AI-Enabled Data Lifecycles Optimization and Data Spaces Integration for Increased Efficiency and Interoperability

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Deliverable 8.8

Report on European Interoperability Framework Contributions

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Disclaimer

Executive Summary

This deliverable (D8.8) presents the contributions of the PLIADES project to advancing the European Interoperability Framework (EIF) and interoperability standardization, with a focus on building a modular, scalable, and trustworthy data sharing ecosystem. The work conducted in Task 8.6 evaluates the project's alignment with the EIF's four layers—legal, organizational, semantic, and technical—and extends this analysis through ISO/IEC 19941's five interoperability facets—policy, behavior, semantic, syntactic, and transport.

By applying a general interoperability-framework approach, the deliverable assesses the interoperability maturity of PLIADES across six use cases in domains including mobility, energy, healthcare, green deal/ circular economy, energy, and industry. These use cases demonstrate how PLIADES supports dynamic, cross-domain data integration through advanced AI capabilities such as federated learning, explainable AI, and declarative querying—while ensuring legal compliance, data sovereignty, and semantic clarity.

The project engages directly with EU standardization and governance initiatives—including SEMIC, DSSC, and the European Trusted Data Framework standardisation request to ensure alignment with emerging regulations like the Data Act. PLIADES actively contributes to the EU's semantic and technical interoperability agenda through workshops, conference participation (e.g., SEMIC 2025, ENDORSE 2025), and alignment with the IDS Rulebook and the Dataspace Protocol.

Gaps identified in current interoperability models—such as limited runtime interoperability, lack of support for decentralized AI, and insufficient metadata expressiveness—are addressed through actionable recommendations. PLIADES proposes enhancements to semantic alignment, dynamic querying, and data governance architectures, helping to shape the next iteration of European data policy frameworks.

Ultimately, this report underscores PLIADES' strategic role in fostering cross-border, cross-sector data interoperability. By operationalizing both EIF and ISO-based principles through real-world use cases and aligning with EU standardization initiatives, PLIADES delivers a blueprint for trusted, AI-enabled, sovereign data spaces that drive innovation and support Europe's digital transition.

Table of Contents

List of Figures

List of Tables

List of Terms and Definitions

Table 1 Definitions

Abbreviation	Definition
ADAS	Advanced Driver Assistance Systems
AGO	Automotive Global Ontology
AI	Artificial Intelligence
ASAM	Association for Standardisation of Automation and Measuring Systems
AUWP	Annual Union Work Programme
AVL	AVL LIST GMBH
BasqueCCAM	ASOCIACION CENTRO VASCO DE MOVILIDAD CONECTADA COOPERATIVA Y AUTONOMA
BDVA	Big Data Value Association
BOR	Blue Ocean Robotics APS
CAMSS	Common Assessment Method for Standards and Specifications
CCAM	Cooperative, Connected and Automated Mobility
CE	Conformité Européenne (European Conformity)
CEIT	ASOCIACION CENTRO TECNOLOGICO CEIT
CERTH	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS
CICbioGUNE	ASOCIACION CENTRO DE INVESTIGACION COOPERATIVA EN BIOCIENCIAS
CSN	Cloud Service Customer
CSP	Cloud Service Provider
CVUT	CESKE VYSOKE UCENI TECHNICKE V PRAZE
DDS	Data Distribution Service
DENN	INDUSTRIAS PUIGJANER S.A.
DSBA	Data Spaces Business Alliance
DSGA	Data Space Governance Authority
DSSC	Data Spaces Support Centre
EIF	European Interoperability Framework
ETSI	European Telecommunications Standards Institute
EU	European Union
FHIR	Fast Healthcare Interoperability Resources
FIWARE	Future Internet Ware (Open Source initiative)
Gaia-X	European initiative for federated data infrastructure
GDPR	General Data Protection Regulation

GNSS	Global Navigation Satellite System
HL7	Health Level Seven International
HRI	Human-Robot Interaction
I4ByDesign	KENTRO IKANOTITON GIA TIN VIOMICHANIA 4.0 APO TO SCHEDIASMO STIN YLOPOIISI IDIOTIKI KEFALAIOUCHIKI ETAIREIA
IA	Information Architecture
IDS	International Data Spaces
IDSA	International Data Spaces Association
IDS-RAM	IDS Reference Architecture Model
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual Property
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
JSON-LD	JSON for Linking Data
KO	Key Objective
KPI	Key Performance Indicator
LIBATTION	LIBATTION AG
MDR	Medical Device Regulation
ML	Machine Learning
MQTT	Message Queuing Telemetry Transport
MU-EPS	MONDRAGON GOI ESKOLA POLITEKNIKOA JOSE MARIA ARIZMENDIARRIETA S COOP
NIFs	National Interoperability Frameworks
NMR	Nuclear Magnetic Resonance
NoSQL	Non-relational Structured Query Language
PATRIC	PRAGUE ADVANCED TECHNOLOGY AND RESEARCH INNOVATION CENTER AS
PII	Personally Identifiable Information
RAS	Robotics and Automation Society
REST API	Representational State Transfer Application Programming Interface
RGB	Red-Green-Blue
ROS	Robot Operating System
SAE	Society of Automotive Engineers
SBTC	Swiss Battery Technology Center

SEMIC	Semantic Interoperability Community
SIMPL	Smart Middleware Platform for Cloud-Edge Federation
SIPBB	SWITZERLAND INNOVATION PARK BIEL/BIENNE AG
STEP	Standard for the Exchange of Product model data
Taltech	TALLINNA TEHNIKAÜLIKOOL
TECNALIA	FUNDACION TECNALIA RESEARCH & INNOVATION
TNO	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO
UC3M	UNIVERSIDAD CARLOS III DE MADRID
V2X	Vehicle-to-Everything
VICOM	FUNDACION CENTRO DE TECNOLOGIAS DE INTERACCION VISUAL Y COMUNICACIONES VICOMTECH
WEEE	Waste Electrical and Electronic Equipment
XML	eXtensible Markup Language
ZERO	ZERO GMBH

1 Introduction

1.1 Scope of the deliverable

This deliverable reports the activities and outcomes of Task 8.6 – Contribute to the European Interoperability Framework (EIF) toward an Open, Standardized, Interoperable and Trusted Data Concept, which aims to contribute to the EIF by promoting best practices, tools, and standards that support an open, standardized, interoperable, and trustworthy European data ecosystem.

The work emphasizes alignment with the EIFs four key interoperability layers—legal, organizational, semantic, and technical—while also addressing cross-sector challenges in data sharing, governance, and trust. Leveraging the results of the PLIADES project, this task evaluates how the project's architecture and use cases meet EIF requirements and proposes enhancements where gaps exist.

Furthermore, Task 8.6 contributes to Key Objective 8 (KO#8) by fostering synergies with relevant European initiatives such as DSSC, SIMPL, IDSA, and Gaia-X. These collaborations avoid duplication of effort and promote alignment across common data space strategies. It also supports Key Objective 4 (KO#4) by advancing data space connectors and architectural models that facilitate full lifecycle data sharing, especially for AI-enabled, cross-domain use cases.

Finally, Task 8.6 contributes to legislative and standardization awareness, supporting Key Performance Indicator 2.1 (KPI-2.1), which calls for introducing a framework that aligns with current legal and security standards.

1.2 Relation to other activities and deliverables

This task builds on earlier PLIADES activities under Work Package 2, particularly:

- Task 2.2 – Consolidation of User and System Requirements.
- Task 2.3 – System Design and Architecture of the Platform.

The outcomes of these tasks are documented in Deliverables D2.2 (User Requirements and Use Cases) and D2.3 (System Technical Specifications and PLIADES Framework Architecture), which serve as key references for the interoperability assessments carried out in this report.

Task 8.6 is also connected with Task 8.3 – Exploitation Plan & Sustainability Policy & Analysis of Standardisation European Landscape, which focuses on the exploitation strategy, sustainability policy, and standardization landscape analysis. The interoperability analysis and the standardisation paper developed and included in this deliverable complement T8.3 by identifying the current standardisation landscape suitable for future PLIADES contributions to standards.

1.3 Document structure

This deliverable is structured as follows:

- **Chapter 1 – Introduction:** Outlines the scope, background, and links to other tasks and deliverables.
- **Chapter 2 – Overview of Interoperability Frameworks:** Introduces the EIF, ISO/IEC 19941, and IDS Rulebook and Dataspace Protocol as foundational models for interoperability.
- **Chapter 3 – Methodology:** Describes the structured approach used to assess interoperability in PLIADES use cases.
- **Chapter 4 – Use Case Analysis:** Applies the interoperability models to six PLIADES use cases across various domains.

- **Chapter 5 – Gaps and Recommendations:** Identifies limitations in current frameworks and proposes actionable improvements.
- **Chapter 6 – Synergies with EU Initiatives:** Describes how PLIADES aligns with and contributes to ongoing European efforts like SEMIC and DSSC.
- **Chapter 7 – Conclusions:** Summarizes the key findings and implications of the interoperability work in the context of EU data strategy goals.

2 Data spaces interoperability frameworks overview

2.1 Introduction

To analyse how PLIADES can contribute to the European Interoperability Framework (EIF), it is not enough to limit the interoperability requirements to EIF, for this reason in this chapter we conducted a data spaces interoperability frameworks overview incorporating the ISO/IEC 19941 interoperability and portability facets (i.e. Policy, Behavior, Semantic, Syntactic, Transport) will significantly strengthen the analysis. It allows us to align PLIADES use cases not only with the EIF's four-layer model but also with the cloud-oriented interoperability stack from ISO 19941. Finally, we complement the overview with adding insights from IDS interoperability.

2.2 European Interoperability Framework (EIF)

The European Interoperability Framework provides a set of actionable recommendations to help public administrations improve the governance and implementation of interoperability across their services. It offers a structured, commonly agreed approach to delivering digital public services that are interoperable, efficient, and accessible across borders and sectors.

In the context of PLIADES, several use cases involve public sector participation, making it relevant to assess how both the project's architecture and specific use cases align with EIF principles. This alignment supports the broader goal of achieving cross-sector and cross-border interoperability in line with the Digital Single Market objectives.

Moreover, the EIF's layered model—covering legal, organizational, semantic, and technical interoperability—serves as a foundational reference for implementing interoperability within emerging data spaces. It ensures that cross-organizational collaboration, end-to-end digital services, and legal compliance are supported without compromising interoperability.

2.2.1 EIF goals

The EIF is designed to help public administrations across Europe deliver public services that are:

- **Digital-by-default** – prioritizing digital channels for accessibility and efficiency,
- **Cross-border-by-default** – ensuring services are usable across EU countries,
- **Open-by-default** – enabling transparency, reuse, and participation.

The EIF offers structured guidance for developing or aligning National Interoperability Frameworks (NIFs) with common EU principles. It plays a key role in breaking down interoperability barriers that hinder progress on the Digital Single Market, fostering seamless data and service exchange across borders, sectors, and levels of government.

By applying EIF principles, public administrations can deliver interoperable, user-focused, and future-proof digital services. The EIF also helps ensure that legal, organizational, semantic, and technical layers of interoperability are consistently addressed, forming a solid foundation for cross-domain cooperation and innovation.

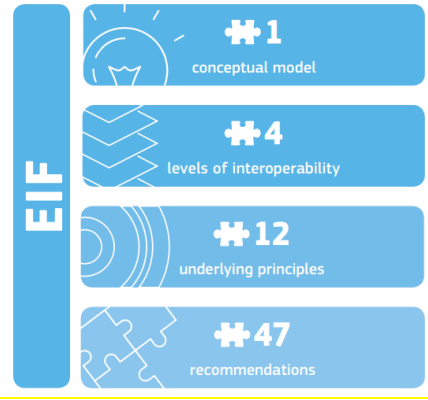


Figure 1 EIF Components – Building Blocks of Interoperability

2.2.2 EIF structure

The European Interoperability Framework defines four levels of interoperability each playing a crucial role in enabling seamless and integrated public service delivery. These layers are supported by overarching public service governance, ensuring cohesion across sectors and borders.

We make a short introduction of these layers but more information can be found on the New European Interoperability Framework publication[1].

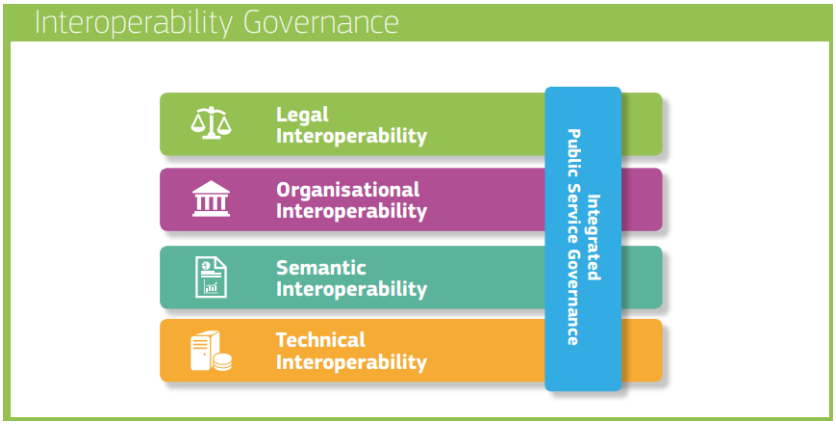


Figure 2 Interoperability Governance – EIF Layers

This deliverable examines how the PLIADES architecture and use cases address each of these interoperability layers:

- **Technical Interoperability:** Evaluates the technical solutions provided by PLIADES for data exchange, system integration, and platform interoperability.
- **Semantic Interoperability:** Assesses how PLIADES supports common understanding of exchanged data by using standard vocabularies, ontologies, and metadata models.
- **Organizational Interoperability:** Analyzes the coordination mechanisms, roles, and responsibilities across stakeholders to ensure aligned operations and governance structures.
- **Legal Interoperability:** Reviews how PLIADES complies with relevant legal frameworks, such as GDPR and domain-specific regulations, and ensures lawful data exchange and consent management.

[1] European Union, 2017 [https://ec.europa.eu/isa2/sites/default/files/eif_brochure_final.pdf]

Further details and reference guidelines are available in the official New European Interoperability Framework publication.

2.3 ISO/IEC 19941 interoperability & portability

The EIF is focused on interoperability in public service delivery. However, since PLIADES also includes private-sector use cases, it was necessary to consider additional frameworks commonly adopted by private companies. In this context, ISO/IEC 19941:2017 provides a standardized framework for understanding and implementing interoperability and portability in cloud computing. These two concepts are key to enabling seamless interaction across cloud systems and to avoiding vendor lock-in.

The standard defines five interoperability facets:

- **Transport:** The ability to exchange data via standard communication protocols.
- **Syntactic:** Shared data formats for compatibility.
- **Semantic:** Common understanding of data meaning across systems.
- **Behavior:** Consistent system responses to shared data/actions.
- **Policy:** Adherence to legal, regulatory, and organizational requirements.

This model supports alignment across **cloud service providers (CSPs), customers (CSCs), and partners (CSNs)**, fostering better integration, migration, and compliance strategies. ISO/IEC 19941 is tightly linked to related standards like ISO/IEC 17788 and 17789, providing a shared vocabulary and structure for discussing cloud service interoperability.

Although published in 2017, the standard is currently under review and scheduled for an update by 2025.

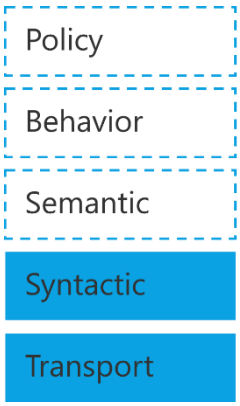


Figure 3 ISO 19941 - Cloud Computing Interoperability and Portability

Why is this important for PLIADES?

Interoperability is foundational to the success of PLIADES, which aims to establish cross-domain, cross-border, and cross-organizational data spaces. ISO/IEC 19941 offers a structured lens through which the complexities of interoperability and portability can be broken down and addressed. The standard's facet model is particularly useful for PLIADES, as it distinguishes between technical system-level aspects (e.g., transport and syntax), organizational challenges (e.g., behavioural alignment), and policy-driven constraints (e.g., governance, data rights, and legal compliance).

This helps PLIADES partners not only to integrate systems and harmonize data formats, but also to ensure that policies and obligations attached to data are themselves interoperable and portable—a key requirement in federated environments where sovereignty, trust, and compliance are non-

negotiable. Applying the ISO/IEC 19941 framework supports the project's ambition to deliver secure, reusable, and explainable AI services across heterogeneous domains like energy, health, mobility, and manufacturing.

By aligning with this standard, PLIADES enhances its ability to scale, interoperate, and future-proof its architecture against vendor lock-in, fragmented governance, or regulatory gaps.

2.4 Key IDS insights on interoperability

To avoid fragmentation and duplication of efforts, participants in data spaces need to communicate in an interoperable way with each other and across multiple data spaces, following common standards and principles.

The IDS Rulebook[2] explicitly links the **EIF's four layers**—legal, organizational, semantic, and technical—and the **five ISO/IEC 19941 facets**—policy, behaviour, semantic, syntactic, transport—to data space interoperability. Both frameworks identify four main levels of interoperability: technical (transport & syntactic), semantic, organizational, and legal:

- **Technical/Syntactic/Transport:** Covers connectivity, protocols, message structures (e.g., IDS Connectors, Dataspace Protocol).
- **Semantic:** Shared meaning via ontologies, metadata, IDS Information Model for describing data assets.
- **Organizational (Behaviour):** Governance, roles, processes structured in IDS Governance Framework.
- **Legal (Policy):** Contracts, usage policies, legal equivalence, data sovereignty tools.

The **Data Space Governance Authority (DSGA)** is also responsible for the semantic modelling of the data space and thus has a huge influence on the interoperability at that layer. Taking the guiding principles above into account leads us to the conclusion that interoperability is a shared responsibility between the participants and the DSGA.

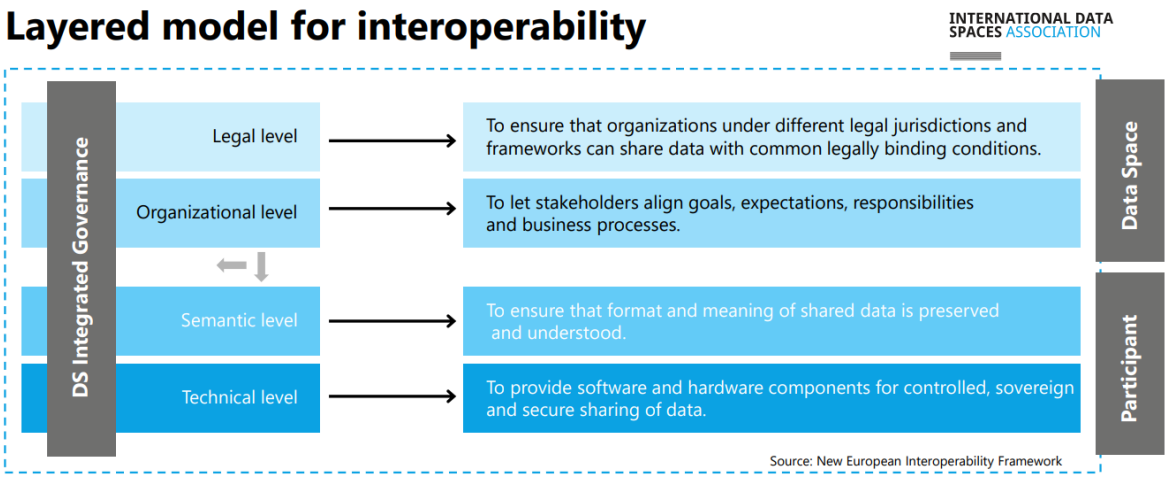


Figure 4 Layered model for Interoperability

[2] Read more here: https://docs.internationaldataspaces.org/ids-knowledgebase/idsa-rulebook/idsa-rulebook/3_interoperability (*Source: IDSA Rulebook – Chapter 3: Interoperability*)

2.4.1 IDSA-RAM and Dataspace Protocol

The **IDS Reference Architecture Model (IDS-RAM)** operationalizes the key levels within a dataspace, and the **Dataspace Protocol** operationalizes the actual exchanges as both are required for consent-based, sovereign data exchange architectures. The Dataspace Protocol enables independent implementations to interact seamlessly within a shared data space. Since many data spaces cannot enforce a uniform technology stack across all participants, it is essential to support a flexible, mix-and-match integration of components.

To ensure interoperability across these diverse implementations, the foundation must be a set of well-defined, implementation-agnostic standards that include normative conformance requirements expressed in a programming language-independent way.

The Dataspace Protocol delivers:

- A clear, standardized specification for data space interoperability
- Independence from specific technical implementations
- Core functionality to enable sovereign, trusted data exchange
- A foundation for international standardization

More information is available in the Dataspace Protocol documentation.

2.5 European standardisation request

As part of the 2024 Annual Union Work Programme (AUWP) for European Standardisation, the European Commission has introduced the European Trusted Data Framework as a new strategic priority (Action 10) to support the implementation of the Data Act.

The standardisation request has been issued to the three European Standardisation Organizations (ESOs): CEN, CENELEC, and ETSI. It calls for the development of harmonised standards to ensure legal compliance, data governance, and technical interoperability across systems and sectors. This initiative is grounded in Regulation (EU) 2023/2854, with a specific focus on Article 33, which outlines the essential requirements for interoperability of data, sharing mechanisms, and common data space services across Member States.

2.5.1 Interoperable Europe framework alignment

The request aligns closely with the Interoperable Europe Framework, supported by the Interoperable Europe Act, which provides a foundation for public sector interoperability, with applicability to private-sector collaboration as well. In particular, this request underscores the critical role of semantic interoperability, which is essential for enabling consistent interpretation and exchange of data between different organizations and systems. Here, SEMIC—the European Commission's initiative under the ISA² and now Digital Europe Programme—serves as a cornerstone.

Further technical and procedural details on this standardisation initiative can be found in the Appendix. IDSA Standardisation paper – Europe and International.

3 Methodology

To assess the interoperability maturity of PLIADES use cases, a structured methodology was applied that aligns each case against the European Interoperability Framework and the ISO/IEC 19941 Interoperability Facets. This dual-layered approach allows for a comprehensive evaluation across both policy-driven and technical dimensions. Each use case was examined by mapping its activities, data flows, stakeholders, and system interactions to the four EIF interoperability levels— legal, organizational, semantic, and technical— to understand how governance, compliance, and coordination are handled. In parallel, the analysis considered the five interoperability facets defined by ISO/IEC 19941—policy, behavior, semantic, syntactic, and transport— to assess how well each use case supports data portability and system-to-system communication at a technical level. This combined assessment highlights interoperability strengths, identifies gaps, and ensures alignment with EU strategic objectives and international standards.

4 PLIADES alignment with interoperability frameworks

4.1 PLIADES contribution to the interoperability framework

1. **Legal interoperability:**
   - Data ownership, sovereignty, and privacy (linked to WP4: Identity Management, Privacy-preserving Data Sharing).
   - Alignment with GDPR and legal frameworks on cross-border data flows.
2. **Organizational Interoperability:**
   - Federated data spaces and collaborative models across sectors.
   - Role of the common data connector and AI Broker (WP5).
   - Stakeholder coordination strategies (linked to WP7 pilots and engagement).
3. **Semantic Interoperability:**
   - Semantic and metadata optimization (T5.1): enables consistent data interpretation.
   - Ontology alignment and domain-agnostic semantic mapping.
4. **Technical Interoperability:**
   - Contributions of:
     - Data creation (Digital Twins, AI-based elaboration – WP3),
     - Processing & analytics (Federated Learning, Explainable AI – WP6),
     - Integration (Declarative querying, broker – WP5),
     - Security (Edge-to-cloud, data security protocols – WP4).

User requirements and use cases are to provide a thorough overview of the derived user requirements and define the specifications of the PLIADES use cases.

4.2 Use cases template:

We will follow a template for the use cases analysis, below there is the proposed template:

Use Case #X – [Title]

Data Space: *[Sector]*

Participants: *[Organizations]*

EIF Interoperability Contribution

1. **Legal:**

   (How legal frameworks, contracts, consent, and ownership are respected or enforced)
2. **Organizational:**

   (How governance, coordination, roles, and responsibilities are structured across entities)
3. **Semantic:**

   (How semantic alignment is achieved: ontologies, vocabularies, mappings)

4. **Technical:**

   (Underlying technologies, connectors, platforms, and integration patterns used)

ISO/IEC 19941 Interoperability Facets

1. **Policy:**

   (Rules, rights management, data access policies – e.g., consent models, role-based access)

2. **Behavior:**

   (Workflow orchestration, robot-patient interactions, process automation)

3. **Semantic:**

   (Consistency of meaning, cross-domain data context, ontological mapping)

4. **Syntactic:**

   (Data encoding, common schemas – e.g., HL7 FHIR for health, JSON-LD for mobility)

5. **Transport:**

   (Communication stack – e.g., IDS Connectors, MQTT, REST APIs)

4.2.1 Use Case 1. Integrating data lifecycles of sustainability, operations and process industry manufacturing operations

Use Case #1 – Integrating data lifecycles of sustainability, operations and process industry manufacturing operations

Data Space: *Industrial*

Participants: *DENN, TECNALIA*

EIF Interoperability contribution

1. **Legal:**
   - Ensures compliance with GDPR, ISO/IEC 27001, EU Data Governance Act, and Machinery Regulation (EU 2023/1230).
   - CE Marking and conformity assessments validate safe integration of AI-driven machines.
   - Strategic emphasis on data usage policies, sovereignty, and secure sharing aligns with the legal pillar of EIF.
   - Future revenue-sharing models with suppliers introduce contractual governance into the data lifecycle.
2. **Organizational:**
   - Clear division of roles between DENN (data provider/operator) and suppliers/partners (data consumers).
   - TECNALIA supports the interoperability roadmap through data space research, DSSC/DSBA engagement, and scientific contribution.
   - Business and governance processes adapt to usage-based licensing, cross-sector sharing, and co-innovation models.
   - Data lifecycle is fully governed: collection → enrichment → brokering → monetization.
3. **Semantic:**
   - DENNDATA integrates semantic metadata for component lifecycle tracking, predictive analytics, and anomaly detection.
   - Future evolution includes annotated datasets, drift detection, and automated semantic enrichment.

- Semantic consistency enables reuse of datasets by different actors (e.g. suppliers, third-party analysts).

4. **Technical:**
   - Based on a cloud-integrated platform with real-time data ingestion, monitoring, analytics, and AI-based parameter adjustment.
   - PLIADES enhancements bring in data spaces connectors, AI brokers, and quality assessment tools.
   - Emphasis on interoperability-by-design, preparing for integration with Gaia-X and other ecosystems.
   - Includes predictive maintenance, model lifecycle automation, and data security enforcement.

ISO/IEC 19941 Interoperability Facets

1. **Policy:**
   - Uses enforceable usage policies and governance models for data access, licensing, and monetization.
   - Prepared for flexible data-sharing contracts, including royalty-based revenue models.
   - Aligned with IDS Rulebook: sovereignty, consent, data-as-a-service frameworks, and usage control.
2. **Behavior:**
   - DENNDATA supports lifecycle workflows: data collection → monitoring → analytics → recommendations → sharing.
   - Workflow triggers (e.g. anomalies, vibrations) activate automated maintenance suggestions or stakeholder alerts.
   - Human-in-the-loop functionality supports real-time operational and analytical decision making.
3. **Semantic:**
   - Metadata includes machine state, energy usage, sensor diagnostics, lifecycle data, etc.
   - Future state includes harmonization across suppliers and customers, enabling enriched, cross-use semantics.
   - Uses ontological mapping and aligns with IDS Information Model for industrial data spaces.
4. **Syntactic:**
   - Data structured through internal schemas for sensors, machine logs, and KPIs.
   - Standardized formats will be extended for cross-platform exchange (e.g. JSON, XML).
   - Emphasis on data harmonization, aligned with PLIADES WP3 and WP6 outcomes.
5. **Transport:**
   - Data transferred securely via cloud infrastructure; evolving toward dataspace-compliant transfer protocols.
   - Future use of IDS connectors and Dataspace Protocol to support dynamic, trusted exchange.
   - Handles both real-time streaming and batch exports, with attention to bandwidth and device constraints.

4.2.2 Use Case 2. Integration of data life cycles of service robots to improve HRI with end users

Use Case #2 – Integration of data life cycles of service robots to improve HRI with end users

Data Space: *Healthcare*

Participants: *BOR, CERTH, I4ByDesign*

EIF Interoperability contribution

1. **Legal:**
   - The use case complies with key EU regulations such as the Medical Device Regulation (EU 2017/745) and GDPR.
   - Ensures data sovereignty, data ownership control, and usage policy enforcement through IDS-compliant frameworks.
   - CE marking, conformity assessments, and accountability models (product + professional liability) are integrated into the design, aligning with healthcare safety standards.
2. **Organizational:**
   - Multiple partners (BOR, CERTH, I4ByDesign) collaborate under predefined governance for data collection, annotation, and reuse.
   - Data provider and consumer roles are clearly defined, including the ability to update datasets.
   - AI-based brokers mediate data access, ensuring dynamic interoperability across robotic technology providers.
3. **Semantic:**
   - Data collected from diverse sensors (camera, LIDAR, microphones) are annotated and extended with semantic metadata.
   - Cultural and human factors are considered in the semantic alignment through context-aware analysis.
   - Future phases integrate semantic interoperability into AI-based data search and retrieval systems.
4. **Technical:**
   - Data is generated in real-time from robots and ingested into the PLIADES distributed data infrastructure.
   - Utilizes AI-based data brokering and AI-based connectors for dynamic and secure data exchange.
   - Planned data space integration will enable real-time search, filtering, and access to HRI training datasets across domains.

ISO/IEC 19941 Interoperability Facets

1. **Policy:**
   - Incorporates usage policies as part of metadata (ownership, access rights, and usage constraints).
   - Data consumers agree on predefined access rules when connecting to the dataspace.
   - Adopts principles from IDS usage control models to ensure compliance, transparency, and trust.
2. **Behavior:**
   - Supports complex workflows such as robotic data collection, filtering, synchronization, and annotation.
   - Future improvements will automate trigger-based data capture, enabling context-sensitive responses.
   - End-to-end lifecycle orchestration enables repeatable, verifiable processes for HRI model training.
3. **Semantic:**
   - Ensures shared understanding of context in HRI scenarios through semantic enrichment and human-in-the-loop labelling.
   - Embeds cross-organizational semantic consistency via metadata and ontological models, aligned with IDS Information Model.
4. **Syntactic:**
   - Uses structured data models and schemas for sensor data (e.g., time-series, video, depth maps).

- Harmonizes heterogeneous data formats via annotation and conversion layers in the PLIADES ingestion process.
- Aligns syntactic structure for compatibility with AI-brokered data discovery and ML-ready formats.

5. **Transport:**
   - Real-time and batch data transfer via secure channels; addresses bandwidth and storage constraints with edge streaming strategies.
   - Connector-to-connector communication based on IDS protocols ensures secure, traceable transfer.
   - Future use of the Dataspace Protocol will enable more agile and decentralized data transport mechanisms.

4.2.3 Use Case 3. Integrating Data Life Cycles of Personalized Medicine Services to Improve Diagnostic and Prognostic Clinical Prediction Models

Use Case #3 – Integrating Data Life Cycles of Personalized Medicine Services to Improve Diagnostic and Prognostic Clinical Prediction Models

Data Space: *Healthcare*

Participants: *MU-EPS, CICbioGUNE*

EIF Interoperability Contribution

1. **Legal:**

   Complies with EU MDR 2017/745, ISO 13485, ISO 14971, and IEC 62304. Anonymization of sensitive healthcare data is enforced. Explicit legal agreements and IP governance are required for onboarding new partners and ensuring regulatory compliance.

2. **Organizational:**

   Clear roles exist between MU-EPS and CICbioGUNE for data generation, processing, and usage. Collaboration across institutions is based on contracts and governed by processes that ensure data quality, privacy, and reproducibility.

3. **Semantic:**

   Semantic interoperability is driven by the use of the Proven Ontology Manager and metadata annotation. Ontologies enhance cross-institutional understanding and facilitate AI model integration with annotated and standardized biomedical concepts.

4. **Technical:**
   Java-based scripts handle data ingestion from NMR systems and other lab devices. Web platform offers APIs, dashboards, filtering tools, and supports federated ML pipelines. Supports structured and unstructured (NoSQL) data repositories

---

ISO/IEC 19941 Interoperability Facets

1. **Policy:**

Role-based access control and governance models are embedded in the platform. Data space infrastructure ensures traceability, compliance, and execution of pre-defined usage contracts.

2. **Behavior:**

AI-based services use federated learning and model sharing, reducing need for raw data exchange. Behavior logic is embedded into the pipelines for automation, explainability, and transparency.

3. **Semantic:**

Standard metadata schemas and ontologies facilitate semantic consistency in shared datasets and AI models. Semantic enrichment also supports cultural/contextual variation in personalized medicine

4. **Syntactic:**

Uses consistent file types (.JPG, .MP4, .XML, JSON) and database structures across labs. Standard APIs enable reliable data exchange and reduce transformation overhead

5. **Transport:**

IDS-compliant connectors ensure secure data sharing across institutional boundaries. Nextcloud is used for data upload. APIs support federated learning and AI model deployment across distributed environments.

4.2.4 Use Case 4. Integrating data life cycles of smart vehicles for CCAM operations and ADAS/AD functions

Use Case #4 – Integrating data life cycles of smart vehicles for CCAM operations and ADAS/AD functions

Data Space: *Mobility and Industrial*

Participants: CERTH, Taltech, UC3M, VICOM, BasqueCCAM, ZERO, AVL, CVUT,CEIT, PATRIC

EIF Interoperability Contribution

1. **Legal:**
   - Ensures compliance with GDPR and EU AI Act for data privacy and trust.
   - Incorporates Regulation (EU) 2022/1426 for type-approval of automated driving systems.
   - Aligns with ISO/SAE 21434 for cybersecurity in vehicle systems.
2. **Organizational:**
   - Defines clear roles for data providers (e.g., CERTH, UC3M, VICOMTECH), consumers (e.g., AVL, ZERO), and coordinators (e.g., VICOMTECH).
   - Supports governance through AI-based data brokering, agreements on usage rights, and access policies.
3. **Semantic:**
   - Introduces standardized annotation formats such as ASAM OpenLabel.
   - Uses Automotive Global Ontology (AGO) for unified semantic interpretation.
   - Plans shared metadata protocols to enhance discoverability.
4. **Technical:**
   - Uses IDS Connectors and AI-based brokering for data exchange.
   - Supports multimodal data formats (LiDAR, RGB, GNSS, CAN, etc.).
   - Implements edge/cloud pipelines and federated analytics for data processing.

ISO/IEC 19941 Interoperability Facets

1. **Policy:**
   - Enforces consent-driven data sharing with role-based access control.
   - Includes automated privacy filtering and data quality validation mechanisms.
2. **Behavior:**
   - Supports human-in-the-loop semi-automated annotation workflows.
   - Establishes structured pipelines for traffic prediction and ADAS decision-making.
3. **Semantic:**

- Utilizes ASAM OpenLabel and AGO for consistent meaning across datasets.
- Ensures cross-domain ontology mapping (mobility ↔ industrial).

4. **Syntactic:**
   - Promotes harmonized data formats (.JPG, .PNG, ROS, JSON-LD, XML).
   - Plans automated dataset conversion tools.
5. **Transport:**
   - Implements secure IDS Connectors for real-time and batch data sharing.
   - Employs MQTT, V2X protocols, REST APIs for inter-system communication.

4.2.5 Use Case 5. Integrating data lifecycles of WEEE/batteries management and car parts manufacturing operations

Use Case #5 – Integrating data lifecycles of WEEE/batteries management and car parts manufacturing operations

Data Space: *Green Deal and Industrial*

Participants: *SIPBB, LIBATTION, SBTC*

EIF Interoperability Contribution

1. **Legal:**
   - Compliance with the EU Battery Regulation, GDPR, and anticipated Battery Passport legal mandates.
   - Data exchange agreements explicitly ensure intellectual property protection, data traceability, and data sovereignty.
   - Use of data anonymization and role-based access controls to ensure legal integrity across all transactions.
2. **Organizational:**
   - Clear delineation of responsibilities:
     - LIBATTION as a data provider (battery lifecycle data).
     - SIPBB for digital twin development and integration.
     - SBTC and other partners consume data for analytics and manufacturing insights.
   - Established governance models within the data space ensure aligned goals and trust among stakeholders.
   - Cross-sectoral alignment is enabled by shared governance structures and interoperability agreements.
3. **Semantic Interoperability:**
   - Use of standard ontologies to annotate battery component metadata, lifecycle status, and environmental impact indicators.
   - Data is harmonized across domains via semantic metadata, ensuring consistent understanding of:
     - CAD model semantics.
     - Battery diagnostic logs.
     - Sustainability metrics and KPIs.
4. **Technical Interoperability:**
   - IDS-compliant connectors and secured APIs ensure secure and interoperable system integration.
   - Unified data schemas and standard file formats (e.g., STEP for CAD, JSON/CSV for logs) reduce integration friction.
   - Federated learning and analytics tools are integrated via cloud-native platforms, promoting seamless cross-domain analysis.

ISO/IEC 19941 Interoperability Facets

1. **Policy Interoperability:**
   - Access rules and usage licenses are embedded in metadata and governed by contractual agreements.
   - GDPR compliance and support for data usage control mechanisms.
   - Federated access supports cross-domain collaboration without violating data governance policies.
2. **Behavioral Interoperability:**
   - Autonomous pipelines manage:
   - Data logging and transformation from operational environments.
   - Trigger-based sharing mechanisms for high-priority lifecycle events (e.g., end-of-life signals).
   - AI-driven battery state estimation and predictive diagnostics are automatically triggered and logged.
3. **Semantic Interoperability:**
   - Domain-specific ontologies are used for:
     - Battery structure and components.
     - Recyclability and health status indicators.
     - Manufacturing traceability and part lineage.
   - Ensures consistent machine-readable interpretation across multiple stakeholders and systems.
4. **Syntactic Interoperability:**
   - Adoption of well-defined data formats:
     - CAD models in STEP.
     - Battery analytics and telemetry logs in JSON/CSV.
     - Annotation schemas in COCO/OpenLABEL for ML model training.
   - Enables automated parsing and integration across diverse platforms.
5. **Transport Interoperability:**
   - Data movement is handled via:
     - IDS-compliant connectors.
     - Secure, federated APIs.
     - Distributed data infrastructure for real-time and batch transmission.
   - AI-powered brokering supports discovery, matching, and routing of data assets across domains.

4.2.6 Use Case 6. Integrating professional service robot data life cycles to improve Human-Robot Interaction (HRI) with robot operators

Use Case #6– Integrating professional service robot datal life cycles to improve Human-Robot Interaction (HRI) with robot operators

Data Space: *Healthcare and Industrial*

Participants: CERTH, BOR, I4ByDesign

EIF Interoperability contribution

1. **Legal:**

The use case respects GDPR and AI Act provisions concerning personal data and operator privacy. Consent mechanisms are embedded in HRI data workflows. Licensing agreements govern shared robotic logs and training datasets.

2. Organizational:

Consortium members take on clearly defined roles: researchers (CERTH) and integrators (BOR, CERTH). Coordination frameworks guide dataset preparation, model development, and deployment in real-world industrial and healthcare scenarios.

3. Semantic:

Standard vocabularies are being harmonized across robotics and healthcare domains. Ontologies align robot kinematics, operator behavior, task sequences, and environmental factors. Work is underway to extend existing standards such as IEEE RAS Ontologies and healthcare HL7/ISO mappings for human-robot collaboration.

4. Technical:

ROS (Robot Operating System) and DDS are used for robotic middleware and data flow. Edge/cloud platforms support log processing and real-time analytics. AI-based annotation tools and robotic simulation environments are integrated through APIs. IDS-compliant connectors ensure secure data exchange.

ISO/IEC 19941 Interoperability Facets

1. Policy:

Access policies are enforced via roles (operator, researcher, integrator). Robotic logs with personally identifiable information (PII) are anonymized or protected through access rules. Usage agreements define purpose-specific data sharing, aligned with health and industrial compliance norms.

2. Behavior:

Data pipelines model interactions between robots and operators, covering handover tasks, gestures, safety stop scenarios, and feedback loops. Simulated behavior logs augment real-world HRI datasets to improve AI robustness.

3. Semantic:

Semantic consistency is ensured by applying cross-domain annotation schemas. Examples include task-level semantics (e.g., pick/place) and contextual tags (e.g., operator fatigue or motion intention). These enhance explainability in HRI analytics.

4. Syntactic:

Standard ROS bag files, JSON/CSV logs, and COCO/OpenLABEL formats are used for data collection and labelling. Annotation pipelines support structured metadata insertion. Syntactic consistency improves reusability across partner infrastructures.

5. Transport:

Data exchange relies on ROS/DDS messaging for live operations and REST APIs or MQTT for inter-platform communication. IDS connectors mediate access across health and industrial data spaces, enabling federated access to robot operation logs and trained HRI models.

5 Gaps Identified and Recommendations

Current interoperability frameworks such as the European Interoperability Framework show limitations when applied to cross-domain data spaces especially in decentralized, AI-driven, and dynamic data environments. These gaps restrict the ability to share, discover, and process data at scale and in real time.

Key gaps include:

- Limited mechanisms for runtime interoperability, such as real-time, declarative querying across federated systems.
- Insufficient support for advanced metadata models, which are essential for managing high-frequency, context-rich, and heterogeneous data. Relevant models in this context include: (1) Dynamic ontologies that evolve with domain knowledge and system states, (2) Event-based contextual metadata that captures time-sensitive, situational information (e.g., geolocation, environmental conditions, or user activity), (3) Self-descriptive mechanisms for IoT systems that allow edge devices to expose semantics, structure, and contextual data autonomously—enabling plug-and-play interoperability and on-the-fly integration.
- Lack of provisions for decentralized AI deployment, which is critical for privacy-preserving and edge-based processing.

Recommendations:

- Extend EIF and related frameworks to support runtime data access and semantic interoperability across heterogeneous systems.
- Define standard models and protocols for dynamic metadata exchange, enabling more granular data discoverability and integration.
- Integrate architectural support for decentralized and federated AI into interoperability guidance, ensuring compatibility with modern AI use cases.

The PLIADES project is positioned to bridge these gaps by operationalizing new interoperability standards and tools. It supports organizations in adopting next-generation data sharing infrastructures, making the shift to trusted, federated data ecosystems smoother and more accessible.

By enabling secure, seamless integration of data from multiple sources—across domains and borders—PLIADES addresses the business, legal, and technical barriers that hinder data reuse today. This unlocks new insights, accelerates innovation, and contributes directly to the EU's goal of building a robust, data-driven economy.

6 Synergies with EU Initiatives

The PLIADES project builds on and contributes to a wide range of EU-level initiatives, acting as a catalyst for interoperability, trust, and sovereignty in cross-domain data sharing. Its technical and governance frameworks are aligned with key European efforts such as IDSA, Gaia-X, DOME 4.0, SIMPL, and emerging standardisation activities. PLIADES not only leverages these initiatives but also contributes back through applied use cases, technical innovation, and active participation in knowledge-sharing platforms.

6.1 SEMIC

6.1.1 About SEMIC

SEMIC (Semantic Interoperability Community) is an initiative of the European Commission under the Interoperable Europe programme. Its goal is to advance semantic interoperability by providing reusable, standards-based assets such as XML schemas, ontologies, and taxonomies, primarily for cross-border public sector services. Originally developed under the IDABC programme, SEMIC supports the harmonization and reuse of interoperability assets to ensure that data exchanged across systems maintains its meaning and can be reliably interpreted by both humans and machines.

Semantic interoperability is a prerequisite for seamless cross-domain data exchange. SEMIC provides a public repository of interoperability assets and fosters a community of experts that share solutions, establish best practices, and drive convergence in semantic standards across Europe.

The Semantic Interoperability Centre Europe (SEMIC.EU) | Interoperable Europe Portal

6.1.2 3rd Workshop on Semantic interoperability in data spaces

PLIADES engaged in the 3rd Workshop on Semantic Interoperability in Data Spaces, organized by the International Data Spaces Association (IDSA), where SEMIC (DIGIT.B2) presented its ongoing work. This workshop reinforced the importance of aligning technical frameworks like PLIADES with public sector semantic specifications to enable robust data interoperability.

6.1.3 CAMSS meeting

IDSA engaged with the **Common Assessment Method for Standards and Specifications (CAMSS) project** [Common Assessment Method for Standards and Specifications (CAMSS)]. This collaboration helped PLIADES evaluate the relevance and quality of standards being considered for data space components, ensuring compliance with European-level assessments and alignment with public sector requirements.

6.1.4 ENDORSE 2025 participation

PLIADES will contribute to **ENDORSE 2025**—the European Data Conference on Reference Data and Semantics—organized by the Publications Office and Interoperable Europe. The theme, *"Reference Data and AI: Transforming Data into Action across Borders and Languages"*, aligns closely with PLIADES' goals. The conference provides a high-impact venue for exchanging practices in knowledge management, reference data, and semantic AI, which are all directly relevant to the project's

objectives.

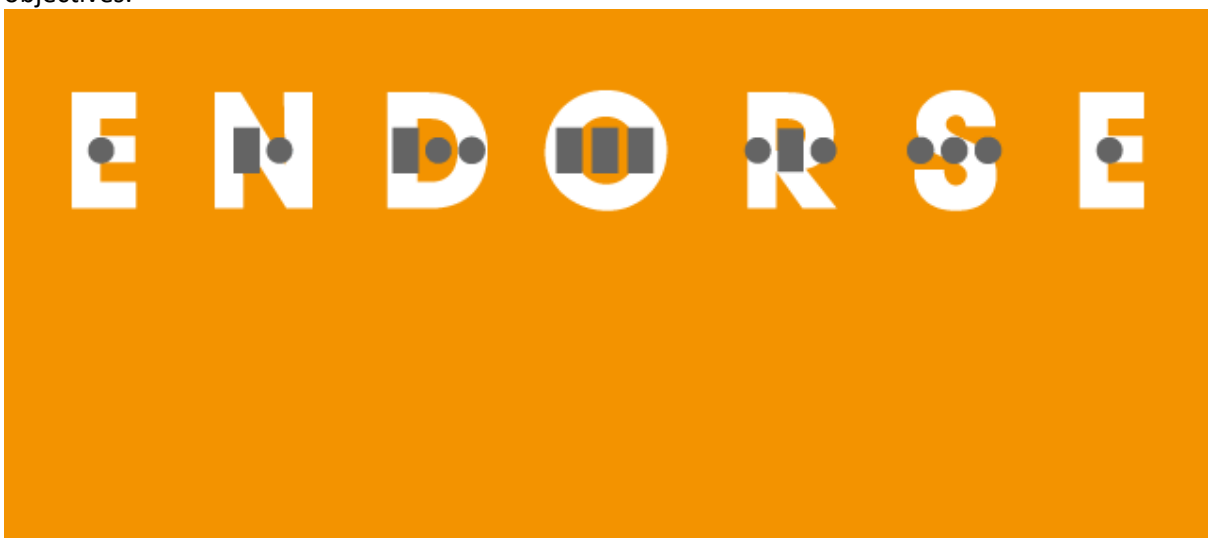


Figure 5 ENDORSE banner

6.1.5 SEMIC 2025 participation

Participation in **SEMIC 2025** will further deepen PLIADES' collaboration with the EU semantic interoperability ecosystem, ensuring that the project's technical outputs are consistent with SEMIC methodologies and support the long-term sustainability of data interoperability assets.

Semic Conference | Interoperable Europe Portal

Figure 6 SEMIC 2025 banner

6.2 DSSC Alignment

The **Data Spaces Support Centre (DSSC)** is a cornerstone of the European data strategy. PLIADES aligns with DSSC's Key Objective 2, which focuses on enhancing data privacy, trust, and sovereignty, and on extending existing standards to give individuals and organizations greater control over their data.

PLIADES addresses these goals by:

- Embedding data ownership and usage policies in its architecture
- Supporting decentralized identity management
- Enabling fine-grained, dynamic control over data access and usage
- Building upon principles from IDSA, Gaia-X, BDVA, and FIWARE

To contribute to DSSC Objective 3 (aligned with Key Objective 8), PLIADES pursues direct collaboration with the DSSC, leveraging shared partners such as IDSA, TNO, and KU Leuven—all active in both

initiatives. This coordination enables common structuring of data exchange formats, shared experiences from use case development, and consistent implementation of trust and governance principles across domains.

By adopting and promoting DSSC guidelines, PLIADES ensures that participants in its ecosystem comply with European regulations (e.g., GDPR, Data Governance Act, Data Act) while maintaining flexibility, scalability, and innovation potential. This synergy also supports EU-level policymaking and the development of data intermediation services that are secure, privacy-aware, and economically impactful.

7 Conclusions

The **PLIADES** project plays a pivotal role in advancing the European Interoperability Framework by delivering modular, secure, and AI-enabled data space architectures that support cross-domain and cross-border collaboration. Through detailed analysis of its use cases, the project demonstrates how interoperability can be achieved in practice across sectors like healthcare, manufacturing, mobility, green deal and industrial.

By evaluating each use case against the EIF's four interoperability layers and the ISO/IEC 19941 interoperability facets, the project provides a rigorous and actionable framework for assessing technical, legal, semantic, and behavioural alignment. These assessments reveal that while PLIADES use cases already exhibit strong conformance with interoperability standards, several strategic enhancements are needed to fully support dynamic, decentralized, and real-time data environments.

This deliverable identifies critical gaps in current interoperability models, particularly in support for federated AI, runtime semantic querying, and dynamic metadata management. It proposes practical improvements and architectural patterns that can evolve the EIF and related frameworks to meet the demands of modern data ecosystems.

Furthermore, the project establishes strong synergies with key European initiatives such as DSSC, SEMIC, and the European Trusted Data Framework, reinforcing its commitment to open standards, semantic alignment, and legal compliance. Through these connections, PLIADES ensures that its results are both reusable and scalable beyond the project's scope.

In conclusion, PLIADES does not merely comply with interoperability standards; it actively contributes to shaping their evolution. It empowers organizations to adopt trusted, sovereign data-sharing practices and helps accelerate the development of a secure, efficient, and innovation-driven European Data Economy.

8 Appendix

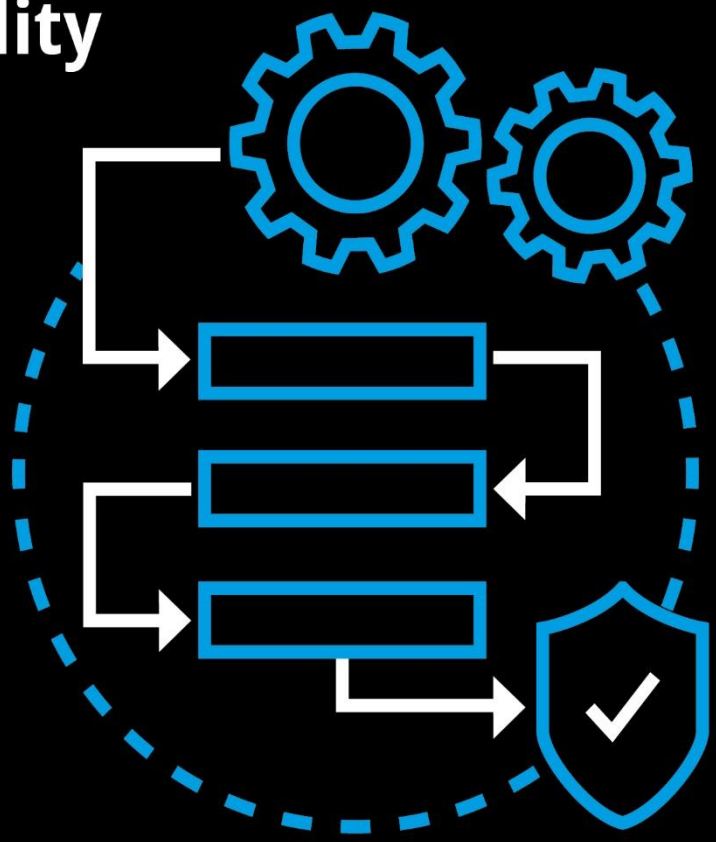
IDSA Standardisation paper – Europe and International.

First version of the paper before publication – This version is part of the deliverable not for publication.

INTERNATIONAL DATA SPACES ASSOCIATION

Position Paper | July 2025

Aligning international standards for data space interoperability



- (●) Position Paper of members of the IDS Association and of the IDS-Industrial Community
- ( ) Position Paper of bodies of the IDS Association
- ( ) Position Paper of the IDS Association
- ( ) White Paper of the IDS Association

PLIADES

This document provides an overview of the standardisation concepts related to Dataspaces. The content provided in this document is based on contributions from experts working on IDSA working groups and the following IDSA documents

Contributing Projects

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Table of content

List of figures

1 Executive summary

This paper explaains the strategic importance of standardization developing and implementing data spaces, with a particular focus on the role of the International Data Spaces Association (IDSA) and its alignment with European and international standardization initiatives.

Data spaces rely on shared standards to enable secure, interoperable, and sovereigndata sharing between organizations. This paper highlights key technical and governance-related areas where standards are essential: data discovery, identity and access management, semantic interoperability, contract negotiation, and conformity assessment. It draws on work by IDSA and its members, who have developed core components such as the IDS Reference Architecture, the Dataspace Protocol, and the IDSA Rulebook.

The paper also surveys the current standardization landscape, including ongoing efforts within ISO/IEC JTC 1 SC38, CEN/CENELEC JTC 25, the IEEE P3800 working group, and initiatives like the European Trusted Data Framework. It underscores the impact of regulations such as the EU Data Act, the Data Governance Act, and the AI Act, which introduce new requirements forinteroperability, trust, and technical infrastructure in data exchange.

Due to time constraints, this paper focuses on European regulations. In the future, we plan to expand it to include international regulations and laws that may introduce additional standardization requirements at the global level.

An analysis of standardization gaps reveals the need for further work in metadata governance, usage control, ontology alignment, and cross-sector interoperability. This gap analysis intended to inform the ongoing efforts of JTC 25 and related committees.

Overall, the paper positions IDSA as both a contributor and a connector—bridging industry practice and regulatory objectives and offering guidance to standardization bodies based on real-world implementation experience.

2 Motivation and scope of the paper

IDSA is well positioned to communicate developments in data space standardization, especially within ISO/IEC JTC 1/SC 38 – Cloud Computing and Distributed Platforms, and CEN/CENELEC JTC 25 Data Management, Dataspaces, Cloud and Edge. The IDSA community has a strong interest in these topics and seeks further information.. The paper aims to offer general information and guidance for a broad audience. This includes references to publicly available sources from ISO/IEC, CEN/CENELEC and the European Commission, as well as IDSA documents contributing to data spaces standardization.

2.1 Scope and purpose of the document

The objective of this report is to highlight the critical importance of standardization within data spaces, emphasizing its role in enabling trusted data sharing, interoperability, and operational efficiency.

The report presents a vision to shapethe future data economy through the development of international standards for data spaces. These standards are vital to ensure sovereign and trustworthy data sharing, particularly as demanded by European stakeholders. Moreover, they enable interoperability across the global landscape, which is indispensable for fostering a connected and efficient data ecosystem.

Standardization plays a pivotal role in the global exchange of data. It harmonizes technical specifications, reducing barriers to data sharing and enhancing global trade. Businesses benefit from standardization as it helps by reducing costs, facilitates entry into global markets, and ensuring the delivery of high-quality products. Additionally, standardization supports innovation, minimizes research and development risks, and promotes environmental sustainability. To stay competitive, companies must influence regulations and adapt to market trends, both of which are facilitated by active participation in standardization efforts.

Standards are also recognized as a key tool for reducing technical barriers to trade. According to the WTO Agreement on Technical Barriers to Trade (TBT), international standards enhance production efficiency and facilitate international trade, provided that technical regulations are not used to create unnecessary obstacles [WTO TBT Agreement, Articles 2 and 4[1]]. The European Commission also emphasizes that avoiding unjustified trade restrictions is essential for maintaining a strong, transparent, and rules-based multilateral trading system[2].

The motivation behind this data spaces standardization paper is to serve as a comprehensive reference, capturing the latest developments and insights in the field to build awareness and alignment among the IDSA community and other stakeholders, ensuring a unified understanding of key data spaces standardization aspects. The report also aims to identify gaps in existing standards that should be addressed by IDSA and standardization committees, thereby fostering improved standardization efforts.

The paper is intended for data spaces experts, stakeholders, projects, initiatives, and standardization committees. Experts will find it a valuable resource for enhancing their knowledge. Stakeholders, including businesses and European Commission (EC) projects, can use it to align strategies with standards. Standardization committees focused on areas such as

[1] World Trade Organization. *Agreement on Technical Barriers to Trade*, Articles 2 and 4. Available at: https://www.wto.org/english/docs_e/legal_e/tbt_e.htm#art4

[2] European Commission. *Technical Barriers to Trade*. Available at: https://policy.trade.ec.europa.eu/help-exporters-and-importers/accessing-markets/technical-barriers-trade_en

artificial intelligence, interoperability, and cybersecurity will benefit from the insights to integrate data spaces standards into broader regulatory frameworks.

Help us improve this paper

This paper can be updated in the future based on feedback and comments received after publication, especially regarding gaps in data space standardization. If you have any suggestions or comments on the paper, please provide them using this form.

2.2 Scope of data spaces standardization

2.2.1 Need for standardization in data spaces

The standardization of data spaces is essential to ensure interoperability, trust, and efficiency in data sharing ecosystems. Key areas of standardization include foundational concepts and terminology, the core functions required for data space operation, and technical specifications and protocols needed to achieve interoperability. The International Data Spaces Association (IDSA) plays a central role in this effort by defining and developing the especifications that enable trustworthy and interoperable data sharing.

2.2.2 Key areas of standardisation in data spaces

While data spaces are a domain-agnostic and cross-sectoral by nature, they require a common, horizontal foundation of standards to enable trusted data sharing. These horizontal standards must be complemented by domain-specific standards that address sector-specific requirements. This report focuses on the key areas of common standardization in data spaces, without aiming to be an exhaustive list.

Data space principles and characteristics

A clear definition of what constitutes a data space is essential for shared understanding among stakeholders. This includes principles such as full autonomy, digital self-determination or digital sovereignty (explained later on chapter 3.3) over their data., decentralization, and neutrality[3], which distinguish data spaces from traditional data-sharing approaches.

Establishing trust

[3] Steinbuss, S., Spiekermann, M., Koen, P., The Data Space Manifesto, International Data Spaces Association, 2025 https://doi.org/10.5281/zenodo. 15190876

Trust is a fundamental requirement in data spaces, ensuring that data providers and consumers can engage securely. Standardization is required for identity management, trust frameworks, participant authentication, and access control policies.

Semantic interoperability through ontologies and vocabularies.

Different organizations and industries use diverse data models and terminologies. Standardization in data spaces ontologies, vocabularies, and semantic data models is necessary to enable meaningful data sharing across different domains and data spaces.

Data discovery

For an efficient data economy, participants must be able to discover relevant data assets. This requires standardized specifications to publish metadata models, registries, and indexing mechanisms that allow efficient search and retrieval.

Data contract negotiation and agreement.

Data offer needs to be negotiated, which specifies all policies and details of the data sharing process, also how the data sharing process is executed. Standardized specifications that define common schemes and protocols for entities to publish data, negotiate agreements, and access to the data.

Interoperability

To connect heterogeneous systems and avoid fragmentation, participants in a data space need to communicate in an interoperable way with the data spaces in which they participate, but also across multiple data spaces following common standards and principles.

Governance framework

Data spaces rely on governance frameworks that, based on participants' requirements, define the strategies, policies, decision-making structures, and accountabilities through which data sharing is organized and managed. Rather than standardizing governance itself, IDSA can support this by providing templates and best practices. *Conformity with technical regulations and standards*

The conformity of data space participants with the regulations and standards applied is crucial. In this regard, Data Space standards need to enable conformity assessment schemes. This is the foundation for certification mechanisms that ensure that data space participants, components, and connectors adhere to security, interoperability, and legal requirements, where applicable. Standardization and conformity testing processes foster trust and widespread adoption.

Non-covered areas in IDSA standardization

General data governance and internal data management: activities such as data quality assurance, internal policies, and access control are essential prerequisites for data sharing but fall outside the scope of IDSA standardization. Data usage practices: IDSA does not standardize operational aspects of data sharing, provenance, or usage guidelines.

Data trading and marketplaces: anything to add here

Cybersecurity and information security: idem

Emerging technologies (Artificial Intelligence and digital twins, IoT): while connected to data spaces, these technologies are not standardized by IDSA.

Reference architecture: idem

Domain-specific standards: IDSA does not cover domain-specific standards, such as sector-specific data spaces, industrial semantics, or metadata models.

2.3 Standardization gaps for data spaces

In this chapter, we have presented an initial first assessment to identify gaps in data space standardization. These gaps are based on ongoing activities in different groups and the European Commission's standardization request. The work will be continued by CEN/CENELEC JTC 25 (see more details in Chapter 4.4 and chapter 4.5 for more details).

Guiding principles for standardizations in data spaces

Data space concepts and characteristics that need to be standardized include aspects such as establishing trust, governance and interoperability aspects, metadata definition, discover data, negotiation and establishing contracts, share data and use data, observability, semantic models and vocabularies, and communication protocols.

In determining what aspects of data spaces require standardization, it's crucial to consider a set of criteria to guide the process effectively. These criteria help delineate between elements that necessitate precise technical specifications and those that may benefit from broader standardization efforts.

Firstly, there are components within data spaces that demand clear technical specifications for seamless interoperability. For instance, the control planes defined in the Dataspace Protocol serve as pivotal elements facilitating technical interoperability among various data spaces.

Standardizing this aspect ensures that data sharing, access control, and governance mechanisms function harmoniously across disparate platforms and across the governance frameworks of data spaces.

Conversely, certain aspects of data spaces, such as the data plane, may warrant a more expansive approach to standardization. The data plane encompasses diverse data communication protocols essential for transmitting and processing data within data spaces. Given the multitude of protocols available, establishing a single standard may prove impractical. Instead, embracing a framework that accommodates multiple standards fosters environments.

By adhering to these criteria, stakeholders can prioritize standardization efforts effectively, ensuring that the resulting standards align with the diverse needs and complexities inherent in modern data ecosystems.

2.3.1 Standardisation gaps for Europe data economy

This chapter identifies the standardisation needs and gaps in key standardisation areas such as data governance, data discovery, data sharing, data usage and policies, data spaces interoperability, data quality and master data in data spaces and cloud and edge computing interoperability.

IDSA is addressing these gaps coming from needs and requirements from data spaces implementations from members and will continue this scan for more data spaces standardization gaps in areas such as (Finalize with further investigation by IDSA is part of its ongoing work). The data space user group[4] is an opportunity for end users to provide requirements based on their needs .

Key standardization gaps in data spaces include:

- The need for governance frameworks for metadata (e.g., DCAT profiles) and protocols for data discovery and notifications.
- Trusted data transactions require rulebooks, secure exchange protocols, integration with initiatives like the EU Digital Identity Wallet, and machine-readable expressions of usage terms and consent.
- In terms of data usage, gaps exist in ontology governance, quality criteria, consistent policy implementation, and standards for data usage monitoring.
- Finally, achieving full data space interoperability calls for common concepts, maturity assessment tools, cross-sector and cross-border standards, and frameworks that support digital sovereignty within the EU.

[4] https://internationaldataspaces.org/data-space-user-group/

About the European Commission's standardization request.

The current Standardization Request (SReq) from the European Commission addresses Article 33(1) of the EU Data Act, Regulation (EU) 2023/2854, which defines essential requirements for data interoperability, data sharing mechanisms and services, and the establishment of common European data spaces. The SReq calls for the development of seven European standardization deliverables by CEN, CENELEC, and ETSI, including:

- 4 European Standards – 2 of which will be offered for citation in the Official Journal of the European Union (OJEU) to support the implementation of Article 33.
- 3 Technical Specifications.

These deliverables aim to support the rules on fair access to and use of data as outlined in the Data Act, ensuring equitable value distribution among participants in the data economy.

The figure below outlines the proposed standards and technical specifications, their deadlines for adoption, and the expected allocation among standardization bodies:

Table 1: list of new European standards and European standardization deliverables to be drafted and deadlines for their adoption

	Reference information	Deadline for the adoption by the ESOs
1	Harmonised standards on Trusted Data Transactions Part 1: Terminology, concepts and mechanisms	1 June 2026
2	Harmonised standards on Trusted Data Transactions Part 2: Trustworthiness requirements	1 November 2026
3	Harmonised standards on Trusted Data Transactions Part 3: Interoperability requirements	1 May 2027
4	Technical specification(s) on a data catalogue implementation framework	1 March 2026
5	Technical specification(s) on an implementation framework for semantic assets	1 September 2026
6	European standard on a quality framework for internal data governance	1 March 2027
7	Technical specification(s) on a maturity model for Common European Data Spaces	1 September 2026

Further details can be found in section 4.3: *European Trusted Data Framework.*

List of new European standards and European standardisation deliverables to be drafted and deadlines for their adoption

3 Selected international standardisation on data spaces

3.1 Aligning IDSA with standardization efforts

Given the IDSA's established role as de facto standards for data spaces, aligning its assets with relevant International and European standardization bodies is essential to foster broad market adoption and support the maturation of the technology.

At IDSA, standardisation is a strategic priority. Our members, working groups and the standardization coordination group, together with the IDSA Head Office, actively engage with key organizations such as ISO, CEN/CENELEC, IEEE and W3C on shaping global standards for data spaces.

These standardization efforts are driven by the dedication of IDSA members and technical experts, who play a leading role in standardization committees, shaping the technical foundations of data spaces. At the core of these efforts are the IDS Reference Architecture Model, the IDSA Rulebook, and the Dataspace Protocol - key frameworks that define technical specifications and ensure interoperability.

3.2 ISO/IEC DIS 20151 dataspaces concept and characteristics

3.2.1 Introduction

ISO/IEC DIS 20151 is a draft international standard titled "Dataspace Concepts and Characteristics". Its goal is to define core data space concepts and essential characteristics in a way that applies to all organizations. (*source* ISO/IEC 20151)

ISO/IEC 20151 was started at the end of 2023 as a new project in ISO/IEC JTC1 SC38. During 2024, the project provided several working drafts, which led to a committee draft in 2024. The project is closely aligned with the developments in International Data Spaces, the Data Spaces Support Centre, the Eclipse Dataspace Working Group, and other relevant initiatives.

The International Data Spaces Association (IDSA) has played a crucial role in laying the groundwork for this standard. While IDSA has previously developed guidelines such as the IDS Reference Architecture Model, the IDSA Rulebook, and Dataspace Protocol, these are good guiding documents rather than official standards. The ISO/IEC I20151 aims to formalize these concepts, addressing existing gaps by clearly defining data spaces, their key characteristics, and optional features (*source: internationaldataspaces.org*).

3.2.2 Status and expected timeline

Status: Under development**Stage**: DIS [40.00] (see also https://www.iso.org/stage-codes.html)

Edition: 1

It moved to the Enquiry stage (see also https://www.iso.org/stage-codes.html) during spring 2025 by ISO/IEC JTC1 SC38 WG6.

As of November,25th, 2024, the standard reached the Committee Draft (CD) stage and, on May 12th, 2024, Enquiry stage, meaning a draft is currently under review and voting within the committee. This phase involves extensive collaboration among international experts to ensure the standard covers critical aspects such as data sovereignty, interoperability, and trust in data-sharing ecosystems.

The final publication of ISO/IEC 20151 is expected in summer 2026, offering industries and governments a standardized guidance for implementing trusted data-sharing solutions. This marks a major step toward formalizing data space concepts and promoting secure, efficient data sharing across various sectors.

3.2.3 Scope

The value created through the use of data has become a key component of modern economies and is now deeply integrated into every part of an organization and the ecosystems it operates in—such as supply chains, marketplaces, and regulatory environments. While organizations can ensure the quality and trustworthiness of the data they produce, much of the data they rely on comes from other organizations. Likewise, data they generate is often used by others.

To ensure consistent quality and trust across these ecosystems—and to uphold the associated rights and responsibilities—a reliable method for sharing data is required.

Dataspaces enable trusted data sharing by providing both multi-organization agreements and supporting software services. They offer clear descriptions of the data available for sharing and define how that data may be used. This transparency allows data providers and consumers to make informed decisions, improving both data operations and overall governance.

ISO/IEC JTC 1/SC 38, focused on cloud computing and distributed platforms, is developing the ISO/IEC 20151 standard to address dataspace concepts and characteristics.

ISO/IEC 20151 defines the foundational concepts and key characteristics of data spaces. This document is intended for use by all types of organizations.

The graphic below illustrates the key features and components of data spaces, which enable trusted data sharing across organizations. By clarifying data descriptions and agreed-upon

usage terms, data spaces help maintain control, build trust, support interoperability, and ensure transparency. They also include essential functions such as policy management, semantic modeling, and communication protocols to orchestrate secure and effective data exchange.

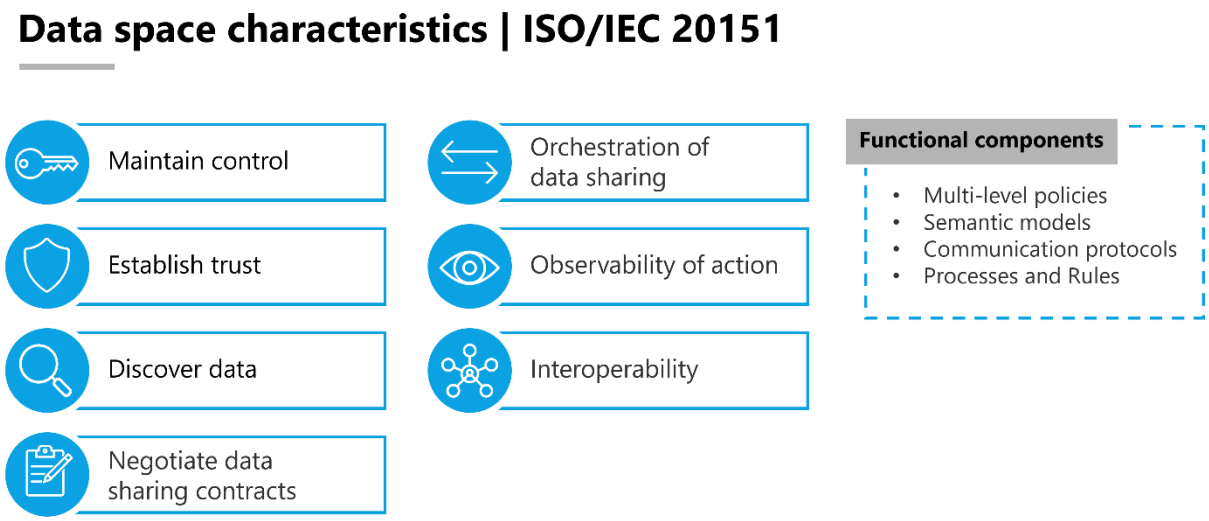


Figure 1. Dataspace characteristics on ISO/IEC 20151

3.2.4 Why is this important

ISO/IEC CD 20151 Dataspace concepts and characteristics covers the fundamental aspects of Data Spaces, as described in the IDSA Rulebook (link). It connects the topic of Data Spaces to other relevant work in the field, like Organizational Autonomy and Organizational Interoperability, but most importantly, it defines the key concepts of data spaces. Based on this work, data spaces can be clearly distinguished from other data-sharing approaches like data lakes, data intermediaries, or data marketplaces. Based on ISO/IEC 20151, future work is required to further define the aspect of multi-level policies as a foundation for data spaces and the need for semantic interoperability from various perspectives.

3.3 ISO/IEC 10866 organizational autonomy & digital sovereignty

3.3.1 Introduction

This ISO/IEC TS 10866:2024, titled "Information technology — Cloud computing and distributed platforms — Framework and concepts for organizational autonomy and digital sovereignty," is a technical specification that defines the intersection of digital sovereignty, organizational autonomy, and digital platforms. The standard provides a structured framework to assist organizations and policymakers understand, implement, and manage these concerns withing could service and distributed platforms.

3.3.2 Status and expected timeline

Status: Published

Publication date: 2024-11

Stage: International Standard published [60.60]

Edition: 1

Number of pages: 16

No further development expected at the moment, will undergo the systematic review 3 years after publication.

Published in 2024, this technical specification is available for purchase through recognized standardization bodies, including the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). iso.org

3.3.3 Scope

This section is part of the public introduction on this Technical Specification and can be found here https://www.iso.org/obp/ui/en/#iso:std:iso-iec:ts:10866:ed-1:v1:en .

Organizational autonomy and digital sovereignty are important, complex and evolving subject areas whose implications have expanded in recent years, as organizations of all types address the challenges inherent to supplying and procuring digital capabilities in evolving environments.

Government objectives and policies can often be addressed through public or private partnerships, as these governments increasingly rely on industry to help address these goals to increase their prosperity while maintaining an appropriate degree of control and independence.

Since the same issues of independence and freedom of action and choice also apply to organizations – including private, public sector and not-for-profit – it is possible that such organizations will need to consider their own independence to achieve their goals.

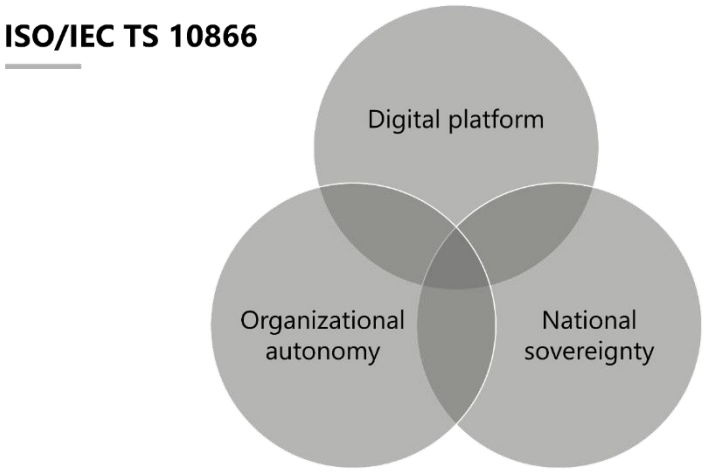
This document defines a framework for understanding and evaluating the implications of digital sovereignty requirements and restrictions on the organization. It describes how the organization can configure its digital platform to appropriately balance those requirements with its own need for organizational autonomy to achieve its goals. The framework may be used by the organization itself, or by the policy makers and regulators of a sovereign entity

which desire to examine the consequences of proposed digital sovereignty requirements and restrictions on organizations and industries.

The audience of this document includes:

1. Organizational leaders (e.g. Chief Information Officer, Chief Data Officer and Chief Compliance Officer), business or technical decision makers and digital platform architects who configure the organization's digital platform to ensure it has the right balance of digital autonomy to support and enable the goals of the organization to be achieved.
2. Policy makers and regulators who wish to understand the impact of digital sovereignty and autonomy matters.

This document is applicable to all organizations and policymakers dealing with organizational autonomy and digital sovereignty in cloud-based services and distributed platforms. The standard outlines how sovereignty concerns arise and intersect across these three dimensions, which are visually represented in Figure 1 of the document.



Source: ISO/IEC 10866

Figure 2: Digital sovereignty matters addressed by organizations

The document addresses sovereignty matters that: a) are imposed by governments; b) affect organizations (including private, public, and non-for-profit organizations); and c) impact the digital platforms that organizations use to support and enable their goals. This is shown as the intersection in Figure 2 of the document.

The document highlights:

- Terms and core concepts.

- How to determine the desired degree of organizational autonomy.
- How to apply the framework, and examples of the framework being applied.

For more detailed information, including purchasing options, you can visit the ISO website and also view the IDSA webinar on https://internationaldataspaces.org/archive/

3.3.4 Why is this important?

This standard helps define how organizations can categorize, classify, and set usage conditions for data, ensuring compliance with regulatory requirements, governance policies, and cross-border data-sharing considerations. The framework supports a systematic approach to structuring digital capabilities within data spaces, ensuring that data is secure, trusted, and aligned with sovereignty principles.

As an example, in the food service supply chain, trusted data sharing is crucial for food safety, traceability, and compliance. ISO/IEC TS 10866 helps organizations define organizational autonomy, classify food-related data, and set usage conditions for sharing sensitive information like ingredient sourcing and quality assurance. By applying this framework, stakeholders—from producers to regulators—can ensure secure, transparent, and compliant data sharing within a trusted data space.

This framework establishes a foundation for data spaces as trusted data-sharing environments, allowing industries and governments to manage cross-border data flows, classification, and jurisdictional laws while ensuring compliance with national and international regulations. It defines access and security policies, supports industry-specific governance models, and addresses sovereignty-related concerns within data spaces. Organizations must carefully manage sovereign data sharing by adhering to government regulations, governance requirements, and digital platform policies to ensure secure, compliant, and interoperable data sharing.

The IDSA Rulebook sets out foundational principles that closely align with ISO/IEC TS 10866, emphasizing the critical role of data sovereignty and organizational autonomy in data spaces. Key principles include:

- **Self-determined data usage**: Data sovereignty, as highlighted in ISO/IEC TS 10866, should underpin every data space, ensuring that participants retain full control over how their data is accessed and used.
- **Organizational autonomy**: Each organization should operate independently, making its own decisions about data sharing and usage.

Control over data assets: Participants must maintain ownership and define access and usage policies for their data within secure and trusted environments.[5]

3.4 ISO/IEC 19941 Interoperability & portability

3.4.1 Introduction

ISO/IEC 19941:2017 is an international standard that provides a common framework for understanding interoperability and portability in cloud computing. It defines key concepts, types, and relationships involved in enabling cloud services to work together and in allowing data or applications to move across cloud environments. Aimed at cloud service customers (CSCs), providers (CSPs), and partners (CSNs), the standard clarifies how interoperability supports integration and service composition, while portability addresses concerns such as vendor lock-in and migration efficiency. Cloud computing is defined as a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand. ISO/IEC 17788 and ISO/IEC 17789 provide a foundational understanding of the various types of interoperability and portability, their relationships with cloud activities and roles, and the types of cloud capabilities. By establishing shared terminology and guidance, ISO/IEC 19941 helps stakeholders evaluate and implement cloud solutions that align with their technical and business goals.

3.4.2 Status and expected timeline

Status: Published

Publication date: 2017-12

Stage: International Standard to be revised [90.92]

Edition:1

Number of pages: 65

This standard is undergoing the systematic review and will be updated during 2025 by ISO/IEC JTC1 SC38 WG6.

The electronic version of this International Standard can be downloaded from the ISO/IEC Information Technology Task Force (ITTF) web site.

[5] *IDSA Rulebook – Interoperability Chapter*

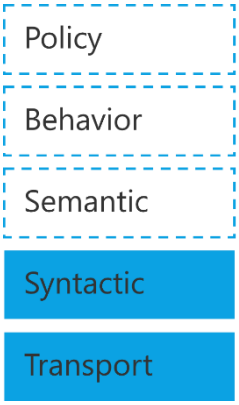


Figure 3: ISO 19941 - Cloud Computing Interoperability and Portability

3.4.0 Scope

This document specifies cloud computing interoperability and portability types, the relationship and interactions between these two cross-cutting aspects of cloud computing and common terminology and concepts used to discuss interoperability and portability, particularly relating to cloud services.

This document is related to other standards, namely, ISO/IEC 17788, ISO/IEC 17789, ISO/IEC 19086-1, ISO/IEC 19944, and in particular, references the cross-cutting aspects and components identified in ISO/IEC 17788 and ISO/IEC 17789 respectively.

The goal of this document is to ensure that all parties involved in cloud computing, particularly CSCs, CSPs and cloud service partners (CSNs) acting as cloud service developers, have a common understanding of interoperability and portability for their specific needs. This common understanding helps to achieve interoperability and portability in cloud computing by establishing common terminology and concepts.

Key Aspects of ISO/IEC 19941:2017:

- **Interoperability:** The ability of two or more systems or applications to exchange information and mutually use the information that has been exchanged.
- **Portability:** The ability to move data or applications from one cloud service to another or between a cloud service and a customer's system.

The standard introduces a facet model to describe the cloud interoperability facet model, which defines five facets within the context of cloud interoperability: transport, syntactic, semantic data, behavior, and policy (see Figure 3).

Transport interoperability refers to the exchange of information using an established communication infrastructure between participating systems. Syntactic interoperability means

that the formats of exchanged information can be understood by the participating systems. Semantic data interoperability pertains to the understanding of the meaning of the data model within the context of a subject area by the participating systems. Behavioural interoperability ensures that the actual result of the exchange achieves the expected outcome. Policy interoperability involves compliance with the legal, organisational and policy frameworks applicable to the participating systems.

3.4.1 Why is this important?

Interoperability on various levels is a key concern of data spaces. It is about interoperable systems, but likewise about interoperable organizations that collaborate with each other. ISO/IEC IS 19941's facets on Interoperability provide guidance to structure the problem of interoperability into aspects that will be realized by systems, i.e., Dataspace Connectors, aspects that require organizational measures, and those aspects that are covered by various policies.

Furthermore, ISO/IEC IS 19941 defines the facets for Data Portability, which is part of the ultimate goal of data space participants, as the combination of syntax, semantics, and policies. Data needs to be processable and understandable by data consumers and users, but for Data Spaces, it is of utmost importance that rights and obligations, the policies, which are related to the data, are also portable, understandable, and executable by data consumers and users.

The *Interoperability* chapter of the IDSA Rulebook defines interoperability as the ability of systems and organizations to exchange and use data, based on shared standards, governance, and trust. It introduces key concepts like connectors, data contracts, and certification to enable secure and sovereign data sharing.[6]

3.5 About ISO/IEC JTC 1 SC38 and relevant resources

3.5.1 General and work plan

ISO/IEC JTC 1 Subcommittee 38 was established with a focus on Distributed Application Platform and Services with the following scope and area of work.

ISO (the International Organization for Standardization) and (the Internatisonal Electrotechnical Commission) form the specialized system for worldwide standardization. National Bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organizations to deal with particular fields of technical activity.

[6] Read more here: https://docs.internationaldataspaces.org/ids-knowledgebase/idsa-rulebook/idsa-rulebook/3_interoperability (*Source: IDSA Rulebook – Chapter 3: Interoperability*)

ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, government and non-governmental, in liaison with ISO and IEC also take part in the work.

In the field of information technology, ISO and IEC have established a Joint Technical Committee 1: ISO/IEC JTC 1 on Information Technology. In November 2009, JTC 1 established a new Subcommittee 38 on Distributed Application Platform and Services (DAPS).

3.5.2 Proposed area of work

Standardization for interoperable Distributed Application Platform and Services including:

- Web Services,
- Service-Oriented Architecture (SOA), and
- Cloud Computing

The Subcommittee was renamed to Cloud Computing and Distributed Platforms and the scope (https://www.iso.org/committee/601355.html) was adjusted as follows to Standardization in the areas of Cloud Computing and Distributed Platforms including:

- Foundational concepts and technologies,
- Operational issues, and
- Interactions among Cloud Computing systems and with other distributed systems

ISO/IEC JTC 1 SC 38 serves as the focus, proponent, and systems integration entity on Cloud Computing, Distributed Platforms, and the application of these technologies. ISO/IEC JTC 1 SC 38 provides guidance to JTC 1, IEC, ISO and other entities developing standards in these areas.

The detailed work program of SC38 can be found here: https://www.iso.org/committee/601355/x/catalogue/p/0/u/1/w/0/d/0, but in relation to the work on data spaces, this document will focus on three items from the work program, namely CD 20151, IS 19941 and TS 10866.

The success of standardization activities depends, among other factors, on strong collaboration with external partners and other standardization committees. SC38 is well connected to related initiatives to ensure that its standards are of high quality and aligned with broader developments in the field of Data Spaces. The work of SC38 is closely aligned with the Eclipse Dataspace Working Group (EDWG) through an active liaison with the Eclipse Foundation. In addition, to ensure that IoT and digital twin aspects are effectively integrated with the cloud dimension of data spaces, SC38 maintains a liaison with ISO/IEC JTC 1/SC 41 - Internet of Things and Digital Twin- ((https://www.iso.org/committee/6483279.html)). These connections help ensure coherence and alignment with related standards, including ISO/IEC 20151.

3.6 IEEE Data trading systems WG

The IEEE P3800 initiative plays a key role in developing frameworks for data transaction systems and data marketplaces, with the goal of fostering global collaboration on data exchange standards.

At the core of this initiative is the IEEE P3800 standard for a data trading system, which establishes a unified architecture for trading data through domain-independent and principled marketplaces. This standard defines a common terminology, a reference model, and outlines the roles and responsibilities of key stakeholders, including data providers, data users, and data marketplaces. It offers a high-level overview of data trading systems using its reference model, which is based on the International Data Spaces Reference Architecture Model (IDS-RAM 4).

The IEEE P3800 family of standards includes:

- **IEEE P3800.1** – *Specification of the Connector*: Defines the technical interface for connecting participants within the data trading system. This project has recently been initiated.
- **IEEE P3800.2** – *Specification of Data Usage Rights*: Establishes a standard format and approach for expressing and managing data usage rights across marketplaces.

It is important to note that IEEE P3800 operates under an individual participation model, meaning that only individuals—not organizations—may contribute to its development. While we are actively monitoring the progress of this standard, our primary focus remains aligned with standardization activities within **ISO/IEC JTC1 SC38**.

The IEEE P3800 standard, titled *Standard for a Data-Trading System: Overview, Terminology and Reference Model*, was officially published in 2024.

4 European Standardization

4.1 Overview

There are three European Standardisation Organizations (ESO): CEN (Comité Européen pour la Normalisation), responsible for all areas except electrotechnology and telecommunications, CENELEC (Comité Européen de Normalisation Électrotechnique) for electrotechnology, and ETSI (European Telecommunications Standards Institute) for telecommunications. Digitalisation topics are a typical junction zone for which the ESOs have established various cooperation schemes.

Standardisation for the data economy and data interoperability is quickly gaining traction. The Data Act, Data Governance Act, Cyber Resilience Act are driving forces behind this trend, and the European economy as a whole increasingly relies on the uninhibited flow and exchange of data.

4.2 European Trusted Data Framework

4.2.1 Introduction to the legislation request for standardisation.

The European Commission's 2024 Annual Union Work Programme (AUWP)[7] for European Standardisation introduces the "EU Trusted Data Framework" as a new priority action (Action 10) to support the implementation of the Data Act. This initiative aims to create a trusted environment for data sharing across the European Union, increasing data availability and fostering innovation. It is part of a broader strategy to establish Common European Data Spaces in key sectors such as health, environment, energy, agriculture, and mobility.

This action calls for the development of a comprehensive set of standards to ensure secure and legally compliant data exchange between different parties, including data intermediaries and data altruism organizations. Specifically, it involves:

- Data catalogue standards to facilitate the publication and discovery of data assets.
- Semantic assets to enable seamless integration and use of shared data.
- Common Key Performance Indicators (KPIs) to drive cross-domain interoperability, enhancing transparency and data usability.

The development of these standards will be closely coordinated with the European Data Innovation Board and, where relevant, the Data Space Support Centre.

One of the main objectives and policies for European Standardisation is to overcome interoperability challenges when combining data from different sources, it is essential to encourage the adoption of common standards and protocols. The European Interoperability Framework and the Rolling Plan for ICT Standardisation play a key role in promoting these efforts.

The standardisation request, a draft document has published[8], to the three European Standardisation Organizations (ESO): CEN, CENELEC and ETSI, aims the creation of a unified European Trusted Data Framework, which aligns with multiple regulations and initiatives aimed at improving the trustworthiness and interoperability of data ecosystems within the European Union (EU).

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ%3AC_202401364&utm_source=chatgpt.com
[8] Draft standardisation request as regards European Trusted Data Framework: https://ec.europa.eu/docsroom/documents/62854

The request is grounded in Regulation (EU) 2023/2854[9], which establishes the framework for data interoperability across EU member states. Specifically, Article 33 of this regulation outlines essential requirements for the interoperability of data, data sharing mechanisms, and services, as well as common European data spaces. Furthermore, Article 33 mandates that one or more European standardisation organisations be tasked with drafting harmonised standards that will meet these interoperability requirements.

Below, the standardization request is explained in detail, highlighting its key aspects, including the request itself, work items, timeframe, and related work.

4.2.2 Key aspects of the request

Essential interoperability requirements (Article 33):

Regulation (EU) 2023/2854 emphasizes the importance of ensuring the seamless exchange of data across various European data spaces. The request outlines the need for standards that guarantee the compatibility of data sharing mechanisms and services. These standards should address the core technical, legal, and organisational aspects of data sharing, contributing to a more integrated European digital ecosystem.

Interoperability of data processing services (Article 35):

Article 35 of the regulation sets out specific requirements for the interoperability of data processing services and the creation of a central Union standards repository for these services. The request to standardisation bodies includes the need for coordination with the repository initiative to ensure that selected standards are aligned with the overarching goals of data processing interoperability.

Artificial Intelligence and data governance:

The Artificial Intelligence Act (AI Act)[10] and its data governance provisions are recognized as important in shaping the European Trusted Data Framework. These provisions will influence how data is processed and shared, especially in the context of AI-driven technologies. The request encourages consideration of the AI Act's requirements in the standardisation efforts to ensure comprehensive data governance.

[9] Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302854&qid=1739875543110

[10] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) (Text with EEA relevance)

European digital identity framework:

Regulation (EU) 2024/1183 establishes a European digital identity framework that aims to provide harmonised electronic identification across the EU. This framework will enable trusted data sharing by establishing reliable digital identities for both individuals and legal entities. The standardisation request highlights the importance of integrating this digital identity infrastructure into the Trusted Data Framework to support secure data exchange.

Interoperable Europe Framework:

The Interoperable Europe Framework, reinforced by the Interoperable Europe Act[11], offers solutions for public sector interoperability, which can also be applied to the private sector. The request stresses the need to consider interoperability solutions such as semantics (SEMIC) in the development of the Trusted Data Framework to ensure that both sectors can seamlessly collaborate on data sharing.

EU Rolling Plan for ICT Standardisation:

The EU Rolling Plan for ICT standardisation, created in collaboration with the Multi-Stakeholder Platform for ICT standardisation, provides a detailed overview of available European and international standards. This plan is critical in ensuring that the proposed standards for the European Trusted Data Framework align with existing and emerging ICT standards.

Data Spaces Support Centre (DSSC):

The DSSC, a project funded under the Digital Europe Programme, is developing the "Data Spaces Blueprint" to support the development of data spaces. The standardisation request calls for the incorporation of elements from this blueprint to ensure that the standards developed under the European Trusted Data Framework are aligned with current best practices and guidelines.

Consultations and coordination:

Various stakeholders, including the European Data Innovation Board (EDIB) and European Standardisation Organisations, have been consulted throughout the process. Their input has been instrumental in shaping the direction of the standardisation request. It is noted that the work covered by this request falls within the competence of the European Standardisation Organisations.

Public access to standards:

[11] Regulation (EU) 2024/903 of the European Parliament and of the Council of 13 March 2024 laying down measures for a high level of public sector interoperability across the Union (Interoperable Europe Act)

The *harmonised European standards* (*hENs*)[12] adopted as part of this request may be subject to access to documents requests under Regulation (EU) 1049/2001. The Court of Justice has acknowledged the overriding public interest in ensuring the disclosure of harmonised standards, particularly for transparency and accountability in the data-sharing ecosystem.

Data Interoperability report:

The final report[13] of the Data Interoperability workstream of the High-Level Forum on European standardisation includes several recommendations on the way to enhance interoperability within and across common European data spaces. The report has served as a basis for this request.

The European Trusted Data Framework is a crucial component of the EU's broader digital strategy. The standardisation request highlights the need for harmonised standards to address data interoperability, governance, and trusted data sharing mechanisms across Europe. These efforts are supported by key regulations and initiatives, including the EU's Digital Identity Framework, the AI Act, and the Interoperable Europe Framework. By integrating these diverse elements, the European Trusted Data Framework aims to create a secure and efficient environment for data exchange, fostering innovation and strengthening the EU's digital economy.

The European Trusted Data Framework requires five standardisation fields as described in the picture below. The Trusted Data Transactions **Harmonised standard** consisting of:

- Part 1: Terminology, concepts and mechanisms
- Part 2: Trustworthiness requirements
- Part 3: Interoperability requirements

enables participants in data spaces to comply with Article 33 (*) of the Data Act.

(*) *Essential requirements regarding interoperability of data, of data sharing mechanisms and services, as well as of Common European Data Spaces*

[12] 'harmonised standard' means a harmonised standard as defined in Article 2, point (1)(c), of Regulation (EU) No 1025/2012
[13] https://ec.europa.eu/docsroom/documents/58914

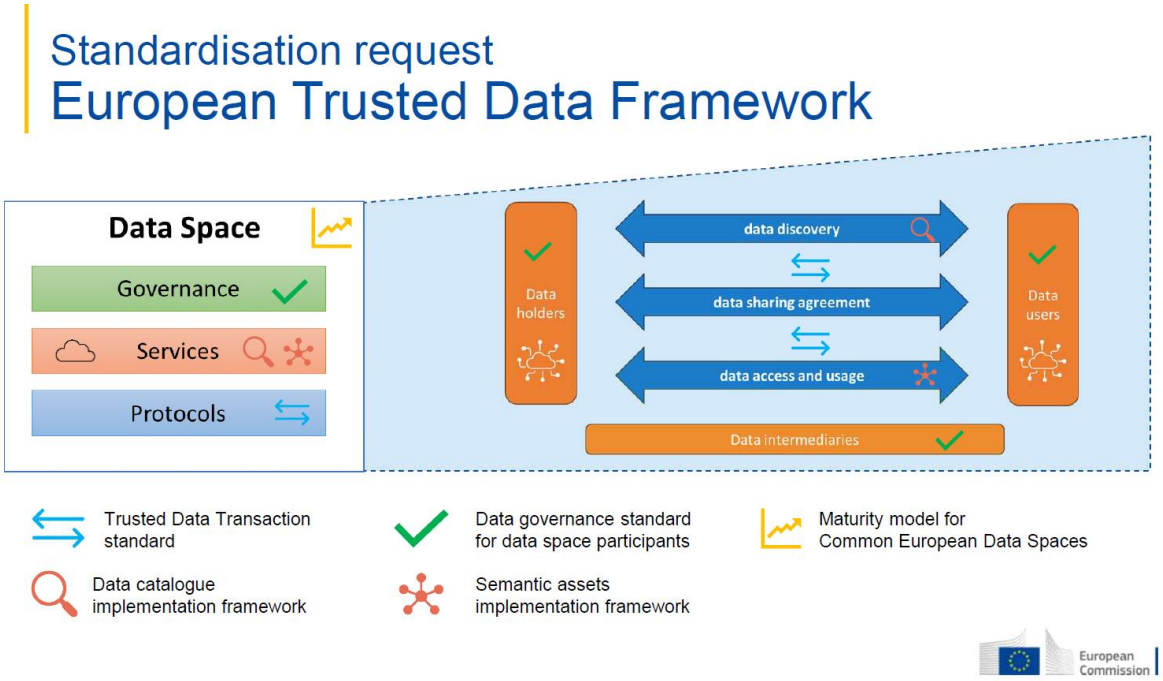


Figure 4: Standardization request: European Trusted Data Framework

This graphic illustrates the **European Trusted Data Framework** in the context of a **standardisation request** from the European Commission, focusing on how **data spaces** operate and are supported by specific standards.

The core components of a data space are Governance (rules, policies, and trust frameworks), Services (functional tools that enable key activities like data discovery and sharing), and Protocols (which ensure standardized, secure, and interoperable data transactions between participants).

At the core of data spaces are trusted data transactions between participants—data holders, data users, and, in some cases, data intermediaries. The framework supports data discovery, data sharing agreements, and data access and usage, all enabled by the standardisation references shown at the bottom of the image.

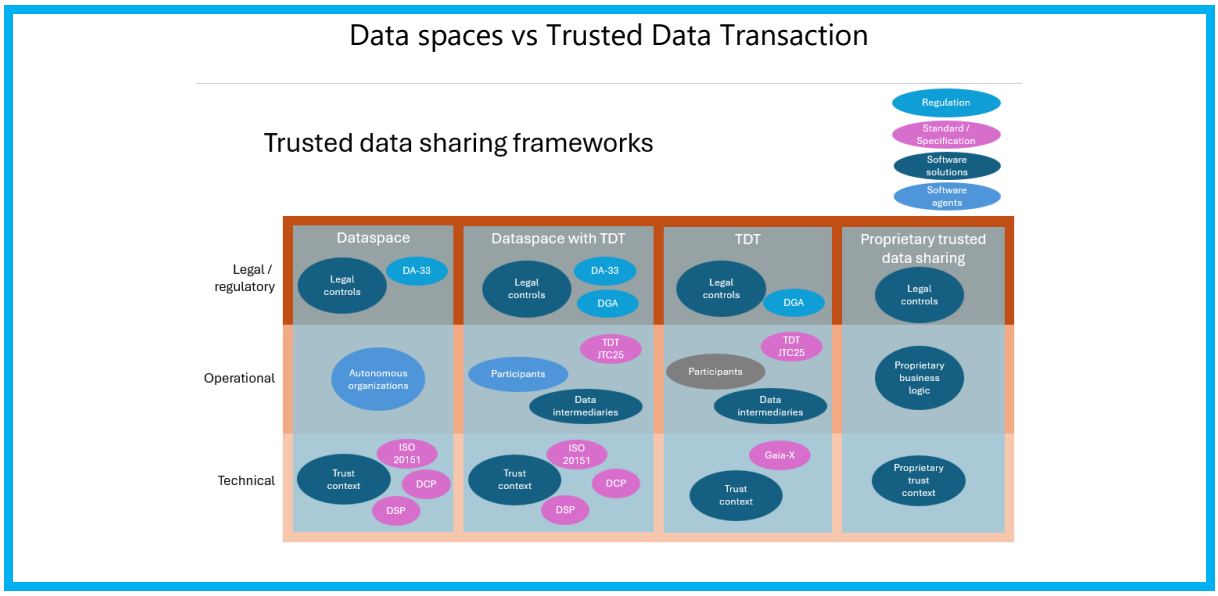


Figure 5.Trusted data sharing frameworks

4.2.3 Work items and time frame

The European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC), and the European Telecommunications Standards Institute (ETSI) are tasked with drafting new European standards and standardisation deliverables. These activities, detailed in Figure 6: Timeline for adoption by ESOs below and support Article 33 of Regulation 2023/2854 (the Data Act). The responsible technical bodies and the timetable for execution are specified to ensure compliance with the requirements outlined in Article 1: *Request standardisation activities.*[14]

14 https://single-market-economy.ec.europa.eu/single-market/european-standards/notification-system_en - replace when it is published

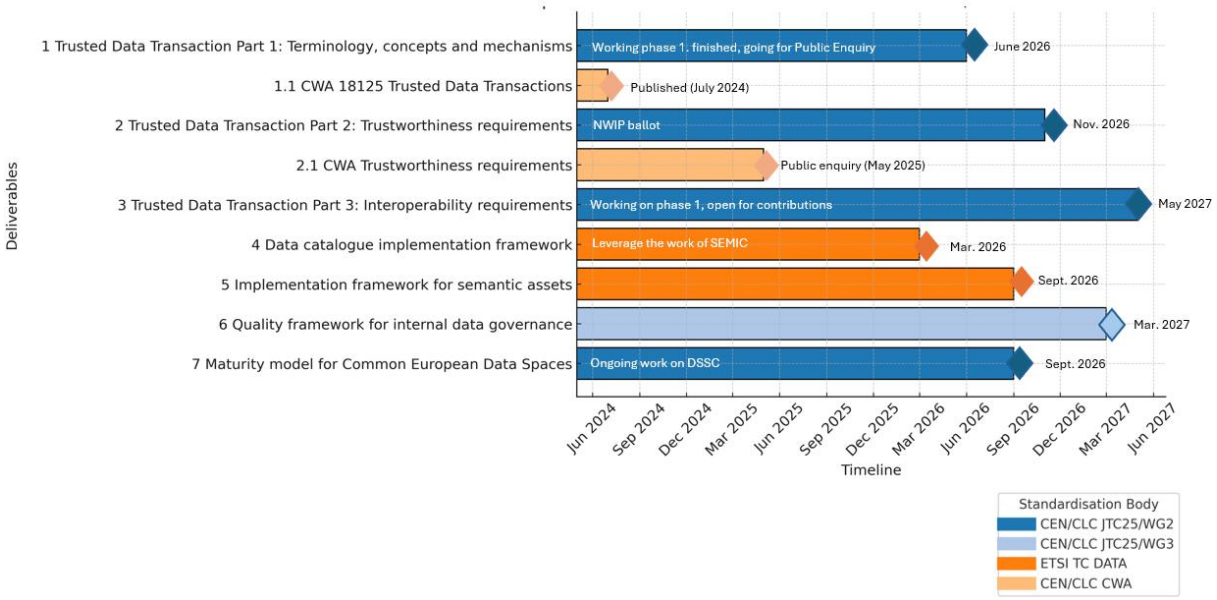


Figure 6: Timeline for adoption by ESOs

4.2.4 Related work

CEN, CENELEC and ETSI shall prepare joint work programmes indicating all the standards and European standardisation deliverables referred on the standardisation request, the responsible technical bodies and a timetable for the execution of the requested standardisation activities in line with the deadlines, see figure 4 for details. The responsible technical bodies should facilitate an appropriate representation and effective participation of the relevant stakeholders, including small and medium-sized enterprises and societal stakeholders.

The standardisation request also ensures that European standards and standardization deliverables comply with a series of requirements, taking into account, where appropriate, the work of the Data Spaces Support Centre and Interoperable Europe. Furthermore, the work program shall include the following actions:

- CEN, Cenelec and ETSI shall submit the work program to the Commission within four months after the notification of this decision and provide access to an overall project plan.
- CEN, Cenelec and ETSI shall inform the Commission of any amendments to the joint work program.

4.3 New legislative framework

4.3.1 Introduction

The European Union has been actively developing a regulatory framework to ensure data sovereignty and competitiveness in the global data economy. This framework encompasses several significant legislative measures, including Data Act (DA), Data Governance Act (DGA), the AI Act (AIA), Digital Markets Act (DMA), and Digital Services Act (DSA). These regulations aim to harmonize data practices across EU member states, ensuring compliance with EU laws and standards related to security, data protection, and consumer rights.

A cornerstone of this framework is the Data Act, which seeks to harmonize the access to and use of data within the EU. Following the Data Governance Act, the Data Act represents the second pillar that creates the framework for the Common European data space (*Figure 4*).

The Data Act introduces measures to promote the development of interoperability standards for data-sharing and for data processing services, aligned with the EU Standardisation Strategy.

This task will directly relate to the activities of data space initiatives such as IDSA, which will play a major role, as they have already developed frameworks, reference architectures and protocols that can act as blueprints for common standards.

4.3.2 Data Act

The Data Act[15] is a law designed to enhance the EU's data economy and foster a competitive data market by making data (in particular industrial data) more accessible and usable, encouraging data-driven innovation and increasing data availability. The Data Act expresses a clear preference for standards to be developed by the EU standardisation bodies.

Data Act provide harmonized rules for accessing and using data, which directly support data spaces. This regulation ensures that users of connected products can access the data generated through their use of the connected product or related services. Additionally, data holders must make this data available to users.

Another key aspect of the Data Act is fostering trust in data. It is essential to implement safeguards that allow citizens, public sector bodies and businesses to control their data. Standardisation and semantic interoperability play a crucial role in providing technical solutions that ensure seamless interoperability within and between common European data spaces. These data spaces can be sector-specific, cross-sectoral, or designed for common

[15] https://eur-lex.europa.eu/eli/reg/2023/2854/oj

interoperable frameworks, common standards and services, scientific research or civil society initiatives. This regulation outlines essential interoperability requirements in Article 33.

The Data Act, Regulation EU 2023/2854, was published on 22 December 2023 and it will become applicable on 12 September 2025.

4.3.3 Data Governance Act

The DGA establishes a framework for data reuse by public sector bodies and introduces data intermediation services. It emphasizes the importance of neutrality and trust in data sharing, and supports data altruism, where data is shared voluntarily for the common good. The act also sets up the European Data Innovation Board to promote standardization and interoperability.

4.3.3.1 Standardisation and interoperability in the DGA

The complexity of the EU's regulatory environment presents challenges, particularly concerning the alignment of new regulations with existing laws on data protection, competition, and intellectual property. The lack of standardized terminology further complicates interpretation and interoperability. Despite these challenges, the DA and the DGA are critical for standardization within B2B data spaces, but not limited to this.

At various points in the DGA, the term "standards" is used more loosely to refer to ethical standards or values, which are distinct from technical standards. Ethical standards in the DGA pertain to maintaining high standards of scientific ethics and ensuring data security. However, the DGA also underscores the importance of standardisation to enable interoperability between data intermediaries, data altruism organisations, and related entities, including data spaces that may not qualify as intermediaries. The regulation emphasises the necessity of domain-specific and cross-domain data and meta-data standards, as well as standardised data formatting.

Despite the emphasis on the importance of standardisation, the DGA itself does not directly advance the creation of technical standards. Instead, creates the European Data Innovation Board (EDIB), which is tasked with facilitating the development of industry standards and promoting interoperability. This board aims to bridge the gap between the existing needs for standardisation and the practical steps needed to achieve it.

4.3.3.2 Challenges and prospects

The DGA and DA present several challenges, including broad definitions and the need for practical solutions aligned with national laws. One of the key challenges highlighted by the DGA is achieving legal interoperability. This involves developing a common understanding of the evolving legal environment and facilitating the implementation of balanced policy

objectives. The complexity of the EU's legal framework, which spans national, horizontal, and sector-specific regulations, necessitates clear guidelines and adaptable policies. The DGA's focus on standardisation is thus not only about technical specifications but also about creating a cohesive legal and regulatory landscape that supports data interoperability and reuse.

International Data Spaces Association (IDSA) have developed the Dataspace Protocol, a standardized framework to integrate key processes common to all data spaces, and a reference architecture that can serve as blueprints for common standards. The Data Spaces Support Centre (DSSC) will play a significant role in providing aligned support for common EU data spaces, ensuring that the EU's data economy is both competitive and sovereign. Building on these initiatives, the EU strategy should aim for interoperability and specification of future infrastructure agreements.

To understand the scope of the DGA regarding data intermediaries and their role within data spaces, we recommend reading the IDSA paper *Reflections on the DGA and Data Intermediaries* (*Source: IDSA paper*).

4.3.4 AI Act

Data space technology plays a key role in fulfilling the requirements of the EU and the Standardization Request for the AI Act. As the AI Act emphasizes the need for strong data governance, management procedures, and dataset quality standards in AI systems, data spaces offer a concrete solution. They provide a structured framework for how data is accessed, shared, and trusted across participants, ensuring transparency, control, and accountability. By embedding mechanisms for data provenance, traceability, and usage control, data spaces directly support the validation of AI-related processes and compliance with regulatory standards. Their technical components—such as connectors and ecosystem services—enable the enforcement of policies and verification of claims, aligning closely with the Act's focus on trustworthy AI.

Because of this, data spaces are already being referenced in European standardization efforts as foundational infrastructure for meeting AI regulatory demands. If you want to know more about how data spaces can support AI Act implementation, read the following document: *Data Spaces for the AI Act – Analysis of the Standardisation Request Regarding the European AI Act in the Context of Data Spaces* (*Link to IDSA Paper*).

4.4 CEN/CENELEC JTC25

The Joint Technical Committee 25 of CEN and CENELEC titled "Data Management, Dataspaces, Cloud and Edge" will develop standards to support the widespread adoption of digitalization and the establishment of a fully functioning Single Digital Market for the EU. The goal is to

ensure the European industry is more efficient, productive, competitive, and fully integrated in the global digital market.

4.4.1 Scope and purpose

The scope of JTC25 is on Standardisation in the area of data management, dataspaces, cloud and edge, including:

- data governance, data quality and data lifecycle management;
- interoperability, portability and switchability;
- organizational frameworks and methodologies, including IT management systems;
- processes and products evaluation schemes;
- smart technology, objects, distributed computing devices, data services.

JTC25 is structured into four working groups (WGs) to focus on specific areas:

- WG 1: Advisory Group: This group will support collaboration among members and with relevant stakeholders, particularly the Focus Group on Data, Dataspaces, Cloud, and Edge.
- WG 2: Dataspaces: This group will address topics specific to dataspace from the Standardization Request related to the Data Act and incorporate the findings from the CWA Trusted Data Transaction.
- WG 3: Data Management and Data Governance: This group will tackle the remaining topics from the Standardization Request, focusing on DCAT, ontologies, and data management.
- WG 4: Cloud and Edge: This group will undertake preparatory activities for the anticipated Standardization Request in this area.

4.4.0 Status

The CEN/CENELEC JTC25 was kicked off in September 2024 in Brussels, Belgium[16]. The second plenary meeting was conducted in February 2025 in Milan, Italy. The JTC 25 Working Groups have established their work programmes.

4.4.1 Reference, documents available.

Following the Standardization Request, JTC 25 will produce first documents during 2025.

[16] CEN and CENELEC launch a new technical committee on Data management, Dataspaces, Cloud and Edge - CEN-CENELEC

4.5 CEN/CLC Focus Group Data, Dataspaces, Cloud and Edge

The CEN/CENELEC Focus Group on Data, Dataspaces, Cloud, and Edge (FG-DDCE) was established in March 2024 to connect various groups of stakeholders working around the concepts of "Data" and "Dataspaces." The group was established to enable coming together groups in support of Data Economy as a key driver of Europe's Digital Transition. The group also engaged with the cloud and edge industries, particularly those with industry-specific use cases. The vision of the group was to identify gaps and close them in a comprehensive and cross-sectoral approach.

4.5.1 Scope and purpose

The CEN/CENELEC Focus Group on Data, Dataspaces, Cloud, and Edge (FG-DDCE) plays a key role in coordinating the identification of standardization needs within the data economy and determining how to address them effectively. Its focus spans the entire data value chain across various dataspaces, emphasizing critical aspects such as data governance, interoperability, quality, and lifecycle, as outlined in the Rolling Plan 2023 for ICT Standardisation[17]

4.5.2 Status

The CEN-CLC/BTWG 6 'ICT Standardization Policy' proposed to create a CEN/CENELEC Focus Group on 'Data, Dataspaces, Cloud and Edge', which was kicked off on March 1st, 2024, in Brussels, after several meetings and due to the overlapping with the recent created CEN/CENELEC JTC 25 committee, the Focus Group was dismantled on December of 2024.

4.5.3 Reference documents and contributions.

During the short duration to the FG-DDCE has develop the following deliverables and contributions: •

- developed standardization landscape and gap analysis report for Europe's data economy with specific focus on "data, dataspaces, cloud & edge", taking into account existing technical bodies, existing and proposed regulations and the EU RP for ICT Standardisation;
- provided recommendations to CEN/CENELEC on priority areas for standardization to address the identified gaps;
- contributed with input to the annual EU Rolling Plan for ICT Standardization to support the work of CEN/CENELEC representatives in the EC Multi-Stakeholder Platform on ICT Standardization; •

[17] https://interoperable-europe.ec.europa.eu/collection/rolling-plan-ict-standardisation/rolling-plan-2024

- provided recommendations to CEN/CENELEC on collaboration with external organizations and initiatives on the basis of concrete requirements limited to the scope of this FG-DDCE.

4.6 CEN/CLC CWA Trusted Data Transaction

4.6.1 Scope and purpose

For digital ecosystems, trustworthiness is key to enable data sharing between stakeholders • Objectives and scope:

- Establish terminology, describe concepts and mechanisms in the field of data sharing to form a foundational understanding on which trusted data transactions can be based.
- Identify attribute-based criteria for the decision-making grid that baselines how to create trust in data transactions.
- Independent of architectural choices or technical implementations.
- Can be used in all cases where stakeholders need to establish trust for the purpose of data exchange.

4.6.2 Part 1: Concepts, terminology, and mechanisms

CEN WORKSHOP AGREEMENT-Trusted Data Transaction- Part 1. Concepts, terminology, and mechanisms has been finalized and is publicly available on the CEN CENELEC website.

CEN WORKSHOP AGREEMENT-Trusted Data Transaction published in July 2024 is available on this link: CWA18125_2024.pdf

The scope of this document is to provide terminology, concepts and mechanisms in the field of data exchange focusing on trusted data transactions. Those elements can be used in the development of standards in support of trusted data transactions. These terminology, concepts and mechanisms constitute the basis to identify key dimensions and criteria that contribute to the trust in a data transaction between interested parties. Therefore, those elements may constitute a foundational understanding on which trusted data transactions can be based, independently of any architectural choices or technical implementation.

In this document is interesting the scope of the data transactions, this concept identifies three phases related to data transactions lifecycle: (1) Granting rights and publication (2) Discovery and negotiation and (3) data exchange or sharing (see figure 6.):

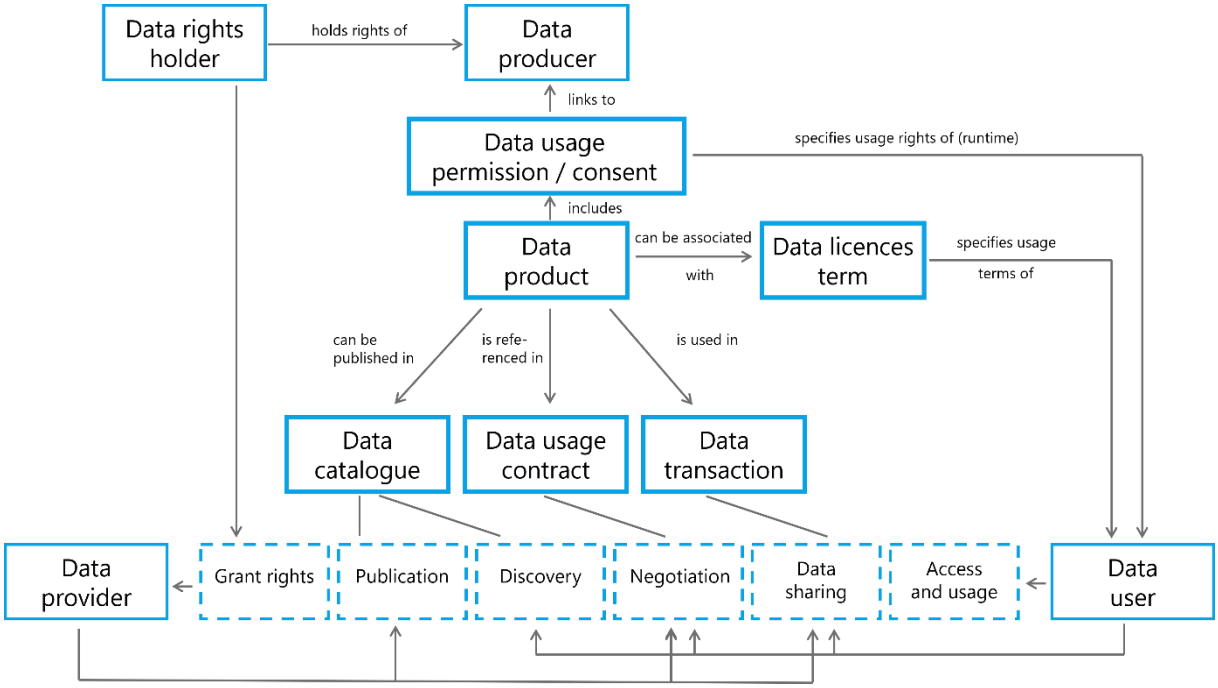


Figure 7: Scope of data transaction

4.6.3 Part 2: Trustworthiness requirements

The CEN Workshop Agreement *"Trusted Data Transaction – Part 2: Trustworthiness Requirements"* defines the trustworthiness requirements necessary to establish trust in support of trusted data transactions across digital ecosystems. The document outlines a set of foundational principles such as transparency, traceability, accountability, and data quality, which serve as the basis for building trust throughout the data transaction lifecycle.

It includes both general requirements that apply to all phases of a trusted data transaction, and specific requirements tailored to each phase—such as granting rights, data publication and discovery, negotiation, data sharing and exchange, and access and usage control. These requirements aim to ensure that data can be securely and reliably exchanged in an interoperable environment, while also respecting legal, ethical, and organizational obligations.

Annex 1 provides an informative overview of trust frameworks, emphasizing their role in aligning technical standards with governance and legal policies to support trustworthy data spaces and enable consistent trust across participants.

For more details on the trustworthiness requirements defined in the CWA *"Trusted Data Transaction – Part 2: Trustworthiness Requirements"*, you can access the full document [here].

4.7 ETSI TC DATA

The ETSI Technical Committee on Data (TC DATA) has been established to provide expertise in data infrastructures, services, and applications. Its primary goal is to develop data solutions that support services for IoT, telecommunications systems, and other industries. This initiative aims to advance data-driven technologies and foster the development of new industry standards in line with the European Data Governance Act, the European Data Act and the European Trusted Data Framework.

The Terms of Reference of the TC Data[18] are provided as follows.

Scope

TC DATA develops deliverables to support the deployment and operation of distributed solutions for data collection, integration, sharing and management, including security and testing aspects.

The distributed solutions considered by TC DATA include data infrastructures, data products, data access services, and application interfaces (APIs) in the ICT domain, to be used by machines and human beings, and their virtual representations. These solutions address the three dimensions of distributed data processing, i.e., Connectivity (data in transit), Storage (data at rest) and Compute (data in process).

TC DATA is also committed to addressing European policy and regulatory requirements, including standardisation needs in the area of data interoperability, semantic interoperability, ontologies, and data governance. TC DATA also engages with other regulatory bodies to ensure that the output supports relevant global, regional, and national requirements.

TC DATA is responsible for providing input on technical aspects of the ETSI responses to EU Standardization Requests and other government requests regarding data solutions. TC DATA also provides relevant technical content for ETSI deliverables related to the European Data Act and to the data-related aspects of the European AI Act.

TC DATA cooperates with open-source initiatives relevant for the data domain standardization, including (but not limited to) relevant existing and future ETSI SDGs providing relevant reference implementations and interoperability testing specifications.

18 https://portal.etsi.org/Portals/0/TBpages/DATA/Docs/202501%20-%20ETSI_Approved_ToR_Board_Approved.pdf?ver=UY052ixUBxb8s97KBzlU6A%3D%3D

TC DATA cooperates with other European and international standards organizations in the data solutions domain to avoid duplication of work and promote harmonization, through the use of partnership agreements

Areas of Activity

The activities of TC DATA include the following:

- Providing a centre of expertise in the area of data infrastructures, services and applications for ETSI, in coordination with the other ETSI activities in this context. This includes data solutions targeting services for IoT, human beings, telecommunication systems and networks, and other industries.
- Developing technical standards to support data interoperability and semantic interoperability.
- Maintaining and evolving specifications related to data solutions and published by other ETSI TGs, upon agreement with them. These TGs include, but are not necessarily limited to:
- TC SmartM2M
- ISG CDM
- ISG PDL
- ISG CIM
- TC ESI
- Supporting the development and maintenance of semantic and data models, such as SAREF (including the SAREF open portal) and NGSI-LD.
- Supporting the transposition in ETSI of the outputs of oneM2M.
- Supporting the maintenance and evolution of relevant industry data standards, such as the data model in the maritime domain

5 Conclusions and future work

Standardization is a critical enabler of operational data spaces and a prerequisite for realizing the goals set out in European and international data strategies. Through its active role in shaping specifications and contributing to standardization committees, IDSA helps translate high-level regulatory and policy objectives into usable, testable, and certifiable tools for industry.

The alignment between the IDS architecture, the Dataspace Protocol, and emerging standards such as ISO/IEC DIS 20151, ISO/IEC TS 10866, and ISO/IEC 19941 shows that foundational elements are converging. At the same time, the European Standardization Request (Article 33 of the Data Act) and the establishment of JTC 25 demonstrate the urgency of delivering concrete, interoperable solutions across sectors.

By documenting the current status and open gaps, this paper aims to serve as both a reference and a starting point for continued collaboration. The insights shared here are informed by working groups, project experience, and regulatory dialogue, and are intended to guide the next phase of technical and policy development.

Looking ahead, the involvement of a broader stakeholder community – especially through mechanisms like the Data Spaces User Group – will be key to refining and scaling the standards that underpin trusted data sharing in Europe and beyond.