A FEDERATED INDUSTRIAL DATA SPACE DEMONSTRATOR

BRAZIL–EUROPEAN UNION COLLABORATION AT HANNOVER MESSE

Open Industry ABINC BRAZILIAN ASSOCIATION OF INTERNET OF THINGS ABDI MINISTRY OF DEVELOPMENT, INDUSTRY, TRADE AND SERVICES BRAZILIAN GOVERNMENT BRASIL STANDING WITH THE BRAZILIAN PEOPLE

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ABDI – Brazilian Industrial Development Agency
ABINC – Brazilian Association of Internet of Things
APEX – National Confederation of Industry
ABINFER – Brazilian Tooling Association
CNI – National Confederation of Industry
GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit
Global Digital Dialogues
SENAI/MG – NATIONAL SERVICE FOR INDUSTRIAL (Minas Gerais HQ)
VDMA – VERBAND DEUTSCHER MASCHINEN- UND ANLAGENBAU
VDI – VEREIN DEUTSCHER INGENIEURE

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ABSTRACT

The trade agreement between Mercosur and the European Union has the potential to expand bilateral trade flows, generate economic scale, and reinforce industrial cooperation. However, the realization of these benefits depends on the capacity of firms to meet regulatory, sustainability, and traceability requirements in a consistent, efficient, and scalable manner.

This paper presents the **Brazilian Industrial Data Space Demonstrator**, deployed during **Hannover Messe**, as a real-world implementation of **federated, sovereign and policy-based industrial data sharing**.

The demonstrator enables secure cross-company data exchange between Brazilian and German industrial stakeholders, following **International Data Spaces Association (IDSA)** and **Gaia-X** principles. It focuses on **CNC machining and toolmaking environments**, integrating operational data, downtime indicators, energy consumption metrics and MES-derived information, while ensuring compliance with **GDPR and LGPD**.

Beyond the exhibition context, the demonstrator establishes the foundation for a **persistent and scalable Industrial Data Space in Brazil**, supporting long-term collaboration, benchmarking and ecosystem development.

Data Spaces concepts

A data space is a secure and federated digital environment that enables the permissioned sharing, analysis, and reuse of data among trusted participants, while preserving data ownership and control.

In the context of the demonstrator, this environment will support the integration of operational and machine data, production indicators, and energy consumption metrics, as well as process benchmarks. These data assets can be used to feed predictive models, support scientific analysis, and enable the development of decision-support tools.

Demonstrator phases:

April 20th – 24th / 2026 – Hannover Messe

May – Sept / 2026 – Brazil Operations

1. INTRODUCTION

The Open Industry Program is an initiative created and managed by ABINC, the Brazilian Internet of Things Association. It is part of Pillar 2, Emerging Technologies, within the Digital Brazil 2030+ Plan. The program brings together companies, industry associations, science and technology institutes, startups, and government entities to develop projects in strategic areas of the industrial sector. These initiatives are implemented through Public–Private Partnerships, with the objective of positioning Brazil at the forefront of the Data Economy and the Connected Industrial Economy.

The program is guided by the objective of strengthening the position of Brazilian industry within the evolving global data economy. It is grounded in the assumption that collaboration and transparency are key enablers of technological and economic development, as well as of resilience and sustainability in production systems. The initiative integrates organizations of different sizes and sectors to develop, adopt, and implement open standards and norms. These standards aim to ensure interoperability, compatibility, security, and data sovereignty, enabling both organizations and individuals to actively participate in this new phase of the digital economy.

The Open Industry Program is supported by the Brazilian Agency for Industrial Development (ABDI), an autonomous social service established by the Brazilian government to promote industrial development policies. The agency focuses on initiatives that foster job creation and align with national strategies in foreign trade, science, and technology. It also plays a central role in supporting the implementation of industrial policies, such as New Industry Brazil (NIB), contributing to the country's socioeconomic development. In addition, ABDI advances the digital transformation of Brazilian industry, enhancing its competitiveness, technological capabilities, operational efficiency, and sustainability.

Manufacturing and Data Usage Overview

Manufacturing ecosystems increasingly rely on **data-driven collaboration that extends beyond organizational and national boundaries**. Although industrial assets generate large volumes of operational data, most of this information remains siloed due to concerns related to data sovereignty, intellectual property, competitive exposure, and regulatory compliance.

Traditional centralized data platforms do not adequately address these constraints, as they often require firms to relinquish control over their data. In contrast, **Industrial Data Spaces** adopt a federated approach, enabling participants to share data under explicitly defined conditions without central storage or loss of ownership.

Demonstrators play a key role in translating these principles into operational settings. They allow stakeholders to assess technical feasibility, governance structures, and potential business value within a controlled environment.

This paper presents the **Data Space Brazil – Hannover Messe Demonstrator**, developed through a Brazil–European Union collaboration. The demonstrator is positioned as both a technical reference implementation and a **strategic instrument to support international industrial cooperation.**

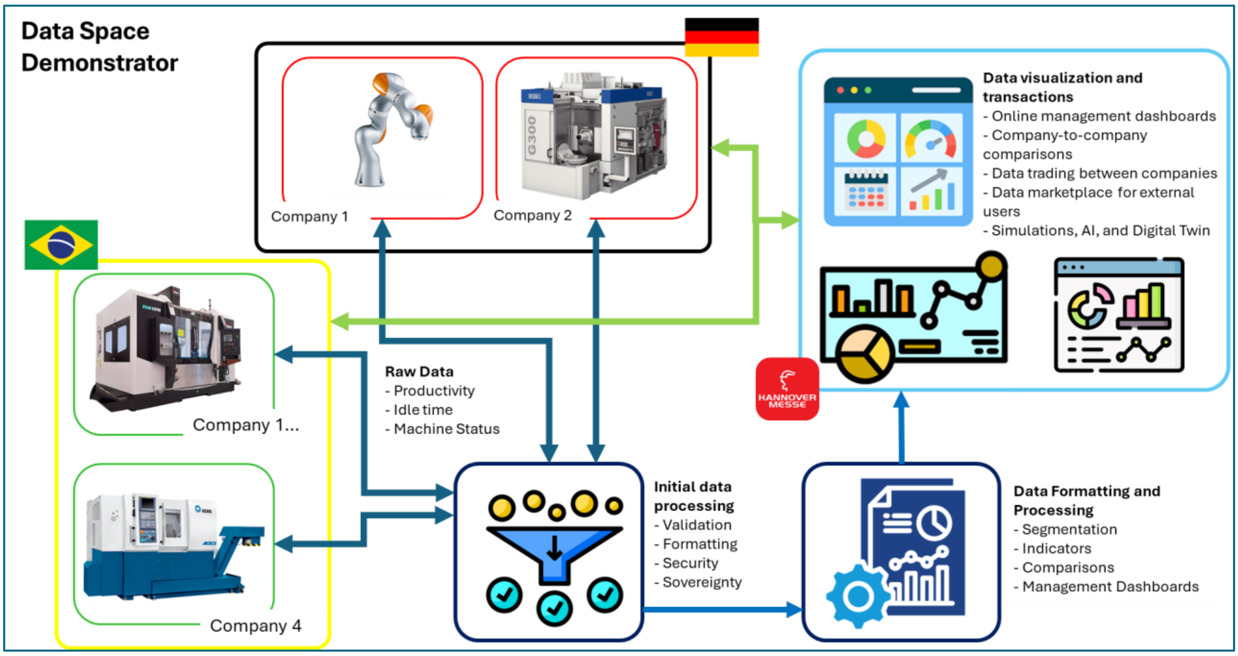

Figure 1 – Data Space Demonstrator Architecture

Key Activities in Demonstrator:

- **Data integration**: Harmonizing existing **SOC (Shopfloor Operations Control)** and management data from processes and equipment into a common format within a permissioned data space, enabling analysis, decision-making, monetization, and data modeling.
- **Standardization**: Implementing a common vocabulary for process and equipment events based on **OPC UA (Open Platform Communications Unified Architecture)** and **MTConnect (Manufacturing Technology Connectivity standard)** and developing a converter to align heterogeneous data with this standard vocabulary.
- **Benchmarking**: Enabling enterprises to compare productivity, downtime, and best practices against peer organizations.
- **Model training**: Using integrated datasets to train predictive models that identify operational patterns and management practices.
- **Decision support**: Prototyping digital interfaces that translate analytical insights into actionable guidance for enterprises.
- **Monetizing**: Developing models for data commercialization within a prototype data marketplace.
- **Governance and incentives**: Establishing transparent agreements, roles, and incentive frameworks to enable trusted data collaboration.

Timeline and Activities:

April 20th -24th / 2026 – Hannover Messe

Participants:
Data Providers: 20 Industries

Data Consumers: 8 Industries and Associations

Participants establish clear trust boundaries, documenting data types and formats, conditions of use and consent, safeguards, reciprocity expectations, internal stewardship roles, and conditional participation and exit terms. The Project Team (see Governance section) supports development and execution of MOUs and Data Sharing Agreements, documents governance behaviors and decision pathways, and produces an initial Data Space Brazil Framework V0 capturing baseline requirements, templates, and norms.

May – Sept / 2026 – Brazil Operation

Participants:
Data Providers: 15 (fifteen) Industries

Data Consumers: 8 (eight) Industries and Associations

Governance processes and agreements from Phase 1 will be tested with new companies and new contexts. MOUs are refined, and (if needed) the Project Team initiates publication of Data Space Brazil Framework V1, incorporating feedback for Governance Committee review.

2. PROJECT OVERVIEW AND GOVERNANCE FRAMEWORK

2.1 Objectives and Scope

The demonstrator was designed to achieve three main objectives:

- **Technical validation** of federated industrial data sharing
- **Demonstration of business value** through benchmarking and analytics
- **Ecosystem creation**, enabling post-fair continuity and scaling in Brazil

The scope includes CNC (Computer Numerical Control) machines, MES (Manufacturing Execution Systems), and energy monitoring solutions, connected across multiple companies and countries.

In addition to CNC machining and toolmaking environments, the demonstrator is extended to include mineral processing operations. This expansion incorporates equipment such as screening machines and crushers, as well as pilot-scale rare earth processing plants. The objective is to validate the applicability of federated data sharing in heavy-duty industrial environments, with a focus on equipment availability, failure modes, and operational reliability across geographically distributed assets. It also includes, as a next step, the development of a Digital Product Passport (DPP) based on Data Spaces technologies.

2.2 Sponsorship and Institutional Context

The project is sponsored by:

• **ABINC: Brazilian Internet of Things Association.** A non-profit organization that fosters the IoT ecosystem in Brazil, connecting companies, startups, and government to drive innovation and digital transformation.

• **ABDI: Brazilian Industrial Development Agency.** A government-linked agency that promotes the digital transformation of Brazilian industry, focusing on competitiveness, productivity, and the adoption of new technologies.

• **VDMA: Mechanical Engineering Industry Association**. Based in Germany, it is one of the largest industrial associations in Europe, representing the machinery and equipment manufacturing sector globally.

• **Digital Dialogues:** A project by **GIZ (German Agency for International Cooperation)** that facilitates bilateral cooperation between governments and stakeholders to discuss digital policy, data protection, and emerging technologies.

With institutional support from:

• **ABINFER: Brazilian Tooling Association**. It represents the interests of the tooling industry, promoting technical development and international competitiveness for mold and die makers.

• **CNI: National Confederation of Industry**. The main organization representing Brazilian industry, acting as a powerful advocate for business-friendly policies and industrial growth.

• **APEX: National Confederation of Industry.** The main organization representing Brazilian industry, acting as a powerful advocate for business-friendly policies and industrial growth.

• **SENAI- MG: National Service for Industrial Training** (Minas Gerais). A regional branch of SENAI that provides vocational training, technical education, and industrial innovation services specifically for the industry in the state of Minas Gerais.

This framework aligns industrial policy, innovation strategy and international cooperation.

2.3 Execution Roles

For the development, implementation, and operation of the project, ABINC, in conjunction with ABDI, selected Brazilian companies for the demonstrator project with the following responsibilities.

• **ABINC** – Technical coordination, institutional articulation and dissemination.

• **COTS / CyberlawStudio** – Governance model, legal framework and data-sharing policies

• **UFRGS / NEO Institute (Organizational Engineering Center)** – Responsible for project execution management, KPI definition and monitoring, and academic dissemination

• **I-SENSI** – Development, deployment and operation of the Data Space infrastructure

Other enterprises will be able to take part in the project and will be evaluated during the process with formal confirmation.

2.4. Resourcing and Governance Snapshot

The demonstrator is a partnership established between the Agência Brasileira de Desenvolvimento Industrial (ABDI) and the Associação Brasileira de Internet das Coisas (ABINC). This project has been under development since 2024, culminating in the creation of the current prototype. ABDI and ABINC hold co-ownership of the intellectual assets developed within the scope of this demonstrator project. Additional contributions have been made by partners such as VDMA, Digital Dialogues, industrial companies, partner firms, researchers, associations, and technical partners.

The demonstrator also is aligned with the Open Industry Program and reflects a collaborative initiative between ABDI and ABINC, with its own governance, scope, and intellectual property arrangements.

Future phases will require diversified funding sources, aligned with the value generated for academia, industry, government, and associations, potentially including a data space membership model.

The demonstrator's governance structure consists of a Project Team and a temporary Governance Committee. This committee operates throughout the project in close coordination with participants, with the purpose of refining previously defined policies, ensuring legitimacy, continuous learning, and adaptability to evolving project conditions.

3. PRELIMINARY ASSUMPTIONS & SUCCESS CONDITIONS

3.1 Preliminary Assumptions

The demonstrator is based on the following assumptions:

- Data sovereignty is mandatory for industrial participation
- Federated architecture is preferred to centralized platforms
- Interoperability across heterogeneous systems is essential
- Demonstrators must generate measurable business value
- Trust must be enforced technically, not only contractually

3.2 Success Conditions

The demonstrator is successful if:

- Secure data exchange is operational during Hannover Messe
- Cross-company benchmarking is technically and legally feasible
- No sensitive or raw data is centrally stored
- GDPR and LGPD compliance is demonstrable
- The Data Space remains operational after the fair

4. DEMONSTRATOR PERSONAS

The Demonstrator is designed to provide continuous improvement of digital ecosystem and infrastructure around real needs of industrial sector.

Main actors responsible to support the Demonstrator are:

- **Industrial Data Provider** – factory or machine owner seeking benchmarking without IP exposure
- **Industrial Data Consumer** – OEM or analytics provider seeking aggregated insights
- **Data Space Operator** – entity responsible for trust, interoperability and operations
- **Institutional Stakeholder** – organization fostering innovation and industrial competitiveness

Note: A member company could be a Provider and Consumer ate same time.

Target Audience

The demonstrator is structured around different types of actors who face similar challenges in distinct ways. Across these actors, there is valuable data that remains inaccessible, fragmented, and unclassified, often characterized by limited accessibility and semantic incompatibility. In addition, multiple systems operate without interoperability and lack effective interconnection.

Each user profile entails specific requirements and perceives value differently. These differences shape the design of value propositions, directly influencing scalability and the development of future business models.

A. Industrial Manufacturers / Factory Operators

Who are they?
Manufacturing companies operating CNC machines and production lines, responsible for daily operations, asset utilization, energy consumption, and production reliability. This group includes toolmakers, machine manufacturers, and advanced manufacturing centers.

What are their needs and pain points?

- Practical, actionable insights to improve productivity and asset utilization
- Peer comparison and benchmarking without exposing sensitive operational data
- Clear guarantees that shared data will not be misused, reverse-engineered, or leveraged for competitive disadvantage

- Compliance with internal governance, GDPR (European General Data Protection Regulation) and LGPD (Brazilian General Protection Data Law), as well as corporate data policies

What do they value in the Data Space Demonstrator?

Early decision-support and benchmarking capabilities grounded in real industrial contexts, enabled by policy-governed, authorized, and purpose-limited data sharing, while preserving full data sovereignty.

B. Industrial Researchers / Academic & Applied Research Institutions

Who are they?

Universities, applied research institutes, and industrial research centers focusing on manufacturing systems, productivity analysis, energy efficiency, Industry 4.0, and sustainability.

What are their needs and pain points?

- Access to high-quality, harmonized industrial datasets
- Reduction of effort related to data cleaning, normalization, and metadata reconstruction
- Ability to collaborate across institutions and countries while respecting company confidentiality and intellectual property

What do they value in the Data Space Demonstrator?

Access to semantically aligned, provenance-rich industrial datasets that enable reliable cross-company and cross-site analysis, supporting research, innovation, and evidence-based industrial policies.

C. Data Space Operators, Stewards & Industrial Associations

Who are they?

Entities responsible for operating, governing, or facilitating the Data Space, including industry associations, neutral coordinators, and governance bodies that maintain trusted relationships with industrial participants.

What are their needs and pain points?

- Secure, compliant, and scalable data-sharing mechanisms
- Recognition of their role in orchestrating trust, governance, and ecosystem coordination
- Practical tools that enforce consent, policy compliance, and revocation in operational terms, rather than only at the contractual level

What do they value in the Data Space Demonstrator?

A governance and technical framework that operationalizes data sovereignty, reduces bilateral legal complexity, and strengthens their ability to enable multi-party, cross-border industrial collaboration.

D. Technology Providers / System Integrators

Who are they?

Providers of MES, industrial IoT platforms, energy monitoring solutions, analytics tools, machine connectivity solutions, and system integrators supporting manufacturing environments.

What are their needs and pain points?

- Interoperability across customers, machines, and platforms
- Alignment with international standards and reference architectures
- Reduction of custom, one-off integrations
- Ability to offer value-added services on top of shared, trusted data

What do they value in the Data Space Demonstrator?

A shared, standards-based integration environment with permissioned access and policy enforcement, reducing integration costs while increasing the perceived value of their solutions for industrial end users.

E. OEMs, Equipment Manufacturers & Industrial Supply-Chain Stakeholders

Who are they?

Machine manufacturers, OEMs (Original Equipment Manufacturers), industrial suppliers, and supply chain stakeholders interested in equipment performance, reliability, lifecycle optimization, and sustainability metrics.

What are their needs and pain points?

- Trustworthy and auditable data flows from operational environments
- Aggregated and anonymized insights across multiple customers
- Reduced effort related to compliance, reporting, and performance monitoring

What do they value in the Data Space Demonstrator?

A trusted, consent-governed interoperability layer that enables cross-company insights and benchmarking, supporting product improvement, service innovation, and ESG-related initiatives.

F. Public Sector, Funding Bodies & Institutional Partners

Who are they?

Public agencies, development organizations, innovation programs, and funding bodies supporting industrial competitiveness, digital transformation, and international cooperation.

What are their needs and pain points?

- Demonstrable economic, technological, and sustainability impact
- Replicable and scalable models
- Clear governance, legitimacy, and alignment with industrial policy objectives

What do they value in the Data Space Demonstrator?

A credible and operational prototype that demonstrates how interoperability, governance, data sovereignty, and value creation can support long-term industrial development and public-interest objectives.

5. PARTICIPATING COMPANIES AND ASSETS

The demonstrator integrates heterogeneous industrial environments, as follows:

DATA PROVIDERS – Machinery Industries and Services

AFRY	AFRY is a European engineering and consulting company that provides services in infrastructure, energy, and industrial digitalization. The company supports industries in developing sustainable and data-driven operations through advanced engineering and digital solutions.
I-SENSI	I-SENSI is a Brazilian technology company that develops IoT and AI-based solutions for industrial environments. Its platform enables factory-floor digitalization through smart sensors, data analytics, and predictive insights to improve productivity and operational efficiency.
OXIPIRA	OXIPIRA is a Brazilian provider of thermal cutting technologies for the metal fabrication industry. The company offers plasma and oxy-fuel cutting equipment, technical services, and industrial solutions for metal processing
GROB	GROB is a German global manufacturer of machine tools and automation systems for industrial production. The company develops high-precision machining centers and advanced manufacturing solutions for automotive and industrial sectors.
LIESPE	LIESPE Toolmaker is a Brazilian company specialized in the design and manufacturing of molds, tooling, and industrial devices. The company provides precision engineering and machining solutions primarily for the automotive and auto parts industries.
Global moldes	GLOBAL Molds is a Brazilian tooling company focused on the development and manufacturing of molds for plastic injection processes. The company provides engineering, design, and high-precision manufacturing solutions for industry.
union moldes	UNION MOLDES is a Brazilian manufacturer specialized in molds and tooling for plastic injection applications. The company supports industrial clients with product development, mold engineering, and precision manufacturing.
iNOVA MATRIZES	INOVA STAMPING is a Brazilian company focused on the design and production of dies, molds, and industrial tooling. The company combines engineering expertise with advanced machining technologies to support manufacturing operations.
RANDONCORP	RANDONCORP is a Brazilian industrial group that develops solutions for the mobility and transportation sectors. The company operates globally in the production of commercial vehicle components, logistics systems, and industrial technologies.
CENTRO 4.0	The SENAI FIEMG Center for Industry 4.0 is a Brazilian technology and innovation center focused on industrial digital transformation. It provides research, testing environments, training, and development of Industry 4.0 solutions for industry.

DATA PROVIDERS – Mining Operations

HAVER & BOECKER	HAVER & BOECKER is a global technology provider specializing in mineral processing solutions, including screening, pelletizing, and washing technologies. Within the demonstrator, operational data from vibrating screening equipment will be integrated, including installation in Brazil and in Germany, enabling cross-regional benchmarking of equipment performance and availability.
METEORIC RESOURCES	METEORIC RESOURCES is an Australian company focused on rare earth elements, operating a pilot processing plant in Poços de Caldas, Brazil. The demonstrator incorporates data from this facility, including mineral processing stages, enabling the evaluation of operational stability, process efficiency, and failure patterns in a critical and emerging industrial segment

DATA CONSUMERS

ABDI	ABDI is a federal agency that promotes innovation and digital transformation in Brazilian industry. The organization develops programs and public policies to strengthen industrial competitiveness and technological development.
ABINFER ASSOCIAÇÃO BRASILEIRA DA INDÚSTRIA DE FERRAMENTAIS	ABINFER is the Brazilian Association of Tooling and Special Processes. The organization represents companies in the tooling, molds, dies, and special manufacturing processes sectors, promoting technological development and strengthening the Brazilian tooling industry.
SENAI FIEMG	SENAI Minas Gerais is one of Brazil's leading institutions for industrial education, technology, and innovation, operated by the Federation of Industries of Minas Gerais (FIEMG). It supports industry through professional training, applied research, and technology services, helping companies adopt advanced manufacturing technologies such as automation, artificial intelligence, and IoT.
RANDONCORP	Same RANDONCORP Datra Provider and will act as a data consumer also in the demonstrator, proving that it is useful to manage assets intracompany

6. GOVERNANCE PRINCIPLES AND DESIGN INTENT

Multi-stakeholder industrial initiatives, such as the Brazil–EU Industrial Data Space Demonstrator, involve higher coordination complexity than single-actor projects. They bring together manufacturers, technology providers, research institutions, industry associations, and public-sector stakeholders, each with distinct objectives and constraints.

In this context, success depends on the ability to build trust, align incentives, and sustain collaboration across a diverse set of participants. To mitigate these challenges, the demonstrator adopts a clear and pragmatic governance structure, with empowered leadership capable of acting efficiently while representing the collective interests of the Data Space.

Governance Design Intent

The governance model is designed to support rapid execution during the demonstrator phase while creating the conditions required for continuity and scaling beyond Hannover Messe. Governance structures are intentionally kept simple, transparent, and efficient, ensuring that trust and compliance are established without constraining execution or participation.

Iterative Governance Development

Governance is treated as an iterative process that evolves through practical experience. Each intake of participants and each operational cycle of the demonstrator tests governance assumptions in real industrial settings.

Based on these learnings:

- Participation agreements and MOUs (Memoranda of Understanding) are progressively refined
- Governance artefacts are versioned and reused
- Trust mechanisms evolve from principles into enforceable operational rules
- This approach enables the gradual consolidation of a robust and scalable Trust Framework.

Role of the Demonstrator in Governance

The demonstrator serves as the central reference point for governance and agreement development. It defines the scope, principles, and non-negotiable requirements related to data sovereignty, consent, and compliance.

All participation agreements refer to the demonstrator as a living operational framework. Lessons learned during execution are systematically incorporated into the demonstrator design through a structured versioning and change-control process, ensuring continuous alignment between governance and practice.

Practice–Governance Feedback Loop

The governance approach establishes a tight feedback loop between practice and policy. Agreements remain sufficiently lightweight to encourage participation, while technical enforcement mechanisms ensure that consent, purpose limitation, and revocation are effectively applied in practice.

Over time, governance converges toward a completer and more enforceable framework, without creating barriers to early adoption.

Governance as an Enabler

Within the Industrial Data Space Demonstrator, governance is positioned as an enabler of collaboration and scale, rather than a constraint. By embedding trust, accountability, and data sovereignty into both organizational and technical layers, the governance framework supports sustainable onboarding, long-term operation, and future expansion across industrial sectors and regions.

Governance Structure

Using this approach, the governance of the demonstrator is structured across three layers:

- **Strategic Governance**
  Defines vision, scope, and alignment with policy and long-term objectives. *Participants to be defined.*

- **Operational Governance**
  Manages onboarding, identity verification, and compliance processes. *Participants to be defined.*

- **Technical Governance**
  Defines standards, connector requirements, and interoperability rules. *Participants to be defined.*

7. TECHNICAL INFRASTRUCTURE

The demonstrator follows a **Federated Data Space architecture**, aligned with the IDSA and GAIA-X principles and architecture:

- Industrial assets (machines, MES, energy meters)
- IDS Connectors operated by each participant
- Identity and trust services
- Data asset catalogues
- Analytics and visualization components

Data flows **directly between participants**, with usage policies enforced at connector level.

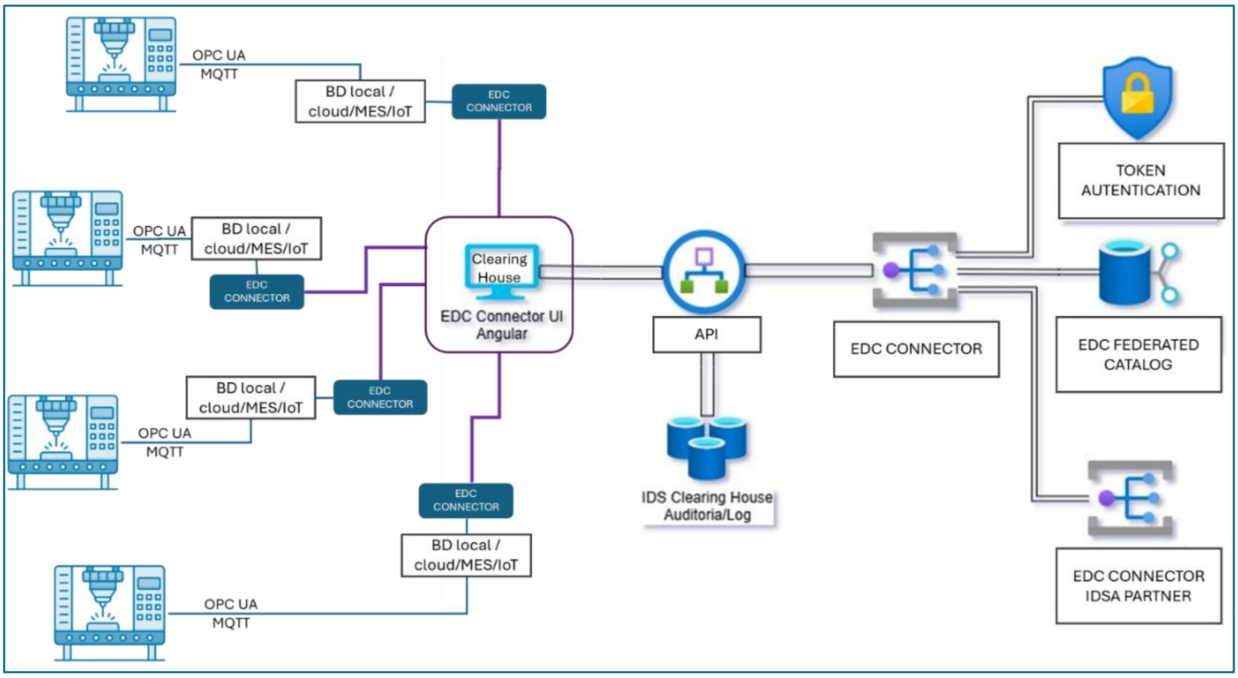

Figure 2 – Federated Industrial Data Space Architecture

8. DATA DOMAINS

In the context of an Industrial Data Space, data domains define coherent and well-bounded categories of information that can be shared among participants under clearly defined governance and usage policies. Rather than exposing raw or highly sensitive production data, data domains group semantically aligned, purpose-oriented indicators that deliver measurable value while preserving data sovereignty and confidentiality.

For the Brazil–EU Industrial Data Space Demonstrator, the selected data domains were deliberately limited to low-risk, high-value industrial indicators. This selection reflects a conscious trade-off between enabling meaningful cross-company benchmarking and analytics and avoiding the disclosure of sensitive information such as production volumes, product specifications, or proprietary process parameters.

The chosen domains are also broadly applicable across different industrial environments, enabling interoperability between heterogeneous machine types, MES (Manufacturing Execution Systems), and diverse organizational contexts.

8.1 Machine State Data

Machine state data captures the basic operational status of industrial equipment, typically classified into three mutually exclusive states:

- **On** – the machine is actively operating or producing
- **Off** – the machine is powered down
- **Idle** – the machine is powered but not producing

These indicators represent the most fundamental level of operational visibility. They are technology-agnostic, easy to collect across different CNC machines, and do not reveal sensitive process or product information.

Relevance in Data Space

Machine state data enables:

- Asset utilization analysis
- Identification of underused or overused equipment
- Cross-company benchmarking of operational availability

Within Data Space, this domain provides a common operational baseline that allows participants to compare performance without exposing proprietary production details.

8.2 Energy Consumption Data

Energy consumption data is captured as kilowatt-hours (kWh) per machine per day, representing a standardized and comparable metric across different industrial environments.

Energy data is increasingly strategic due to:

- Rising energy costs
- Sustainability and ESG requirements
- Carbon footprint reporting obligations

Relevance in Data Space

Sharing energy consumption data enables:

- Benchmarking of energy efficiency across machines and plants
- Identification of best-in-class performance
- Support for ESG reporting and sustainability initiatives

By aggregating data at daily and machine level, the demonstrator avoids exposing sensitive production rhythms while still delivering actionable insights for efficiency and sustainability.

8.3 Downtime Indicators

Downtime indicators capture periods during which equipment is not producing, segmented into:

- Planned downtime (e.g. set-up, scheduled maintenance)
- Unplanned downtime (e.g. failures, breakdowns, unexpected stops)
- This segmentation is critical, as planned and unplanned downtime have very different operational and economic implications.

Relevance in Data Space

- Downtime indicators enable:
- Reliability and maintenance maturity assessment
- Identification of systemic inefficiencies
- Cross-company comparison of operational stability

In a federated Data Space, downtime metrics allow participants to benchmark operational resilience while keeping root process parameters protected.

8.4 Root Causes Derived from MES Systems

Root-cause data, derived from MES systems, categorizes the reasons behind equipment downtime using a standardized taxonomy (e.g. mechanical failure, setup, material shortage).

Rather than sharing detailed event logs, the demonstrator focuses on aggregated and categorized root causes, preserving confidentiality while enabling meaningful analysis.

Relevance in Data Space

This domain supports:

- Identification of recurring operational bottlenecks
- Exchange of best practices across companies
- Evidence-based process improvement initiatives

By standardizing root-cause categories, Data Space enables comparability across different organizations, transforming individual operational experiences into shared industrial knowledge.

8.5 Rationale for Domain Selection

The selected data domains share common characteristics:

- Low sensitivity – no exposure of product, customer, or proprietary process data
- High comparability – applicable across machines, plants, and companies
- High business relevance – directly linked to productivity, reliability, cost, and sustainability
- Technical feasibility – readily available from machines, IoT systems, and MES platforms

Together, these domains form a minimal yet powerful dataset capable of demonstrating the value of Industrial Data Spaces while building trust and confidence among participants.

8.6 Strategic Role of Data Domains in the Demonstrator

Within the demonstrator, data domains serve not only as technical constructions, but also as governance instruments. By clearly defining what data is shared, at what level of aggregation, and for which purposes, data domains help operationalize:

- Data sovereignty
- Purpose limitation
- Consent and revocation
- Compliance with GDPR and LGPD

As the Data Space evolves beyond the demonstrator phase, these domains can be progressively expanded, refined, or complemented with additional indicators, based on trust maturity and participant needs.

8.7 Equipment Availability (Mining Context)

In mineral processing environments, equipment availability is a critical performance indicator, particularly for assets such as vibrating screens, crushers, and classification systems.

Availability is defined as the ratio between actual operating time and total scheduled time, considering both planned and unplanned downtime.

Importance in Data Space

- Enables benchmarking of heavy-duty equipment performance across sites and countries
- Supports maintenance strategy optimization (preventive vs predictive)
- Identifies structural inefficiencies in asset utilization

In the Data Space context, availability data is shared in aggregated form, ensuring that operational competitiveness and process-specific parameters remain protected.

8.8 Failure Modes and Degradation Patterns

Failure mode data captures the classification of equipment failures based on standardized categories, such as mechanical wear, vibration anomalies, misalignment, material overload, and process-related disturbances.

In mineral processing, failure patterns are often influenced by harsh operating conditions, including abrasive materials, high loads, and continuous operation cycles.

Importance in Data Space

- Enables cross-company comparison of failure patterns
- Supports predictive maintenance model development
- Facilitates knowledge sharing on equipment reliability

Instead of sharing raw sensor signals, the demonstrator focuses on categorized and aggregated failure modes, preserving confidentiality while enabling actionable insights.

9. ILLUSTRATIVE DATA SPACE SCENARIOS (USE CASES)

The following use cases illustrate how the Industrial Data Space Demonstrator enables controlled, sovereign, and value-oriented data sharing among participating organizations. Each use case is designed to deliver clear operational and strategic benefits while ensuring compliance with data governance principles, confidentiality requirements, and regulatory frameworks.

Rather than focusing on complex or high-risk data exchanges, the demonstrator prioritizes practical and repeatable scenarios that can be easily understood, implemented, and scaled across the tooling and machining industry.

UC-01 – Equipment Usage Sharing

This use case enables the sharing of aggregated equipment operating hours across participating organizations.

Data shared:

- Operating hours per machine, aggregated on a defined time basis (e.g. hourly or daily)

Purpose and value: The primary objective is enabling benchmarking of asset utilization across different companies and production environments. By comparing operating hours, participants gain insight into:

- Utilization levels of similar equipment
- Capacity absorption and idle potential
- Differences in operational strategies and scheduling practices

Data Space relevance: Operating hours are considered low-risk indicators, as they do not reveal production volumes, product types, or customer information. Within the Data Space, this use case establishes a common performance reference that supports peer learning and continuous improvement.

UC-02 – Downtime Sharing

This use case focuses on the sharing of aggregated downtime metrics, segmented into planned and unplanned downtime.

Data shared:

- Total downtime per machine or per day
- Segmentation into planned vs. unplanned downtime

Purpose and value: Downtime analysis provides insights into:

- Equipment reliability and maintenance effectiveness
- Operational stability and planning maturity
- Differences between reactive and preventive maintenance approaches

Data Space relevance: By sharing downtime data at an aggregated level, participants can assess operational maturity without exposing sensitive internal processes. This use case supports cross-company learning and helps identify structural improvement opportunities.

UC-03 – Downtime Reasons

This use case extends downtime analysis by enabling the sharing of standardized root-cause categories derived from MES systems.

Data shared:

- Aggregated downtime reasons using a common taxonomy (e.g. mechanical failure, setup, material shortage)

Purpose and value: Standardized downtime reasons allow participants to:

- Identify recurring operational bottlenecks
- Compare failure patterns across plants and equipment types
- Exchange best practices for mitigation and prevention

Data Space relevance: The use of a shared taxonomy is critical to interoperability. Rather than exchanging raw event data, the Data Space enables semantic alignment, transforming individual operational experiences into collective industrial knowledge while preserving confidentiality.

UC-04 – Energy Consumption Sharing

This use case addresses the sharing of energy consumption indicators at machine level.

Data shared:

- Energy consumption (kWh per machine per day)

Purpose and value: Energy data supports:

- Energy efficiency benchmarking
- ESG and sustainability reporting
- Identification of best-performing machines and operating patterns
- Carbon footprint estimation and comparison

Data Space relevance: Energy consumption is increasingly recognized as a strategic industrial indicator. Within Data Space, this use case demonstrates how sustainability objectives can be supported through trusted, governed data sharing without compromising competitive positioning.

UC-05 – AI model Training for Failure Prediction

Training of Small Language Models (SML) using machinery data

Data shared:

- Integration of operational and historical performance datasets

Purpose and value:

- Support for data-driven decision-making
- Enhancement of failure prediction accuracy
- Continuous model improvement through shared industrial data
- Strengthening of predictive maintenance capabilities
- Real raw data in real operations segmented by industry type and size

Data Space relevance: AI models gain accuracy via collaborative dataset training and segmented data can support SML´s edge application providing cost reduction in cloud processing.

UC-05 – Anonymized Benchmarking

This use case combines the previous scenarios into a fully anonymized benchmarking framework.

Data shared:

- Aggregated and anonymized performance indicators
- Statistical distributions (average, top performers, best-in-class)

Purpose and value: Participants gain access to:

- Best-in-class performance benchmarks
- Performance distributions across the cohort
- Relative positioning without exposing individual company identities

Data Space relevance: Anonymized benchmarking is a cornerstone of trust in multi-party data sharing. It enables collective performance improvement while fully respecting data sovereignty, confidentiality, and competitive boundaries.

UC-06 – Equipment Availability Benchmarking (Mining)

This use case enables the sharing of aggregated equipment availability metrics across mineral processing operations.

Data shared:

- Availability percentage per equipment (daily or weekly aggregation)
- Segmented availability (planned vs unplanned losses)

Purpose and value:

- Benchmark operational performance of screening and crushing equipment
- Identify best-performing operational practices
- Support maintenance and reliability improvements

Data Space relevance: Availability is a non-sensitive, high-value indicator that enables meaningful comparison across companies and geographies without exposing proprietary process data.

UC-07 – Failure Mode Sharing and Pattern Analysis (Mining)

This use case focuses on sharing standardized failure mode categories derived from equipment monitoring and maintenance systems.

Data shared:

- Aggregated failure mode occurrences (e.g., vibration failure, mechanical wear, overload)
- Frequency distribution over time

Purpose and value:

- Identify recurring failure patterns across similar equipment
- Improve predictive maintenance models
- Enable cross-industry learning in reliability engineering

Data Space relevance: Standardized failure modes allow interoperability between different equipment types and manufacturers, transforming isolated operational data into shared industrial intelligence.

Cross-Cutting Governance Considerations

Across all use cases:

- Data is shared only for clearly defined purposes
- Access is governed by data contracts and usage policies
- Participants retain full control over their data, including consent and revocation
- Aggregation and anonymization mechanisms are applied where appropriate

These use cases collectively demonstrate how an Industrial Data Space can move beyond theoretical concepts and deliver tangible operational, sustainability, and strategic value through responsible data sharing.

10. TRACTION & ADOPTION

The adoption strategy for the Industrial Data Space Demonstrator follows a phased and evidence-driven approach, designed to build trust, validate technical and governance assumptions, and progressively scale participation. Rather than pursuing rapid expansion from the outset, the demonstrator prioritizes controlled growth, ensuring that each phase delivers validated outcomes that support the next stage of adoption.

10.1 Phase 1 – Hannover Messe Demonstrator

The first phase centers on a live demonstrator presented at Hannover Messe, involving a limited and carefully selected group of industrial participants from Brazil and Germany companies.

Scope and characteristics:

- Participation of a small number of industrial companies and technology providers
- Real-time data exchange between machines, systems, and Data Space components
- Live dashboards illustrating selected use cases

Objectives: The primary objectives of Phase 1 are:

- Validate the technical interoperability of Data Space architecture
- Test IDS-based data contracts and access policies in a real industrial setting
- Assess the governance framework, including consent management and data usage control
- Demonstrate tangible value to industrial, institutional, and policy stakeholders

Adoption relevance: By operating as a live demonstrator, Phase 1 lowers adoption barriers, builds confidence among participants, and provides concrete evidence that Data Spaces can function reliably in an industrial context.

10.2 Phase 2 – Expansion and Operation in Brazil

The second phase focuses on the post-fair expansion and sustained operation of the Data Space in Brazil.

Scope and characteristics:

- Expansion to approximately ten industrial companies
- Focus on CNC machining and toolmaking as a coherent industrial domain
- Integration of additional machines, MES systems, and data providers
- Transition from demonstrator to operational Data Space

Objectives: Phase 2 aims to:

- Validate scalability across multiple companies and sites
- Strengthening network effects through increased participation
- Support long-term use cases such as benchmarking, energy efficiency, and operational maturity assessment
- Establish the Data Space as a persistent collaboration infrastructure, not a one-off pilot

Adoption relevance: This phase transforms the demonstrator into a living industrial ecosystem, enabling continuous value creation and reinforcing trust through repeated, governed data exchanges.

10.3 Adoption Drivers and Enablers

Adoption across both phases of the demonstrator is driven by a combination of technical, organizational, and governance-related enablers. A key factor is the deliberate selection of clearly defined data domains that are immediately relevant to industrial operations, allowing participants to perceive tangible value from the outset. By focusing on aggregated and standardized indicators, the demonstrator lowers entry barriers and mitigates concerns related to data sensitivity and competitive exposure.

Equally important is the use of low-risk data sharing models based on aggregation, anonymization, and purpose limitation. These mechanisms ensure that data is shared only within clearly defined usage contexts, reinforcing trust among participants and enabling collaboration without compromising confidentiality. Transparent governance structures, supported by data contracts and enforceable access policies, further strengthen confidence by clarifying rights, obligations, and control mechanisms.

Together, these drivers create an environment in which technical interoperability, governance maturity, and stakeholder confidence evolve in parallel. This alignment is essential for sustained adoption, as it ensures that participation in the Data Space is perceived not as an experimental burden, but as a reliable and value-generating component of industrial collaboration.

10.4 Pathway to Scale

The two-phase adoption model establishes a clear pathway from:

Demonstration → Validation → Operation → Scale

Lessons learned during each phase feed back into the Data Space design, governance framework, and onboarding processes, ensuring that expansion is replicable, controlled, and aligned with industrial realities.

11. KPIS & IMPACT

The Industrial Data Space Demonstrator defines a structured set of Key Performance Indicators (KPIs) to evaluate both the technical performance of the Data Space and its broader operational, organizational, and strategic impact. These KPIs are designed not only to measure system functionality, but also to assess how data sharing contributes to industrial value creation, trust building, and long-term adoption.

The KPI framework reflects the dual nature of the initiative: as a technical demonstrator and as a collaborative industrial ecosystem.

11.1 Technical KPIs

Technical KPIs assess the robustness, reliability, and interoperability of the Data Space infrastructure.

Key indicators include:

- Number of successfully onboarded participants and connectors
- Availability and uptime of Data Space services
- Data exchange success rate between providers and consumers
- Latency and performance of data access and retrieval
- Compliance with IDS-based data usage policies

These indicators validate whether the Data Space can operate reliably in real industrial conditions and support scaling beyond the demonstrator phase.

11.2 Data Quality and Interoperability KPIs

Data quality and semantic alignment are critical for meaningful cross-company analytics.

Relevant KPIs include:

- Percentage of data sets compliant with defined schemas and taxonomies
- Completeness and consistency of shared indicators
- Reduction in manual data cleansing and harmonization efforts
- Reusability of data across multiple use cases

These KPIs measure the effectiveness of standardization efforts and the ability of the Data Space to transform heterogeneous industrial data into interoperable assets.

11.3 Operational and Business Impact KPIs

Operational KPIs focus on the tangible benefits generated for participating companies.

Examples include:

- Improvements in equipment utilization rates
- Reduction in unplanned downtime
- Identification of best-in-class operational benchmarks
- Improvements in energy efficiency at machine or plant level

While the demonstrator does not aim to optimize individual operations directly, these KPIs capture the decision-support value enabled by shared insights and benchmarking.

11.4 Mining-Specific Operational KPIs

For mineral processing environments, additional KPIs are introduced to capture the specific operational characteristics of heavy industrial assets.

Examples include:

- Equipment availability rate (screens, crushers)
- Mean Time Between Failures (MTBF)
- Mean Time To Repair (MTTR)
- Failure mode frequency distribution
- Throughput stability in processing plants

These KPIs complement existing indicators by incorporating reliability engineering metrics, enabling the Data Space to support asset-intensive industries beyond discrete manufacturing.

11.4 Sustainability and ESG Impact KPIs

Energy-related indicators play a central role in assessing sustainability impact.

Relevant KPIs include:

- Energy consumption per machine or per operating hour
- Comparative energy efficiency across participants
- Estimated reductions in energy intensity over time
- Readiness for carbon footprint reporting and ESG compliance

These indicators demonstrate how Industrial Data Spaces can support sustainability objectives through trusted, auditable, and governed data sharing.

11.5 Governance and Trust KPIs

Governance KPIs evaluate whether the Data Space effectively supports data sovereignty and trust.

Key indicators include:

- Number of active data-sharing agreements and contracts
- Frequency of consent updates and revocations
- Compliance with defined usage purposes
- Participant satisfaction with governance clarity and control mechanisms

These KPIs provide insight into the maturity and effectiveness of the governance framework as Data Space evolves.

11.6 Ecosystem and Adoption KPIs

At ecosystem level, KPIs measure growth and engagement.

Examples include:

- Number of active data providers and consumers
- Frequency of data access and reuse
- Expansion of use cases beyond the initial demonstrator scope
- Transition from pilot usage to recurring operational use

These indicators reflect the emergence of network effects and the long-term viability of Data Space.

11.7 Impact Assessment

Taken together, the KPI framework enables a holistic assessment of impact across four dimensions:

- Technical feasibility
- Operational value
- Sustainability contribution
- Governance and trust maturity

By systematically measuring these dimensions, the demonstrator moves beyond qualitative narratives and provides evidence-based insights into how Industrial Data Spaces can deliver measurable value at scale.

12. CONCLUSIONS

The Brazil–EU Federated Industrial Data Space Demonstrator represents a concrete step from conceptual discussions on data spaces toward operational, cross-border implementation in real industrial environments. By focusing on low-risk, high-value industrial indicators and embedding governance, interoperability, and trust mechanisms by design, the demonstrator shows how federated data sharing can be realized in practice without compromising data sovereignty or competitive positioning.

The evaluation of mineral processing use cases further demonstrates the versatility of Industrial Data Spaces across different industrial sectors. By extending the demonstrator to heavy-duty environments such as mining and rare earth processing, the initiative validates that federated data sharing can support not only discrete manufacturing but also continuous and process industries, where equipment reliability and availability are critical drivers of value.

The demonstrator confirms that industrial data spaces are not abstract infrastructures, but operational instruments capable of reducing friction in data exchange, improving transparency, and enabling collaboration across organizational and national boundaries. The use of standardized indicators, shared semantics, and policy-based access control demonstrates that meaningful industrial insights can be generated while maintaining strict control over data usage and purpose limitation.

From a governance perspective, the project highlights the importance of lightweight, iterative structures during early phases. Rather than defining a complete and rigid framework upfront, the demonstrator adopts a progressive approach in which governance mechanisms, data contracts, and trust policies evolve through real-world use. This approach strengthens institutional trust, reduces onboarding barriers, and produces reusable governance components for future cohorts.

From a technical perspective, the demonstrator confirms the feasibility of integrating heterogeneous industrial systems, including CNC machines, MES platforms, and energy monitoring solutions, into a federated data space architecture aligned with International Data Spaces Association and Gaia-X principles. The results reinforce that interoperability is not achieved solely through technology, but through the combined alignment of data models, semantics, identity, and governance.

Beyond its technical outcomes, the demonstrator has strategic relevance. It illustrates how industrial data spaces can act as an enabling layer for international industrial cooperation, particularly in the context of evolving trade relations between Brazil and the European Union. As regulatory requirements related to sustainability, traceability, and product information increase, data spaces provide a scalable mechanism to operationalize compliance, transparency, and trust across value chains.

The next phase of the initiative, focused on expansion within Brazil and the onboarding of additional industrial participants, will further test scalability, economic sustainability, and long-term governance models. In this sense, the demonstrator should be understood not as a final solution, but as a foundational building block toward a persistent industrial data space ecosystem connecting Brazilian and European manufacturing sectors.

Ultimately, this work provides practical evidence that federated industrial data spaces are viable, valuable, and necessary instruments for the digital transformation of industry. By combining technical interoperability, governance by design, and real industrial use cases, the demonstrator offers a reference model that can be replicated and extended across sectors, regions, and future international collaborations.

13. REFERENCES

- GLCDI – Data Space Prototype Blueprint
- International Data Spaces Association – Reference Architecture
- Gaia-X Architecture and Policy Rules
- SIMPL Open Source Data Space Infrastructure
- European Data Spaces
- DSSC - Data Spaces Support Centre
- EDC - Eclipse Dataspace Components
- Manufacturing X- Interoperable Data Sharing Reference Architecture