DELPHI

FeDerated nEtwork of pLatforms for Passenger and freigHt Intermodality

Grant Agreement Number: 101104263

D.6.5: Standardization Contributions and Policy Recommendations

Document Identification			
Status	Final version	**Due Date**	Tuesday, 30 June 2026
Version	1.2	**Submission Date**	29/06/2026
Related WP	WP6	**Document Reference**	D.6.5
Related Deliverable(s)	D2.1, D2.5	**Dissemination Level**	PU
Lead Participant	ALICE	**Document Type:**	Report
Contributors	ICCS, ICP, ERTICO, DHL	**Lead Author**	Liz Araceli Cristaldo
		Reviewers	Nikoletta Karitsioti (SEAB)
			Emmanouela Koumparou (KTELM)

Funded by the European Union

DELPHI project has received funding under grant agreement No 101104263. It is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Document Information

Author(s) – in alphabetical order		
First Name	**Last Name**	**Partner**
Liz Araceli	Cristaldo	ALICE
Marion	Cottet	ALICE

Document History			
Version	**Date**	**Modified by**	**Modification reason**
1.0	08/06/2026	Liz Araceli Cristaldo & Marion Cottet	Final first draft, ready for review
1.1	12/06/2026	Liz Araceli Cristaldo	Peer review
	16/06/2026	Sofia Kokonesi, ICCS	Internal Review
	17/06/2026	Nikoletta Karitsioti, SEAB	Internal Review
	23/06/2026	Sokratis Barmpounakis, WINGS	Internal Review
1.2	24/06/2026	Liz Araceli Cristaldo	Peer review

Quality Control		
Role	**Who (Partner short name)**	**Approval Date**
Deliverable leader	ALICE	08/06/2026
Quality manager	WINGS	23/06/2026
Project Coordinator	ICCS	16/06/2026

Executive Summary

Data interoperability has become a key enabler of the digital transformation of urban mobility and logistics systems. Despite significant progress through European policies, standardization efforts, data space initiatives, and research and innovation projects, effective interoperability remains partially achieved. Persistent fragmentation across technical, semantic, governance, and operational dimensions continues to hinder data sharing and reuse. In this context, this deliverable provides an overview of the European data interoperability landscape, identifies the main implementation barriers, and formulates recommendations to support interoperable data-sharing ecosystems.

The work builds upon DELPHI Deliverable 2.5: *Methodology Framework for Secure, Safe and Efficient Data Sharing/Storage/Usage* (Psara, 2024), which reviewed governance frameworks, standards, methodologies, and data-sharing architectures relevant to mobility and logistics, and DELPHI Deliverable 2.1: *State-of-the-art report in governance, relative technologies and stakeholder ecosystems in passenger and freight transport* (Li and Cottet, 2024), which provided a State of the Art in governance, technology and stakeholder analysis in traffic management, passenger and freight transport related to DELPHI's four use cases. The present deliverable extends this analysis by focusing specifically on data interoperability challenges, implementation gaps, and opportunities for improvement within urban mobility and logistics ecosystems.

The study follows a methodology consisting of 4 steps: First, a State of the Art was done. It included European data space initiatives, standards, regulations/policies, and research and innovation projects. Second, the State of the Art findings were analyzed to identify data interoperability challenges applied to urban mobility and logistics. Third, these challenges were validated and enriched through a stakeholder survey. Finally, these challenges were translated into recommendations.

Table of Contents

List of Tables

List of Figures

Abbreviations & Acronyms

Abbreviation / acronym	Description
API	Application Programming Interface
BDVA	Big Data Value Association
CEN-CENELEC	European Committee for Standardization
CSV	Comma-Separated Values
D2.1	Deliverable number 1 belonging to WP 2
D2.5	Deliverable number 5 belonging to WP 2
DATEX II	European standard for the exchange of road traffic and travel information
DCAT	Data Catalog Vocabulary
DGA	Data Governance Act
DSBA	Data Space Business Alliance
DTLF	Digital Transport and Logistics Forum
DUF	Digital Urban Freight
EC	European Commission
eCMR	electronic consignment note
EDI	Electronic Data Interchange
EDIC	European Digital Infrastructure Consortium
eFTI	Electronic Freight Transport Information
EIF	European Interoperability Framework
EMDS	European Mobility Data Space
EPCIS	Electronic Product Code Information Services
EU	European Union
FIWARE	Open-source platform and foundation supporting interoperable digital platforms and data spaces
GAIA-X	European initiative for federated, secure, and sovereign data infrastructure
GLN	Global Location Number
GS1	Global organization developing standards for supply chain identification and data exchange
GTIN	Global Trade Identification Number

Abbreviation / acronym	Description
IDSA	International Data Spaces Association
IDS-RAM	International Data Spaces Reference Architecture Model
ISO	International Organization for Standardization
ITS	Intelligent Transport System
JSON	JavaScript Object Notation
MMT-RDM	Multimodal Transport Reference Data Model
NAP	National Access Point
NAPCORE	National Access Point Coordination Organization for Europe
NGSI	Next Generation Service Interfaces
OLF	Open Logistics Foundation
SDO	Standard Development Organization
SSCC	Serial Shipping Container Code
UVAR	Urban Vehicle Access Regulations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UN/EDIFACT	United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport
WP	Work Package
XML	Extensible Markup Language

1. Introduction

1.1 Purpose of the Document

This deliverable has been created to provide a consolidated State of the Art on standardization contributions and policy recommendations in the context of urban multimodal transport and logistics. It compiles the work carried out under Task 6.3, *Standardization Contributions and Policy Recommendations*, throughout the duration of the DELPHI project. Its purpose is to support DELPHI's ambition to federate urban platforms and integrate passenger and freight flows by ensuring that the project outcomes are aligned with, and contribute to, ongoing European and international standardization, policy, and interoperability initiatives.

The document serves as a reference for identifying relevant standards, regulatory frameworks, data-sharing initiatives, governance mechanisms, and implementation practices, as well as the remaining challenges that limit effective data interoperability in urban mobility and logistics. It also provides evidence-based recommendations to support the deployment and scaling of interoperable data-sharing ecosystems.

The central questions addressed are: **What are the main barriers preventing effective data interoperability in urban mobility and logistics ecosystems, and how can existing standards, policies, and governance frameworks be better implemented to support scalable and interoperable data-sharing environments?**

1.2 Intended Readership

Beyond the project, this deliverable is relevant to a wider set of stakeholders:

- **Policymakers and regulators**, particularly those engaged in European Commission initiatives.
- **Standard Development Organizations (SDOs)** who may use DELPHI insights as input to future standards.
- **Industry alliances and logistics operators**, interested in data interoperability and federation of platforms.
- **Researchers and innovation projects** working on data spaces, urban multimodal transport, and the Physical Internet paradigm.

Given its open dissemination level, the document may also be of interest to city authorities, urban mobility providers, and business actors exploring the adoption of multimodal and data-driven transport solutions for urban environments.

1.3 Document Structure

This document is organized into the following sections (Figure 1):

Section 1 - Introduction

Section 2 – Methodology: Explains the approach used to build the State of the Art.

Section 3 – European Context on Data Interoperability: Provides an overview of European and international standardization bodies, European regulatory and policy frameworks, cross-sector data-sharing initiatives, and European research and innovation projects relevant to urban multimodal transport.

Section 4 – Identified Challenges and Gaps: Synthesizes the main data interoperability challenges, highlighting key gaps and limitations in real-world data-sharing practices.

Section 5 – Validation and Expert Input: Validates the findings through a stakeholder survey, confronting analytical results with practitioner experience to ensure their operational relevance.

Section 6 – Recommendations: Translates the findings into actionable recommendations, focusing on improving implementation and scalability of existing policies and standards.

Section 7 – Conclusion: Synthesizes the key insights on systemic data interoperability challenges and highlights DELPHI's role in advancing the deployment and scalability of data-sharing frameworks.

Appendix: Provide supporting information.

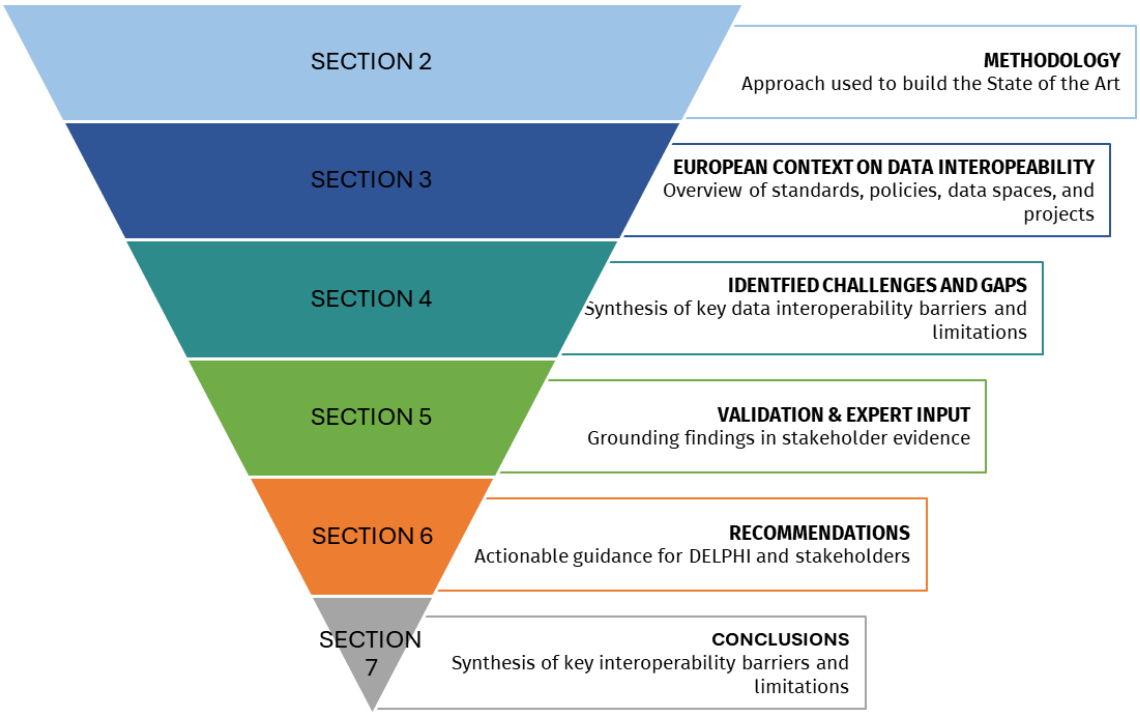


Figure 1. Document Structure

2. Methodology

The methodology follows a four-step process (Figure 2). It's based on the work previously conducted in DELPHI Deliverable D2.5, *Methodology Framework for Secure, Safe and Efficient Data Sharing/Storage/Usage*, which provided a review of relevant governance frameworks, standards, methodologies, regulatory initiatives, and data-sharing architectures applicable to the mobility and logistics sectors. The current deliverable aims to complement and extend this analysis by focusing specifically on the current state of data interoperability in urban mobility and logistics.

First, a **State of the Art analysis** is conducted to examine the European data interoperability landscape, including standardization bodies, regulatory and policy frameworks, data-sharing initiatives, and research and innovation projects. This analysis builds on the basis established in Deliverable D2.5 and incorporates additional materials consolidated from multiple sources, including project deliverables, regulatory and policy documents, standardization artefacts, such as reports and implementation guidelines, and recent initiatives relevant to data interoperability.

Second, the results of this review are synthesized through a **mapping and synthesis phase**, identifying key data interoperability challenges and gaps across technical, semantic, governance, and operational dimensions.

Third, the findings are validated through a **stakeholder survey**, targeting actors involved in urban mobility, logistics, and data-sharing initiatives. This step serves to validate and prioritize the previously identified gaps, ensuring alignment with actual practices and experiences.

Finally, the combined insights are translated into **actionable recommendations**, to support the deployment and scalability of data-sharing ecosystems.

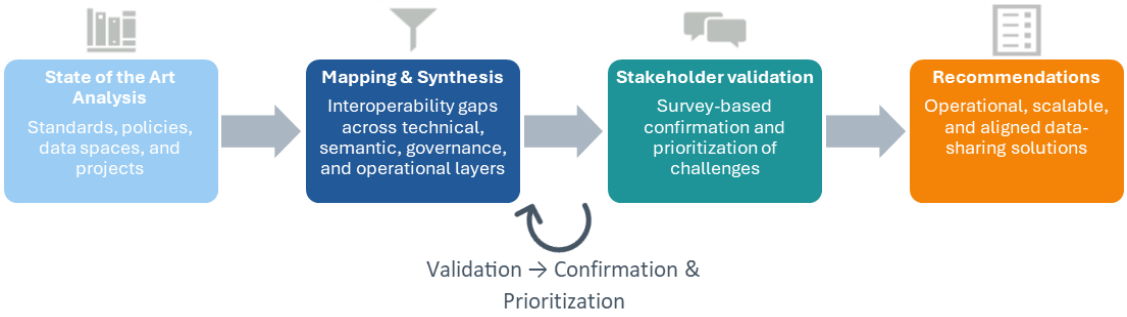


Figure 2. Methodology process of Task 6.3

2.1 Screening and Coding

To ensure comparability across diverse initiatives, a two-step procedure was applied:

1. **Screening**: each source was checked for relevance (clear link to urban mobility and logistics data interoperability) and completeness (availability of specifications or documented outcomes). Non-relevant items (e.g., press releases, promotional material) were excluded.

2. **Coding**: each included artefact was documented capturing:
    - *Body/Initiative:* the entity responsible for the artefact, which may correspond to an institutional body (e.g., standardization organization, regulatory authority) or to a specific initiative or project in which the artefact was developed.
    - *Reference:* specific model, regulation, or specification.
    - *Layer:* interoperability dimension addressed (Refer to 2.2)
    - *Maturity:* reflects both the stage of development and the degree of operational adoption of each element, distinguishing between conceptual frameworks, emerging or pilot implementations, actively deployed initiatives, and mature, widely adopted standards.

2.2 Interoperability Layers (EIF Definitions)

Each artefact was classified according to the European Interoperability Framework (EIF)[1], which distinguishes four core layers and two cross-cutting governance dimensions:

Legal interoperability: ensures that organizations operating under different legal frameworks, policies, or strategies can cooperate. It requires screening legislation for barriers and aligning requirements across borders. *Example:* The EU's eFTI Regulation (2020/1056) obliges Member States' authorities to accept freight transport information in electronic form. This removes the legal barrier where one country requires paper documents while another accepts digital ones.

Organizational interoperability: refers to the alignment of business processes, roles, and responsibilities so that multiple organizations can jointly deliver services effectively. *Example:* In Madrid's DELPHI pilot, Metro Madrid, DHL, and KOIKI aligned their roles: metro provided infrastructure, DHL supplied parcels, and KOIKI managed last-mile delivery. This process redesign allowed passenger transport assets to also serve urban logistics.

Semantic interoperability: guarantees that the *meaning* of exchanged information is preserved and understood consistently across contexts by the different actors involved. It includes both semantic aspects (vocabularies, ontologies) and syntactic aspects (formats, structures).

[1] https://interoperable-europe.ec.europa.eu/collection/iopeu-monitoring/european-interoperability-framework-detail

Technical interoperability: focuses on the technologies that allow different systems to exchange and use information. This includes interfaces, communication protocols, and data exchange mechanisms that enable organizations to connect their systems. In DELPHI, this is reflected in the federated approach, where data remains with individual stakeholders but can be exchanged.

Interoperability governance (cross-cutting): concerns the rules, responsibilities, and decision-making processes needed to ensure that interoperability works in practice. It defines how stakeholders collaborate, how interoperability is managed over time, and how compliance is monitored.

Integrated public service governance (cross-cutting): addresses situations where several organizations must work together to deliver a service. It focuses on coordination, role definition, and agreed procedures across institutional boundaries. This is particularly relevant in DELPHI use cases where public authorities, mobility operators, and service providers need to coordinate data sharing and service delivery.

3. European Context on Data Interoperability

In the last decade Europe has developed a rich ecosystem to support data interoperability, including policy frameworks, regulatory instruments, standardization efforts, and technical and operational initiatives. This ecosystem is particularly complex in the field of urban mobility and logistics, involving a multitude of actors, heterogeneous systems and varying operational contexts.

This landscape is based on data space initiatives which define federated data-sharing architectures, standardization frameworks which provide common data models and exchange rules, European policy and regulatory instruments which establish strategic and legal conditions, and implementation-oriented projects and tools which translate these elements into practice.

This section reviews these components and their interactions, highlighting how they contribute to data interoperability in urban mobility and logistics, and where fragmentation and gaps persist in practice. A visualization is presented in Appendix 1.

3.1 Data Space Initiatives

At the technical and organizational level, data space initiatives have emerged as a central approach to enabling data interoperability in complex, multi-actor environments such as urban mobility and logistics. Rather than focusing solely on data formats or exchange protocols, these initiatives define the conditions under which data can be shared in a federated, secure, and sovereign manner, allowing heterogeneous actors to collaborate while retaining control over their data.

Data space initiatives can be broadly divided into two complementary categories: (i) enabling frameworks and architectures, which define the technical and governance principles for data sharing, and (ii) concrete implementations and ecosystems, which apply these principles in real-world contexts.

3.1.1 Data Space Frameworks and Architectures

Data space frameworks provide the building blocks for interoperable data-sharing environments. They define **reference architectures, governance models, and technical components** that enable organizations to exchange data securely while preserving data sovereignty.

Among the most prominent initiatives are the International Data Spaces Association (IDSA)[2] and GAIA-X[3].

[2] https://internationaldataspaces.org/
[3] https://gaia-x.eu/

IDSA proposes a comprehensive reference architecture (IDS-RAM) that structures data-sharing ecosystems around standardized components such as connectors, identity management systems, access control mechanisms, and usage policies. A key feature of this approach is that data providers retain control over how their data is accessed and used, even after it has been shared. This is supported by governance frameworks and rulebooks that define roles, responsibilities, and contractual conditions for data exchange. In addition, IDSA promotes semantic interoperability through shared vocabularies and ontologies, contributing to a more consistent interpretation of data across systems.

GAIA-X complements this approach by focusing on the federation and trust infrastructure required to connect distributed data ecosystems. Rather than providing a single platform, GAIA-X defines a set of governance rules, compliance mechanisms, and interoperability requirements that allow different actors and infrastructures to interoperate within a common framework. It emphasizes transparency, data sovereignty, and trust through mechanisms such as self-description, identity management, and certification processes.

In addition, initiatives such as the FIWARE Foundation[4] provide practical tools to support the implementation of interoperable data-sharing solutions. FIWARE offers a set of open-source components and standardized APIs that help organizations develop digital platforms based on shared data models, particularly in areas such as smart cities, mobility, and logistics. Its approach also supports the development of federated data-sharing environments, helping organizations put data space concepts into practice.

At a higher level of coordination, the Data Spaces Business Alliance (DSBA)[5] brings together major European initiatives, including Gaia-X, IDSA, FIWARE, and the Big Data Value Association (BDVA), to accelerate the development and adoption of data spaces. By aligning governance frameworks, technical architectures, and implementation tools, DSBA aims to reduce fragmentation and provide an unified ecosystem for data space deployment across sectors.

Together, these frameworks address both technical and organizational dimensions of interoperability. However, important limitations remain. While IDSA and GAIA-X define how data can be shared, they do not provide fully specified, domain-specific data models for sectors such as urban mobility or logistics. As a result, semantic definitions are often developed independently within each data space, leading to inconsistencies in data interpretation across systems (Bakri et al., 2023; Delaplace, 2024).

In addition, challenges persist regarding liability, accountability, and governance clarity. Although these frameworks define mechanisms for identity, access, and usage control,

[4] https://www.fiware.org/foundation/
[5] https://data-spaces-business-alliance.eu/

they do not fully resolve how responsibility should be allocated when data is reused, combined, or used for decision-making processes (Picht, 2020; Vellinga and Hailevich, 2024). This creates uncertainty for stakeholders and may limit adoption at scale.

3.1.2 Data Space Implementations and Ecosystems

Building on these frameworks, a growing number of initiatives aim to implement data space principles in real-world contexts, translating architectural concepts into operational ecosystems.

At the European level, the European Mobility Data Space (EMDS)[6] aims to establish a common framework for sharing mobility and transport data, enabling public authorities, transport operators, infrastructure managers, and service providers to exchange data in a secure and interoperable manner. Rather than creating a centralized platform, EMDS follows a federated approach, where existing data ecosystems remain autonomous but can connect through shared governance and technical standards. As part of the broader European Data Strategy, EMDS provides both a strategic direction and an emerging operational framework for mobility data interoperability.

Complementing this European-level initiative, sectoral ecosystems such as EONA-X[7] illustrate how data space principles can be applied across multiple industries. EONA-X aims to create a decentralized data-sharing environment across logistics, mobility, and tourism, enabling actors to share and reuse data through a common governance framework while maintaining control over their assets. By connecting actors across sectors, it addresses fragmentation not only within mobility systems but also across related domains.

At the national level, German initiatives such as Mobilithek[8] and the Mobility Data Space Germany[9] provide concrete examples of implementation. Mobilithek operates as a regulatory data access point, ensuring that mobility data required under the Intelligent Transport System (ITS) Directive is published in a standardized and accessible manner. It represents the deployment of European regulatory requirements at national level.

In contrast, the German Mobility Data Space extends beyond regulatory data publication by enabling federated data exchange between public and private actors under shared governance and trust mechanisms. The integration between Mobilithek and the Mobility Data Space illustrates how regulatory platforms and data-sharing

[6] https://transport.ec.europa.eu/transport-themes/smart-mobility/creating-common-european-mobility-data-space_en
[7] https://eona-x.eu/
[8] https://mobilithek.info/
[9] https://mobility-dataspace.eu/

ecosystems can complement each other, linking data availability with data exchange and reuse.

These examples demonstrate that data space principles are increasingly being translated into practice. However, they also reveal important challenges. Implementations remain fragmented across countries, sectors, and projects, with differences in governance models, technical architectures, and levels of maturity. Moreover, many initiatives are still in pilot or early deployment phases, raising questions about scalability, interoperability between ecosystems, and long-term sustainability.

3.2 Standardization Frameworks

Standardization frameworks play a central role in enabling data interoperability by providing shared rules, structures, and definitions for how data is described, exchanged, and interpreted. In the context of urban mobility and logistics, data standardization occurs at multiple levels: (i) standardization bodies, (ii) domain-specific standards and data exchange models, and (iii) semantic models, legacy standards, and identification systems.

3.2.1 Standardization Bodies

At the institutional level, data standardization is driven by organizations such as the International Organization for Standardization (ISO)[10] and the European Committee for Standardization (CEN-CENELEC)[11]. These bodies define formal standards through consensus-based processes, providing the basis for data interoperability across sectors (Bakri et al., 2023).

ISO develops global standards that support interoperability in areas such as data management, information exchange, and logistics operations. These standards are widely adopted across international transport and supply chain systems, enabling consistency across countries and industries. At the European level, CEN complements this role by developing standards aligned with EU regulatory frameworks and market requirements, particularly in transport, infrastructure, and digital systems.

Together, these organizations provide the institutional basis of standardization, ensuring that interoperability standards are defined, validated, and disseminated across stakeholders. However, while they establish common reference frameworks, their impact depends on how standards are interpreted and implemented in practice.

3.2.2 Domain-Specific Standards and Data Exchange Models

[10] https://www.iso.org/home.html
[11] https://www.cencenelec.eu/

At the operational level, standards focused on specific domains define how data is structured and exchanged. Examples include DATEX II[12] for road traffic information and NeTEx[13] for public transport data exchange.

These standards help ensure that information can be exchanged and interpreted consistently across different systems. They are commonly used in areas such as traffic management, journey planning, and multimodal transport coordination. However, in practice the heterogeneity of implementation across stakeholders tends to limit their effectiveness (Gharehgozli et al., 2019).

While standards define common structures, they frequently allow flexibility in interpretation, which can lead to inconsistencies. For example, *"delivery event"* may refer to different operational moments (e.g., vehicle arrival at a hub versus confirmation of delivery).

In addition, actors often introduce local adaptations to fit better their operational needs. While such customization increases the usability of the solutions at their level, it is not always properly documented or shared, reducing its potential for reuse.

As a result, even though the adoption of standards is necessary, differences in interpretation, implementation, and usage can lead to fragmentation, so on their own, they are not sufficient to ensure effective interoperability. Additional alignment across semantic, organizational, and operational dimensions is required.

3.2.3 Semantic Models, Legacy Standards, and Identification Systems

Apart from standards applied to specific domains, other initiatives contribute to interoperability by defining shared semantic structures, legacy data exchange formats, and identification systems.

An example is the Multi-Modal Transport Reference Data Model (MMT-RDM)[14], developed by UN/CEFACT which provides a mode-neutral semantic framework for structuring transport and logistics data. It covers elements such as shipments, actors, transport equipment, and operational events (Apostolov, 2024; Probert and Roff, 2025). Rather than prescribing a specific standard, it provides a common framework that helps connect different data models and facilitates interoperability across transport modes and systems.

Legacy standards such as UN/EDIFACT[15] are still widely used in international freight and trade operations. They provide a common way for organizations to exchange information electronically across companies and countries. Although newer

[12] https://datex2.eu/
[13] https://transmodel-cen.eu/index.php/netex/
[14] https://unece.org/trade/uncefact/rdm
[15] https://unece.org/trade/uncefact/introducing-unedifact

approaches based on APIs and data spaces are gaining traction, many systems used in ports, customs, and multimodal transport continue to rely on EDIFACT messages. For this reason, ensuring compatibility with existing systems remains an important interoperability consideration.

In addition, GS1[16] standards play an important role in supporting interoperability across supply chains. Through globally recognized identifiers such as GTIN, GLN, and SSCC, as well as data-sharing standards like EPCIS, they help organizations identify and track goods, locations, and logistics units in a consistent way.

3.3 European Policies and Regulatory Frameworks

European policies and regulatory frameworks define the legal, strategic, and organizational conditions under which data interoperability can be developed and implemented across mobility and logistics systems. These instruments operate at different levels and address complementary dimensions of interoperability. They can be categorized in: (i) strategic policy frameworks, which define the overall vision and guiding principles for data sharing and interoperability; (ii) regulatory and legal instruments, which establish binding rules governing data access, exchange, and use across stakeholders; and (iii) coordination and governance mechanisms, which support stakeholder alignment, facilitate collaboration, and guide the implementation of interoperability frameworks.

3.3.1 Strategic Policy Frameworks

At the strategic level, European policy frameworks define the overall vision and guiding principles for data interoperability across sectors. The European Strategy for Data[17], adopted by the European Commission in 2020, establishes a human-centric and values-driven approach to the data economy, aiming to create a single market for data in which information can flow securely across sectors and borders. A central objective of the strategy is the development of Common European Data Spaces, designed to increase data availability while ensuring that organizations and individuals retain control over their data. To achieve this, the strategy combines policy measures, regulatory instruments, and investments in data infrastructures, governance mechanisms, and digital technologies.

Complementing this vision, the European Interoperability Framework (EIF)[18] provides a structured reference model for interoperability across public administrations. It defines interoperability as the ability of organizations to exchange and use information to achieve shared objectives, emphasizing alignment across four key dimensions: legal,

[16] https://www.gs1.org/
[17] https://digital-strategy.ec.europa.eu/en/policies/strategy-data
[18] https://interoperable-europe.ec.europa.eu/collection/iopeu-monitoring/european-interoperability-framework-detail

organizational, semantic, and technical. Although it is not specific to mobility or logistics, EIF gives a systemic perspective that is the basis for many European initiatives in the digital and data-sharing domains.

Together, these frameworks establish the strategic basis for data interoperability, defining common principles for data sharing, governance, and cross-sector integration. However, their high-level nature means that they provide direction rather than concrete implementation mechanisms.

3.3.2 Regulatory and Legal Instruments

Regulatory and legal instruments enable data interoperability by establishing binding rules for how data is accessed, shared, and used across stakeholders. Unlike strategic frameworks, which define overall objectives, these instruments translate policy ambitions into enforceable requirements that structure data exchange practices across sectors and Member States.

At a horizontal level, regulations such as the Data Governance Act (DGA)[19] (Regulation (EU) 2022/868) and the European Data Act[20] define general conditions for data sharing across the European economy. The DGA focuses on creating trusted data-sharing environments by establishing mechanisms for data reuse, data intermediation, and governance structures, particularly for sensitive or public-sector data. The Data Act complements this approach by defining rights and obligations related to access and use of data generated by connected products and digital services, aiming to ensure fairness, transparency, and increased data availability. Together, these instruments provide the legal basis for data sharing, addressing key issues related to trust, access rights, and data control.

At the sectoral level, domain-specific regulations further structure data interoperability within transport systems. The Intelligent Transport Systems (ITS) Directive[21] establishes a common framework for the coordinated deployment of digital mobility services across Member States, defining requirements for data availability and exchange in areas such as traffic management and multimodal information systems. Building on this directive, National Access Point (NAP)[22] regulations require Member States to provide standardized access to mobility data through dedicated platforms, ensuring that key datasets are discoverable and reusable across borders. However, in practice, differences in implementation across countries have led to fragmentation, highlighting

[19] https://digital-strategy.ec.europa.eu/en/policies/data-governance-act
[20] https://digital-strategy.ec.europa.eu/en/policies/data-act
[21] https://transport.ec.europa.eu/transport-themes/smart-mobility/road/its-directive-and-action-plan_en
[22] https://transport.ec.europa.eu/transport-themes/smart-mobility/road/its-directive-and-action-plan/national-access-points_en

the need for coordination mechanisms such as NAPCORE[23] to align standards, interfaces, and data-sharing practices at European level.

In the freight domain, the eFTI Regulation[24] (Regulation (EU) 2020/1056) focuses on the digitalization of regulatory freight information exchanges between economic operators and public authorities. It defines common data requirements and procedures to replace paper-based documentation with electronic data, facilitating interoperability in administrative processes across borders. This regulatory framework is complemented by instruments such as the electronic Consignment Note (eCMR)[25] which demonstrate how legally recognized digital documents can support standardized and interoperable data exchange in operational contexts, such as in road transport.

Together, these regulatory instruments contribute to a structured legal environment for data interoperability by defining common rules for data access, exchange, and governance. However, despite their strong potential, important limitations remain. Many of these frameworks operate at a high level and provide general principles rather than concrete implementation guidance. In addition, their scope is often limited to specific types of data exchange (e.g., business-to-administration interactions in the case of eFTI), leaving gaps in operational interoperability between private actors. As a result, differences in interpretation, implementation, and alignment across Member States continue to limit the effective and scalable realization of data interoperability in practice.

3.3.3 Coordination and Governance Mechanisms

Beyond strategic policies and regulatory instruments, coordination and governance mechanisms support data interoperability by aligning stakeholders, facilitating collaboration, and guiding the implementation of data-sharing frameworks across fragmented ecosystems.

At this level, initiatives do not define technical standards or binding rules, but instead provide platforms for dialogue, coordination, and institutional structuring. For example, the Digital Transport and Logistics Forum (DTLF)[26] acts as a European coordination platform, bringing together public authorities, industry actors, and research stakeholders to identify interoperability barriers and promote common approaches to data exchange in multimodal transport systems. Similarly, governance instruments such as the European Digital Infrastructure Consortium (EDIC)[27] provide a

[23] https://napcore.eu/
[24] https://transport.ec.europa.eu/transport-themes/logistics-and-multimodal-transport/efti-regulation_en
[25] https://openlogisticsfoundation.org/ecmr/
[26] https://transport.ec.europa.eu/transport-themes/logistics-and-multimodal-transport/digital-transport-and-logistics-forum-dtlf_en
[27] https://digital-strategy.ec.europa.eu/en/policies/edic

formal legal and organizational framework for joint development and long-term management of cross-border digital infrastructures, including data spaces.

These mechanisms play a critical role in bridging the gap between the policy objectives and operational implementation by supporting stakeholder alignment, governance design, and coordination across countries and sectors. However, their effectiveness ultimately depends on whether public and private actors actively participate in these initiatives and integrate them into their operational practices.

3.4 European Projects, Implementation Initiatives, and Supporting Enablers for Data Interoperability in Mobility and Logistics

In parallel with policy frameworks and standardization efforts, European research and innovation projects play a key role in advancing data interoperability in mobility and logistics. These initiatives contribute by testing concepts, validating architectures, and translating interoperability principles into operational environments. However, their contributions vary significantly depending on their objectives, scope, and level of maturity.

To better understand their role, these initiatives can be categorized in: (i) experimental and pilot-based interoperability projects, (ii) federated interoperability and cross-platform integration initiatives, and (iii) regulatory implementation and data space deployment projects. In addition, a complementary set of supporting tools and implementation enablers contributes to deploying interoperability frameworks by providing concrete technical solutions.

3.4.1 Experimental and Pilot-Based Interoperability Projects

The first group of projects focuses on experimenting with interoperability solutions in controlled or semi-operational environments, typically within specific cities or regions. This includes initiatives such as DELPHI[28], DISCO[29], DECARBOMILE[30], GREEN-LOG[31], UNCHAIN[32], and URBANE[33].

These projects explore different dimensions of data interoperability, including integration of heterogeneous data sources (public and private), development of data-sharing platforms and digital services, testing of multimodal coordination mechanisms, and implementation of data space concepts at local scale.

Many of these initiatives either develop their own data-sharing infrastructures or align with existing frameworks such as IDSA and GAIA-X. They often aim to demonstrate how

[28] https://cordis.europa.eu/project/id/101104263
[29] https://cordis.europa.eu/project/id/101103954
[30] https://cordis.europa.eu/project/id/101069806
[31] https://cordis.europa.eu/project/id/101069892
[32] https://cordis.europa.eu/project/id/101103812
[33] https://cordis.europa.eu/project/id/101069782

interoperability can support specific use cases, such as last-mile logistics optimization, multimodal transport coordination, or sustainable urban mobility planning.

However, despite their strong innovation potential, these projects face several limitations from an interoperability perspective. First, solutions are often designed for specific contexts, making them difficult to transfer or replicate across cities or regions. Second, there is limited reuse of data models, APIs, and architectures between projects, leading to duplication of effort. Finally, interoperability is frequently achieved through ad hoc integration and manual adaptation, rather than through standardized and reusable mechanisms.

3.4.2 Federated Interoperability and Cross-Platform Integration Initiatives

A second group of initiatives focuses on enabling interoperability between existing systems and platforms, rather than creating new isolated solutions. This includes projects such as FEDeRATED[34] and FENIX[35].

These initiatives address a key challenge in the European landscape: the coexistence of multiple digital platforms across transport modes, countries, and stakeholders. Instead of centralizing data, they promote a federated approach, where systems remain autonomous but can interoperate through shared rules and architectures.

The FEDeRATED project established a common European vision and reference architecture for federated data exchange in transport and logistics. It defined principles for: interoperability between platforms, alignment of business processes, and governance mechanisms for data sharing.

Based on this, the FENIX project validated these concepts through large-scale pilots across multiple transport modes, demonstrating how federated architectures can support: end-to-end visibility, cross-border data exchange, and coordination across heterogeneous systems.

From a data interoperability perspective, these initiatives represent a significant step forward, as they move beyond isolated pilots toward system-level integration. They explicitly address interoperability challenges related to system heterogeneity, data exchange between independent actors, and alignment of governance frameworks. However, despite these advances, their adoption remains limited, and integration with broader policy and standardization frameworks is still evolving.

3.4.3 Regulatory Implementation and Data Space Deployment Projects

[34] https://www.federatedplatforms.eu/
[35] https://fenix-network.eu/

The third group of initiatives is concerned with **turning policies and data space concepts into operational solutions**. This category includes three main types of initiatives: (i) regulatory implementation projects, (ii) coordination and harmonization initiatives, and (iii) data space deployment projects.

A first subset concerns **regulatory implementation projects**, particularly those supporting the deployment of the eFTI Regulation. Projects such as *eFTI4EU*[36] and *eFTI4ALL*[37] aim to implement the electronic exchange of freight transport information between economic operators and public authorities. Their contribution to data interoperability lies in translating legal requirements into concrete technical, organizational, and procedural solutions, including the development of interoperable platforms, cross-border data exchange mechanisms (e.g., eFTI Gates), and harmonized data structures. These projects address interoperability not only at the technical level, but also in terms of legal recognition, compliance, and coordination between national systems, which are essential for scaling data exchange across Member States.

A second subset includes **coordination and harmonization initiatives**, such as *NAPCORE*[38], which focuses on improving interoperability of mobility data at the European level. *NAPCORE* addresses fragmentation in National Access Points (NAPs), which serve as the official gateway for publishing mobility and traffic data under the ITS Directive. While NAPs are widely implemented across Europe, differences in data formats, metadata standards, and access conditions have limited their interoperability. NAPCORE contributes by aligning technical specifications, harmonizing access procedures, and fostering coordination between national authorities. From an interoperability perspective, this initiative is critical, as it supports cross-border data discoverability, accessibility, and reuse, particularly for public-sector mobility data.

A third subset focuses on **data space preparation and deployment**, aiming to establish federated environments for large-scale data sharing. Projects such as *PrepDSpace4Mobility*[39] and *deployEMDS*[40] contribute directly to the development of the European Mobility Data Space (EMDS). PrepDSpace4Mobility focuses on defining the basic elements of the data space, including governance models, architectural components, and interoperability requirements. It plays a more structuring role by identifying interoperability gaps, aligning stakeholders, and proposing common building blocks. In contrast, deployEMDS moves toward more operational implementation, supporting real-life deployment in multiple cities and regions. It tests how data can be shared, accessed, and reused in practice, addressing challenges related to system integration, governance enforcement, and scalability.

[36] https://efti4eu.eu/
[37] https://efti4all.eu/
[38] https://napcore.eu/
[39] https://mobilitydataspace-csa.eu/
[40] https://deployemds.eu/

In addition, **domain-specific initiatives** such as *UVAR Box*[41] and *UVAR Exchange*[42] contribute to interoperability by standardizing specific categories of data. These initiatives focus on making urban access regulations machine-readable and interoperable across systems, enabling their integration into routing, planning, and logistics platforms. While more limited in scope, they illustrate how interoperability can be achieved at the level of specific data domains.

From a data interoperability perspective, these initiatives are important because they operate at the interface between policy, technical implementation, and real-world deployment. They address challenges that are often not fully covered by standards or frameworks alone, including: cross-border interoperability, alignment between national systems, integration of regulatory and operational data, and the transition from pilot solutions to scalable infrastructures.

However, despite their strong potential, several limitations remain. Implementation is still heterogeneous across Member States, reflecting differences in technical capabilities, governance structures, and institutional priorities. Interoperability between initiatives is not yet fully achieved, and integration with other data-sharing ecosystems (e.g., logistics platforms, private-sector systems) remains partial. Furthermore, many of these initiatives are still in deployment or early operational phases, meaning that their long-term impact and scalability are not yet fully demonstrated.

3.4.4 Supporting Tools and Implementation Enablers

A set of supporting tools and implementation-oriented programs also contributes to data interoperability by providing concrete technical solutions for organizations to implement interoperability frameworks in real systems.

A first example is the Open Logistics Foundation (OLF)[43], which focuses on the development of open-source software solutions for logistics. Unlike standardization bodies or policy frameworks, OLF provides reusable and directly implementable software components designed to improve interoperability between logistics systems. By promoting collaborative development and shared digital tools, it helps reduce duplication of effort and facilitates the adoption of interoperable solutions across supply chains. From a data interoperability perspective, OLF is particularly relevant as it helps to translate abstract interoperability principles into usable applications within operational environments.

[41] https://uvarbox.eu/
[42] https://uvarbox.eu/uvar-exchange/
[43] https://openlogisticsfoundation.org/

Another important initiative is the SIMPL programme[44], supported by the European Commission, which provides a middleware layer to support interoperability across European data spaces. SIMPL offers a set of modular, open-source components (SIMPL-Open) that enable secure data access, exchange, and federation across distributed systems. In addition, SIMPL-Live and SIMPL-Labs support real-world deployment and experimentation, allowing stakeholders to test interoperability solutions and assess their scalability. By focusing on reusable technical building blocks aligned with European data governance principles, SIMPL contributes to reducing fragmentation and lowering the technical barriers to data sharing.

These initiatives highlight that achieving data interoperability requires not only frameworks, policies, and pilot projects, but also concrete technical tools that support implementation.

Table 1. Coding frame for standardization artefacts and initiatives

Body / Initiative	Reference	Layer	Maturity
ISO – International Organization for Standardization	ISO/IEC 19845 (UBL); ISO 23355:2024 (visibility data interchange)	Semantic + Technical	Mature: Widely adopted globally (especially maritime, trade, logistics); continuously updated
CEN / CENELEC – European Committee for Standardization	EN 16931 (e-invoicing); transport-related EN standards	Semantic + Technical + Legal	Mature but evolving: Strong EU adoption, often linked to regulation
UN/CEFACT	MMT-RDM (Multi-Modal Transport Reference Data Model)	Semantic (conceptual model)	Emerging: Conceptual reference model, limited real-world implementation
UN/CEFACT	UN/EDIFACT (UNTDID message standards)	Technical + Semantic	Mature: Widely used in international freight, legacy but still operationally critical
GS1 – Global Standards Organization	EPCIS, barcodes (GTIN, SSCC), EDI standards	Semantic (identification, traceability) + Technical	Mature: Global cross-sector adoption (retail, logistics, healthcare)
European Commission	European Strategy for Data	Governance + Strategic	Established: Defines EU data-sharing vision and direction
European Union	Data Governance Act (Regulation EU 2022/868)	Legal + Governance	Adopted: In force since 2023; implementation ongoing
European Union	Data Act (Regulation on fair access to and use of data)	Legal + Governance	Adopted: Applies from 2025
European Union	ITS Directive (2010/40/EU) + delegated regulations	Legal + Technical + Organizational	Mature: Implemented across Member States

[44] https://simpl-programme.ec.europa.eu/dashboard/home

Body / Initiative	Reference	Layer	Maturity
European Union	National Access Points (NAPs) regulations (under ITS Directive)	Technical + Organizational + Semantic	Operational: Implemented across EU Member States
eFTI Framework	eFTI Regulation + delegated acts; common datasets	Legal + Semantic + Technical	In deployment: Regulatory framework adopted; implementation ongoing
eCMR – Electronic Consignment Note	Digital CMR protocol and data model	data model Legal + Semantic + Technical	Technical Mature: Operational in road freight; adoption expanding
DTLF – Digital Transport and Logistics Forum	Federated Network of Platforms; eFTI subgroup outputs	Governance + Semantic	Active: Advisory role; ongoing EU coordination
EDIC – European Digital Infrastructure Consortium	Legal framework for cross-border digital infrastructures	Legal + Organizational	Emerging: Recently established; early implementations supporting data spaces
IDSA – International Data Spaces Association	IDS-RAM, IDS Connector, Dataspace Protocol, Rulebook	Technical + Organizational + Semantic	Mature: Widely used in EU pilots and data space implementations
Gaia-X	Federated Services, Policy Rules, Trust Framework	Governance + Technical	Ongoing: Implemented in pilots; still consolidating
FIWARE Foundation	Context Broker, NGSI-LD APIs, data models	Technical + Semantic	Mature: Widely used in smart cities and mobility platforms
DSBA – Data Spaces Business Alliance	Cross-initiative alignment (Gaia-X, IDSA, FIWARE, BDVA)	Governance + Technical	Active: Coordination initiative; structuring ecosystem
NAPCORE	Coordination of National Access Points (NAPs)	Governance + Technical + Semantic	Active: Large-scale EU coordination; harmonization ongoing
FEDeRATED Project	Federated architecture & governance guidelines	Governance + Technical	Completed (conceptual maturity): Basis for further projects (e.g., FENIX)
FENIX Project	Federated network of logistics platforms	Technical + Governance	Advanced pilot: Validated in large-scale pilots
eFTI4EU / eFTI4ALL	eFTI implementation pilots	Technical + Legal + Organizational	Ongoing: Real-world deployment across Member States
PrepDSpace4Mobility	Mobility data space preparation framework	Governance + Technical	Completed (conceptual): Basis for EMDS
deployEMDS	Operational mobility data space deployment	Technical + Governance	Pilot phase: Active deployment in cities
EMDS – European Mobility Data Space	deployEMDS, PrepDSpace4Mobility	Technical + Governance + Organizational	Pilot phase: Early deployment in cities/regions; evolving framework
EONA-X	Federated data-sharing ecosystem	Governance + Technical	Emerging: Early-stage ecosystem development

Body / Initiative	Reference	Layer	Maturity
Mobilithek (Germany NAP)	National mobility data platform	Technical + Organizational	Operational: National implementation of EU rules
Mobility Data Space (Germany)	National data-sharing ecosystem	Governance + Technical	Operational / scaling: Connected to EU initiatives
UVAR Box / UVAR Exchange	DATEX II-based urban access regulation data	Semantic + Technical	Pilot / emerging: Increasing adoption across cities
OLF – Open Logistics Foundation	Open-source logistics modules	Technical + Semantic	Early stage: Growing adoption; implementation-focused
SIMPL Programme	Middleware for data spaces	Technical + Governance	Emerging: Under development and testing

4. Identified Challenges and Gaps

The State of the Art analysis showed that, despite significant efforts to improve data interoperability in urban mobility and logistics in Europe, important challenges remain. This section analyses the implications of these challenges.

4.1 Persistent Semantic and Technical Fragmentation

A common challenge for data interoperability is that data is not always described and arranged in the same way. While many projects build on existing standards, they often adapt them to their own requirements. Over time, this can lead to differences in definitions, data structures, and metadata, making it difficult for stakeholders to interpret information consistently.

As a result, solutions developed in one project (e.g. APIs, ontologies, data schemas) are not always easy to reuse in another. Organizations often need to adapt, map, or reformat data before it can be exchanged and used effectively. These additional steps increase implementation efforts, raise costs, and can introduce inconsistencies or errors into the data-sharing process (Steinbuss et al., 2025).

4.2 Governance, Trust, and Data-Sharing Conditions

Another challenge relates to data governance. Although several initiatives have been introduced to support data sharing, stakeholders still face uncertainty around practical issues such as who can access data, how it can be used, whether it can be shared with others, and who is responsible if problems arise from its use.

These questions become even more difficult when data is exchanged across organizations or countries, where governance practices and interpretations of regulations may differ. As a result, data-sharing arrangements often need to be negotiated on a case-by-case basis, making collaboration more time-consuming and complex.

Participants also pointed out that trust-building mechanisms, such as neutral intermediaries or dedicated governance structures, are not yet common in many operational settings. This can make organizations hesitant to share data, even when the technical solutions are already available.

4.3 Gaps Between Policy Objectives and Operational Implementation

Another challenge is turning policies and standards into practical solutions. Although in the last years, Europe has developed and introduced many frameworks, stakeholders do not always have clear guidance on how to apply them. In many cases, stakeholders dealing with the implementation of these solutions are left to interpret requirements themselves and adapt them to their own context, making it harder to achieve consistent interoperability.

4.4 Challenges of Implementation, Scalability, and Replication

Another challenge concerns the transfer of interoperability solutions from project environments to everyday operations. Many solutions perform well during pilot projects, where stakeholders work closely together and specific governance arrangements are put in place. However, these conditions are not always present outside the project.

When organizations try to apply the same solution in another city, region, or initiative, they often encounter different rules, processes, technical infrastructures, and stakeholder requirements. As a result, solutions frequently need to be adapted to fit the new context.

While these adaptations can make a solution work locally, they can also make it harder to reuse elsewhere. Over time, different implementations may diverge from one another, reducing the ability to replicate successful approaches and limiting interoperability across projects and territories.

4.5 Limited Empirical Understanding of Operational Challenges

While the State of the Art analysis provides a useful overview of the European data interoperability landscape, it does not fully capture how these challenges are experienced in practice. Existing studies tend to focus on policies, standards, and governance frameworks, while providing less insight into the day-to-day difficulties faced by organizations when sharing and reusing data.

To gain this practical perspective, an exploratory survey was conducted with stakeholders involved in urban mobility and logistics data sharing initiatives. The aim was to better understand the challenges they encounter and to examine whether the issues identified in the literature are also reflected in operational contexts. The results are presented in the following section.

5. Validation and Expert Input

The validation phase aims to confirm and refine the findings of the State of the Art analysis by with actual stakeholder experience.

5.1 Methodology: Stakeholder Survey

Validation was conducted through a targeted online survey using an anonymous questionnaire (Microsoft Forms). It was distributed via the DELPHI consortium mailing lists, expert networks, and targeted invitations. Participation was voluntary. The survey remained open for six weeks (from the beginning of March to mid-April 2026) and gathered 55 valid responses.

The questionnaire combined closed-ended questions with open-ended questions. Four thematic blocks were defined:

- **Technical and semantic interoperability:** reuse of data models, interface stability, semantic heterogeneity, and compatibility with existing standards.
- **Governance and trust:** roles and responsibilities, access conditions, trust mechanisms, and organizational coordination in data-sharing environments.
- **Policy and standardization:** awareness, use of, and contribution to formal standards and European policy instruments.
- **Deployment and scaling:** barriers to integrating pilot solutions into legacy systems and to scaling them beyond their initial context.

The complete survey is included in Appendix 2

The survey pursued four main objectives:

1. To **validate and prioritize data interoperability gaps** identified in technical, semantic, organizational, and governance dimensions, and to determine which of these are considered most critical from a practitioner perspective.
2. **To identify barriers affecting the reuse, scaling, and standardization of data from pilot results**, including factors that prevent successful initiatives from being replicated or extended beyond their original context.
3. **To understand how data interoperability challenges are experienced in practice**, and to identify the most critical limitations for enabling effective and scalable data sharing across stakeholders.

5.2 Results Stakeholder Survey

To ensure analytical clarity and consistency with the survey design, results are structured around four key dimensions of data interoperability: (1) technical and

semantic interoperability, (2) governance and trust, (3) policy and standardization, and (4) operationalization and scalability.

5.2.1 Respondent Profile

To establish the context of the sample, respondents were first asked to **define their organizational background**. As shown in Figure 3, the largest share of respondents comes from research and innovation projects (40.4%), followed by transport and logistics operators (17.3%) and public authorities (15.4%). Digital platform providers account for 13.5% of responses, while an additional 13.5% selected the *Other* category. This *Other* group includes a diverse mix of actors, such as consulting firms, logistics and innovation clusters, EU institutions, and hybrid organizations (e.g., foundations funded by public authorities and private stakeholders, or membership-based logistics competence networks).

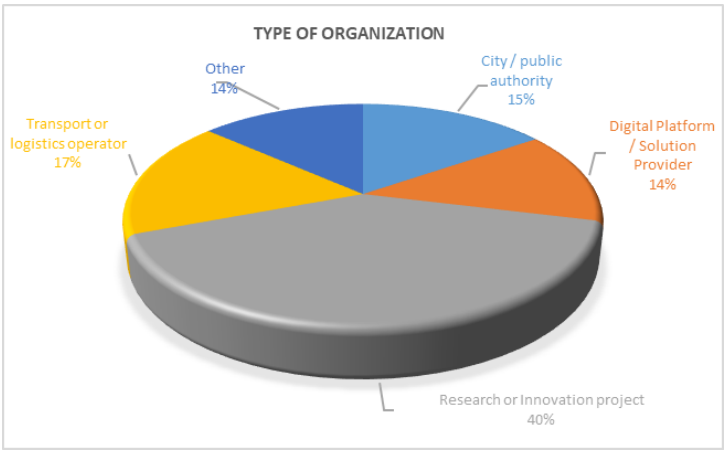


Figure 3. Distribution of respondents by type of organization

To complement the organizational perspective, respondents were asked to **specify their primary role in relation to data sharing**. As illustrated in Figure 4, respondents identify primarily as Data users (26.9%) and those in Policy or coordination roles (26.9%), followed by Platform or infrastructure providers (19.2%), and Data providers (9.6%). The remaining 17.3% of respondents indicated *Other* roles, which included data space operators, R&I managers, and data processing or coordination functions.

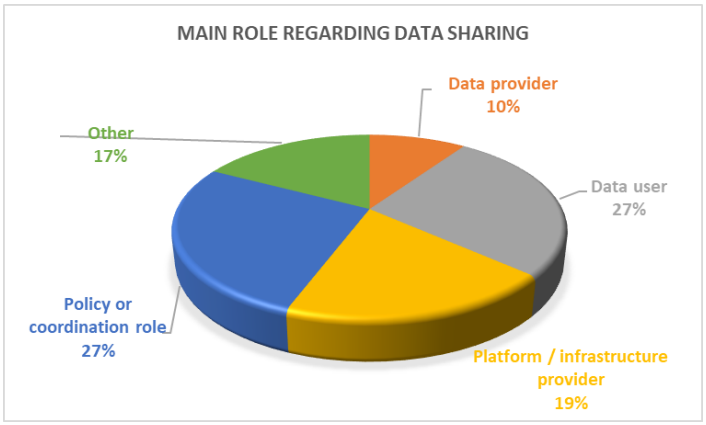


Figure 4. Distribution of respondents by role in data sharing ecosystems

Respondents were also asked to indicate the **primary territorial or operational scale at which they are involved in data-sharing activities** (Figure 5). The results show a strong concentration at the local / city level (46%), highlighting the role of municipalities in implementing data-sharing practices in mobility and logistics systems.

A significant share of respondents also operate at the European or cross-border level (29%), reflecting the importance of EU-funded projects and collaborative research initiatives in shaping data-sharing frameworks across countries.

In comparison, involvement at broader governance levels is more limited, with regional-level activities accounting for 15% and national-level involvement representing only 10% of responses.

These results suggest that data-sharing activities are predominantly driven by local implementation needs.

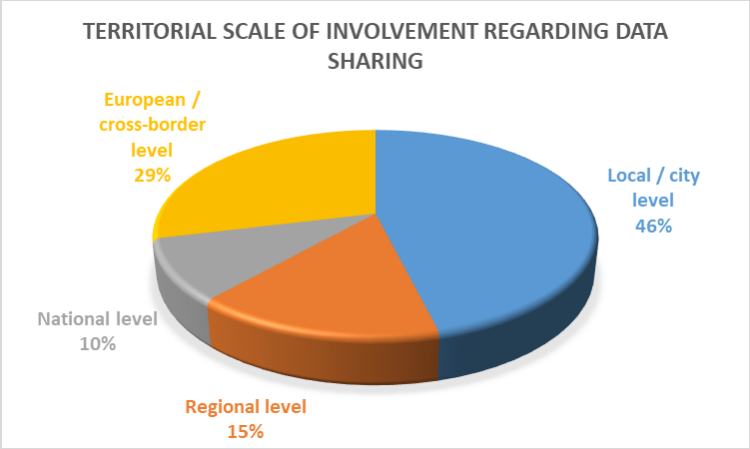


Figure 5. Territorial scale of involvement in data-sharing activities

At the territorial or operational scale previously identified, respondents were then asked to specify their primary role in data-sharing activities (Figure 6). The results highlight a strong presence of technical and implementation-focused roles (37%).

At the same time, a significant share of respondents occupies strategic and policy-oriented roles (27%) and coordination or project management roles (23%). Together, these two categories represent half of the respondents, pointing to a strong involvement of actors responsible for shaping frameworks, guiding initiatives, and facilitating collaboration across stakeholders.

For advancing data interoperability, this distribution is particularly relevant since strategic and policy-oriented actors play an important role in defining governance structures and regulatory conditions for data sharing, while coordination and project management roles translate these objectives into concrete initiatives.

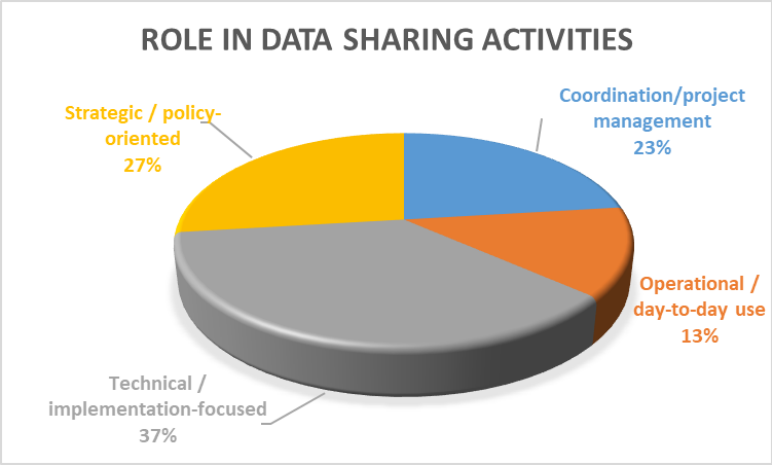


Figure 6. Role of respondents in data-sharing activities

Survey results are organized according to key dimensions of data interoperability, including technical interoperability, governance and trust, policy and standardization, implementation and scalability. They are as follows:

5.2.2 Technical and Semantic Interoperability

The survey results provide a rich view of how semantic differences across data models affect interoperability in practice. Beyond the quantitative result (strong majority agreeing that semantics is a barrier) (Figure 7), the qualitative responses reveal five dimensions structuring stakeholders' experiences.

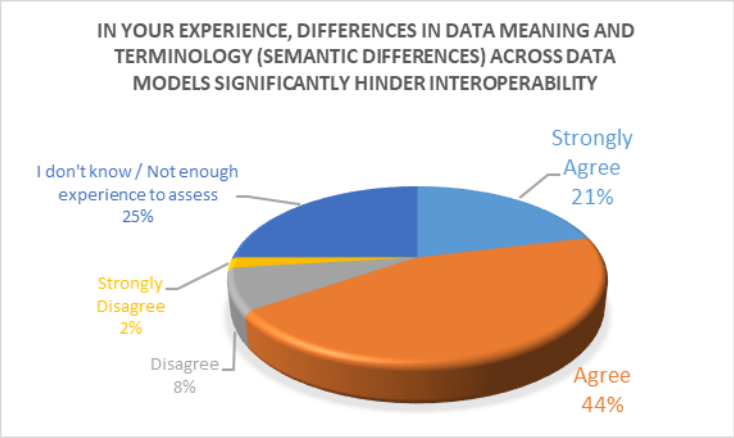


Figure 7. Perceived impact of semantic differences on data interoperability

Dimension N° 1: Strong awareness of semantic challenges, but differing views on their priority

Most respondents agreed that semantic heterogeneity remains an important obstacle to interoperability. At the same time, many qualified their responses by noting that semantic issues are only one part of a broader challenge. Several participants described semantics as *"a challenge, but not the main one",* while others pointed to governance, business alignment, or data availability as more pressing concerns.

These responses suggest that, although a common understanding of data is important, it is not enough on its own to enable effective data sharing. Semantic issues are closely linked to organizational, technical, and economic challenges, and are often experienced alongside them rather than as separate problems.

Dimension N° 2: Three main types of semantic interoperability issues

1. Conceptual misalignment (meaning of data): First, stakeholders do not always assign the same meaning to the same concepts. Terms such as deliveries, customers, or vehicle categories may be defined differently across organizations, while similar concepts may be described using different terminology. These differences can lead to misunderstandings and inconsistencies when data is exchanged or analyzed.

2. Structural and format heterogeneity: A second issue relates to the structure of the data itself. Respondents highlighted differences in data models, formats, attributes, and levels of data quality. In many cases, data must be cleaned, transformed, or reorganized before it can be integrated with other sources and reused effectively.

3. Linguistic and contextual differences: Several respondents referred to differences in terminology between sectors, regions, and countries, as well as the use of technical terms that may not be interpreted in the same way by all stakeholders. These differences can complicate communication and make it more difficult to scale interoperability solutions across domains and territories.

Dimension N° 3: Operational consequences: cost, delay, and manual effort

Rather than being a purely technical issue, semantic heterogeneity often creates additional work throughout the data-sharing process. Several participants explained that data frequently needs to be mapped, transformed, or cleaned before it can be integrated with other sources, increasing both the time and resources required for implementation.

These challenges can also slow down projects and limit opportunities for automation. As one respondent noted, interoperability can become *"costly",* while another pointed out that integration often requires *"manual coding and contracts".* Others emphasized that semantic differences can *"undermine automated data integration"*, making it more difficult to scale solutions and reuse data efficiently across systems.

Dimension N° 4: A structural gap between system design and real-world

Several responses suggest that semantic interoperability issues are often linked to broader coordination challenges. Participants referred to differences in perspective between public authorities and logistics operators, varying interpretations of operational needs, and a lack of alignment across projects, cities, and sectors.

These observations indicate that interoperability challenges do not arise solely from the way data is structured or described. In many cases, they reflect differences in how stakeholders understand, manage, and coordinate information. As a result, improving semantic interoperability requires not only technical alignment, but also stronger collaboration and a shared understanding across the actors involved.

Dimension N° 5: Actions and solutions: convergence around four main strategies

(a) Standardization and common data models: Respondents underline standardization as the most cited and most mature approach to bridging semantic gaps. This includes the adoption of shared schemas (e.g., CDS, open standards) and the development of common vocabulary, enabling a consistent understanding of data across systems and stakeholders.

(b) Ontologies and semantic alignment layers: Another approach involves the use of ontologies and semantic alignment layers, such as shared semantics, metadata frameworks, and common data layers. While more advanced in concept, these solutions are less widely implemented in practice.

(c) Data governance and coordination mechanisms: Respondents also emphasize the importance of data governance and coordination mechanisms, including agreements between stakeholders, project-based alignment efforts, and policy-driven frameworks. These are critical for interoperability but remain fragmented across contexts.

(d) Technical solutions and emerging approaches: Technical solutions and emerging approaches such as APIs and interoperable platforms, AI-based semantic mapping, and data integration pipelines were also identified. However these are still evolving and not yet fully mature.

Although most respondents considered semantic interoperability to be an important challenge, a smaller group viewed it as a secondary concern. These respondents argued that other issues deserve greater attention, particularly the availability of data, technical connectivity between systems, and the lack of business incentives for data sharing. In their view, interoperability efforts are unlikely to succeed if organizations do not have access to the necessary data, if systems cannot communicate effectively, or if stakeholders do not see sufficient value in participating.

The results show that semantic interoperability remains an important challenge for data sharing and reuse. Without a common understanding of data, exchanging information across systems becomes more difficult and often requires additional manual work. However, respondents also made it clear that semantic issues are only part of the picture. Progress also depends on governance arrangements, trust between stakeholders, and clear incentives for participation. While many initiatives and standards already exist, interoperability efforts still rely heavily on project-based approaches and local adaptations, making broader adoption more difficult.

Reuse of Data Models and APIs

Respondents were asked how frequently they reuse data models or APIs beyond their original purpose or primary context of use (Figure 8). The results reveal a generally low level of systematic reuse, with only 3.8% of respondents indicating that they do so systematically.

The largest share of respondents reports occasional reuse (30.8%), suggesting that while reuse does occur, it remains context-dependent rather than included as a standard practice. Similarly, 28.8% indicate that they rarely reuse data models or APIs.

An additional 28.8% consider the question not relevant to their role, which may reflect the presence of stakeholders not directly involved in technical implementation, but also highlights a broader fragmentation in how data-sharing responsibilities are distributed across actors.

Finally, 7.7% of respondents report never reusing data models or APIs, reinforcing the idea that interoperability is still largely constrained within project-specific boundaries.

Overall, these results suggest that reuse, a key indicator of interoperability maturity, remains limited. Data models and APIs are often designed for specific use cases, projects, or local contexts, rather than as scalable and reusable components. From an interoperability perspective, this finding indicates that despite ongoing efforts in

standardization and data-sharing initiatives, the ecosystem has not yet reached a level where solutions can be efficiently replicated, scaled, or reused across contexts.

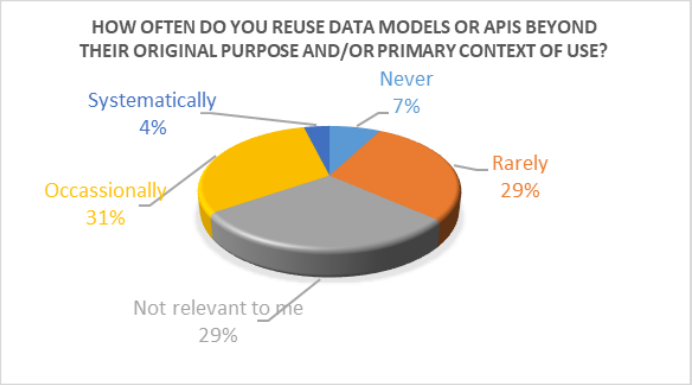


Figure 8. Reuse of data models and APIs beyond their original purpose and/or context

To better understand the barriers to reusing data models and APIs (Figure 9), this question was only analyzed for respondents who reported some degree of reuse in the previous question. Participants who answered “Never” (7%) or “Not relevant to me” (29%) were excluded from this analysis.

As a result, the findings are based on the 64% of respondents who indicated rare, occasional, or systematic reuse. Within this group, all four proposed barriers (semantic differences, interface stability, documentation quality, and legacy IT systems) were identified as obstacles to reuse, although their perceived importance varied.

Legacy IT systems are perceived as the most significant barrier, with 81.8% of respondents agreeing or strongly agreeing that they limit the reuse of data models and APIs. They also received the highest share of strong agreement (33.3%). This suggests that existing systems remain a major obstacle to interoperability, as integrating new solutions often requires substantial modifications, increasing both technical complexity and implementation costs.

Interface-related issues follow closely, with 78.8% agreement, indicate that even when data models exist, poorly defined interfaces prevent effective system integration, limiting data reuse.

Semantic differences also represent a significant barrier, with 72.7% of respondents agreeing. This reflects the difficulty of reusing data models when terminology is not aligned, requiring data reinterpretation or transformation.

Finally, **insufficient or unclear documentation** reaches the same level of agreement (72.7%), suggesting that limited accessibility to clear data constrains reuse. In such cases, data reuse often depends on personal knowledge.

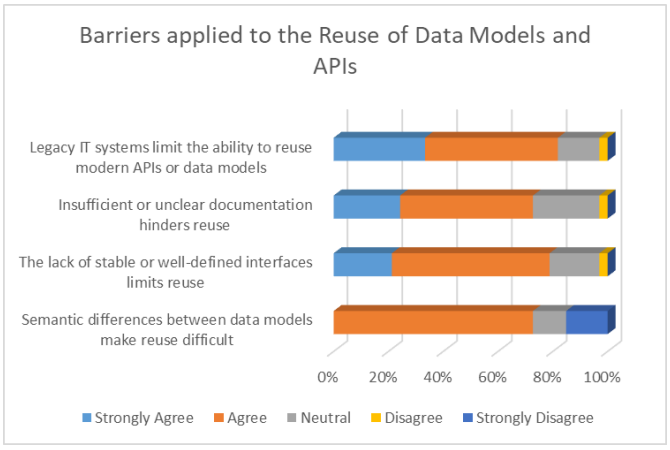


Figure 9. Perceived barriers to the reuse of data models and APIs across interoperability dimensions

To complement the previous multi-factor assessment, respondents were asked to identify the single most critical barrier to the reuse of data models and APIs in their context (Figure 11Figure 10). Consistent with the previous question, this analysis is based on the same subsample of 64% of respondents who reported engaging in reuse practices (rarely, occasionally, or systematically).

Legacy IT systems emerge as the most critical constraint, selected by 36.4% of respondents. The lack of stable or well-defined interfaces is the second most cited barrier, identified by 24.2% of respondents.

In contrast, documentation quality (15.2%) and semantic differences (15.2%) are less frequently identified as the primary barrier. Finally, 9.1% of respondents selected *"none of the above / not applicable"*, indicating that other factors may also influence reuse practices in certain contexts.

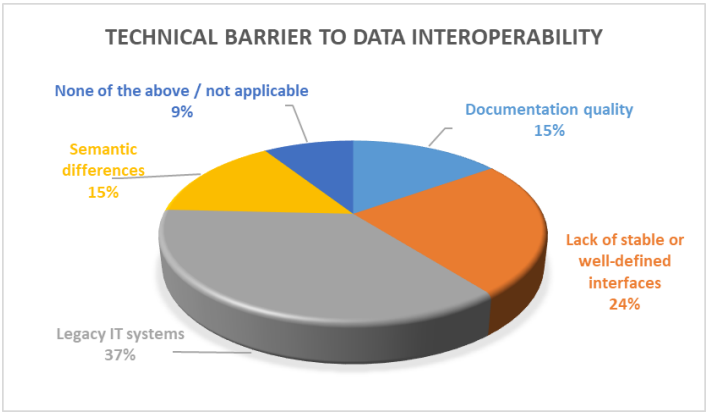


Figure 10. Distribution of the most critical technical barriers to data interoperability

Beyond the predefined barriers, respondents were invited to identify additional factors affecting the reuse of data models and APIs. The qualitative responses reveal a set of challenges which extend beyond purely technical issues.

Governance and lack of incentives: Several respondents noted that the benefits of data sharing are not always clear and that responsibilities remain poorly defined. Some also mentioned a reluctance among certain actors to share data, particularly when competitive interests are involved. These comments suggest that technical solutions alone are not sufficient; stakeholders also need clear rules, trust, and tangible value from participation.

Many respondents also highlighted the **fragmented nature of the current ecosystem**. Data is often managed differently across organizations, territories, and use cases, resulting in variations in formats, protocols, and data availability. This diversity makes it difficult to apply common solutions and frequently requires additional adaptation efforts.

Data quality and availability constraints: Respondents referred to incomplete datasets, inconsistent updates, and differences in the level of detail available from one source to another. In practice, considerable effort may be required to clean, harmonize, or enrich data before it can be reused effectively.

Beyond these issues, respondents pointed to a number of **technical challenges**, including difficulties related to standard implementation, compatibility between system versions, cybersecurity requirements, and API performance. Several participants also stressed the **importance of organizational capabilities**, noting that a lack of training for end users, limited expertise, and insufficient maintenance of already deployed solutions can hinder the long-term use of interoperability solutions.

Lack of use-case-driven development: Finally, several responses emphasized the importance of starting from concrete operational needs. According to these stakeholders, standards, APIs, and data-sharing mechanisms are more likely to be adopted when they address clearly identified use cases and deliver visible benefits to the actors involved.

5.2.3 Governance & Trust Barriers

To complement the analysis of technical barriers, respondents were asked to identify the most critical data and governance-related barrier affecting data sharing and interoperability in their context Figure 11.

The results show a clear dominance of economic and competitive concerns, with **commercial sensitivity and competition** emerging as the primary barrier, selected by 48.1% of respondents. This indicates that organizations are often reluctant to share data due to concerns over loss of competitive advantage and strategic positioning.

The second most important barrier is **lack of governance clarity** (25.0%), highlighting the need for well-defined rules, roles, and responsibilities in data-sharing ecosystems.

In the absence of clear governance frameworks, stakeholders face uncertainty regarding data access, ownership, and usage conditions.

Other barriers such as **data protection mechanisms** (9.6%) and **data misuse risks** (7.7%) reflect concerns related to security, privacy, and trust. **Technical trust mechanisms** (5.8%) indicate the importance of secure and reliable data exchange infrastructures, and **legal uncertainty** (3.8%), although less frequent, represents a constraint.

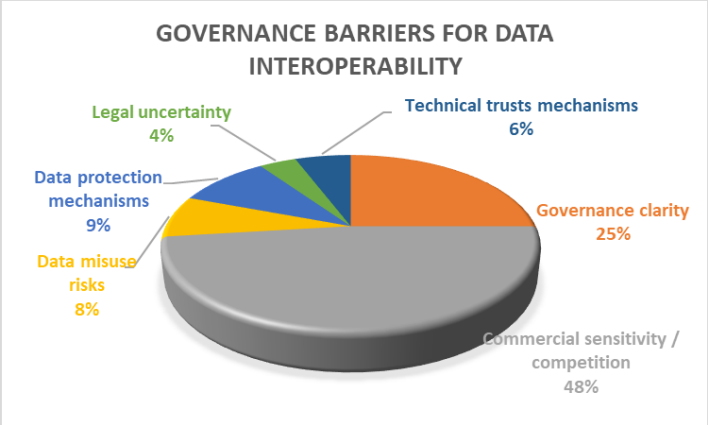


Figure 11. Data governance barriers to data interoperability

The qualitative responses suggest that many interoperability challenges are rooted in organizational and governance issues rather than purely technical limitations.

Several respondents highlighted a limited understanding of interoperability concepts and data-sharing practices among some stakeholders, particularly within public administrations. As a result, organizations often struggle to make effective use of available data and may depend on external expertise to implement interoperability solutions.

Participants also referred to institutional and contractual barriers. In some cases, concession models and procurement cycles create discontinuities in data management and reduce incentives for long-term data sharing. Data may therefore be treated as a strategic asset rather than as a shared resource.

Another recurring theme concerns fragmentation across territories and organizations. Data-sharing arrangements are often defined within administrative boundaries, while mobility and logistics activities extend across wider geographic areas. This mismatch can complicate coordination and data exchange.

Economic considerations were also frequently mentioned. Several respondents questioned the value proposition of data sharing, noting that implementation efforts and integration costs are often more visible than the expected benefits.

Finally, concerns related to data ownership, quality, and responsibility continue to affect trust between stakeholders. When responsibilities are unclear, organizations may prefer to limit data exchange rather than assume potential risks.

An importance should be given to governance arrangements to provide clear rules, build trust among participants, and support cooperation across organizations and territories. Several respondents also expressed the need for stronger coordination and greater harmonization at the European level.

Data Access and Usage Conditions

When asked about the clarity of the rules governing data access and usage within their initiatives, only 11.5% of respondents considered these rules to be clear and well defined. Most respondents (73%) indicated that the conditions were either only partially clear or unclear, while 15% considered the question not applicable to their situation.

For respondents identifying these rules as unclear, the survey explored the specific sources of uncertainty which turned out to be three:

Usage rights and restrictions (31.6%): highlighting a lack of clarity around what data can be used for and under which conditions.

Data ownership and redistribution (21.1% each): uncertainty regarding who holds legal ownership of the data and whether it can be shared with third parties. Combined, these issues account for over 42% of the total uncertainty.

Liability and responsibilities (15.8%): lack of clarity regarding accountability in cases of data errors, misuse, or security breaches.

A smaller share of respondents (5.3%) identified uncertainty related to **data access duration and retention conditions**.

These results confirm that unclear data governance rules are a major barrier to data interoperability, reinforcing the need for standardized frameworks that clearly define rights, responsibilities, and permitted uses.

Operational Responsibility regarding Data Interoperability

When asked who should be responsible for operations within a data-sharing ecosystem, respondents did not converge toward a single model (Figure 12), indicating the absence of a widely accepted governance structure.

The most common perspective is a **shared responsibility model** (23.1%), where accountability is distributed between data providers and data users. At the same time, a significant proportion of respondents (28.9%) favor a **flexible, case-by-case**

approach, where responsibilities are defined either through specific contractual arrangements (15.4%) or depending on the use case (13.5%).

Finally, smaller groups assign responsibility to a single actor, either the **data provider**, the **data user**, or a **public authority**, each representing between 11.5% and 13.5% of responses.

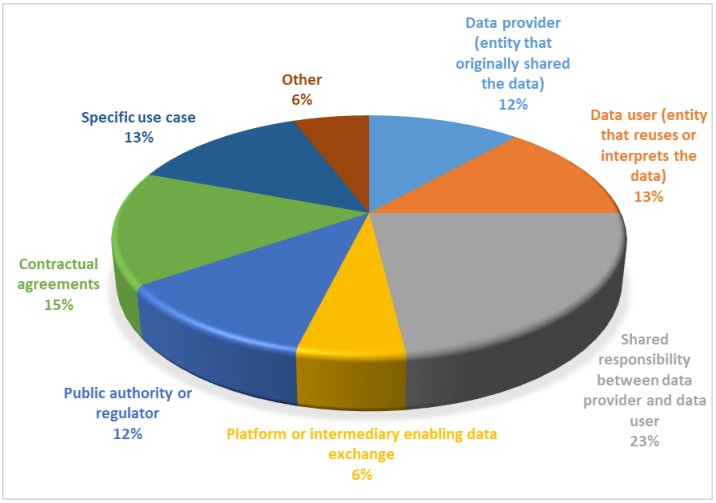


Figure 12. Preferred models for operational responsibility in data-sharing ecosystems

To further assess the maturity of governance practices, respondents were asked whether data control mechanisms are standardized or fragmented (Figure 13). The results show a strong consensus: over 94% of respondents indicate that governance mechanisms are currently implemented on a project-by-project basis.

This finding confirms that fragmentation remains a major obstacle to interoperability, limiting the scalability and long-term sustainability of data-sharing initiatives.

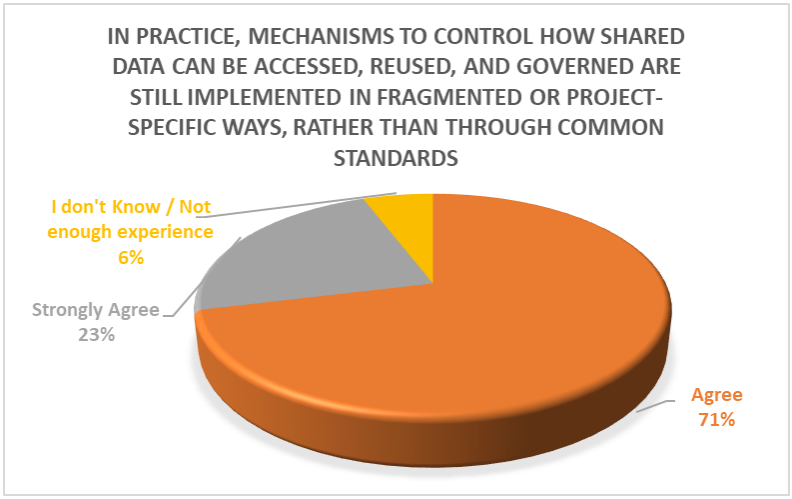


Figure 13. Stakeholder perception of fragmentation in data access and governance mechanisms

5.2.4 Policy and Standardization

The results indicate a moderate but uneven level of stakeholder engagement with EU regulatory frameworks related to data sharing and mobility, combined with a notably high level of non-participation.

The most striking result is that **42.3% of respondents selected *"None of the above"***, indicating that a large share of stakeholders is not directly involved in any of the listed EU frameworks. This suggests limited awareness, relevance, or operational integration of these policies within a significant portion of the respondents.

Among the listed instruments, **GDPR (34.6%)** shows the highest level of involvement. This is expected, as it is a mandatory and cross-sector regulation, affecting all organizations dealing with personal data.

The **European Mobility Data Space (EMDS)** follows with **32.7%**, representing the most engaged initiative among the mobility- and data-specific frameworks. This relatively high value suggests that EMDS is gaining visibility, particularly within innovation-driven and policy-oriented environments, although it is not yet universally adopted.

The European Data Strategy (25.0%) and the **Data Governance Act (19.2%)** show moderate levels of engagement. These frameworks tend to be more strategic and conceptual, which may explain their uptake among stakeholders involved in policy design, research, or ecosystem coordination, rather than operational actors.

Finally, lower levels of participation are observed for the **eFTI Regulation (17.3%)** and the **Data Act (17.3%).** Despite their operational relevance, particularly for freight transport and data access, these results suggest that both frameworks are still in early stages of adoption or implementation.

To further investigate the effectiveness of existing EU regulatory frameworks, respondents were asked: *"Do you see gaps in these policies that limit their effectiveness? If yes, which gap(s) do you consider the most important?"*. The question referred to EU initiatives, including the European Mobility Data Space (EMDS), Data Governance Act (DGA), Data Act, European Data Strategy, GDPR, and the eFTI Regulation.

While some respondents indicated limited knowledge or no direct experience, a substantial share provided insights highlighting recurring challenges.

Gap Between Policy Design and Operational Implementation: Many respondents noted that, although policies define what should be achieved, they do not always explain how to achieve it. This can make it difficult for stakeholders to identify the standards, tools, and practical actions needed for implementation. As one respondent noted, there is a *"lack of clear and consistent guidelines regarding data sharing and interoperability"*, limiting effective deployment. Another commented that policies are

"*constraining and far from reality. They make data exchange extremely fragmented and difficult to implement even within projects."*

Fragmentation Across Governance Level: The responses also referred to differences in interpretation between countries, variations in implementation between cities, and limited alignment between European initiatives and local planning processes. One of the answers stated: there is a *"lack of harmonization between European-level frameworks and local or national planning instruments",* which contributes to uneven implementation.

Lack of Standardization and Interoperability Enforcement: Several respondents indicated that promoting data sharing does not necessarily guarantee interoperability. In their view, the absence of commonly applied data models, definitions, and formats continues to create barriers to data exchange and reuse: *"Guidelines on data structure and collection are not well defined leading to diversity on format and presentation which makes analysis difficult"*.

Misalignment with Business Incentives: Economic considerations emerged in a number of responses. Participants noted that data-sharing initiatives are difficult to sustain when stakeholders do not see a clear benefit from participation: *"In some cases, policies do not sufficiently address the business incentives of stakeholders. Without aligning economic and operational interests, their effectiveness can be limited".*

GDPR Constraints and Uncertainty: Data protection regulations were also mentioned. While respondents generally recognized the importance of GDPR, many described difficulties related to its interpretation and implementation. Concerns included uncertainty about what data can be shared, differences in interpretation across contexts or by stakeholders, and restrictions affecting research and innovation activities. One participant noted that GDPR can *"hinder research and pilot projects"* or be *"difficult to overcome"* in practical use cases.

Scaling and Deployment Limitations: Several responses referred to the challenges of moving beyond pilot projects. While policies may support experimentation, their application at regional or European scale introduces challenges related to data inconsistencies, fragmentation across cities, and increased implementation costs, *"Another gap is the limited alignment between policies, technical standards, and operational practices, which can create inconsistencies when organizations try to apply them."*

To understand which European initiatives are perceived as having the greatest impact on interoperability, respondents were asked to identify the policies and regulatory instruments they consider most effective in supporting data exchange and reuse across actors and systems (Figure 14).

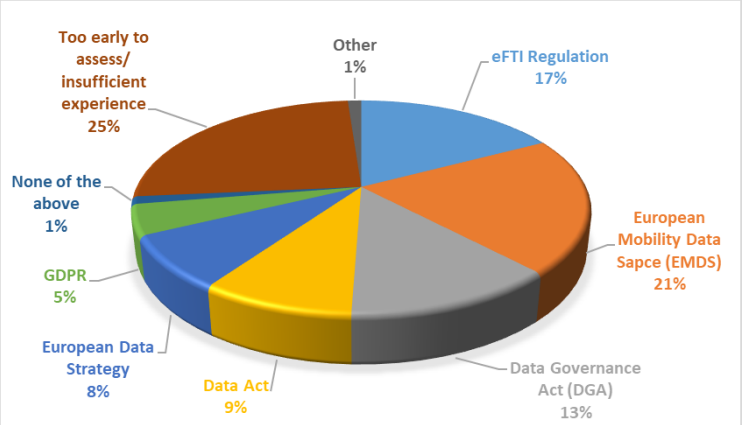


Figure 14. Stakeholder perceptions of the effectiveness of EU policies for enabling real interoperability

High Level of Uncertainty and Limited Practical Maturity: The most striking result is that 42.3% of respondents selected *"Too early to assess / insufficient experience".* This indicates that, despite the existence of multiple EU frameworks, a large share of stakeholders don't have sufficient practical exposure to evaluate their effectiveness yet.

EMDS and eFTI as the Most Promising Instruments: Among the frameworks evaluated, the European Mobility Data Space (EMDS) is perceived as the most effective, selected by 34.6% of respondents. This reflects its explicit objective of enabling trusted and interoperable data sharing across mobility and logistics actors. The eFTI Regulation follows with 28.8%, indicating recognition of its role in facilitating standardized electronic freight information exchange, particularly in operational contexts.

Moderate Recognition of Governance Frameworks: The Data Governance Act (21.2%) and the Data Act (15.4%) show moderate levels of perceived effectiveness. These frameworks provide important legal and structural foundations for data sharing, but their lower scores suggest that stakeholders may perceive them as: less directly linked to operational interoperability, or too abstract to demonstrate concrete impact.

Lower Perceived Impact of Strategic and Regulatory Instruments: The European Data Strategy (13.5%) and GDPR (7.7%) are less frequently identified as enabling interoperability. This reflects their nature: the European Data Strategy provides high-level direction rather than operational tools, and GDPR, while essential for data protection, is not designed to facilitate data interoperability and is sometimes perceived as a constraint.

Minimal Rejection of Existing Frameworks: Only 1.9% selected "None of the above", indicating that stakeholders generally recognize that existing policies have some potential to support interoperability, even if their effectiveness remains limited in practice.

These results reveal a clear gap between policy potential and operational reality. While frameworks such as EMDS and eFTI are recognized as promising enablers of interoperability, the high level of uncertainty indicates that real interoperability is not yet fully achieved or demonstrated in practice. This reinforces the broader finding that interoperability challenges are not only about policy availability, but about implementation and large-scale deployment.

5.2.5 Deployment & Scalability

Stakeholder Involvement in Standardization Activities

To better understand the role of standardization in enabling data interoperability, respondents were asked whether they are currently or have previously been involved in standardization or specification activities related to mobility, logistics, or data interoperability.

The most striking result is that 65.4% of respondents selected “None of the above.” This indicates that a large majority of stakeholders are not directly involved in standardization processes, whether at European or international level. This suggests that standardization remains largely disconnected from a significant part of the practitioner ecosystem.

Among those involved, participation is relatively low and dispersed across different initiatives: ISO (21.2%) shows the highest level of engagement, reflecting its global relevance across sectors. Gaia-X (13.5%) follows, indicating growing interest in data space architectures and federated data infrastructures. CEN/CENELEC (9.6%) and IDSA (9.6%) show moderate involvement, mainly among stakeholders engaged in European-level initiatives. UN/CEFACT (5.8%) and GS1 (5.8%) show the lowest levels of participation, despite their relevance for trade, logistics, and data exchange standards.

Use of Formal Standards in Practice

To complement the analysis of standardization involvement, respondents were asked whether they use existing formal standards and, if so, which ones.

The results show limited and highly fragmented use of formal standards. Out of 52 respondents only 10 provided concrete examples, 9 explicitly indicated they do not use standards, and 33 did not provide an answer, suggesting either lack of use or lack of awareness.

Among the responses, the cited standards span a wide range of domains:

- Information security and management standards (e.g., ISO/IEC 27001, ISO 9001, ISO 14001, ISO 50001),
- Data formats and technical protocols (e.g., JSON, XML, CSV, REST APIs),

- Data exchange standards (e.g., GS1, UN/CEFACT-related standards),
- Transport-specific standards and frameworks (e.g., DATEX II),
- Data space and interoperability-related tools (e.g., NGSI, DCAT).

Contribution of Projects and Pilots to Standardization

To assess the link between innovation activities and standardization processes, respondents were asked whether results from pilots or projects they were involved in have contributed to formal standards or specifications.

The results indicate that only 25% of respondents report having contributed to standardization activities, while 25% report no contribution, and 50% indicate that the question is not applicable, highlighting that standardization remains peripheral to a large share of project-based activities.

Among those who reported contributions, engagement is concentrated within a relatively small group of actors involved in EU-funded research and innovation projects (e.g., MODALSHIFT, DECARBOMILE, eFTI4EU), data space and interoperability initiatives (e.g., IDSA, Gaia-X-related activities), and technical standardization processes (e.g., ISO working groups, DATEX II, OSLO standards).

This suggests that standardization is primarily driven by specialized stakeholders, rather than broadly embedded across the ecosystem.

5.3 Limitations

This analysis is subject to some limitations that should be considered when interpreting the results.

First, participation in the survey was voluntary and the sample of 55 respondents is not statistically representative of the entire European mobility and logistics ecosystem. Therefore, the results provide indicative expert perspectives rather than generalizable quantitative evidence. However, since the respondents represent a diverse range of organizations, the analysis remains reflective of the reality.

Also, it should be noted that the results are influenced by differences in the respondents' levels of experience with data interoperability. This is reflected in the number of responses indicating limited experience or lack of involvement in some topics.

Finally, the survey relies on personal perceptions. Responses may be influenced by the professional roles of the respondents, or their organizational contexts, and exposure to specific situations, introducing a certain degree of subjectivity into the results.

6. Recommendations

The recommendations presented in this section derive from the State of the Art analysis and the survey conducted on data interoperability in urban mobility and logistics. These are described as follows:

Recommendation 1: Strengthen Operational Implementation and Feedback Loops

The findings suggest that the main challenge is not the absence of solutions, but their practical implementation. Therefore, the efforts should focus on helping stakeholders apply existing policies/regulations, standards, and interoperability frameworks through clearer and practical guidance.

Achieving this requires top-down and bottom-up mechanisms. Stronger institutional support is needed to accelerate implementation, while the practitioners' experiences should be considered in future policy and regulation developments or updates, as many of the challenges identified in this study only become visible during implementation.

While focusing on strengthening operational implementation and feedback loops, stakeholders emphasized the importance of collaboration. Participants highlighted that, in their experience, the successful implementation of data interoperability solutions often depends on strong working relationships, trust, and regular communication between all involved. They also stressed the value of long-term partnerships, as these foster collective problem-solving and adaptation of solutions to local contexts.

Support stakeholders in applying existing policies, standards, and interoperability frameworks through practical implementation support, while creating stronger feedback mechanisms between practitioners and policymakers.

Recommendation 2: Develop Urban Logistics Specific Implementation Guidelines

From an operational perspective, existing frameworks should be supplemented with clear implementation guidelines specifically focused on urban logistics. Although regulatory frameworks provide the basis for interoperability, they often lack precise technical guidance tailored to the unique use cases in urban logistics, causing uncertainty for stakeholders when applying them to operational systems.

Attention should also be given to integrating new interoperability solutions with existing systems, for instance by promoting plug-and-play options, as compatibility with legacy infrastructures is a key enabler for adoption.

Complement existing frameworks with implementation guidance tailored to urban logistics use cases and operational realities.

Recommendation 3: Strengthen Capacity Building and Knowledge Transfer

Stakeholders observed that many interoperability frameworks, standards, and tools already exist, yet awareness and understanding of them remain uneven. This challenge was considered especially relevant for public authorities, the smaller organizations, and the operational staff responsible for managing the data sharing activities. One stakeholder stressed the importance of extending training beyond policy and technical experts to include the actors involved in daily operations.

To address this, targeted capacity-building initiatives, such as workshops focused on concrete use cases in urban mobility and logistics or collaborative communities of practitioners should be developed to support peer learning, exchange of best practices, and dissemination of implementation experiences.

Develop training activities, practitioner communities, workshops, and peer-learning mechanisms to improve awareness and adoption of interoperability solutions.

Recommendation 4: Demonstrate Clear Value and Incentives for Data Sharing

Many private organizations show reluctance to share data due to economic and competitive concerns. To overcome this, they need to see clear benefits from participation and understand what value data sharing can bring to their activities.

The value of data sharing should be demonstrated through concrete use cases and services facilitated by the process of data sharing, such as route optimization with real-time traffic and demand data, or better utilization of infrastructure.

More than demonstrating value, incentives may be needed to encourage participation. For example, in specific contexts, funding programmes or regulations can include data-sharing requirements.

Demonstrate the tangible benefits of data sharing (new services, improved efficiency, etc.) and create incentives that encourage stakeholders to participate.

Recommendation 5: Clarify Governance Frameworks and Responsibilities

Even when technical solutions are available, uncertainty often remains regarding data access rights, permitted uses of data, and accountability when issues arise. As a result, organisations may be reluctant to share data. Stakeholders also highlighted that trust-building mechanisms, such as neutral intermediaries, are not yet widespread in many operational settings.

Several stakeholders emphasised that governance mechanisms, data protection measures, and legal safeguards should not be seen as incentives for data sharing in themselves. Rather, they act as enablers by reducing uncertainty and building trust between stakeholders. While organisations share data when they perceive a clear benefit, these measures provide the confidence needed to do so by addressing concerns related to confidentiality, liability, and misuse. This observation further supports Recommendation 4: there is a close relationship between incentives and

governance, while short-term benefits can encourage initial participation, it is trust and clear governance between those sharing and using data which builds engagement on the long term.

Clarify clear governance rules and promote a more consistent application of existing regulations to build long-term confidence in data-sharing initiatives

Recommendation 6: Strengthen Semantic Interoperability through Shared Models

Different data definitions and structures continue to limit data interoperability. As one stakeholder explained, this leads to extra effort, verifying definitions, transforming datasets, and resolving discrepancies. In the end, this may not only cause delays but discourages reuse of existing data.

To address this, promoting the use of common data models, shared vocabularies, and semantic standards can help to ensure that data is interpreted in a consistent way by different actors. Stakeholders emphasized that the goal isn't to enforce a single language, but to ensure mutual understanding across sectors and systems. In short, leverage existing semantic resources to ensure consistent interpretation of data.

Promote the reuse of existing semantic resources to ensure consistent data interpretation across systems.

6.1 Recommendation Validation Methodology

After proposing the recommendations, they were validated and refined during the first workshop of the ALICE Digital Urban Freight (DUF) [45]Community, held for 1 hour on May 28th, 2026 (Figure 15). The workshop was specifically organized to review the challenges identified through the survey and to assess the relevance, feasibility, and priority of the corresponding recommendations.

Figure 15. First Workshop from Digital Urban Freight Community

[45] https://www.etp-logistics.eu/alice-urban-freight-community/

The session lasted approximately one hour and brought together 24 participants representing a diverse range of stakeholder groups, including:

- Universities and research institutes
- Logistics and transport operators
- Industry associations and clusters
- Technology and digital solution providers
- Public authorities and metropolitan administrations
- Research and innovation organizations
- European projects and innovation initiatives

The validation process followed three steps:

1. Presentation of the survey findings and the six identified data interoperability challenges.
2. Presentation of a preliminary recommendation for each challenge.
3. Open discussion with participants to collect feedback, challenge assumptions, identify interdependencies between recommendations, and refine the final proposals.

The objective was not to vote on recommendations but to enrich them through practitioner experience and ensure they reflected real operational needs and constraints.

Beyond validating the recommendations, the workshop discussions and the feedback from the participants helped to reveal strong interdependencies between them. While the recommendations were initially formulated as different responses to specific challenges, participants highlighted existing links between some of them. As a result, the recommendations were grouped into 3 pillars (Figure 16).

Pillar 1. Operational Deployment of Data Interoperability Solutions

Included in this pillar are recommendations 1 (Strengthen operational and feedback loops), 2 (Develop urban-logistics-specific implementation guidelines), and 3 (Strengthen capacity building and knowledge transfer).

The workshop discussions revealed a strong interdependence between the challenges related to policy implementation, operational guidance, and stakeholder capacity building. Across the discussions, it was emphasized that the primary challenge is no longer the absence of policies, standards, or interoperability frameworks, but on how

many organizations still face difficulties when trying to apply them. Some participants noted that existing frameworks often define objectives and principles without providing enough guidance on how to implement them in specific urban logistics contexts.

This led to a broader discussion on the role of implementation support. One participant stressed that guidance documents alone are not enough if stakeholders are unaware of them or do not know how to use them. Others mentioned that sharing experiences and providing practical support are as equally important as developing new guidance, and highlighted the value of training activities, practitioner networks, and peer-learning initiatives to help organizations build the necessary knowledge and skills needed to apply interoperability solutions.

Another topic of discussion was the importance of collaboration. Participants shared their experiences on how successful implementation of data interoperability solutions depended on strong working relationships, trust, and regular communication between the different stakeholders taking part in the implementation of the solution. Long-term partnerships were viewed as particularly valuable by the participants, because they create opportunities to address challenges collectively and adapt the solutions to local circumstances. This discussion was closely related to the need to have continuous feedback loops between the practical implementation of solutions and the regulations and/or policies framing them so that developments are informed by operational experience rather than designed in isolation from practitioners.

Finally, capacity building emerged as a cross-cutting issue. Participants observed that many interoperability frameworks, standards, and tools already exist, yet awareness and understanding of them remain uneven. This challenge was considered especially relevant for public authorities, the smaller organizations, and the operational staff responsible for managing the data sharing activities. One participant stressed the importance of extending training beyond policy and technical experts to include the actors involved in daily operations.

Pillar 2. Trusted and Value-Driven Data Sharing Ecosystems

Within this pillar are recommendations 4 (Demonstrate clear value and incentives for data sharing) and recommendation 5 (Clarify governance frameworks and responsibilities).

A recurring theme throughout the discussion was the difference between the incentives and the enabling conditions for data interoperability. Several participants argued that governance mechanisms, data protection measures, and legal safeguards should not be considered incentives in themselves. Rather, they help reduce uncertainty and build trust between stakeholders. As one participant noted, organizations do not share data simply because governance mechanisms are in place.

They are more willing to share data when they see a clear benefit and when appropriate safeguards exist to address concerns related to confidentiality, liability, or misuse.

Other participants further emphasized that organizations are unlikely to share data simply for the sake of sharing it. Instead, they need to see a clear benefit, for example through more efficient operations, better route planning or use of infrastructure, or access to new services. For this reason, participants said it is important to start with concrete use cases and clearly demonstrate which benefits can data sharing deliver, as from their experience, stakeholders are more willing to participate when the expected outcomes are clear and directly relevant to their activities.

At the same time, participants agreed that demonstrating value is only part of the solution. Stakeholders also need confidence that data will be handled appropriately. Without this level of trust, organizations may continue to be reluctant to share data even when potential benefits are evident.

The discussion also highlighted the close relationship between incentives and governance. It is true clear benefits can encourage participation, but the long-term engagement depends on trust, which is why participants agreed that governance and incentives are complementary elements which need to be developed together in order to support data sharing practices.

This point was also reflected during the discussion on emerging mobility data spaces. Participants noted that many of the elements included in the recommendations are already developed or being developed.

Pillar 3. Semantic Interoperability and Shared Understanding

Within this pillar is recommendation 6 (Promote shared semantic models).

The discussions highlighted semantic interoperability as a key condition for effective data sharing. Participants agreed that data interoperability can only be fully effective when stakeholders share a common understanding of the information being exchanged. Even if data is technically accessible, differences in terminology and/or data structures can make it difficult to interpret and reuse.

One participant described that the lack of semantic interoperability gets translated into real operations by a significant amount of additional work. This means that before the data can be reused, there is a need to verify definitions, transform datasets, and reconcile different interpretations. In the end, this increases the effort and may cause delays, which in the end is what discourages the reuse of existing data.

Finally, participants stressed the importance of making better use of existing semantic standards rather than developing new ones. In their view, the goal is not to impose a common language on all stakeholders, but to ensure that information can be

understood across different sectors and systems. To achieve this, existing initiatives, including those by GS1, were seen as possible starting points that should be further promoted and reused.

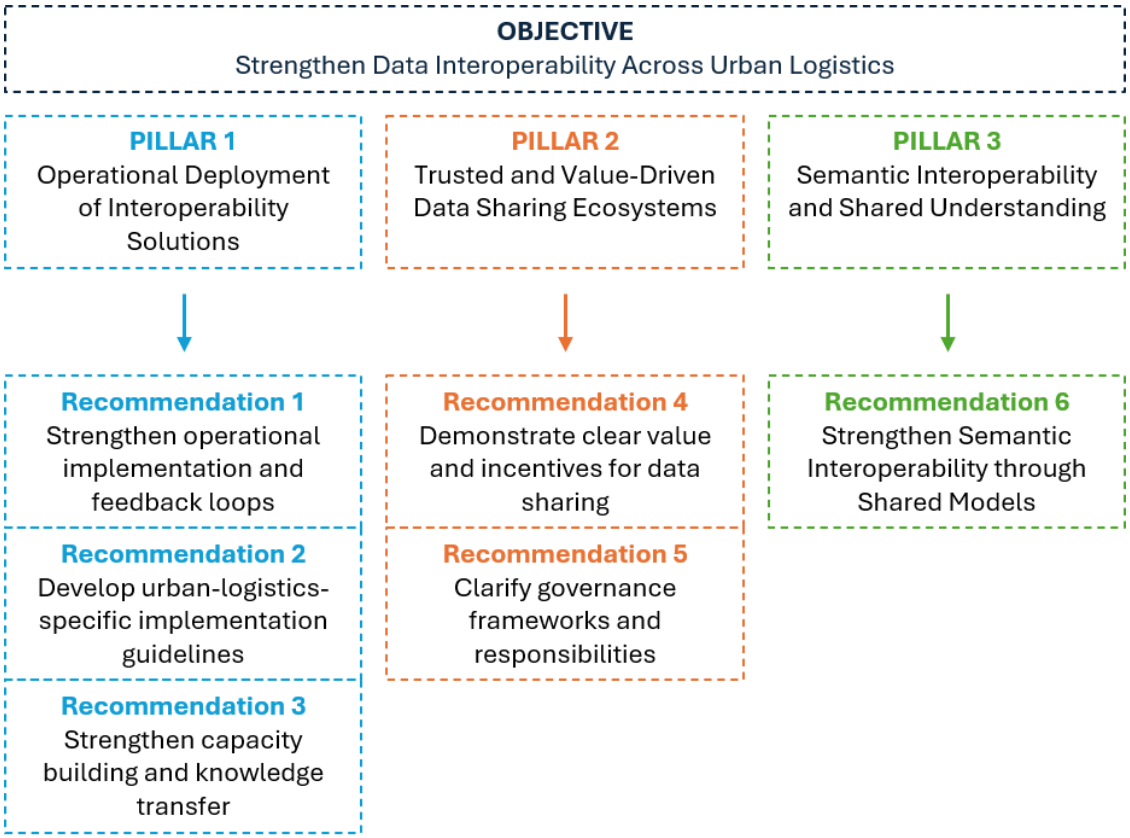


Figure 16. Strategic framework of validated recommendations for urban logistics data interoperability

6.2 DELPHI Contributions to Interoperability and Standardization Ecosystems

The activities carried out within DELPHI went beyond the analysis of existing interoperability frameworks. Through stakeholder engagement, validation activities, community building, and dissemination actions, the project contributed to the broader interoperability ecosystem and supported the exchange of knowledge among urban mobility and logistics stakeholders. Table 2 summarizes the main DELPHI contributions and planned legacy actions.

Table 2. DELPHI Contributions to Data Interoperability and Standardization Ecosystems

Contribution	Description	Type of Contribution	Evidence / Output	Status
State-of-the-Art Analysis	Analysis of standards, regulatory frameworks, governance	Knowledge contribution	D2.1, D2.5, D6.5	Completed

Contribution	Description	Type of Contribution	Evidence / Output	Status
	models, data spaces, and R&I projects relevant to data interoperability in urban mobility and logistics.			
Stakeholder Consultation	Collection of stakeholder perspectives on interoperability challenges through a dedicated survey targeting mobility, logistics, research, and public sector stakeholders.	Stakeholder engagement	Survey with 55 valid responses	Completed
Validation of Data Interoperability Challenges in Urban Mobility and Logistics	Validation and prioritization of identified challenges through discussions with stakeholders.	Experts' validation workshop	First Digital Urban Freight Community Workshop (May 2026) with 22 participants	Completed
Development of Recommendations for Data Interoperability	Formulation of recommendations based on the State of the Art analysis, stakeholder survey, and validation workshop.	Recommendations co-developed with stakeholders	DELPHI D6.5 Standardization Contributions and Policy Recommendations	Completed
Dissemination and Knowledge Exchange	Presentation and discussion of DELPHI findings within European research and innovation communities.	Knowledge sharing and exchange	12th International Physical Internet Conference (IPIC 2026) paper presentation *"From Fragmented Digitalization to Physical Internet Coordination: Achieving Concrete Data Interoperability"* [46]and dedicated	Completed

[46] https://www.etp-logistics.eu/interoperability-foundations-from-fragmented-digitalization-to-physical-internet-coordination-achieving-concrete-data-interoperability-at-ipic-2026/

Contribution	Description	Type of Contribution	Evidence / Output	Status
			special session *"Data Spaces as Enablers of Sustainable and Integrated Urban Logistics"*[47]	
Digital Urban Freight (DUF) Community	Establishment of a community to facilitate continued dialogue, collaboration, and exchange of experiences on data interoperability in urban mobility and logistics.	Community building	Digital Urban Freight (DUF) Community	Ongoing
Long-Term Legacy Activities	Continued collection of use cases, dissemination of lessons learned, and promotion of interoperability practices beyond the DELPHI project lifetime.	Knowledge dissemination	DUF Community activities Find Spaces for Mobility and Logistics Data Webinar Series	Ongoing

[47] https://www.etp-logistics.eu/data-spaces-as-enablers-of-sustainable-and-integrated-urban-logistics-at-ipic-2026/

7. Conclusions

This study examined the European landscape of data interoperability in urban mobility and logistics by analyzing European policies and regulations, standards, data-space developments in this field, and stakeholder perspectives.

The analysis shows that, despite the progress made in Europe in recent years, data interoperability in urban mobility and logistics is still not fully achieved in practice, but not because of a lack of solutions, but on how these solutions are interpreted and implemented among the different contexts by the different stakeholders.

The difficulties in this regard are related to semantic heterogeneity, unclear governance conditions, limited reuse of existing solutions, insufficient or lack of incentives for data sharing, and challenges in scaling data interoperability initiatives beyond their projects. Many stakeholders also reported a limited familiarity with interoperability frameworks and certain governance mechanisms.

A particular strength of the content of this deliverable lies in the methodological approach adopted to develop and validate its content. Challenges identified through the State of the Art were first analyzed versus the experiences and perceptions of practitioners through the survey. From the challenges they expressed, a series of recommendations to tackle data interoperability challenges in urban mobility and logistics was drafted and these were then further discussed, refined, and validated during a dedicated workshop. As a result, the recommendations presented in this deliverable benefit from having a dual validation process.

The workshop discussions not only confirmed the relevance of the identified challenges but also highlighted the strong interdependencies between them. Rather than being represented in isolation, the recommendations can be organized in three pillars: (i) operational deployment of interoperability solutions, (ii) trusted and value-driven data-sharing ecosystems, and (iii) semantic interoperability and shared understanding.

A key finding from this work is that data interoperability cannot be achieved through isolated technical, policy, or standardization efforts. Technical interoperability alone is not enough; stakeholders must also have trust in the governance frameworks that oversee data exchange for it to be effective and secure. Similarly, governance mechanisms alone will not lead to participation unless stakeholders perceive clear operational or business value. Likewise, the fact that standards and frameworks are available does not guarantee they will be adopted if the stakeholders lack the practical guidance needed to implement them. Effective data interoperability therefore depends on the alignment of technical, semantic, organizational, governance, and economic dimensions.

Therefore, future efforts should focus further on implementation support, stakeholder capacity building, semantic harmonization, and demonstrating the value of data sharing to encourage long-term engagement.

Beyond the recommendations presented in this deliverable, an important legacy of the DELPHI project is the establishment of the Digital Urban Freight (DUF) Community. While the project formally concludes, the community will continue to provide a collaborative space where public authorities, logistics operators, mobility providers, researchers, technology developers, and innovation projects can continue the dialogue on data interoperability in urban mobility and logistics, exchange/promote good practices, and increase awareness of already existing standards, governance frameworks, or data sharing approaches.

Ultimately building interoperable urban mobility and logistics ecosystems is not only a technical challenge, but also an organizational and collaborative one. Achieving this transition requires strong collaboration between actors from different sectors and initiatives, and facilitating knowledge and experience transfer is a key first step.

References

Apostolov, M., 2024. Digitalization of multimodal data and document exchange using UN standards in electronic corridors | UN Trade and Development (UNCTAD). URL https://unctad.org/news/digitalization-multimodal-data-and-document-exchange-using-un-standards-electronic-corridors (accessed 1.21.26).

Bakri, T., Bastiaansen, H., Benmayor, A., Blaya, M., Böge, G., Cases, J.-F., Eisenrauch, A., Engh, E., Epardeau, D., Federl, S., Fernandes, E., van der Hoeven, G., King, L., Kirstein, L., Kraft, V., Lenz, G., Lilja, J., Morgan, J., Nagel, I., Öörni, R., Pretzsch, S., Scholliers, J., Schulz, H., Spijkers, N., 2023. Towards a common European mobility data space: Perspectives, recommendations and building blocks (Deliverable). PrepDSpace4Mobility.

Delaplace, J., 2024. Digitalization of the logistics - Cartography of the data sharing and exchange initiatives in Europe and recommendations for the introduction of the "Shared Data Language" developed by Geodis into this landscape. Paris, France.

Gharehgozli, A., De Vries, H., Decrauw, S., 2019. The role of standardisation in European intermodal transportation. Marit. Bus. Rev. 4, 151–168. https://doi.org/10.1108/MABR-09-2018-0038

Li, Y., Cottet, M., 2024. D.2.1: State-of-the-art report in governance, relative technologies and stakeholder ecosystems in passenger and freight transport (Project Deliverable).

Picht, P.G., 2020. Towards an Access Regime for Mobility Data. IIC - Int. Rev. Intellect. Prop. Compet. Law 51, 940–976. https://doi.org/10.1007/s40319-020-00974-3

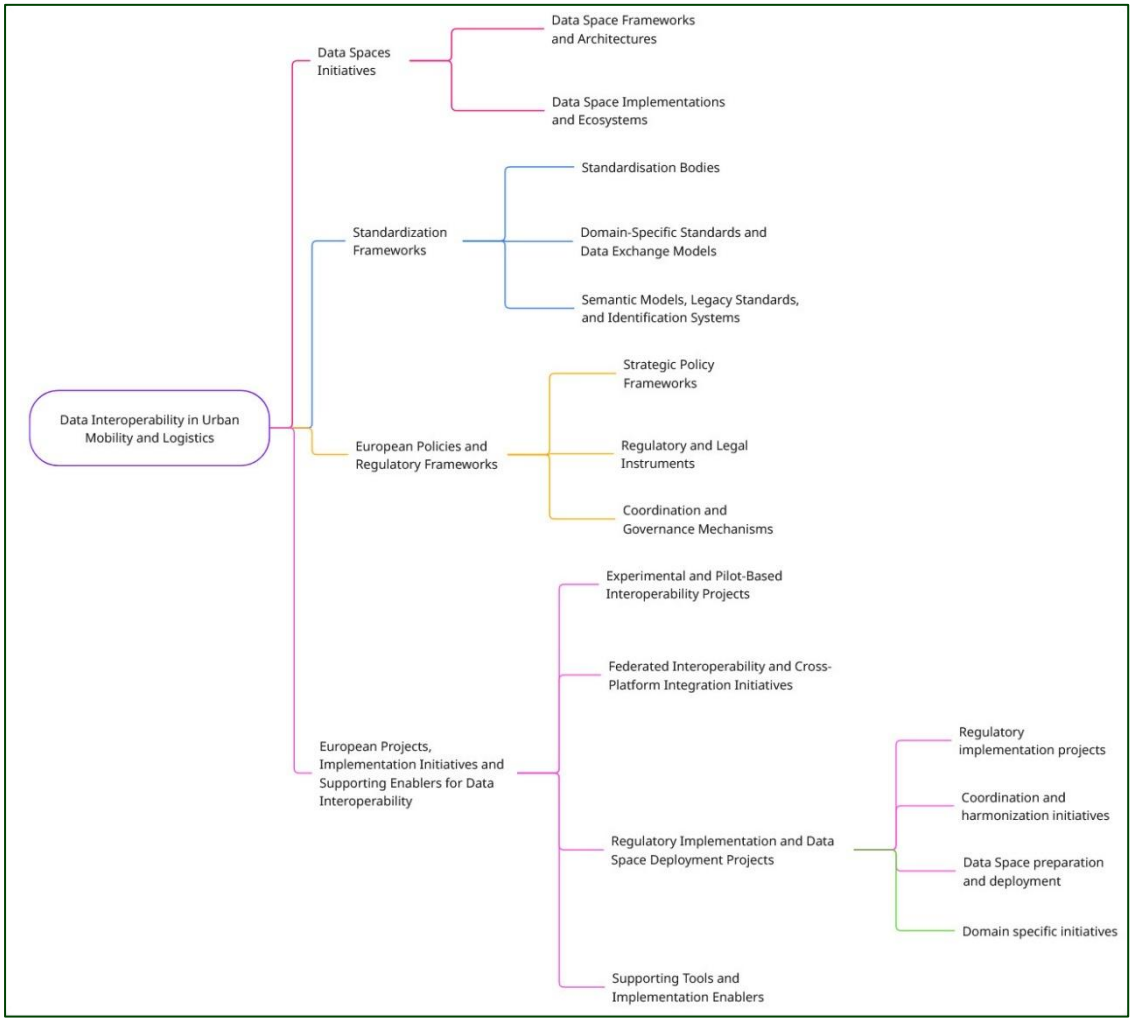
Probert, S., Roff, D., 2025. MMT RDM and Role in Transport Data Exchange.

Psara, K., 2024. D.2.5: Methodology framework for secure, safe and efficient data sharing/storage/usage (Project Deliverable).

Steinbuss, S., Almeida, A.H., Wouter, van den B., Sthefan Gabriel, B., 2025. Semantic Interoperability in Data Spaces. Zenodo. https://doi.org/10.5281/ZENODO.17630664

Vellinga, N., Hailevich, E., 2024. The Legal Framework for Sharing Mobility Data: On the Road to an EU Mobility Data Space. https://doi.org/10.2139/ssrn.5031628

Appendix 1: European Ecosystem on Data Interoperability Visualization



https://miro.com/app/board/uXjVHXOLWeQ=/

Appendix 2: Survey Questionnaire

Digital Urban Freight Community – Survey

ALICE launches its DUF Community to contribute to operational digitalization of urban freight.

This survey aims to capture the perspective of practitioners and prioritize key interoperability, governance, policy and operational gaps in current mobility and logistics data initiatives. Outputs will serve as foundation for the Community.

Section 1 — Respondent Profile (Context)

1. Type of organization (one answer possible)
    - City / public authority
    - Transport or logistics operator
    - Digital platform / solution provider
    - Research or innovation project
    - Other (please specify in the question below)
2. If you answered 'Other' in the previous question, and none of the above categories fully apply, please specify your organization type.
3. What is your **main role** regarding data sharing? (one answer possible)
    - Data provider
    - Data user
    - Platform / infrastructure provider
    - Policy or coordination role
    - Other (please specify in the question below)
4. If you answered 'Other' in the previous question, and none of the above categories fully apply, please specify what your main role regarding data-sharing is.
5. At which territorial or operational scale are you primarily involved in with regard to data-sharing activities in mobility or logistics? (one answer possible)
    - **Local / city level** (e.g. urban mobility platforms, city logistics pilots, municipal data portals)
    - **Regional level** (e.g. regional transport authorities, inter-city coordination, regional platforms)
    - **National level** (e.g. national access points, regulatory reporting, national platforms)
    - **European / cross-border level** (e.g. EU-funded projects, cross-border services, data spaces)
    - **Not applicable**
6. At the territorial or operational scale, you indicated above, **what best describes your role** in data-sharing activities related to mobility or logistics? (one answer possible)
    - Strategic / policy-oriented
    - Technical / implementation-focused
    - Operational / day-to-day use
    - Coordination / project management

Section 2 — Technical Interoperability

7. In your experience, differences in data meaning and terminology (semantic differences) across data models significantly hinder interoperability (one answer possible)

   - Strongly agree
   - Agree
   - Disagree
   - Strongly disagree
   - I don't know / not enough experience to assess

8. If you selected *"Strongly agree"* or *"Agree"* in the previous question, please shortly explain how interoperability is hindered. Are you taking actions to bridge these gaps? If yes, which ones? If not, why?

9. If you selected *"Disagree"* or *"Strongly disagree",* please briefly describe a case where semantic differences do not hinder interoperability.

10. How often do you reuse data models or APIs (Application Programming Interfaces used to exchange data between systems) beyond their original purpose and/or primary context of use? (one answer possible)

    - Systematically
    - Occasionally
    - Rarely
    - Never
    - Not relevant to me

11. To what extent do you agree with the following statements about technical barriers to reusing data models and/or APIs?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Semantic differences between data models make reuse difficult					
The lack of stable or well-defined interfaces limits reuse					
Insufficient or unclear documentation hinders reuse					
Legacy IT systems (older IT systems not designed for modern APIs, real-time exchange) limit the ability to reuse modern APIs or data models					

12. Which of the above technical factors is the most critical barrier in your context? (one answer possible)
    - Semantic differences between data models
    - Lack of stable or well-defined interfaces
    - Insufficient or unclear documentation
    - Legacy IT systems
    - None of the above/not applicable

13. Are there any other technical barriers that significantly affect data models or APIs reuse in your context? If yes, please describe

Section 3 — Governance and Trust

14. To what extent do the following factors limit your trust in data-sharing? (Please indicate your level of agreement for each statement)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Lack of clarity on data governance rules and usage rights limits trust in data sharing.					
Concerns about commercial sensitivity or loss of competitive advantage limit trust.					
The risk of misuse or misinterpretation of shared data limits trust.					
Insufficient data anonymization or protection mechanisms limit trust					
Legal and regulatory uncertainty (e.g. GDPR compliance, contractual obligations) limits trust.					
Lack of technical trust mechanisms (e.g. access control, traceability, auditability) limits trust.					

15. Which of the above factors is the most critical barrier in your context? (One possible answer)

    - Governance clarity
    - Commercial sensitivity / competition
    - Data misuse risks
    - Data protection mechanisms
    - Legal uncertainty
    - Technical trusts mechanisms
    - None of the above/not applicable

16. Are there any other trust-related barriers that are important in your context but not listed above? If yes, please describe

17. How clear are data access, usage, and reuse conditions in the initiatives you are currently involved in? (one answer possible)

    - Clear and well defined
    - Partially clear, with some ambiguities
    - Unclear or poorly defined
    - Not applicable

18. If partially clear or unclear, what is mainly unclear? (one answer possible)
    - Data ownership
    - Usage rights and restrictions
    - Reuse and redistribution conditions
    - Liability and responsibilities
    - Duration of access / retention
    - Other (please specify in the question below)

19. If you answered 'Other' in the previous question, are there any other aspects related to data access or reuse conditions that you find unclear?

20. In your opinion, in the context of a data platform or data space (i.e. an environment where multiple organizations exchange and reuse data under agreed rules), who should bear **operational responsibility** for decisions made based on shared data (interpretation and use in operations)? (one answer possible)

    - The data provider (entity that originally shared the data)
    - The data user (entity interpreting and acting on the data)
    - Shared responsibility between data provider and data user
    - The platform or intermediary enabling data exchange
    - The public authority or regulator (in regulated contexts)
    - Operational responsibility should be defined case by case through contracts
    - Operational responsibility depends on the specific use case
    - Other (please specify in the question below)

21. If you answered 'Other' in the previous question, please specify who do you think should be responsible for **operational decisions** made based on shared data?

22. In your opinion, in the context of a data platform or data space (i.e. an environment where multiple organizations exchange and reuse data under agreed rules), who should bear **legal responsibility** for decisions made based on shared data (e.g. liability, damages, regulatory compliance)? (one answer possible)

    - The data provider (entity that originally shared the data)
    - The data user (entity interpreting and acting on the data)
    - Shared responsibility between data provider and data user
    - The platform or intermediary enabling data exchange
    - The public authority or regulator (in regulated contexts)
    - Legal responsibility should be defined case by case through contracts
    - Legal responsibility depends on the specific use case
    - Other (please specify in the question below)

23. If you answered 'Other' in the previous question, please specify who you think should bear **legal responsibility** for decisions made based on shared data.

24. In practice, mechanisms to control how shared data can be accessed, reused, and governed (e.g. consent, usage rules, sovereignty) are still implemented in fragmented or project-specific ways, rather than through common standards (one answer possible)

    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree
    - I don’t know / Not enough experience to assess

Section 4 — Policy and Standardization

25. Do you participate or have any involvement with any of the following policies or regulatory instruments affecting mobility, logistics or data-sharing? (This may include compliance, implementation, pilot projects, consultations or operational use) (Multiple answers possible)

    - eFTI Regulation (EU regulation enabling electronic freight transport information exchange)

- European Mobility Data Space (EMDS) *(EU initiative to enable trusted and interoperable sharing of mobility and logistics data across public and private actors)*
- Data Governance Act (DGA) (EU framework for data sharing, intermediaries, and data altruism)
- Data Act *(EU regulation on access to and use of data generated by connected products and services)*
- European Data Strategy *(EU policy framework guiding the development of common European data spaces)*
- GDPR *(EU regulation on personal data protection and privacy)*
- None of the above

26. If you are involved in other policies, regulations, or regulatory frameworks not listed above, please specify:

27. Do you see gaps in these policies that limit their effectiveness? If yes, which gap(s) do you consider the most important?

28. In your opinion, which European policies or regulatory instruments most effectively support real interoperability in mobility and logistics data sharing? (i.e. data can be exchanged, understood, and reused across actors and systems, beyond basic digitalization or reporting) (Multiple answers possible)

    - eFTI Regulation
    - European Mobility Data Space (EMDS)
    - Data Governance Act (DGA)
    - Data Act
    - European Data Strategy
    - GDPR
    - None of the above
    - Too early to assess/ insufficient experience
    - Other (please specify in the question below)

29. If you answered *Other* in the previous question, please specify which policy or regulatory instrument you believe supports interoperability in mobility and logistics data-sharing.

30. Are you currently involved, or have you previously been involved, in standardization or specification activities related to mobility, logistics, or data interoperability? (This may include formal participation, expert groups, working groups, consultations, or indirect contributions through projects e.g. eFTI-related specifications, CEN/ISO transport standards, UN/CEFACT, GS1, EDIFACT, Gaia-X specifications.) (multiple answers possible)

    - CEN / CENELEC (European standardization)
    - ISO (International Organization for Standardization)
    - UN/CEFACT (trade, transport and e-business standards)
    - GS1 (identification, logistics and supply chain standards)
    - IDSA (International Data Spaces Association)
    - Gaia-X
    - None of the above

31. If you are involved in other standardization or specification bodies not listed above, please specify:

32. Do you use existing formal standards? (e.g. ISO 19845) If so, which ones?

33. Have results from pilots or projects you were involved in contributed, directly or indirectly, to any formal standards or specifications?
    - Yes
    - No
    - Not applicable
34. If yes, to which one?
35. How did/will this contribution take place? (multiple answers possible)
    - Direct input to standardization working group / technical committee
    - Project results referenced in a standard or technical specification
    - Informal exchange with standardization bodies or experts
    - Other (please specify in the question below)
36. If you answered 'Other' in the previous question, please specify how did/will this contribution took place

Section 5 - Digital Urban Freight Community

ALICE is launching its Digital Urban Freight Community to address the concrete challenges of digitalization and data sharing in urban logistics, with a focus on interoperability, data governance and secure data exchange grounded in operational realities.

Within this framework, this survey seeks to capture the operational perspective of practitioners and will serve as a foundation for the Community's future recommendations and strategic outputs.

37. Are you interested in knowing more or getting involved in the Digital Urban Freight Community?
    - Yes
    - No
    - Maybe later
38. If you are interested in knowing more or getting involved in the Digital Urban Freight Community, please leave your email below.