EuPro Gigant

FEDERATING A MANUFACTURING DATA SPACE. ASPECTS OF BUSINESS MODELLING AND GOVERNANCE

WHITE PAPER 2024

EuPro Gigant

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Revision:	Version 1.0
Project Title:	EuProGigant – Europäisches Produktionsgiganet zur kalamitätsmindernden Selbstorchestrierung von Wertschöpfungs- und Lernökosystemen
Project Acronym:	EuProGigant
Grant Agreement number:	DLR ID: 01MJ21008A - FFG ID: 883413

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

Gefördert durch: Bundesministerium für Wirtschaft und Klimaschutz aufgrund eines Beschlusses des Deutschen Bundestages

FFG Forschung wirkt.

DLR Projektträger

STATEMENT OF ORIGINALITY

This publication contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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The authors would like to thank all project partners and interviewees who gave us important suggestions and practical information during the preparation of this white paper.

Special thanks go to:

Stefan DUMSS (TU Wien), who always guided and accompanied us through the “cliffs of technical architecture”

All project partners from TU Wien and TU Darmstadt, especially Univ.Prof. Dipl.-Ing. Dr. techn. habil. Friedrich BLEICHER and Prof. Dr. Matthias WEIGOLD

All colleagues from EIT Manufacturing Central and East

Dr. Gerald RISTOW (Software AG), Kai MEINKE (Delta DAO AG) and all members of the EuProGigant consortium

Roland FADRANY and the colleagues from Gaia-X AISBL

Maurice PROSOTOWITZ and the German Gaia-X Hub Team at acatech

Thank you for the very constructive and efficient cooperation!

EXECUTIVE OVERVIEW

Gaia-X creates the foundation for a sovereign, federated, open data infrastructure based on European values. This document proposes business and governance models respecting those values and enabling data sharing collaboration between manufacturing domain stakeholders, thus, contributing to build up federated data sharing services in a Manufacturing Data Ecosystem using the Gaia-X framework and aligning with the European Manufacturing Data Space initiatives (Gaia-X AISBL 2020). This white paper is referring to the European Production Giganet („EuProGigant"), which aims to create a smart, resilient, and sustainable manufacturing industry in Europe (Dumss et al. 2021). By March 2025, a digitally connected production network will be established based on the European data infrastructure Gaia-X, referred to as the „production internet of the future." This network aims to build a reliable and compliant data service system, enabling the necessary scale for manufacturing stakeholders to succeed in Europe. In this ecosystem, companies will be able to exchange data securely and confidently and develop the technical and semantic interoperability needed to fully utilise manufacturing data. While Gaia-X focuses on setting standards and technical frameworks, the business modeling component of the EuProGigant project will address the governance challenges associated with this goal.

A Manufacturing Data Ecosystem[1] can be composed of a rich set of shared capabilities and value-adding services, enabling data value chains between data holders and data users, across the broad and complicated manufacturing domain. It allows creating a number of federated benefits for stakeholders in manufacturing ecosystems, where data is granularly and selectively accessible in line with Europe's privacy and security provisions and other applicable laws and regulations on regional, national and European level. Business models for federated data sharing services should contribute to the core processes in manufacturing (primary use of data) as well as to secondary use of data in ecosystems that include a variety of different stakeholders.

Within this white paper, we summarise the results of our stakeholder analysis tasks and how the diverse stakeholders in manufacturing ecosystems would contribute to and benefit from trusted data sharing. The document furthermore illustrates how a so-called multi-sided business modell can be set up to respond to the diverse range of stakeholders' interests. It invites also for collaboration with the manufacturing data sharing initiatives by illustrating the individual steps in the defined data sharing processes. Moreover, it is aiming for deploying several concrete and valuable use cases and its related business models that may be enabled in the frame of the federated services.

This white paper sets a baseline for further discussion: with the Gaia-X technical community to validate the standard and architecture propos-

1 Note: we use "data space" in the singular form throughout this document, not assuming there will be one single, monolithic "space" but a large collection of new as well as existing data sharing and data collection initiatives. We anticipated there will be multiple data spaces, all connected in a federated approach. We use "ecosystem" for the large and rich set of stakeholders in the manufactuiring domain. This ecosystem will use multiple data spaces to manage and share manufactuirng-related data between stakeholders.

als, with the manufactuirng domain stakeholders to adopt the learning from existing data initiatives, with additional use case owners, with contributors of requirement specifications and solution components, and with funding partners to support the implementation of these ambitious plans.

HOW A DATA SPACE FACILITATES PARTNERSHIPS IN MANUFACTURING ECOSYSTEMS (DR. CHRISTIAN BÖLLING)

The increase in cross-company production and usage scenarios makes data sharing a key element in terms of productivity, quality assurance and ultimately the competitiveness on the global market. The possibilities of analysing ever larger volumes of data based on artificial intelligence offer enormous potential for the European economy.

Data spaces create trust and reduce reservations

There are reservations within companies who fear that data analysis could lead to a transfer of know-how to competitors. This effect is exacerbated by the fact that the traditional strength of the manufacturing sector in Europe is based on enormous knowledge in the fields of mechanical and electrical engineering as well as mechatronics. The area of information technology, however, is a fairly new element and expertise is still being developed. Conversely, this means that either trust is required between the actors involved and that the provision of data must be secured by technical precautions.

Transferring "traditional" collaboration to the digital space

A data space creates the conditions for both and thus makes it possible to overcome reservations and drive forward the data economy through trusted partnerships. It forms the technical basis for a manufacturing ecosystem that consists of trusted players and ensures that data can only be processed and used in accordance with the owner's specifications. It also simplifies cross-company collaboration through the use of (de-facto) standards such as Gaia-X. The established "traditional" collaboration of many companies can thus be transferred to the digital space.

European manufacturing ecosystems secure global competitiveness

The use of data to improve production processes and increase the understanding of the entire product lifecycle is highly relevant in the transformation process towards environmental and social sustainability. However, competitiveness must be ensured at all times. Cross-company collaboration through the use of data spaces is the enabler here. The efficient use of data improves the competitive situation of individual companies and ensures that manufacturing ecosystems in Europe remain intact. Dependencies are thus minimised.

INCENTIVES AND ECONOMICS FOR DATA SHARING IN THE MANUFACTURING INDUSTRY (ING. MAG. JOHANNES HUNSCHOFSKY)

Sharing data between actors along the entire value chain is critical for manufacturing companies to drive innovation, enhance efficiency, and maintain competitive advantage. The success of various data sharing initiatives hinges on the availability and exchange of high-quality data. Incentives and economic considerations therefore play a pivotal role in encouraging data exchange across companies and national borders.

Economic benefits of data sharing

Data sharing between manufacturing companies can lead to significant economic advantages, such as enhanced sustainability through decreased resource consumption and the reduction of scrap parts, directly impacting cost effectiveness. Shared production data fosters better interaction between processes and actors along the manufacturing value chain and accelerates innovation by providing a richer dataset for developing new products and services. Collaborative data environments enable manufacturers to innovate more quickly and effectively, leveraging insights that would be impossible to obtain in isolation. This can lead to the creation of new business models and revenue streams, as companies can offer data-driven services and solutions.

Incentives for data sharing

Despite obvious benefits, companies often hesitate to share their production data due to concerns about data security and sovereignty, the associated costs as well as a lack of expertise on the implementation and execution side.

Various kinds of incentives are suited to promote data sharing among manufacturers. Examples include subsidies from government bodies aimed at accelerating industry-wide data initiatives or the establishment of federated data marketplaces where companies can monetise their data, selling it to other industry players who can derive value from it. Trust-building measures, such as standardised data sharing protocols, independent and certified data brokers, and robust cybersecurity frameworks, can alleviate concerns about data misuse and breaches.

Challenges and considerations

To realise the full potential of data sharing, several challenges, such as data interoperability, need to be addressed. While disparate data formats and systems make integration difficult, industry-wide standards for data formats and communication protocols will facilitate smoother data exchange.

Robust cybersecurity measures and clear guidelines on data ownership and usage rights are essential to protect sensitive information. Additionally, legal frameworks to govern data sharing practices, ensuring compliance with regulations and protecting intellectual property are needed.

The economics of data sharing must address disparities between large and small manufacturers. Large companies can invest in data infrastructure and analytics, but smaller ones may struggle. Thus, cooperative models and support mechanisms are needed to ensure all industry players benefit.

Conclusion

New technologies and the exchange and use smart data revolutionise the way manufacturers operate. Overcoming financial, technical, and cultural barriers to data sharing, and offering incentives, can boost efficiency, innovation, and economic opportunities. This requires industry, government, and tech providers to create a collaborative, secure data-sharing ecosystem.

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Today, there is a common understanding that data is of high value. Leveraging this value, trading, and sharing data may create huge revenues for the stakeholders involved. However, nowadays the creators of data are benefitting rarely from this value in an adequate way. Often, only the cost for data creation and management remains with them. Furthermore, many give their data away for free or pay with it for the use of a service. And in many cases, others keep it for themselves without taking advantage of the value.

In many industries, digitalisation impacts and changes the traditional business models of companies in some cases dramatically. Digitalisation and the associated ICT solutions bring numerous advantages and opportunities, especially for small and medium-sized enterprises (SME). The basis here is the usability of data. By analysing the data relevant to the business or industry, internal processes can be made significantly more efficient. This primarily affects the efficiency and effectiveness of value creation in the core business. However, through the intelligent use of digitalisation technologies and data analysis, new business models and services can be created to position the company more broadly and thus make it more competitive and resilient. In addition to product and service innovations, process innovations are also possible by networking processes with the help of software or automation technologies or artificial intelligence, thereby increasing added value. And not just within the company: in a completely new form of cross-industry cooperation with partners and other service providers, additional value can be generated by actively integrating them into the digital process and sharing relevant data all along the value and supply chains. This means that Industry 4.0 not only increases efficiency and productivity, but also enables additional added value through new products, services, and business models. One of the greatest potentials, which advancing digitalisation impacts, lies in the area of business model innovations: existing business models are coming under pressure and new models are being developed and established (Förster et al. 2021). In the manufacturing industry, there is a trend of evolving from being a product provider to being a solution provider. Thus, new business models based on availability can emerge through intelligent products and services, open-source concepts, or personalised products (Kaufmann 2015).

Nevertheless, extensive digital networking, increasingly blurring industry boundaries and the development of linear value chains towards dynamic value networks increase the level of complexity that companies are confronted with (Breitfuss et al. 2019). New business models are largely cross-company and cross-industry, making the interoperability of systems and applications a key factor in getting the best possible benefit from Industry 4.0. Consensus-based international standardisation plays a crucial role in connecting existing systems from different manufacturers in an uncomplicated, reliable, and efficient manner and in integrating new technologies. The use of standards is also a good tool for minimising risks when developing and introducing new business models, because they create a basis of trust between users and man-

ufacturers, make investment decisions easier and ensure market compatibility through cross-system consistency of technologies and processes. Therefore, another major challenge for manufacturing companies is maintaining an overview of the relevant norms and standards, which is not made easier by the increasing interconnection of industries and domains.

This current complexity to deploy a data management solution across European borders limits the ability to aggregate manufacturing data for science and research. Without a more open market for manufacturing data in Europe, innovative companies are forced to focus on China and the USA as their lead markets, because that is the only way to achieve scale. And without a more seamless access to manufacturing data, both academic and commercial R&D are forced to turn to other geographies to accumulate data for innovation and validation, and they will be hesitant to deploy solutions to smaller countries.

In summary, in today's digitalised world, large amounts of data are generated, but we cannot fully exploit its value. Data sharing could foster innovative data-driven applications, help meet regulatory requirements, and create financial value. However, organisations are reluctant to share their data with each other because they fear losing control over who can access it and what it is used for. In order for data to be routinely exchanged between organisations, a collaborative environment, a so-called data space, is required in which participants can securely exchange and use data and related services and

Figure 1: Challenges for data sharing in manufacturing ecosystems, Source: Own figure.

in which established technical and legal standards ensure interoperability, sovereignity and trust.

Consequently, to overcome these challenges, European manufacturing systems should ensure that all relevant stakeholders have access to essential, high-quality, affordable services, in line with Europe's Sustainable Development Goals (European Commission 2020c). The simple, performant, secure and affordable exchange of information is an essential enabler for those goals. The current highly fragmented and heterogeneous EU market limits the ability to roll out digital manufacturing innovation at any sufficient scale. Numerous ambitious for data driven initiatives exist across Member States, however, few to none of these have ever achieved scale with economic and ecological impact. EU privacy legislation (GDPR) is world-leading, nevertheless, stakeholders in the manufacturing domain struggle with interpretation and with local legislative variations.

The Gaia-X initiative cannot resolve these challenges on its own, but it can advocate these with policy makers. Gaia-X develops a standard-based, technical framework to implement distributed data systems in all European countries in a legally secure manner, enabling compliance with GDPR and other data regulations. The aim of the Gaia-X initiative is to bridge the gap between high-level concepts and framework-specific technical documentation and to provide an overview of the current technical landscape of data space components. A data space is a decentralised, open infrastructure for sovereign data exchange, whose participants are aware of and control the data they produce and consume as well as the services (hardware and software) involved. There are various initiatives developing data space software, but there was a lack of guidance on the capabilities, status and usability of these available tools and on how to implement data rooms for specific purposes.

Already more than 15 years ago, the concept of data rooms emerged in computer science, which envisaged a shift from central databases to storing data at the source (Franklin et al. 2005). The research at Fraunhofer ISST continued this idea and ultimately resulted in the founding of the International Data Spaces Association and the development of an initial concept and standard for data spaces in 2015 (International Data Spaces e. V.). Their reference architecture, the International Data Spaces Reference Architecture Model (IDS RAM), describes the necessary components and their requirements in detail (International Data Spaces e. V.). These initiatives still have various technical and non-technical challenges to overcome. Although the software for data exchange already exists, the processes and technical solutions that enable interoperability, ensure legal compliance, and strengthen trust in the ecosystem are still under development and must be streamlined. The business and management models for the operation and use of such data spaces are also still being developed; first federator concepts have already established their legal entities . Key to all areas is collaboration, achieved through communities and initiatives that include organisations in government, academia, and the private sector. Many of the data spaces currently being developed aim to provide a federated, open infrastructure for sovereign data exchange based on common standards and rules.

Gaia-X goes one step further than the data space concept by considering generic data-related services such as storage, interconnection, compute capabilities, and web servers to enable interoperability between different cloud providers and IT infrastructures. Gaia-X is an initiative that develops, based on European values, a digital governance that can be applied to any existing cloud/edge technology stack to obtain transparency, controllability, portability and interoperability across data and services, aiming at sovereign data exchange (Gaia-X AISBL 2020).

Gaia-X provides concepts that include the data storage and cloud-related elements, which can complement the EuProGigant architecture. The conceptual mapping results in the following high-level relationship: The „Federation Service of Sovereign Data Exchange" stems on usage control and the so-called Gaia-X Clearing House; the "Federated Catalogue" comprises the IDS or other brokers, vocabulary providers and information models, the "Gaia-X Federation Service of Identity & Trust" benefits from identity providers, and the "Gaia-X Nodes" are aligned with so called "Connectors" as gateways (Sprenger 2024).

Within the framework of the Austrian-German lighthouse project for Gaia-X called "EuProGigant", a common data infrastructure is being designed and implemented according to the principles of Gaia-X for the value generating ecosystem in the manufacturing industry. The aim of the project is to demonstrate and scale a multi-site, digitally connected ecosystem of manufacturing companies and other relevant stakeholders, contributing to a resilient, data-driven, and sustainable value chain to strengthen European industrial leadership (Weber et al. 2022). Value creation for the EuProGigant consortium occurs at the producing machine or plant. Functions for enabling the production process to react to unexpected and unknown interfering factors and to keep the process stable (resilience) or to increase the speed of the value creation process are to be understood as quality features in the production environment. This requires the processing of large amounts of data from machine controls and sensors as well as a fast reaction to the information obtained; in other words, almost latency-free feedback to controls in response to local or also higher-level warning and diagnostic messages (so-called events) (Dumss et al. 2021). Therefore, the focus of the project is connecting various machines and systems, independent of manufacturers and software or firmware versions of the control components. In addition to the requirements for a common data infrastructure with regard to IT security, safety, reliability, interface configuration for interoperability and a functioning update management, it is worth mentioning the requirements for integrated digital functions (services) of heterogeneous origin, which in the Gaia-X architecture are obtained from the data ecosystem via the federation services. The utilisation of data from production processes opens up tremendous potential for implementing industrial use cases.

For the project consortium, it is crucial for the development and research on the target systems and the use cases to clarify terminology, describe general approaches and thus achieve a broad impact of the solution. Ultimately, the consortium aims to build an infrastructure and data ecosystem in which all entities of production, such as machines, plants, measuring equipment, conveyor systems, warehouses, building infrastructure, etc., are interconnected. In this way, the need for vendor independent data ecosystems and marketplaces, open to all at low cost and with low entry barriers is addressed by the EuProGigant project. The EuProGigant project specifies an architecture, interfaces and sample code for an open, secure data ecosystem of trusted partners, which shall result in added value. The technical architecture of Gaia-X is used for cross-company and cross-location networking. Thus, the EuProGigant Data Ecosystem is the place where Data Provider and Data Con-

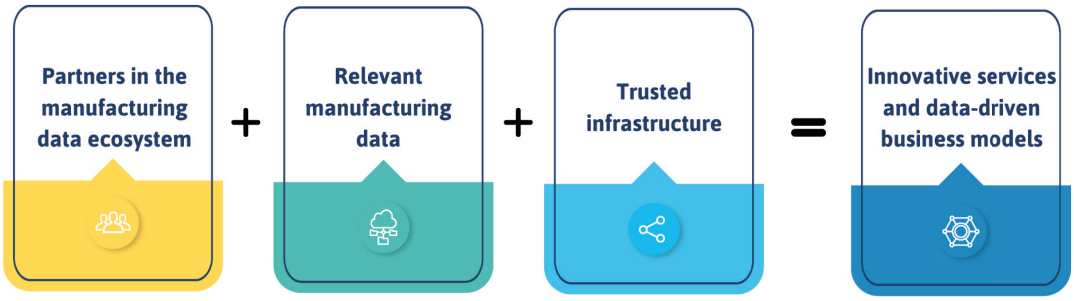


Figure 2:Elements of successful data sharing culture, Source: Own figure

sumer are conceptually located. The specification of data exchange orchestration forms the basis for a data marketplace based on European values, i.e. data privacy and security, equal opportunities through a federated design, and ensuring data sovereignty for the creator of the data and trust among participants.

This white paper focuses on the business models and business architecture for a so-called Federator, orchestrating data exchange and complying to Gaia-X requirements and related regulations. It shall illustrate the business potential of digital ecosystems from very different, yet complementary and not contradicting perspectives: the perspective of different players and partners in the manufacturing community, the perspective of how to share data relevant for sustainable and resilient manufacturing and the perspective of a trusted infrastructure and architectural frame for trusted and sovereign data exchange. The integrated view on those different perspectives will make a manufacturing data ecosystem successful, with innovative technologies enabling new business opportunities, leading to value creation in the hand of each actor and to value flow orchestrated by a federator.

Our starting point was to describe and analyse the important stakeholders (such as stakeholders from industry, NGOs, academia, governments, etc.) in the value-generation chain. Through analysing the stakeholders and their expectations towards data providers and data consumers, a process of performing and offering federated services referring to data exchange can be described, and the value-generation chains can be documented. For this purpose, desk research was conducted, and its result was enriched with interviews conducted with a representative sample of manufacturing stakeholders.

As analysis result, individual flows like money flow, information flow and product flow from data provider to a data sharing federator and from a data sharing federator to data consumers can be presented, including how the different stakeholder groups may interact. A summary of those interactions allows drawing applicable value-chains for data exchange and data sharing. And based on those value chains we were able to derive and describe business and service delivery models for the EuProGigant Federator, serving the manufacturing ecosystem. The conception of the service delivery models is based on the applying use cases within the EuProGigant project. Consequently, the selected use cases are also described and insights into their enabled business models are provided. By implementing those business concepts, a common, federated European Manufacturing Data Ecosystem will foster better exchange and provide access to different types of manufacturing data.

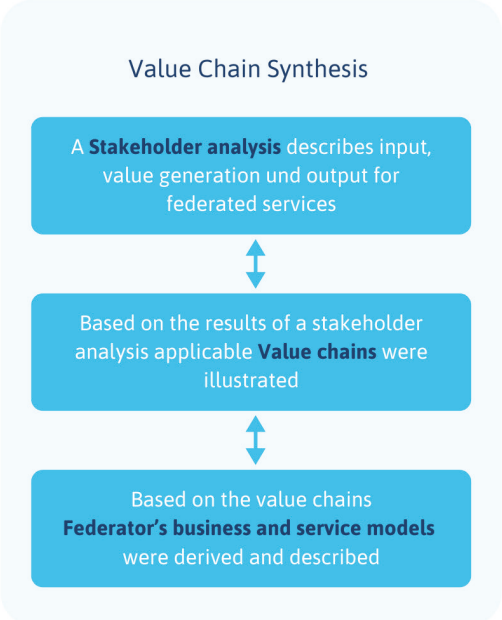


Figure 3: Elements of business model development, Source: Own figure

2.MISSION AND GOALS OF THE GAIA-X COMPLIANT MANUFACTURING DATA ECOSYSTEM

EuProGigant was launched and motivated by the conviction that we can push forward the development of a sustainable and innovative data economy in the manufacturing sector in Europe. This manufacturing ecosystem will foster innovation and proliferate new data-driven services and applications. Encouraged by widespread support, the development of a sustainable business model for the orchestration and federation of data sharing services based on trust and sovereignty remains the declared goal. Thereby, it is not geographically restricted but refers more to European values. To this end, Gaia-X compliance will enable interoperability and portability of infrastructure, data and services and establish a high degree of trust for users. The EuProGigant Federator will be closely aligned with the European Data Strategy, which strives towards a genuine single market for data, as well as the EU Recovery Plan.

However, designing a business concept that enables digital sovereignty is only one side of the coin. The other side is to enable sovereign data exchange by transferring the data to the infrastructure, but also to utilise the data for new data-driven services. Currently, in EuProGigant four (4) use cases describe scenarios that benefit from Gaia-X and are expected to foster data sharing concepts and technologies also in the future. The Gaia-X Association publishes all specifications of the Gaia-X framework and makes the software code for compliance with them publicly available under an open-source license for all interested parties such as: industrial companies, SMEs, startups, research institutions, public administration organisations, developers, IT and cloud providers and many more interested stakeholders. All these actors can present their products and services, exchange data and jointly develop innovative business models based on the Gaia-X principles and with the help of the Gaia-X compliant technical architecture framework, in which the federated services are being offered and delivered. Data owners are able to decide, control and monitor what happens to their data, who receives it and what it is used for. This is achieved by uniform economic and legal procedures and standards on the one hand, and, on the other hand, by an information technology procedure to enable and exercise data sovereignty in the first place (Otto 2021; Bader et al. 2020). These principles determine the **Vision** for the EuProGigant Federator as follows:

Enable a trusted decentralised digital manufacturing ecosystem.

Providers and consumers of data, analysed data, infrastructures, and value-adding services as well as any other participant in the manufacturing data ecosystem will understand the advantages and benefits of data sharing activites.

Complemented by the Gaia-X compliant framework, which includes fundamental European principles: sovereignty, openness, fairness, security and trust, the EuProGigant Federator will therefore not only serve a few large players, but will also make it easier for countless companies and organisations in manufacturing-related sectors worldwide to participate in the digital market. This is reflected in the **Mission** for the EuProGigant Federator:

Access and share manufacturing-related data safely, securely, trustworthy, and confidentially for creating and delivering value in manufacturing industries based on Gaia-X standards and aligned with European values.

Sharing data is technically easy. But when it comes to provide your data (= your IP) to a community, the challenges arise. Up to today, existing difficulties like diverse cloud-edge landscapes, legal uncertainties or technological integration issues hinder the emergence of a strong digital single market. Therefore, transparency is needed in all manufacturing sectors and verticals on available data (e.g. scope 3 emissions upstream and downstream in the supply chains). This has to be accomplished by the EuProGigant Federator and needs to be reflected in its operational goals:

- Building Trust: Provide the means to link currently isolated data and disparate applications between data providers, data consumers and other stakeholders within countries and across borders in a transparent manner, adhering to international interoperability standards (European Commission 2018). Enable the storage and access of manufacturing information in trusted and collaborative cloud infrastructures, with elasticity to scale and with a proper legal basis (consent, anonymisation, etc.).

- Ensure Security and Sovereignty: Provide federated services as a framework to implement the Manufactuirng Data Space at scale, in a compliant, secure, and trustable manner.

- Enable Cooperative Business Models: Implement clear governance for the use of data on individual, regional, national, and European level all along the manufacturing value chains for research, for commercial and for governmental use by respecting the legal requirements (European Union 2016).

- Enable Standardised Interoperability to interact with each other as well as with other data ecosystems.

3. UNDERSTANDING THE STAKEHOLDER INTERACTIONS

3.1. THE ROLE OF PROVIDERS AND CONSUMERS

The state of mind (psychological factor) within the data-sharing economy is very important for the acceptance of a solution and the penetration of the market. According to the Bitkom study dated May 2022 (Rohleder 2022), the biggest obstables for data sharing are stated as:

- 50% - data sets are not compatible,
- 45% - no matching partner
- 38% - legal uncertaincies
- 37% - difficulties to find common ground with partners
- 36% - economical attractiveness as data providers
- 35% - data privacy concerns
- 29% - economical attractiveness as data consumers

Within such a delicate and often very competitive environment, this represents a very strong barrier to enter the data exchange market. Demystification and awareness rasing with successful reference cases can support the willingness of manyfold stakeholders to participate in ecosystem activities.

Consequently, the business model for federating and orchestrating data exchange in the manufacturing sector has to take those circumstances into consideration and has to respond properly not only to the needs of stakeholders, but also to their concerns and specific requirements. This may vary significantly from one stakeholder to another. Therefore, before developing business concepts for data exchange federation services, the stakeholders participating in the data exchange value chains as well as their expections and requirements must be described. EuProGigant targets stakeholder groups that can be commonly identified based on their specific characteristics. They vary depending on the industry, but generally, they encompass a diverse range of entities involved in the manufacturing ecosystem. Often, an event, most typically the need to innovate in order to ensure competitivness, or other incidents, is the trigger to the start considering the use of data sharing solutions. Furthermore, compliance with relevant regulations, industry standards, and legal requirements is a fundamental expectation. Stakeholders look for a commitment to meeting and exceeding compliance standards to mitigate risks and ensure ethical data practices.

Active participation in data exchange should contribute to value creation for all stakeholders involved. This could include improvements in efficiency, cost savings, enhanced product quality, and overall business competitiveness. So, it must be clearly understood what values stakeholders expect from actively participating in data exchange and how those value can be transformed successfully into active participa-

tion and engagement. This is accomplished in the following sub-chapter, describing the different stakeholder groups, their participation in the value generation and their interaction potential.

A participating entity ("**Participant**") is, in accordance to the definition in ISO/IEC 24760-1, an "item relevant for the purpose of operation of a domain that has recognisably distinct existence" (ISO/IEC 24760-1:2019) which is onboarded and has a Gaia-X Participant Credential. A Participant can take on one or more of the following roles: provider, consumer, operator (Kraemer et al.). A provider has the specific role to provide federation services. Provider and consumer present the core roles in a business-to-business relationship while the operators enable their interaction.

In the manufacturing ecosystem, a **provider** manages resources and offers them as services through Gaia-X compliant credentials. For each service, the federator outlines the service offering, including terms and conditions as well as technical policies. Additionally, the federator supplies the service instance, which includes a credential and associated policies, ensuring conformity to the stated claims.

When third-party data, services, or infrastructure are part of the service offerings, the federator can integrate these resources (e.g., through service composition), but remains accountable for them. The federator must ensure appropriate back-to-back coverage for these third-party elements.

Federators are Gaia-X compliant data exchange orchestrators authorised by ecosystem governance to operate federation services and manage the federation business, which can function independently.

A **consumer** is a participant who searches for service offerings and utilises service instances within the ecosystem to create digital offerings for end-users. Both providers and consumers in a Gaia-X compliant ecosystem are identified and described through valid credentials created during the onboarding process.

Providers define their service offerings and publish them in a catalog managed by the federator. Consumers then search this catalogue for suitable service offerings. Once a consumer finds a matching service offering, contract negotiations between the provider and consumer establish the terms under which the service instance will be provided. Although the federator does not intervene in the contract negotiations, it ensures the trustworthiness of all participants and service offerings.

3.2. STAKEHOLDER SEGMENTATION IN EUPROGIGANT

Stakeholder segmentation is the process of dividing a broad value consumer or value provider community into sub-groups of stakeholders (known as segments) based on some type of shared characteristics (Garrison 2021). Stakeholder segmentation is critical for the go-to-market strategy and for offering sustainably and successfully federated data sharing services as well as related value-adding services. Therefore, the relations of the participating entities are described in the following:

The following diagram presents the general value flow for Gaia-X compliant service provisioning and consumption processes

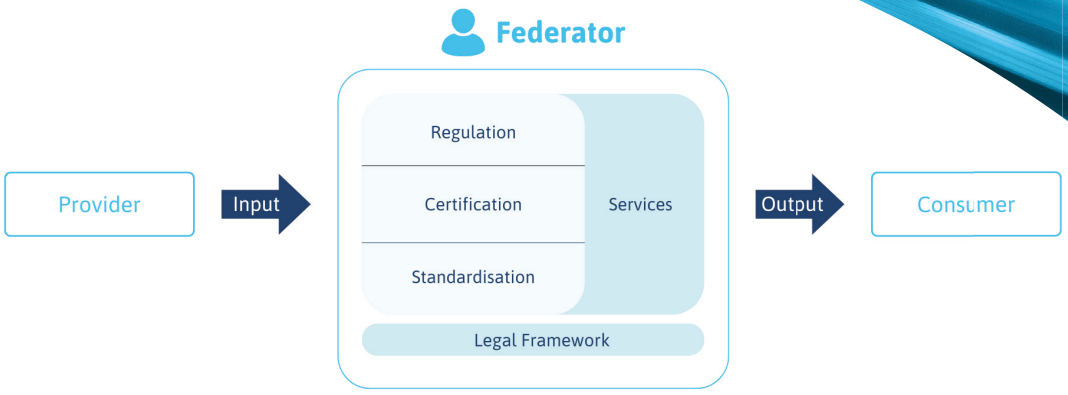


Figure 4: Schematic illustration of the data sharing value-chain, Source: Own figure

Based on these definitions, the flow of value between the different participants can be described in the following four categories:

- Information Flow: Data associated with value-generation input or output; Form: raw data, analysed data and data aggregations
- Product/Service Flow: Technologies/Products/Equipment/Software/Services as input for value generation or output from value generation
- Quality of Life Flow: Provision of input to improve modes of operation, shorten documentation processes and relief employees
- Money Flow: Money associated with payments/investments

These relations (value flows) between the different participants in the manufacturing ecosystem may vary between each group of stakeholders. Therefore, the essential contributors to the data sharing business in the manufacturing

domain have to be considered separately to understand the specific interests of benefits in their participation:

- Data holders & data users and industrial associations: We use the terms data holder and data user as defined in the EU Data Governance Act: 'data holder' means a legal person or data subject who, in accordance with applicable European Union or national law, has the right to grant access to or to share certain data under its control; 'data user' means a natural or legal person who has lawful access to certain data and is authorised to use that data for commercial or non-commercial purposes (European Commission 2020a).

- Application and service providers: The providers of data management and data processing applications and services include creators and operators of such applications and services for a specific target audience, a group of users, a cohort or a population. The manufactuirng ecosystem enables an equal playing field for application and service developers, taking the burden away of building a trustworthy and compliant data services stack. Small, medium and large companies, together with governmental and non- governmental institutions can take the lead in developing an agile, innovative and front-running market that has the potential to transform the manufacturing markets in Europe, and to set an example globally. The value created from access to European manufacturing data is significant and ranges from developing new applications, to training AI algorithms, to providing better user experience, to realising operational efficiency gains. Seamless access to data also facilitates new business models: platform, software, analytics, data, and more "as-a-service models". It will enable European players to scale, and ultimately, to compete globally.

- Data space governance and operating entities: The manufacturing domain has many requirements: some are essential but not sector-specific (access, permission and consent management, auditing, etc.), others are essential and manufacturing-specific (data standards, etc.). All data applications and services require a number of these common standards and common components. Data governance entities defining the governance and the rules of the data space, the common data standards and the minimal requirements for the secure storage, processing and exchange of information. This will typically be a combination of governmental, non-governmental and industry actors issuing laws, guidelines, standards, and code of conduct. This framework enables semantic interoperability, it guides the ethical use of data and controls the commercial or non-commercial exploitation of such data, it enables data sovereignty and a level playing field for data sharing and exchange.

- Operating entities: Operating entities provide guidelines within the soft infrastructure, and they run the mechanics of the data storage, access management, data processing and exchange. They also may run the "connectors", linking currently isolated data in a transparent, secure and audited way, and providing the services that enable data consumption by authorised consumers.

- Cloud service providers: Manufacturing ecosystems comprise of a variety of cloud services and edge components. Gaia-X compliance will support creating ecosystems of trusted, safe, and secure cloud and edge infrastructures in Europe to allow manufacturing data to flow securely and in line with Europe's regulations and values. The federated cloud and edge ecosystem will enable the creation of a competitive marketplace for cloud services while avoiding dominant vendor 'lock-in'. European cloud users need freedom-of-choice to select local or international providers, depending on the use case, in a transparent way, with documented and certified compliance to Gaia-X policies and standards.

- Academic and research institutions: universities, institutes, etc.: These stakeholders are active in the research and development phase, they are supporting technology advancement from innovative ideas to market-ready technology levels, and they manage education on a population and societal level. Collaboration between these entities and manufacturing companies is essential for staying competitive.

- Government agencies/Policy makers: National and regional government bodies play a crucial role in regulating and supporting the manufacturing sector. They may provide incentives, subsidies, and policies to promote manufacturing activities.

- European regulations, standards entities, and IP offices: They impact manufacturing practices. Adherence to these regulations is crucial, and companies must work with environmental agencies to ensure compliance.

- Non-governmental organisations or charities and a few others (unions, chambers, etc.)

- General public (Civil Society)

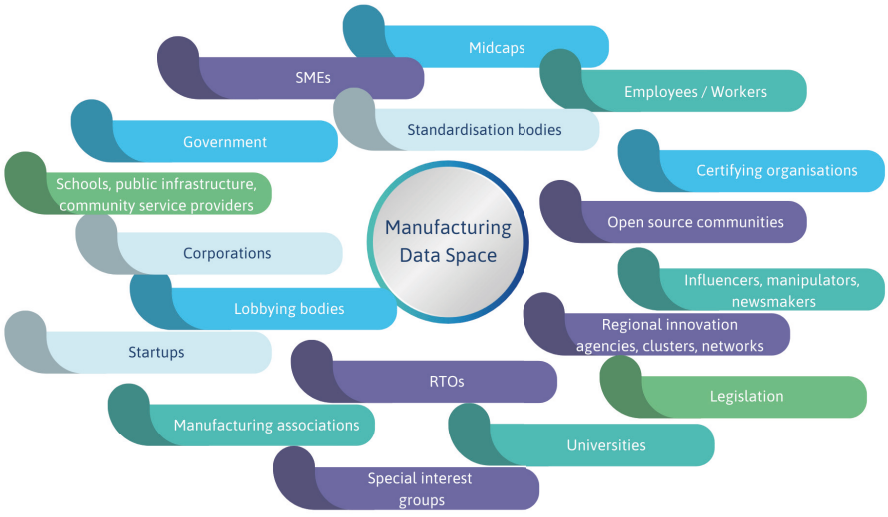


Figure 5: Overview on stakeholders and participants in a manufacturing data space, Source: Own figure

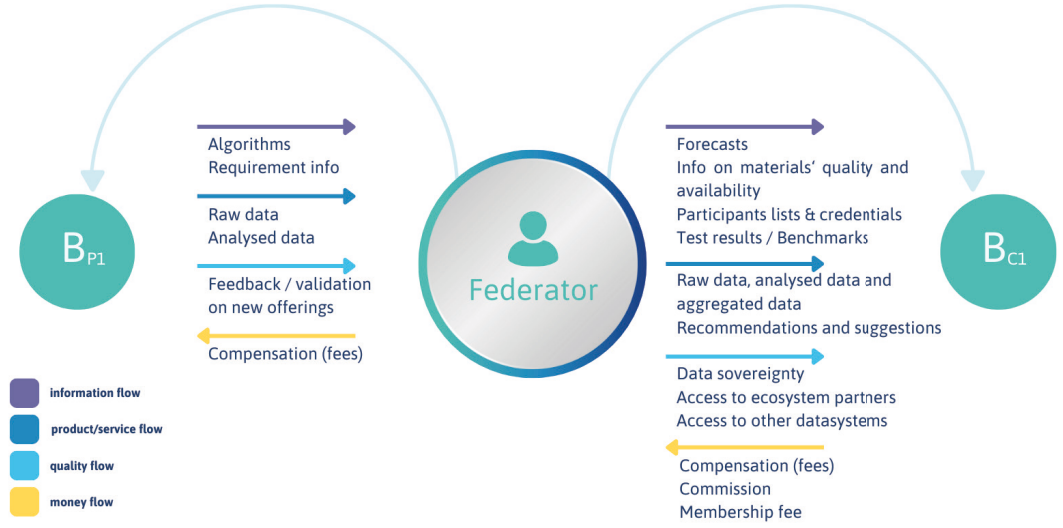


Figure 6: Value flows between manufacturing companies and a federator in a manufacturing ecosystem, Source: Own figure

All of these stakeholders will contribute to or benefit from data-driven applications and services built on trusted, safe and secure federated services for data exchange. Some of these stakeholders will become EuProGigant participants when they choose to make use of the Gaia-X compliant cloud and data services in order to provide data and data-driven services to specific end users or to consume from providers. The breadth of stakeholders and application areas is illustrated in Figure 5 with a non-limiting overview of relevant stakeholders in the manufacturing ecosystem.

The classification criteria of stakeholders, with respect to their different value flow levels, depends on a number of factors where the type of entity is not necessarily among the most important ones. Factors such as size of the entity, economic role (i.e. producer or other roles in value and supply chains), cultural/maturity level, network relationships, and other factors, often have a greater impact in their willingness for acknowledging value in acting in a data space.

According to the desk research and stakeholder interviews, which were conducted between March and August 2023, one of the most important ecosystem stakeholders are manufacturing companies. These are the individual entities that purchase supplies, hire resources, produce components or entire products, and distribute products and services, thus playing a major role in the sector. They are also the driver of the man-

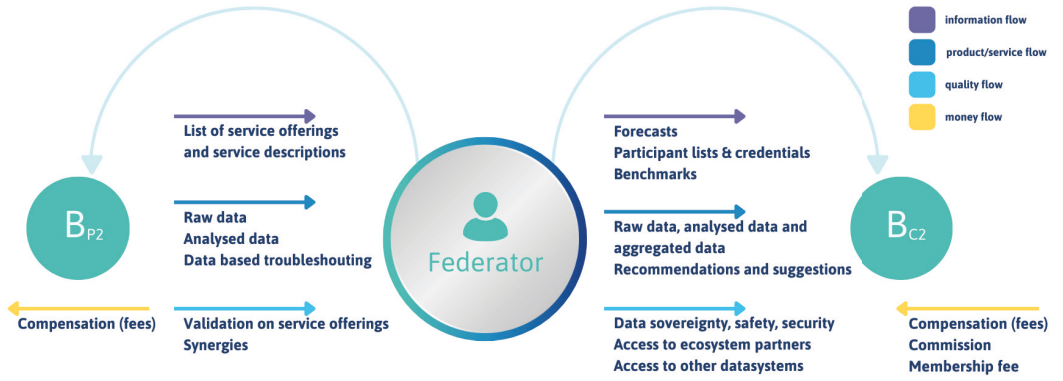


Figure 7: Value flows between IT service provider and a federator in a manufacturing ecosystem, Source: Own figure.

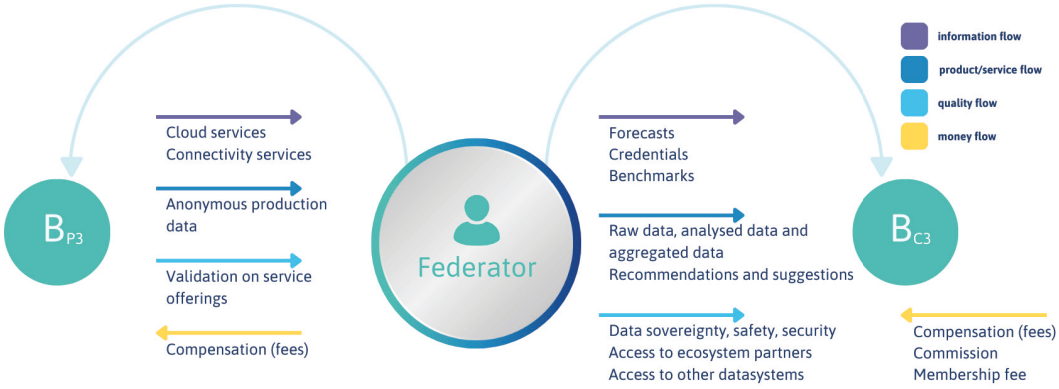


Figure 8:Value flows between infrastructure providers and a federator in a manufacturing ecosystem, Source: Own figure

ufacturing sector being the main contributor to the economic growth of European economies (with a contribution to the Gross National Product varying from 15% to 22% in the different EU member states) (Eurostat 2024). Figure 6 shows the flow of values (information – products/services – quality – money) between manufacturing companies as providers (BP1) and a Federator (Fed), respectively between a Federator and manufacturing companies as consumers (BC1):

But also, other business entities are playing an important role: IT services providers are not only interested in data sharing within different data ecosystems, they expressed interest in providing i.e. lists of service offering and service descriptions and to consume i.e. forecasts, benchmarks etc. Figure 7 shows their flow of values (information – products/services – quality – money) between IT services providers as providers (BP2) and a Federator (Fed), respectively between a Federator and IT services providers as consumers (BC2).

According to the results of the already mentioned desk research and stakeholder interviews, also infrastructure providers expressed significant interest in playing provider and/or consumer roles in the context of federated service offering in a manufacturing ecosystem. Figure 8 shows the flow of values (information – products/services – quality – money) between infratructure providers as providers (BP3) and a Federator (Fed), respectively between a Federator and infrastructure providers as consumers (BC3).

Following those value chain synthesis examples, the desk research and stakeholder interviews considered all stakeholders and participants in a manufacturing data space as they were illustarted in Figure 5 above. Summarising the synthesis activities for all relevant stakeholders, one can state that these stakeholders can be clustered according to their role in the value generation chain into the following categories:

- Business (B) – providing and consuming data, products and services, i.e. manufactuirng corporates, midcaps, SMEs and startups, TelCo providers, IT service providers, certifying companies, software developers and algorithm providers;
- Government (G) – governmental agencies, legislation, public infrastructure, schools and community service providers/consumers;
- NGOs (N) – manufacturing associations, certifying associations, standardisation bodies;
- Academia (A) – universities and research and technology development institutes;
- Leveraging Groups (L) - Regional innovation agencies, open-source communities, clusters, networks and lobbying bodies;
- Individual consumers (C) - Employees/Workers, benefitting from reskilling/upskilling activities e.g. in topics addressing ecological sustainability.

Stakeholder groups	ID	Key Stakeholder	Primary stakeholder	Secondary stakeholder
Business	B	Manufacturing corporates SMEs Micro-SMEs and startups	Telecom provider IT service provider Certifying organisations	Software developers Algorithm provider
Government	G	Governmental agencies	Legislation, Public infrastructure	Schools, community service providers
NGOs	N	Manufacturing associations	Certifying organisations Standardisation bodies	
Academia	A	Universities RTOs		
Leveraging groups	l		Regional innovation agencies Open-source communities, Clusters, networks	Lobbying bodies
Individaul consumers	C		Employees/workers	

Table 1: Horizontal and vertical clustering of stakeholders in a manufacturing ecosystem, Source: Own figure

Furthermore, stakeholders can also be divided and then clustered in accordance to the influence and impact they have in the data sharing business:

- Key Stakeholders - have the highest impact and efficiency, or large international influence;
- Primary Stakeholders - provide a medium amount of impact and efficiency, or have more national influence than international; and
- Secondary Stakeholders - have the lowest impact, efficiency and have mainly regional (local) influence.

In Table 1, we combine these two main groups with their subgroups into a full stakeholder overview.

3.3. EUPROGIGANT VALUE-GENERATION CHAINS

The business modelling approach exemplifies how to design collaborative models between different types of stakeholders and a federating (=orchestrating) entity. The core of this tool is the value created by the interactions of multiple organisations, including data provider, provider of business applications, provider of compliance services, provider of enabling services (e.g. clearinghouse services), provider of core services

(data catalogue, data exchange etc.) as well as data receivers and consumers of the mentioned services.

For every individual role and the whole data space it is crucial to understand the value creation and value capturing by individual participants, and the overall value created. For example, manufacturing companies and suppliers can exchange data with partners in their supply chain easier, faster, and more reliably. The overall value created is a governed secure data exchange for a more resilient supply chain. Such a data-driven application is one of the many similar applications in the manufacturing domain that could use an underlying data space. Data spaces must also be managed and maintained, and consequently, a collaborative business model is needed to address the different organisations and roles necessary to keep the data space up and running. Collaboratively, the organisations will have the above-mentioned growth and network effects and reflect the different objectives, or patterns, like cost sharing, joint value creation or marketplaces.

So far, we highlighted the business organisations as target participants in a manufacturing data space (see Figures 6 through 8). However, the different types of flows of information/data, products/services, quality and money can also be assumed as relations between other stakeholders and a federator. That means for example information/data may also be provided by universities and RTOs, by NGOs or by regional innovation agencies, clusters and networks (i.e. open data for business modelling, computed data). Governmental agencies/legislation entities might provide input to guidelines, regulations and laws, input to standards and information about existing standards, data from local market participants or information on governmental investigation or audit organisation data.

In terms of products/service flow, regional innovation agencies, clusters, and networks may want to provide search engine services for data spaces and data frameworks, while academic stakeholders could contribute to value generation by providing staff, consultancy, support services, data analysis or data aggregation services. Regarding quality enhancement in value creation, universities and RTOs could provide concepts and ideas, invitations to project consortia, or validation of new offerings. The latter value could also be provided by governmental entities, while associations and special interest and lobbying groups may have an interest to provide access to their networks or to standardisation activities. NGOs may be interested to provide validation or certification services. In summary, it is obvious that on the provider's side there are several flows generating value leading to B2F, G2F, N2F, A2F and L2F relations between the stakeholder groups and a federator. Money runs from the federator to the input/value providing stakeholder, e.g. as payment for services or performance fees. It also flows from the data and service consumer to the federator as service or performance compensation or even as membership fee.

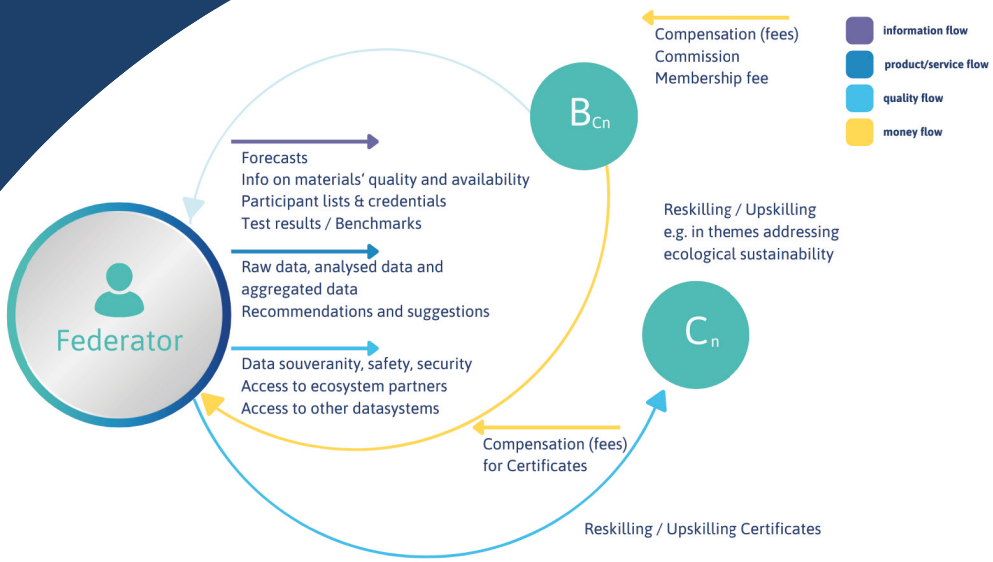


Figure 9: Flows in a manufacturing ecosystem between a federator ("F"), a manufacturing company as service consumer ("BCn") and its employees ("Cn"), Source: Own figure

One could even recognise that there are more relations possible constituting additional processes of value generation chain, i.e. involving individuals ("C").

The connection for instance could be F2B2C. The federator ("F") could provide value added services to business organisations ("B"), i.e. manufacturing companies that are consumers of data infrastructure, paying for these services with a service fee or a commission, or receiving those service as part of their membership in a federating organisation. "B" could use the access to the data infrastructure or especially access to CO2 emission data in their supply chains for upskilling/reskilling their workers ("C") in matters addressing ecological sustainability. The value created for "C" may be considered as enrichment of skills or as part of the employer's social benefit policy. The federator "F" could even issue "qualification certificates", that would constitute another money stream from "B" to "F". All these relations are in a triangle and are linked by different flows as they are illustrated in Figure 10. The flows are explained by a legend on the bottom of the figure. The colours help the observer to differentiate the kinds of flows: green for the service, blue for information/data, orange for the quality enhancement and yellow for money. Arrows explain the flow direction.

3.4. CONCLUSIONS FROM THE VALUE-GENERATION CHAIN ANALYSIS

The main point of the analysis is to get an overview about the interaction of the different flows. Which flows are based on other flows? Which flows have contrary aims in their characteristic needs, for example to get what kind of service at what type of compensation (= money flow). Out of the results and models of the value-chain analysis one can recognise for example obstacles by or during implementation of federated data sharing and data exchange services. In addition, the knowledge that needs to fulfill the desire of each stakeholder group can be very helpful for future technical implementation of value streams as well as for their promotion and sustainable operations.

All stakeholders in the manufacturing domain interact in a broad and complex ecosystem. Consequently, in general terms the EuProGigant business model could be regarded as a platform specifically targeted to the needs of very heterogeniuos stakeholder groups, but with the main focus of orchestrating the exchange or sharing of data between a provider and a consumer. So, it has to acknowledge that it will link products, people and processes. However, this business opportunity comes at the high price of a serious risk related to the wide rage of additional options for value creation available. Understanding the interactions between different stakeholder groups (segments) leads to the development of a so-called multi-sided business model.

Figure 10 illustrates the consolidated data value chain in a desired target state. The data holders create and aggregate data. The data users consume data, in line with the access permissions they have been granted. In most situations the data holders are data users at the same time, and they combine data to improve the services

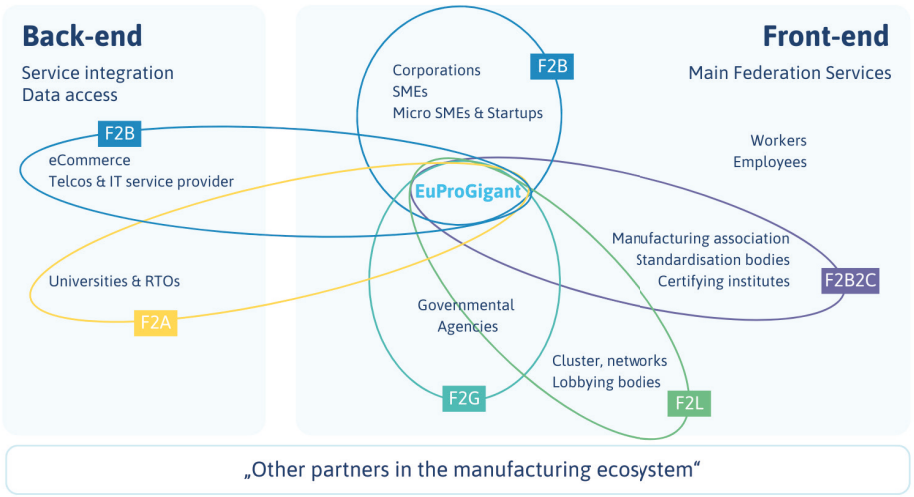


Figure 10: EuProGigant's multi-sided business model, Source: Own figure

they provide. The central part of the figure symbolises the EuProGigant Federator, the core of the Gaia-X compliant federated service delivery.

As result of the value-chain analysis and synthesis tasks it can be stated that the federation (orchestration) of data sharing may enable or contribute to one or several impacts within the very heterogenious stakeholder groups in the manufacturing sector. To that end, federation activities should aim at delivering results that are directed at, tailored towards and contributing to several of the following expected outcomes:

- Participants (providers and consumers of data, infrastructure, or services) have access to and use effective data federation schemes and data counselling that consider their individual characteristics and situation. Participants can be assigned to particular groups based on their characteristics and receive benefits adequate to that group. Stratification of different stakeholders into groups that are showing similar traits allows for effective orchestration of data sharing as well as provision of related services.
- Companies generate opportunities for new product, service, and business developments, i.e. to cater to the needs of data-enabled business models.
- International, national, and regional programmes make better use of funds, data infrastructure and personnel in data exchange promotion. They can consider the use of new or improved ambitious policy and intervention options, with expected high and sector-wide impact, for effective data promotion.

The risk of this complex model is a potential dilution into many different business scenarios. To avoid diluting resources and weakening the impact of the EuProGigant Federator, the implementation and realisation strategy has to identify a clear focus with well-defined steps to access the market actors successfully. The goal of a federated business in the manufacturing domain is to orchestrate the matching and interactions of ecosystem participants and to create values. While products have features, platforms have communities, and, consequently, this federated business can be accomplished best in a

so-called platform business model (Clauss et al. 2019). The differences to traditional linear business models lie in their structure, value flow, and interactions:

- Linear models: A linear business model is a traditional way that businesses operate, scale and grow with the focus on producing and delivering products/services directly to customers via a supply chain. A company creates added value through various activities along the process chain and controls this. Value flows one way from one entity to another one. The analysis of company success is fundamentally based on goods, services, sales and profits. Interactions are limited, and revenue comes primarily from product/service sales. Linear business models have been dominant models in today's world's businesses.

- Platform models: The focus is on creating and managing an ecosystem that connects multiple participants and user groups and to facilitate interactions and value exchanges between them. The most valuable asset is the network of providers and consumers. The company managing the platform acts as an orchestrator and generates revenue from various sources related to the platform's activities. Platform business models are initially evaluated based on the number of interactions between consumers and producers (van Alstyne et al. 2016).various sources related to the platform's activities. Platform business models are initially evaluated based on the number of interactions between consumers and producers.

Platforms are often associated with digital technologies and have become prominent in the modern economy due to their ability to leverage network effects and provide innovative solutions for various industries or various industry segments.

4. PLATFORM DESIGN FOR VALUE CREATION

4.1. PLATFORM-BASED ECOSYSTEMS

Digital platforms have become fundamental to business, media, politics, and society, evolving into intricate systems. The term „platform-based ecosystems“ draws from the metaphor of natural ecosystems, describing defined habitats for various organisms and their environment. Platform-based ecosystems can thus be defined as value creation networks grounded in existing technical network architectures (Schauf 2012).

Platforms are increasingly important in both B2C and B2B sectors, but they serve different purposes in each. In the B2C sector, platforms are often created and managed by a single entity to support new business models. In contrast, B2B platforms typically emerge to facilitate secure communication or data and goods exchange. These platforms are often initiated by industrial consortia, associations, or cooperatives, with separate entities handling the technical and commercial aspects.

Europe has a significant opportunity to strategically develop platform-based ecosystems across various social, scientific, and economic sectors. To enhance the European manufacturing industry, it is essential to establish competitive conditions that protect digital sovereignty for individuals, companies, research institutions, and the state. This includes promoting digital self-determination, distributed data storage, and the independent use of self-generated data, as advocated by Gaia-X. Such measures will lower market entry barriers for data exchange, secure innovation potential, and benefit Europe's medium-sized, competitive, and innovative economic systems without stifling growth or new revenue opportunities.

Key market conditions include ensuring immediate self-determination over data generated on platforms and the ability to use or share this data. Processes for data cooperation must be transparent, predictable, and verifiable, which is exemplified by the EuProGigant ecosystem. A balanced regulatory framework, like Gaia-X, is crucial for the success of these ecosystems, enabling cooperation models even among competitors. Participatory processes are needed to establish rules for data cooperation, such as pricing and contractual arrangements, supporting a federated multi-cloud platform architecture that reinforces European digital sovereignty (Gaia-X AISBL 2020).

Economic platform operators, including public sector entities, are motivated by the platform's existence and have an economic interest in defining interaction rules and technical design. Technical operators provide the technological structure and ensure flawless IT infrastructure operation. Both are central to platform-based ecosystems, supported by content, goods, or application providers, and users. Interactions within digital ecosystems are facilitated by interfaces and standards. The EuProGigant federator operates a platform connecting data providers and consumers, integrating data and services in a central database („catalogue service“). Additional services, such as price negotiations, contract conclusion, data exchange, invoicing, and customer service, are offered, with Gaia-X compatibility requirements shaping the interaction framework and terms of use. This integration of

services and industrial production fosters additional knowledge about transactions, users, and usage behavior, enhancing technological elements and platform offerings, accelerating growth, and increasing network effects.

4.2. ASPECTS OF VALUE CREATION IN THE PLATFORM BUSINESS MODEL

Definitions of "business model" vary, but most people would agree that it describes how a company creates and captures value. The features of the model define the customer value proposition and the pricing mechanism, indicate how the company will organise itself and with whom it will partner to produce value, and specify how it will structure its supply chain. Basically, a business model is a system whose various features interact, often in complex ways, to determine the company's success. In any given industry, a dominant business model tends to emerge over time. In the absence of market distortions, the model will reflect the most efficient way to allocate and organise resources (Kavadias. Stelios et al. 2016).

After we already identified the active stakeholders or participants of the data space, we put our focus now on the questions, how the data space creates value and how the governance model of the data space looks like. Furthermore, in chapter 5, we will illustrate the organisation of the process enabling data sharing and data cooperation. In the following chapter 6, we will provde examples on use cases illustrating individual and collaborative business models for actors in the data space.

As stated, the EuProGigant data space is a strong and collaborative platform, creating "multi-sided business models" that rely on network effects, serving both "supply" and "demand" of data and data-related services. Offering a useful collection of data resources and services attracts users of data, and a large user base attracts additional data resources and services (Stolwijk und Berkers 2020). The challenge in making this work, however, is organisational rather than technical. Creating substantial value requires consensus through collaborative efforts from multiple users and organisations. It requires also a technical architecture using standardised, interoperable data models, components and interaction patterns.

Beyond the key objective of secure and sovereign data sharing for value creation, data spaces can be established for different purposes. In fact, patterns of collaborative business cases can be identified. For example, a data space can reduce the overall cost of linking systems or collectively ensuring compliance with data regulations, typically in established industries like in manufacturing (i.e. AI Act, Supply Chain Act, Data Governance Act, etc.).

Principles and rules need to be set according to the business-case pattern to help govern and coordinate the contributing organisations that help a data space meet its objectives and progress through the different lifecycle stages. These rules and principles are set by the architecture framework, which has been developed within the EuProGigant project in compliance to Gaia- X technical architecture settings.

In conclusion, the EuProGigant data space can only be sustained if it creates value for the involved organisations, following the logic of multi-sided business models. The use of data-driven applications also need business models, which are decribed in chapter 6.

Within those settings, the EuProGigant Federator – if operated as strong and collaborative platform – is enabled to unlock the potential for the following benefits that cannot be achieved individually as in the EuProGigant manufacturing data space. It can operate as a marketplace where the data space can be seen as a sales channel between data service providers and data service consumers. Table 2 contains a first set of business-case patterns (which are not necessarily mutually exclusive), including an indicative assignment of the EuProGigant project.

All these features represent potential solutions for linking market demand and technological capability. For example, greater personalisation in the value proposition responds to the fragmentation of consumer preferences and the resultant demand for more diverse offerings. On the market side, although the steady progress of developing countries has led to a stable increase in demand worldwide, it is complicated by a greater diversity in customer preferences (both across and within countries). Higher factor prices (despite the commodity price reductions of 2015) and heightened regulation (notably on environmental effects and business conduct) further increase the challenges for companies looking to gain market share.

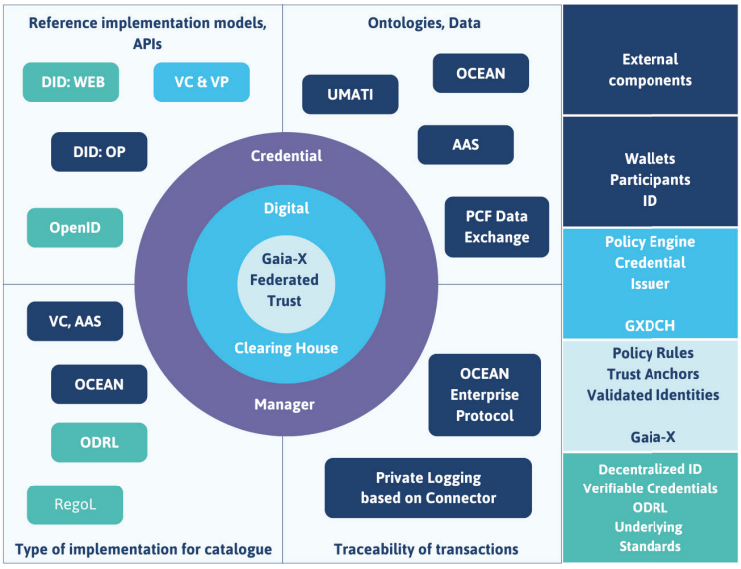


Figure 11: Development model of the technical architecture; Source: Data governance: A conceptual framework, structured review, and research agenda, Rene Abraham, Johannes Schneider, J. Brocke; published in International Journal of information management, 1 December 2019, Computer Science

Values	Description
Facilitator Role	The platform company acts as a facilitator that provides the infrastructure, tools, and rules for interactions to occur. It doesn't produce all data or services itself.
Cost Sharing	Data space participants share their data to meet shared requirements (e.g., compliance, process efficiency, transparency). Every member saves money and time by sharing the burden.
Two-Way Value Flow	The platform facilitates interactions and value exchanges between multiple parties. Users on one side can create value for users on the other side.
Diverse Revenue Streams	Platform businesses can generate revenue from various sources, including transaction fees, subscriptions, advertising, data monetization, and more.
Joint Innovation	Customer innovation can only be realized by ecosystem members working together. No single ecosystem member has all the necessary data.
Combined Forces	Ecosystem members team up to prevent a limited number of dominant market players from emerging. No single ecosystem member has the necessary resources and commitment to do this alone.
Shared Marketplace	Ecosystem members team up to provide quality-assured, easy access to data of a domain of common interest (open data, business partner data, etc.). Transaction costs go down for all ecosystem members
Networking Effects	The value of the platform increases as more participants join. This encourages growth and can create a self-reinforcing cycle.
Scalability	The platform business therefore can scale rapidly because the focus is on expanding the user base and enhancing interactions rather than linear service production and delivery.
Greater Common Good	Public and private sector share data for a greater common, societal goal (e.g., climate protection). To meet legal requirements e.g. CO2 reporting

Table 2: Business case patterns for value creation in EuProGigant

Data spaces go through different lifecycle stages, i.e., preparatory stage, implementation stage, operational stage (including maintenance and improvement), and scaling stage. The value of data spaces, as with any multi-sided business model, is most prominent in the scaling stage. This is because the data space and its technologies and services become available to more users and organisations compared to the previous stages (Abraham et al. 2019).

4.3. A DESIGN APPROACH FOR ORGANISATIONAL GOVERNANCE

The EuProGigant Federator's daily tasks typically involve orchestrating Gaia-X compliant data sharing activities within a specified organisational structure. This structure encompasses the governance of the legal entity „EuProGigant Federator" and outlines its operational framework. Within this framework, operations can be categorised into two main areas: operational governance and business operations.

Operational governance includes ensuring compliance and trust, managing the acquisition of participants and the provision of data and related services, onboarding participants, monitoring and logging services, decision-making, risk mitigation, and dispute resolution; just to name a few core functions (Fadler et al. 2021). Meanwhile, business operations entail tasks such as process management and automation, raising awareness, marketing and sales efforts, and other key elements essential for the organisation's functioning . Governance and business models are closely related, since in a data space, multiple organisations together, and in different roles, need to collaborate to design, realise and maintain the data space. This requires organisations to build together a view on the why, what, and how of such collaboration. Consequently, governance must ensure that the data space virtually operates as a single organisation.

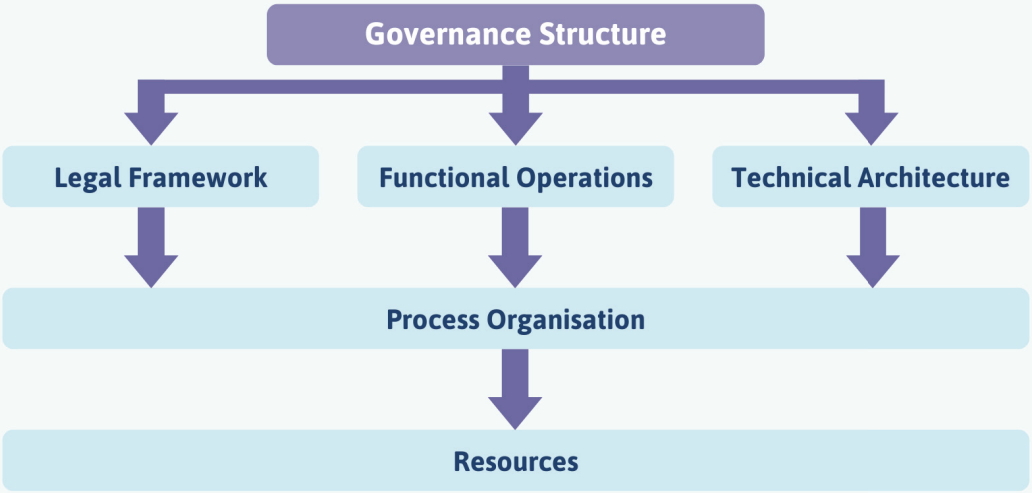


Figure 12: EuProGigant's governance modelling; Source: Own figure

To deal with this, we approach governance modelling as a design process to be composed of the lines illustrated in Figure 12. Consequently, all these governance building blocks will thoroughly allow a stabil resource and business planning for sustainable operations of the EuProGigant data space.

One cannot guarantee the success of our approach of establishing a EuProGigant Federator for orchestrating and managing a manufacturing data space. But we can load the dice by ensuring that our business and governance modelling links market needs with technology-based value propositions and value delivery. The more such links can be established, the more likely we will support the transformation in the manufacturing industry.

4.4. LEGAL ASPECTS OF DATA GOVERNANCE

To function, the EuProGigant data space needs to navigate through a patchwork of domestic and EU legal entitlements to data, the intense European legislative agenda, and different relevant regulatory instruments. One of the objectives of the EuProGigant Federator is to support its data space participants in navigating these legal challenges. Therefore, the EuProGigant Federator will be built on legal and governance building blocks with the following instruments to be developed:

Cross-cutting legal frameworks: This area focuses on the laws and regulations that apply to data spaces, which include contract law, data protection, intellectual property, competition law, and cybersecurity. It also looks at new rules and enforcement measures that have been introduced to manage data and data spaces. The goal is to use guidelines provided by Gaia-X to help management of the EuProGigant Federator understand and navigate the complex legal landscape. This will clarify how different legal rules relate to each other and how legal responsibilities and risks are distributed. The aim is to make the implementation and compliance more practical and useful.

The recently proposed Data Governance Act facilitates data sharing across sectors and EU countries, in order to leverage the potential of data for the benefit of EU citizens and businesses. It makes many sectors of the economy more efficient and sustainable, and leads to more transparent governance and more efficient public services. For European data spaces, it is recommended to have a central governance authority overseeing all aspects in connection with interoperability of data spaces (here the Gaia-X AISBL) as well as a (domain) governance authority for each data space (in our case the EuProGigant Federator).

The European Data Governance Act (DGA) will boost the development of trustworthy data-sharing systems, (a) by ensuring that data intermediaries will function as trustworthy organisers of data sharing or pooling within the common European data spaces, and (b) by measures to facilitate data sharing, in particular to make it possible for data to be used across sectors and borders, and to enable the right data to be found for the right purpose. For instance, Art. 12a governs that the provider of data sharing services is actually a neutral third party, a legally sepa-

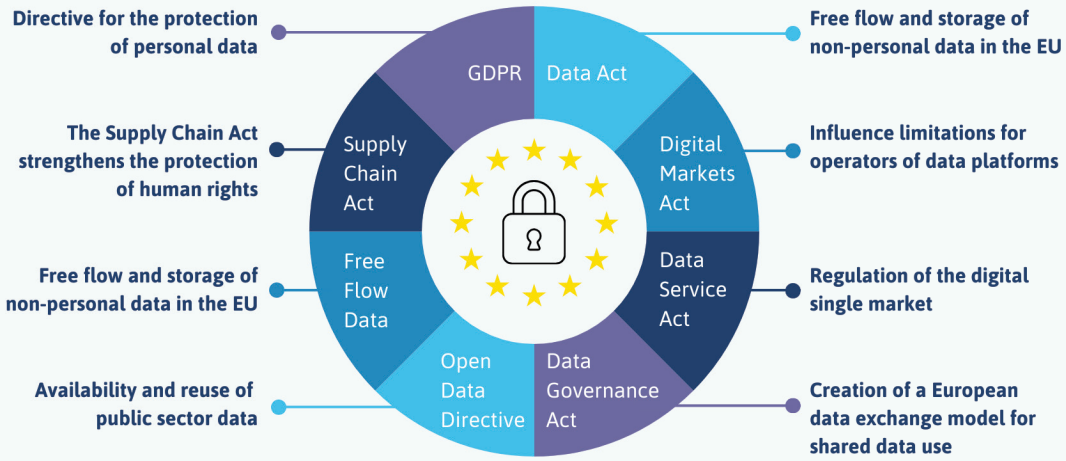


Figure 13: Examples of regulatory requirements; Source: B. Otto, J. Seidelmann, J. Schmelting, O. Sauer: Manufacturing-X Data Space Study; VDMA and ZVEI, 2023

rate company that acts as an interface between the actors, and not at the same time the data owner or user.

Consequently, the EuProGigant Federator will be established as non-profit entity branded as trustworthy organisation and recognised „player" in a European manufacturing ecosystem. It shall be eligible for public support as well as for tax benefits and employer benefits. Its governance should allow transaction-based revenue generation as well as income trough membership fees, grant and donations. At the same time, it will operate a for-profit entity for offering profitable value-adding services and to gain profits in the expansion stage:

Figure 14: Legal entity structure of the EuProGigant federator; Source: Own Figure

This structure allows that the data exchange orchestration - also with regard to its pricing – will be fair, transparent and non-discriminatory, which should particularly play into the hands of the cooperating SMEs.

Organisational aspects: This area is about organising who has the right to make decisions and who is responsible for different information-related tasks. It looks at the various roles within the EuProGigant data space, the business strategies discussed earlier, and the legal rules. Additionally, the tools for managing data in the EuProGigant Federator will be based on real-world examples to ensure they provide value.

Contractual dimension: This area focuses on models, templates and architectures relating to data exchanges. The EuProGigant Federator will have a library of contractual modules offering guidelines, modular model agreement templates and a range of checks on how to set out general terms and conditions for data-sharing agreements within the data cooperation processes. The purpose of the library is also to support different data usage and transaction types, providing participants with an easily accessible and user-friendly starting point for defining the legal agreement terms. The templates and sample agreements will be based on pre-existing principles, templates and rulebooks and will be developed (and over the time enhanced) through co-creation processes, involving the participants.

Documentation in the form of user, developer, and administrator guides is also essential to support the day-to-day operations of the data space. This documentation helps users to understand how to use the system and provides guidance for developers and administrators on how to manage and maintain the system.

These different considerations of legal aspects of data governance will work towards promoting values that are core to the European way, such as privacy, integrity, trustworthyness, fairness, etc. These values will be enshrined in concrete settings and brought to the level of technical implementation to ensure individual and collective control of data and safeguard a human-centered and trustworthy approach.

4.5. FUNCTIONALITY OF THE DATA SPACE

In the EuProGigant data space present today and the one to be developed in the future, several building blocks need to be considered when setting up effective and trusted sharing of data among the participants. The assembly of those building blocks relies on reference architectures[1] that specify a role model and the distribution of building blocks and technology stacks among roles. As a data space is an infrastructure that enables data transactions between different participants based on the governance framework of that data space, the data (service) providers and data (service) consumers connect with each other and use optional third-party services. A set of guidelines and architectures will guarantee compliance to Gaia-X values, rules and regulations. Thereby the major pillars are interoperability, shared workflows, standardised processes, trust and data values.

Interoperability is an important goal for all organisations involved in developing a distributed data economy. The intended seamless exchange of data and services across systems, networks and organisations requires a shared understanding of data exchange and interaction patterns. EuProGigant will provide a solid framework for efficient data exchange among participants, supporting the complete decoupling of data providers and consumers, making data services FAIR (Findable, Accessible, Interoperable and Reusable). This requires the adoption of a "common language" for every participant: data formats, the meaning of information data descriptions and the process workflows driving them (Siska et al. 2023). Furthermore, the self-sovereign approach of Gaia-X requires the exchange of intended and unintended usage declarations. This understanding is necessarily enabling interoperability helping to provide users with more value by reducing integration and adaptation costs.

Shared workflows and standardised processes: The core requirement for any higher-level interaction are shared identity management mechanisms, as outlined before as well as in the description of processes in chapter 5. In addition to that, several infrastructure components promote information validation and request meaningful workflows. Such workflows have been defined already by Gaia-X. Together with the interoperability pillar, this layer enables the basic technical communication between components of the data space architecture.

Trust: Self-sovereign business models require a further understanding about what is actually intended and which permissions each participant has received. In addition to the productive data, the components need to be enabled to also exchange the requirements and obligations imposed by the provisioning and consumption of data assets and data services. Data spaces should bring technical means for guaranteeing that participants in a data space can trust each other and exercise sovereignty over the data they share based on user-controlled consent (European Commission 2024). This requires managing the identity of participants, verifying their trustworthiness, and enforcing policies agreed upon for data access and usage control.

Data value: The EuProGigant data space will provide opportunities for participants to generate value from sharing data. Therefore, our data space contains multi-sided markets, in which participants buy and sell data, data sets and data services as part of their business model. This requires the adoption of interoperable mechanisms enabling the description of terms and conditions (including pricing) linked to data service offerings, the publication and discovery of such offerings and the management of all the necessary steps supporting the lifecycle of contracts that are established when a given participant acquires the rights to access and use data (European Commission 2020b).

Additionally, a support infrastructure is necessary to enable users to report technical and operational issues and seek support when required. Overall, effective operational activities are crucial for the smooth and successful functioning. The functional and operational aspects of the EuProGigant data space encompasses the day-to-day activities that are required for the successful functioning data cooperation. These activities are typically addressed in the scope of the process design[2].

4.6. THE TECHNICAL ARCHITECTURE

4.6.1. The EuProGigant data space stack

A federated technical architecture is unimaginable without an underlying interconnected network infrastructure. Interconnection and networking represent the main building blocks to connect and federate the different entities of the ecosystem with each other. Based on the "Self-Description", EuProGigant ecosystem participants are able to seek for and choose the appropriate interconnection and networking services according to their needs.

The use of standardised data models and interaction patterns is crucial for making sure different nodes can work together, providing user-friendly services, allowing providers to be interchangeable, and connecting to other data ecosystems (Eggers et al. 2020).

To maintain high-level data protection, security, transparency, and trust within the EuProGigant ecosystem, a set of policy rules is being developed. These rules outline the common principles for collaboration and participation in Gaia-X compliance. All participants must accept these rules to join the ecosystem, and any services offered must adhere to them. Most policy rules are based on European regulatory frameworks and focus on data sovereignty and self-control over critical information, allowing seamless data and service exchange in a federated cloud architecture (DIN SPEC 27070:2020-03).

2 Please see chapter 5 below.

The core principles of the architecture include openness, transparency, interoperability, federation, authenticity, and trust. The following technical guidelines enforce these principles and ensure compliance with the Gaia-X vision:

- Security-by-design and Privacy-by-design,
- Enabling federation, distribution and decentralization,
- User-friendliness and simplicity,
- Machine-processability, and
- Semantic representation

The Gaia-X de-facto standards ensure that the policy rules agreed upon between the participants are verified and can be validated at any time, allowing participants to adopt the governance, using the infrastructures "to access and use data in a fair, transparent, proportionate and non-discriminatory manner with clear and trustworthy data governance mechanisms."

- **Compliance:** for a common digital governance based on European values (decentralised services to enable objective and measurable trust).
- **Federation:** enables interoperable & portable datasets and services.
- **Data exchange:** to perform data exchange with anchored contract rules for access and data usage taking data contract negotiation results into the infrastructure (contracting, access control, usage control, usage tracking and tracing).

Each pillar has one or more artefacts in the form of functional specifications, technical specifications, open source software components and label (Gaia-X AISBL 2024a).

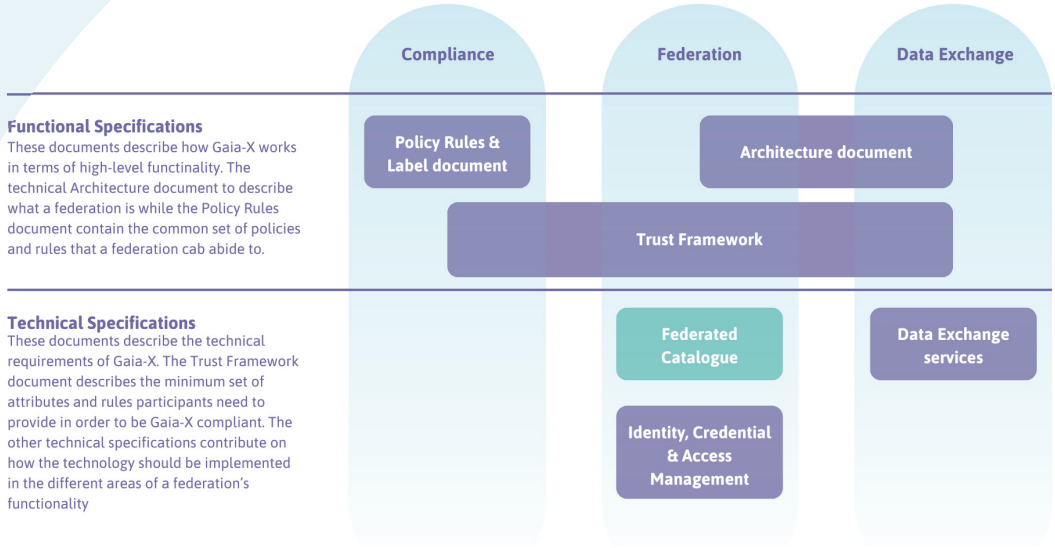


Figure 15: Schematic illustration of functional and technical specifications; Source: Gaia-X AISBL

In addition, the Gaia-X framework concept builds on externally contracted services accredited by Gaia-X Clearing Houses (GXDCH) to operate the compliance services.

4.6.2. Gaia-X compliance architecture

In order to create a basis of trust in the EuProGigant data space, special services are required that issue and verify certificates to ensure compliance with regulations and standards. Compliance plays a role in the inclusion of participants and services in an ecosystem and must remain verifiable at all times. In the Trust Framework, Verifiable Credentials signal the compliance of each entity (participant, resource, service offering). These credentials of conformity are mandatory to be part of the Gaia-X ecosystem and additional seals of approval certifying compliance with specific rules (e.g. European Control, Art. 6 GDPR) are available for verified and verified service offerings.

Gaia-X requires three main components for compliance: (1) the Gaia-X Registry with compliant services and participants, (2) the Compliance API, through which certificates can be obtained and verified, and (3) the Notary (for the legal registration number).

In addition, the software components and operating environments can be certified at the data space level, e.g. for the IDS standards using the IDS certification scheme (Otto et al. 2021).

4.6.3. Federation

In order to establish Gaia-X compliant federation services, EuProGigant's manufacturing data space facilitates collaboration between different actors, creating opportunities for innovation and value creation. From an architecture perspective, it is the collection of the necessary components that enable the sovereign exchange of data and services. The term "data space" refers to a type of data relationship between trusted partners who adhere to the same high standards and policies for storing and sharing data. However, a crucial aspect of the EuProGigant data space concept is that the data is not stored centrally, but rather at the source and only transferred when necessary.

Figure 16: Necessary components of the federation architecture; Source: Gaia-X AISBL

Data sovereignty and trust are essential prerequisites for the functioning of this data space and support the relationships between participants. The software required to implement data spaces runs ideally on cloud/edge cloud infrastructures (minimum requirement per participating company would be a server that can permanently be reached through the internet).

Although there are various initiatives related to data spaces in the Gaia-X context, we will focus on tools that are Gaia-X compliant and usable/applicable for EuProGigant.

4.6.4. Data Exchange

These architecture components enable services that handle the transaction between provider and consumer, including but not limited to contracting, setting and enforcing usage policies, logging transactions, data transfer (tools for exchanging data or other services are an essential part of a data space) and audits:

Authentication: The Identities and Trust Framework are essential. Without this, you cannot connect two Participants. Identities provide general information on the Participant, and the Trust Framework appends additional claims, like verified location, or verified application of other standards or regulations.

Policy negotiation and contracting: include the ability to negotiate access and usage policies between two parties. This should be a sequence between the parties, but a contracting service can support here, when one or multiple parties do not have the technical abilities for this.

Monitoring and logging of day-to-day data exchange between data producers and consumers is another essential aspect of operational activities. This ensures that the flow of data is monitored, tracked, and logged, which helps in detecting issues and resolving them quickly. Furthermore, monitoring of software infrastructure, resource consumption, and availability is critical to ensure that the Data Space is running efficiently and effectively. Logging enabes also measuring the traffic in the data space (for instance for accounting and billing for individual transactions).

4.6.5. Gaia-X Clearinghouse

It is important to note that the services required to comply with the Gaia-X framework must be provided by (but not necessarily operated by) the Gaia-X framework, while the data space participants must use such services to themselves to be compliant. Specifically for Gaia-X, in the latest "Gaia-X Trust Framework", the Gaia-X Digital Clearing Houses (GXDCH) will serve as the locations where compliance is achieved, with independent entities operating separately, such as the EuProGigant Federator (Sprenger 2024). The data space components that enable compliance by connecting to the

Gaia-X compliance services will therefore be part of our technology stack, but not the compliance services themselves.

The GXDCH operationalises the Gaia-X mission. It is the necessary element to operationalise Federated Data Exchange and related services on the market. The clearing house makes the various mechanisms and concepts applicable in practice as a ready-to-use service set. Therefore, a distinct specification and implementation of the GXDCH exists. It is the one-stop place to go and get verified against the Gaia-X rules to obtain compliance in an automated way. The Gaia-X Clearinghouse contains both mandatory and optional components. All the mandatory components of the clearinghouse are open-source software. The development and architecture are under the governance of the Gaia-X Association.

A Gaia-X Clearinghouse instance runs the engine to validate the Gaia-X rules, therefore becoming the go-to place to become Gaia-X conformant. The instances are non-exclusive, interchangeable, and operated by multiple market operators.

PONTUS-X

The Pontus-X (https://www.pontus-x.eu/) digital service ecosystem, powered by Gaia-X, is based on Web3 technologies and uses a distributed ledger and smart contracts as secure, distributed storage and to provide all of the Gaia-X federated services. It is also implemented in the EuProGigant architecture and other European and Gaia-X lighthouse initiatives and projects. The components build on the Ocean Enterprise, Gaia-X Digital Clearing Houses (GXDCH) and Oasis network software stack to provide the federation services required for data spaces and digital service ecosystems. All components are provided as free open-source software under an Apache 2.0 license. The current public sandbox implementation uses its own Ethereum Virtual Machine (EVM) compatible distributed ledger, the Pontus-X network. To increase the resiliency of the network, it is distributed both geographically and across European cloud service providers; meanwhile, each of the underlying services can be operated by individual service providers also known as "federators" or "operating companies/institutions". The Pontus-X network uses Proof-of-Stake, an environmentally friendly and scalable consensus mechanism where approved accounts („validators") are allowed to verify transactions and create blocks. The distributed ledger also serves as an interoperability layer between data spaces and participants of the Gaia-X Web3 ecosystem: they can be viewed as subsets of participants and offerings with their own portals, middleware, infrastructures, connected networks, and optional additional rules. The catalogue can be stored on-chain or off-chain in the form of (optionally encrypted) metadata for each service offering, which the portal accesses via a cache (Aquarius) or directly via the network. The Pontus-X catalogue stores the minimum necessary metadata to enable usage of services and to describe services to potential consumers. This metadata can be expaneded with additional metadata for domain-specific ontologies and Gaia-X compliant credentials. Basic metadata is stored through ERC721 smart contracts while extendended meta data is refered to via pointers to a webspace or decentralised off-chain storage, i.e. IPFS. Contracts specifying the terms of use for assets are recorded on-chain as smart contracts and as part of the service offering's self-descriptions, which in turn can be stored off-chain or on-chain. Smart contracts are automatically executed when consumers and service providers sign an agreement, and the conditions are met, thus documenting the contracting process and result. Usage restrictions (e.g. download or exclusive use for computations, contract expiration, licensing, access control and pricing) can be part of these contracts. Audit trails are enabled by logging all transactions on the blockchain. Services for SSI-based authentication and authorisation are also included, such as role-based access controls (RBAC) and fine-grained permissions. The Pontus-X ecosystem supports participants when complying with the Gaia-X Trust Framework by providing Gaia-X compliant self-descriptions that are verified via the Gaia-X Compliance Service and Gaia-X Digital Clearinghouses (GXDCH). The underlying framework, Ocean Enterprise/Ocean Protocol, supports static and dynamic data access as well as performing computations on data without directly accessing it but only obtaining the results („compute-to-data"). The latter paves the way for preserving and enhancing data privacy, on-demand aggregation/anonymisation, and federated analytics and learning. Monetisation and instant settlement are an integral part of the stack: access to a given offering is managed via its own ERC20 utility token („data token" / "access token"). These tokens can currently be acquired in exchange for other ERC20 tokens (e.g. EUROe token) or in the future through off-chain payments, e.g. via credit card or SEPA.

Documentation of Pontus-X can be found here: https://docs.pontus-x.eu/

5. THE PROCESSES ORGANISATION

All of the EuProGigant architecture elements as well as the federation services as such need to be in place to enable in an initial data sharing approach the use cases described in chapter 6 below and to step into a sustainable future orchestration business. The participants will need to operate these with the full system of policies, rules, compliance and certification and governance aspects, in order to create trust with all stakeholders in the complex manufacturing ecosystem. No single component can be left out of control, out of sight, out of audit, or without certification.

The entire process can be divided up into four general sub-processes:

I. Preparation of onboarding (= user onboarding: with landing page, acceptance of general terms and conditions and user identification)

II. Onboarding and compliance (building trust among the participants in the design process)

III. Service offerings and catalogues (list of data, data sets and data services offered for sharing)

IV. Execution (contracting, data exchange, monitoring).

The four subprocesses can be visualised as in the following figure and will be described in the following sub-chapters:

Figure 17: Processes to federate data sharing in the EuProGigant ecosystem; Source: Own figure

5.1. PREPARATION OF ONBOARDING

In order to create a basis of trust in data spaces, special services are required that issue and verify certificates to ensure compliance with regulations and standards. Compliance plays a role in the inclusion of participants and services in an ecosystem and must remain verifiable at all times. This trust layer forms the basis for all data spaces in the Gaia-X framework. The EuProGigant data space will add additional support, rules and regulations. Consequently, the Federator's portal or website needs a landing page consisting of the following information:

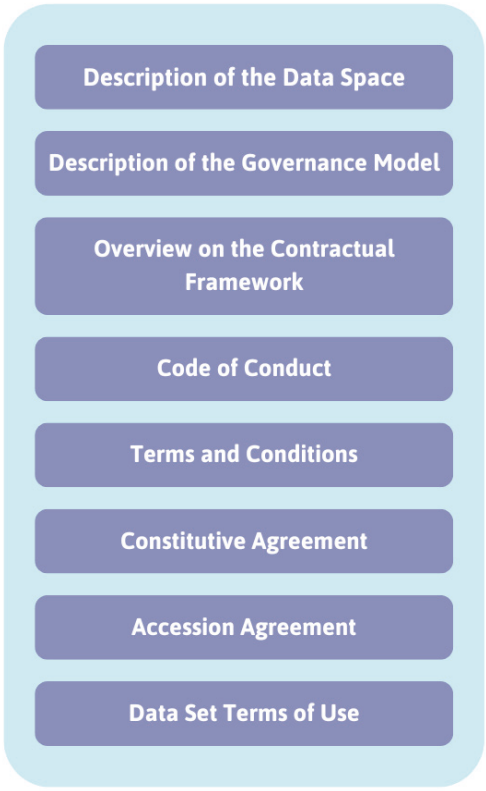


Figure 18: Governance information on the Federator's landing page; Source: own figure

The user will have to enter the landing page (website or portal) to create a user account. The user will be asked to accept the "Code of Conduct" as well as the "General Terms and Conditions". This federated service to compose and to view an account of any or all access to information shall be easily accessible, readable and traceable. At this stage, a trial case or demonstrator might be offered to allow the new user entering a test environment. This "demonstrator" is not only important to aquaint the user to data sharing activities, but also an important marketing tools for future customer acquisition.

These initial steps are then followed by an electronic identity management (eID/eIDAS) for natural persons (physical persons) as well as legal persons (private or public entities). It is an essential enabler for consistent identity & access management. If at this stage the user does not have an electronic ID, a list with suggestions for service providers that can issue certificates conform to eID/eIDAS will be available. As soon as the user has received the digital identity, the basic frame agreements (as referred to in Figure 18) shall be signed.

Within all these subprocesses, it is important to avoid login barriers in order to ease the customer onboarding.

Figure 19: The EuProGigant portal; Source: own figure

5.2. SUB-PROCESS: ONBOARDING

In the EuProGigant trust framework, "Verifiable Credentials" signal the compliance of each entity (participant, resource, service offering). These credentials of conformity are mandatory to be part of the Gaia-X ecosystem.

EuProGigant will offer three main components for compliance:

I. the Gaia-X Registry with compliant services and participants,
II. the Compliance API, through which certificates can be obtained and verified, and
III. the Notary (for the legal registration number).

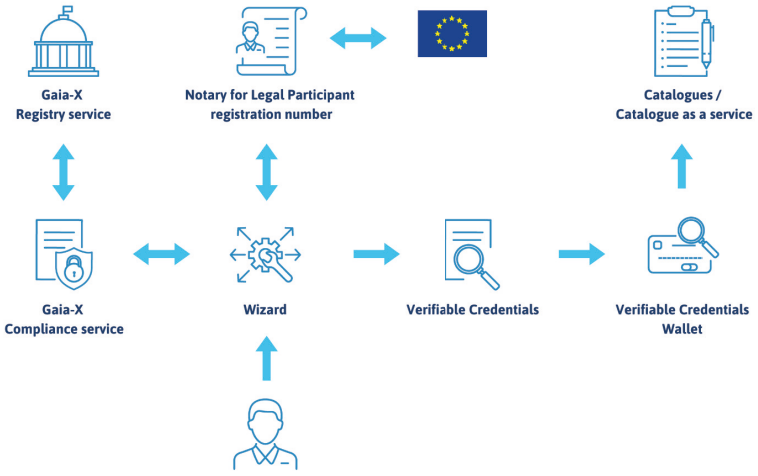


Figure 20: Illustration of the onboarding process; Source Gaia-X AISBL

Gaia-X Registry Service provides the list of valid credential schemes and trust service providers. They also valid and revoke public keys. Furthermore, the Gaia-X Registry can be used as the seeding list for the network of catalogues.

Compliance Services validate the shape, content and signature of Gaia-X credentials and issues back a Gaia-X credential attesting of the result. Required fields and consistency rules are defined. The Compliance Services thus safeguard semantic interoperability.

The **Registry Number Notarisation** API is a tool used to return an unsigned Verifiable Credential once all registration information provided by the participant are sucessfully checked by the API.

Guiding the users through these subprocesses results in a federated solution for attributing, withdrawing and verifying the access rights to specific types of data with a specified legal basis. This includes the authorisation of others to act on behalf of a specific individual (e.g. in accordance with the organisational chart und authorisation rules in an organisation). Thus, a hierarchical structure will be established, including the allocation of rights for the company (similar to the EU project management system "ECAS") (ibau GmbH 2024). It is a structure that issues „internal authorisations" at the legal entity level. This can even be enriched by interfaces to rights delegations within the company, which would be a "nice to have" but not a mandatory function.

Designing a decentrally managed approach for employee authentication and access control to cloud services ecosystems based on a real decentral Self-Sovereign Identity (SSI) concept involves several steps and considerations. It requests a high-level design approach how to authenticate employees and manage their access rights to cloud services in a decentralised and secure manner.

At this point, also the company must instruct its affected employees how they should behave or interact in the data space (e.g. paying for services - pre-paid, credit cards, etc.). The company needs a wallet, a download link to several variants (browser wallets, connector wallets such as EDC, et. al.) will be provided.

Having passed these steps successfully, the users are prepared to receive Gaia-X compliant Verifiable Credentials as participant in the data sharing ecosystem. The credentials enable the interaction with the federator. The standard that is likely to prevail for issuing verifiable credentials is OPEN ID CONNECT. For this subprocess, user may use their logins from the platform and pass this credential on to their wallet. To apply for the Verifiable Credentials, a form (Wizzard) is being provided (e.g. https://wizard.lab.gaia-x.eu/). Credentials can also be applied through direct APIs (e.g.https://compliance.gaia-x.eu/) or through a so-called "third-party application". It is important to undertand that the Verifiable Credentials are not only needed for each participant, but also for each data set. The so-called Verifiable Presentation includes all the Verifiable Credentials that are required to get the conformity for the Participant or their service(s).

Verifiable Credentials are digital identities that may be described as follows (World Wide Web Consortium 2022):

- Any ecosystem (such as the EuProGigant ecosystem) is acting self-sovereign (100% independent) and defines its own trust framework.

- Gaia-X is an ecosystem, like any other, that acts in a self-sovereign manner. It defines its own trust framework and manages its members as trusted accreditation organisation (TAO) conform to its own Gaia-X policies and rules.

- Each ecosystem can link to any other ecosystem's trust framework to establish a mesh of trust. This allows, for example, Gaia-X to utilise eIDAS-compliant trust frameworks for issuing credentials during onboarding - the process of bringing new members into the ecosystem.

- Each ecosystem manages its trustworthy members as trusted accreditation organisation (TAO). This TAO is published in its ecosystem trust list, which includes only the identifiers (like IDs or DIDs) of members, and does not reveal any attributes about them.

- In addition, the ecosystem issues a membership credential to each member. This credential grants access and also includes information like member name, ID, and status.

- After having received the Verifiable Credential (VC) one can claim they are a Gaia-X Conformant Legal Participant, or have Gaia-X Conformant Services based on the proof in the VC returned by the Compliance Service.

5.3. SUB-PROCESS: SERVICE OFFERINGS THROUGH THE CATALOGUE

A federated catalogue enables the search and selection of providers of data/data sets and their service offerings based on their Self-Descriptions. It also supports monitoring of relevant changes in service provision (Continuous Automated Monitoring Service). Producers promote their offerings while keeping full control of the level of visibility and privacy of their offerings, and consumers find best-matching offerings and can monitor them for relevant changes in the offerings. Every catalogue in a Gaia-X compliant data space is aware of existing verifiable credentials generated in the Gaia-X ecosystem. Thus, it can attest, depending on its own rules, that the chain of trust is valid and publish a service or provide a list of service providers to a consumer. To help the consumer choose, the list of service providers can be reduced by filtering criteria or service composition indexes: it can be added to a shortlist of providers.

The catalogue constitutes a list of professional data providers including physical and digital addresses and affiliations – essential enabler to identify providers in a trustworthy manner (for individuals and the organisations they work for). In the federated catalogue, pseudonymisation and anonymisation services for records, images, monitoring signals, measurements, outcomes data, etc are essential for compliance with the GDPR, privacy and security requirements.

Consequently, the EuProGigant federated catalogue is a marketplace for data and data-based services. It includes the means to track prove-

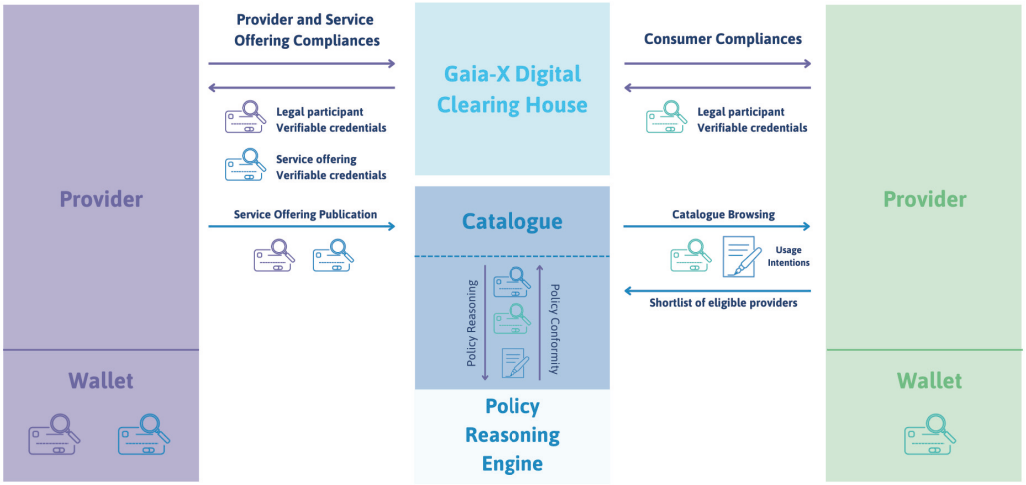


Figure 21: Workflow in the use of the federated catalogue; Source Gaia-X AISBL

nance of data and the legal ground for sharing and processing such data. This is essential to improve the ease of data discovery and to stimulate a more data-driven manufacturing. A data request repository may be added as additional service as a shared space to publish data needs and to solicit for data providers to collect and to contribute the requested data.

The federated catalogue may also include listings of:

- Data institutes: statistics, science and research institutes as well as commercial entities. This could be an aggregation of national catalogues; an essential enabler to identify these entities in a trustworthy manner.
- Manufacturers being experts in certain verticals or application areas. This is an essential enabler to identify providers in a trustworthy manner (for individuals and the organisations they work for).

It is of utmost importance that the EuProGigant Federator offers so-called terminology translation services: an ontology to translate from a coding or system or format (machine-readable resources that include terminology, syntax and coding definitions) into a description language that is user-oriented, easy to read and to understand.

The catalogue is EuProGigant's "face to the customers". The related services have to be set to be usable and readable. This will support EuProGigant's competitiveness and the acquisition of participants, in particular, the manufacturing SMEs.

5.4. EXECUTION (CONTRACTING, DATA-EXCHANGE, MONITORING)

Once the consumer has selected a service offering, he can directly contact its provider using the information provided by the catalogue, initiate pricing negotiation, contracting terms and technical means of data exchange.

Data are furnished by data producers to data providers who compose these data into a data product to be used by data consumers, whereby data producers, data providers and data consumers must be participants with Gaia-X conformant descriptions. Each data product description must contain a data license defining the usage policy for all data in this data product. The data provider is accountable of the data product description declarations.

The data exchange service must enable the data provider, the data producers and the data licensors to define clear rules – permissions, prohibitions, duties – and consent (e.g. consent as per GDPR, authorisation as per EU acts on data, permissions as per the EU Finance Data Access regulation, etc.). A Data Usage Agreement (DUA), including usage terms and conditions associated with these data, is then to be signed by both data producer and data provider, and gives the data provider the legal authorisation to use these data in accordance with the specified constraints.

Before using a data product, the data consumer negotiates and co-signs a data product usage contract (DPUC) with the data provider. For each licensed data included in the data product, the

data product usage contract must include an explicit data usage agreement signed by the corresponding data licensor.

Policies for data exchange shall reflect different aspects to specify terms and conditions for the data and the exchange of the data. Therefore, such policies have a different scope and concern:

- Contract policies are interoperable to be clear and unambiguous as a basis for a contract between the participants. This contract policies are machine and human readable. It must be able to contain access and usage policies; and
- Runtime policies are derived from the contract policies and are used for the execution of the contract policies in the system of the participants.

In summary, the data sharing services consists of the following elements and/or functions:

- Data Contract Negotiation: A Data Contract Negotiation component is required to negotiate a contract for the use of the data. This can be used to ensure that the data is only used on the basis of agreed conditions.
- Data Sharing and Usage: In addition to the described negotiation process, another service is responsible for the actual data sharing and its use. This is based on the agreements on usage created in advance.
- Shared Data Processing: Another aspect is the processing of the data. In a business context, most of the value of the data arises from the actual use, which is subjected to processing beforehand, which can also be shared.
- Data Trustee: A trustworthy third party, specifically a data trustee, can be called in to mediate between a company providing data and a company using data. This third party assumes a neutral position, especially with regard to data that needs to be protected.
- Data Broker/Marketplace: Both a (meta-)data broker and a data marketplace can be used to find data offers in a data space. These can be offered under certain conditions or for certain fees.
- Metering, Billing and Clearing: This service acts as a data service that records and measures data transactions based on common key figures (e.g. data volumes, number of accesses, etc.) and enables the billing of data transactions. A clearing component is used for specific payment and billing services.
- Dashboard with an overview of all active and inactive services, the status of booked services and the history of used services.
- Logging: A logging component is an auditable transaction log that is only accessible to the contracting parties. It is used to track the logging of data transactions in the data space. It tracks:
  - whether data has been transmitted and received and

- whether data usage policies have been respected or violated, e.g. to clarify operational issues or detect fraudulent transactions.

For implementing exchange services, the following solutions are currently available:

- decentralised EDC solutions (Gaia-X AISBL 2024b)
- a GXFS solution (Böcker 2022)
- the OCEAN Protokoll (Ocean Protocol Foundation Ltd. 2024)
- a FIWARE solution („DOME") (FIWARE 2023)

Data providers and data consumers typically need so-called Connectors communicating with each other. In the EuProGigant portal, the Pontus-X ecosystem connects data providers, software providers and data service consumers. After access control, data exchange can then take place via the so-called compute-to-data mechanism. The compute-to-data approach allows algorithms and calculations to be executed directly at the source of the data, instead of transporting the data to the algorithms. This means that data processing takes place in the data provider's secure environment where the data is stored, without sensitive data leaving this environment. This approach offers significant benefits in terms of data protection and data security, as it reduces the risk of data compromise while increasing efficiency by minimising data transfer. This system is used for access control in cloud and edge/IoT environments. It acts as a connector and proxy for data exchange and the orchestration of data transfers, and the coordination of infrastructure, data and software in the context of compute-to-data and compute-to-edge.

Taking these kind of service elements and functions into consideration, a generic operating model for the EuProGigant Federator as data intermediary role can be scetched. However, many variants of this generic model can be defined. For instance, a general Data Usage Agreement may be proposed to the Data Licensor upfront when the Data Product is inserted in the Catalogue and the Licensor can trust the Data Intermediary to check the conditions and purpose before delivering data usage to a consumer.

Hence, the EuProGigant ecosystem is free to define and implement the operating model adapted to the needs and requirements of the participants, users and use cases:

Gaia-X as de-facto standard provides a solid legal and technical foundation to enable many different use cases to unlock from these traditional boundaries and to scale within and across the European Member States at the required pace to sustain manufacturing value-chains. All the participants and use case contributors in EuProGigant have prior experience with the design and setup of data lakes, data space and/or data exchange services. There is a strong drive in the community to team up, to scale and to accelerate an efficient and sovereign data exchange. The ambition of these use cases, of which four of them are detailed in the following chapter, is to contribute to data cooperation for manufacturing delivery and manufacturing research. The current state of data collection, exchange and processing in Europe is limited by scale, gaps in standardization and by legal challenges and national boundaries.

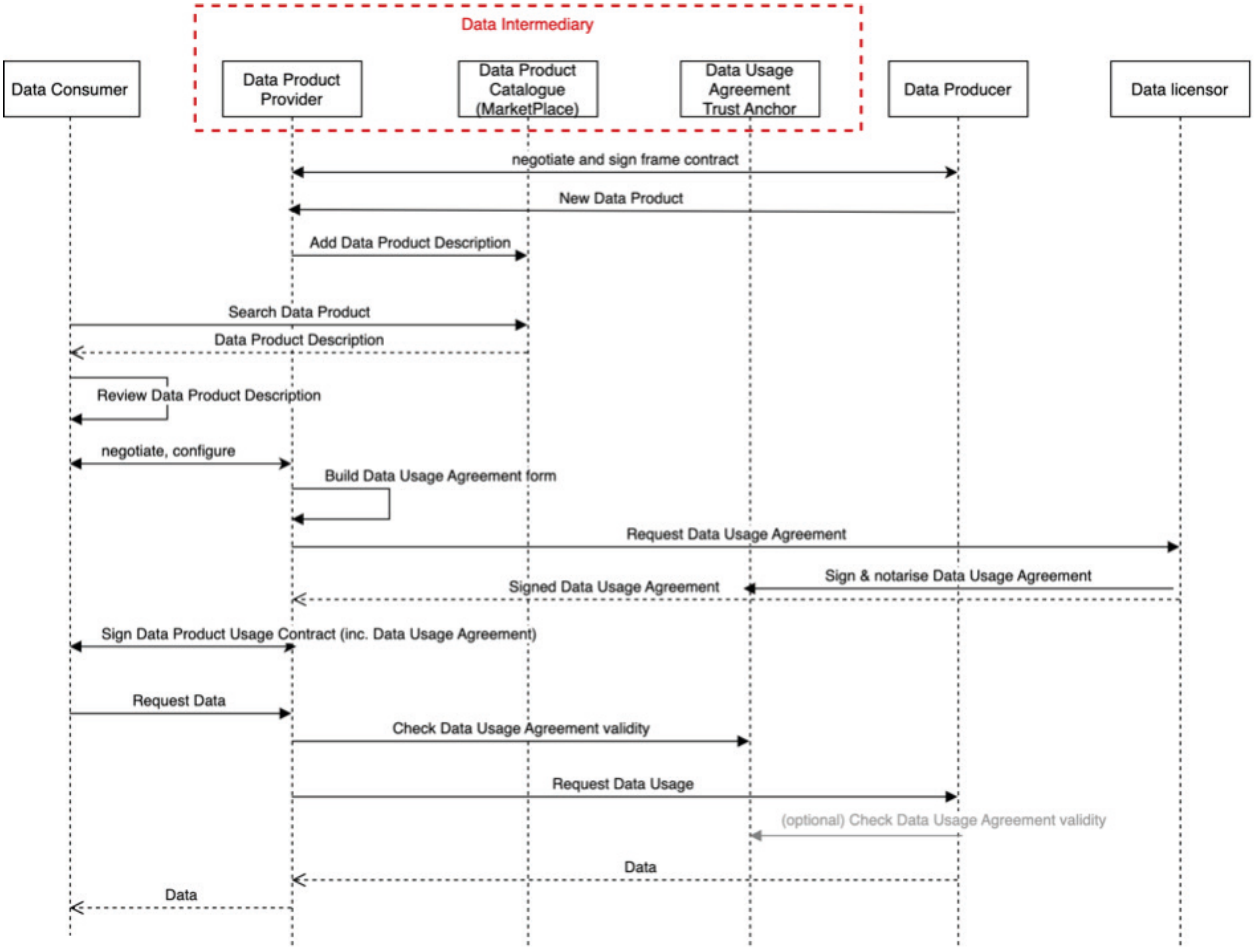
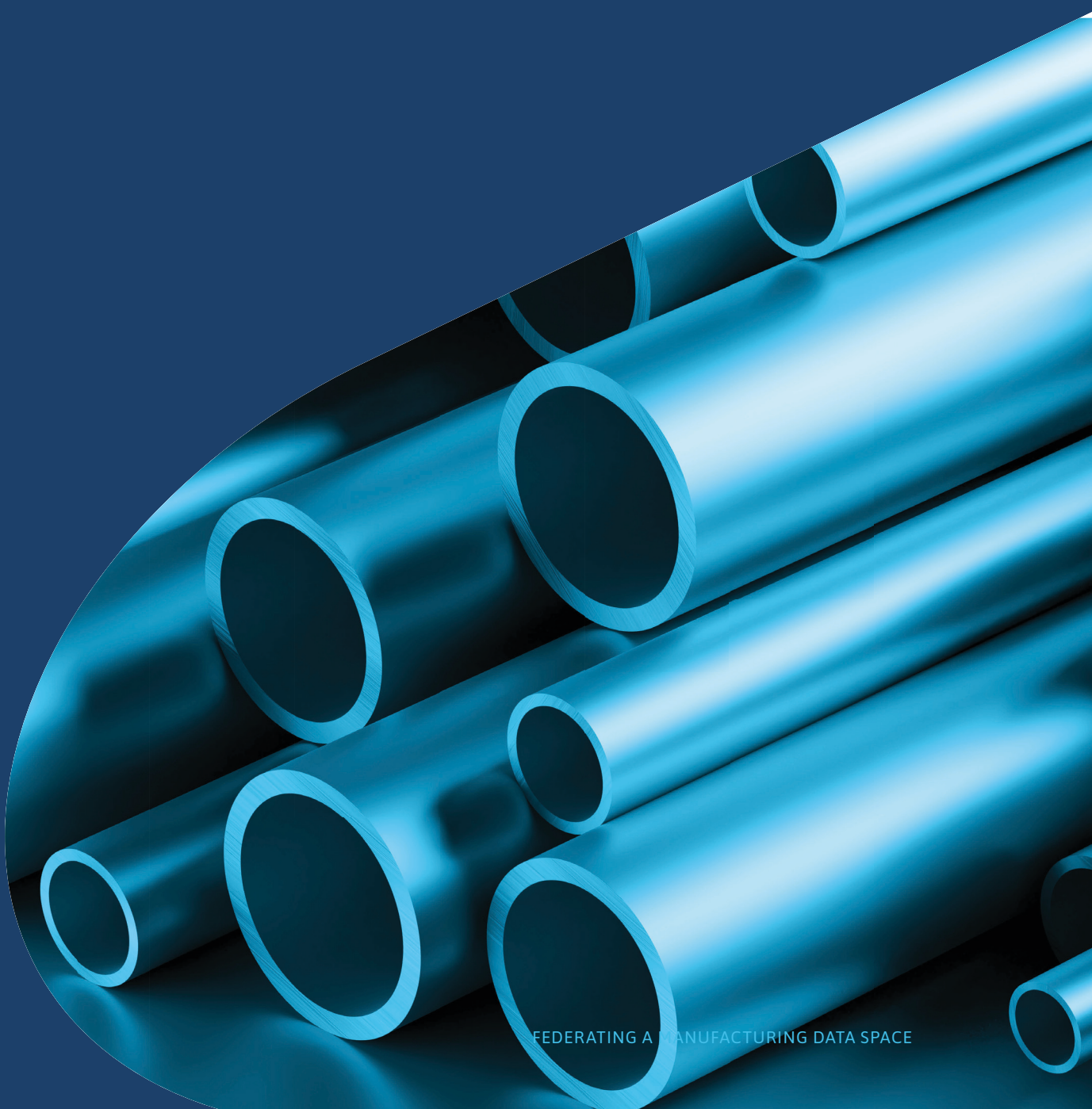


Figure 22: Workflow in the data exchange and the role of the EuProGigant Federator as intermediary; Source Gaia-X AISBL

6. THE DATA EXCHANGE USE CASES



In this context, it is no surprise that manufacturing data initiatives exist in many countries with many different variations. There is no single data space for the entire manufactuirng sector across all Member States. Therefore, the EuProGigant initiative can strive towards a better integration of existing and future data space initiatives, towards coordination across a federated landscape, and towards a smarter reuse of concepts, infrastructure, and common components.

For the scope of this white paper, we have described a small, representative set of manufacturing sector use cases. The ambition of these use cases is to become a new orientation for manufactuirng delivery and to illustrate the underlying new business model opportunities. By lowering the thresholds to adopt and deploy these enabling capabilities, the expectation is to leverage data sharing and data exchange in the future and to accelerate adding further use cases to the roadmap while the data sharing initiative will progress.

Use Case 1: Validation Platform

Predictive maintenance in production holds the promise of reducing maintenance costs and mitigating unplanned machine downtimes, thereby enhancing economic efficiency and increasing the availability of machines and systems (Hoffmann et al. 2020). While many companies recognise the potential of this technology, practical implementation often proves challenging (Metternich et al. 2021). Leveraging mathematical models, often derived from machine learning, predictive maintenance relies on sensor data from machine components for both training and operation. Models predicting the remaining lifetime of components particularly depend on a robust historical data basis for reliable outputs (Liao und Köttig 2016). For components that constitute a significant proportion of a machine's cost, such as a machine tool spindle, it is essential to gather long-term data records from multiple comparable machines to track degradation and wear events adequately (Bossler et al. 2021). However, small and medium-sized enterprises (SMEs) face challenges in providing comprehensive and high-quality datasets, often having access only to limited historical datasets (Heimes et al. 2019). Additionally, their heterogeneous machine fleets make collecting data on similar machines and components more challenging.

The concept of a validation platform addresses these challenges, allowing companies without extensive databases to monitor machines and assemblies collaboratively, enabling predictive maintenance. In the EuProGigant project, this concept is being tested on several similar machine tools across various sites of different production companies. Figure 24 illustrates the validation platform concept, emphasising the close interaction of data suppliers, data enablers, and data users. The machine operator and maintenance engineer act as both data suppliers and users, generating condition-relevant data during machine operation and maintenance. This data is stored by the storage provider, and used by the analytics provider to train and operate

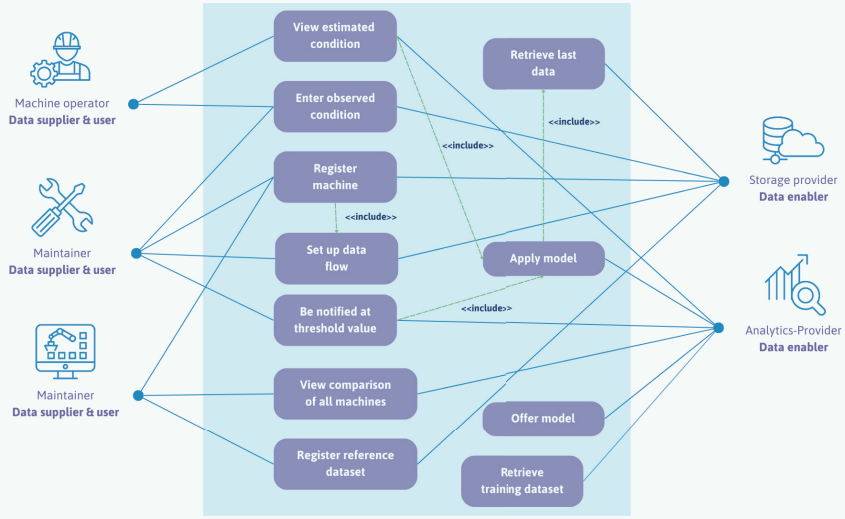


Figure 23: Players and connections within the "validation platform" use case; Source: Own figure

the provided condition monitoring model. The machine tool OEM registers the machine, determining the reference dataset for similar machines. The platform assesses the machine condition and notifies the maintainer when the remaining service life of a component falls below a threshold. Feedback from both actors improves the condition monitoring model, with the machine tool OEM, storage provider, and analytics provider assuming the roles of data enablers.

The approach enables companies with a heterogeneous machine park to apply predictive maintenance to a more significant part of their machines, speeding up the building of a comprehensive database and enhancing prediction accuracy with actual process data from machine operation. A Gaia-X-compliant platform ensures trustworthy data transfer and merges data streams from different companies, safeguarding authorised access and preventing intellectual property leakage. Data enablers, including the machine tool OEM, storage provider, and analytics provider, can generate new cash flows through an appropriate revenue model. A subscription model is recommended for continuous services, with payment per connected machine or component. Tiered pricing is also considered, based on expected cost savings from enabled or improved predictive maintenance. The machine tool OEM can use the data to optimise products and product-service offerings, compensating a portion of the payments. This revenue stream allows data providers to cover operating costs, develop and maintain predictive models, and receive a profit incentive to participate in the business model.

Use Case 2: Ideal component matching

The assembly of modules, such as a shaft-hub connection, involves integrating individual components from various sources. Typically, machining companies produce some components in-house, while the remaining parts are sourced from different suppliers. Due to stochastic variations in each company's manufacturing environment, the actual geometries of components may slightly deviate from specifications. Assembly combination tolerances and allowable deviations for individual parts are set within specified limits. Specially manufactured components compensate for deviations within a sum tolerance. This innovative solution employs sensory tools and workpiece clamping devices, with data processed using artificial intelligence methods. This allows for the identification of statistical correlations between component dimensions and processes, enabling manufacturers to enhance assembly quality and produce precisely matched components as needed.

In the EuProGigant project, this novel concept is being tested on a machine tool spindle, where two project partners manufacture relevant components in the spindle housing and the spindle rotor at different locations. The machine tool spindle is ideal for this concept due to its high value, accounting for a significant proportion of the total product cost. Additionally, the spindle is crucial for manufacturing accuracy and the quality of components produced on a machine tool (Stanula et al. 2021). Consequently, stringent requirements exist for the manufacturing accuracies of the housing and rotor, as well as for fitment accuracy and concentricity in the resulting assembly. The concept of ideal component

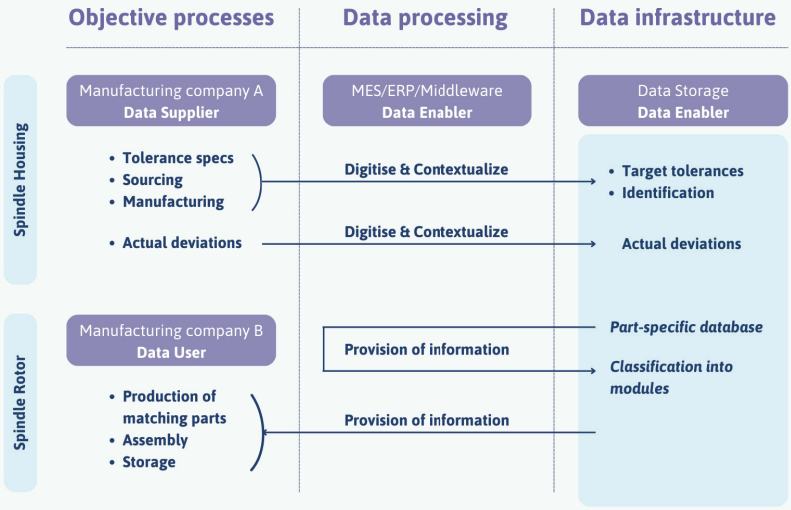


Figure 24: Players and activities within the "ideal component matching" use case; Source: Own figure

matching relies on close collaboration among the data supplier, data enabler, and data user. Manufacturer A produces the spindle housing according to tolerance specifications, capturing data, including actual deviations. This data is digitised, contextualised via middleware, and stored, uniquely assigned to each produced component. With this data, manufacturer B can identify the ideal counterpart for the spindle rotors it manufactures, merging component data for matching via middleware. The result, classified into modules, is stored, allowing manufacturer B to plan component assembly and produce a matching spindle rotor if no corresponding counterpart is available.

A key value proposition of ideal component matching is a significant reduction in non-value-adding tasks, leading to higher resource efficiency with fewer rejected parts. Trustworthy data transfer within Gaia-X eliminates the need for a direct sequence of final goods inspection at the supplier and incoming goods inspection at the customer. Instead, the customer receives trustworthy component information directly from the supplier's final inspection. This concept also enables time flexibility in cross-company value chains, offering a sustainable value contribution through increased speed of value creation. A potential 10% productivity increase is achievable in the case of the machine tool spindle, stemming from a reduction in assembly time. The revenue model for data providers and enablers involves renumeration for added benefits to the data user, aligned with expected cost savings per assembled component. In this use case, payment is made per purchased component for which matching data was provided during handover, with billing occurring at regular intervals to accommodate the high number of individual contacts and transactions. This approach allows data providers and enablers to cover their costs for operating the digital infrastructure and collecting trusted data while creating a profit opportunity as an incentive to participate in the business model.

Use Case 3: CO2-Footprint in product creation

The „CO2-Footprint in product creation" approach is situated within the domain of plastic injection molding. In this energy-intensive field, even minor efficiency improvements present significant potential for savings. The importance of this subject is underscored by the global annual plastics production, which stands at 370 million tons (Reckter 2022). Within the relevant stakeholder cluster, participants currently lack or have only limited access to digital tools throughout the product creation process that would facilitate early assessment and evaluation of the aforementioned aspects. Existing tools are not interconnected, hindering the ability to provide a comprehensive carbon footprint prognosis that aids in identifying the optimal combination of raw materials, processes, and machinery to minimise greenhouse gas emissions. A viable business model is required to incentivise data exchange and extensive data evaluation through computational models within the ecosystem.

The stakeholders in this specific use case include a process simulation provider, a machine manufacturer, a polymer producer, and an IoT platform software company. Leveraging opportunities include considerations such as raw material selection, tool construction, machine type

(hydraulic or electric), and appropriate tool and machine dimensions. These configuration options are interdependent; for example, a change in polymer necessitates adjustments in injection pressure and temperature, prompting corresponding modifications to the tool or machine.

Within this particular domain, there is currently no central federator or effective data exchange, leading to suboptimal configurations that result in energy inefficiencies and the development of complex customised machines. Consequently, EuProGigant has reached a consensus on establishing an ecosystem to achieve three primary goals:

- Raise awareness among designers about their influence on the product carbon footprint.
- Provide a quantitative prognosis of the carbon footprint (e.g., for adaptation to CO2e restrictions or estimation of energy costs).
- Offer assistance in selecting the greenhouse gas optimal machine and raw material configuration.

Hence, we propose the model delineated in Figure 26 to manage data streams and service requests, elucidating the corresponding business model. The tool's user is a (potential) customer affiliated with one of the stakeholders in the injection molding domain, seeking a carbon footprint prognosis and willing to pay a usage fee. Collaborating with this stakeholder allows the application of the calculation tool, providing additional services that confer a competitive edge and foster stronger customer relations in the manufacturing domain.

While all participants possess at least partial means and capabilities for calculating aspects of the carbon footprint, a central orchestration of data flows (to downstream services) and revenue streams is imperative. Various options exist for fulfilling the role of the federator in this case, including an external third party or one of the aforementioned stakeholders. Nevertheless, legal constraints preclude the CO2e calculator from concurrently acting as the federator, in compliance with the provisions of the Data Governance Act, which prohibit data brokers from utilising brokered data for their own business purposes. Consequently, the only viable data analyses are those conducive to data exchange (Ditfurth und Lienemann 2022).

The IoT-provider oversees the development and provision of the user interface, also assisting the federator and carbon footprint calculator in establishing the ecosystem's infrastructure and collaboratively forming the carbon footprint provider group. We consider this group the most cost-intensive, heavily reliant on the usage fee. To calculate the footprint, orchestrating various services and databases is essential for obtaining a valid and comprehensive carbon footprint prognosis. The injection molding machine manufacturer contributes a service for calculating machine energy consumption, contingent on required pressure and temperature. These values, provided by the process simulation provider with access to product geometry and material properties from the designer and polymer producer, ensure a complete footprint analysis.

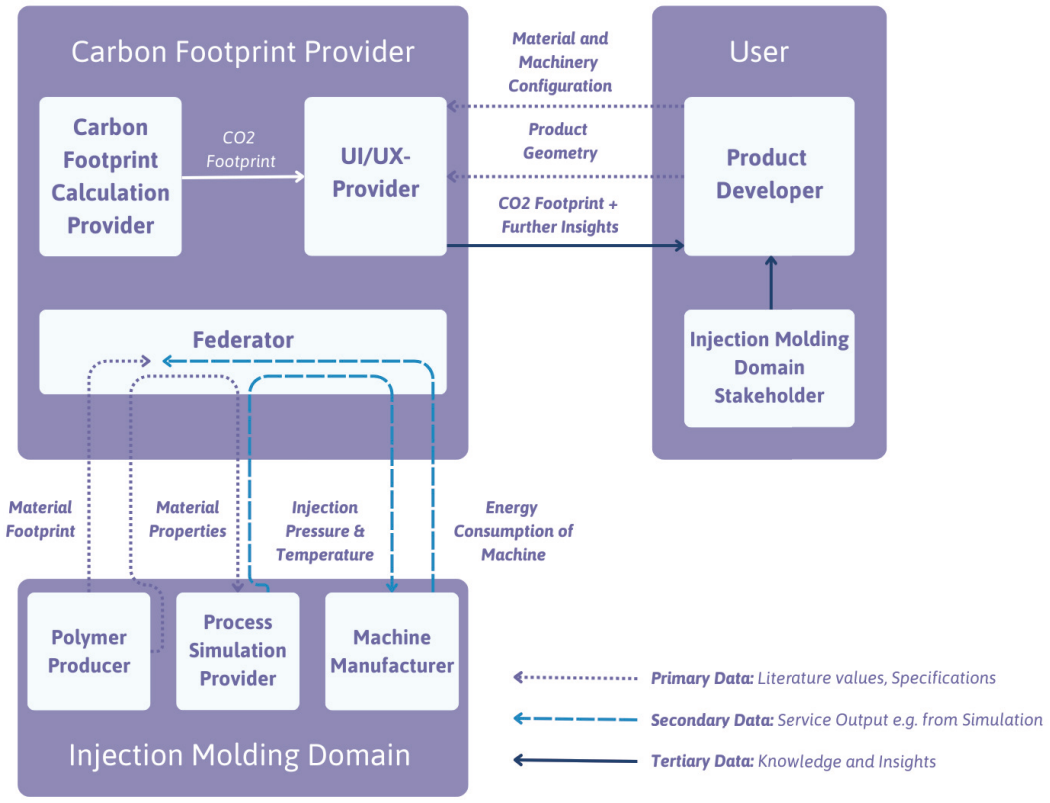


Figure 25: Business model and architecture of the "CO2-footprint in product creation" use case; Source: Own figure

While it is conceivable for polymer producers and machine manufacturers to participate without a direct revenue stream, showcasing their products, the process simulation provider relies on payment due to the intricate nature of simulations, which remain not fully automated.

There are different business models and business mechanics for the three different use cases presented. In most cases there will be a need for initial funding, for research and innovation and for public-private collaborations to establish a working architecture, the common enablers, and the initial demonstrators of the federated Manufacturing Data Space. Thereafter, usage-based payment models will fund the sustainable operation of infrastructure and services.

7. VALUE PROPOSITIONS AND FINANCIAL ASPECTS OF DATA SHARING

7.1. EUPROGIGANT'S CORE VALUES AND VALUE PROPOSITIONS

A business model defines how an organisation generates benefits for its stakeholders and thus generates revenue. The elements of the business and governance concepts presented in this white paper are currently being implemented. We are working on models that have the potential to enable the interaction of participants in the manufacturing data space and to unlock the potentials for efficiency advantages for themselves, which can be represented in the form of cost and time savings, or new revenue opportunities impacted by data cooperation.

The main ambition of the EuProGigant project is to improve data sharing in the manufacturing value networks. Data sharing has been on the agenda in research and in industry, but still there are major barriers to efficient sharing of data and information between organisations even in the same value network or chain. In EuProGigant we are now able to demonstrate that there is a huge potential for value generation and that data sharing among actors in a value network is crucial for data space participants and for legislators requiring increasingly values like sovereignty, transparency, trustworthiness, safety and security.

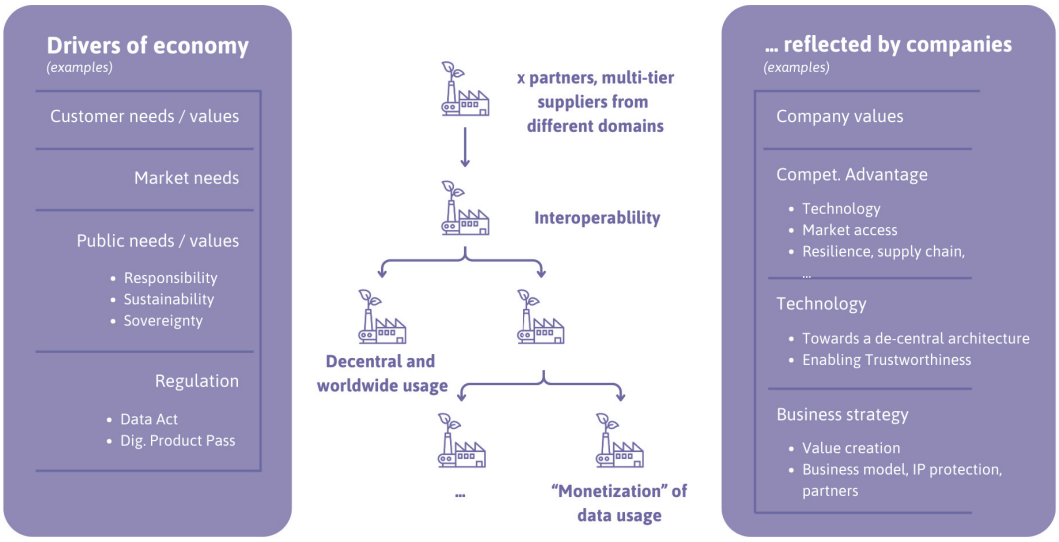


Figure 26: The industrial context in data economy and data spaces; Source: Gaia-X AISBL

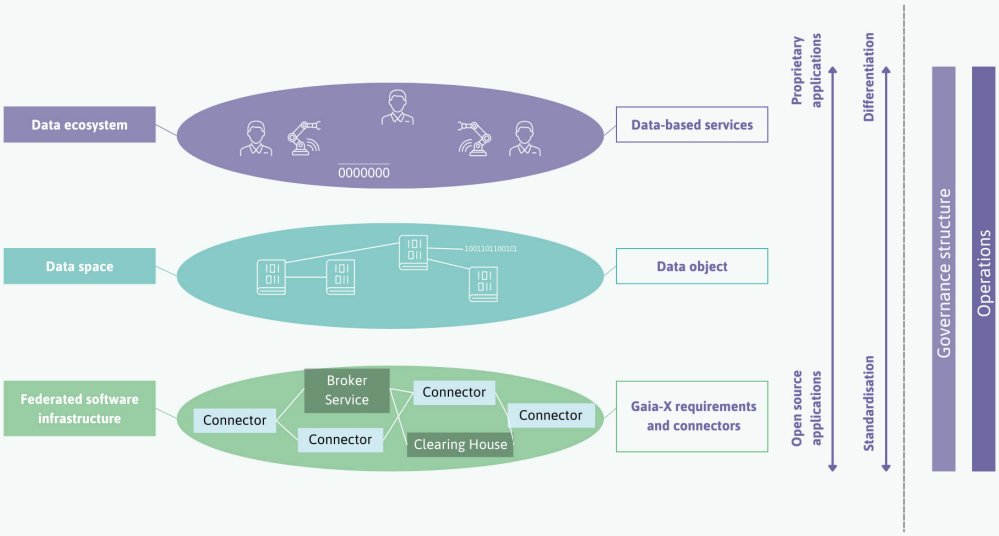


Figure 27: Elements of EuProGigant's data space; Source: VDMA, ZVEI, Fraunhofer

A central challenge to data sharing is data ownership. Especially in SMEs, there is a lack of know-how on how and what data and information can be shared. A central reason is the absence of a legal framework at EU level that duly protects 'property-type rights' over data and enables control over their usage. Our herein presented governance and business concept for the EuProGigant Federator will take this circumstance into consideration and will make suggestions for improvement.

The data quality and integrity are central topics in data sharing. In order for data sharing to make sense, the data has to be complete, accurate, valid, unique, consistent, up-to-date, traceable, clear and available. Our ambition is to create a governance and business framework that enables high-quality and high-integrity data sharing in the manufacturing ecosystem through a data sharing culture in the value networks and through proper technical means for interoperability.

The data sharing culture requires involvement of all kind of stakeholders. This provides a credible foundation to the EuProGigant initiative in the long term. It also requires breaking down of silos within and between companies, establishing robust and proactive data quality programmes, enabling self-service data quality, and measurement, communication and continuous improvement of data and data management processes. We recognise that data sharing is not only a question about interoperability of IT systems, but also a significant effort in human work involved in data curation in both the supplying and the using participants. Therefore, within this white paper we illustrate data sharing rules and data exchange models for making data secure to share. These rules shall be made easily accessible, especially for SMEs. The aim is to create a culture where the people know how to share data and how to benefit from data sharing.

The EuProGigant Federator will operate an independent and open marketplace for sharing data and data services that are relevant to all production processes. The elements are in the final development stages:

The current engagement rate is seen as one of the main criticalities in achieving the business outcomes. Therefore, it is crucial, to reach paticipants' growth and commercialisation, to attract new active users and to activate those already in the platform. One of the main challenges we face is to explain companies, especially those without technical skills, the data space concept and how the „data spaces" paradigm is different from previous data sharing approaches. Furthermore, it must be clearly demonstrated what are the real benefits of using the data space approach and how it can improve data valorisation both inside the company and externally.

We have the important assets available to work on the criticalities. The conceptual model and building blocks approach provide a good and detailed overview of the main concepts like trust, data sovereignty, interoperability, business models and data governance. Now it is about making our stakeholders perceiving the value. And «value» equals dimensions, activity rate and relevance of the outputs gained through the participation in the activities of our data space community. This will support framing the plat-

Figure 28: How EuProGigant's data sharing creates value for its stakeholder, Source: Own figure

form position and our strategy even more with orientation towards participants needs and requirements.

The participants in the data space will be offered to provide data, acquire data, consume data, generate new revenues using data-driven business models, save costs and create additional values by networking. Through direct exchange, participants can find new partners, develop common ideas for data-driven products and services, and establish innovative business models.

Taking all elements of the technical, legal, functional and architectural framework into consideration, our EuProGigant data room offers customer values such as:

- Growth opportunities
- Unlocking potential for value-adding services,
- Networking: enabling companies to discover new value chain or new business with other companies
- Security, support and customer care
- Enabling a fair and trustworthy data sharing economy
- Resilience: data sharing opens opportunities for more resilient production models in manufacturing processes
- Decentralisation: data is not stored centrally, but securely transferred peer-to-peer
- Replicability: building blocks and guidance for easy adoption
- Freedom to negotiate contract terms and prizes
- Contribution to standards

The value proposition of the EuProGigant Federator kann be summarised in the following key message:

EuProGigant provides vendor-neutral, business-friendly and industry-grade open-source tools for sharing data that can be exploited via innovative business models. This data marketplace contributes to resilient and sustainable production by providing a secure and trustworthy environment for sovereign data exchange.

7.2. MONETISATION OF DATA SHARING VALUES

New business models in the realm of Industry 4.0 emphasise a consistent service-oriented approach. Many business models have already evolved based on the shift from product/service/data ownership to on-demand usage. This means that producers no longer just make and sell products; instead, they offer comprehensive services tailored to individual customer needs. Applying this to business modeling for data sharing and data cooperation, companies may unlock now the potential to develop new models where data is shared and used as a service. Instead of simply selling data, businesses can provide data-driven services that offer real value

to customers. This can include analytics, insights, or integrated data solutions that are tailored to the specific needs of the user. By networking data sources, production facilities, and business processes, companies can create flexible revenue models that depend on the value and intensity of data usage. This service-oriented approach to data can lead to innovative business opportunities and stronger cooperation among businesses.

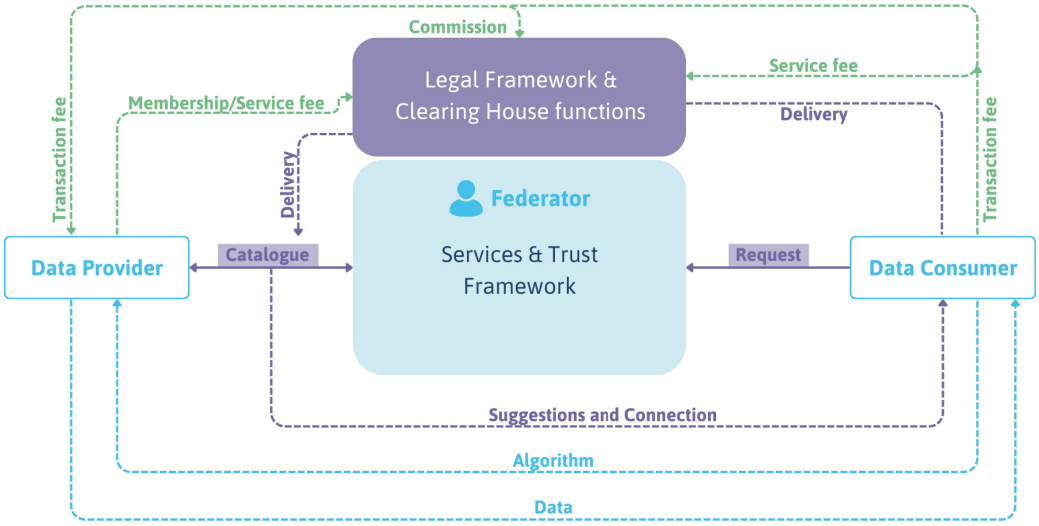


Figure 29: Schematic flow of data and money in EuProGigant's data sharing ecosystem; Source: Own figure

In platform-driven initiatives, developing business models is challenging because many project partners with different goals, attitudes, and motivations come together. Individual partners might focus solely on their personal interests, neglecting broader goals and outcomes. Therefore, alongside business and governance modeling, it is crucial to foster a strong culture of trustworthiness. This culture of trust is essential for successfully attracting and integrating participants into the data-sharing ecosystem. Trust-building measures at personal, organisational, and technical levels can ensure a productive and harmonious working environment and lead to unlocking innovative business opportunities. The following chart simplifies the data and money flow that can be incurred in the EuProGigant data sharing ecosystem:

The schematic flow can be described as follows: (a) The onboarded consumer has access to the data and service catalogue and finds the required dataset as well as its provider. (b) He connects to the provider and agrees on terms and conditions for contracting, prizing and data transfer. (c) Via the Distributed Ledger Technology, the consumer sends his algorithm to the dataset provider, (d) who loads the algorithm with the data and (e) returns it to the consumer. (f) The consumer is now prepared to apply the purchased dataset. (g) The data consumer pays for the dataset a transaction fee, (h) whereby a

small percentage of the transaction fee goes to the federator for orchestrating the deal. (i) Also, other compensation schemes are possible (direct service fee, membership fee, etc.).

EuProGigant is a binational project, currently funded by the Austrian Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology (BMK) and by the Germany Federal Ministry for Economic Affairs and Climate Action. The Federator shall be established as a legal entity in 2025 and should have a sustainable fee and business model in the medium and long term. There are several tactics for revenue generation that can be used by an entity, which is federating data sharing directly through the platform or through third-party services. They are briefly addressed in the following to conclude on the monetisation strategy for the EuProGigant Federator.

For this purpose, we will distinguish between three different fee models: membership fee, transaction fee and service fee:

The membership fee is purely a participation fee granting access to the data space and its services. It is the simplest and most widespread form of monetisation in platform-based business models. Members pay a recurring fee to the platform operator (Federator). Membership fees constitute a flat rate (no matter how much data or services are exchanged), they are regular and plannable payments. They are easy to administer because the billing is less complex than in other payment schemes. Nevertheless, there is a need for stagged fees based on member size (i.e. SMEs) and type (i.e. universities and RTOs). The option to withdraw inactive users allows the Federator to focus on the needs of the active users. Members, that are active in multiple data spaces might face high cumulative costs for membership.

With the transaction fee, the platform operator receives a fixed fee or a percentage of the purchase volume for every transaction carried out with the help of the Federator. The data consumer benefits because he only pays for transactions that are carried out (transparency). For both, consumers and providers, the fluctuating of transaction volumes make planning difficult. This disadvantage of unpredictable revenues (for the provider) or costs (for the consumer) is compensated by the advantage that the transaction fee only occurs for each data transfer, which promotes efficient use and reduces unnecessary or redundant transactions. For the Federator it is a scalable mechanism with revenues growing with increasing usage. Obstacles for the participants may be that the actual value of data can be less than the transaction fees and that an uncertainty exists due to clarification needed as to what counts as a transaction. However, a Federator can justify higher values for transactions, if the ecosystem-based transaction is using Gaia-X regulations and standards and is therefore preferred by the participants over classical transaction fees (Strnadl 2023).

Charging service fees in data spaces is a justified practice, especially considering the different types of services provided. These fees ensure the sustainability and continued development of the data space infrastructure, fostering an environment where value can be created and maintained for all participants. The justification can be based on the following considerations:

- Services provided by the data space itself (i.e. value-adding services, data analysis reports, consulting fees, etc.). Generating insightful reports from raw data as well as expert consulting requires significant computational resources and expertise. Charging fees for this knowledge ensures that the data space can continue to invest in advanced analytics tools and skilled personnel.
- Services provided by external service providers in the data space. It is conceivable that the Federator charges a kind of „brokerage fee“ for services from trusted partners who offer services such as data pricing, data harmonisation, data aggregation, etc. via the data space infrastructure. The Federator can charge a brokerage fee for facilitating access to these trusted partners. This fee compensates for the vetting process and the maintenance of a reliable network of service providers. By acting as a broker, the Federator ensures that the services offered meet high standards of quality and reliability. This adds value to the data space participants, who can trust that the services they are accessing through the data space are vetted and credible.

Benefits of service fees are:

- Sustainability and Growth: Service fees provide a revenue stream that supports the ongoing operation and enhancement of the data space. This financial stability allows for continuous improvement of the infrastructure and services offered.
- Quality Assurance: Fees associated with services help maintain high standards by enabling the data space to invest in quality assurance processes. This includes regular audits, performance evaluations, and updates to ensure that all services remain top-notch.

- Enhanced User Experience: Revenue from service fees can be reinvested into the platform to improve user experience. This could include developing user-friendly interfaces, enhancing customer support, and expanding the range of services available.

In conclusion, implementing service fees in data spaces is a strategic approach to ensuring the ecosystem's sustainability, fostering trust, and enhancing the overall value provided to participants. By charging for both internal and external services, the data space can continue to offer high-quality, reliable, and innovative solutions that meet the evolving needs of its users.

There can be also mixed fee schemes, in which, for instance, a membership fee is charged for access to the data space and then a fee is due for every transaction that exceeds an agreed basic volume. A common alternative to the monetisation presented is advertisement financing, which can also be designed as a combination of membership-financed and advertising-financed monetisation.

The sharing of data has recently received increasing attention across organisations. The focus is now shifting from established concepts such as data bases, data warehouses, data lakes, etc. to so-called data platforms. The EuProGigant Federator has the opportunity to "sail in this wind of change" and to unlock the potential for a sustainable business in a manufacturing ecosystem.

CONCLUSION

Data is an increasingly important part of the manufacturing industries, and with the emergence of Industry 4.0, this importance is set to grow exponentially. Since technological change has occurred so rapidly, the systems and processes we use to collect and share data have emerged alongside the technology incrementally and inconsistently. This has created several challenges for European policymakers who want to ensure that regulations and legislation remain one step ahead of technological change (Ahle 2024). One initiative that is providing coordination and leadership in the regulated Gaia-X context to address the social, economic, and technical challenges for the manufacturing ecosystem is EuProGigant.

EuProGigant is seeking to create a federated data infrastructure, a decentralised ecosystem where data can flow seamlessly while ensuring privacy, security, and sovereignty. European manufacturers now have the potential to make data easier to access and to use. They are an important part of driving that change, recognising the benefits that data collaboration can have.

By sharing data, companies can collaborate more effectively, leading to innovative solutions that may not have been possible in isolation. This collaboration can drive advancements in product development, process optimisation, and new service offerings.

Shared data pools provide access to a wider variety of data, which can improve machine learning models, enhance research and development efforts, and lead to more accurate predictive analytics.

Data sharing allows for better synchronisation of supply chains, improved inventory management, and streamlined production processes. This can result in significant cost savings and increased operational efficiency.

Access to real-time data enables manufacturers to make informed decisions quickly, reducing downtime and improving overall productivity.

The data sharing economy paves the way for new business models such as data-as-a-service, where companies can monetise their data by providing valuable insights to others. This can create additional revenue streams and economic opportunities.

Companies that leverage shared data can gain a competitive edge by staying ahead of market trends, understanding consumer behavior better, and tailoring their products and services accordingly.

Data sharing initiatives can lead to the development of industry standards for data management and sharing, simplifying compliance with regulatory requirements and ensuring data quality.

Federated data infrastructures like EuProGigant ensure that data sharing is done securely and in compliance with privacy regulations, protecting sensitive information and building trust among participants.

Long-term benefits will only come when these initiatives achieve significantly larger scale, a higher level of semantic interoperability, and a high degree of trust within the user community. Many of the existing initiatives struggle with the same or similar basic functionality issues.

Networking with other Gaia-X lighthouse projects in domains such as energy, mobility, and aerospace will create a framework in which existing data initiatives can be integrated with reasonable efforts and costs. This will also make it easier to establish new initiatives.

The EuProGigant federated services should provide some of these basic capabilities in a sovereign and trustworthy environment. However, the data space will only be sustainable if it has attractive data offerings. EuProGigant's participants are already putting their first data into a catalogue, addressing key use cases, which are all very relevant for the industries. Leveraging

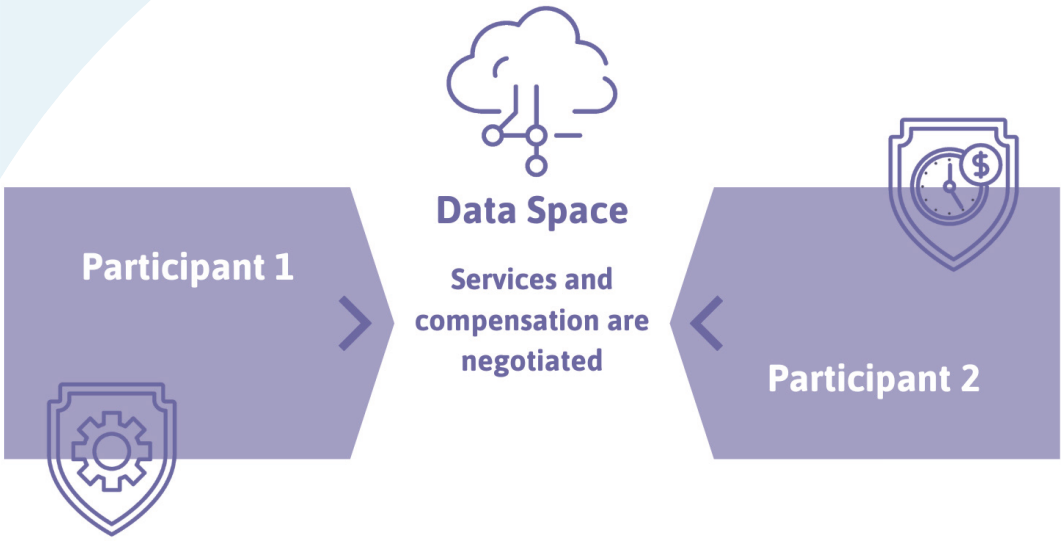


Figure 30: Business in EuProGigant's data sharing ecosystem; Source: Own figure

this initial success and networking with external projects will enhance the framework, allowing for the integration of existing data initiatives and the establishment of new ones with minimal effort and cost.

And there have to be attractive offerings for active participants and for those to be acquired. For this purpose, the following steps should be taken:

1. Finalise the development of an interoperable, distributed, public-private infrastructure: It will be mandatory to develop functional, legal, technical and operational agreements and proedures that support the most pressing needs of the participants in the manufacturing ecosystem. It is now a matter of agreeing on the optimal, coherent approach across all relevant disciplines and prioritising the most urgent use cases of manufacturing-related businesses.

2. Set up trusted governance: To facilitate trust, all stakeholders in setting up the governance should be included in the decision process and feel equally important in the co-creation. Different stakeholder groups represent different market needs and segments.

3. Promote data trust and data governance: Strengthen the achieved agreements to respect the standards and the guidelines for ethical use the data. We will have to harmonise these values and guidelines as much as possible. We have to demonstrate and to communicate our commitment to privacy and security and to the principles of data sovereignty by design.

4. Create awareness in the market: It will be key to create awareness of the rationale, concept, and functional range of the EuProGigant data space. Creating awareness beyond first movers will support the process of adoption. Ensuring adoption and scalability will be essential for the success of the endeavour.

5. Provide adequate level of funding (from EU programmes, national plans and initial revenues) to stimulate adoption of the EuProGigant framework to kick-start the deployment.

In conclusion, the potential and benefits of the data sharing economy are vast. By fostering a culture of trust, ensuring privacy and security, and creating a scalable and interoperable infrastructure, initiatives like EuProGigant can unlock significant value for the manufacturing industry and beyond. This will drive innovation, efficiency, and economic growth, ensuring that Europe remains at the forefront of the global data economy.

ANNEX 1: TABLE OF ACRONYMS

Acronym	Description
AAL	Ambient Assisted Living
App	Application
B2B	Business to Business (sales relationship)
B2B2C	Business to Business to Consumer (sales relationship)
B2C	Business to Government to Business (sales relationship)
CAGR	Compound Annual Growth Rate
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
EU	European Union
EU27	The 27 European Union Countries
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GP	General Practitioner
GTM	Go-to-Market
GTMS	Go-to-Market Strategy
ICT	Information and Communications Technolody
ISO	International Standards Organization
IT	Information Technology
n/a	not applicable
OECD	Organisation for Economic Co-operation and Development
OTT	Over The Top
PPPs	Public Private Partnerships
SMEs	Small and medium-sized enterprises
SWOT	Strengths, Weaknesses, Opportunities, Threats
USP	Unique Selling Proposition

ANNEX 2: LIST OF REFERENCES

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ANNEX 3: SUGGESTED FURTHER READINGS

Name	Description	Organisation
Data Spaces		
Designing Data Spaces	It provides a comprehensive view of data ecosystems and platform economics, from methodical and technological foundations to reports from practical implementations and applications in various industries. (https://link.springer.com/book/10.1007/978-3-030-93975-5)	Fraunhofer
Data Spaces: Design, Deployment, and Future Directions	Data sharing and exchange techniques using data spaces. Theory, technologies, methodologies, and best practices. (https://link.springer.com/chapter/10.1007/978-3-030-98636-0_1)	BDVA
Data Sharing Canvas	The Data Sharing Canvas is the foundation for generic and harmonised agreements which, once implemented, enable data sharing at scale within and across domains and sectors. This has been created together with the 40+ Data Sharing Coalition participants from different domains that represent over 100.000 organisations. (https://datasharingcoalition.eu/app/uploads/2021/04/data-sharing-canvas-30-04-2021.pdf)	Data Sharing Coalition (DSC)
FIWARE for Data Spaces	This white paper brings a perspective on how data spaces enabling the trusted and effective exchange of digital twin data between smart applications can be achieved. Furthermore, it brings the first perspective on how FIWARE and IDS Reference Models can be reconciled and contribute to accelerate the materialisation of Gaia-X. (https://www.fiware.org/marketing-material/fiware-for-dataspaces/)	FIWARE
Gaia-X Clearing Houses	Gaia-X Clearing Houses (GXDCHs) are nodes of verification of the Gaia-X rules. It is the place to go to obtain Gaia-X compliance and become part of the Gaia-X ecosystem. (https://gaia-x.eu)	Gaia-X
How to build Data Space	The knowledge base (a.k.a. „How to build Data Spaces?“) is the store of information that relies on IDS expertise that is meant to support building IDS components and contribute to the existing open source components based on a five-step approach. (https://docs.internationaldataspaces.org/knowledge-base/)	IDSA
Principals for Data Spaces	It defines the design principles for data spaces, agreements on the building blocks for a soft infrastructure and governance for data spaces. (https://design-principles-for-data-spaces.org/)	OPEN DEI

European Governed data sharing space	It enables data exchange and unlocking AI potential to create the conditions for developing a trusted European data-sharing framework. (https://www.bdva.eu/sites/default/files/BDVA DataSharingSpaces PositionPaper V2_2020_Final.pdf)	BDVA
The European Common Data Space	Data.europa.eu and the European Common Data Spaces (ECDS). (https://internationaldataspaces.org/wpcontent/uploads/dlm_uploads/EN_data_europa_eu_and_the_European_common_data_spaces_0.pdf)	EC
Gaia-X Trust Framework	Gaia-X aims to connect the Data and Infrastructure Ecosystems and relies on conceptual pillars to achieve that. In concrete terms, for each of these pillars there are 3 types of deliverables: Functional specifications, Technical Specifications and Software (Gaia-X Framework - Gaia-X: A Federated Secure Data Infrastructure)	Gaia-X
Business: Value and Models		
Data Spaces Brochure 2021	Use cases are cross-company business processes enabled by the IDSs standard. They help identify, analyse, and evaluate user requirements for IDS. (https://internationaldataspaces.org/wpcontent/uploads/dlm_uploads/220812_Use-CaseBro_2022_35-MB.pdf)	IDSA
Fair Data Economy Rulebook	Designed to guide forming of trust-based data-sharing networks with a common mission, vision, and values. (https://www.sitra.fi/en/publications/rulebook-for-a-fairdata-economy/)	SITRA
New Business Models for Data Spaces Grounded in Data Sovereignty	This paper applies frameworks and methods, including the business model and business ecosystem canvases, to the IDS perspective. These support a structured approach and a checklist for business planning purposes. (https://internationaldataspaces.org/wpcontent/uploads/IDSA-Position-Paper-New-Business-Modelssneak-preview-version.pdf)	IDSA
Legal Landscape and Governance Models		
Analytical report on EU law applicable to sharing of nonpersonal data	A report focusing on a thorough analysis of EU legislation applicable to sharing non-personal data, aiming to provide a structured overview of all the relevant European instruments within this field. (https://eudatasharing.eu/legal-aspects/report-eu-lawapplicable-sharing-non-personal-data)	SCDS
EU regulation builds a fairer data economy	Working paper that summarises the European Data Strategy and the new legislative proposals for the data economy (Data Governance Act, Digital Markets Act, Digital Services Act, Artificial Intelligence Act and Data Act). It complements this overview with an exploration of the proposals' opportunities from the perspective of the public sector, SMEs, and individuals. (https://www.sitra.fi/app/uploads/2022/06/sitra-eure-gulation-builds-a-fairer-data-economy.pdf)	SITRA
Principles for a Data Economy: Data Transactions and Data Rights	Set of transnational Principles that can facilitate the drafting of model agreements or provisions to be used voluntarily by parties in the data economy. (https://www.europeanlawinstitute.eu/fileadmin/user_upload/p_eli/Projects/Data_Economy/Principles_for_a_Data_Eco nomy_Final_Council_Draft.pdf)	ALI-ELI

Rulebook for a fair data economy	data economy Guide for creators of fair data economy networks, providing agreement templates and other tools to facilitate building and joining data networks. (https://www.sitra.fi/en/publications/rulebook-for-a-fairdata-economy/)	SITRA
White Paper on the Data Act	The data act white paper attempts to provide a first detailed analysis of the various provisions of the data act in light of the broader EU data economy policy and regulatory landscape. (https://www.law.kuleuven.be/citip/en/news/item/whitepaper-data-act)	KU Leuven
White Paper on the Data Governance Act	The white paper offers an academic perspective to the discussion on the Data Governance Act proposal ("DGA proposal"), as adopted by the European Commission in November 2020. It contains a legal analysis of the DGA proposal and includes recommendations to amend its shortcomings. The White Paper aims to cover the full spectrum of the DGA proposal and therefore offers an indepth analysis of its main provisions. (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3872703)	KU Leuven
Functionality and Technology: Blueprints and Building Blocks		
Data Connectors	This report captures 16 Data Connector variants and provides insights into their current development and usage status. Beyond the Data Connectors, this report provides insights into emerging technologies and concepts in data spaces and fundamental technologies that form a basis for data spaces. (https://internationaldataspaces.org/download/35299/)	IDSA
Data Usage Control in the IDS	This paper focuses on data usage control and data provenance, which are conceptual and technological solutions to cope with data sovereignty challenges. It presents three approaches researched and developed within Fraunhofer: The MYDATA control technologies, the logicbased usage control and degree. (https://internationaldataspaces.org/wpcontent/uploads/dlm_uploads/IDSA-Position-Paper-UsageControl-in-the-IDS-V3..pdf)	IDSA
FIWARE for Digital Twins	It describes how smart applications from multiple domains can be developed based on the Digital Twin paradigm using FIWARE software building blocks. Central in the vision, the NGSI-LD API is proposed as an open standard API for getting access to digital twin data and the use of standard data models is promoted to ensure the portability and replicability of solutions. (https://www.fiware.org/marketing-material/fiware-fordigital-twins/)	FIWARE
iSHARE	iSHARE is a coherent model ("Trust Scheme") of functional, technical, and legal agreements and standards used in the Dutch transport and logistics sector to exchange data. (https://ishare.eu/)	iSHARE
IDS Reference Architecture Model 4.0	The IDS RAM contains the conceptual level, including technology-agnostic specifications. The general outline of the IDS RAM is based on the five layers and the three perspectives. Each layer should reflect the main components and aspects of the IDS. (https://github.com/International-Data-SpacesAssociation/IDS-RAM_4_0)	IDSA

Smart Data Models	Smart Data Models is a collaborative program to provide data models for digital twins and data spaces. The SDMs are free and open-licensed, multisector, based on real use cases and adopted open standards, collaborative, at market speed, customisable to local needs and compatible with linked data. (https://smartdatamodels.org/)	FIWARE
Technical Convergence Discussion Document	The discussion document is an agile paper that defines a common reference technology framework for creating data spaces. This framework is based on the technical convergence of existing architectures and models for data spaces defined by members of the Data Spaces Business Alliance. (https://data-spaces-business-alliance.eu/dsba-releasestechnical-convergence-discussion-document/)	DSBA
Gaia-X Architecture	Set of description models and operating rules for decentralized cross-dataspace interoperability. (https://docs.gaia-x.eu/)	Gaia-X
DCAT-AP	The DCAT Application profile for data portals in Europe (DCAT-AP) is a specification based on W3C's Data Catalogue vocabulary (DCAT) for describing public sector datasets in Europe. Its basic use case is to enable a crossdata portal search for data sets and make public sector data better searchable across borders and sectors. This can be achieved by the exchange of descriptions of data sets among data portals. (https://github.com/SEMICeu/DCAT-AP)	EC
Organisations and Associations		
BDVA	With more than 230 members all over Europe, Big Data Value Association - BDVA focuses on enabling the digital transformation of the economy and society through Data and Artificial Intelligence by advancing in areas such as big data and AI technologies and services, data platforms and data spaces, Industrial AI, data-driven value creation, standardisation, and skills. (https://www.bdva.eu/)	BDVA
Data Space Business Alliance	Bringing together data providers, users and intermediaries, data spaces are key to driving businesses to extract value from data competitively. With its combined cross-industry expertise, resources and know-how, the Alliance drives awareness, evangelises technology, shapes standards and enables integration across industries. (https://data-spaces-business-alliance.eu/)	DSBA
DSC	The Data Sharing Coalition - DSC aims to drive (crosssectoral) data sharing, under control of the entitled party, by realizing data sharing use cases, enabling interoperability between data spaces, and strengthening individual initiatives. It explores and defines agreements on topics such as technical standards, data semantics, legal agreements, and trustworthy and reusable digital identities. (https://datasharingcoalition.eu/)	DSC

FIWARE	Together with its members and partners, FIWARE Foundation drives the definition – and the Open Source implementation – of key open standards that enable the development of portable and interoperable smart solutions and the trusted and effective exchange of data among solutions. (https://www.fiware.org/)	FIWARE
Gaia-X	With Gaia-X, representatives from business, science and politics on an international level create a proposal for the next generation of data infrastructure: an open, transparent, and secure digital ecosystem, where data and services can be made available, collated, and shared in an environment of trust. (https://gaia-x.eu/)	Gaia-X
IDSA	With 130 member companies, the International Data Spaces Association - IDSA aims to develop a reference architecture for international data spaces IDS, including a governance model and adoption strategy. Continue to evolve IDS-based on use cases. Establish IDS as the international standard for data exchange in the economy of the future. And support certifiable software solutions and business models. (https://internationaldataspaces.org/)	IDSA
MyData Global	The purpose of MyData Global is to empower individuals by improving their right to self-determination regarding their personal data. (https://mydata.org/)	MyData
Sitra	Sitra is a Finnish Fund that is influential nationally and internationally and acts as a think tank, promoter of experiments and operating models and a catalyst for cooperation. They collaborate with partners from different sectors to research, trial and implement bold new ideas that shape the future. (https://www.sitra.fi/)	Sitra
Team Data Space	Team Data Spaces brings together the leading European players in data spaces from European associations, industry, and research organisations with a common vision to deliver European data spaces. (https://dataspaces4.eu/)	Team Data Space

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Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Gefördert durch:
Bundesministerium
für Wirtschaft
und Klimaschutz
aufgrund eines Beschlusses
des Deutschen Bundestages

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