCSA standard, released in May 2020 was referenced. IoT sensors provide data in real time and allow the review historical data.
- GS1 EPCIS 2.0 was found to be the most promising standardization path capable to make available the data in a common language thought for logistics transactions.

2. LL2 (Last-mile Delivery) did not use standard solutions as part of its research.

Instead, the following technologies and innovations were considered in the integrated modelling capability for LL2:

- PI
- IoT
- Optimization for decision making - Linear programming
- Green Logistics

Two major observations were made:

- for all levels of PI adoption greener vehicle alternatives contribute to lower last-mile delivery costs. This result can be partly attributed to the shorter routes that are traversed by cargo bikes and e-bikes
- as the PI adoption levels increase, irrespective of the type of vehicle used for making the last-mile deliveries, not only does the distance travelled by vehicles reduce, but also the associated operational costs reduce.

3. LL3 (New Silk Route) used the following standards for testing within the individual test cases:

- Identification standards: UPU standards, GS1 standard (SSCC, GTIN, GLN), CN standards
- IoT core architecture: GS1 EPCIS 1.1
- IoT standards for transport monitoring: DASH7.
- AI

The analysis performed by LL3 (see [D1.9] Figure 29 Comparison of operational, economic, and environmental indicators across different ICT and T&L implementation scenarios in UC3) can be concluded that the combined implementation of GS1 standards, IoT, and AI results in significant changes across all the KPIs considered. Thus, is important to consider the possible potential benefits that each of these ICT and T&L technologies and innovations can help achieve in intercontinental rail freight corridors to enable the existing TEN-T network to transform to an EGTN.

4. EGTN Connectivity infrastructure

The EGTN Blockchain Service acts as a proxy between the project actors, which exchanges hashes of the documents along with metadata through their Blockchain systems, with the actual documents being shared through the EGTN Platform and retrieved only by trusted actors. The standards tested by the teams of LLs were:

- the Blockchain in Transport Alliance (BiTA)
- GS1 standards.

The EGTN Blockchain Service adopts a mix of the above standards to define a common data model and accommodate the different structures. The analysis of the data employed additional smart contracts and IoT data from the EGTN platform. The Deliverable D2.15 presents all data identified, both static and transactional, for redirection through the EGTN Blockchain component. This Deliverable describes also its the technical implementation, identifying the initial technology framework to support the PLANET requirements as well as the business scenarios defined by LLs, which was **SOFIE Interledger**.

In the meantime, the Hyperledger Cactus framework emerged as a new and very promising addition to the Hyperledger ecosystem. Hyperledger Cactus is an advanced and powerful framework that supports the development of applications on top of the interoperability layer. Users can submit transactions and the business logic residing at the Cactus component manages the forwarding of transactions to the appropriate ledgers. It also handles verification and validation of transactions coming from the underlying ledgers, before replying to the user.

But the EGTN Blockchain service will be based on SOFIE, unless Cactus:

- proves to be stable enough to be used in the near future
- brings more value than SOFIE to the solution
- it required reasonable efforts to migrate from SOFIE.

The **SOFIE Interledger component** enables activity on an Initiator ledger to trigger activity on one or more Responder ledgers in an atomic manner. The ledgers can be of the same or different types (e.g., Ethereum, Hyperledger Fabric, Hyperledger Indy, or KSI), and once triggered, the Interledger passes a customisable payload from the Initiator ledger to the Responder ledger(s).

In case the EGTN Blockchain service uses the SOFIE Interledger component, Initiators and Responders for both directions need to be implemented as the interfaces with the backend systems (Figure 9). The Initiator/Responder interfaces play the role of the Connector interface of the EGTN Blockchain service (see Figure 6). In addition to this, a smart contract needs to be deployed in each side as the interface listens for events and forwards them to the Interledger Core (the core service of the EGTN BC component). Even though the SOFIE Interledger implementation could be considered as a centralised approach hosted by a single node, the database in the Core can be replaced by a permissioned Blockchain network, e.g., Hyperledger Fabric, where each organisation can host a node to ensure decentralisation.

Integration and interfaces within the EGTN Platform

The Blockchain component of the EGTN Platform acts as the integration point of the three different entities:

- the Connectivity Layer
- the connected Blockchain systems of T&L organisations
- the Analytics Layer.

It also exposes data to the EGTN Dashboard to increase the visibility of inter-organisational workflows.

The backend Blockchain systems of the PLANET stakeholders are the main components that interact with the EGTN Blockchain to exchange static data about the dispatch, the destination, the freight volume/weight, and transactional data, such as logistics events. The data exchange is happening through commonly agreed smart contracts which act as the interface between the distributed ledgers of the stakeholders.

Another interface of the Blockchain component within the EGTN Platform is its connection with the IoT infrastructure through the Apache streaming service. As described in D2.1 and D2.3, IoT data is ingested into the Platform through an event streaming service (Kafka Cluster of 24TB), which aggregates heterogeneous data and

makes them available to other services in a scalable and reliable manner. The Blockchain component registers to specific Apache Kafka topics to listen to logistics events, which in turn trigger smart contracts and inform automated and trustful decisions through their decentralised execution.

Finally, the Blockchain component interacts with the Prediction component of the Analytics layer to strengthen the reliability of the IoT data that trigger the smart contracts execution. As described in section 5.3 of D2.17, the combination of prediction models and smart contracts provides a sophisticated approach for reliable prediction, and it is a powerful tool that assists T&L stakeholders in several use cases.

The EGTN Blockchain component offers a solution that addresses the issues raised by the lack of collaboration and coordination between different T&L and supply chain stakeholders, as they all use their own, proprietary Blockchain solutions. More specifically, the solution offers integrity and immutability of the data throughout the entire workflow, automated and safe contract execution using smart contracts (more on this in D2.17), reduction of overheads and time delays, and a distributed and community-driven approach. In that regard, the EGTN Blockchain component is a great enabler for the PI concept.

5. EGTN Smart Contracts

The smart contracts were developed and integrated in the EGTN Interledger Service in the context of PLANET. The smart contracts code can be found in the PLANET's GitLab repository, https://gitlab.com/planet-h2020/egtn-smart-contracts.

Also more advanced concepts like the AI-enabled smart contracts were analyzed.

The main objective behind the use of this technology is to develop a Blockchain network capable of managing multiple interactions and transactions performed during import procedures, involving many different stakeholders, both public and private, such as port and maritime authorities, customs and other inspection bodies, transport companies, port terminals and rail terminals, freight forwarders, importers, and exporters, etc.

The EGTN Interledger Service offers a solution that addresses the challenges raised by the lack of collaboration and coordination between different T&L stakeholders, as they all use their own, proprietary Blockchain solutions. It succeeds in unifying multiple backend Blockchain systems and in this manner supports interorganisational and intercommunity trade workflows.

It takes advantage of the cutting edge microservices provided through the EGTN Platform - i.e., AI and DSS - and consumes data from the different datasets available in the EGTN Data Lake to enable advanced functionalities, such as forwarding logistics events between disconnected communities, cross-checking the validity of events through IoT data and automatic generation of smart contracts based on AI predictions.

Since standards make interoperability possible, the EGTN Interledger Data Model provides a common language of standards that creates an ecosystem of platforms, applications, and networks that securely link people, places, and things.

The EGTN Interledger Service is an open-source solution (available on https://gitlab.com/planet-h2020/egtn-bc-interoperability), while it offers best practices and guidelines on how T&L stakeholders of all sizes and budgets can easily adopt and extend the offered solution in their own use cases.

Overall, the developed solution offers data integrity and immutability throughout the entire T&L workflow, automated and safe contract execution using smart contracts (more on this in D2.18), reduction of overheads and time delays; all this using a distributed and community-driven approach. Through this approach, the EGTN Interledger Service becomes a great enabler for the PI paradigm.

5.2 Benefits, risks and cost estimation of standards implementation from the perspective of the stakeholders

The basis for an efficient and effective supply chain is the availability of all relevant information at the right time, at the right place, with the right quality and in real time in order to enable connectivity of all participants in the entire value chain. As more events are recorded along the process chain, the more fine grained the information becomes which can then be processed, evaluated and evidence-based decisions drawn regarding transparency of product location and efficiency. With the availability of real time information greater transparency is achieved in the process chain, tracking & tracing is viable down to the individual part level, the potential for the automation of business processes is more likely, simple integration of new business partners and opportunities for new business models and processes become possible.

IoT technologies and EPCIS platform along with other GS1 standards could facilitate transmission of data between the partners involved in the logistics operations within an e-commerce channel and generally in the whole supply chain. This is the most important benefit related to recommended standards of IoT descibed in this document.

Certainly the problem and also the risk is the level of awareness in the area of the Physical Internet and the possibility of implementing its components into operational processes. There are some detailed risk are follows related to implementation of IoT, Blockchain and AI solutions and standards:

- the availability of data sources is typically one of the main restrictions for the development of Physical Internet and Artificial Intelligence solutions where large amounts of data are needed for training and testing models.
- to ensure data privacy and confidentiality when exchanging relevant data is a crucial aspect that needs to be considered for defining available data sources.
- the definition of a common data model is a key aspect that needs to be addressed for enabling the exchange of events between different blockchain solutions.

It should be added that the sources of costs for IoT solutions or PI support technologies in general are not only related to the hardware infrastructure (e.g. sensors, base stations connected to the data exchange platform), but also to the integration of IT systems responsible for processing and exchanging data between supply chain partners and the EGTN platform.

In order to have all relevant information available for the implementation of a smart supply chain, the physical world must reflect the digital world. Whereas the internet was previously characterised by human communication or humans to machine, now, any physical object can now be automatically read, uniquely identified which makes it possible for them to communicate with each other. This means that not only computers or networks have an identity, but the objects and their information can be exchanged directly between the objects.

The GS1 system can be used to generate cross-industry unique identification keys for almost all objects. This allows a wide variety of objects such as products, locations, companies, assets or transactions to be identified. GS1 identification keys allow companies to efficiently access information about goods in their supply chains and share this information with trading partners. The fact that GS1 identification keys are globally unique ensures that the information about the objects they represent can be shared between organisations and therefore increases supply chain visibility for trading partners. To build a GS1 identification key, your organisation must become a member of GS1 and obtain a GS1 company prefix. This will form the basis of company ID keys. All GS1 keys are unique (within the GS1 coding scheme), non-significant, international (GS1 identification keys may be used in all countries and all sectors) and secure (GS1 identification keys have a defined structure and most include a check digit).

Standards are indispensable for linking the physical world with the digital world. The real world can only be connected with the digital world if it can automatically identify the information along the value chain which can then be exchanged digitally. The standards to be used relate primarily to the identification of objects (Identify), the capture of data (Capture) and the exchange of data (Share) for objects along the supply chain. By means of these enabling technological standards, various business processes such as traceability can also be standardised.

The GS1 standards for identification, data carriers, electronic communication and process design create the conditions for transparency at all stages of the value chain. These standards enable the automation of processes through a uniform and unambiguous language. Only through the global uniqueness of objects with uniform semantics can the automatic recording of objects and the exchange of information be made available to participants in both horizontally and vertically integrated value chains. However, this can only work if organisations speak a common language, 'The language of uniform standards.'

In order to connect the physical and the digital world, goods and commodities must be clearly marked with global identifiers e.g., sGTIN, GRAI or SSCC, recorded by an appropriate data carrier such as GS1-128 Barcode, GS1 DataMatrix or RFID and then ultimately exchanged by standardised methods like EDI or EPCIS.

The cost of implementing GS1 standards varies depending on the size and complexity of the business, the scope of implementation, and the specific GS1 standards being implemented. Here are some factors that can affect the cost:

1. Membership fees: Becoming a member of GS1 requires paying an initial fee and annual renewal fees. The fee structure varies by country and region.
2. Barcode creation: Businesses will need to create unique product barcodes using GS1 identification keys. The cost of creating barcodes can vary depending on the quantity of barcodes needed and the services used to generate them.
3. Hardware and software: Implementing GS1 standards may require upgrading or purchasing new hardware and software, such as barcode scanners, inventory management systems, and enterprise resource planning (ERP) software.
4. Training and implementation services: Businesses may need to invest in training and implementation services to ensure that employees understand how to use GS1 standards and that the implementation is carried out correctly.

Overall, the cost of implementing GS1 standards can range from a few hundred to several thousand Euro, depending on the size and complexity of the business and the scope of implementation. However, the benefits of implementing GS1 standards, such as improved efficiency and traceability, may outweigh the cost of implementation. GS1 has a wealth of knowledge and expertise across different industries, including retail, healthcare, foodservice, and logistics. This enables it to develop standards that meet the unique needs of each industry and provide guidance and support to its members. One of the key factors that speaks to the superiority of GS1 over other organizations is its widespread adoption and recognition by businesses, governments, and other stakeholders around the world.

To demonstrate best implementation practices, we are including an example of the implementation of GS1 standards in France. The following case study can serve as a role model:

Food Traceability: GS1 Traceability implementation between China and France

Traceability is an important concern for food manufacturers around the world, since there were some food quality and safety accidents in recent years, customers are concerned about food quality and safety and exporting companies are facing growing international pressure to prove that its food exports are safe to eat. **Traceability is a global concern for all manufacturers** and given the increased concerns around overall safe food handling and manufacturing, the importance of global standards to enable today's food manufacturer's ability

to track and trace the immediate links between sources and recipients, has become an important contributor to the overall quality and safety of the food products they deliver.

The Global Traceability Standard has been published by GS1 and is mainly used in Europe to support all national and European good flows. All goods imported to Europe coming from overseas countries and therefore from Asia such as China were traced manually at the delivery point. While the imports are growing, some difficulties to perform the retrievals / recalls processes may occur. China has to face retrieval cases both in food and non food goods. China wanted to get a more secured process to achieve those retrievals / recalls and decided to apply for GS1 Global Traceability Standard.

Goals and Objectives

GS1 China helped Synbroad Ltd to set up a traceability system which enabled them to be compliant with GS1 Standards as implemented and rolled out in Europe in the food good flows. Casino had already rolled out most of its French and European vendors in such standards and was looking to do so with its food imports from China. Casino and GS1 believed in successful application of such standards for the benefit of customers.

More about the case study:
https://gs1go2.azureedge.net/cdn/ff/WiG6ORwQt7iNgh9Z601TMVMUz8NCiIygin55CXS7mtg/1417169792/public/docs/casestudies/traceability_case_study_chine.pdf

Description of GS1 standard implementation process

The implementation process for GS1 standards can vary depending on the size and complexity of the business, as well as the specific standards being implemented. However, here is a general overview of the implementation process:

1. Assess the business needs: The first step is to identify the business needs and objectives for implementing GS1 standards. This may involve evaluating current processes, systems, and data capture methods, as well as considering regulatory requirements and customer demands.
2. Obtain GS1 membership: To access and use GS1 standards, businesses must become members of their local GS1 organization. Membership fees vary by country and region.
3. Obtain GS1 identification keys: GS1 identification keys are used to create unique product identifiers, such as barcodes and Global Trade Item Numbers (GTINs). Businesses will need to obtain identification keys from their local GS1 organization.
4. Create and assign product identifiers: Once the identification keys are obtained, businesses can create and assign product identifiers to their products, such as barcodes or GTINs.
5. Implement systems and processes: Implementing GS1 standards may require upgrading or purchasing new hardware and software, such as barcode scanners, inventory management systems, and ERP software. Businesses will also need to establish processes for capturing and sharing data using GS1 standards.
6. Train employees: Employees will need to be trained on how to use GS1 standards and the new systems and processes that are put in place.
7. Test and validate implementation: It is important to test and validate the implementation of GS1 standards to ensure that data capture and sharing is accurate and reliable.
8. Monitor and maintain: Once GS1 standards are implemented, businesses will need to monitor and maintain their systems and processes to ensure ongoing compliance and accuracy.

Overall, the implementation of GS1 standards may require a significant investment of time, resources, and money. However, the benefits of improved efficiency, traceability, and interoperability may make the investment worthwhile.

If a new standard is needed, the Global Standards Management Process (GSMP) provides a structured approach to develop and implement it. Below is an overview of the stages involved in creating a new standard.

The Global Standards Management Process is a community-based process for creating deliverables. GSMP is founded upon a set of principles intended to ensure fairness and broad acceptance:

Openness & Transparency - the standards development process is open to all organisations to join and its workings are made visible to all participants.

User Driven Standards - GS1 standards are created in response to business needs clearly articulated by participating organisations. Equally important, they are developed only where there is the expressed will (by stakeholders) to implement the resulting standards.

Consistency - GS1 standards drive consistency and interoperability between the stakeholders who adopt them. All GS1 standards are validated during their development to fit in the GS1 System Architecture and adhere to architectural principles.

Stakeholder Participation - Participation in GSMP is open to all GS1 system users and all stakeholders impacted by a defined business issue; this includes End Users, Solution Providers and GS1 Member Organisations representing their local End Users and Solution Providers. These stakeholders come from companies of all sizes, in multiple industries, and across all geographies.

Standards Protection - Standards developed through the GSMP are maintained by GS1 on behalf of all GS1 stakeholders. The GS1 standards are protected by the GS1 Intellectual Property Policy for the benefit of all GS1 stakeholders.

Governance - The GSMP is accountable to GSMP governance groups and ultimately to the GS1 Management Board, all of which are populated by End Users of the GS1 system.

Consensus and Voting - All GSMP deliverables are developed in a process that strives for consensus of all stakeholders. All voting members have an equal voice in determining outcomes. When consensus is not possible, a formal process exists for recording the approval or (any) disapproval of final standards solutions. Participation and voting minimums ensure that the result of a vote is not unduly influenced by any one stakeholder or group.

Global Applicability - GS1 standards strive for global applicability across multiple industry sectors. Priority is given to commonality wherever possible across different sectors, and for relevance to companies of all sizes.

The deliverables from Global Standards Management Process are:

1. GS1 standards: documented agreements that trading partners agree to follow in order to achieve interoperability goals. The rules that must be followed are called normative statements. A GS1 standard is a specification that defines the behaviour of one or more system components so that interoperability goals are achieved. Standards contain normative statements, which specify what a system component must be or do in order to be in conformance to the standard; a standard is written in such a way that conformance to the normative statements is a sufficient condition for a component to achieve the interoperability goals for which the standard is designed.
2. GS1 guidelines: non-normative documented agreements that assist individual organisations in understanding and applying GS1 standards. A GS1 guideline is a document that provides information considered useful in implementing one or more GS1 standards. A GS1 guideline never provides additional normative content beyond the standards to which it refers; instead, the purpose of a GS1 guideline is to provide additional explanation and suggestions for successful implementation.

3. Collateral materials: other publications that provide an understanding of GS1 standards and guidelines and how to use them.

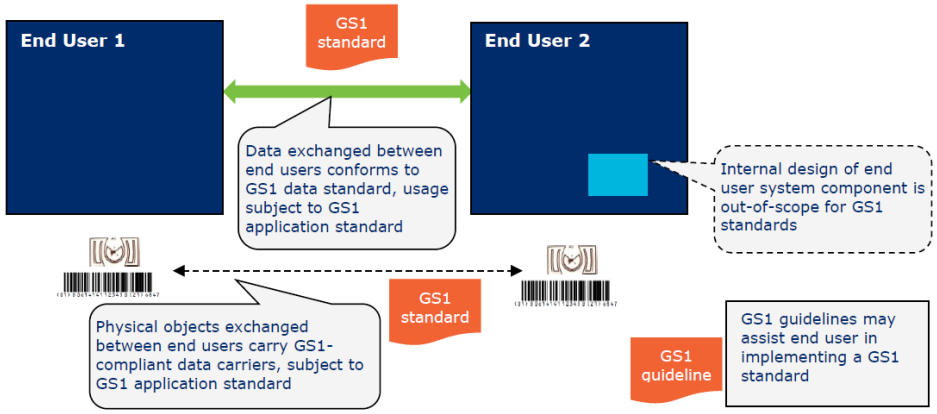

Figure 17: Deliverable developed in GSMP.
Source: GSMP Manual

Deliverables are created through the GSMP 4-Step Process. In each of the four steps, an intermediate deliverable or final deliverable is created by a Work Group through a Consensus Development Process which is designed to ensure that all members of the GSMP Community have the opportunity to shape and approve each deliverable. The four steps are: Steering, Requirements, Development, and Collateral. GS1 standards and guidelines are created in the Development step, based on the intermediate deliverables created in the Steering and Requirements steps. The Collateral step creates any additional collateral materials that are needed.

Every GSMP Deliverable is created by a Work Group or in some cases a deliverable is developed outside of the group and submitted to the group for review and processing. A Work Group consists of members of the GSMP Community who come together to work on a particular Deliverable. Any member of the GSMP Community may join any Work Group (exception Global Data Model (GDM) Regional and Local work groups, membership is defined in the Global Data Model Governance Manual) by opting into the Work Group. Membership in Work Groups is balanced to ensure that each Work Group has sufficient representation and subject matter expertise, so that the final deliverable reflects a balance of concerns across all affected stakeholders.

Each deliverable reflects the consensus of the GSMP community. Consensus is achieved first among members of the Work Group that contribute to the authoring of the deliverables, then confirmed through a review and eBallot by the entire GSMP community (exception GDM Regional and Local work groups do not have community eBallot). In some cases, an even wider consensus is obtained by offering the public at large the opportunity to review and comment.

Once the GSMP community confirms its acceptance of a GS1 standard or guideline, it is ratified by the GS1 Management Board and published by GS1. The GS1 standard or guideline is then freely available for anybody in the world to download, read, and adopt.

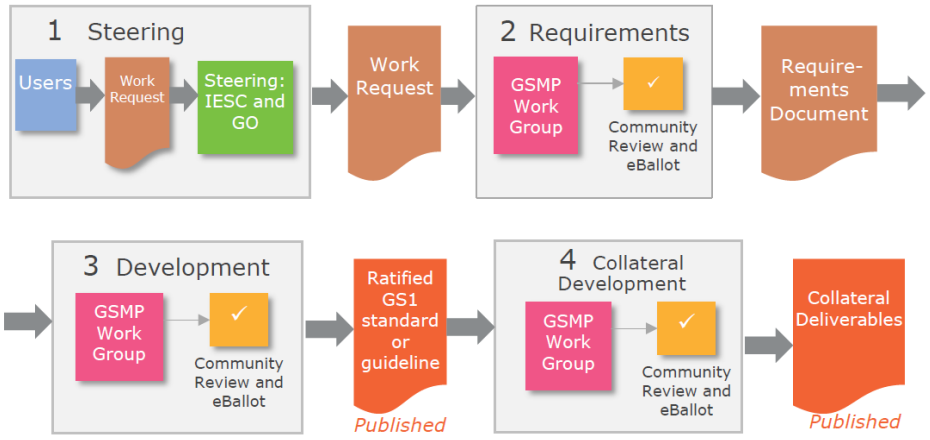

Figure 18: The 4-Step Process for Creating a GSMP Deliverable
Source: GSMP Manual

The GSMP 4-Step Process is designed to ensure that business needs and requirements are understood before standards and guidelines are developed, and that supporting materials are created afterward. Each step culminates in the completion of one or more outputs, created through a consensus-based process within a working group and with larger consensus confirmed through community review and eBallot.

#	GSMP Step	What Happens	Outputs
1	Steering	A Work Request enters the system from a GSMP Community or Staff Member **Development**: GSMP Operations, with final consideration and approval by the IESC considers pending Work Requests. Most of the work in this step is carried out by GSMP Operations, with the IESC **Maintenance:** GSMP Operations with the final consideration by the SMG considers pending Work Requests for entrance into the SMG. Information to assess the GSMP entrance criteria provided by the submitter in the original Work Request becomes the initial draft of the Business Case.	*Internal outputs:* Approved Work Request
2	Requirements	Work Group analyses and documents business requirements for meeting the stated business need.	*Internal outputs:* Business Requirements Analysis Document (BRAD) or other documented requirements
3	Development	Work Group develops a GS1 standard or guideline to meet the requirements.	*Public outputs:* Ratified GS1 standard or guideline, or ratified revision to existing GS1 standard or guideline
4	Collateral	Work Group develops collateral materials (for example: impact statement, value proposition, migration plans, FAQs, etc.).	*Public outputs:* Collateral materials

Figure 19: Outputs from 4-Step Process
Source: GSMP Manual

Publication of GSMP Deliverables

Following community review of a new or revised GS1 standard, GS1 guideline, or the GSMP Manual, the new document is published in GSMP Step 4. Here is how publication takes place.

Documents Published as Changed

Most GS1 standards and guidelines are published each time they are changed.

1. The Work Group delivers the candidate GS1 standard or guideline for eBallot. The document delivered is the complete GS1 standard or guideline including all changes that were made from the previous version (if applicable).

2. Following a successful eBallot, and subsequent ratification by the BCS in the case of a GS1 standard, to the GS1 Global Office publications staff.
3. GS1 publications staff is responsible for final formatting. This is limited to formatting, legal notices, file naming, and the content of the title page. GS1 publications staff may not alter the content in any way.
4. GS1 publications staff releases the published form of the standard or guideline to the GS1 public website.

Documents Published Using Change Notifications

The GS1 General Specifications is not published each time it is changed. Instead, each change results in publication of a General Specification Change Notification (GSCN), which is a document that specifies precisely what changes are to be made to the last published version of the primary document. Periodically (typically once per year), a new version of the primary document is published that incorporates all of the change notifications that have been published since the last time the primary document was published.

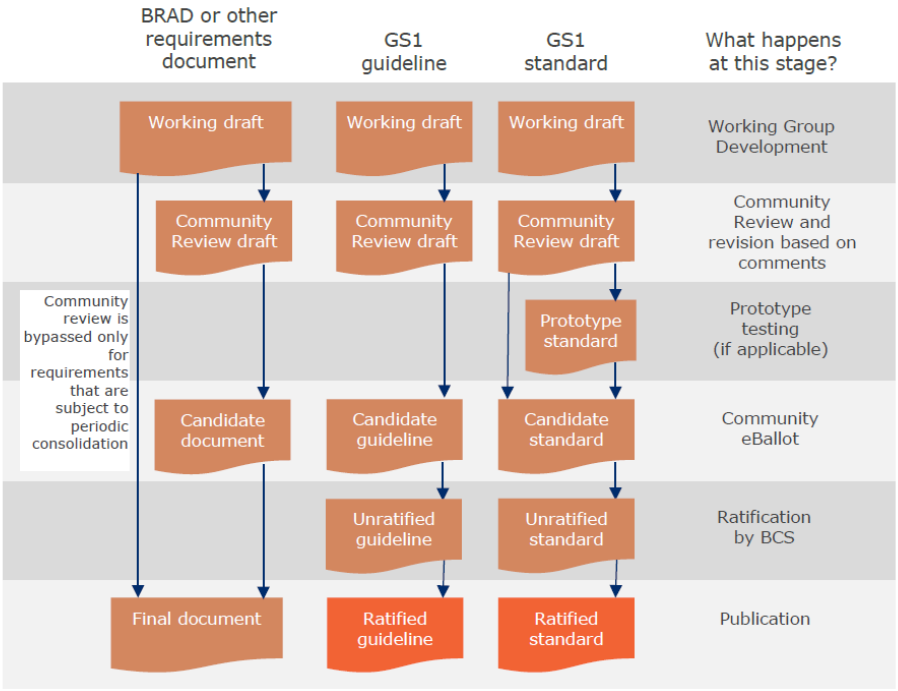

Figure 20: The Global Standards Management Process
Source: GSMP Manual

All GS1 standards and guidelines are subject to a mandatory review 3 years after the original publication date. This review will result in reaffirmation or a Work Request for the GS1 standard or guideline to be withdrawn, updated, or the determination that no change is needed. The review is conducted by the Standards Maintenance Group (SMG) responsible for the standard or guideline, or by another group appointed by the Vice President of Standards Development.

Blockchain and Smart contracts

The emergence of blockchain technology has revolutionized modern transportation and logistics (T&L) networks. It has the capability to transform information and financial streams, which support the physical flow of goods in the supply chain. The integration of advanced distributed ledger technologies in T&L networks has paved the way for novel cross-organizational, collaborative platforms that facilitate data sharing.

The development of smart contracts and their integration in modern T&L networks is highly interconnected with the evolution of the Physical Internet (PI). PI is a new T&L paradigm that is based on physical, digital, and operational interconnectivity through encapsulation, interfaces, and protocols. It is driven by technological, infrastructural, and business innovation. Blockchain features and functionalities have the potential to address PI implementation requirements, as well as overcome key PI barriers and deficiencies. However, according to latest research the PI cannot rely on centralized networks or a leading authority to continue. Instead, it must be a distributed and community-driven concept and approach for it to proliferate.

The implementation of these technologies will improve the transparency of logistics data and ensure the integrity of logistics events. Smart Contracts will add the possibility of automating processes, which should have a positive impact on the flow of information in the supply chain. On the risk side, it is worth mentioning that blockchain technology does not automatically provide any functionality. It is only a data carrier. Hence, it is important that the implementation of this technology is done with due diligence. There is still the question of implementing software that integrates into current logistics processes and uses blockchain technology. A similar issue relates to smart contracts technology. It is likely that, in its initial variant, the smart contract will perform actions to notify and send appropriate alerts to operators. Only once the areas in which smart contracts provide additional value have been validated, can process automation be iteratively increased.

Blockchain and smart contracts have become key players in the emerging Physical Internet paradigm. By leveraging the benefits of Blockchain technologies, the advantages of the PI are amplified, including improved data tracking across T&L networks, secure contract execution through smart contracts, and enhanced security through encryption. In addition to these benefits, the decentralized and community-driven nature of Blockchain also makes it a great enabler for the PI. Blockchain Interoperability is an emerging technology that allows for existing blockchain systems to interoperate and share data, such as shipping manifests, smart contracts, customs declarations, and transport events, which is a fundamental component of the EGTN Platform and the PLANET project. Ensuring data integrity, protection, and sovereignty is another crucial factor in the success of the PI. Data providers in the T&L industry expect to maintain sovereignty over sensitive data, particularly when sharing with data consumers like authorities, customs, and other logistics companies. However, current data sovereignty concepts are often limited to closed communities with their own specific solutions. Blockchain technology can help overcome these challenges by providing enhanced data protection and integrity across the entire supply chain.

In the context of the Physical Internet, the traditional attitudes and practices of T&L stakeholders present a significant obstacle to its adoption. Convincing them to participate in this paradigm shift and to share data without compromising their competitive advantage requires a demonstration of the mutual financial benefits that it can provide. Blockchain can be an essential tool in this regard, as it enhances data integrity and increases stakeholders' trust in technology. A critical mass of participants is necessary for the full advantages of blockchain to be realized, particularly in terms of rapid and trusted information sharing using automated smart contracts, which significantly reduce time and overhead costs. Blockchain's integration with other technological advances, such as IoT data and AI models, can further increase efficiency and decrease reaction time to unforeseen events. This combination of technologies can achieve triple bottom line sustainability, including social, economic, and environmental benefits. Proprietary blockchain systems used by individual stakeholders create coordination and collaboration issues within the entire workflow, leading to delays and inefficiencies. Blockchain solutions and interoperability between systems can address these challenges by standardizing and streamlining interorganizational workflows, simplifying border crossings and clearance of goods.

To sum up, numerous T&L stakeholders utilize their own proprietary blockchain systems within their respective ecosystems, resulting in coordination and collaboration problems across the entire workflow. For instance, clearance of goods at border crossings can be sluggish and prone to manipulation due to opaque border administration procedures and lack of coordination between different border agencies. Blockchain solutions, particularly interoperability between various systems, tackle these challenges directly by simplifying, standardizing, and streamlining inter-organizational workflows.

5.3 Impact of EU legislation on implementation

GS1 standards are widely used in supply chain management and are designed to ensure the accurate identification, tracking, and tracing of products and shipments throughout the supply chain. These standards are voluntary, but they are widely adopted by businesses operating in various industries to improve supply chain efficiency and transparency. The EU has adopted regulations that require the use of specific GS1 standards for certain products and industries.

There are several EU regulations where GS1 standards are indicated or mentioned, including:

1. EU Food Information to Consumers Regulation (1169/2011): This regulation requires food businesses to provide accurate and clear information about food products to consumers. GS1 standards, such as barcodes, are mentioned as a means to provide this information.
2. EU Medical Devices Regulation (2017/745): This regulation requires medical device manufacturers to use unique device identification (UDI) to ensure traceability and safety. GS1 standards, such as Global Trade Item Numbers (GTINs), are mentioned as one of the accepted UDI formats.
3. EU Tobacco Products Directive (2014/40/EU): This directive requires the use of unique product identifiers (UPIs) on tobacco products to combat illicit trade. The first implementation deadline was the 20th of May 2019 for cigarettes and roll-your-own tobacco. To meet the EU requirements, multiple technical solutions were developed by several solution providers. GS1 maintained focus on ensuring that decades-long investments of retail trading partners in GS1 supply chain standards could be leveraged, as much as possible, to support the new EU requirements. These include Serialised Global Trade Item Numbers (SGTINs) to identify serialised trade items at all levels of packaging and Serialised Shipping Container Codes (SSCC) for logistic units across all GS1 sectors. **The EU 2018/574 text clearly permits** (but does not mandate) **GS1 identifiers**. It also requires all serialised identifiers for unit packs to be issued by independent third parties called “ID Issuers”, which are appointed by each Member State. As of May 2019, the ID Issuers of both Portugal and Spain have adopted a GTIN-based unit pack identifier. The other ID Issuers have chosen to implement solutions that are based on proprietary and non-GS1 standards (which do not include the interoperable, familiar, standards based SGTIN). Independent of this, GS1 standards are positioned as the basis for the majority of reporting events.
4. EU Falsified Medicines Directive (2011/62/EU): GS1 global standards meet the EU Commission’s criteria for the issuance of UDIs, supporting the EU regulators in ensuring a successful implementation of the UDI system as defined by the EU Medical Device Regulation and In-Vitro Diagnostics Medical Devices Regulation and enabling manufacturers to comply with these requirements. The Unique Device Identification (UDI) is a system used to mark and identify medical devices within the healthcare supply chain. Next to the device identifier (Global Trade Item Number, GTIN) in the EU regulation a new identifier for UDI is introduced: the “Basic UDI-DI” (the Global Model Number, GMN), which allows to group medical devices with similar features within the EU regulatory database EUDAMED. On top of that, if applicable, a production identifier (Application Identifier, AI) can be assigned by the manufacturer. The implementation of UDI can enhance patient safety and improve efficiency in the healthcare supply chain. It will enable more accurate reports of adverse events, more effective management of medical device recalls and reduction of medical errors.
5. EU Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (1907/2006): This regulation requires the identification and registration of chemicals used in products. GS1 standards, such as GTINs, are mentioned as a means to identify the products.

Overall, the impact of EU legislation on the implementation of GS1 standards can be seen as a positive force for the adoption and use of these standards in the EU, as it promotes standardization and interoperability across various industries and supply chains.

Blockchain and Smart contracts – legislation change

At the end of February 2023, the European Parliament voted to pass the 'Data Act', which includes a single clause directly addressing blockchain smart contracts.

In the Parliament's report on the proposal for a regulation of the Data Act, the EP announced its Draft European Parliament Legislative Resolution on the proposal for a regulation of the European Parliament and of the Council on harmonised rules on fair access to and use of data (Data Act) - 28.2.2023 - (COM(2022)0068 – C9-0051/2022 – 2022/0047(COD)) (Ordinary legislative procedure: first reading)[8]

In the text of Resolution proposing amendments to the Data Act (Text with EEA relevance), reads as follows:

…..

Preamble (79): "… the Commission should be enabled to adopt common specifications in areas where no harmonised standards exist and to mandate the development of harmonised standards for the portability and interoperability of data processing services. The European Data Innovation Board should build on existing European and global initiatives for cross-sectoral interoperability of data. …"

……

CHAPTER VIII: INTEROPERABILITY:

Article 30

Essential requirements regarding smart contracts for data sharing

The party offering smart contracts in the context of an agreement to make data available shall comply with the following essential requirements:

(a) robustness and access control: **ensure that the smart contract has been designed to offer rigorous access control mechanisms and a very high degree of robustness to avoid functional errors and to withstand manipulation by third parties**;

(b) safe termination and interruption: **ensure that a mechanism exists to terminate the continued execution of transactions: the smart contract shall include internal functions which can reset or instruct the contract to stop or interrupt the operation to avoid future (accidental) executions; in this regard, the conditions under which a smart contract could be reset or instructed to stop or interrupted, should be clearly and transparently defined. Especially, it should be assessed under which conditions non-consensual termination or interruption should be permissible**;

(ba) equivalence;: a smart contract shall afford the same level of protection and legal certainty as any other contracts generated through different means.

(bb) protection of confidentiality of trade secrets: ensure that a smart contract has been designed to ensure the confidentiality of trade secrets, in accordance with this Regulation."

There have been some discussions and comments in response to this publication.

In the article "EU Data Act requires smart contracts to have kill switch, not be permissionless"[9], the author comments on the proposed regulation and quotes an expert.

The European Union (EU) has passed the 'Data Act', which **includes a clause addressing blockchain smart contracts, requiring "a kill switch" to stop their functioning in case of problems**, causing concern among some members of the crypto community. However, the Act is mainly focused on the Internet of Things and data sharing

for industrial purposes, and the smart contract clause is not well-defined. Professor Thibault Schrepel suggests that if the scope of the clause is limited to machine-to-machine (M2M) data sharing, the concerns may be reduced. The legislation limits the scope of smart contracts to "the context of an agreement to make data available," implying that not all smart contracts are smart legal contracts.

In other article[10], we may find some interesting statement, e.g.:

"Because smart contracts are a type of contract, from a legal perspective **if they were to be broken, all remedies that are available for traditional contracts would be applicable**. … smart contracts have one major disadvantage: They cannot be changed. … There is next to no flexibility with smart contracts, … They do not give much in the way of change, even as conditions change." (attorney Isaac Marcushamer)

"The other disadvantages are much more complex. ... They include performance, user experience, and overall comprehension of the requirements. **The developer also needs to understand both the legal intricacies of the contract and how to convert that into programming language**." (Vlad Dzhidzhiyeshvili, CEO of Ventive, a digital transformation agency)

The other potential problem is presented in the article "EU Data Act, the smart contract regulation is being baked"[11]:

“What if the requirements for smart contracts under the Data Act are not met?

Conformity with the essential requirements will be assessed by the vendor or provider of the smart contract who will then have to issue an EU declaration of conformity and becomes responsible for compliance with the essential requirements. It is unclear what “responsible” means in this context and whether there is any potential civil liability for users of the smart contract.

If a supplier does not provide a compliant smart contract the consequences will be determined by applicable Member State law. This means the customers and possibly even third parties would be able to claim breach of contract and damages for non-compliance with the essential requirements.”

The law must now be finalised in trialogue negotiations, which will allow time for possible amendments. If the law is finally passed, there will only be a 12-month national implementation period.

6 Conclusions

The Conclusions chapter of this report serves as a comprehensive summary of the findings drawn from the research conducted in the Planet project. This chapter identifies the primary recommendations, and underscores the importance of implementing standardized approaches in the logistics industry. By leveraging the insights and recommendations presented in this report, stakeholders can navigate the evolving landscape of IoT, BC, and SC standards to enhance their operations, improve performance, and contribute to the advancement of the global supply chain ecosystem. Major themes arising from Task T4.5 worth highlighting:

1. The report identifies stakeholders interested in the research results to tailor the report to their specific needs and ensure that the results are relevant and useful. The recipients of the results from the Planet project, particularly regarding the standards supporting the Internet of Things (IoT), Blockchain (BC), and Supply Chain (SC), include various actors and entities involved in global trade optimization, industrial and consulting service providers, open-source communities, academic and research institutions, funding institutions, policy-making bodies, and the general public. The stakeholders have specific needs and expectations related to the project outcomes, such as the development of multimodal transport flow models, end-to-end transport chain models with IoT, BC, and AI integration, synchromodal platforms on Blockchain for transport solutions, smart ports and hubs, integration of Eurasian rail freight with European networks, e-commerce distribution, and decision support systems for strategic development of transport corridors. These areas require research, testing, and support for the operation of the innovative technologies mentioned.
2. Many different organizations have been actively working on developing communication and identification standards. Some of these organizations deal with standardization in a very limited way or for selected industries or groups of companies. That makes the adoption of these standards limited in large part due to the complexity and fragmentation of the standards landscape. The only organization that comprehensively addresses standardization in both - identification and communication context throughout the supply chain, is GS1.
3. Vast majority of logistics processes which are the subject of particular Business Case's did not use any identification and communication standards. The lack of standards affected process efficiency and the difficulty of achieving interoperability in the supply chain.
4. There are sets of recommended standards, which can be used to improve T&L processes (Transport Management, Shipping & Receiving, Warehouse Management, Assets' Management and Border Procedure Management). The lack of adoption of data standards and awareness of existing standards hinders the seamless flow of data along supply chains and diminishes efficiency gains.
5. The conclusion from the recommendation regarding GS1 standards to support logistics processes is that the use of the EPCIS standard is particularly suitable and recommended. This recommendation is based on the investigation of various logistics processes described in the earlier chapter:
    - For LL1 (Living Lab 1), which focuses on optimizing warehouse operations and automation, as well as last-mile delivery efficiency and sustainability, the recommendation is to use EDI (Electronic Data Interchange) and EPCIS (Electronic Product Code Information Services). The EPCIS standard, along with other GS1 standards, facilitates the transmission of data between partners involved in logistics operations within an e-commerce channel.
    - In LL3 (Living Lab 3), the recommendation is to implement IoT technologies and the EPCIS platform, along with other GS1 standards, to control resource parameters in real-time and identify them during the transport process. The data collected from IoT devices is exported to a sensory data aggregation platform and converted to EPCIS 2.0 compliant events.
6. The report emphasizes that the vast majority of partners in the surveyed Living Labs do not currently use identification and communication standards in their logistics processes. Therefore, the aim of the recommendation is to show companies the existing standards in the supply chain and how they can be

utilized in their processes. GS1 standards provide a common language for identifying, capturing, and sharing product data, ensuring accessibility, accuracy, and understanding of important information.

7. The recommendation proposes the implementation of GS1 standards for various logistics processes:
    - Transport Management: Using GS1 identifiers (SSCC, GLN, GSIN, GINC) and communication standards (LIM-based transport planning, transport instruction, transport status messages, eCMR, and real-time event data using EPCIS).
    - Shipping & Receiving: Utilizing SSCC for identifying logistic units, GTIN for trade items, GLN for delivery locations, and communication standards for sharing data (GDSN, GS1 XML, GS1 EANCOM, and EPCIS).
    - Warehouse Management: Recommending the use of GTIN, SSCC, and GLN for warehouse management, along with communication standards (GDSN, GS1 XML, GS1 EDI EANCOM, and EPCIS).
    - Returnable and Individual Assets Management: Adopting GRAI and GIAI for identifying assets, GLN for asset locations, and communication standards (GS1 XML, GS1 EANCOM, and EPCIS) for exchanging asset movement information.
    - Border Procedure Management (Customs): Utilizing GTIN, SSCC, GSIN, GDSN, GS1 XML, GS1 EANCOM, and EPCIS to improve product visibility, enhance security, and streamline customs procedures.
8. The benefits of using GS1 standards in each process are outlined, highlighting the improvements in efficiency, accuracy, traceability, and overall supply chain performance that can be achieved through their implementation. The recommendation also provides links to guidelines and documentation for the implementation of each standard.
9. IoT technologies and EPCIS platform along with other GS1 standards could facilitate transmission of data between the partners involved in the logistics operations within an e-commerce channel and generally in the whole supply chain.
10. GS1 EPCIS 2.0 (and its old releases) can be seen a good opportunity since it provides a secure, ad-hoc and standardised approach to implementing data sharing to authorized users, identified by GS1 codes and also GS1 EPCIS data-models is the proper tool to communicate with the EGTN platform.
11. Elements of blockchain technology can be successfully used in the role of the EPCIS GS1 event repository. The content of event messages can be stored as a blockchain which will ensure the integrity and transparency of logistics events reported in the systems. It is necessary to use connectors to ensure data integrity between multiple instances of blockchain registers.
12. Smart Contracts can be successfully used as a tool to automate information or logistics processes. The technology can be used to automatically generate logistics events in EPCIS format based on the terms and conditions in the contracts.
13. The emergence of blockchain technology is transforming transportation and logistics networks by enabling secure data sharing and financial transactions. Smart contracts, integrated with the Physical Internet (PI) paradigm, offer opportunities to automate processes and improve information flow in the supply chain. However, the PI concept requires a distributed and community-driven approach for widespread adoption. Blockchain and smart contracts enhance transparency, automate processes, and improve data integrity, but careful implementation is necessary to fully leverage their potential. Blockchain interoperability enables seamless data sharing across systems, including shipping manifests, customs declarations, and transport events, supporting the PI's goals. Data integrity and sovereignty can be ensured through blockchain, addressing the challenges of data protection and sharing in the industry. Convincing stakeholders to participate in the PI and share data requires demonstrating the financial benefits, and blockchain can increase trust and enable rapid information sharing. Integrating blockchain with IoT and AI technologies further enhances efficiency and sustainability. Standardizing and streamlining workflows through blockchain and interoperability address coordination and collaboration issues among stakeholders. In summary, blockchain solutions and interoperability streamline inter-

organizational workflows, simplify border crossings, and enhance coordination in transportation and logistics.

7 References

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8 Annex I: GS1 & ISO Partnering for Standards

Table 12: GS1 standards recognized by ISO and other standard bodies

GS1 component	External standard
GTIN (Global Trade Item Number)	ISO/IEC 15459-6
SGTIN (Serialised Global Trade Item Number)	ISO/IEC 15459-4

GS1 component	External standard
GLN (Global Location Number)	ISO/IEC 6523
SSCC (Serial Shipping Container Code)	ISO/IEC 15459-1
GIAI (Global Individual Asset Identifier)	ISO/IEC 15459-4 & 5
GRAI (Global Returnable Asset Identifier)	ISO/IEC 15459-5
GSRN (Global Service Relationship Number)	ISO/IEC 15418
GDTI (Global Document Type Identifier)	ISO/IEC 15418
GINC (Global Identification Number for Consignments)	ISO/IEC 15418
GSIN (Global Shipment Identification Number)	ISO/IEC 15459-6
GCN (Global Coupon Number)	ISO/IEC 15418
CPID (Component / Part Identifier)	ISO/IEC 15418
Application Identifiers	ISO/IEC 15418
Global Product Classification (GPC)	ISO 22274
EPC URI Syntax	IETF RFC 3986
EANCOM syntax	ISO 9735
EANCOM content	UN/CEFACT UNSMs
GS1 XML syntax	W3C XML
GS1 XML content	W3C XML
Symbology identifiers	ISO/IEC 15424
EAN/UPC	ISO/IEC 15420
ITF-14	ISO/IEC 16390
GS1-128	ISO/IEC 15417
GS1 DataBar	ISO/IEC 24724

GS1 component	External standard
GS1 DataMatrix	ISO/IEC 16022
GS1 Composite	ISO/IEC 24723
GS1 QR Code	ISO/IEC 18004
UHF Class 1 Gen 2	ISO/IEC 18000-63
HF Class 1 Gen 2	ISO/IEC 18000-3
EPC Tag Data Standard	ISO/IEC 15962
Low-level Reader Protocol (LLRP)	ISO/ICE 24791-5
Application Level Events (ALE)	ISO/IEC 24791-2
Reader Management (RM)	ISO/IEC 24791-3
Discovery, Configuration, and Initialization (DCI)	ISO/IEC 24791-3
EPC Information Services (EPCIS)	ISO/IEC 19987
GS1 Core Business Vocabulary (CBV)	ISO/IEC 19988
ISO application standards which refer to GS1 standards	
ISO 15394	Packaging - Bar code and two-dimensional symbols for shipping, transport and receiving labels
ISO 22742	Packaging -- Linear bar code and two-dimensional symbols for product packaging ISO 28219
ISO 17363	Supply chain applications of RFID -- Freight containers
ISO 17364	Supply chain applications of RFID -- Returnable transport items (RTIs) and returnable packaging items (RPIs)
ISO 17365	Supply chain applications of RFID - Transport unit
ISO 17366	Supply chain applications of RFID -- Product packaging

GS1 component	External standard
ISO 17367	Supply chain applications of RFID -- Product tagging
ISO/TS 16791 Health Informatics	Requirements for international machine-readable coding of medicinal product package identifiers
ISO 11615	Health informatics — Identification of Medicinal Products — Data elements and structures for the unique identification and exchange of regulated Medicinal Product information
ISO/TS 18530 Health Informatics	Automatic identification and data capture marking and labelling -- Subject of care and individual provider identification
ISO 10685-1	Ophthalmic optics — Spectacle frames and sunglasses electronic catalogue and identification — Part 1: Product identification and electronic catalogue product hierarchy
CEN/CLC/ TR 14060	Medical device traceability enabled by unique device identification (UDI)