

DATA ECOSYSTEMS INTEROPERABILITY BUILDING UNION FROM FRAGMENTATION

Turning Data Space islands into
a European Data & AI continent

THINK-DO-TANK
**DIGITAL
NEW DEAL**

June 2026



EUROPE MUST
INTEROPERATE BY CHOICE,
NOT BY DEPENDENCY.

FOREWORD

Europe has entered a decisive phase of the digital and AI economy: no longer just writing rules, but shaping and structuring markets. The purpose of this report is straightforward: to show that the single market for data is no longer a purely technical or administrative exercise. It has become one of Europe's most powerful strategic levers. The question is not whether Europe can regulate the digital world, it already has. The question is whether Europe can turn regulation into enforceable, operational standards that create scale, unlock investment, and ultimately shape power relations.

The United States and China remain essential partners for Europe, but partnership does not imply full alignment of values, governance models, or industrial strategies.

The single market for data, therefore, is not only a question of the European internal market. It is also a condition for Europe to cooperate at scale, on its own terms, when the agenda is global. Europe must move beyond "regulation", the comfort zone of principles, compliance checklists, and fragmented implementation towards true standardisation: the capacity to define standards that deliver measurable value and are testable, deployable, and adopted at a pace consistent with market and technological needs.

"Europe can shift from sovereignty by regulation to strategic autonomy by shared standards"

This shift is urgent because Europe is competing with global digital platforms that impose de facto standards by controlling distribution, developer ecosystems, and cloud-data-AI stacks.

And Europe is not alone in entering this phase. China, India, Korea, Japan, and other major economies are developing Data & AI strategies, along ecosystem approaches, that increasingly resemble, in logic, what Europe calls "data spaces": decentralised, organised and urbanised data-sharing under governance, legal, business, and technical rails. The question is no longer whether the world will standardise, it is whose standards will become the default, and whether Europe will be interoperable with others by choice or by dependency.

Arno Pons, Digital New Deal

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EUROPE CAN SHIFT
FROM SOVEREIGNTY
BY REGULATION TO
STRATEGIC AUTONOMY BY
SHARED STANDARDS.

INTRODUCTION

Europe too often stops halfway: strong on rights and trust, weaker at converting them into shared market rails. The single market for data must be treated accordingly. It is not an engineering nice-to-have; it is a condition of power, scale, and autonomy. Regulation can set the frame of trust, but it does not by itself create markets large enough to sustain profitability and investment. Markets emerge when actors can connect in a low-friction environment, where rules are encoded in standards and supported by reference implementations. In network industries such as telecommunications, interoperability is essential to organise large markets with effective competition.

“Data interoperability is no longer a technical nice-to-have but a strategic condition for scale”

Europe's diagnosis of AI dependency increasingly reveals a broader stack problem: chips, cloud, models, and data are tightly coupled; sovereignty cannot be solved at one layer only. Where should Europe place its bet? Digital New Deal believes the data layer to be the most effective leverage point in the digital stack. Data governance propagates upstream (infrastructure choices, cloud architectures, portability) and downstream (AI training with its data set, evaluation, deployment, accountability, operational model). There is no trustworthy AI without trustworthy data, and no competitive and agentic AI without interoperable, actionable, capable and governable data.

“No scalable AI without data space interoperability”

This is why data spaces matter, not as another technical architecture paradigm, but as an industrial governance mechanism, and a new organisation form for digital ecosystems (not only data ecosystems, as the name “data space” would wrongly suggest). Data spaces are the cornerstone of the European data strategy. Data spaces are governed and federated ecosystems where access to private & protected data is managed under common rules and standards. Interoperability in data spaces spans technical, semantic, legal, business and organisational dimensions.

Yet a strategic risk remains: Europe can build hundreds of “data spaces” or more and still fail to build a single market for data, if these initiatives remain fragmented into sub-critical networks. Fragmentation, however well regulated, creates dependency by default through lack of market reach. This fragmentation is not merely conceptual: in operational sectors such as transport¹, practitioners describe a proliferation of locally optimised but weakly connected systems, effectively creating a “data archipelago” that undermines end-to-end service continuity.

¹ Alliancy, « L'interopérabilité entre acteurs, la clé de l'expérience client de demain, » March 2026.

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Avoiding fragmentation, Europe has done it before. GSM was not only a technical standard; it was a political and industrial decision to impose interoperability as a market condition, reaching global dominance, through a decade-long process, with over 90% market share at its peak. The lesson is contemporary: when a region sets enforceable interoperability rules and aligns industry behind them, it can reshape global markets.

“Europe needs a GSM moment for data & AI”

In network-based economies, value follows network effects. Europe cannot activate B2B and B2C network effects while each ecosystem reinvents identity, consent, catalogues, contracts, semantics, connectors, API and compliance in isolation.

“No interoperability, no B2B or B2C Metcalfe effect”

The challenge is no longer technological. It is political and economic: whether Europe is willing to treat data interoperability and urbanisation as a strategic condition for scale, and as a condition to cooperate globally without surrendering control, and to act accordingly. Together, we are stronger.

EXECUTIVE SUMMARY

DATA ECOSYSTEMS INTEROPERABILITY: BUILDING UNION FROM FRAGMENTATION

TURNING DATA SPACE ISLANDS INTO A EUROPEAN DATA & AI CONTINENT

→ The single market for data is not a technical detail, it is a strategic precondition for Europe's digital sovereignty and AI competitiveness. Europe now faces a clear choice: move beyond convergence through dialogue toward convergence by design. The next step in Europe's digital agenda is not more principles, but shared market rails that make trusted data exchange possible at scale. **Data space interoperability is the missing link between Europe's commitment to trust and its ambition for scale.** Without it, Europe may succeed in creating multiple data spaces, yet still fail to build a genuine single market for data & AI.

Key message

Europe needs a **"GSM moment" for data & AI**: a political and industrial commitment to a minimal, enforceable interoperability core that is common, measurable and reusable across sectors and Member States.

Thesis

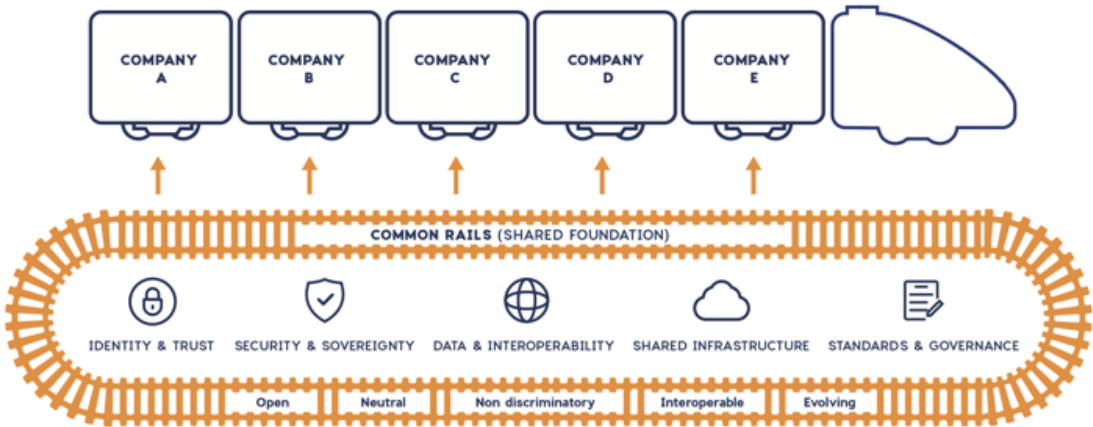
Europe will not win the next phase of the digital and AI economy by copying the raw-scale model of foreign platforms. Its comparative advantage lies in its regulation and partnership culture, and in governed access to high-value private & protected data. But that advantage becomes economic and geopolitical leverage only if identity, catalogues, contracts, semantics and compliance can work across ecosystems at low cost. The real objective is therefore not more data spaces as such, but a **Data & AI Union built on coordination without centralisation: many actors, many implementations, and shared rails.**

USERS & SOCIETY

More choice, more innovation, more trust, in a secure and controlled environment

COMPUTE ON SERVICES

Freedom to innovate, different



COOPERATE ON RAILS

Pooling infrastructure, standards and rules to build a trusted and resilient foundation

KEY ISSUES TO ADDRESS

- Europe already has laws, policies and pilots. The missing piece is composition.
- The landscape remains fragmented across stacks, onboarding, semantics, governance and sector initiatives. Interoperability is still more declared than proven.
- Regulation creates trust, but it does not by itself converge implementations. Public funding has not yet enforced the adoption of shared rails or conformance tools.
- If Europe settles for “siloesd data spaces”, foreign cloud-data-AI platforms will supply the missing integration layer and capture network effects.
- SMEs bear the fragmentation tax first. Success should be measured by ROI² per organisation and faster onboarding, not by the number of initiatives.

² Return On Investment. Return on investment (ROI) should be measured as the ratio between the measurable benefits created by joining and using a data space (revenues, avoided costs, risk reduction, faster compliance or better AI performance) and the organisation’s onboarding, integration, governance and operating costs.

PRIORITY PROPOSALS OF THE DIGITAL NEW DEAL REPORT

		PROPOSAL	CORE IDEA	KEY INNOVATION	STRATEGIC IMPACT
WHY	1	Interoperability as Strategic Autonomy	Sovereignty = coordination without centralisation	Reframes autonomy as architectural capability rather than isolation	Enhances resilience, reversibility, and dependency management
	2	From fragmented Data Spaces to a Digital Single Market	Success metric = cross-space transactions, not internal maturity of isolated initiatives	Redefines KPIs around scale, composability and federation	Builds a smart EU-wide data market rather than isolated ecosystems
	3	Interoperability as Soft Infrastructure	Treat interoperability as a strategic governance and market-making instrument, not only technical standards	Reframes interoperability as economic / physical infrastructure (open source and governed software) shaping power and scale.	Turns EU regulation into operational market leverage and business capacities.
	4	Full-Stack Perspective (Cloud-Data-AI)	Interoperability must span infrastructure, data sharing, and AI deployment	Moves beyond "data exchange" to complete legal, business and technical	Prevents value capture by vertically integrated foreign stacks
HOW	5	A "GSM Moment" for Data & AI	Political and industrial commitment to a minimal enforceable interoperability core	Moves from voluntary convergence to coordinated, binding alignment	Creates EU-scale network effects similar to GSM telecom success
	6	MUST vs SHOULD doctrine	Define a minimal mandatory interoperability core per capacity	Moves from fragmented suggestions to realistic obligations	Prevents fragmentation while preserving innovation
HOW	7	Shared and governed mandatory open-source infrastructure layer; competitive differentiation above it.	Institutionalises cooptation as industrial architecture	Avoids both fragmentation and single-stack monopoly	Prevents fragmentation while preserving innovation
	8	Interconnect data spaces and marketplace platforms through mandatory interoperability "Enter through one, connect to all."	Turns fragmented platforms and specifications into a reusable federation model and trusted exchange across ecosystems	Builds the operational backbone of the European single market for data	Builds a smart EU-wide data market rather than isolated ecosystems

WHAT	9	European Data Space Interoperability Framework (DSIF)	Governance and publication of minimal requirements for interoperability on all layers.	Integrates and combines fragmented and competing technical specifications and rulebooks	Make interoperability realistic without imposing one stack and capitalising on existing investments.
	10	Compliance-as-Code	Translate legal and governance obligations into machine-readable, enforceable policies	Bridges law and executable architecture	Enables scalable trusted transactions and agentic AI
	11	Shared digital commons	Common open-source components to facilitate interoperability and deliver needed functionalities (cloud, data, AI).	Moves from various interpretations of standards to common reference	Mutualise investments for infrastructure development.
	12	The data spaces social network	Introduces network-effect logic to data spaces between organisations, federations, practitioners, citizens.	Shared information, discoverability, interoperability & social graphs.	Scalability through participation rather than platform lock-in.
	13	Smart Data Ecosystems Academy	Launch a European training programme to build practical skills on data space interoperability	Creates shared curricula, certifications and hands-on playbooks	Builds the human capacity needed to make interoperability operational

BOTTOM LINE

→ Europe already has the rules and the building blocks. The choice now is whether it remains a power of regulation or becomes a power of implementation. If interoperability becomes a real market condition, Europe can turn trust into transactions, transactions into scale, and scale into strategic autonomy.



EUROPE'S STRATEGIC
ASSET IS NOT MORE OPEN
DATA, BUT GOVERNED
ACCESS TO PRIVATE
& PROTECTED DATA.

I. WHY EUROPE NEEDS DATA INTEROPERABILITY

1.1. FROM VALUES TO VALUE: MAKE GOVERNED DATA-SHARING THE NEW NORMAL

Europe has already proved it can shape the digital world through rights, rules, and trust. But trust alone does not create scale, and scale does not happen by institutional design alone. **Scale happens when people and customers actually want to use what is offered**, because it is useful, reliable, affordable, and easy to adopt. In the data economy, scale comes when demand meets repeatability: predictable legal terms, standard technical interfaces, auditable obligations, low integration costs, and proven return on investment. That is the real transition Europe must now make: from values to value, without betraying either.

From “principles” to “transactions”

Over the past decade, Europe has built a strong normative framework for the digital age³. Yet the next decade will be decided by something more operational: **can Europe turn compliance to its values, and regulations, into market power and capability?** The European Commission's data strategy is explicit: the objective is to create **a single market for data**, where data can flow across borders and sectors, and that supports “data sovereignty”, while keeping those who generate data in control. This is the heart of the data interoperability agenda. Interoperability is not “nice-to-have plumbing.” It is the condition for moving from:

- **one-off data-sharing** → **repeatable, governed transactions**
- **pilot ecosystems** → **a real European market**
- **local compliance** → **EU-scale capability**

And this shift must apply not only to open/public data, but especially to the data that matters most for industrial transformation and AI: **private & protected data**.

Europe's strategic asset is not “more open data”, it is governed access to private & protected data

Europe is already one of the world's champions of open data policy. The Open Data Directive⁴ sets a Union framework to facilitate the re-use of public-sector information (and certain publicly funded research data), helping create a baseline of openness across Member States.

But open data is, by definition, available to everyone, including the largest global platforms. In practice, non-European Big Tech actors combine (1) globally harvested public web data and open data with (2) massive proprietary datasets collected through worldwide platforms, and (3) integrated cloud-to-AI stacks that make deployment fast and frictionless. The result is structural: **Big Tech can extract value from open and private & protected resources they hold faster**, because they already control the distribution and execution layers.

Europe's differentiator is therefore not “opening more of what is already open.” **Europe's**

³ European Commission, « A European strategy for data »: <https://digital-strategy.ec.europa.eu/en/policies/strategy-data>.

⁴ Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information, OJ L 172, 26 June 2019.

differentiator is to unlock what is currently trapped in organisational silos, while preserving control and trust, and ensuring fair outcomes:

- **industrial and B2B data,**
- **personal B2C data,**
- **data held by administrations** under protection regimes,
- **sector datasets under strict governance** (health, mobility, energy, climate, defence),
- **cross-domain and cross-industry** combinations of actors, and
- **cross-border and cross-geography** combinations that no single national market can generate alone.

This is fully aligned with the direction of EU policy. The European Commission presents data spaces⁵ as trusted, secure and privacy-preserving environments, governed by clear rules and fair conditions of access, where **data holders can choose to grant access and make data available for reuse**, whether **free of charge or for compensation**. This approach should, in turn, pave the way for interoperable trust frameworks as one of the key building blocks of a functioning European data economy. **That “against compensation” clause matters.** It is the bridge between Europe's value model and Europe's growth model: governed sharing must also be an economic proposition, not only a compliance exercise.

Data governance is necessary, but data interoperability is what makes it scalable

The EU has started to build the governance layer for sharing private & protected data:

- **The Data Governance Act⁶** (Regulation (EU) 2022/868) establishes mechanisms for re-use of certain categories of protected public-sector data and creates a framework for data intermediation services and data altruism, with the aim of building trust in data-sharing.
- **The Data Act⁷** (Regulation (EU) 2023/2854) introduces harmonised rules on fair access to and use of data, aiming to enable a competitive internal market for data and rebalance access conditions.

This is Europe doing what it does best: setting conditions for trust, fairness, and contestability. But a decisive point follows: **regulation does not automatically converge in implementation.** The market will not emerge simply because the law exists. **The market emerges when demand meets supply**, and when actors can connect at low friction, because the rules become operational in standards, profiles, and compatible technological building blocks.

This is why the Commission insists on the fact that data spaces should share common infrastructures and governance frameworks, and that they will be **gradually interconnected to form the single market for data.**

“Urbanising” private & protected data sharing: making it boring, safe, and routine

Europe needs to do for private & protected data what it already did, partly, for public

⁵ European Commission, “Common European data spaces,” Shaping Europe's digital future, updated 19 November 2025.

⁶ Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance (Data Governance Act), OJ L 152, 3 June 2022.

⁷ 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 (Data Act), OJ L, 2023/2854, 22 December 2023.

information through open data: make reuse structured, discoverable, and legally reliable. This is what it means to “urbanise” data sharing: move it from artisanal, bespoke projects to **infrastructure-like normality**.

In practical terms, governed sharing becomes “normal” when:

- data can be **discovered** across ecosystems, not hidden inside one organisation or consortium/federation,
- access can be **negotiated** through predictable rolebooks, rulebooks and contracts,
- obligations can be **expressed and enforced** (policy/contract attached to the data product),
- transactions can be **audited** (traceability, accountability),
- and onboarding is **repeatable** (identity, trust, certification patterns).

That is the logic behind Europe's data space support organisations ecosystem, including:

- **Data Spaces Support Centre (DSSC)**⁸ provides guidance, glossary, blueprints, and shared conceptual building blocks to help data spaces converge rather than reinvent everything in isolation.
- **Simpl**⁹ is positioned by the European Commission as an open-source middleware effort meant to support data spaces and cloud-to-edge federations, i.e., to lower the cost of “doing interoperability” in practice, either within and across data spaces.
- **Gaia-X**¹⁰ develops and provides an international interoperable trust framework where compliance with arbitrary data space rulebooks and trust frameworks can be automatically verified.
- **IDSA**¹¹ promotes a reference architecture model and protocols focused on data sovereignty and interoperability across environments, without prescribing a single vendor stack.
- **Prometheus-X**¹² governs open-source components for data spaces with a cross-data space technological stacks logic and a focus on personal data-sharing.

These initiatives represent, among others, the emerging “soft infrastructure” of Europe's data economy: standards, trust frameworks, and shared components that make governed collaboration possible at scale.

Data value is non-linear: Europe needs EU-scale network effects

Data does not behave like a traditional commodity. Its value is combinatorial: **combining datasets across borders and sectors often creates disproportionate gains**, your “1 + 1 = 3” dynamic. This is precisely why the internal market matters so much in the data economy: Europe has a unique potential scale, but it is still too often expressed as **27 or more integration projects**.

⁸ <https://dssc.eu/>

⁹ European Commission, “Simpl: Cloud-to-edge federations and data spaces made simple,” Shaping Europe's digital future, accessed May 2026. <https://simpl-programme.ec.europa.eu/>

¹⁰ <https://gaia-x.eu/>

¹¹ <https://internationaldataspaces.org/>

¹² <https://prometheus-x.org/>

The economic logic is simple:

- **The maximal network wins:** Actors rationally join the network with the highest volume of exchanges and the lowest cost of integration.
- **Fragmentation is a tax on participation:** If each data space, sector, or Member State requires bespoke onboarding, bespoke contracts, bespoke semantics and bespoke technical interfaces, the result is predictable: only the biggest actors can afford the integration burden and overhead, everyone else becomes a spectator.

Data interoperability would change this dynamic. It would make it possible to build **EU-scale services** without re-engineering per country and per consortium, because the rails are shared. That is how Europe can translate its single market for data logic into digital reality: not by centralising data, but by standardising how governed access works.

Interoperability also enables “regional federations” inside the Union

EU-scale data interoperability does not only serve “Brussels-scale” services. It also enables **regional cooperation** driven by language, geography, history, sectoral culture, or shared infrastructure realities: Mediterranean corridors, Baltic logistics and energy, Danube industrial ecosystems, Alpine climate and mobility systems, cross-border health regions, and much more. The key is the same: once systems are interoperable, cooperation becomes a policy choice, not an IT project.

Public-interest coordination becomes feasible when infrastructures interconnect with shared rules

Many of Europe's most strategic objectives require data collaboration between:

- public and private actors,
- civil and defence ecosystems,
- local, national and EU levels,
- and across sectors (health × mobility × energy × climate).

This is exactly why **the European Commission frames data spaces as governance + infrastructure systems** that enable trustworthy exchange while preserving control. Data interoperability is therefore not only about market efficiency. It is about the **capacity to coordinate** at scale, without building a centralised “super database” and without depending on a small number of foreign-controlled stacks.

SMEs: from negotiating dozens of environments to accessing one continental market

For SMEs, the interoperability question is existential. In a fragmented landscape, SMEs face a choice:

- pay repeated integration and legal costs, or
- stay out of cross-border data ecosystems, or
- plug into a dominant platform (most often US-based) that offers “ease” at the price of dependency.

Europe's data strategy and Data Union agenda explicitly link data availability, simplification, and AI competitiveness, especially for SMEs. Interoperable data spaces offer a different

route: **join once, transact anywhere** (under shared rules), while retaining control over assets and choices of partners¹³.

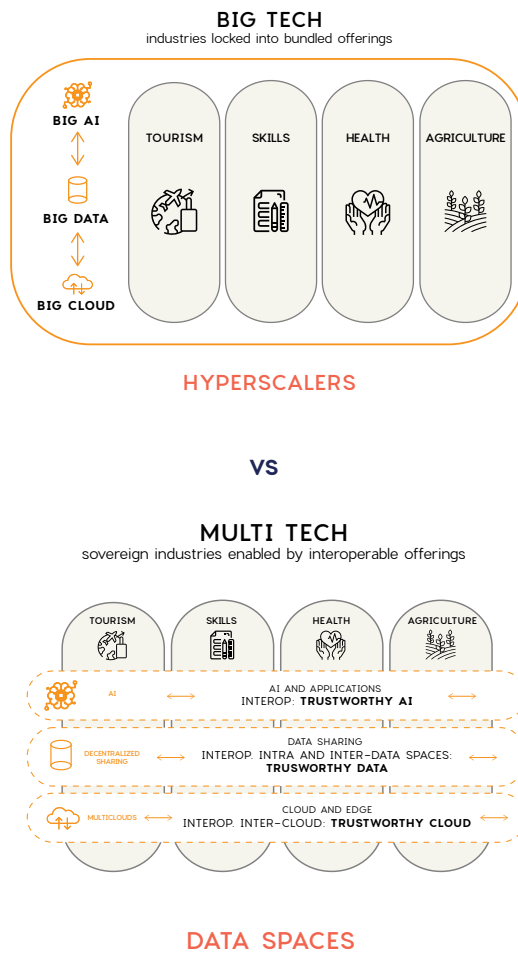
Sovereignty as “coordination without centralisation”

Europe’s sovereignty objective in the data economy should be stated clearly:

- not autarky,
- not “European platforms only”,
- not centralisation,

but **coordination without full centralisation**: many actors can connect, cooperate, and even compete, while keeping control over their data and governance constraints. That is the architectural promise of the European approach: federated data spaces under common rules, gradually interconnected into a single market for data.

AMERICAN MONOPOLY STACK VS EUROPEAN INTEROPERABILITY STACK



¹³ European Commission, “Data Union”: <https://digital-strategy.ec.europa.eu/en/policies/data-union>.

1.2. THE KEY IN THE RACE FOR AI: GOVERNED ACCESS TO PRIVATE & PROTECTED DATA

The AI race is often framed as a contest of **compute** and **data volume**. That frame is already obsolete. The decisive capability is becoming something else: **reliable, governed access to high-quality and, specifically, private & protected vertical data**, at scale, across organisations and sectors, under enforceable constraints.

Digital New Deal has been consistent on this point across its AI reports¹⁴: Europe will not win by imitating the web-scale model of the dominant platforms; it must win by **turning trust into a productive advantage**, and by building the conditions for industrial cooperation rather than isolated performance.

High-performing AI needs “usable” data, not just “available” data

In the real economy (e.g., health, manufacturing, public services), AI performance is constrained less by model architecture than by the availability of **fit-for-purpose datasets** that are (1) diverse and high-quality and (2) **legally and technically usable**.

This is not just a policy intuition; it is now embedded in EU law. The EU AI Act explicitly links trustworthy AI performance to **data governance and data quality**: training/validation/testing datasets for high-risk AI must be relevant, representative, and, “to the best extent possible”, free of errors and complete, and must be managed with appropriate governance practices¹⁵.

And the AI Act makes the connection with Europe’s data strategy explicit: it states that data spaces and business-to-business / business-to-government data sharing will be instrumental to **provide trustworthy, accountable and non-discriminatory access to high-quality datasets** for training, validation and testing¹⁶.

So the real race is not “who scrapes more”. It is: **who can produce more high-quality, reusable datasets with enforceable constraints**, and who can do it repeatedly, across sectors and borders.

The “raw scale” advantage is structurally asymmetric, and increasingly commoditised

Non-European AI leaders already benefit from structural asymmetries:

- **privileged access to web data and open data,**
- **vast proprietary datasets** harvested through global consumer and enterprise platforms,
- **integrated cloud-to-AI stacks** that reduce friction for deployment.

Digital New Deal’s 2024 report on generative AI makes the strategic diagnosis sharply: trying to “scrape the whole web” is not a rational European objective; the priority should shift to **the data with the most strategic value and the least platform capture: enterprise/public organisation data**, private & protected, personal and non personal.

This is also where the European Commission’s current trajectory is converging: the **European Data Union Strategy** is framed as a response to the need to “fuel AI with high-quality data”,

¹⁴ “GENERATIVE AI: UNITE OR SUBMIT Private data sharing, a strategic advantage for European Agentic AI”, November 2024 (Olivier Dion, Michel Marie-Maudet, Arno Pons) <https://www.thedigitalnewdeal.org/en/generative-ai-unite-or-submit/>

¹⁵ Regulation (EU) 2024/1689 (AI Act), especially Article 10 on data and data governance for high-risk AI systems. ELI: <http://data.europa.eu/eli/reg/2024/1689/oj>.

¹⁶ Regulation (EU) 2024/1689 (AI Act), recitals and Article 10: <http://data.europa.eu/eli/reg/2024/1689/oj>.

with a first priority explicitly stated as “scaling up access to data for AI”.

The implication is clear: Europe should stop measuring itself against the worldwide dominant players on “their” battlefield (raw scale), and instead organise the battlefield where it can lead: **governed access to private & protected data**.

Private & protected data is the cornerstone of “trustworthy AI”

Private & protected data, held by companies and administrations, is not only a “last card” for Europe. It is the most under-activated industrial asset in the European digital economy.

Digital New Deal’s argument in *Generative AI: unite or submit* is that European companies face a risk of “double lock-in” (cloud + AI), and that the realistic counter-strategy is collective: **share private & protected data under governance to co-build trustworthy, performant, sovereign agentic AI**, not just general-purpose chatbots.

This is exactly where data spaces become more than a concept: they are the industrial mechanism to pool and reuse private & protected data without centralising it, provided that interoperability makes them connectable beyond their local or sector perimeter.

Agentic AI changes the technical requirement: “AI that acts” needs machine-readable governance

The next phase of AI is not only generative; it is agentic: systems that plan, execute sequences of actions, and operate across interconnected tools and data sources.

The European Commission-hosted report *Agentic AI: Leveraging European AI talent and Regulatory Assets to Scale Adoption* describes agentic AI precisely in these terms, moving from isolated automation to goal-driven systems capable of planning, acting and learning across complex environments, and identifies “fragmented data and technological dependence” as a core barrier to scaling in Europe¹⁷.

This matters for interoperability because agentic AI does not “consume datasets” occasionally. It needs continuous, reliable access across many actors. In practice, agentic AI requires:

- **machine-readable discovery** (what exists, where, under what conditions)
- **machine-to-machine negotiation** (rights, obligations, pricing/compensation, liability)
- **machine-enforceable permissions** (purpose limitation, retention, onward sharing, audit)
- **traceability by default** (logs that prove compliance across multi-step chains)

In short: the scarce resource becomes **not data**, but **permissioned access at low friction**. In fragmented environments, AI is often used as a workaround for incomplete, heterogeneous or poorly structured data landscapes, rather than as a substitute for interoperability itself.

This is where Digital New Deal’s “trust standards” line becomes operational: as argued in *Trustworthy AI* (2022), regulation alone does not produce leadership; Europe must translate its values into standards and industrial cooperation mechanisms that scale.

And it is also where Digital New Deal *AI is Law* (2025) report becomes directly relevant: the report insists that the norm must be scalable, acceptable, and “activable”, including through a vision of “law as a platform” and a “droit API” approach, i.e., rules that can become

¹⁷ European Commission, “Agentic AI: Leveraging European AI talent and regulatory assets to scale adoption”: <https://digital-strategy.ec.europa.eu/en/library/agentic-ai-leveraging-european-ai-talent-and-regulatory-assets-scale-adoption>

machine-actionable. That is exactly the direction agentic AI forces: **governance must become computable**¹⁸.

Sovereign AI is not a slogan: it is an operational capability

Europe often speaks of “sovereign AI” as though sovereignty required owning every layer of the stack: chips, cloud, models and data. Digital New Deal’s 2026 report on the AI dependency¹⁹ economy dispels that illusion. It shows that **most countries are pursuing “autonomy” through technologies they do not control**, and that AI should be understood as a geopolitical supply chain shaped by a small number of critical chokepoints, notably chips, compute, cloud infrastructure and foundation models. From this perspective, the real strategic challenge is not to eliminate dependence altogether, but to **master critical dependencies and preserve the capacity to operate under disruption**. Sovereignty does not mean autarky, no nation can realistically do everything alone. It means retaining sufficient strategic choice and control over the parts of global value networks that matter most to the resilience and development of one’s own ecosystem.

In the agentic AI era, sovereignty becomes concrete and testable:

- **Auditability**: can we reconstruct what the system did, on what basis, using what data, under what permissions?
- **Choice**: can we select partners and components (data, AI models, cloud, tools) rather than accept a bundled stack?
- **Reversibility**: can we exit, technically, legally, and economically, without losing continuity or compliance?

This is precisely the “resilience by design” logic promoted in the 2026 dependency report (diversification, exit capabilities, control of data and models). And it is aligned with the European Commission’s current framing of an “AI Continent”: the **AI Continent Action Plan** explicitly positions Europe as aiming for trustworthy, human-centric AI with speed and ambition²⁰.

What this means for Europe's strategy

Europe's competitive AI strategy should therefore pivot from raw scale to governed access:

- 1. Create the conditions for private & protected data to be reused**, where appropriate, under clear, enforceable and trusted frameworks rather than remaining inaccessible in practice.
- 2. Interconnect data spaces so that access is EU-scale**, not trapped in sector or national silos.
- 3. Encode governance so machines can comply**: discovery, permissions, obligations, smart contracts, traceability, built for agentic AI, not for PDF-era compliance.

¹⁸ Means obligations are represented in structured policies, credentials, contracts or APIs so that systems can check and enforce them automatically, subject to legal and organisational controls.

¹⁹ The Dependency Economy of AI, Damien Kopp, Digital New Deal, 2026. <https://www.thedigitalnewdeal.org/en/the-dependency-economy-of-ai/>

²⁰ European Commission, “AI Continent Action Plan”: <https://digital-strategy.ec.europa.eu/en/library/ai-continent-action-plan>

This is the hinge of this whole Digital New Deal report: **no governed access at scale without data interoperability**, and no competitive agentic AI without governed access to data.

1.3. FROM SECTOR INITIATIVES TO A DATA UNION AND AI CONTINENT

Europe is no longer designing its data economy. It is deploying it. Over the last five years, the EU has moved from strategy to rollout: a “single market for data” built through **Common European Data Spaces**²¹, now tracked across **14 sectors/domains** and funded with dedicated support instruments. At the same time, Europe is accelerating a second track: becoming an **“AI continent”** by scaling compute infrastructure (AI Factories and gigafactories) and industrial adoption.

The strategic question is no longer whether Europe has a vision. It is whether these two tracks will **connect into one continental capability**, or remain a patchwork of interesting but isolated initiatives.

Europe's diagnosis is converging: fragmentation is now a competitiveness problem

Europe's core gap is not talent or ideas, it is scale and diffusion of digital capabilities:

- The Draghi competitiveness strategy links the EU–US productivity gap to digital technology and **Europe's missed opportunity to fully capitalise on earlier digital waves**²².
- It also gives a concrete, sector-level example: **access to health data is a precondition for AI in pharma**, yet it remains constrained by fragmentation and uneven practices across Member States.
- The same report argues for **cross-industry coordination and data sharing** to develop AI verticals and industrial digital twins, an explicit call for EU companies to contribute data across sectors to overcome the lack of large datasets.

This matters for interoperability because Europe is structurally strong in regulated, high-value sectors (health, energy, manufacturing, mobility, public services). But those strengths only compound if data can move across borders and sectors with low friction.

The “Data Union” is the political bridge, but data interoperability is the engineering bridge

The **Data Union Strategy** (adopted November 2025) is a signal that the EU wants to move from a set of sector programmes to a true economic space for data, expanding data spaces and proposing **“data labs” to link data spaces and AI ecosystems**.

That shift is important: a Data Union is not just “more data spaces”. It is **cross-data spaces composition** as a default.

²¹ Common European data spaces are EU-backed, sectoral or cross-sectoral trusted data-sharing ecosystems designed to make data available and reusable across Europe under shared governance, technical, legal, and interoperability rules. A data space is the generic model, any governed ecosystem for trusted data sharing, while a Common European Data Space is the EU policy implementation of that model, usually linked to a strategic sector such as health, mobility, energy, skills, tourism, agriculture, public administration, culture, or manufacturing. As an example, a Common European Data Space can be a sectoral federation of smaller, local, data space initiatives (e.g., the EMDS - European Mobility Data Space - is a sectoral EU-backed federation of existing mobility data space initiatives such as EONA-X and the German Mobility Data Space).

²² Mario Draghi, “The future of European competitiveness” (2024): https://commission.europa.eu/topics/competitiveness/draghi-report_en

AI continent: Europe is scaling compute fast, data must become composable fast

Europe's AI ambition is becoming infrastructure-heavy:

- The **AI Continent Action Plan** (COM(2025)165) explicitly targets large-scale AI infrastructures and mentions **AI gigafactories** as a goal (notably via InvestAI)²³.
- The Commission's InvestAI announcement launched an initiative to mobilise **€200 billion** for AI investment, including a dedicated **€20 billion fund for AI gigafactories**.
- The Commission's AI Factories policy track sets expectations for **multiple AI Factories becoming operational by 2026**, reinforcing the pan-EU infrastructure narrative.

But Draghi's report is equally clear-eyed about the stack reality: **cloud and compute markets reward scale and integrated offerings**, making it hard to "catch up" purely by replicating hyperscaler economics.

So Europe's most realistic lever is the one it uniquely controls: **the rules, interfaces, and interoperability of governed access to European datasets across sectors**, the data layer as a continental capability.

The missing link: data interoperability across initiatives, not only within them

Europe has many moving parts, sector projects, national initiatives, common building blocks, but without interoperability, they do not add up.

The good news is that **Europe already has the basis for shared rails: a "data access layer", spread across complementary initiatives**. The strategic problem is therefore not "absence of components", it is lack of enforced convergence across the sector rollouts, so the Data Union does not become "14 parallel Europes as 14 Common European Data Space projects in 14 key sectors".

What EU-wide composition can look like: cross-data spaces initiatives (illustrative)

Below is a practical way to show how data spaces become a Data Union only when they are interoperable enough to combine:

²³ European Commission, "AI Continent Action Plan": <https://digital-strategy.ec.europa.eu/en/library/ai-continent-action-plan>; European Commission, InvestAI announcement: <https://digital-strategy.ec.europa.eu/en/news/eu-launches-investai-initiative-mobilise-eu200-billion-investment-artificial-intelligence>; European Commission, AI Factories: <https://digital-strategy.ec.europa.eu/en/policies/ai-factories>.

	EXAMPLE "DATA SPACE OUTPUTS"	EXAMPLE CROSS-DATA SPACES COMPOSITION
SKILLS & EDUCATION (DS4SKILLS ²⁴)	Learning AI assistants, career path recommendations, AI course generation, advanced skills analytics and foresight, personalised professional training paths.	Education + Media, Tourism, Cultural: include media, tourism, cultural content into learning journeys and content (first cross data space use case in production: education + media).
MOBILITY (deployEMDS ²⁵)	Multimodal travel, logistics status, network/infrastructure signals.	Mobility + Tourism for end-to-end travel services and cross-border customer journeys.
TOURISM (DEPLOYTOUR ²⁶)	Destination services, availability, sustainability indicators.	Tourism + multiple sectoral destination influences (Cultural Heritage, Smart Cities, Mobility, Green, Energy...).
HEALTH (EHDS ²⁷)	Cross-border care services (MyHealth@EU), secondary-use frameworks.	Health + Research & Innovation (EOISC) for federated research pipelines.
ENERGY (e.g., OMEGA-X ²⁸ , etc.)	Grid & flexibility data, metering, asset telemetry.	Energy + Manufacturing + Transportation for industrial flexibility / optimisation.
MANUFACTURING (e.g., Data Space 4.0 ²⁹)	Supply-chain data products, asset twins, maintenance data.	Manufacturing + Aerospace/Defence ecosystems (e.g., DECADE-X + EONA-X for logistics) for resilient supply chains.
PUBLIC ADMINISTRATION (OOTS ³⁰ , legal data space, procurement)	Once-only information flows, legal & procurement datasets.	Horizontal enabler for cross-border onboarding, compliance checks, and EU-wide service delivery.

Some industry ecosystems are already building across borders. For example, **EONA-X** explicitly positions itself at the intersection of mobility, logistics and tourism. This is exactly what the Data Union should make normal: **cross-sector composition without bespoke**

²⁴ <https://www.skillsdataspace.eu/>

²⁵ <https://deployemds.eu/>

²⁶ <https://deploytour.eu/>

²⁷ <https://www.european-health-data-space.com/>

²⁸ <https://omega-x.eu/>

²⁹ <https://manufacturingdataspace-csa.eu/>

³⁰ <https://ec.europa.eu/digital-building-blocks/sites/spaces/OOTS/pages/610468075/About+OOTS>

integration every time. It means MoU signed and common use cases between important European initiatives like DECADE-X³¹ (Aerospace and defence data space) and EONA-X³² (mobility, logistics and tourism data space) which are just the beginning of this evolution.

BOTTOM LINE

→ Europe has the regulatory foundations, the sector programmes, and now the macro-strategies ("Data Union" and "AI continent"). The make-or-break factor is whether these initiatives become **composable at EU scale**, which is an interoperability problem, not a vision problem.

1.4. GLOBAL COMPETITION: STANDARDS, STACKS AND INFLUENCE

In the digital economy, "standards" are rarely imposed by committees first. They are most often imposed by platforms, stacks, and ecosystems, through APIs, developer tools, distribution chokepoints, and end-to-end integration. Formal standards then often arrive as confirmation of what already became the default³³.

This is the battlefield Europe must name clearly. The strategic risk is not only that Europe becomes outcompeted; it is that Europe becomes interoperable by necessity, plugging into foreign defaults because the cost of doing otherwise is too high. The strategic objective, therefore, is not isolation. It is cooperation on Europe's terms: influence the standards that shape markets, avoid dependency-by-default, and keep freedom of choice across the cloud–data–AI stack.

Two dominant poles: US and China set defaults differently, but both shape the global baseline

The United States: de facto standards via private stacks; governed sharing mostly sectoral.

The US model is structurally (central) platform-led³⁴. Cloud hyperscalers, mobile ecosystems, and enterprise software suites set de facto technical norms at global scale. In parallel, the US has serious governance and interoperability instruments, but they are mostly **sector-anchored** or **agency-driven**, not an economy-wide "data space" programme equivalent to Europe's.

What the US does build (and it matters for Europe's benchmarking):

- **Federal data governance and management rails:** the Evidence Act implementation guidance (including mandated roles like Chief Data Officers) and the Federal Data Strategy operationalise data as a strategic asset inside government, with concrete cross-agency actions and inventories³⁵.

³¹ <https://www.decade-x.org/>

³² <https://eona-x.eu/>

³³ The Dataspace Protocol (DSP) and the Decentralized Claims Protocol (DCP) are two examples of de facto specifications that may later influence formal standardisation.

³⁴ Here, "platform-led" refers to platforms governed by a single hierarchical organisation. Data space protocols and components may also function as platform technologies, but they are not normally governed by a single for-profit organisation setting the rules of admission and operation.

³⁵ Federal Data Strategy: <https://strategy.data.gov/>; NIST Digital Identity Guidelines SP 800-63-4: <https://csrc.nist.gov/pubs/sp/800/63/4/final>; TEFCFA: <https://rce.sequoiaproject.org/tefca/>; CFPB Personal Financial Data Rights rule: <https://www.consumerfinance.gov/about-us/newsroom/cfpb-finalizes-personal-financial-data-rights-rule-to-boost-competition-protect-privacy-and-give-families-more-choice-in-financial-services/>.

- **Strong “building block” doctrine** (identity, privacy, security) through NIST guidance that becomes a reference across public and private sectors (e.g., digital identity guidelines).
- **Sector-scale interoperability frameworks that resemble “data space logic”** (rules + trust + technical framework), especially in health and finance:
 - TEFCA in health is explicitly designed to enable network-to-network trusted exchange via a governance and legal framework plus a technical framework.
 - In finance, the CFPB’s Personal Financial Data Rights (Section 1033) final rule pushes a standardised, secure data-sharing direction (“open banking” style), again through a sector pathway.

What the US does not currently prioritise in the European sense is an EU-style, horizontal “value creation” rail for the private economy comparable to Europe’s Data Governance Act and Data Act logic (i.e., a broad framework to rebalance access, foster intermediaries, and make cross-sector governed B2B exchange repeatable at scale).

This gap matters because it shapes the transatlantic friction line. The US debate has increasingly framed EU platform enforcement as discriminatory and has threatened countermeasures against EU firms in response to European digital regulation and fines, an illustration that the US is willing to contest Europe’s protective platform agenda (DSA/DMA) while not converging on Europe’s market-structuring data agenda (DGA/Data Act).

Finally, **the closest thing to a “harmonisation data layer” in the US consumer/platform world often emerges through private protocols and industry initiatives** (e.g., cross-service portability frameworks initiated by major platforms) rather than public, economy-wide interoperability obligations.

BOTTOM LINE

→ The US exports standards by shipping stacks to worldwide dominant B2C and B2C services. Europe must assume US defaults will continue to diffuse globally through integrated products, unless Europe makes interoperability a competitive, low-friction alternative that partners can adopt without joining a foreign stack. A further complication, the majority of European data space deployments currently rely on US cloud infrastructure. True interoperability autonomy requires addressing the cloud layer, not only the data governance layer above it.

China: state-orchestrated data infrastructure + trusted data spaces at scale

China is pursuing a more centralised and state-organised route, explicitly treating data circulation, data infrastructure, and standardisation capacity as a strategic programme.

Two signals are especially important for Europe’s benchmarking:

- **A national “trusted data spaces” rollout at scale:** China’s National Data Administration has an action plan (2024–2028) aiming to establish **more than 100 trusted data spaces** (often translated as “trusted data matrixes”) by 2028, with breakthroughs targeted across operations, technology, ecosystem building, standards, and security³⁶.

³⁶ State Council/Xinhua on the national trusted data matrix action plan: https://english.www.gov.cn/news/202411/23/content_WS67418c47c6d0868f4e8ed5ab.html; CSET translation and analysis of China national data infrastructure guidelines: <https://cset.georgetown.edu/publication/china-national-data-infrastructure-guidelines/>.

- **A national data infrastructure vision with catalogue ambition:** translated policy guidance analysed by CSET³⁷ describes an approach aiming to make a large share of datasets discoverable and usable through a unified catalogue by 2029, i.e., a top-down architecture for discoverability and usability, not only local pilots.

The acceleration via the “Data Elements X” plan (2024–2026):

This operational framework targets twelve priority sectors to unlock the “multiplier effect” of data. The objective is to transform raw resources into productive assets to generate 20% annual growth in the data industry by the end of 2026. This plan mandates the creation of “typical application scenarios” (more than 300 expected), forcing immediate vertical interoperability between major public data holders and private technology champions³⁸.

The institutionalisation of data exchange:

China is not merely building technical flows; it is constructing a financial market for data. Exchanges in Shanghai, Beijing, and Shenzhen enable the listing, auditing, and trading of data usage rights. In 2025, Shanghai launched the first trusted mobility data ecosystem, automating data transactions between connected vehicle manufacturers, public transport operators, and Mobility as a Service (MaaS³⁹) providers. Underpinning this financial market architecture is a regulatory move with no European equivalent: since 1 January 2024, Chinese enterprises can capitalise data assets on their balance sheets under rules issued by the Ministry of Finance (Provisional Measures on Accounting Treatment of Enterprise Data Resources). Data held for internal use is recognised as an intangible asset; data held for sale in the normal course of business is recognised as inventory. This accounting recognition gives data a formal financial valuation, creating direct economic incentives to participate in data exchanges, and unlocking data as a financial instrument in its own right: collateral for loans, input to equity valuations, basis for insurance, and consideration in mergers and acquisitions. Europe has no equivalent framework, and the absence of a harmonised accounting treatment for data remains an underappreciated structural gap in the European data economy.

The “Public Data Authorized Operation” model:

Unlike European Open Data, China is deploying a system of delegated operations. The state authorises specific entities to process and enrich sovereign data to create commercial data products. This mechanism ensures that added value remains under sovereign control while providing domestic AI with datasets of a depth inaccessible to foreign actors. This is not “Europe’s data spaces with Chinese characteristics.” It is a different model: stronger central steering, tighter coupling between industrial policy and technical standards, and an explicit ambition to industrialise data circulation as a national capability.

Exporting the model via the “Digital Silk Road”:

Chinese strategy now aims to project these technical specifications internationally. By

³⁷ Center for Security and Emerging Technology

³⁸ National Data Administration, “Data Elements X” action plan (Chinese): https://www.nda.gov.cn/sjj/xxgk/gknr/gjih/09/09/20240909160155798592998_pc.html; State Council report on accounting treatment of enterprise data resources: https://english.www.gov.cn/news/202406/27/content_WS667cc54fc6d0868f4e8e89e2.html.

³⁹ Mobility as a Service

standardising data formats and trust protocols with its trading partners (notably in Southeast Asia and BRICS+ nations), China is creating an area of influence where interoperability becomes synonymous with adhering to its own technology stack, effectively bypassing Western standardisation efforts.

At the same time, China's AI ecosystem is also using open-source models and tooling as a channel for diffusion and influence. An apparent paradox only if one assumes that open-source automatically entails open governance or symmetrical openness. In practice, open-source releases can help shape global technical defaults and accelerate adoption abroad, while strategic control remains concentrated elsewhere in the stack. This strategy also appears uneven rather than fully reciprocal: openness outward does not necessarily translate into equivalent openness inward, given the tighter regulatory constraints that structure model development and deployment within the domestic ecosystem.

BOTTOM LINE

→ China is scaling "trusted data spaces" as national infrastructure, prioritising transactional fluidity and rapid execution. This state-orchestrated coherence ensures that Chinese specifications travel with its industrial ecosystems, increasing the risk that they emerge as the de facto global standards for tomorrow's data-driven markets.

Emerging models: India, Japan, Korea, interoperability as strategic public infrastructure

Beyond the US–China axis, several major economies are building models that are highly relevant to Europe's strategy because they treat interoperability and governed exchange as infrastructure, not only as compliance.

- **India: consent-based data sharing as DPI (Digital Public Infrastructure)** India's DEPA (Data Empowerment and Protection Architecture) frames consent-based sharing through interoperable rails, illustrated by the Account Aggregator model for financial data sharing. This is not identical to EU data spaces, but it is structurally aligned with the idea that governed exchange must be repeatable and low-friction to unlock innovation and competition⁴⁰.
- **Japan: Data Free Flow with Trust (DFFT) as a cross-border doctrine** Japan has championed DFFT as an approach to enabling cross-border data flows while maintaining trust conditions, pushing the debate toward international arrangements where trust, security, and governance become the enablers (not the blockers) of data circulation⁴¹.
- **Korea: portability and trust, plus structured cooperation with EU data initiatives** Korea is extending data portability-type approaches, notably through its economy-wide MyData⁴² policy direction, while also engaging directly with European data ecosystem initiatives. The establishment of the Gaia-X Korea Hub, announced with the support of Korea's Ministry of Science and ICT (MSIT), reflects a strategic effort to connect

⁴⁰ NITI Aayog, "Data Empowerment and Protection Architecture": <https://www.niti.gov.in/sites/default/files/2020-09/DEPA-Book.pdf>

⁴¹ Japan Digital Agency, Data Free Flow with Trust: <https://www.digital.go.jp/en/policies/dfft>

⁴² <https://mydata.org/>

Korean companies and institutions with European data space frameworks, global data norms, and interoperability standards. Beyond the hub itself, Korea is also structuring this cooperation through the International Data Research and Collaboration Institutes (IDRI), presented as a Korean organisation supporting the development of Korea's data ecosystem through sustained exchange with the EU data ecosystem and participation of Korean experts in international data standardisation processes. This suggests that Europe's data space approach can become an exportable partnership model when it is operational, predictable, and supported by concrete institutional relays abroad⁴³.



KOREA X EUROPE PARTNERSHIP

A concrete illustration of this EU-Korea cooperation is ChemX, a EUREKA bilateral R&D project co-funded by Bpifrance (France) and KIAT (Korea Institute for Advancement of Technology). ChemX aims to develop a trusted, standards-compliant data space and AI-powered services for the chemical industry, addressing a critical sector dilemma: EU regulations such as the Digital Product Passport and the Carbon Border Adjustment Mechanism mandate transparent supply chain data sharing, while chemical companies remain reluctant to share data due to sensitivity around formulations and process know-how. The project partners Seabury Solutions and KRICT, the largest government-sponsored repository for foundational chemical data and research in South Korea, on the Korean side, with Dawex on the French side. It uses a European data exchange infrastructure to enable secure, governed, and traceable trusted data transactions between data providers and AI service users, showing how European data space approaches, built on governance and trust frameworks, can become an exportable model for bilateral industrial cooperation.

BOTTOM LINE

→ These countries are building "rails" (consent, portability, trust frameworks, cross-border rules) that can either align with Europe's approach, or become competing interoperability baselines. Europe is building bridges already, but it should treat them as priority partners for standards influence.

What this means for Europe: cooperate globally, but never by default

Europe should not misread the landscape as a call for digital autarky. Europe's opportunity is larger, and more realistic: **Europe has more to gain from partnering than from fighting, if Europe controls the interfaces.** The strategic objective is to make European interoperability the easiest "neutral option" for global partners: adoptable without joining a foreign stack, compatible with international norms, and protected by a verifiable trust framework.

⁴³ Gaia-X Korea hub cooperation: <https://sciencebusiness.net/network-updates/korea-eu-strengthen-data-cooperation-launch-gaia-x-korean-hub>.

To do so, Europe must operationalise a clear external posture:

- **Export an interoperability core, not a European stack monopoly.** Europe's path is "one non-negotiable interoperability core, many competitive implementations." This is consistent with the Commission's data spaces approach (common governance + common infrastructures) and with the role of enabling components like Simpl (middleware supporting interoperability among European data spaces)⁴⁴ and the free open-source software implementation of the Gaia-X Trust Framework (Trust Protocol).
- **Make trust machine-verifiable and reusable across borders.** Trust cannot remain a narrative; it must become a testable property. Europe's existing assets (e.g., open and neutral Gaia-X Trust Framework/Trust Protocol⁴⁵); DSSC blueprint⁴⁶; IDSA Dataspace Protocol⁴⁷) are the right direction, if they converge into measurable profiles and conformance.
- **Choose interdependence, not dependency.** Europe should connect with US, Chinese, and emerging ecosystems (e.g., Korea) where it serves European industrial interests, but with explicit safeguards: reciprocity auditability, exit rights, and the ability to substitute components (e.g., cloud, connectors/APIs, identity, catalogues) without breaking the market.
- **Treat standards influence as an industrial policy instrument.** In this cycle, standards are not a "technical appendix" to regulation; they are how value is captured. If Europe wants European value creation (not only European compliance), it must show up where defaults are set: reference implementations, developer experience, procurement rules, certification, and international alliances.

In a nutshell: the world will not wait for Europe's internal convergence. Others will keep imposing standards through bottom-up market-driven stacks and top-down states approaches. Europe's winning strategy is **to partner aggressively, shape standards early, and make European interoperability the global "trusted neutral" option, so Europe can cooperate by choice, not by dependency.**



FULL STACK COMPARISON BETWEEN US, CHINA AND EUROPE

Published in January 2026, our previous Digital New Deal report *The dependency economy of AI* maps the global technological dependencies in the AI value chain and introduces a new AI Resilience Index based on eight structural pillars. The study assesses 25 national AI strategies, scoring them out of 40, and reveals surprising results for Europe.

The conclusion is striking, the study demonstrates that the **EU is a sleeping AI giant. Europe's gap is not a lack of talent, innovation capacity, or industrial depth. It is a fragmentation crisis.** If Europe acted as a unified strategic bloc, its AI Resilience score would reach **36 out of 40**, placing it on par with the United States and China.

⁴⁴ Simpl: <https://digital-strategy.ec.europa.eu/en/policies/simpl>

⁴⁵ Gaia-X Trust Framework: https://docs.gaia-x.eu/policy-rules-committee/trust-framework/22_10/

⁴⁶ DSSC Blueprint: <https://dssc.eu/page/blueprint>

⁴⁷ IDSA Reference Architecture: <https://internationaldataspaces.org/offers/reference-architecture/>

The roadmap is clear:

Step 1 – Unify. By pooling existing capabilities, research, infrastructure, talent, regulatory leverage, and industrial assets, Europe’s score would immediately rise from **28 to 34**, without inventing anything new.

Step 2 – Co-invest. By matching the investment levels of Japan or South Korea in the “hard layers” of AI (compute infrastructure and semiconductors), Europe would reach **36/40**, fully entering the top tier of global AI powers.

1.5. THE STRATEGIC RISK: AN ARCHIPELAGO INSTEAD OF A SINGLE MARKET FOR DATA

Europe’s data spaces were never meant to be a collection of disconnected sector pilots. The Commission’s own objective is explicit: **data spaces should be gradually interconnected to form a “single market for data.”**

If that interconnection does not happen fast enough, the outcome is not a “plural Europe”. **It is an archipelago:** many small, internally coherent networks that remain externally costly to use together. And in digital markets, whoever reduces the cost of coordination captures disproportionate value.

The “archipelago trap”: fragmentation creates a value vacuum

“Small data spaces” are not neutral. They create a structural vacuum at EU scale:

- **Local network effects stay local.** Each data space can reach critical mass inside its perimeter, but EU-scale reuse remains marginal because cross-data spaces discovery, contracting, semantics, and access paths stay bespoke.
- **Cross-border and cross-sector use cases become integration projects.** Every additional data space becomes another “adapter”, another negotiation, another mapping exercise, costly for SMEs and slow for time-to-market.
- **The integration layer becomes the real market.** When a continent builds dozens of semi-compatible infrastructures, the strategic prize shifts to the actor that can sit above them and offer “one API, one contract, one onboarding”.

This is the moment where Europe can unintentionally recreate, at the data layer, what it historically tried to prevent at the telecom and platform layers: **a few gatekeepers controlling the gateways.** The difference is that this time, Europe’s own public funding would have helped finance the underlying fragmentation.

Why the risk is now strategic: AI amplifies platform power

The move from “data economy” to “AI economy” changes the stakes. In practice, **AI adoption rewards integrated pipelines:** data ingestion + data governance + compute + tooling + distribution. The more continuous the pipeline, the stronger the compounding effects (faster iteration loops, better productisation, lower marginal cost of onboarding new datasets/users).

Europe is, in parallel, building a distributed compute layer through AI Factories and Antennas, with an explicit pan-EU ambition and 2025–2026 operational targets. **But compute does not create leverage by itself** if high-value datasets remain hard to combine across initiatives. In that scenario, the integrated stacks, those that offer end-to-end “data-to-

model-to-deploy" products, win by default, because they collapse transaction costs and capture the network effects.

This is exactly the strategic fork:

- **Multitude model (European advantage):** many actors, many data spaces, but concrete partnership culture and coordination at scale through open interconnection ("coordination without centralisation").
- **Platform model (default outcome if interconnection lags):** a small number of actors provide the "integration operating system" for everyone else.

Europe already set the direction in law, now the market will test it

The Data Act and Data Governance Act are not only about access rights. They are also a **market-shaping interoperability instrument**, designed to reduce dependency and make switching and multi-provider strategies feasible. It explicitly targets vendor lock-in as a competition and innovation problem.

Crucially for data spaces, **Article 33 of the Data Act sets "essential requirements" for participants offering data or data services**, including requirements around dataset descriptions, shared vocabularies and classification schemes, API descriptions enabling automated access, and interoperability of tooling (including automation of data sharing agreements). And the Regulation applies from **12 September 2025**, meaning the interoperability turn is not hypothetical, it is already the legal reality the market is adapting to⁴⁸.

What this means strategically: Europe has begun to define the conditions for interoperability, but **the winning side will be the one that operationalises them first**, in procurement, in funding conditions, in certification, in deployable reference implementations, and in markets.

Standardisation is becoming the battlefield for cross-data spaces interconnection

Interconnection is not achieved by declarations; it is achieved by **repeatable conformity**. The standardisation pipeline is already moving: CEN and CENELEC accepted the Commission's standardisation request for a **European Trusted Data Framework (Mandate M/614)**, explicitly linked to meeting Data Act Article 33 requirements, with planned deliverables including European Standards and Technical Specifications. This is a significant signal: the EU is treating data space interoperability as a European-wide standardisation object, not a voluntary alignment exercise.

But the risk remains: if standards arrive after ecosystems have already entrenched incompatible implementations, Europe will have "standards on paper" and "platform dominance in practice".

Financing: fund the rails, not the islands

If Europe does not finance interoperability **as a continent-level common good**, the market will finance it as a **platform rent**.

This is not theoretical. The European Commission is already demonstrating, through its compute strategy, that a network approach can be built beyond the usual "leading hubs": AI

⁴⁸ Regulation (EU) 2023/2854 (Data Act), Article 33 on essential requirements for interoperability of data, data-sharing mechanisms and services, and common European data spaces; Article 35 on interoperability of data processing services. ELI: <http://data.europa.eu/eli/reg/2023/2854/oj>.

Factory Antennas were announced across multiple Member States and extended to partner countries as part of a broader European infrastructure footprint.

EuroHPC itself keeps widening participation (Albania joined EuroHPC in June 2025⁴⁹), explicitly framed around Europe's technological sovereignty in supercomputing, AI and quantum technologies.

The political lesson is clear: **Europe knows how to build distributed capacity when it treats it as strategic infrastructure.**

The same principle must apply to data spaces: EU funding should prioritise what only the EU scale can provide, shared, reusable, non-proprietary interoperability layers, rather than multiplying standalone sector deployments that cannot compose.

The strategic failure mode: "interoperability inside, incompatibility outside"

Europe can easily end up in the following equilibrium:

- **Inside each data space:** compliance improves, governance frameworks mature, pilots run.
- **Between data spaces:** interoperability remains partial, late, or optional.
- **At EU scale:** value capture shifts to whoever offers the missing cross-data spaces integration service.

This is why the risk is no longer administrative. It is strategic, because it determines:

- whether Europe gets an EU-scale market infrastructure (and thus bargaining power),
- or**
- whether Europe becomes a set of data reservoirs feeding integrated stacks built elsewhere.

The *Interoperable Europe rolling plan*⁵⁰ captures the core technical reality behind this risk: interoperability problems impede combining data **within sectors**, and "even more so **between sectors**."

Academic and practitioner literature converges on the same diagnosis: the landscape is expanding fast, but the research and implementation space is still fragmented and difficult to synthesise into shared building blocks.

BOTTOM LINE

→ If Europe accepts "siloes data spaces" as a sufficient endpoint, it implicitly accepts a second step: **someone else will provide the EU-scale layer**. And the actor that provides that layer will control gateways, set de facto standards, and capture the compounding value created by network effects. Interoperability is therefore not a technical nice-to-have. It is the **make-or-break condition** for turning Europe's many data initiatives into a Digital Single Market infrastructure, and for ensuring that Europe's AI investments translate into European autonomy rather than European dependency-by-design.

⁴⁹ EuroHPC Joint Undertaking, "Albania joins EuroHPC Joint Undertaking": https://www.eurohpc-ju.europa.eu/albania-joins-eurohpc-joint-undertaking-2025-06-25_en.

⁵⁰ European Commission, Interoperable Europe Portal, "Data interoperability - Rolling Plan for ICT Standardisation 2025," accessed May 2026.

ENTER THROUGH ONE,
CONNECT TO ALL.



INTEROPERABILITY
IS THEREFORE NOT A
TECHNICAL NICE-TO-HAVE.
IT IS THE MAKE-OR-BREAK
CONDITION.

II. WHAT EUROPE HAS TODAY: MOMENTUM WITHOUT COMPOSITION

2.1. MULTIPLE DATA-SHARING PARADIGMS

Europe does not have one data-sharing model. It has a heterogeneous stack of coexisting paradigms, open data portals, internal data lakes and warehouses, point-to-point exchanges, marketplaces, platform ecosystems, and now data spaces. Each paradigm is rational in isolation. Together, they do not compose.

The result is structural: **every new data collaboration almost starts “from scratch”**, new onboarding, new contracts, new security reviews, new mappings, new semantics, new monitoring. Interoperability becomes a project cost, not a market feature. That is why Europe can have strong intent, strong pilots, and still weak diffusion.

A landscape of partial solutions

Open data has built an essential baseline: one-to-many publishing of public-sector related information, reusable by anyone. This works well for transparency, civic innovation, research, and baseline economic reuse, but it does not solve governed B2B and private & protected data-sharing at scale, and it does not prevent value capture by actors that already control compute and distribution. Highest market value data is not open data.

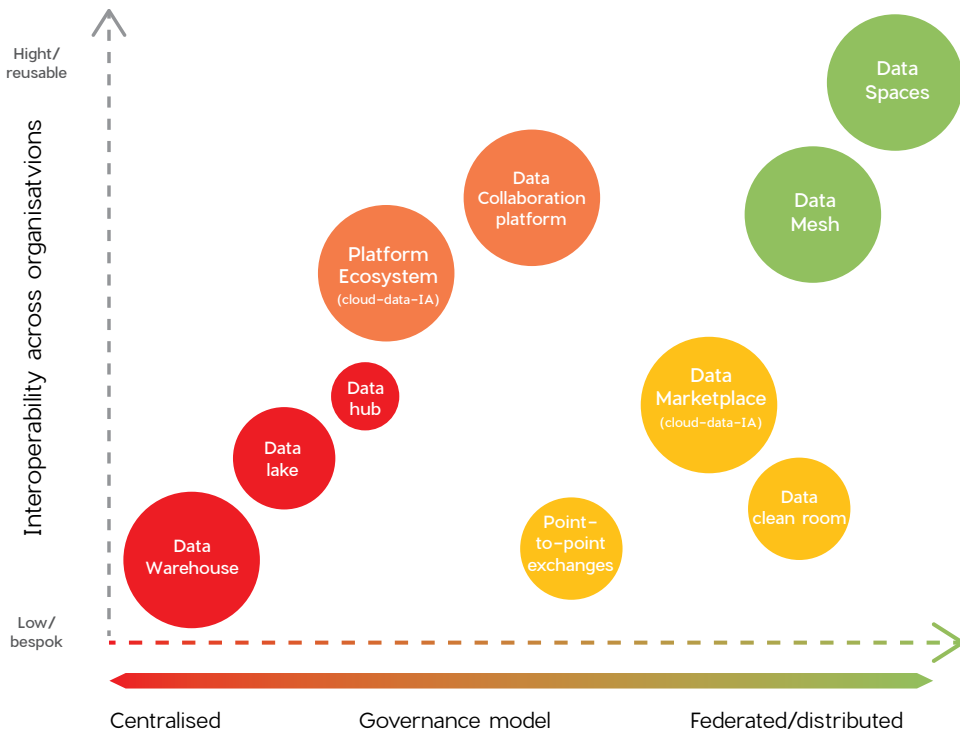
Closed data lakes and warehouses optimise internal analytics: centralised repositories that ingest and organise data for reporting, BI, and AI inside organisations. They solve “make data usable internally,” not “make data reusable across firms”. When repurposed as sharing mechanisms, they typically export the problem into bilateral integration and access-control complexity.

Point-to-point exchange (APIs, EDI, bespoke pipelines) remains the default pattern for many supply chains and regulated collaborations: bilateral agreements and technical connections between partners. It works, until it must scale. The network cost grows with every new participant: integration time, mapping, maintenance, and compliance overhead compound quickly. This is the classic $N \times N$ trap.

Data hubs aim to consolidate and distribute “trusted” enterprise data (often around key domains like customer, product, operations). They reduce internal fragmentation and can enable internal reuse, but they rarely solve cross-ecosystem reuse because their governance, identifiers, and semantics remain organisation-specific.

Data mesh is a response to the limits of centralised enterprise data teams: it decentralises ownership to domain teams, treats data as a product, and relies on a self-serve platform plus federated governance. It improves internal scaling dynamics, but it is not, by itself, a cross-organisation interoperability mechanism. Without shared external profiles, a “mesh” risks becoming many internal products that still cannot be reused across ecosystems.

Data marketplaces promise discoverability and simplified procurement (“data shopping”), often packaged as a catalog-plus-licensing proposition. They can reduce search and contracting friction within a given marketplace, but they usually do not solve end-to-end interoperability



Scalability/network-effect potential (size)

- Low
- Medium
- High
- Very High

Main structural risk (colorful)

- Internal optimisation
- Fragmentation
- Lock-in/ platform capture
- Federated interoperability potential

What is different with data spaces?

A data space is not simply a new technical pattern sitting next to open data portals, data lakes, hubs, meshes, collaboration platforms or marketplaces. It is, by design, an organisational model: a way to structure who can share what, with whom, under which conditions, with what accountability, and with what enforceability. In other words, it is a governance-first system that makes data sharing repeatable and trustworthy across organisations, and that helps

⁵¹ Databricks Series J announcement: <https://www.databricks.com/company/newsroom/press-releases/databricks-raising-10b-series-j-investment-62b-valuation>;

⁵² Snowflake Ventures: <https://www.snowflake.com/en/why-snowflake/startup-program/snowflake-ventures/>.

create federations, and federations of federations.

This is captured in the core definition: a data space is “**a distributed system defined by a governance framework that enables secure and trustworthy data transactions**”⁵³. Governance is not an afterthought; it is the operating logic. The governance framework is what turns “sharing” into **roles, decision rights, onboarding rules, access & usage conditions, oversight mechanisms, and enforceable processes**, so transactions can scale beyond bespoke one-offs.

That is why data spaces can **integrate all other paradigms instead of replacing them**. Open data can remain open (as a specific publication and reuse regime), internal lakes/warehouses can remain internal (as production and analytics backbones), data hubs can remain aggregation points, data mesh can remain an enterprise operating model, and marketplaces can remain commercial front-ends. What data spaces add is the missing layer that those paradigms don’t provide at **ecosystem scale**: common rules of the road, shared trust and onboarding, and governed reuse, so assets can move across boundaries without rebuilding contracts, access rules, and compliance from scratch each time.

Finally, the term “data space” is misleading because it sounds like a place where data sits. In reality, data spaces enable the governance of **full-stack ecosystems**: they are underpinned by common infrastructures and governance frameworks, and are meant not only to access and share data, but also to process and use it under well-defined governance mechanisms. This is the strategic point: **data governance propagates upstream and downstream**, into infrastructure choices, portability, and into AI training, deployment, accountability, so what is really being organised is a cloud–data–AI capability, not only “data exchange”.

2.2. THE SCALING BOTTLENECK: MANY INITIATIVES, FEW REUSABLE TRANSACTIONS

Europe has reached a new phase: the problem is no longer initiating data spaces; it is scaling them into something that behaves like a “single market” infrastructure. The signal is clear: the ecosystem has already multiplied across sectors, geographies and technological stacks. The International Data Spaces Association (IDSA) Data Spaces Radar⁵⁴ already catalogues **145 entries** across **14 sectors** (from manufacturing and mobility to public services, health, finance and smart cities).

But proliferation is not scale. A large number of initiatives can still produce a small number of **operational, reusable, cross-border data transactions**, especially when each ecosystem has to solve the same integration problems again and again.

Recent maturity evidence is sobering. In its January 2026 *Maturity assessment report*⁵⁵, the Data Spaces Support Centre (DSSC) reports that the assessment covered 14 out of 18 targeted initiatives, and that, under strict development-cycle criteria, **64% data space initiatives were still preparatory**, 22% exploratory, and 14% implementation, with 0% classified as operational or scaling.

Even when applying a more “use-case-driven” classification (i.e., looking at delivery of use

⁵³ DSSC, data space definition: <https://dssc.eu/space/DSSSE/791740421>

⁵⁴ Data Spaces Radar: <https://www.dataspaces-radar.org/>; IDSA Data Spaces Radar: <https://internationaldataspaces.org/use/data-spaces-radar/>.

⁵⁵ <https://assets.dssc.eu/rsr/papers/DSSC%20T2.5%20maturity%20assessment%20report.pdf>

cases rather than full organisational maturity), only a minority reaches the right side of the curve (**7% operational; 29% scaling**), suggesting that “scaling” is often happening in pockets, but remains fragile and uneven.

This gap matters because Europe is now entering the **network-effects moment** of the data economy. At that point, the cost is not “building one more data space.” The cost is **making each single data space work, and connecting data spaces**, and doing so without bespoke integration every time.

The real scaling cost: bespoke interconnection (repeated N times)

When ecosystems remain unconnected, every cross-data space use case becomes a custom systems-integration project: new contracts, new onboarding, new trust checks, new semantic mappings, new APIs, new liability discussions. The EU’s own diagnosis in the Data Act is explicit about the structural barriers to data sharing: contracting and technical interface implementation costs, fragmented silos, poor metadata management, and the absence of semantic and technical interoperability standards are repeatedly cited as obstacles.

This is why **interoperability is not a “technical nice-to-have”**. It is the mechanism that turns local feasibility into EU-scale repeatability. The *Interoperable Europe Rolling Plan* (ICT Standardisation)⁵⁶ frames the same issue bluntly: interoperability problems impede combining data even within sectors, and even more across sectors.

Data space literature aligns with this diagnosis: the landscape is rich, but still fragmented. A recent systematic mapping study of **149 peer-reviewed publications**⁵⁷ **notes that research and implementation remain under-synthesised and fragmented across foundations and building blocks**, mirroring the fragmentation we see in practice⁵⁸.

At the architectural level, **Europe is still operating through multiple reference models and technology stacks** (e.g., IDS-RAM, Eclipse Dataspace Components or EDC, FIWARE, Prometheus-X, Ocean Enterprise / Pontus-X, Tractus-X, and more). This diversity is not a weakness in itself; on the contrary, it reflects legitimate differences in use cases, sectoral needs and non-functional requirements, and allows organisations to choose the solutions best suited to their context. The challenge arises when this plurality is not matched by interoperability. Without shared, testable and enforceable requirements across stacks, useful diversity can turn into coordination costs, limited portability and fragmented adoption. The issue, therefore, is not the existence of multiple stacks, but the absence of common rails that allow them to interoperate reliably. A major structural constraint lies in legacy systems, which were originally designed for internal optimisation rather than for data exposure or cross-organisational integration, making interoperability costly and technically difficult to scale.

Semantics is a practical illustration of the scaling constraint. If data meaning is not aligned, organisations spend time and money mapping, cleaning and reinterpreting, work that does not compound across projects. IDSA’s position paper on semantic interoperability⁵⁹ stresses

⁵⁶ https://interoperable-europe.ec.europa.eu/collection/rolling-plan-ict-standardisation/data-interoperability-rp-2025?utm_source=chatgpt.com

⁵⁷ https://www.sciencedirect.com/science/article/pii/S1574013725000954?utm_source=chatgpt.com

⁵⁸ Systematic mapping study in the Journal of Systems and Software / ScienceDirect: <https://www.sciencedirect.com/science/article/pii/S1574013725000954>

⁵⁹ https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Position-Paper-Semantic-Interoperability-in-Data-Spaces-V1.1-1-5.pdf

that unclear meaning leads to misinterpretation, and that organisations end up investing significant effort into mapping data to expected structures.

In other words: **Europe is paying the “data interoperability tax” repeatedly**, in every new consortium, instead of financing reusable interoperability once and amortising it across the continent.

Interconnection is the condition for the “multitude model”

Europe's competitive proposition is not to build one monolithic platform. It is to make a federated model work: many actors, many implementations, shared rules, and frictionless transactions. The DSSC definition is explicit: **a federation of data spaces is a data space that enables seamless data transactions between participants of multiple data spaces based on agreed common rules** (typically set in a governance framework and rulebook).

Without this cross-data spaces capability, the “multitude model” cannot generate strong network effects. The result is predictable: value concentrates in the integrated stacks that already offer seamless discovery, contracting, identity, and execution, because they remove friction by design.

A few verticals are moving first

Some sectors are already being pushed, by EU initiative, towards deployment at a scale where interoperability stops being theoretical. These initiatives will be further developed in part §4 of this report.

Skills and media is the first cross-data space implementation. The DS4SKILLS project (Digital Europe Programme) funds the interconnection between the education & skills data space and the media data space (TEMS) to enable trustworthy content generation through AI based on protected media and learning content⁶⁰.

Tourism is one of the examples. The **DEPLOYTOUR** project (Digital Europe Programme) launched **1 October 2024** with the explicit goal of establishing a secure and trusted **common European Tourism Data Space (ETDS)**, implemented through **five pilot projects**.

Tourism is structurally cross-border, SME-heavy, and dependent on real-time composition (availability, bookings, events, transport, sustainability indicators). It cannot scale through isolated national portals or closed ecosystems. It needs interoperable rails.

Mobility/transport is the other advanced vertical, because it is inherently multi-actor and multi-domain (public and private, local and cross-border, passenger and freight). The Commission's EMDS approach is explicit: the European Mobility Data Space is not one database, but a framework for **interlinking and federating many heterogeneous transport-data ecosystems**, including mechanisms that exist in **passenger and freight** ecosystems, and it explicitly includes an **interlinking layer** expected to become the core of EMDS and to enable interconnectivity with other mobility/transport data spaces and domains (and with data spaces from other sectors).

The Commission also documents the concrete build-out steps: a completed coordination and support action (DeployEMDS), a **deployment action launched in November 2023** (three

⁶⁰ DS4Skills, "When media data meets education: empowering media literacy," use case page, accessed May 2026; Visions, "Data Space Media," technical approach, accessed May 2026.

years; **€8 million**) focused on traffic data and urban mobility use cases, a proof-of-concept on personal data management, and additional technical assistance, plus a **€15 million** project (Boost EDIC M&L) supporting a multi-country project for European common data infrastructure and services in mobility and transport. The EDGE-Skills project (20m€) coordinated by Prometheus-X⁶¹ co-funds the first operational cross data space and solution components to enable interoperability across sectors.

These verticals (skills, media, tourism and transport) are not just “more projects.” They are early stress-tests of Europe’s ability to industrialise **repeatable interoperability** across many stakeholders, jurisdictions, and datasets, where the alternative is not neutral. The alternative is that cross-border services will be assembled by whoever controls the easiest integrated stack.

BOTTOM LINE

→ Europe has achieved momentum. The radar is filling up; the pilots are multiplying. But the maturity and scaling evidence shows a bottleneck: too few initiatives are truly operational at EU level, and fewer still are scaling in a way that can be reused across sectors without custom integration each time. At this point, interoperability is not a future improvement. It is the binding constraint on whether public investment in data spaces produces a continent-scale market infrastructure, or a landscape of well-governed mini-networks that never compound.

⁶¹ EDGE-Skills co-funded cross data space work: <https://prometheus-x.org/community-impact-prometheus-x-open-source-infrastructure-for-european-data-spaces/>

DATA SPACE	SECTOR(S)	DATA SPACE	SECTOR(S)	DATA SPACE	SECTOR(S)
3DBIGDATA SPACE	Cultural Heritage	DS4SSCC - CSA PRELIMINARY STUDY + DEP	Smart Territories	INT:NET - CSA PRELIMINARY STUDY	Energy
4GROWTH	Agriculture	DUTCH METROPOLITAN INNOVATIONS (DMI) ECOSYSTEM	Smart Territories	LANGUAGE DATA SPACE (LDS)	Language
5DCULTURE	Cultural Heritage	EDAH - CSA PRE-LIMINARY STUDY	Health	LEGAL DATA SPACE	Legal
ACCURATE	Manufacturing, Logistics	EDDIE	Energy	LIP3D	Cultural Heritage
AEROSPACE-X	Aeronautics, Space	EDGE-SKILLS	Skills	MACHINERY-X	Manufacturing
AGRIDATASPACE - CSA PRELIMINARY STUDY	Agriculture	ELINOR-X	Smart territories	MANUFACTURING-X	Manufacturing
AGRIDATAVALUE	Agriculture	EMPOWER-X	Energy	MARISPACE-X	Sea activities
AI4CULTURE	Cultural Heritage	ENERGY DATA-X	Energy	MARITIME DATA SPACE	Sea activities, Logistics
AI4EOSC	Research and Innovation	ENERSHARE	Energy	MARKET4.0	Manufacturing
ALL DATA 4 GREEN DEAL (AD4GD)	Green Deal	EONA-X	Mobility, Tourism, Logistics	MERLOT	Skills
ALT-EDIC	Language	EOSC BEYOND	Research and Innovation	MESEO	Space
AQUAINFRA	Research and Innovation	EOSC FOCUS	Research and Innovation	MICELIODATA	Manufacturing
AUSTRIA TOURISM DATA SPACE	Tourism	EOSC-ENTRUST	Research and Innovation	MOBILITY DATA SPACE (MDS)	Mobility
AUTO WERKS-TATT 4.0 - CAR REPAIR 4.0 (AW4.0)	Automotive, Manufacturing, Mobility	EOSC4CANCER	Research and Innovation	MOBISPACES	Mobility, Sea activities
B-CUBED	Green deal	EUCAIM	Health	MYHEALTH@EU	Health

BASIC DATA INFRASTRUCTURE (BDI)	Logistics	EUPROGIGANT	Manufacturing	OMEGA-X	Energy
BIOMETRICS DATA SPACE	Security	EUREKA3D	Cultural Heritage	OOTS - ONCE ONLY TECHNICAL SYSTEM	Public administration
BLUE-CLOUD 2026	Research and Innovation	EURODAT	Finance	OPENGPT-X	Language
CATENA-X / COFINITY-X	Automotive	EUROPEAN AUDIO DATA SPACE (EAD)	Audio	OSCARS	Research and Innovation
CHEM-X	Manufacturing	EUROPEAN DEFENCE AGENCY (EDA) AI DEFENCE DATA SPACE	Defence	OSTRAILS	Research and Innovation
COMMON EUROPEAN AGRICULTURAL DATA SPACE (CEADS) - IMPLEMENTATION	Agriculture / Agri-food	EUROPEAN GENOMIC DATA INFRASTRUCTURE (GDI)	Health	PLATAFORMA DE INNOVACIÓN ABIERTA (PIA) SEGITTUR	Tourism
COMMON EUROPEAN DATA SPACE FOR CULTURAL HERITAGE (CEDCHE) - EUROPEANA	Cultural Heritage	EUROPEAN LANGUAGE DATA SPACE (LDS)	Language	POSSIBLE	Skills
COMMON EUROPEAN ENERGY DATA SPACE (CEEDS) - CSA PRELIMINARY STUDY	Energy	EUROPEAN LEGAL DATA SPACE	Public administration	PREPARATORY ACTIONS FOR THE DATA SPACE FOR TOURISM (DSFT) - CSA PRELIMINARY STUDY	Tourism
COMMON EUROPEAN ENERGY DATA SPACE (CEEDS) - IMPLEMENTATION	Energy	EUROPEAN MEMORY DATA SPACE	Cultural heritage / Remembrance	PREPSPACE-4MOBILITY - CSA PRELIMINARY STUDY	Mobility
CONSTRUCT-X	Construction	EUROPEAN RAIL DATA SPACE	Mobility	PUBLIC PROCUREMENT DATA SPACE (PPDS)	Public administration
COOPERANTS	Aeronautics, Space	EUROSCIENCE-GATEWAY	Research and Innovation	RAISE	Research and Innovation
COPERNICUS DATA SPACE ECOSYSTEM	Green deal	EVERSE	Research and Innovation	RCTODC	Cultural Heritage
CRACKSENSE	Agriculture	FACTORY-X	Manufacturing	RDA TIGER	Research and Innovation
CRAFT-OA	Research and Innovation	FAIR DATA SPACES	Research and Innovation	REGENAG-X	Agriculture

CULTURE DATA SPACE	Culture	FAIR-EASE	Research and Innovation	SCALEAGDATA	Agriculture
DASLOGIS - DUTCH DATA SPACES FOR LOGISTICS - (DLDS)	Logistics	FAIR-IMPACT	Research and Innovation	SCILAKE	Research and Innovation
DATA CELLAR	Energy	FAIRCORE4EOSC	Research and Innovation	SCSN	Logistics, Manufacturing
DATA SPACE 4.0 - CSA PRELIMINARY STUDY	Manufacturing	FAIRCUBE	Green deal	SECTORAL - COMMON EUROPEAN DATA SPACE CSA PRELIMINARY STUDY	Tourism
DATA SPACE FOR A SUSTAINABLE GREEN EUROPE (SAGE) - DEP	Green Deal	FAME-HORIZON	Finance	SECTORAL - COMMON EUROPEAN DATA SPACE CSA PRELIMINARY STUDY	Skills
DATA4FOOD2030	Food	FINTRAFIC - MARITIME DATA SPACE (MDS)	Logistics	SEMICONDUCTOR-X	Manufacturing
DATA4INDUSTRY-X (D4IX)	Manufacturing	FISH-X	Sea activities	SIESTA	Research and Innovation
DATA-4NUCLEAR-X - NUCLEAR-X	Nuclear	FLEMISH SMART DATA SPACE - VLAAMSE SMART DATA SPACE (VSDS) - MOBILITYDATA, DATA-INTEGRATIEDIENSTEN VOOR SLIMME MOBILITEIT (DIM), INTERNET OF WATER FLANDERS, DJUSTCONNECT "DATASPACE 2.0"	Smart territories	SKILLS4EOSC	Research and Innovation
DATAPORTS	Logistics	FLEX4RES	Manufacturing	SM4RTENANCE	Manufacturing
DATASPACE-4HEALTH	Health	FOREST DATA SPACE (FDS)	Forestry	SPHIN-X	Health
DE-BIAS	Cultural Heritage	GAIA-X4 FUTURE MOBILITY - KI, ROMS, MOVEID, AMS, PLC-AAD, AGEDA	Mobility	SYNERGIES	Energy
DECADE-X	Aerospace & Defence	GRASPOS	Research and Innovation	TEAM-X	Health

DEPLOYEMDS	Mobility	GREAT - COMMON EU-ROPEAN GREEN DEAL DATA SPACE (GDDS) - CSA PRELIMINARY STUDY	Green deal	TEHDAS (TOWARDS EU-ROPEAN HEALTH DATA SPACE) - CSA PRELIMINARY STUDY	Health
DEPLOYTOUR	Tourism	GREEN DEAL DATASPACE - SPELL, PAIRS, SCALETRUST	Green deal	TEMS	Media
DESTINATION EARTH DATA LAKE (DESTINE)	Green deal	GREENDATAHUB (GDH) - LIGDS, INGDS	Green deal	THE EUROPEAN OPEN SCIENCE CLOUD (EOSC)	Research and Innovation
DIG4LIVE	Agriculture	HEALTH-X DATA-LOFT	Health	TITAN	Research and Innovation
DIGIGO	Construction	HEALTHDATA@EU PILOT	Health	TRAFFIC FLOW DATA SPACE	Mobility
DIGITAL TER-X	Construction	HERAKLION	Smart Territories	TRIREGIO DATA SPACE	Smart territories
DIVINE	Agriculture	IECO	Construction	UNDERPIN	Manufacturing
DS4MOBMODELS	Mobility	INDAGA	Manufacturing	USAGE	Green deal
DS4SKILLS-GO	Skills	INGEO-X	Geospatial	XRCULTURE	Cultural Heritage

2.3. WHY DATA SPACES STILL COMPETE

Europe did not launch data spaces to create a new layer of fragmentation. The ambition is the opposite: **data spaces should be underpinned by shared governance frameworks and shared infrastructure components**, precisely to enable coherent development and eventual interconnection.

Yet the field reality is uncomfortable: **data spaces increasingly behave like competing ecosystems**. Competing stacks, competing models, and competing vocabularies create “data spaces stack war”, with too few live cross-data spaces use cases, and too much optimisation inside each individual data space.

From “federation” to “walled gardens”: how stack wars emerge

Data spaces were designed to make governed data sharing repeatable. Yet **many initiatives reproduce the very fragmentation they were meant to overcome**: each consortium defines its own onboarding process, connector choices, policies and contracts, catalogue model, semantics, and interpretation of compliance. These choices are often justified by local needs, or shaped by **ill-suited public funding and procurement incentives**, but their cumulative effect

is fragmentation at European scale.

Three dynamics drive the “data space wars” problem:

1) Multiple standards and multiple technology stacks, interoperability becomes optional instead of guaranteed

The landscape contains several architectural frameworks and implementation families. Even where convergence begins to appear (for example, strong traction around a connector approach), this does not automatically produce interoperability across data spaces, because connectors are only one building block, and because behaviour, semantics, identity patterns, policy expression, business models and compliance workflows still diverge.

Europe is at risk of repeating the cloud lesson: **when integration is hard, actors follow the most integrated option**. If European data spaces do not interoperate, the “default interoperability layer” will be provided by someone else, typically by vertically integrated platform ecosystems, often US-based.

2) Too much intra data space optimisation, too little cross-data space composition

Most initiatives focus on making sharing work within their own perimeter rather than building the ability to transact across perimeters. Overlaps between programmes and bodies then create competition for adoption and legitimacy, rather than a shared “connect once, reuse everywhere” logic.

This is why Europe can have many promising projects and still fail to activate network effects: **public money buys pilots; it does not automatically buy interconnection**.

3) National and sector origins dominate; the European level is often retrofitted

Many data spaces originate from a single Member State's industrial ecosystem or national programme (automotive, mobility, “France 2030”, etc.). That is not a problem by itself, innovation starts somewhere. The problem is when European interoperability is treated as “phase two”, once local governance, semantics, and tooling are already locked in.

The outcome is structural: investment optimises local success metrics (membership, pilots, national visibility) rather than **EU-scale market metrics** (cross-data spaces transactions, cross-border reuse, low-friction onboarding).

The full-stack blind spot: few initiatives cover cloud + data space + AI together

A deeper issue sits behind the stack wars: many initiatives still treat data spaces as “data exchange projects” rather than as **full-stack ecosystem governance**.

In practice, competitive advantage now sits in the integrated cloud–data–AI stack. If data spaces cannot interoperate with cloud-to-edge infrastructure choices and cannot connect to AI development and deployment workflows, they remain peripheral to where investment and developer gravity accumulate. **Very few initiatives currently integrate the three levels together (European cloud, data space, and AI)**, which makes it harder to turn data spaces into the backbone of a European AI continent rather than a parallel track.

This is why enabling layers and common components matter, but also why Europe must be careful: **a “shared layer” that becomes just another competing stack merely relocates fragmentation from the data spaces layer to the infrastructure layer**.

Coordination exists, convergence mechanisms are still too weak

Europe is not lacking initiatives. It is lacking alignment power.

Many bodies and programmes cover parts of the puzzle (blueprints, trust frameworks, connector stacks, catalogues, governance guidance). But coordination is still insufficient; overlaps create stack competition instead of interoperability. And when actors are forced to choose “which stack” rather than “which service”, the stack becomes a proxy for power, exactly what the data spaces strategy was meant to avoid.

The missing KPI: cross-data spaces transactions

Today, success is still too often measured inside each initiative: number of onboarded participants, pilots launched, architecture elements published, connector deployed, and so on.

Europe's strategic KPI should be different and brutally simple:

- **Can a participant onboard once and reuse credentials, policies, and tooling across multiple data spaces?**
- **Can a data product be discovered and negotiated across data spaces without bespoke integration?**
- **Can policies and obligations travel with the data across spaces and clouds, without breaking compliance?**

If the answer is “not reliably”, then data spaces are still competing (sometimes even within the same industry/sector), not interoperating, and Europe is still paying the fragmentation tax, just at a higher level.

Europe does not need more or fewer data spaces. It needs **interoperability as a market condition**, so that hundreds of initiatives add up to one European network, not hundreds of local networks with European branding.

2.4. REGULATION HELPS BUT DOES NOT CONVERGE IMPLEMENTATIONS

EU data space-based strategy is explicitly built around interoperability and trust: Common European Data Spaces are meant to enable a single market for data, with shared governance principles and (over time) interconnection across sectors. The European Commission supports this with reference architecture, reusable building blocks, interoperability specifications and data models, yet it also recognises that stakeholders drive each data space's evolution, resulting in “unique forms and characteristics” across domains.

That tension is now visible in interoperability practice: **EU law increasingly frames what “trustworthy data sharing” should look like, but it does not automatically make implementations converge**. Even where regulation provides strong building blocks (identity, trust services, intermediary rules, portability/switching, interoperability “essential requirements”), **integration choices remain uneven across data spaces**, because the legal layer rarely dictates a single technical profile, onboarding journey, credential model, or reference implementation.

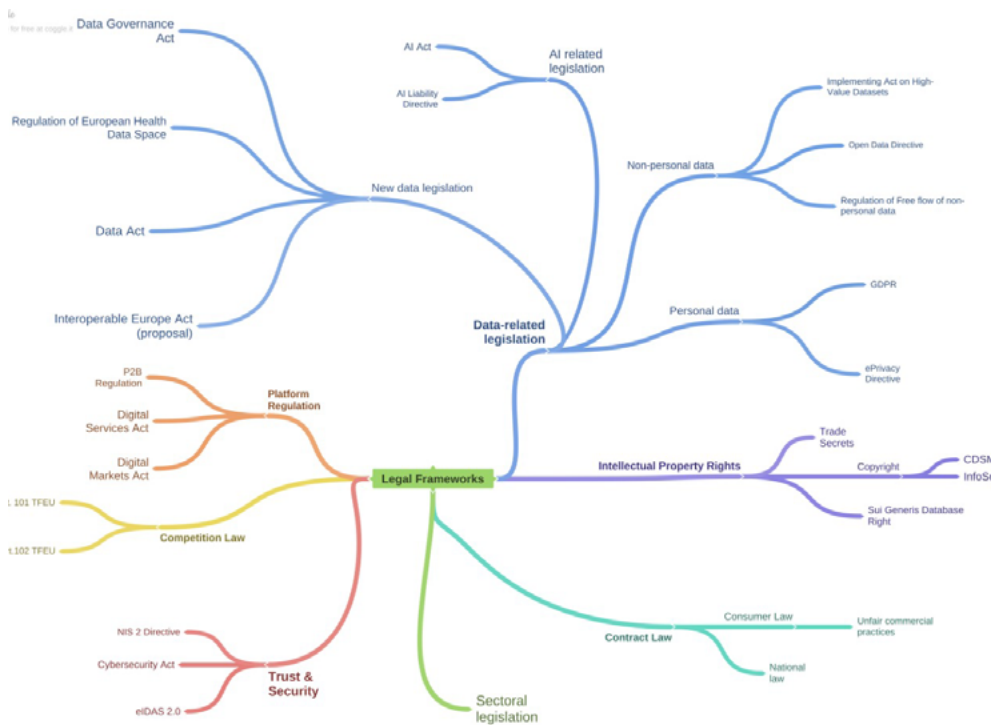
DSSC legal landscape: a complex baseline, not an implementation blueprint

The Data Spaces Support Centre (DSSC) has recently underlined that **the legal framework governing data spaces is complex and fluid**, shaped by many EU instruments whose interplay

"often creates uncertainty for participants". In practice this means that, beyond knowing the rules, **each data space must still define the technical and organisational measures that make compliance operational** (contracts, governance controls, security measures, access workflows)⁶².

This is a core interoperability insight: **regulation sets constraints and trust anchors, but interoperability still depends on coordinated implementation decisions** (e.g., which identity stack, which credential format, which policy language, which connector protocol, which semantics), and those decisions are currently being made in parallel across sectoral and thematic data spaces.

DATA SPACES LEGAL LANDSCAPE - DSSC



Key data space regulations: where they align actors, and where divergence persists

1) Data Governance Act: trust framing but ambiguous mapping to "data intermediaries"

The Data Governance Act (DGA) introduced an EU framework for data intermediation services, a model designed to foster trusted data sharing via neutral third parties, with constraints such as limits on using intermediated data for the intermediary's own commercial purposes and requirements to avoid conflicts of interest. The Commission maintains an EU register of notified data intermediation service providers, reinforcing the intended "trust infrastructure" around neutrality and transparency.

⁶² DSSC, "Legal Landscape Shaping Data Space": <https://assets.dssc.eu/rsc/papers/Legal%20Landscape%20Shaping%20Data%20Space.pdf>

Interoperability relevance: the DGA can encourage consistent governance patterns (neutral brokerage, transparent terms, separation of roles) and could, in theory, make it easier to connect participants across ecosystems.

But implementation convergence is not guaranteed, because the data space community still does not share a stable interpretation of “intermediary status.” Two sources of divergence stand out:

- **Scope ambiguity for data space orchestrators/operators.** DSSC analysis notes that whether a data space orchestrator falls under the DGA's “data intermediation service provider” concept can be unclear (notably around how “open” the service must be vs. membership/closed-group structures).
- **Concept mismatch between “data intermediaries” in data space architecture literature and “data intermediation services” in the DGA.** The International Data Spaces Association (IDSA) has argued the DGA definition is broad and leaves room for interpretation, and that further guidance is needed to avoid misunderstandings, especially given pre-existing “intermediary” concepts and business models in data spaces.

RESULT

→ Some data space initiatives may design themselves to be clearly inside the DGA regime (and potentially seek notification/registration), while others structure themselves as governance bodies, consortia, or technical enablement layers and consider themselves outside scope, leading to inconsistent compliance postures and, downstream, non-uniform onboarding, liability allocation, and trust assertions across data spaces.

2) eIDAS 2: strong identity and trust foundations yet inconsistent data space integration

The updated European Digital Identity Framework (eIDAS 2)⁶³ strengthens EU-wide digital identity and trust services for organisations and citizens, through the EUDI Wallets⁶⁴. The European Commission's policy position is explicit: Member States must provide EU Digital Identity (eID) Wallets to citizens by the end of 2026, backed by implementing rules for wallet functionality and certification.

Interoperability relevance: eIDAS 2 provides “hard” trust anchors that data spaces can reuse:

- cross-border identification (including for regulated use cases),
- qualified electronic signatures/seals,
- emerging mechanisms like qualified attestations of attributes, highly relevant for verifiable credentials and selective disclosure.

DSSC's legal analysis highlights exactly this potential: trust services could strengthen integrity, provenance, and trustworthy transactions within data spaces; and where proof of identity is required by law or contract, relevant private services may be obliged to accept the EUDI wallet.

⁶³ Regulation (EU) 2024/1183 establishing the European Digital Identity Framework. ELI: <http://data.europa.eu/eli/reg/2024/1183/oj>; European Commission, EUDI Regulation: <https://digital-strategy.ec.europa.eu/en/policies/eudi-regulation>; EUDI Wallet home: <https://ec.europa.eu/digital-building-blocks/sites/spaces/EUDIGITALIDENTITYWALLET/pages/694487738/EU+Digital+Identity+Wallet+Home>.

⁶⁴ <https://ec.europa.eu/digital-building-blocks/sites/spaces/EUDIGITALIDENTITYWALLET/pages/694487738/EU+Digital+Identity+Wallet+Home>

Why convergence still doesn't happen by default: eIDAS 2 does not, on its own, standardise the data space onboarding and credential journey end-to-end. Even if wallets become widely available, each data space still has to decide:

- what "participant credential" means (legal entity? natural person? role-based? delegated mandates?),
- how wallet-based identity is combined with data space-specific authorisations,
- how to bind identity to connector endpoints, policy enforcement points, and usage-control models.

So while **eIDAS 2 can reduce fragmentation at the identity root**, data spaces can still diverge in how identity is operationalised inside the data space (enrolment, delegation, revocation, attribute assurance, signatures vs. seals), unless common onboarding/credential profiles are agreed at sectoral level or even across sectors.

3) Data Act: interoperability requirements and standardisation, helpful, but still maturing

The Data Act is now a central horizontal instrument for the data economy: it entered into force in early 2024 and applies from 12 September 2025. Its policy intent includes cloud switching/portability and explicitly **enhancing data interoperability, data-sharing mechanisms and services, and Common European Data Spaces**.

DSSC's legal landscape highlights that the Data Act includes a dedicated interoperability chapter and foresees a standards-led route, while also enabling "common specifications" where harmonised standards do not exist.

Interoperability relevance: unlike earlier instruments, the Data Act is closer to "implementation shaping," because it:

- sets expectations for interoperability and switching in data processing services,
- encourages standardisation around Common European Data Spaces,
- provides levers for common specifications if standards lag.

Yet the convergence bottleneck remains: standards and profiles take time to be produced, cited, adopted, and tested for conformance.

Omnibus impact on data spaces: simplification may reshape (and temporarily destabilise) alignment

A key "recent news" driver for interoperability planning is the Commission's **Digital Package** (adopted as a package on 19 November 2025), which includes a **Digital Omnibus** proposal and a broader **Data Union Strategy**⁶⁵.

Two elements are particularly material for data spaces:

- 1. Consolidation of the "data acquis" into fewer instruments.** The Commission's FAQ frames the direction as "two laws, not five" (Data Act + GDPR), with consolidation of data rules into the Data Act. The Digital Omnibus proposal text on EUR-Lex explicitly indicates repeal of multiple acts (including the Data Governance Act) as part of simplifying the

⁶⁵ European Commission, Digital Package FAQ: <https://digital-strategy.ec.europa.eu/en/faqs/digital-package>; Digital Omnibus proposal COM(2025)837: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52025PC0837>; EDPB/EDPS opinion: https://www.edpb.europa.eu/news/news/2026/digital-omnibus-edpb-and-edps-support-simplification-and-competitiveness-while_en

framework. The EDPB⁶⁶ and EDPS⁶⁷ have also referred to integrating the DGA (and parts of other instruments) into the Data Act as a simplification move, while warning about safeguards and legal certainty.

2. **A potential redesign of the DGA-style intermediary regime.** The European Commission's FAQ states the Omnibus proposes to remove mandatory registration and the label for data intermediation service providers, lowering entry barriers and shifting towards more voluntary trust mechanisms and thus lowering trust.

Interoperability implications (short-term vs. long-term):

- **Short-term:** this can increase uncertainty and divergence, because data spaces may hesitate between "designing for today's DGA regime" and "anticipating tomorrow's consolidated Data Act regime," especially when building governance and onboarding processes that are costly to change.
- **Long-term:** if consolidation succeeds and results in clearer, more enforceable interoperability mechanisms, it could reduce fragmentation, particularly if paired with standardisation outputs and practical guidance.

Why interoperability still fragments even with regulation

Across these instruments, a consistent pattern emerges:

- **Regulation provides trust "anchors"** (identity, signatures, neutrality constraints, essential requirements), **but not a single executable specification.** Data spaces still must implement and profile these anchors into real workflows.
- **Guidance is increasingly available, but often non-binding.** For example, the Commission published non-binding model contractual terms and cloud contractual clauses to support Data Act implementation, useful for alignment, but voluntary by design.
- **The standards pipeline is real but time-lagged.** Standardisation work under the ETDF⁶⁸ mandate supports convergence, yet implementations are already running and making choices before standards are final and widely adopted⁶⁹.

NET EFFECT

→ EU law helps create the conditions for interoperability, but **does not, by itself, converge implementations across data spaces.** Convergence still requires: shared technical profiles, conformance testing, interoperable onboarding/credential patterns, and cross-data space operational agreements, layered on top of the regulatory baseline.

⁶⁶ European Data Protection Board

⁶⁷ European data protection Supervisor

⁶⁸ European Trusted Data Framework (ETDF). See CEN/CENELEC, Data Act standardization request M/614: <https://www.cencenelec.eu/news-events/news/2025/brief-news/2025-07-11-data-act-standardization-request/>.

⁶⁹ CEN/CENELEC, EN 18235-1:2026 "Trusted Data Transactions": <https://www.cencenelec.eu/news-events/news/2026/en-in-the-spotlight/2026-04-30-en-18235-1-2026-data/>

EUROPE DOES NOT LACK
STANDARDS. IT LACKS
CONVERGENCE.

2.5. STANDARDS AND MODELS: TOO MANY DIALECTS, NOT ENOUGH PROFILES

When every consortium defines its own concepts, the result is not “diversity”, it is **non-interoperability**. This is particularly acute in data spaces, where interoperability is not only a technical property (APIs, connectors, catalogues), but also an organisational and semantic property (roles, contracts, policies, vocabularies). The European Commission explicitly positions Common European Data Spaces as relying on reference architecture, interoperability specifications, semantics and data models, supported via the DSSC; yet this support operates in an ecosystem where many initiatives evolve in parallel and where data space initiatives themselves are also producers of standards and specifications.

A data space is therefore **both**:

- an important **consumer of standards** (identity, trust frameworks, catalogues, policy languages, audit/provenance, security); and
- a **standard-setter** in its own right, because each data space must define shared semantics between participants (domain vocabularies, data product definitions, usage policy profiles, service descriptions, onboarding attributes).

This dual role is why the “standards question” in data spaces is not only which standards exist, but **which ones become the shared core**, and how quickly the ecosystem can converge on a small set of interoperable choices.

De jure and de facto: from parallel tracks to convergence

De jure standards (formal standards and harmonised European standards) are essential for long-term market stability and legal certainty, but they move on institutional timelines. A current EU example is the push for a **European Trusted Data Framework (ETDF)**: identified as a policy priority in the European Commission's 2024 annual Union work programme for European standardisation, with a regulatory basis spanning both the Data Governance Act and the Data Act, it led to Standardisation Request M/614, tasking **CEN, CENELEC, and ETSI** with a comprehensive programme of **seven deliverables**, four European Standards and three Technical Specifications, covering trusted data transactions (harmonised European Standards), data catalogue implementation frameworks, semantic asset frameworks, internal data governance quality, and data space maturity (in support of the **Data Act**, notably **Articles 33 and 35** on interoperability)⁷⁰.

Positioned by the European Commission at the core of the ETDF, EN 18235 “Trusted Data Transactions” is the harmonised European Standard on trusted data transactions developed by CEN/CLC JTC 25 WG2 under M/614. Crucially, this standard did not emerge from a blank page: it was directly informed by the **CEN pre-standardisation Workshop on “Trusted Data Transaction”**, which itself drew extensively on existing de facto frameworks and ecosystems including Gaia-X, IDSA, and DSSC. The Workshop produced two CEN Workshop Agreements, CWA 18125:2024 (Part 1) and CWA 18245:2025 (Part 2), which served as the primary technical input to EN 18235-1 and EN 18235-2 respectively. EN 18235-1:2026 is now published, ratified ahead of its M/614 deadline.

⁷⁰ CEN and CENELEC, “Data Act standardization request” (M/614): <https://www.cencenelec.eu/news-events/news/2025/brief-news/2025-07-11-data-act-standardization-request/>



TRUSTED DATA TRANSACTIONS: FROM PRE-STANDARDISATION TO HARMONISED EUROPEAN STANDARD

Pre-standardisation: the CEN Workshop on “Trusted Data Transaction” (2023–2025)

In 2023, a broad ecosystem including Gaia-X, IDSA, Dawex, Prometheus-X, Fraunhofer ISST, TNO, BDVA, FIWARE, Microsoft, EDF, Airbus, and Hub One participated in a CEN WORKSHOP. The European Commission participated actively as an observer throughout. The Workshop drew on and synthesised existing de facto frameworks and ecosystems (Gaia-X, IDSA, and DSSC) translating their operational experience into the normative technical foundations of a trusted data transaction.

The Workshop produced two voluntary pre-standards:

- CWA 18125:2024 (Trusted Data Transaction) **Part 1: Terminology, Concepts & Mechanisms (July 2024)**⁷¹
- CWA 18245:2025 (Trusted Data Transaction) **Part 2: Trustworthiness Requirements (July 2025)**⁷²

Formal standardisation: EN 18235 “Trusted Data Transactions” (2025–2027)

The CWA work was transposed into formal European standardisation within CEN/CLC JTC 25 WG2, following M/614 (accepted July 2025). The resulting EN 18235 “Trusted Data Transactions” series comprises three parts:

- EN 18235-1:2026 **Part 1: Terminology, concepts and mechanisms.** Published (ratified February 2026, ahead of the M/614 deadline of 1 June 2026).
- EN 18235-2 **Part 2: Trustworthiness requirements.** Under public enquiry. M/614 deadline: 1 November 2026.
- EN 18235-3 **Part 3: Interoperability requirements.** Public enquiry phase starting. M/614 deadline: 1 May 2027.

Significance

This is the **first European initiative to formalise, in a cross-sectoral approach, the normative technical foundations of a trusted data transaction.** The pre-standardisation work anticipated the European Commission’s formal standardisation request by more than two years, enabling rapid transposition and providing operational foundations to data space participants from the date the Data Act became applicable (12 September 2025). As a technology-agnostic standard, EN 18235 provides the regulation-aligned baseline that allows the diversity of existing technical ecosystems (Gaia-X, IDSA, DSSC and others) to adopt a common baseline vocabulary and framework. As harmonised European Standards developed under M/614, the EN 18235

⁷¹ CWA 18125:2024, Trusted Data Transaction Part 1: https://www.trusted-data-transaction.org/hubfs/Assets%20and%20Publications/cwa18125_2024-Part1.pdf; Trusted Data Transaction initiative: <https://www.trusted-data-transaction.org/en/>.

⁷² CWA 18245:2025, Trusted Data Transaction Part 2: https://www.trusted-data-transaction.org/hubfs/Assets_and_Publications/CEN-CWA_18245_2025-Part_2.pdf.

series is designed to confer a **presumption of conformity** with the Data Act's interoperability requirements under Article 33, most directly through Part 3 (Interoperability requirements), which builds on the terminology and trustworthiness framework established in Parts 1 and 2.

Limits: EN 18235 provides a baseline of standards across trusted data transaction solutions; however this does not guarantee these implementations are natively interoperable as EN 18235 does not address cross solution discovery, legally compliant contract ontologies, contract mechanisms standardisation, common legal and organisational standards.

De jure processes bear a classic risk: **they can land late**, after markets have already implemented competing "good enough" solutions.

De facto standards (widely adopted specifications and market conventions) often deliver faster implementation traction, but their convergence is also slow in a different way: it can take years to establish "clear winners", and adoption can remain uneven across sectors. Even when a de facto stack emerges, it may be incomplete against European policy needs (e.g., lawful personal data sharing, consent workflows, or assurance levels) unless explicitly designed for them.

A helpful illustration of both clocks is digital credentials and identity. W3C's **Verifiable Credentials Data Model v2.0** reached Recommendation status in 2025 after a multi-year maturation process; it is now a global reference point for credential ecosystems. At the same time, interoperability in real deployments also depends on protocol layers like OpenID for Verifiable Credential Issuance (OID4VCI), which builds on OAuth 2.0 patterns that developers already know⁷³.

This illustrates a recurring pattern in data spaces: formal models may be widely agreed, while the operational interoperability depends on de facto protocol stacks that are still evolving.

Multiple reference models: DSSC, IDSA, Gaia-X, iSHARE, FIWARE... and the mapping problem

European data spaces are currently shaped by **several overlapping reference models**, each valuable, yet each adding its own conceptual layer. Here are some examples:

- **DSSC Blueprint / Building Blocks:** aims to provide a shared conceptual model, building blocks and recommended standards/specifications to reduce fragmentation and help spaces become interoperable (including across data spaces).
- **IDSA (IDS-RAM):** provides a layered reference architecture describing concepts, roles and components for sovereign data sharing; the RAM is explicitly technology-agnostic and complemented by more binding specifications in IDS-G.
- **Gaia-X Trust Framework / Architecture:** focuses on interoperable trust layers across digital ecosystems and defines machine-readable "self-descriptions/credentials" and trust framework mechanisms.
- **iSHARE Trust Framework⁷⁴:** offers a combined legal/functional/operational/technical

⁷³ W3C, Verifiable Credentials Data Model v2.0: <https://www.w3.org/TR/vc-data-model-2.0/>; OpenID for Verifiable Credential Issuance: <https://openid.net/specs/openid-4-verifiable-credential-issuance-1.0.html>.

⁷⁴ <https://ishare.eu/about/trust-framework/>

trust framework for business data sharing, with defined roles and agreements.

- **FIWARE / NGSI-LD ecosyste⁷⁵m**: advances interoperability through open implementations and an ETSI-standardised API and information model for context data (NGSI-LD), relevant for digital twins and cross-domain information exchange. The support of the FIWARE data space stack is now operated by SEAMWARE.

Each is defensible in isolation; the interoperability **challenge is the mapping** across them: aligning what a “participant”, “credential”, “catalogue entry”, “data product”, “policy”, “service description”, or “connector” means across models and stacks.

The Data Spaces Business Alliance (DSBA), created in 2021, was an explicit attempt to foster convergence. It published a technical convergence document showing the coverage and gaps across the inputs and solutions from IDSA, Gaia-X and FIWARE. At the same time, convergence initiatives also carry lifecycle risk. The DSBA is no longer active as a joint initiative: its former partners now continue their cooperation through bilateral channels rather than under a shared and maintained framework. This **weakens the long-term gravitational pull toward a common reference architecture**.

Glossaries are not neutral: semantic drift becomes a barrier to entry

Data spaces are extremely sensitive to **semantic drift**: when different ecosystems use the same words for slightly different concepts, or different words for the same concept, onboarding costs rise and interoperability degrades.

This is visible in the proliferation of **parallel glossaries**:

- DSSC maintains a glossary⁷⁶ to establish consistent terminology for its publications and to support information sharing across initiatives.
- Gaia-X publishes an extensive glossary⁷⁷ tied to its trust framework and ecosystem concepts.
- iSHARE⁷⁸ defines “data space” and many other terms in its own glossary, reflecting its scheme perspective and governance roles.
- IDSA maintains glossaries⁷⁹ and a “point of truth” for specifications (IDS-G), with its own vocabulary and term definitions.

This is not just a documentation issue. In practice:

- **semantic drift becomes a barrier to entry** (new participants must learn multiple dialects), and
- **fragmentation becomes a competitiveness issue**, because fragmented semantics undermine the promise of a single market for data services and cross-space scalability.

EU standardisation planning increasingly recognises this at policy level: the Rolling Plan for ICT Standardisation (2025) emphasises machine-actionability and explicitly links interoperability to countering market entry barriers and fragmentation, echoing the legal push toward cross-sector interoperability.

⁷⁵ <https://www.fiware.org/>

⁷⁶ <https://dssc.eu/space/Glossary>

⁷⁷ <https://gaia-x.gitlab.io/glossary/>

⁷⁸ <https://framework.ishare.eu/glossary-and-legal-notice/glossary>

⁷⁹ <https://github.com/International-Data-Spaces-Association/glossary>

Why DCAT became widespread: a template for “interoperability that actually scales”

A useful success case is **catalogue interoperability** through DCAT/DCAT-AP.

- At global level, W3C's DCAT⁸⁰ is explicitly designed to enable interoperability between data catalogues on the Web and improve discoverability and aggregation of metadata.
- Europe then operationalised this through DCAT-AP, an application profile that enables cross-portal search and metadata exchange across borders and sectors.
- Crucially, adoption was not only “recommended”: it was implemented in aggregators and infrastructure. The European Data Portal (and its successor data.europa.eu ecosystem documentation) states its metadata model is DCAT-AP, enabling harvesting and federation.
- Recent Commission-linked guidance continues to frame DCAT-AP as the EU's recommended semantic layer and positions it as relevant for future Common European Data Spaces (not just open data portals).
- Academic work on DCAT evolution shows that DCAT's revisions were driven by implementation experiences, use cases, and the need to document not only datasets but also data services/APIs, reinforcing the lesson that metadata standards succeed when they continuously absorb real operational requirements.

Why this matters for data spaces

DCAT/DCAT-AP demonstrates a viable European path to interoperability⁸¹:

1. anchor to a global standard (W3C DCAT),
2. define a European profile for consistency (DCAT-AP),
3. embed it into aggregators and tooling, and
4. provide implementation guidance and conformance expectations.

The same dynamic can be seen in policy languages. **W3C's ODRL is widely used to express policies (permissions and prohibitions), in data spaces.** Yet recent research also points to its limitations and to the need for stronger theoretical foundations, with direct implications for policy interoperability across ecosystems⁸².

Still, ODRL and DCAT-AP illustrate the kind of recognisable standardisation pattern that is missing from many other building blocks, such as participant credentials, interoperability test suites, onboarding data models, and other operational components.

De facto blind spots: personal data and natural persons are still “edge cases” in many stacks

One persistent gap is **personal data sharing** and “human-in-the-loop” participation.

Many data space standards and trust frameworks are still primarily designed **for organisation-to-organisation** exchange. Meanwhile, the DSSC Blueprint explicitly flags that implementations need additional considerations for exchanges involving natural persons and/or personal data to remain compliant, signalling that personal-data readiness is not automatically covered by the mainstream technical stack.

⁸⁰ W3C, *Data Catalog Vocabulary (DCAT) - Version 3*, W3C Recommendation, accessed May 2026.

⁸¹ W3C, Data Catalog Vocabulary (DCAT) v3: <https://www.w3.org/TR/vocab-dcat-3/>; SEMIC, DCAT-AP 3.0.0: <https://semiceu.github.io/DCAT-AP/releases/3.0.0/>; data.europa.eu metadata model: <https://dataeuropa.gitlab.io/data-provider-manual/our-metadata-model/>

⁸² W3C, ODRL Information Model 2.2: <https://www.w3.org/TR/odrl-model/>

This matters because the “winning” de facto technical requirements in data spaces can easily overlook citizen-centric requirements unless they are deliberately integrated (consent, delegated authority, representation, selective disclosure, revocation/status, assurance levels).

A significant portion of the European data economy (in education, health, smart cities and mobility) depends on the ability to share and process personal data under GDPR, not only industrial or open data. **Yet Prometheus-X is, at the time of writing, the only European data space stack that natively addresses personal data sharing**, with components that collect and manage consent, and a personal dashboard through which individuals can view, grant and revoke their consents across data spaces⁸³.

This gap is now being addressed within the Data Space Interoperability Framework working group (DSIF⁸⁴, see 4.3): the cross-stack consent interoperability workstream is working to extend these capabilities across the other connectors (Athumi, EDC⁸⁵, FIWARE)⁸⁶, with concrete pilots in education, health, smart cities and mobility. Without this layer, a substantial part of the European data market remains out of reach for interoperable data spaces.

Global alignment vs European requirements: the case for a clear EU interoperability core

European data spaces cannot be “Europe-only dialects” if they aim to scale: they must align with global norms (W3C vocabularies, OpenID/OAuth patterns, ETSI APIs, widely used semantics) while also preserving European legal requirements (identity assurance, governance expectations, regulatory obligations). This adds complexity, and increases the value of a **clear EU interoperability core** that:

- identifies a minimal set of cross-sector standards/profiles (like DCAT-AP did for catalogues),
- provides stable mappings across the major European “model families” (DSSC IDSA Gaia-X iSHARE FIWARE), and
- is backed by conformance testing, reference implementations, and governance guidance (so interoperability is *measurable*, not aspirational).

Without that core, “standards pluralism” becomes de facto fragmentation: higher entry costs, slower federation across data spaces, and weaker competitiveness relative to ecosystems that converge around fewer, better-tested interoperability primitives.

2.6. BUILDING BLOCKS EXIST BUT STACKS DO NOT COMPOSE

Europe is not lacking components. Europe is lacking composition.

Connectors, trust frameworks, catalogues, and reference architectures exist, but **cross-stack compatibility remains partial**. The risk is strategic: **“the stack” becomes a proxy for power**, instead of interoperability becoming the shared rule.

Building blocks are real, but they don't yet form a single market rail

Europe already has valuable ingredients:

⁸³ Prometheus-X, “BB04 Consent,” building block documentation, accessed May 2026.

⁸⁴ <https://dsif.eu/>

⁸⁵ Eclipse Dataspace Components. <https://projects.eclipse.org/projects/technology.edc>

⁸⁶ Data Space Interoperability Framework, “PoC Consent Proposition,” GitLab wiki, accessed May 2026.

- **Trust frameworks** that structure who can participate and under which assurances (e.g., Gaia-X labels/clearing-house patterns, iSHARE).
- **Reference architectures and protocols** that formalise data sovereignty and policy-driven exchange (e.g., IDSA lineage).
- **Cataloguing practices** that enable discoverability and onboarding patterns.

These are not theoretical assets. They are the start of Europe's "soft infrastructure" for governed collaboration. But today they still land unevenly across initiatives, sectors, and Member States, often implemented differently, with varying levels of operational maturity and compliance tooling.

What a connector is, and why it matters so much

A **connector** is the controlled gateway, deployed on the data producer or consumer system, that enables an organisation to participate in a data space (or more broadly, governed data collaboration) without centralising data. It is where governance stops being a "PDF" and becomes something enforceable in software.

In practice, connectors concentrate the hardest problems of collaboration:

- **Identity and trust:** who is the participant, what is their status, what assurances apply.
- **Policy and usage control:** what may be accessed, under what obligations, for what purpose, for how long, with what onward-sharing restrictions.
- **Contracting and negotiation:** how terms are agreed and attached to assets.
- **Auditability and traceability:** proving compliant usage and reconstructing what happened.

This is why "data spaces are about connectors", but not only connectors. A connector can move bytes safely; it does not automatically solve coordination, use case building, semantic alignment, legal templates, compensation models, or compliance-as-code across ecosystems.

The fragmentation point: "a few stacks exist" and they don't fully interoperate

Europe currently runs multiple data space implementation families and stack choices (for example: EDC, FIWARE-based patterns, Prometheus-X⁸⁷, Ocean Enterprise/Pontus-X⁸⁸, Simpli Open and others). This plurality is not a problem if interoperability is enforced.

But interoperability across stacks is still uneven:

- Even when a connector stack becomes popular (EDC currently has the strongest traction), this does not guarantee cross-data spaces interoperability in practice, due to different versions and custom modifications and extensions.
- Differences in how participants are identified, how policies are expressed and enforced, how catalogues expose metadata, and how contracts are handled can still block real cross-ecosystem reuse.
- The result is predictable: organisations optimise within their own data space first, and cross-data spaces interoperability remains "later" (or never), because it is no one's short-term incentive.

If cross-stack interoperability remains partial, Europe recreates inside data spaces what it already suffered in cloud and platforms: **dominance through integration**.

⁸⁷ Prometheus-X Dataspace Connector - Data Exchange," GitHub wiki, accessed May 2026.

⁸⁸ <https://portal.pontus-x.eu/>

CROSS-STACK INTEROPERABILITY

What is needed to make interoperability across stacks efficient and functionally relevant.

DIMENSION	WHAT IS NEEDED	CURRENT STATE AND LIMITS
CATALOGUE & DISCOVERY	A common metadata standard for exposing datasets, services and AI components, and a federated lookup mechanism (DNS-like) allowing any participant to discover catalogues on the network and query their offers without bilateral agreements	Existing initiatives (DCAT-AP-DS, Gaia-X self-descriptions, NGSi-LD registries, IDSA catalogue) define metadata formats but not the discovery API, and provide no federated lookup. Catalogues are addressable only through private arrangements; cross-stack search does not exist in production.
CONTRACT	A complete contract ontology with legally robust clauses, native multi-party capability (service chains, supply-chain triangles, broker-mediated exchange) and a shared subset of ODRL policies enforceable across stacks	Stacks use distinct contract models (IDSA DSP, ODACS/tmForum, PTX Contract Manager, Pontus-X, FIWARE TMForum extensions). They are often legally incomplete (no liability, no termination, no audit), bilateral only most of the time, and their ODRL policies are not aligned.
CONSENT	A common format and shared protocol for individual consent, with cross-stack mechanisms enabling individuals to view, grant and revoke their consents, and have those revocations propagate across data spaces	Almost no current initiative addresses personal data sharing. Only Prometheus-X natively implements consent collection, dashboard and revocation; other stacks have no equivalent component. Without this, GDPR-bound use cases (health, education, smart cities, mobility) cannot cross stack boundaries.
IDENTITY & TRUST	A common participant identification and credential verification standard, with mutual recognition between trust anchors (Gaia-X compliance, IDSA participants, eIDAS2 EUDI wallets, sectoral registries)	Multiple incompatible standards in production: OID4VC for verifiable credentials (eIDAS2 direction), DSP identity (IDSA), Gaia-X compliance credentials, sector-specific trust frameworks. No mutual recognition layer between them.
LEGAL	Shared contractual clauses, standard SLAs, common AI Act compliance declarations, and harmonised obligations for data intermediaries (DGA Article 12, NIS2, GDPR role qualification, eIDAS2 trust-service obligations)	No common legal work across data spaces. Each data space currently produces its own clauses, SLA templates and intermediary obligations. Cross-stack transactions therefore require bespoke legal negotiation each time, defeating the purpose of interoperability.
BUSINESS	Common onboarding rules (minimum requirements to join the federated network), common rules on commissions and pricing transparency, and a shared model for revenue sharing and liability allocation on cross-stack transactions	No cross-data space business work. Onboarding criteria, pricing rules and commission structures are defined per stack or per data space; there is no convergence on how value is shared when a service operates across several data spaces.

Some of these dimensions are partially addressed within a single stack or single initiative, never across the whole European ecosystem. The fragmentation is therefore not only technical: it cuts across legal and business layers that no European standardisation body currently owns.

Simpl⁸⁹ : a necessary EU rail, but it must interconnect, not become “the stack”

Simpl is progressing as a Commission-backed, open-source enabling layer meant to lower the cost of building and operating interoperable data spaces and cloud-to-edge federations.

A key signal is the funding level: **€41 million** was awarded to develop Simpl-Open, the infrastructure layer behind common European data spaces.

That matters, but it creates a strategic design requirement:

- **Simpl must become an interlinking enabler**, a bridge across existing European ecosystems.
- It must not become a new mandatory monoculture that triggers internal “stack wars” (or simply shifts fragmentation to a new layer).

Europe's goal is not to pick a single winner. Europe's goal is to impose a **non-negotiable interoperability core** that allows many implementations to coexist.

The global asymmetry: US “data + AI collaboration stacks” operate at a different scale

Even if Europe fixes internal interoperability, it is competing with massively funded, vertically integrated ecosystems that bundle cloud, governance, sharing, and AI tooling into one experience. This is how de facto standards are imposed today: not by committee, but by adoption.

⁸⁹ European Commission, Simpl programme, open-source middleware infrastructure for European data spaces and cloud-to-edge federations; two implementation consortia were selected: SovereignX and InfraTex, the latter initiated by Digital New Deal together with Sopra Steria.

Here are the relevant scale markers (recent public figures):

ACTOR	WHAT THEY STANDAR- DISE IN PRACTICE	USERS / CUSTOMER SCALE INDICATORS	REVENUE / FUNDING SCALE INDICATORS
SNOWFLAKE	"Data cloud" platform where sharing, governance, and marketplace dynamics become native product features	>12,600 customers	Quarterly revenue around \$1.28B ; 733 customers above \$1M trailing-12-month product revenue
DATABRICKS	Unified data + AI platform: collaboration and deployment are integrated with the data layer	>20,000 organisations; >60% of Fortune 500 cited as users; >800 customers above \$1M annual revenue run-rate	Announced \$5.4B revenue run-rate; > \$7B total investment; valuation reported at \$134B
PALANTIR	End-to-end operational data/AI stack (ontology + workflows + AIP): governance embedded into operational use	954 customers (reported)	FY revenue \$4.48B ; Q4 revenue \$1.41B ; U.S. commercial Q4 revenue \$507M

Why these metrics matter for Europe: these companies don't just sell software, they **manufacture default patterns** for data access, governance, sharing, and AI deployment. Their "interoperability" is high inside their own ecosystem, and that is enough to attract adoption when the alternative is a fragmented market of bespoke integration.

BOTTOM LINE

→ Europe already has many of the right building blocks. The competitiveness question is whether Europe can make them **compose at continental scale**, fast enough to avoid dependency-by-default on integrated foreign stacks. This requires a hard pivot from "encouraging convergence" to **engineering convergence**:

- Define **cross-stack conformance requirements** (what every connector/stack must do to interoperate).
- Operate **test suites and certification** so interoperability is measurable, not asserted.
- Make Commission-backed components (including Simpl) **interlinking by design**.
- Treat collaboration tooling (discovery, use case development, negotiation, compliance-as-code, quality, audit, compensation) as first-class infrastructure, not optional add-ons.

Interoperability is not a feature. It is a market condition. If Europe does not impose it, someone else will impose a stack.

2.7. GOVERNANCE: MULTI-LEVEL IS NORMAL BUT FRAGMENTATION IS NOT

Data spaces do not fail because governance is multi-level. **Multi-level governance is the normal state** in a Union built on subsidiarity, sector competences, and national enforcement. What fails is something else: **fragmentation by default**, where each level optimises its own perimeter and produces rules, processes, and implementations that do not compose at EU scale.

Sitra's holistic governance⁹⁰ work captures the reality precisely: data-sharing rules come from **three arenas at once**, EU institutions and legislation, Member States (authorities and national rules), and the data spaces themselves (sectoral and/or local governance choices and architectures). Participants face the combined effect of these layers, not a clean separation.

Three levels are inevitable. Misalignment is optional.

1. EU level:

The EU sets the legal and institutional frame (e.g., the Data Governance Act, the Data Act) and builds support structures intended to reduce fragmentation. Sitra notes that the Commission's implementation power is not only legislative: it is also exercised through **procurement and funded projects**, which actively shape practices, standards, and technologies used in data spaces.

The Data Governance Act explicitly recognises that data spaces require "sound governance" with stakeholder participation, and it creates the European Data Innovation Board (EDIB) as a coordination and guidance mechanism. The EDIB's mandate goes beyond advice in the abstract: it includes work on **prioritising cross-sector standards, enhancing cross-border/cross-sector interoperability to address fragmentation, and proposing guidelines for Common European Data Spaces** (interoperable frameworks of standards and practices).

2. Member State level:

Member States sit at the hinge: they translate EU law into enforcement practice and often add national rules that shape sector behaviour (explicitly highlighted in Sitra's analysis). Importantly, Sitra's interviews suggest that **national coordination can be decisive** for turning EU strategy into concrete and coherent local initiatives.

Multiple sectors are creating EDIC⁹¹ structures (i.e., boost EDIC M&L for Mobility & Logistics) to involve Member states in the governance of data spaces.

3. Data space level (sector / local / private initiatives):

At an operational level, each data space needs an internal governance framework. In the literature, this is consistently treated as foundational rather than "nice to have". Sitra uses the term **rulebook** to codify a data space's legal, business, technical, and ethical rules.

IDSA defines the governance framework as the core agreement (technical policies, business rules, regulations) that participants must adhere to, maintained and enforced by a governance authority. The DSSC blueprint aligns: a Data Space Governance Framework is

⁹⁰ Sitra, "Towards a Holistic EU Data Governance", May 2026. <https://www.sitra.fi/en/publication/towards-a-holistic-eu-data-governance/>

⁹¹ An EDIC is a European Digital Infrastructure Consortium. It is a legal vehicle created by the EU so several Member States can jointly build and operate strategic digital infrastructure, instead of each country setting up its own separate project structure.

operationalised as a **rulebook**, and the governance authority is responsible for managing it in a way participants can comply with.

So the structure is not the problem, all data spaces support organisations converge. The **composition** is. The European Commission is funding multiple Common European Data Space in key sectors and domains (e.g., EMDS for mobility, CEEDS for energy, CEADS for agriculture, and more), which act as sectoral federations of data space initiatives and should help align the rulebooks of all initiatives within a sector/domain.

Why fragmentation is the default outcome

Sitra's diagnosis is blunt: many pain points come from **gaps, duplication, and overlap of roles** across levels. **People "struggle to know who does what and who decides what"**, and data spaces struggle to align their internal governance with a shifting, multi-body regulatory environment.

This is not surprising. Europe is building a dense institutional ecosystem: boards, support organisations, sector actions, national hubs, procurement vehicles. The Cambridge analysis of the EU's "new data acts" makes the same structural point from a legal governance perspective: interoperability is a common denominator, but **the overall framework is complex, with overlapping instruments** and collaborative governance arrangements across public bodies and private stakeholders.

In that environment, fragmentation is not a bug. It is the default equilibrium, unless Europe enforces a shared interoperability frame that makes divergence expensive and convergence cheap.

The SME test: if governance requires expertise, it won't scale

The most practical warning sign is the SME barrier. Sitra explicitly notes that, for smaller companies, the accumulated complexity of EU rules, national oversight, and data space governance is hard to navigate, and that participating in data-sharing should not require understanding the whole machinery. **The goal should be "effortless" compliance, ideally automatable.**

This is a governance point with market consequences: **if governance remains artisanal** (human-readable only rulebooks, bespoke onboarding, human negotiation each time), then **only large actors can participate** at speed and across sectors. The rest will either stay local, or join whichever integrated stack offers "one-click compliance" (on its terms).

Rulebooks everywhere: a governance asset, or a fragmentation engine

Data space literature converges on rulebooks as the practical governance unit, but also reveals the structural risk:

- The DSSC blueprint explicitly states that participants can **join multiple data spaces** and therefore must adhere to **multiple rulebooks**; rulebooks can be "connected", with generic rules specified at a higher level (e.g., common European frameworks), and more specific rules underneath.
- Sitra similarly frames the applicable rules as a combination of **hard law, soft law, and internal rules** that must be integrated into each data space's rulebook.

This is the crucial point: rulebooks are not only "internal governance". They are the

interoperability surface of the governance layer. If rulebooks cannot be compared, mapped, and executed consistently across spaces, then cross-data spaces transactions become legal interpretation exercises and dispute resolution projects.

Sitra goes one step further and proposes a governance mechanism precisely aimed at this failure mode: complement rulebooks with a **rolebook**, a shared, dynamic registry that documents “**who does what**” and “**who decides what**” across EU, national and data space levels. The rolebook is explicitly designed to reduce overlaps and enable cross-data space coordination, including conflict detection when multiple data space rulebooks collide.

Whether Europe adopts Sitra’s exact tooling or not, the underlying insight is decisive: **interoperability is not just APIs and semantics. It is also the interoperability of governance roles, scopes, and rulebooks.**

Public money is shaping governance, often without EU-scale optimisation

Most data space initiatives in Europe are not purely private-market creations. They are strongly shaped by public programmes and public procurement. The Commission’s own policy framing emphasises that European data spaces are built on common infrastructures and governance frameworks, and that they should progressively interconnect into a single market for data, supported by EU funding (e.g., DSSC and Simpl under Digital Europe / Horizon Europe) and EDIB guidance. Sitra confirms the operational mechanism: beyond law, the Commission’s main implementation actions are **procurement and funded projects**, including support initiatives (DSSC), technology initiatives (Simpl), and sector deployments.

Here is the governance problem hidden inside the funding architecture:

- **EU programmes** fund sector rollouts and horizontal enablers.
- **Member States** fund national strategies and local consortia, often aligned to national priorities and language/regulatory familiarity.
- **Sector/private initiatives** fund “what works now” to ship pilots and win early adopters.

Sitra explicitly observes that, at least initially, many data space initiatives will likely **operate within a single Member State** because stakeholders share language, market understanding, and national compliance contexts.

This is rational and it is also how public money can unintentionally **optimise for local success metrics** (a working pilot, a national consortium, a sector demonstrator) rather than EU-scale network effects (repeatable cross-data space onboarding, reusable governance services, interoperable rulebooks, cross-border transactions).

What this implies (without jumping ahead to solutions)

Europe should not try to “flatten” governance into one level. That would be politically unrealistic and operationally counterproductive.

But Europe **must** distinguish between two things:

- **Multi-level governance:** inevitable, legitimate, often valuable.
- **Fragmented governance:** optional, costly, and strategically self-defeating.

The dividing line is whether there is a **shared interoperability frame**, clear enough that (1) data spaces can implement it through their rulebooks, (2) Member States can align enforcement and procurement around it, and (3) EU funding creates compounding EU-scale value rather than parallel local optimisations.

Sitra's holistic framework makes the stakes concrete: **without mechanisms that clarify roles and make rulebooks comparable** and increasingly machine-actionable, **the governance layer becomes the next fragmentation layer**, exactly where Europe can least afford it.

2.8. ECOSYSTEM AND COMMUNITY: FROM SOFT COORDINATION TO HARD ALIGNMENT

Europe's data space landscape is intentionally plural. The EU vision for **Common European Data Spaces** assumes many sectoral and thematic initiatives will emerge in parallel and progressively interconnect. That plurality is not, by itself, a flaw. The challenge is that **the ecosystem's coordination and convergence capacity remains too weak** relative to the ambition of cross-border, cross-sector interoperability.

The core problem is not goodwill. The European data space community is highly active, collaborative, and well-funded across multiple programmes. The recurring bottleneck is **alignment mechanisms**: shared implementation profiles, conformance tests, compatibility kits, certification schemes, and adoption levers that turn "recommended interoperability" into repeatable interoperability. Without these, coordination stays largely advisory, useful, but insufficient to drive convergence at scale.

Why the ecosystem is hard to understand from the outside

For an outsider (a potential participant, SME, public buyer, or integrator), the landscape can look opaque because:

- **many organisations and initiatives overlap**, each with their own architecture, governance templates, and technical stacks;
- the same concepts are described using different terms (and different meanings), creating "**semantic drift**" that raises onboarding costs;
- there are **multiple entry points** and **as many sources of truth** (policy hubs, technical frameworks, open-source components, labels, registries, events), but limited "single" operational pathway that guarantees compatibility across data spaces.

In practice, the ecosystem has responded by creating inventories and mapping tools (e.g., "radars" and landscape catalogues). That helps visibility, but visibility alone does not guarantee interoperability.

The community of practice exists, but it needs stronger "hard alignment" tools

Data space literature repeatedly frames interoperability as a **coordination problem**: the ecosystem needs commonly accepted standards and design principles, plus mechanisms to ensure implementations remain compatible over time. This is exactly where Europe still lacks scale: not in conceptual frameworks, but in **testable conformance** and **adoption pressure**.

What "hard alignment" looks like in practice:

- **Implementation profiles** (a small number of agreed choices for identity, catalogues, policy expression, onboarding attributes, APIs)
- **Conformance testing** (test suites, validation services, plugfests, compatibility kits)
- **Reference implementations** (shared open-source components and deployable federation services)
- **Market levers** (labels, certification, procurement requirements, and funding conditionality tied to conformance)

A key signal that the ecosystem is moving in the right direction is the growing emphasis on **conformance infrastructure** (not just guidance), including EU-supported testbed approaches for interoperability validation.

Multiple initiatives already help the ecosystem (and what each contributes)

The **Data Spaces Support Centre (DSSC)** acts as a central coordination pillar, with a strong focus on making data space practices “portable” across sectors. Its main ecosystem contributions are:

- a **Community of Practice** to convene implementers and share patterns;
- a **Glossary** to reduce semantic confusion and help terms spread consistently;
- the **Blueprint** to align on concepts, roles, and building blocks;
- the **Toolbox** to operationalise building blocks and guide implementation choices;
- a **standards and technologies landscape** to help initiatives choose from (and converge on) a shared interoperability toolkit.

These artefacts reduce ambiguity and accelerate learning. Their limitation is structural: **guidance doesn't automatically force convergence** unless paired with tests, profiles, and procurement/funding incentives.

Gaia-X: European mobilisation driven by hubs; different levels of “labels”, clearing houses, generic trust frameworks, and cross-data space interoperability as adoption levers

Gaia-X contributes mechanisms oriented toward **trust and compliance alignment**:

- **national hubs** that mobilise stakeholders, consolidate requirements, and reduce duplication across countries;
- **digital clearing house** concepts to operationalise compliance and trust checks;
- **labels** designed as market signals (useful in procurement and partner selection) that can drive adoption of shared trust and interoperability expectations,
- a **generic trust model** allowing for ecosystem-specific trust frameworks to be operationalised, and
- a solution for creating **cross-data space/cross-ecosystem interoperability**.

These are strong levers because they can influence decision-making (who is “trusted”, what is “compliant”), but they still need tight coupling to concrete technical profiles and conformance evidence if they are to reduce fragmentation end-to-end.

IDSA: protocol/specifications convergence, ecosystem tooling, and community capacity

The International Data Spaces Association (IDSA) contributes directly to interoperability plumbing:

- the **Dataspace Protocol (DSP)** and the **Decentralized Claims Protocol (DCP)**, as a shared approach to publishing offers, negotiating agreements, accessing data in a federation, and managing claims. In 2025 DSP and DCP moved into the ISO/IEC standardisation process;
- work toward **compatibility mechanisms** (the recognition that specifications alone do not guarantee interoperability);
- community capacity through hubs, competence centres, and events;
- ecosystem visibility and comparability through tools like the **Data Spaces Radar**.

This approach is aligned with the main diagnosis: interoperability requires **shared protocols plus compatibility assurance**.

EU-level “alignment infrastructure”: shared middleware and interoperability test capacity

Two EU-level instruments are particularly relevant as ecosystem-wide convergence levers:

- **Simpl** (open-source middleware): the idea is to provide reusable infrastructure that supports data access and interoperability across data spaces, reducing engineering divergence and enabling shared defaults.
- **Interoperability Test Bed (ITB)**⁹² **approaches**: conformance tooling makes interoperability measurable and repeatable; this is the kind of “alignment mechanism” that can change behaviour across the ecosystem because it creates objective compatibility evidence.

These mechanisms matter because they can shift the system from “coordination by documents” to “coordination by running code and tests.”

Adoption networks: regional scaling and SME onboarding capacity

Beyond the core frameworks, a set of hub networks accelerates adoption:

- **IDSA Adoption Forum (DSAF)**⁹³: is a neutral ecosystem platform hosted by IDSA that brings together industry, cloud and data space actors to turn data spaces into practical, market-ready deployments and accelerate large-scale adoption.
- **BDVA i-Spaces**⁹⁴: labelled innovation hubs supporting experimentation and capacity building in data/AI ecosystems;
- **FIWARE iHubs**: nodes supporting adoption, solution development, and market building;
- related “connector-as-a-service” and onboarding accelerators: these reduce entry costs and help translate standards into deployable capabilities for SMEs and local ecosystems.

These networks improve uptake, but their effect on interoperability depends on whether they adopt shared technical profiles and participate in conformance regimes.

Open-source as a de facto convergence engine

Open-source projects increasingly act as practical interoperability baselines:

- **Eclipse Dataspace Components (EDC)**: a reusable framework allowing to build data space connectors that implements common data sharing patterns (and is used across multiple ecosystems);
- **Tractus-X**⁹⁵ (notably in manufacturing ecosystems): demonstrates how a shared open-source stack can become a de facto reference implementation for a sector.

This is a powerful convergence force: shared code often aligns behaviour faster than shared documents.

Convergence attempts and their limits

Cross-initiative convergence efforts (such as alliance-style cooperation between major framework organisations) have produced valuable mapping artefacts and shared narratives. But the sustainability challenge is real: when convergence relies on voluntary coordination without durable institutional anchoring (or without being tied to certification/procurement levers), the “gravitational pull” toward a single interoperable core remains limited.

⁹² European Commission, Interoperable Europe Portal, “Interoperability Test Bed,” accessed May 2026.

⁹³ <https://internationaldataspaces.org/data-space-adoption-forum>

⁹⁴ <https://bdva.eu/task-forces/i-spaces/>

⁹⁵ <https://eclipse-tractusx.github.io/>

2.9. HALFWAY SITUATION: EUROPE HAS COMPONENTS, NOT YET A MARKET RAIL

Part 2 shows a clear pattern: Europe has common will and many promising initiatives, but they don't yet add up to a Single Market rail for data. The limiting factor is not "more projects"; it is repeatable interoperability (profiles + tests + adoption levers) across data spaces, sectors, and stacks.

WHAT PART 2 ESTABLISHES IN ONE VIEW

SECTION	CORE POINT	WHAT IT MEANS IN PRACTICE
2.1 MULTIPLE PARADIGMS	Europe has many data-sharing models that don't compose	Each collaboration restarts onboarding, contracts, security, mappings, semantics → interoperability stays a project cost
2.2 SCALE VS READINESS	Many initiatives ≠ EU-scale transactions	Proliferation without federation → bespoke interconnection becomes the dominant scaling cost
2.3 FUNDING PRESSURE	Public money created momentum; sustainability risk grows	If funding buys pilots but not reusable rails, value won't compound across Europe
2.4 DATA SPACES COMPETE	Stack wars emerge inside "data spaces"	Success measured inside perimeters (members, pilots) instead of cross-space transactions
2.5 REGULATION	Law frames trust, not implementation convergence	Same legal anchors, different technical workflows → inconsistent onboarding and trust assertions
2.6 STANDARDS/ MODELS	Too many models + glossaries → semantic drift	Confusion becomes a barrier to entry; fragmentation becomes a competitiveness issue
2.7 TECHNOLOGY	Building blocks exist; composition is weak	Multiple stacks, uneven interoperability → integration becomes power; risk of defaulting to integrated platforms
2.8 GOVERNANCE	Multi-level governance is normal; misalignment is costly	Rulebooks multiply; SMEs face complexity; governance becomes another fragmentation layer
2.8 ECOSYSTEM	Many organisations exist; convergence capacity is too weak	Coordination is mostly "soft" (guidance/ events); missing "hard" alignment (tests/ profiles/certification/levers)

Europe is successfully **creating data spaces**, but not yet **creating a data space market**. To turn hundreds of initiatives into one network, Europe must shift from encouraging convergence to engineering convergence: **shared requirements, conformance testing, and adoption levers** that make interoperability repeatable across spaces, so that "connect once, reuse everywhere" becomes the default.

THE DATA SPACE TURNING POINT:

Gaia-X's Shift from Interoperability Foundations to Market Adoption

ACHIEVEMENTS OF 'SEASON 1.0' PAVED THE WAY FOR TECHNICALLY INTEROPERABLE DATA SPACES	SEASON 2.0' FOCUSES ON DATA SPACE MARKET ADOPTION
<p>1. Development of a unified architecture and required building blocks</p> <ul style="list-style-type: none"> • Technical building blocks for defining & implementing trusted data transactions within a data space • Organisational building blocks for business, legal and governance interoperability • Gaia-X Trust Framework for automating compliance checking • First reliable software implementations • First de jure standards (CEN/CENELEC & ISO/IEC) <p>2. Trust framework automation via Gaia-X Digital Clearing Houses</p> <p>3. CISPE catalogue with 600 market available services, 14 of them complying to Gaia-X Label Level 3</p> <p>4. 200+ use cases, both experimentation projects and first real world implementations</p>	<p>1. Focus on economically sustainable operation for new and existing data space initiatives</p> <p>2. Market adoption of existing technology. Simpl to fill remaining technical gaps</p> <p>3. Providing trustful data for trustful AI</p> <p>4. Easy participation also for SMEs</p> <p>5. Tackle cross-data space interoperability to overcome fragmentation and secure strategic data autonomy</p> <p>6. Continued formal standardisation via CEN/CENELEC and ISO/IEC</p> <p>→ Result: Trust becomes automated, sovereignty becomes actionable, and Europe's digital future can be built on solid, shared foundations</p>



EUROPE DOES NOT NEED
ANOTHER FRAMEWORK, BUT
A GSM MOMENT.

III. CONCRETE INTEROPERABILITY INITIATIVES



HOW DID THE GSM WIN?

1) "Make it real" by locking in harmonised spectrum (a credible commitment)

The decisive move was political/regulatory: reserve the same frequency bands across countries so everyone could deploy the same system.

- In **June 1987**, the EU adopted **Council Directive 87/372/EEC**, requiring Member States to reserve spectrum for a "public pan-European cellular digital" service, with a target to have spectrum **reserved by 1 January 1991**, and planning to make the broader 900 MHz bands available according to demand.
- The companion **Council Recommendation 87/371/EEC** set expectations for coordinated rollout (e.g., introduction by **1991 at the latest**, major urban coverage by **1993**).

Why this mattered: spectrum harmonisation reduced risk for operators and manufacturers, products could scale across borders, not just within one country.

2) Build an operator coalition with a shared deadline (the MoU)

Technology standards often fail because nobody commits to deploy. GSM tackled that with an operator pact:

- In **September 1987**, operators from multiple countries signed the **GSM Memorandum of Understanding (MoU)** committing to deploy GSM and coordinate launch/promotion.
- Contemporary histories emphasise the MoU's two big undertakings: **one agreed standard + networks going live in 1991**, creating a predictable market for vendors to invest into.

Why this mattered: it turned "a spec" into "a market with a date," which is gold for supply chains, R&D budgets, and procurement.

3) Put standardisation in a purpose-built institution (CEPT → ETSI) and keep it open to multi-vendor competition

Work started under CEPT (European PTT administrations), then moved into ETSI:

- CEPT created ETSI and transferred telecom standardisation activities there (late 1980s).
- GSM work (and its technical secretariat) transitioned from CEPT structures into ETSI/related bodies, tightening governance and industrial participation.

Strategic effect: ETSI's process enabled **multiple manufacturers** to build

interoperable kit, preventing a single-vendor lock-in and accelerating adoption through competition.

4) Handle patents in a way that enabled broad implementation (FRAND)

GSM drew on patented innovations. The key was making access feasible for implementers:

→ ETSI's IPR policy is explicitly designed to balance SEP holders' rewards with implementers' access under **FRAND** terms.

Why this mattered: it reduced "IP deadlock" risk, vendors could ship equipment and handsets with clearer licensing expectations.

5) Bake in user-facing "killer enablers": SIM + roaming-ready architecture

Two features made GSM feel different to users and operators:

→ **Roaming** as a first-class concept (commercially enabled by operator agreements and the fact that the network tech was shared).

→ **SIM cards** (identity decoupled from handset), which lowered switching friction and helped create a competitive handset market.

Even if roaming agreements were negotiated commercially later, the precondition was a single interoperable standard and pan-European deployment commitments (the whole point of the MoU + EU coordination).

6) Scale globally by adapting bands without breaking the core standard

GSM started at 900 MHz, then expanded to 1800 MHz and later to other bands (including North America), keeping a common technology family:

→ ETSI notes GSM was designed for **900 MHz**, soon adapted for **1800 MHz**, and later adapted for **800/1900 MHz** and more.

Why this mattered: vendors could export the same ecosystem worldwide with band variants rather than reinventing the standard.

The story in one timeline

→ **1982:** CEPT forms "Groupe Spécial Mobile" to design a pan-European digital system.

→ **25 June 1987:** EU issues Recommendation 87/371/EEC (coordination + 1991 target) and Directive 87/372/EEC (reserve spectrum for pan-European digital cellular).

→ **Sept 1987:** Operators sign the GSM MoU committing to deploy.

→ **1988–1989:** Specs mature for tenders; GSM work moves into ETSI structures.

→ **1991:** First commercial GSM networks/calls appear; momentum becomes self-sustaining.

3.1. A GSM-STYLE STRATEGY

Europe has entered the decisive phase of the data and AI economy: not the phase of writing more rules, but the phase of **structuring markets**. Interoperability is the market-making instrument. Without it, Europe will keep financing pilots while importing the integrated stacks that capture network effects, standards, and value.

The lesson from Parts 1 and 2 is consistent and urgent:

- The global game is increasingly shaped by **platform ecosystems** that impose “standards” through stacks, distribution, and developer gravity.
- Europe's strength is **governed access** to high-value data (private & protected) and the capacity to turn trust into productive collaboration.
- But today, fragmentation dominates: multiple paradigms, multiple stacks, competing vocabularies, and too few cross-data spaces use cases. Even data spaces risk becoming “mini networks” instead of a Digital Single Market.

Europe does not need another polite recommendation on data interoperability. **Europe needs a shock: a “GSM moment”** where policymakers and industry decide, together, that interoperability is no longer optional but a condition for competing in the European market.

The GSM meta-lesson, applied to data

GSM did not win because it was the most elegant technical design. It won because Europe combined:

1. **Credible commitment** (harmonised spectrum and a deadline)
2. **Market commitment** (an operator coalition that pledged deployment)
3. **A purpose-built governance home** (open standardisation enabling multi-vendor competition)
4. **Implementability** (IP handled to avoid deadlock)
5. **Killer enablers** (SIM + roaming that made the network feel pan-European)
6. **Exportability** (extensions without breaking the core)

For EU data interoperability, the mapping is clear: Europe must engineer convergence through adoption levers, conformance, and a small set of user-facing “network effect” capabilities.

A strategy overview in six moves

The GSM analogy is instructive but imperfect. Spectrum harmonisation worked because Member States controlled a scarce public resource. With data, the instruments are different. Funding conditionality, procurement requirements, and certification schemes replace spectrum mandates. Political commitment must therefore be higher, not lower.

1. **Make it real: “reserve the spectrum” by locking an EU interoperability core with deadlines**
Standards become real when the market believes they are unavoidable.

Europe should define a **minimal, non-negotiable interoperability core**, as MUST requirements per building block (identity, trust, catalogues/discovery, policy/contract, onboarding, semantics,

exchange, traceability, measurability, inter-stack compatibility). Everything else remains optional best practice and competitive differentiation.

Then Europe must lock this core through three adoption levers:

- **Funding conditionality:** public money should build EU network effects, not local islands. New publicly supported deployments should be required to conform; existing ones should have a migration path.
- **Procurement alignment:** public buyers should procure interoperable capabilities and conformance, not bespoke integration projects.
- **A shared deadline:** convergence never happens “later.” Europe needs a date when cross-data space interoperability becomes the normal expectation for funded initiatives.

This is the equivalent of harmonised spectrum: it reduces risk, signals scale, and makes investment rational.

2. Build a coalition with a shared launch date: a “Data Roaming MoU”

GSM avoided the classic failure mode of standards: a specification without deployment. Data interoperability needs the same move. Europe should organise a coalition, major sector data spaces, key public operators, and industrial users, and have them sign a **Data Roaming MoU** with two undertakings:

- **One agreed core** (the **MUST** requirements + conformance tests)
- **Cross-data spaces services live by a set date** (real transactions, not demos)

The MoU matters because it turns “interoperability” into “a market with a date.” That is what vendors, integrators, and internal IT roadmaps can commit to.

3. Put the core in a purpose-built governance home: one place to decide, version, certify

Europe's current weakness is not goodwill. It is alignment power. A GSM-style interoperability institution is needed to:

- Decide what is **MUST** vs optional (SHOULD)
- Publish and maintain versioned **profiles**
- Operate **conformance testing** (plugfests, test harnesses, certification)
- Arbitrate interoperability disputes (so interpretation doesn't fragment the market)
- Ensure sector extensibility without breaking the horizontal core (subsidiarity done right)

This does not mean centralising all data spaces. It means governing the rails so competition can flourish above them, preventing stack wars and reducing transaction costs for everyone.

4. Make implementation feasible: multi-vendor competition, mixed models, no licensing traps

Interoperability fails if it forces a single stack, a single vendor, or a licensing approach that deters implementers. The rule should be explicit:

- **Interoperate, do not unify.** Avoid a single-stack monopoly while preventing fragmentation.
- **Open standards, mixed implementations.** Both open-source and proprietary implementations should be possible above the core, because adoption depends on business reality, not ideology.
- **Avoid licence traps.** Overly “contaminant” licensing can repel private investment and push actors back to foreign integrated stacks by default.

The goal is the GSM effect: multiple manufacturers competing on products, while remaining interoperable on the core, the “rails”.

5. Ship killer enablers: “onboard once, transact anywhere”

GSM felt pan-European because roaming and SIM reduced friction for users and operators. Data interoperability needs the same user-facing outcome: data roaming. A small set of “killer enablers” should be universal across conformant ecosystems:

- **Portable organisational identity and roles** across data spaces (no per-consortium reinvention)
- **Machine-verifiable trust** (attestations, credentials, revocation, audit)
- **Cross-data spaces discovery by default** (a federated “publish once, be discoverable everywhere” capability, if and only if data providers want it)
- **Machine-readable policies and obligations** (compliance-as-code, not compliance-as-PDF) **with a shared “codex” of rules and roles**
- **Interoperable commercial patterns** (metering, pricing, billing options) so the market can scale beyond grants and pilots
- **Operational toolchains for collaboration** (negotiation, tracking, auditing) so SMEs can participate without a permanent integration team

These are the network-effect triggers. Without them, Europe stays in high transaction costs, low reuse, and slow adoption, no matter how many data spaces exist.

6. Scale globally without breaking the core: align internationally, keep Europe's governance intact

Europe should not pursue digital autarky. Others will standardise through stacks. Europe must cooperate globally, but on Europe's terms. The rule should mirror GSM's band expansion: adapt requirements and align where possible, but **protect a stable EU core** so Europe remains interoperable with others by choice, not by dependency. This also makes Europe a credible partner: a stable core enables external alignment, certification, and predictable cross-border cooperation.

How standards become real in practice: the deliverables that force convergence

A strategy is only real if it produces operational artefacts and adoption mechanisms. A GSM-style rollout for data interoperability requires four concrete deliverables:

1. **Requirement/profiles** (the MUST core, per building block)
2. **Open-source reference implementations** (to reduce ambiguity and accelerate adoption)
3. **Conformance tests and certification** (to make interoperability measurable)
4. **Adoption levers** (funding, procurement, MoU commitments, flagship cross-data spaces services)

This is the shift from “principles” to “transactions”: from normative ambition to market rails.

The success condition: measurable interoperability, not declared interoperability

If it can't be tested, it can't scale. Europe should steer progress with a small set of brutal KPIs that reflect real network effects:

- **Time-to-onboard into a second data space after joining the first** (target: days, not months)
- **Cross-data spaces transaction volume** (not just intra-space activity)
- **Share of publicly funded initiatives passing conformance** against the EU core
- **Inter-stack compatibility pass rate** (different implementations transact without bespoke glue)
- **Cross-data spaces discovery coverage** (publish once, discover broadly under governed visibility)

If these KPIs move, Europe is building a single market for data. If they don't, Europe is building many "sub-scaled data spaces", and the integrated foreign stacks will win by default. That is why Europe needs a GSM moment for data and AI: not another framework, but an enforceable commitment that makes interoperability the shared market rule.

3.2. THE COOPETITION DEAL: COOPERATE ON RAILS, COMPETE ON SERVICES

This bargain is the industrial translation of the GSM lesson. Europe should not ask the ecosystem to choose between fragmentation and a single stack. It should make the common layer unavoidable, measurable and reusable, while leaving every actor free to differentiate above it.

1. The bargain: avoid fragmentation without creating a monopoly

The first failure mode is fragmentation-by-default: every consortium rebuilds identity, catalogues, policy expressions, contractual workflows, audit logs and compliance evidence. The result is not diversity; it is a tax on participation. SMEs pay it first, and dominant integrated platforms turn it into a business opportunity by offering the missing "one-stop" layer.

The second failure mode is unification-by-capture: because interoperability is hard, one integrated stack becomes the easiest route and then the de facto gateway. Europe should reject both. The right equilibrium is "interoperate, do not unify": mutualise what is necessary for cross-space transactions, and let the market compete on everything that creates user value.

2. The rails: the non-differentiating layer Europe must mutualise

Rails are the parts of the system where fragmentation destroys scale and raises entry barriers. Data spaces rail can include:

- **identity and attestation** (for organisations and for persons)
- **discovery/catalogues and self-descriptions**
- **roles, rules and policy language** and definitions
- **policy negotiation & enforcement**
- **compliance proof** (auditability, traceability, certification)
- **core protocols for trust** and other communications

These components are largely **non-differentiating**: nobody wins long-term because their identity system is unique, quite the opposite. What happens instead is duplication, cost inflation, and slower adoption.

3. The services: where Europe should let the market compete

In contrast, **services** are where competition is healthy and value is created:

- **UX, onboarding experience, developer tooling**
- **performance, reliability, enterprise-grade operations**
- **sector specialisation and domain features**
- **integration services and managed offerings** (including AI tooling)

This is where startups, SMEs, integrators, sector champions and large groups can build sustainable businesses. The problem is not proprietary services. The problem is proprietary gateways: closed identity, closed discovery, closed policy engines or closed trust anchors, especially when they are financed by public money. Competition should improve the experience and reduce costs; it should not decide who is allowed to enter the market.

This split is already implicit in mature ecosystems. Simpl, for instance, is presented by the Commission as **open-source middleware** to support data access and interoperability among data spaces, with "Simpl-Labs" explicitly framed as an environment to **experiment and assess interoperability**, not a mandate to replace everything with one stack. The "coopetition deal" therefore is not anti-market. It is the opposite: it is what makes an EU market possible.

4. Open standards, mixed implementations: the European compromise

The coopetition deal is not "open source everywhere" and it is not "proprietary everywhere". It is open standards and testable interfaces for the rails, supported by open-source reference implementations where they reduce ambiguity and accelerate adoption, with proprietary and managed implementations allowed above and around them.

This is aligned with long-standing EU procurement logic: open standards are repeatedly presented as a way to **promote interoperability and reduce vendor lock-in**, especially where public money is involved.

It is also consistent with the Data Act's market intent: reduce dependency and enhance interoperability, including through rules aimed at facilitating switching between data processing services.

In practice, "mixed implementations" means:

- Any actor can implement the **MUST interoperability core** (including proprietary vendors), because the interfaces are open and testable.
- The EU ecosystem benefits from **open-source reference implementations** to accelerate adoption and lower entry cost.
- Market actors are still able to invest because they can monetise the **service layer** (hosting, operations, performance, support, vertical products).

This is exactly the model that prevents a single-stack monopoly without tolerating fragmentation.

5. Open source vs proprietary: both are necessary, but they must sit in the right layer

i) Why open source is essential (for the rails)

- It reduces entry costs and allows broad reuse for SMEs and public actors.
- It improves auditability and trust in shared infrastructure (especially for identity, policy enforcement and compliance evidence).
- It creates continuity and resilience: critical rails don't disappear when a single vendor changes strategy.
- It is consistent with the Commission's own "think open / share and reuse" posture in its open source strategy.

ii) Why proprietary solutions remain important (for the services):

- They incentivise performance engineering and product-level UX.
- They make it possible for startups and large groups to build sustainable business models that scale internationally.

The mistake is not “proprietary”. The mistake is proprietary rails, closed identity, closed policy engines, closed discovery layers, especially when most initiatives involve public sector actors and public financing. That is where dependency, interoperability barriers, and long-tail exclusion appear.

A mature ecosystem (Catena-X / Tractus-X / Eclipse Dataspace Components) makes this separation explicit: Tractus-X documents an “**open core**” **mindset** based on a distribution of Eclipse Data Space Components, collaborating on common, non-differentiating core functionality while enabling participants to enrich it with OSS⁹⁶ extensions, commercial products, or managed services. That is the coopetition deal in operational form.

iii) Licensing: don't sabotage adoption at the rail layer

Europe also needs a pragmatic stance on licensing. If the goal is EU-wide adoption and interop, licensing must be **compatible with mixed implementation models**.

- Copyleft/reciprocal licences can be valuable to protect a commons, but they impose obligations on derivative works that some commercial actors consider risky and detrimental for their distribution models⁹⁷.
- Non-copyleft (permissive) open source licences are explicitly recognised as enabling use inside proprietary products, which can increase adoption⁹⁸.
- The European EURL illustrates a third path Europe often underuses: reciprocal protection **with compatibility mechanisms**, and explicit attention to interoperability (including interface reuse)⁹⁹.

The point is not to choose one ideology. The point is to ensure the rail layer is shareable, adoptable, and investment-compatible, so private actors do not rationally bypass the European route and default to integrated platform stacks.

5. Convergence without replacement: require behaviour, not uniformity

A key incentive reality is path dependency: the most mature data space initiatives have already invested in stacks, tooling, and operational processes. They will add components to interoperate, but they will resist replacing their stack.

This “augment, don't replace” posture is visible in today's ecosystem:

- The **Eclipse Dataspace Components framework (EDC)** provides a framework for building connectors that is open source under Apache-2.0 and explicitly designed to be extensible and to integrate into various ecosystems, supporting alternative protocols¹⁰⁰.

⁹⁶ open-source software

⁹⁷ Free Software Foundation Europe, “Free Software Legal FAQ,” accessed May 2026.

⁹⁸ Open Source Initiative, “Frequently Asked Questions,” accessed May 2026.

⁹⁹ European Commission, Interoperable Europe Portal, “EURL licences and complementary agreements,” accessed May 2026.

¹⁰⁰ Agera / Catena-X, “EclipseDataSpaceConnector,” GitHub repository, accessed May 2026.

- The **Prometheus-X Dataspace connector** is open source (MIT licence), lightweight (does not duplicate catalogue and contract functionalities, DSP compliant and adds unique features: consent management, multi party contracts, pipeline orchestration; it also enables interoperability with other connects (EDC, Fiware, Simpl)¹⁰¹.
- The **FIWARE Data Space Connector** positions itself as a deployable connector suite, integrating catalog + IAM + policy components, and explicitly notes it can support different APIs by replacing/extending parts of the connector¹⁰². It also includes the possibility of OID4VC-based credential exchange.
- The **Data Transfer Agent** provides a light-weight extensible (data space) participant agent¹⁰³.
- The **TNO Security Gateway (TSG)** is an open-source implementation of a connector that enables secure and sovereign data sharing within federated data spaces. Developed in line with European standards such as the Eclipse Dataspace Protocol (DSP), it ensures interoperability across domains while allowing organisations to retain full control over their data (e.g., including an option of OID4VC credential exchange).

This is the practical meaning of “convergence without replacement”:

- Do not force a stack.
- Define what existing stacks **must implement** to interoperate (requirements/profiles + conformance tests + certification).
- Reward upgrades and adapters that increase cross-data spaces composability.

This is also why certification and testbeds are not optional. IDSA's certification scheme explicitly targets interoperability and trustworthiness of connectors; it exists because interoperability is not credible without verification¹⁰⁴.

6. The contract between Europe and its ecosystem

The deal must be explicit. Europe funds and mandates the rails: profiles where friction is highest, shared reference implementations where useful, testbeds, technical compatibility kits and certification pathways. Europe leaves services open to competition: managed offerings, vertical solutions, UX, performance, hosting, AI tooling, analytics and integration.

Europe should also state what it refuses. Public money should not finance infrastructure-level lock-in; a publicly supported data space should not require a specific vendor, closed trust anchor or non-portable gateway as the price of entry. And interoperability-by-press-release should no longer count: no tests, no conformance, no market claim. The bargain is demanding, but it is rational for every actor. Public authorities get scale, firms get a larger addressable market, and users get more choice in a secure and controlled environment.

¹⁰¹Prometheus-X Association, “Dataspace Connector - Data Exchange,” GitHub wiki, accessed May 2026.

¹⁰²FIWARE, “Data Space Connector,” GitHub repository, accessed May 2026.

¹⁰³Gaia-X Community, “Data Transfer Agent - proof of concept,” GitLab repository, accessed May 2026.

¹⁰⁴International Data Spaces Association, “Certification,” accessed May 2026.

BOTTOM LINE:→ **Coopetition is the operating model of a European Data & AI Union**

The objective is not to make every data space identical. It is to make them composable. Europe should cooperate where duplication destroys network effects, and compete where differentiation creates value. That is how regulation becomes market power: shared rails, competitive services, verified interoperability.

3.3. THE MUST/SHOULD DOCTRINE¹⁰⁵

The coopetition deal only works if Europe separates two questions that are too often mixed: **what must be common for the market to exist**, and **what should remain open for innovation**. The doctrine is therefore simple: make mandatory only the minimum needed to interconnect data spaces, and leave the rest to competition, sector adaptation and experimentation.

"MUST is the anti-fragmentation minimum, not a unification project."**1. From recommendation to obligation**

SHOULD is useful while an ecosystem is learning: it encourages convergence without freezing choices too early. But at EU scale, a **SHOULD**-only approach produces alignment in principle, not interoperability in practice. Data spaces need a small **MUST core**: the shared behaviours, interfaces and obligations without which identity, discovery, policy, exchange, traceability or commercial settlement cannot cross ecosystem boundaries.

This is precisely the ambition of the **Data Space Interoperability Framework (DSIF)** working group, launched in 2025 by data space practitioners from multiple sectors: not to crown one stack as the European winner, but to define the minimum requirements that any stack must meet to connect to the European network.

2. Use the words as engineering commitments

In serious interoperability work, uppercase requirement words are not rhetorical. They are market commitments:

- **MUST** applies only where absence breaks interconnection, creates lock-in, or prevents legal and operational trust. It must be open, profile-based, versioned and testable.
- **SHOULD** marks recommended practices that improve security, usability, governance maturity or sector quality, without becoming a condition of market access yet.
- **MAY** protects experimentation, differentiation and future innovation above the common rail.

The discipline is therefore: **interoperate, do not unify**. Europe should require equivalent behaviour at the interface, not identical products underneath it.

¹⁰⁵Terminology note: this report uses **MUST** and **SHOULD** in the sense popularised by IETF RFC 2119: **MUST** denotes a binding requirement, while **SHOULD** denotes a recommended requirement that may be varied with documented justification. Reference: <https://www.rfc-editor.org/rfc/rfc2119>.

INTEROPERABILITY LAYER	MUST - COMMON RAIL	SHOULD / MAY - SERVICE LAYER
IDENTITY, TRUST & CONSENT	Recognised participant identity, credentials, mandates and revocation; minimum consent or authorisation proof where personal data is involved.	Sector trust models, reputation, delegated dashboards, advanced assurance levels.
DISCOVERY & CATALOGUES	Common metadata profile; federated discovery and query interface; verifiable provider and offer information.	AI-native search, ranking, proprietary catalogue UX, sector extensions.
POLICIES & CONTRACTS	Machine-readable policy profile; minimum contract and obligation model; multi-party transaction readiness where relevant.	Advanced negotiation engines, dynamic pricing, sector model clauses.
DATA EXCHANGE & APIS	Open exchange profiles; documented access APIs; connector behaviour that supports cross-stack transactions.	Performance optimisation, managed connectors, proprietary orchestration layers.
SEMANTICS	Minimal shared vocabulary, identifiers, mappings and versioning needed for cross-space understanding.	Rich sector ontologies, implementation guides, domain knowledge graphs.
TRACEABILITY & COMPLIANCE EVIDENCE	Portable transaction logs; proof of permissions, obligations and execution; common audit evidence formats.	Risk analytics, observability dashboards, automated compliance reporting.
PORTABILITY & COMMERCIAL INTEROPERABILITY	Switch and exit capability; basic metering, billing data and settlement evidence for transactions.	Marketplaces, premium migration, revenue-sharing and a services.
CONFORMANCE & GOVERNANCE	Test suites, versioned profiles, conformance register, change process and dispute-resolution mechanism.	Continuous certification tooling, plugfest automation, maturity benchmarks.

3. Make every MUST profile-based and testable

A MUST requirement should never remain a principle. It should become a profile: a constrained subset of standards, conventions and behaviours that implementers can follow and auditors can assess. Profiles should start from existing standards and stacks, not replace them.

The operational test is simple: **can two conformant implementations transact without bespoke glue?** To pass that test, each MUST should come with four artefacts: a versioned profile, at least one reference implementation where useful, a technical compatibility kit or conformance test suite, and a certification or verifiable self-assessment pathway.

4. Keep the core small enough to be adopted

Over-standardisation would be another form of failure. Europe should not mandate user experience, sector services, managed offerings, performance engineering, advanced AI tooling or commercial differentiation. These belong above the rail. A requirement deserves to become MUST only if its absence raises cross-data space transaction costs, prevents trust or traceability, or creates dependency.

This doctrine gives policymakers, funders and data space operators a practical filter: **mandatory where fragmentation destroys scale; open where diversity creates value.**

THE DOCTRINE IN ONE LINE

→ Define the smallest MUST core per building block. Profile it. Test it. Certify it. Let everything above it compete.

If interoperability remains optional, fragmentation becomes permanent. If interoperability becomes small, testable and mandatory, Europe can turn many data spaces into one market without turning them into one platform.

3.4. THE MINIMAL MANDATORY INTEROPERABILITY CORE

Europe does not need a long catalogue of mandatory components. It needs **a minimal common core that can turn many data spaces into one market**. That logic is already implicit in the Commission's own vision: common European data spaces are meant to rest on shared infrastructures and governance frameworks, and to be progressively interconnected into a single market for data¹⁰⁶.

The purpose of that core is not to prescribe one architecture, one vendor or one stack. **It is to ensure that different architectures can recognise one another**, transact under common rules, and prove compliance at low cost. In that sense, the interoperability core is not a technical blueprint. It is the operating system of a Data & AI Union.

"The core should be small enough to be adopted, but strong enough to make a market."

The core should define market functions not technical products

The right level of definition is not "which product should Europe use?" but "**which functions must always work across data spaces?**" The Data Act already points in that direction: it frames interoperability through machine-readable descriptions, publicly documented structures and vocabularies, sufficiently described access interfaces, and mechanisms for automated data-sharing agreements, rather than through one prescribed implementation¹⁰⁷.

This is the right level of ambition for Europe. The core should define what must be common for interconnection; it should not overreach into what can legitimately remain diverse. That is the practical meaning of the doctrine developed in the previous section: interoperate, do not unify.

¹⁰⁶ European Commission, "Common European data spaces," Shaping Europe's digital future, updated 19 November 2025.

¹⁰⁷ 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 (Data Act), OJ L, 2023/2854, 22 December 2023, Article 33.

Five capabilities Europe should make common

If Europe wants cross-data space interoperability to become routine rather than heroic, the common core should remain focused on a small number of cross-cutting capabilities. DSSC's work is useful here because it treats interoperability as a combination of shared requirements, building blocks and best practices, rather than as one monolithic technology choice¹⁰⁸.

1. **Trusted identity and roles including a common specification language.** Participants, credentials and mandates should be recognisable across ecosystems, so that onboarding does not restart from zero each time. Similar to the machine-readable sections of our passports, which are read on a world-wide scale without any difficulty, we need to agree on a shared vocabulary for formulating the trust profiles of every ecosystem.
2. **Discovery and understandability.** Data, services and policies should be described in ways that can be found, interpreted and compared across ecosystems.
3. **Governed transactions.** Permissions, obligations, contracts and, where relevant, commercial terms should travel with the transaction instead of remaining trapped in local PDFs or consortium-specific practices.
4. **Technical portability.** Exchange should remain possible across different implementations and stacks, so interoperability does not collapse into a hidden stack monopoly.
5. **Traceability and proof.** Transactions should leave auditable, portable evidence, so trust can be measured, compliance can be verified, and procurement can reward real interoperation rather than declarations.

Everything beyond this core should remain open to competition, sectoral choice and experimentation: domain-specific semantics, service design, business models, user experience, managed offerings and AI layers. Europe's objective is not to standardise the whole ecosystem. It is to make diversity composable.

The test is simple: does the next transaction become cheaper?

A real interoperability core should deliver visible outcomes: onboard once, discover across data spaces, negotiate under shared rules, exchange across stacks, and demonstrate compliance afterwards. If these outcomes are not achievable, Europe does not yet have a market rail; it still has a collection of promising initiatives.

This is why **conformance infrastructure matters.** The question is not only whether a profile exists, but whether it can be tested, reused and trusted across implementations. The European Commission's Interoperability Test Bed already reflects this logic of self-service conformance testing against semantic and technical specifications¹⁰⁹.

In short, the interoperability core should be judged not by the length of its specification, but by its effect on the cost of the next transaction. That is how Europe turns coordination without centralisation into something operational.

¹⁰⁸ European Commission, "The Data Spaces Support Centre," Shaping Europe's digital future, updated 18 March 2025; Data Spaces Support Centre, "DSSC Blueprint 3.0*."

¹⁰⁹ European Commission, "Interoperability Test Bed," Interoperable Europe Portal, accessed May 2026.

3.5. GOVERNANCE OF STANDARDS: DECIDE HIGH, DRAFT LOW, TEST CONTINUOUSLY

Europe does not lack standards candidates. It lacks a clear order for turning candidates into market rules. The strategic issue is not which community writes the most elegant specification. It is **who decides what becomes mandatory for the Single Market**; who drafts profiles close enough to implementation; who tests them across stacks; and which adoption levers make «mandatory» real.

«Decide high, draft low, test continuously.»

1. Decide high: the mandatory core is a public choice

MUST requirements shape market access, procurement, competition, integration costs and SME onboarding. They cannot be set by one vendor, one association or one implementation community. The EU level should decide and version the minimal interoperability core, anchored in public legitimacy: the Commission and the European Data Innovation Board for the mandate, and **the DSSC as the operational European host** of the Data Space Interoperability Framework (DSIF).

This does not mean Brussels should write every technical profile. It means Europe decides what cannot fragment: identity and trust, discovery, contracts and policies, exchange, semantics, traceability, conformance, portability and, where needed, commercial interoperability. Everything above this core remains open to sectoral design and competition.

2. Separate roles: neutrality by design

A credible data space cannot allow the same actor to define mandatory rules, operate the market infrastructure and certify its own compliance. **Role separation is not bureaucracy. It is the condition for neutrality, market openness and trust.**

LAYER	MAIN RESPONSIBILITY	NON-NEGOTIABLE GUARDRAIL
EU GOVERNANCE	Decides, versions and publishes the horizontal DSIF core; aligns it with the Data Act, the European Trusted Data Framework and formal standardisation.	No operational or commercial intermediation role. The mandate must remain public and neutral.
SECTORAL GOVERNANCE	Extends the core with domain rules, ontologies, rulebooks and sector conformance profiles.	Cannot weaken the horizontal core or make one private stack compulsory.
TRUST AND ASSURANCE	Tests, audits and certifies compliance of participants, intermediaries and implementations; maintains public evidence.	Cannot certify its own services or operate the services it accredits.
MARKET INFRASTRUCTURE	Provides competitive services: catalogues, identity, consent, contracting, clearing, connectors and managed operations.	Cannot define mandatory standards or self-certify against them.
PARTICIPANTS	Provide and consume data, express use-case needs, and feed operational evidence back into the profiles.	Must retain portability, exit options and the ability to use compliant alternatives.

The participant layer cuts across the whole structure. Data providers and consumers should apply the common rules, but they should not be forced into one stack, one service provider or one certification channel. **Any actor entering one layer must not control the layers it depends on or accredits.** Without this discipline, interoperability becomes capture.

3. Draft low: profiles must be doer-led

Technical profiles should be drafted close to practice. Data spaces, participants, technology providers, open-source communities, not-for-profit associations and standardisation bodies are the right places to map existing practice, identify friction points and produce reference assets. The EU-level home hosts, validates and arbitrates; it does not replace deployment expertise.

- **Data spaces define the need.** Start from concrete cross-data-space use cases and legal constraints: discovery across catalogues, consent revocation across services, contract negotiation across stacks, or traceability across providers.
- **Providers map the implementation.** Connector, catalogue, trust, policy and consent providers agree on interfaces, mappings, reference code and compatibility kits.
- **DSSC formalises the baseline.** The output becomes a DSIF profile and, when mature, feeds European or international standardisation.
- **Deployments test it.** At least two independent implementations prove interoperability in testbeds, plugfests or certification environments.
- **Adoption levers close the loop.** Funding, procurement and certification reward profiles that pass; failed tests feed the next version.

The direction of travel is essential: **data spaces define what cross-stack interoperability must achieve; providers agree how to implement it; European bodies validate, publish and formalise the result. Never the reverse.**

4. Test continuously: if it cannot be tested, it cannot scale

A profile is not a market rail until it can be tested. **Each MUST requirement should therefore be attached to a conformance artefact:** a machine-readable specification, a reference implementation where useful, a test suite, a certification route and a public result.

The standardisation pipeline should be simple: **ecosystem profile, formal standardisation, conformance tests, then procurement, funding and certification uptake.** This is the logic behind the Data Act interoperability requirements and the European Trusted Data Framework under Mandate M/614. The EN 18235 “Trusted Data Transactions” series is a first signal of this pipeline. But the value appears only when standards become executable: test harnesses, plugfests, compatibility kits and public evidence that systems really interoperate.

5. Make adoption real

Europe should stop funding fragmentation by accident. Public money, public procurement and regulatory assurance should converge on the same rule: conform to the minimal core, or publish a migration path.

- **EU funding:** new publicly supported deployments conform to DSIF profiles; legacy initiatives receive a timetable to migrate.
- **Procurement:** public buyers require conformance evidence, not only claims of compatibility.
- **Certification:** trust marks depend on independent testing and periodic renewal.
- **Public register:** conformance status is visible, versioned and comparable across stacks.

This is not punishment. It is market-making. It gives vendors confidence, lowers integration risk for SMEs and prevents interoperability by press release.

6. Govern the core, let services compete

Europe should not crown one winning architecture. It should select a winning set of protocol conventions: the rules that make different architectures recognise, negotiate, exchange, audit and exit. The objective is not one stack but one market.

The final test is practical: can a new participant onboard once, discover offers across data spaces, negotiate under shared rules, transact across stacks, prove compliance afterwards and switch providers without losing continuity? If not, the governance model has produced coordination, not interoperability.

BOTTOM LINE

→ public institutions decide the minimal mandatory core; the ecosystem drafts profiles and reference assets; standardisation bodies stabilise mature outputs; independent assurance makes compliance testable; funding and procurement make adoption unavoidable. That is how Europe moves from convergence by dialogue to convergence by design.

TOO MANY ISLANDS, NOT
ENOUGH BRIDGES.



THE INTEROPERABILITY
CORE IS THE OPERATING
SYSTEM OF A DATA & AI
UNION.

IV. INTEROPERABILITY INITIATIVES

4.1. TOP-DOWN EU INITIATIVES

Europe does not start from a blank page. A set of EU-backed initiatives is already forming the shared rail layer that data spaces need in order to align: policy direction, legal requirements, standardisation mandates, open-source middleware, identity and public-sector interoperability. This overview is deliberately non-exhaustive. Its purpose is not to rank initiatives, and even less to create a new competition between them. Its purpose is to show where the community should plug in, extend, test and reuse what already exists.

"Use and extend the rails. Do not ignore or compete with them"

1. The policy spine: Data Union, Common European Data Spaces and DSSC

The Common European Data Spaces are the political frame: Europe is developing them across 14 sectors and domains, and the Commission supports them through reference architecture, building blocks, semantics, interoperability specifications and data models, with DSSC advisory support. The Data Union Strategy adds the missing strategic acceleration: scaling access to data for AI, simplifying data rules and safeguarding EU data sovereignty, including data labs that link data spaces and AI ecosystems and further EU investment in common data spaces. In practice, this means data spaces should not treat the DSSC Blueprint, glossary and building blocks as optional documentation. They are the common language on which sector rulebooks, technical profiles and conformance practices should build. DSSC is therefore not "another body"; it is one of the places where fragmentation can be turned into reusable alignment.

2. The legal anchor: DGA/EDIB and Data Act Article 33

The Data Governance Act created the European Data Innovation Board (EDIB), whose tasks include addressing fragmentation by enhancing cross-border and cross-sector interoperability and proposing guidelines for Common European Data Spaces. The Data Act then moves the agenda from encouragement to requirements. Article 33 requires participants offering data or data services in data spaces to describe datasets, use restrictions, licences, data quality, vocabularies, classifications and APIs in ways that enable automated access, transmission and, where relevant, automated execution of data-sharing agreements. This is exactly the direction of the MUST/SHOULD doctrine developed earlier in this report: not one software stack, but a minimal, enforceable and machine-readable baseline. The community should actively bring practical use cases into EDIB and Data Act implementation work, so the legal baseline becomes useful rails rather than abstract compliance.

3. The standardisation pipeline: European Trusted Data Framework

The European Trusted Data Framework is the most important top-down standardisation path now available. Under Mandate M/614, CEN, CENELEC and ETSI accepted a Commission request to deliver seven standardisation deliverables supporting the Data Act, including trusted data transactions, catalogue metadata, semantic assets, data governance and maturity.⁶ Once relevant harmonised standards are cited in the Official Journal, they can provide a presumption

of conformity with the Data Act. This is a lever the community should embrace. Standards must not arrive after the market has already fragmented: data spaces, stack providers and sector initiatives should feed implementation experience into CEN-CLC/JTC 25 and ETSI TC DATA, and ask for testable profiles, not only generic documents.

4. The open-source implementation rail: Simpl-Open, Simpl-Labs and Simpl-Live

Simpl is the Commission-backed open-source middleware effort designed to support data access and interoperability among European data spaces and cloud-to-edge federations. Its value should be read in the right way: Simpl can reduce ambiguity, provide common components and accelerate adoption; it should not become a mandatory monopoly. Simpl-Labs can help initiatives experiment and assess interoperability; Simpl-Live is already bringing sector initiatives into feasibility and implementation work. The right posture is therefore “Simpl as a bridge”: connect existing investments, expose gaps, feed requirements back into Simpl-Open, and keep interoperability with EDC, FIWARE, Prometheus-X, Gaia-X/IDSA approaches and proprietary deployments as a design principle.

5. The trust and public-sector layer: EUDI Wallet, OOTS and Interoperable Europe

Data spaces will not scale if every consortium reinvents identity, attributes, mandates and cross-border trust. eIDAS 2 and the EU Digital Identity Wallet give Europe a powerful trust anchor: every Member State must provide at least one wallet to citizens, residents and businesses, built on common specifications. For data spaces, the immediate task is to profile this into participant onboarding, organisational representation, delegation and consent patterns. The Once-Only Technical System (OOTS) is another practical precedent: it streamlines trusted cross-border evidence exchange among public administrations and citizens. The Interoperable Europe Act extends the same logic across public services, enabling administrations to cooperate across territorial, sectoral and organisational boundaries while maintaining sovereignty. Data spaces should reuse this public-sector interoperability momentum, especially where public data, authorisations, procurement, licensing, reporting or compliance evidence must travel across borders.

6. The domain profiles: catalogues, smart cities and Local Digital Twins

Finally, several more targeted EU-backed profiles should be treated as building blocks for alignment. DCAT-AP, maintained under Interoperable Europe/SEMIC, provides a minimal common basis for sharing catalogue, dataset and data-service descriptions across borders and domains; it is a strong candidate pattern for federated discovery across data spaces. In smart cities, ETSI STF704 is for instance developing European standards for Local Digital Twins and Minimal Interoperability Mechanisms, aligned with CitiVerse, Living-in.EU and existing urban interoperability communities. These initiatives are not substitutes for sector data spaces. They are profile factories: places where concrete domains turn the horizontal interoperability core into deployable patterns.

BOTTOM LINE

→ Top-down EU initiatives are not a constraint on the data space community; they are the public infrastructure that can make the community scalable. The right stance is adoption with reciprocity: use the rails, test them with real cross-data-space transactions, report gaps, extend them through open profiles and reference implementations, and keep competition above the shared layer. Europe should not choose between top-down alignment and bottom-up innovation. It needs both: public rails stable enough to create a market, and communities of practice dynamic enough to keep those rails useful.

4.2. BOTTOM-UP INITIATIVES FROM ACTUAL DATA SPACES

Bottom-up initiatives are **where interoperability stops being a concept and becomes an operational test**. They reveal the frictions that generic architectures often hide: credentials that do not travel, catalogues that do not federate, contracts that remain bilateral, vocabularies that diverge, consent and legal bases that are not portable, and business models that do not yet reward cross-space exchange.

The good news is that **the community is no longer waiting for a perfect framework**. Across sectors, data spaces are already building services that no single ecosystem can deliver alone. These use cases should not be treated as anecdotal pilots. They are the first testbeds for the common rails Europe needs.

“Ship the use cases, share the frictions, scale the rails”

Each example below follows the same reading grid: the service need, the interoperability test, and the lesson the rest of the community can reuse.

1. DS4SKILLS x TEMS - skills and media

Service need: Education and media need to compose trusted learning services with protected media and fact-checking content. In one of the first production cross-data space implementations identified in the report, media and fact-check content from TEMS media data space¹¹⁰, including AFP content, can be used by AI learning-generation services connected to DS4SKILLS, such as Tralalere. The value moves both ways: teachers enrich learning material with verified media; fact-checking actors can reuse AI services to extend the reach of their content.

Interoperability test: DS4SKILLS and TEMS rely on different technologies: Prometheus-X for DS4SKILLS and EDC for TEMS. Their connection through the Data Space Interoperability Framework (DSIF) proves the right principle: interoperability must not require migration to one stack.

Shared lesson: The next step is to move from one-shot bilateral exchange to reusable chains: negotiation, multi-party contracts, consent, service orchestration and traceability across several actors. This is exactly the type of friction that should feed the common interoperability core.

¹¹⁰ <https://tems-dataspace.eu/>

2. EMDS, EONA-X and the German Mobility Data Space - mobility and tourism

Service need: Mobility and tourism are cross-border by nature. EV charging, multimodal travel, tourism services, road safety data and AI travel assistants cannot be delivered from one isolated data space. A French provider publishing EV charging infrastructure data through EONA-X should be discoverable and usable by actors connected through other European mobility data spaces, including Swedish, Spanish or German participants.

Interoperability test: Current work connects federated catalogues, identity management and semantic alignment around mobilityDCAT-AP, OCPI, AFIR and related standards. Discussions between EONA-X and the German Mobility Data Space also test mutual recognition of credentials and access across ecosystems.

Shared lesson: Mobility shows that interoperability is not only a connector issue. It requires legal alignment on usage policies and liability, shared vocabularies, operational federation rules and a business case for providers. Highly visible services such as EV charging and road safety should become launch use cases for data roaming.

3. EONA-X x Decade-X - logistics, mobility and aerospace-defence

Service need: Industrial supply chains cross sector boundaries. EONA-X and Decade-X illustrate the value of exploring interoperable transaction flows such as purchase orders, advance shipping notices, goods receipt acknowledgements, Certificates of Conformity, non-conformance tracking and SME onboarding. These are not abstract datasets; they are the documents and events that structure daily operations.

Interoperability test: The potential bridge would require standardised formats, federated identity, catalogue mapping, policy interpretation, lifecycle management for quality documents and, where needed, sealing or archiving mechanisms. These ideas should be read as directions of exploration, not formal commitments.

Shared lesson: Cross-data space interoperability becomes valuable when it removes operational duplication for companies active in several ecosystems. The design priority is therefore trust and governance: versioning, roadmap visibility, dispute resolution and gradual scaling from a small number of services to multi-party flows.

4. DS4SSCC - smart and sustainable cities

Service need: Cities need cross-city benchmarking, urban resilience analytics, citizen-service portability, pooled procurement and coordination with mobility, environmental and energy data spaces. These services cannot scale if every municipality remains locked in its own stack and governance model.

Interoperability test: DS4SSCC operates in a heterogeneous landscape: pilots use EDC, Simpl, FIWARE, Tractus-X, Ocean Protocol, proprietary solutions and other technologies. The project is therefore exploring a common decentralised layer that can connect local data spaces without creating a central hub or forcing one technology choice.

Shared lesson: Territorial data spaces will scale only through interoperability across local choices. Citizen identity, consent, entitlements and local digital twin data must become portable under common rules. DS4SSCC should therefore remain closely connected to DSIF, Simpl-Live and Local Digital Twin standardisation work.

5. DEPLOYTOUR - European tourism

Service need: Tourism requires multi-region itineraries, visitor-flow management, sustainability reporting, links with mobility and cultural heritage, and portability of traveller preferences and consent. It is also an SME-heavy sector, which means interoperability must be simple enough to adopt without bespoke integration.

Interoperability test: DEPLOYTOUR is federating destinations, DMOs and platforms that rely on EDC, FIWARE, proprietary and emerging Simpl-based stacks. A first interconnection MVP has been delivered, and regional adoption environments such as bitDS, the Balearic Islands Tourism Data Space, show how local ecosystems can connect to the European Tourism Data Space without losing their governance.

Shared lesson: Tourism can make data roaming visible to citizens and SMEs. Its priority should be a lightweight interoperability path between regional, sectoral and European initiatives, including mobility, cultural heritage, green data and agriculture.

6. CEADS - agriculture and agri-food

Service need: Agriculture needs continuity from farm to fork: traceability, precision advisory services, CAP and sustainability reporting, supply-chain resilience, logistics, climate adaptation and rural digital twins. The value is in the chain, not in one isolated platform.

Interoperability test: CEADS faces a common European problem. Cooperatives, agritech platforms, advisory services and downstream food-chain actors use EDC, deltaDAO/Pontus-X, FIWARE-based platforms and proprietary solutions. Using EDC as an added cross-solution layer can help in the short term, but it also creates duplication when participants must maintain both their native stack and an additional connector.

Shared lesson: Interoperability should protect existing investments, not punish them. DSIF-style catalogue and contract interoperability can allow conformant stacks to work directly with each other rather than forcing permanent additional layers. Agriculture is therefore a key test for 'augment, do not replace'.

7. Location Europe - geospatial data and local digital twins

Service need: Location data is a horizontal asset for AI urban planning, mobility-as-a-service, environmental monitoring, digital twin services and neighbourhood resilience. Its value increases when spatial data can be reused by services built in mobility, smart-city, Local Digital Twin and environmental data spaces.

Interoperability test: Location Europe is deploying data space infrastructure, including a Prometheus-X connector and DSIF alignment, so high-value spatial data can be discovered, governed and reused across domains rather than remaining confined to specialised portals.

Shared lesson: Geospatial interoperability is a multiplier. It can provide a shared spatial layer for AI agents, public planning and climate-action services, provided that identity, policy, provenance and usage conditions travel with the data.

8. AID-Care / Dataspace4Health - Europe-Japan health data collaboration

Service need: Health research and clinical innovation require trusted access to diverse datasets across borders. AID-Care, built on Dataspace4Health, aims to enable collaboration

between Luxembourg and Japan around neurodegenerative diseases.

Interoperability test: This use case makes the central point clearly: technical compatibility is not enough. Partners must align GDPR and APPI¹¹¹ assumptions, personal data definitions, anonymisation and pseudonymisation standards, lawful bases, transfer requirements, data subject rights, audit, breach notification, consent transparency and security safeguards.

Shared lesson: Cross-border health data collaboration shows that legal, governance and trust interoperability are part of the infrastructure. DSIF can help turn bilateral legal engineering into a reusable framework for lawful, auditable and scalable international health data exchange.

The common lesson: make bottom-up experience reusable

These stories are different, but the frictions repeat. The community is converging around the same hard points: mutual recognition of participants, federated discovery, shared vocabularies, machine-readable policies and contracts, consent and legal interoperability, traceability, operational federation and incentives for providers.

That repetition is encouraging. It means Europe is not facing hundreds of unrelated problems; it is discovering the common interoperability core through practice. The role of the community is now to make these lessons reusable: publish test scenarios, share vocabulary mappings, document failures as well as successes, feed DSIF and Simpl-Live, and connect bottom-up evidence to Data Act standardisation and conformance.

Bottom-up initiatives should therefore become the proving ground of Europe's data roaming capability. No stack monopoly. No isolated pilot. A community of interoperable data spaces, learning in public and scaling together.

4.3. CONVERGENCE FROM THE DATA SPACE STACKS AND PROVIDERS

The most concrete answer that has emerged at ecosystem level to the fragmentation described in Parts 2 and 3 is the **Data Space Interoperability Framework (DSIF)**¹¹² a community-driven initiative whose stated purpose is to make Europe's heterogeneous data space stacks interoperate in production, rather than coexist on paper.

It is a working group where the existing stacks define what they must share to interconnect, and what each can continue to do differently. Its objective: allow any participant of any data space to transact with any participant of any other data space, regardless of the underlying technology, without bespoke integration and without forcing migration to a single implementation.

Structure: a Core Team of providers, anchored by the data spaces

DSIF is organised in two layers.

The **Core Team**¹¹³ is composed of the technology providers behind the principal European data space stacks (Athumi, deltaDAO, Libelium, Orange Business Services, Seamware, Startin'Blox, Visions). Their composition is deliberate: the actors whose short-term incentive

¹¹¹ Act on the Protection of Personal Information — Japan's main personal data protection law.

¹¹² Data Space Interoperability Framework, official website, accessed May 2026.

¹¹³ Data Space Interoperability Framework, "Core Team and Governance," GitLab wiki, accessed May 2026.

would normally be stack consolidation are instead the ones engineering the interconnection. In a fragmented market no single European stack will prevail; in an interoperable market every conformant stack accesses the whole network. The five stacks represented cover the bulk of European data space deployments:

- **EDC (Eclipse Dataspace Components)** – the most widely deployed connector framework, with traction in industrial sectors (Catena-X, Manufacturing-X).
- **Prometheus-X (PTX)** – open-source building blocks deployed across skills, media, mobility and smart cities, with native support for consent, multi-party contracts and service chains.
- **Simpl** – the European Commission's middleware programme for common European data spaces.
- **Pontus-X** – trust-anchoring and decentralised infrastructure, present in environmental, energy and agricultural ecosystems.
- **FIWARE** – open-source generic enablers and NGSI-LD-based context exchange, used in smart cities and IoT-heavy verticals.

No stack is the reference; each provider implements the agreed interoperability requirements in its own codebase, and decisions are documented in an open repository.

The second layer is composed of the data spaces themselves, who participate in DSIF governance and supply the framework with concrete use cases⁷¹⁴. DS4SKILLS, TEMS, DEPLOYTOUR, DS4SSCC, the Legal Data Space, CEADS and others bring their operational requirements and contribute the policies and test scenarios against which the interoperability work is validated. The framework only ships what has been demonstrated to work between at least two stacks on at least one production use case.

Scope and first reference implementations

DSIF addresses the points of friction where data spaces today fail to compose: **cross-catalogue discovery**, a **common contract model** with shared semantics for data sharing agreements, **multiple exchange protocols** (bilateral peer-to-peer, multilateral and broker-mediated), **identity and trust alignment** between ecosystems, and **ODRL policy alignment** so that governance attached to data remains enforceable when it flows across stacks.

Three concrete workstreams⁷¹⁵ have been funded to date, each delivering interoperability between Prometheus-X, EDC, Simpl and FIWARE:

- **Cross-catalogue discovery** – consistent metadata and policy attachment across stacks.
- **Cross-data-space multi-party contracts** – extending bilateral negotiation to agreements and service chains involving more than two participants.
- **Cross-data-space consent interoperability** – ensuring a consent collected in one data space remains recognised and enforceable when the data flows into another (GDPR continuity across stacks).

Position in the wider landscape

⁷¹⁴ Data Space Interoperability Framework, "Use cases," GitLab wiki, accessed May 2026.

⁷¹⁵ Data Space Interoperability Framework, "Workstreams and specifications," GitLab wiki, accessed May 2026.

Existing European bodies cover the **technical layer** of interoperability: DSSC defines the building blocks and the conceptual model; Gaia-X provides a generic trust protocol; IDSA defines the Dataspace Protocol and operates connector certification; CEN-CENELEC will deliver the harmonised standard EN 18235 under Mandate M/614.

DSIF builds on these outputs and extends them on three fronts. On the **technical layer**, it consolidates existing specifications and closes the gaps they leave open in practice (discovery, multi-party negotiation, consent, identity recognition) through running code validated between at least two stacks, rather than through additional specification documents. On the **legal layer**, it develops what existing technical bodies do not address: a shared rulebook and a registry of machine-readable ODRL policies contributed by sectoral data spaces. On the **business layer**, it tackles what no other body currently treats: concrete cross-data-space use cases and the economic model that goes with them, how value is created, shared and monetised when a service operates across several data spaces running on different infrastructures.

DSIF does not replace the existing bodies where they operate; it consolidates their outputs and adds the legal and business dimensions without which cross-stack interoperability would remain a specification rather than a market.

4.4. FEDERATED DISCOVERY AND THE HYPERCATALOGUE

A complementary illustration of what an interconnected European ecosystem could deliver is the prototype **meta-catalogue**¹¹⁶ developed within the DSIF community. It aggregates, in a single interface, the offerings currently published across the main European data space marketplaces and public platforms (datasets, services, AI models, data products).

The aggregation is built by indexing the public listings of these marketplaces. On top of the aggregated offer, an AI assistant, itself based on an open-source Prometheus-X component¹¹⁷, provides two modes of interaction:

- **Search and exploration** – natural-language queries across the full ecosystem, with filtering by sector, data type, governance rules and geographical scope.
- **Use-case matching** – users describe a use case in their own terms and receive either matched offerings already available across the ecosystem, or suggested adjacent use cases drawn from what is being deployed elsewhere.

The point of the demonstrator is not the interface itself but what it reveals once the offer is consolidated: **the European data space ecosystem already exposes a substantial breadth of datasets, services and AI components across sectors**. The bottleneck is not the supply, it is the lack of cross-catalogue visibility. A user, a developer or a public buyer wanting to assemble a service today must navigate each marketplace separately; the same query, run across the aggregated offer, returns a markedly richer set of options.

The architecture recommended by this report is not, however, the creation of a single central catalogue. Centralising the European offer in one platform would reintroduce, at the discovery layer, exactly the dependency the data space architecture is designed to avoid, and would create a single point of governance, capture and failure for the whole ecosystem. The right answer is federation: each data space catalogue should be able to surface offerings published in the others, under each provider's chosen visibility rules, with discovery happening peer-to-peer rather than through a central index. This is precisely the work being conducted

¹¹⁶ Data Space Interoperability Framework, "Connect DSIF," accessed May 2026.

¹¹⁷ Prometheus-X Association, "Dataspace Assistant - design document," GitHub repository, accessed May 2026.

under the DSIF cross-catalogue discovery workstream described in Section 4.3.

The meta-catalogue stands as a proof of what is technically feasible today on the aggregated offer; the federated implementation is what should be delivered tomorrow at the level of the ecosystem itself.

4.5. OBSERVATORY AND KNOWLEDGE COMMONS

Europe cannot steer what it cannot observe. The federated discovery layer described above makes data products, services and AI components visible to users; an observatory would make the data space ecosystem visible to decision-makers. Its role would not be to produce another static landscape map, but to maintain a living view of initiatives, technical choices, rulebooks, trust frameworks, connectors, catalogues, use cases and cross-data space transactions. This is the level at which public investment can be steered: **duplication can be detected before it hardens into fragmentation, gaps can be prioritised, and shared rails can be funded** where they create the greatest EU-scale leverage.

The observatory should therefore measure convergence, not only activity. Counting projects, members or events says little about whether Europe is becoming interoperable. The useful indicators are more operational: whether maturity models are comparable, whether conformance tests are passed, whether onboarding time falls, whether credentials and policies can be reused across data spaces, whether catalogues can be queried across ecosystems, and whether real transactions are happening between stacks and sectors. **A public conformance and maturity dashboard would make progress visible to funders, public buyers and market participants, and would make divergence harder to ignore.**

This measurement layer should be paired with a **knowledge commons**. The commons would collect and curate the assets that reduce the cost of implementation: reusable governance patterns, standard clauses, policy vocabularies, onboarding templates, maturity models, conformance tools, mapping tables between stacks, reference implementations and lessons from real deployments. Its value would come from curation, versioning and evidence, not from accumulation. **Europe does not need another repository of PDFs; it needs an operational memory of what works**, where it has been tested, under which legal and technical assumptions, and how it can be reused by the next data space without starting again.



DIGITAL RESILIENCE INDEX (DRI)

The DRI is an open measurement standard designed to assess, in a systemic and comparable manner, the level of digital resilience of an organisation, company, public authority, or critical infrastructure operator. Its objective is to make visible and measurable the technological, legal, economic, and operational dependencies that currently shape information systems and digital value chains.

Unlike approaches focused exclusively on cybersecurity or regulatory compliance, the DRI adopts a transversal perspective on resilience, integrating:

- dependencies on critical suppliers and technologies (cloud, software, AI, data, infrastructure);
- capabilities related to control, reversibility, and business continuity;
- governance challenges, regulatory compliance (DORA, NIS2, Data Act, AI Act), and accountability;
- the organisation's integration within interoperable trust ecosystems, notably within European data spaces.

The index is based on a structured methodology built around public pillars and criteria, developed collaboratively with public authorities, industry leaders, academic experts, and institutional stakeholders. This methodology enables the production of an overall digital resilience score.

Interoperability is a highly strategic dimension. This is why aDRI made a deliberate choice in designing the Digital Resilience Index: to use a **weighted geometric mean** rather than a simple average.

Because resilience is not an average, it is a chain. And a **chain** is only as strong as its weakest link.

Interoperability, in particular, often acts as a **bottleneck**, limiting integration and scalability. The model is designed to make this visible, rather than allowing strong performances elsewhere to mask underlying fragilities.

In other words, it enables a more **rigorous and honest assessment** of resilience.

4.6. TOMORROW: THE DATA SPACE SOCIAL NETWORK?

1. From technical interoperability to human interoperability

This report has focused on the hard machinery of interoperability: standards, profiles, catalogues, connectors, rulebooks, rolebooks, compliance, conformance, certification, contracts, semantics, identity, trust, and cross-stack transaction capabilities. That machinery is indispensable. But it is not sufficient.

“Data spaces are not only made of protocols. They are still made by people”

The community now faces a gigantic level of complexity: aligning technical standards; mapping vocabularies and ontologies; interpreting law in digital environments; developing cross-sector and cross-border use cases; defining business practices; testing compliance; navigating sectoral and horizontal standards; and connecting local data space initiatives with broader federations. No community aligns this kind of complexity through documentation alone. Standards do not adopt themselves. Rulebooks do not interpret themselves. Use cases do not federate themselves. People do.

Europe should therefore be ambitious, but not unfair to itself. **GSM took roughly a decade to align one sector** around one major interoperability trajectory. **Data spaces are harder:** they require alignment across many sectors, jurisdictions, technologies, legal regimes, business models, and communities of practice at the same time. The conclusion is not patience as an excuse. It is patience turned into method: if alignment is the bottleneck, then the tools for alignment must become part of the infrastructure.

“The final bold proposal of this report is simple: make the data space community interoperable with itself”

2. An open social graph for the data space movement

Europe should collectively build the social network and knowledge hub of the data space community. Not a communication website. Not another newsletter. Not a proprietary professional network used because nothing better exists. Not a single platform that centralises the community. A shared, open, federated, machine-readable social and knowledge graph for data spaces: a common rail connecting practitioners, organisations, projects, federations, standards, rulebooks, rolebooks, components, use cases, conformance evidence, skills, and needs.

The lesson of Facebook is useful here. Its power never came only from the interface. It came from the social graph: the representation of people, organisations, content, interests, actions, and relationships whose value increases as more nodes and connections are added. This graph is the incarnation of the network effect. But in the dominant platforms, the graph is proprietary: access, visibility, ranking, APIs, and business logic are controlled by the platform.

The data space community needs the opposite model: **an open social graph as part of the rails.** The graph should not belong to one vendor, one association, one project, one stack, one institution, or one user interface. It should be governed as a commons, accessible through open APIs, and reusable by many interfaces. In other words: not the Facebook of data spaces, but the open graph of the data space movement.

3. What the graph should connect

The purpose of this tool is to make the community discoverable to itself. Today, too much knowledge is hidden in meetings, working groups, slide decks, Git repositories, newsletters, national projects, sectoral consortia, bilateral conversations, and personal networks. This creates avoidable gaps and overlaps. One project reinvents a legal clause already drafted elsewhere. One sector builds an ontology mapping that another sector also needs. One data space tests a connector bridge without knowing that another team has

already solved the same problem. One SME cannot find the right onboarding path. One use case dies because the right partners never meet.

The graph should connect, at minimum:

- **people:** architects, legal experts, semantic experts, business developers, compliance specialists, public officials, researchers, open-source maintainers, entrepreneurs, investors, and users;
- **organisations:** public authorities, companies, SMEs, research institutions, associations, standardisation bodies, open-source foundations, data intermediaries, and sectoral governance bodies;
- **projects and federations:** local initiatives, Common European Data Spaces, sectoral federations, cross-border projects, digital commons, DSIF workstreams, and data space agentic AI ecosystems;
- **knowledge assets:** standards, profiles, vocabularies, ontologies, legal templates, rulebooks, rolebooks, conformance tests, case studies, and training resources;
- **operational assets:** connectors, catalogues, policy engines, consent modules, contract services, SDKs, reference implementations, deployments, and certification or conformance evidence.

This would not be only a directory. It would be a living map of the ecosystem: who is building what, with whom, under which rules, using which components, with what evidence, and with what reuse potential.

4. From repository to knowledge hub

A repository stores documents. A knowledge hub connects meaning. A rulebook should be linked to the roles it defines, the obligations it creates, the legal clauses it references, the technical components that implement it, the conformance tests that verify it, and the use cases that rely on it. A connector should be linked to the protocols it supports, the standards it implements, the data spaces where it is deployed, and the evidence of interoperability it can provide. A use case should be linked to its participants, data products, semantic models, legal basis, business model, contracts, consent requirements, and replication potential in other sectors.

This is what it means to integrate rulebooks and rolebooks natively in a standard manner. They should not remain PDF artefacts interpreted differently by each initiative. They should become typed, referenceable, versioned objects in the common graph: human-readable where needed, machine-readable where possible, and executable where the ecosystem is ready.

This also prepares the ground for agentic AI. If future AI assistants are expected to navigate data spaces, propose use cases, compare legal patterns, identify reusable components, and support compliance, they will need structured knowledge. A fragmented landscape of PDFs, websites, repositories, and informal networks will not be enough. The knowledge hub should become the retrieval and reasoning layer of the data space community.

5. A federated community platform, not a new central platform

The architecture should follow the doctrine of this report: interoperate, do not unify. The common object should be the graph, the minimum schemas, the APIs, the provenance rules,

and the governance framework. The interfaces should remain plural. A data space project could embed the graph in its own portal. A sectoral federation could expose its members, rulebooks, and use cases through its own interface. A public authority could use it as a monitoring and funding tool. An SME could access it through an onboarding assistant. A researcher could query it as a knowledge base. A provider could build services, dashboards, and AI copilots on top.

This is the same cooperation logic as the rest of the report: cooperate on rails, compete on services. **The open social and knowledge graph is the rail.** The user interfaces, analytics tools, recommendation engines, community features, and AI assistants are the services.

To remain trustworthy, the graph must distinguish between claims and evidence. A self-declared “interoperable” component is not the same as a tested one. A pilot is not the same as a production deployment. A draft mapping is not the same as a maintained profile. A rulebook clause is not the same as an enforceable policy. Trust in the graph will determine trust in the ecosystem.

6. The human rail of the Data & AI Union

The hypercatalogue answers: what exists? The observatory answers: what is progressing? DSIF answers: what must interoperate? **The data spaces social network and knowledge hub answers: who is building what, with whom, under which rules, and how can others reuse it?**

This is not a “nice to have.” **It is the human interface of the Data & AI Union.** Europe cannot scale data spaces if expertise remains concentrated in a few insiders, if newcomers cannot understand where to start, if SMEs cannot find partners, if public buyers cannot see what is genuinely interoperable, and if every initiative must rediscover the same legal, technical, semantic, and business knowledge. Capacity building must therefore be treated as an infrastructure function, directly connected to the Smart Data Ecosystems Academy, real components, real rulebooks, real tests, and real deployment journeys.

Europe's data space strategy is based on a promise: many actors, many implementations, shared rails, and scale without monopoly. That promise now applies to the community itself. If the data space movement wants to avoid fragmentation in the market, it must avoid fragmentation in its own knowledge and relationships.

“Make the community visible to itself. Make its knowledge reusable. Make its relationships interoperable. That is the final rail.”

CALL TO ACTION

→ **Let's build the social graph of data spaces together.**

Digital New Deal, alongside all the contributors to this report representing multiple sides of the data spaces community of practice, welcomes every newcomer willing to join this endeavour. The next phase will not be built only by those who wrote the first rulebooks, deployed the first connectors, or launched the first pilots. It will be built by all those ready to turn Europe's fragmented initiatives into a shared, open, trusted, and interoperable Data & AI Union.



INTEROPERABILITY IS
THE MARKET-MAKING
INSTRUMENT OF EUROPE'S
DATA AND AI STRATEGY.

CONCLUSION

From regulatory power to market power

Europe is already a regulatory power. The question now is whether it can become a market-making power.

Without this shift, Europe may create many data spaces without building a single market for data: well-governed but disconnected local-networks, strong principles but weak network effects, public investment but limited market composition. The missing integration layer will then be supplied by others, most likely vertically integrated cloud-data-AI platforms offering one API, one onboarding path, one execution environment and one de facto standard.

Europe can either build the rails of its own Data & AI Union, or become a set of high-value data reservoirs feeding infrastructures governed elsewhere.

The choice is not between fragmentation and centralisation. Europe should not unify the digital stack under one architecture, vendor or platform. Its comparative advantage lies in coordination without centralisation, and scale without monopoly.

This is why Europe needs a GSM moment for Data & AI. GSM prevailed because Europe turned interoperability into a market condition, aligned public authorities and industry, and created certainty for investment, competition and scale. Data spaces are more complex, but the lesson remains: network effects do not appear by declaration. They appear when actors can join a network knowing that the cost of connecting will fall, not rise, as the network grows.

At stake is more than technical efficiency. Interoperability is the mechanism by which Europe can convert trust into transactions, transactions into scale, and scale into strategic autonomy. It is also the condition for competitive AI. **There is no trustworthy AI without trustworthy data**, and no competitive European AI without governed access to high-quality private and protected data across organisations, sectors and borders.

Europe must therefore stop funding fragmentation-compatible projects and start funding composability. Public money, procurement, certification and standardisation must reward those who build for the network. **If a data space is publicly supported, it should contribute to the common rails.**

This is how Europe moves from regulatory power to market power.

Regulatory power defines the rules of the game. Market power makes those rules operational in the infrastructures through which actors actually exchange, invest, innovate and compete.

But the final message of this report is not only technical. It is human.

Data spaces are built with protocols, standards, catalogues, connectors, rulebooks, contracts, policies, ontologies and compliance tools. But none of these align by themselves. **Standards do not adopt themselves.** Rulebooks do not interpret themselves. Use cases do not federate themselves. **People do.**

Only human beings are ultimately the true vectors of cooperation.

This is why Digital New Deal calls for a **common data spaces social network and knowledge hub as part of the European data space rails**. This common graph should be governed as a commons, accessible through open APIs and reusable by many interfaces. The graph should be shared. The interfaces should compete. The principle remains: cooperate on rails, compete on services.

Europe's Data & AI Union will not be created by technology alone. It will be created by people who decide to connect their work, align their efforts and build the rails together.

FROM DATA SPACES TO SMART DATA ECOSYSTEMS

In practice, what Europe is building is not merely a federation of data infrastructures. It is the foundation of a new generation of **Smart Data Ecosystems**. The term data space may now have reached its limits: it does not fully capture AI, governance, trust, business models or the human cooperation needed to make the system work.

With Smart Data Ecosystems, Europe may finally have its answer to the platform age. The second season of data spaces is not a technical adjustment. It may become the second act of Europe's digital project: the moment when Europe stops imitating platforms and starts building its own model of scale.

Not platform power, but ecosystem power.

Not lock-in, but interoperability.

Not centralisation, but coordinated intelligence.

From Data Spaces to Smart Data Ecosystems, Europe can turn fragmentation into network effects, and trust into market power.

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ACKNOWLEDGEMENTS

FOR THEIR CONTRIBUTIONS:

With the support of the Caisse des Dépôts Research Institute

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February 2026

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