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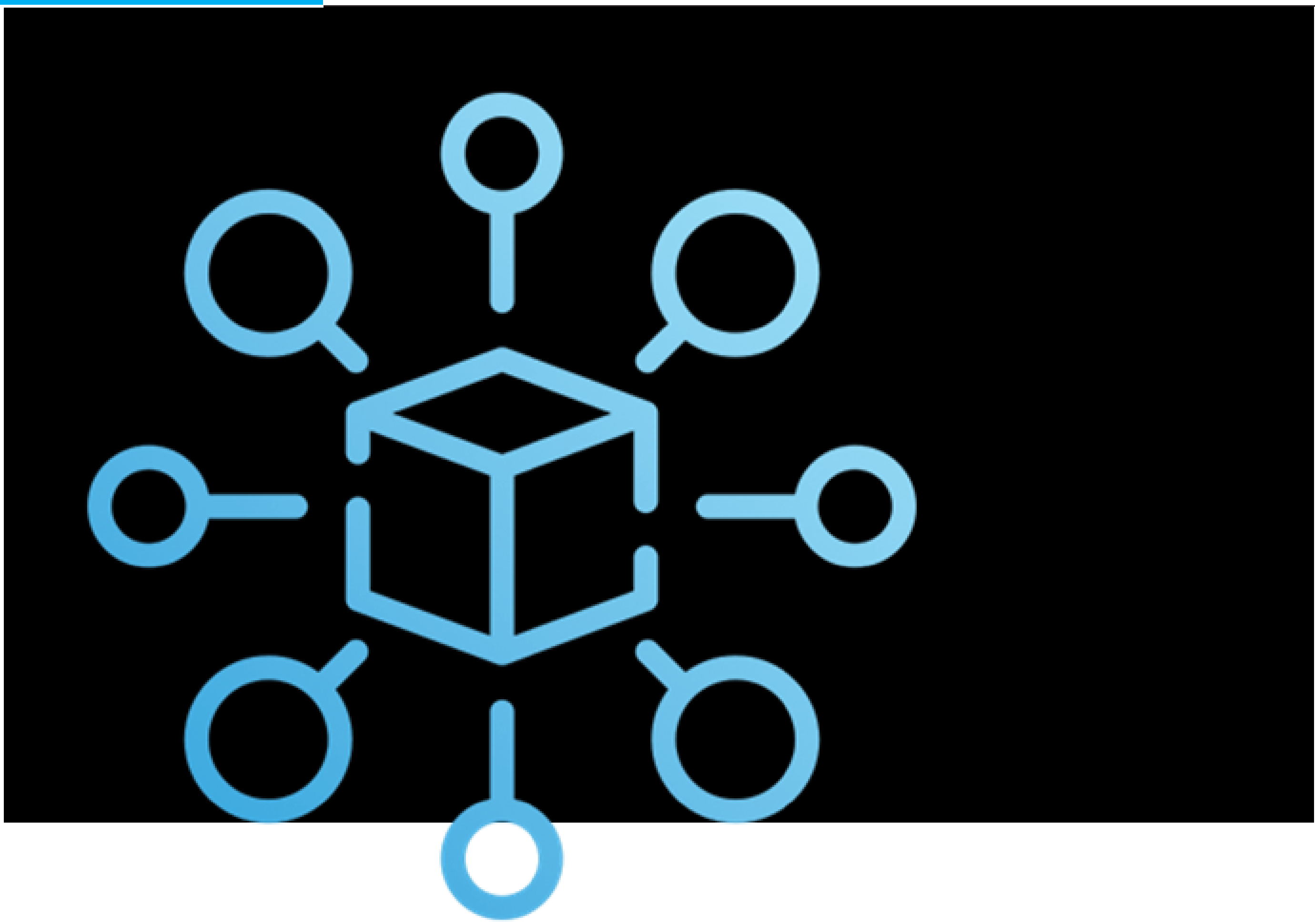

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Executive Summary (VDI)

This report shows up the need and process for developing a federated data space for the manufacturing industry in Europe. The core idea is to enhance collaboration and data exchange among companies by specifying and certifying standardized Basic Services. These services encompass Identity Management, Access Control, secure communication, and others, facilitating an interoperable data infrastructure. The text emphasizes the importance of shared governance and underscores that Basic Services must be tailored to the specific requirements of the manufacturing industry. The involvement of small and medium-sized enterprises is highlighted as a key factor for success, along with transparency, the publication of specifications, and the accreditation of operator companies. The integration of Business Applications and ongoing adaptation to evolving requirements are also identified as crucial steps toward achieving a successful European data space for the manufacturing industry.

Keywords: Manufacturing Industry, Data Spaces, Interoperability, Governance, Basic Services

Disclaimer

Acknowledgement

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Abbreviations and Acronyms

Acronym	Meaning
ADRA	Artificial Intelligence, Data and Robotics Association
BDVA	Big Data Value Association
DFA	Digital Factory Association
DS	Data Space
DSBA	Data Spaces Business Alliance
DSSC	Data Space Support Centre
DVC	Data Value Chain
EDIH	European Digital Innovation Hub
EIT	European Institute of Innovation and Technology
EFFRA	European Factories of the Future Research Association
IDSA	International Data Space Association
MaaS	Manufacturing as a Service
MiE	Made in Europe
P4P	Process for Planet
RA	Reference Architecture

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1 Introduction

Digitization provides tools for companies to solve complex tasks of their customers that cannot be solved by their own hardware alone (machines, plants, components). Core elements of digitization in the manufacturing industry include the collection of data in as many areas and lifecycle phases related to production and products as possible, and the use of this data to improve the status quo or as a basis for the development of new products, services, and business models.

This concept for digitization in production, also known as "Industry 4.0," is based on a study by acatech on "Cyber-Physical Systems" [1]. Until 2012, factories and their machines were like islands, separated from IT and without internet connectivity. With Industry 4.0, however, cyber-physical systems spread to the field level, become internet-enabled, and interconnected. The Reference Architecture for Industry 4.0 (RAMI 4.0) was developed as a framework in this context and has been adopted by many companies worldwide. In the report of the present project on Deliverable D4.2 "Blueprints for Data Spaces 4.0," the Data Space Building blocks were also related to RAMI 4.0.

The degree of digitization in manufacturing companies is still very heterogeneous, as in other industries. While digital entrepreneurs are already deriving the first benefits from the information obtained, digital followers are working to establish their infrastructure for data acquisition, often driven by the requirements of their customers who demand this for the implementation of regulatory requirements such as the Supply Chain Transparency Act in Germany [2].

Data spaces are now another step in the development of Industry 4.0. This is not only about individual factories but also about achieving additional benefits in terms of quality, time, and costs through the sharing and use of data in complete supply chains or in the lifecycle of products, machines, and components.

In Europe, numerous flagship projects for data spaces have been initiated, especially through public funding. These projects aim to replace bilateral approaches by creating data spaces in which a variety of partners can participate under uniform conditions, both for private and public purposes. By creating basic services necessary for collaboration, these projects are intended to increase efficiency and make proprietary, bilateral agreements unnecessary for building data exchange. Prominent examples include Catena-X Automotive Network, Mobility Data Space, Silicon Economy, Smart Connected Supplier Network (SCSN), FabOS 35, InterOpera, EuProGigant, and SmartAgriHubs.

Such, partly sovereign, data spaces that come together based on common governance are a European approach to meet international competitive pressure and to counteract the offerings of the major hyperscalers with sustainable, future-oriented solutions. However, even these flagship projects are classic silos, as their governance and basic services have emerged independently, and interoperability is only ensured among participating actors. Therefore, it is not yet the one European data space for the manufacturing industry, as there is little permeability between the data spaces, and the use of data is generally limited to the respective data spaces to which the participating companies belong.

This report therefore addresses the challenges to be addressed and the steps to be taken on the way to the one European data space for the manufacturing industry.

1.1 Document Structure

The overall document begins with an introductory overview of the necessity and goal of a European Data Space for the manufacturing industry. It introduces fundamental building blocks and services for data spaces, emphasizing interoperability across different industries and categorizing expected services for the manufacturing sector, with an assessment of their maturity. A significant focus is placed on operationalizing existing data space initiatives, highlighting the importance of widespread usage for cost efficiency.

The plan for establishing a European Data Space involves initiating a structured development process for Basic Services. A governance organization is formed, consisting of key actors such as the Data Space Support Center (DSSC) and other organizations. Specific challenges and requirements of the manufacturing industry, including security aspects in horizontal communication, are emphasized. Developing compelling migration concepts for small and medium-sized enterprises (SMEs) is seen as crucial for the success of the data space.

Security aspects in horizontal communication are discussed in detail, highlighting advantages and challenges. It is emphasized that companies need to develop a comprehensive security strategy to address potential risks associated with horizontal communication.

Furthermore, the certification and operation of business applications are treated as a crucial step for creating a successful data space. Certification is done by the governance organization to ensure uniform standards. The operation of the European Data Space is facilitated by establishing a robust infrastructure for accrediting data space initiatives and implementing Basic Services through operator companies.

The summary of roles and tasks is visualized in Figure 5 provides a concise overview of key aspects and recommendations from the overall document.

2 Approach for the One European Data Space for the Manufacturing Industry

Against the backdrop of European values, regulations, and the robust landscape of flagship projects (cf. 2), a federative network of data spaces appears to be a plausible approach to realize the one seamless European data space for the manufacturing industry.

In the federative network of data spaces, various data spaces are interconnected to enable a more comprehensive and coherent data exchange. The term "federative" refers to the fact that control over individual data spaces largely remains with the initiators while they are interconnected—similar to the federative system of a federal government, where individual states or regions retain their autonomy.

The key features of federative data spaces are:

- **Decentralization**: The administration of data spaces remains decentralized and under the control of their original operators. Each data space may have its own rules, security measures, and access rights.
- **Interoperability**: Federative data spaces allow collaboration and data exchange between different data spaces (permeability) without the units having to relinquish their independence.
- **Scalability**: Through federation, the common data space can easily scale, as new data spaces can be added without affecting the structure of existing ones.
- **Security**: The federative structure can help ensure that sensitive information remains protected, as access to data is strictly regulated according to the respective security guidelines of each data space.

Figure 1 illustrates the conceptual structure of the federated, seamless, European data space for the manufacturing industry. The data spaces cooperate based on a common governance and the use of basic services, or the recognition of basic services in the data spaces, against the backdrop of agreed-upon standards.

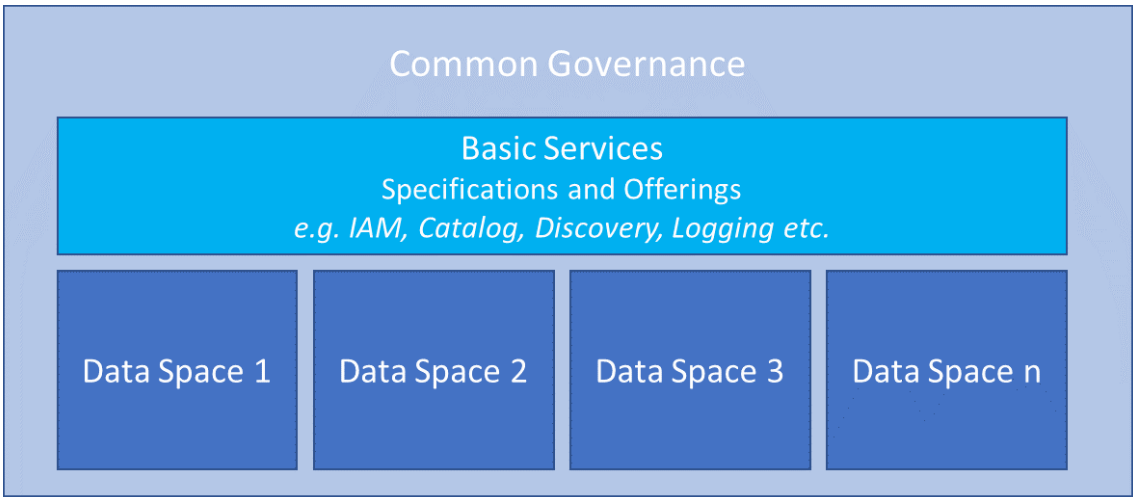

Figure 1 Conceptual Design of the federated European Manufacturing Data Space

2.1 Axioms

The globally operating economy requires a globally functioning ecosystem in the long term. Therefore, it is crucial from the outset to open the process for the establishment of the federative network of data spaces to international participation, in order to instill trust in the overall system for those who are to share and receive data. This applies to both organizational rules (governance) and software components. Additionally, the added value, in terms of economic potential arising from participation in the seamless data ecosystem for the respective organization, must be evident. Without trust and simultaneous economic potential, it will otherwise be challenging to motivate decision-makers to participate in the data ecosystem.

From these descriptions, the following axioms can be derived:

1. **Global Collaboration Axiom:**
    - The global economy necessitates a functioning global ecosystem for long-term prosperity.
2. **Open Participation Axiom:**
    - To establish a federated network of data spaces, it is crucial to welcome international participation from the beginning.
3. **Trust Enablement Axiom:**
    - Building trust in the overall system requires opening the process to international participants who need to share and receive data.
4. **Comprehensive Governance Axiom:**

- Trust relies on transparent and inclusive governance, encompassing both organizational rules (Governance) and software components.

5. **Economic Value Proposition Axiom:**
   - Participation in the continuous data ecosystem should visibly offer economic potential for each organization involved.

6. **Motivation and Responsibility Axiom:**
   - Without trust and simultaneous economic potential, motivating responsible individuals to participate in the data ecosystem becomes challenging.

2.2 Focus of the deployment roadmap

As part of the preliminary study for the German initiative Manufacturing-X [3], it was outlined that data spaces consist of three levels:

1. **Data Ecosystem (Cyber-Physical Systems, Payload of Participants)**
2. **Data Space (Semantics)**
3. **Federated Software Infrastructure (Basic Services)**

The Data Ecosystem refers to the real world where Cyber-Physical Systems operate, and the generation of original data occurs. Examples include production facilities, products in different lifecycle phases, and corporate administrations. This is where the transition takes place between the tangible world on one side and the digital world on the other. There is significant differentiation potential among providers, particularly involving proprietary offerings with competitive intentions.

The Data Space level represents the semantic description of the data generated in the Data Ecosystem. It is crucial to clearly describe and logically connect the parts of data to exchange data between different machines and improve processes. In cross-domain interactions, mappings of potentially different semantics to the semantics of the federated data ecosystem are added.

At the level of the Federated Software Infrastructure, there are basic services required by all participants and should, therefore, not have market differentiation potential to avoid lock-in effects. These services include Identity and Authentication Management (IAM), catalog services, or discovery services (for data, services, and participants), among others. They should be provided as open source with a high degree of standardization to enable their use in establishing a decentralized infrastructure by various operating companies.

The path to the data space of the manufacturing industry involves companies and organizations coming together, considering antitrust laws, to collaboratively develop the basic functionalities of the data space (Data Space level and Federated Software Infrastructure level). Subsequently, they continue to compete for market share and/or revenue based on the created foundations (Data Ecosystem level).

According to [3], the focus of the roadmap described here is on outlining the steps for establishing the Data Space level and Federated Software Infrastructure level.

Three perspectives must be considered:

- **Standardization and Specification:** Clear responsibility must be defined for setting standards at the Federated Software Infrastructure level. Additionally, the reference architecture must be adopted, and the coordination of the release approval process for new releases of the overall initiative must occur within this aspect.
- **Rules and Governance:** Clear rules for the decentralized network must be established, including regulations and positions related to open-source software.
- **Operator Model:** An operator model must be developed for the operation of basic services in the network.

2.3 Objectives

The necessary fundamental building blocks for the establishment of data spaces have already been comprehensively developed[1]. In the course of establishing the federated data space, they need to be further specified for application in the manufacturing industry. The aim is to ensure that basic services can be used across industries to guarantee interoperability between data spaces in different sectors.

The specifications must result from coordination processes based on regulatory conditions and the values of the European Union among stakeholders. Currently, different approaches

[1] See e.g. OPEN DEI Project," [Online]. Available: https://www.opendei.eu/; Data Space Business Alliance," [Online]. Available: https://data-spaces-business-alliance.eu, "Gaia-X - European Association for Data and Cloud AISBL," [Online]. Available: https://gaia-x.eu/; BDVA - Big Data Value Association," [Online]. Available: https://www.bdva.eu/; DSSC – Data Space Support Centre," [Online]. Available: https://dssc.eu/

are being tested in European flagship projects. For example, the use of specific connectors such as the IDS-Connector or the Eclipse Data Collector (EDC) for establishing connections between partners and subsequent data exchange is mentioned, while other approaches seek data exchange through Electronic Data Interchange (EDI), Asset Administration Shell (AAS), or OPC UA, using connectors only for metadata exchange in this case.

In Figure 2, the services expected in individual data spaces for the manufacturing industry are categorized, and their maturity is assessed. Four categories are distinguished: Domain-Specific Services, Shared Data Services, Data and Onboarding Services, and Data Space Infrastructure Services. The authors' assessment of maturity is based on a qualitative evaluation derived from insights and discussions in various data space initiatives. It is evident that there are already initial tested examples for the relevant level of federated software infrastructure (see 3.2) in the context of the manufacturing industry (labeled as Data Space Infrastructure Services in the graphic).

At the level of an individual data space, optional services, in addition to basic services, can facilitate entry into data sharing for companies or form the basis for subsequent business applications. These services are not necessarily required to ensure the function of the data space, but they promote the use of the data infrastructure. Simultaneously, they are considered non-differentiating and should, therefore, be provided as open source to the greatest extent possible, simplifying entry into the data space.

For the minimal operation of a data space, especially the building blocks of Identity Management, Catalog, and Logging (see 3.2 - Federated Software Infrastructure level) and a specifying data model (see 3.2 Data Space level) are required. Identifying, specifying, and offering common technologies is crucial to enable a thriving data space for the manufacturing industry.

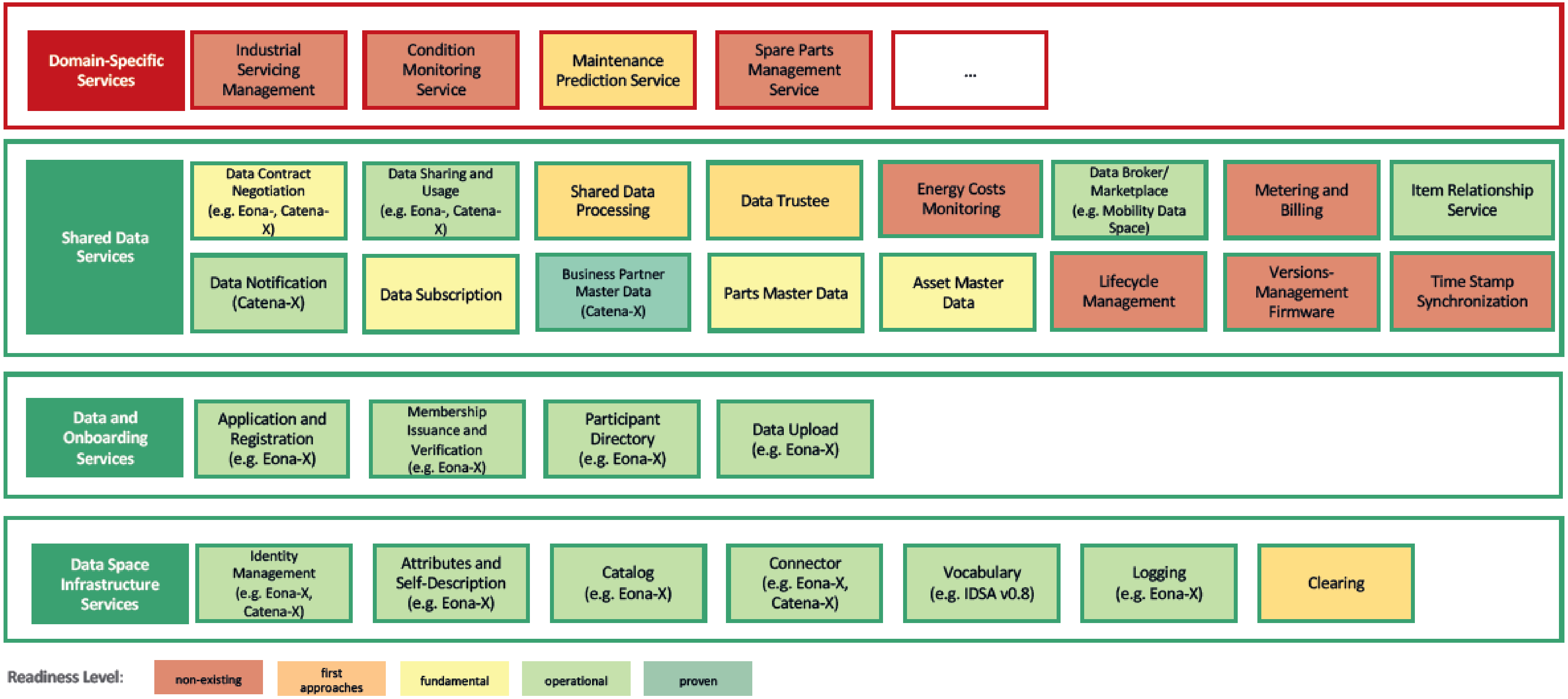

Figure 2 Service Classification and Services in a single Manufacturing Data Space [3]

Figure 3 illustrates the heterogeneity of the European landscape of various data space initiatives. Each data space exhibits unique manifestations of the categorization introduced earlier. Only the Data Infrastructure Services must be present in every data space (depicted in green); however, they may have been implemented differently.

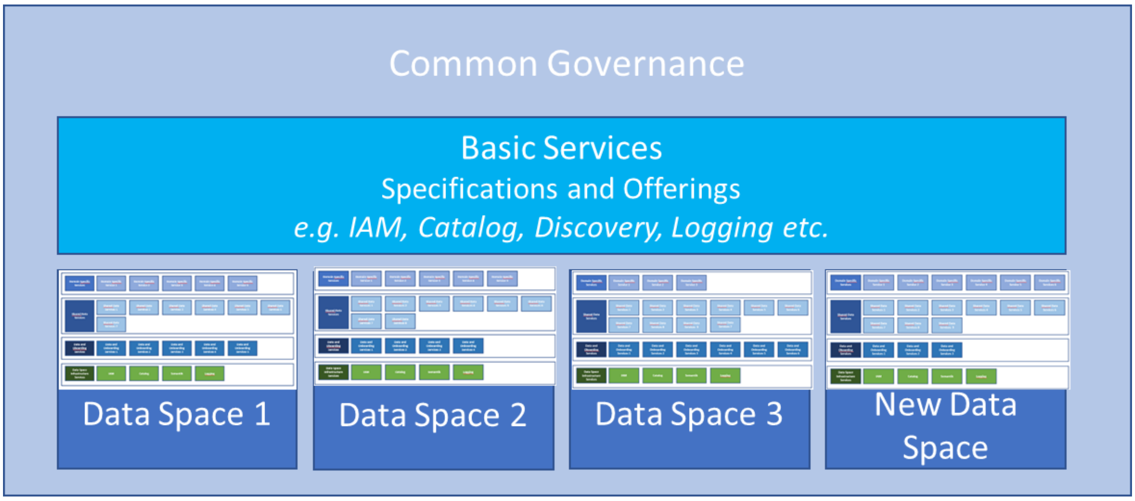

Figure 3 Heterogeneous field of existing data spaces and different Portfolio of non-mandatory services

The goal of the deployment roadmap is, therefore, to bring together the already existing data spaces in the manufacturing industry through shared governance, a common specification of basic services, and the certification of individual implementations. Simultaneously, it aims to establish the foundations for the easy establishment of new data spaces in the manufacturing industry through these specifications or the provision of corresponding basic services.

2.4 Important steps on the way to the European data space for the manufacturing industry

This Section describe the steps necessary to engage in deployment and operalisation of data spaces. We have followed the roadmapping guidance provided by the DSSC – see https://dssc.eu/space/News/blog/223379465/Recommendations+for+the+FUTURE+ROADMAP+FOR+DATA+SPACES

Figure 4 DSSC recommendations for data space deployment and operationalization roadmapping

In particular the following aspects have been addressed in this roadmapping work:

1. Fully operationalization of individual data spaces
2. Interoperability in data spaces
3. Transparency, enablement and reproducibility
4. Synergies and federation
5. Beyond data spaces and scale-up
6. National and regional dimension
7. AI in and for data spaces
8. Personal dimension in data spaces
9. Fostering the adoption of data spaces

2.4.1 Data Space Roapmap Areas

The development of the roadmap for manufacturing data spaces should consider three different layers. These 3 layers originate and align with emerging frameworks; e.g. SIMPL, Eclipse Tractus-X and ecosystems; Catena-X that need to be extended to additional manufacturing sectors beyond automotive and integrated.

The Catena-X ecosystem is organized in 3 areas – See Figure below:

- The Association in which the association members, with the support of the association's management office and the board of directors, exercise neutral data space governance and perform the tasks of standardisation, certification, release management, transfer and communication via the Catena-X data space
- The Development Environment which includes the Catena-X Eclipse Tractus-X Open Source project and the consortium.
- The Operating Environment, which ensures the operation of the Catena-X data ecosystem.

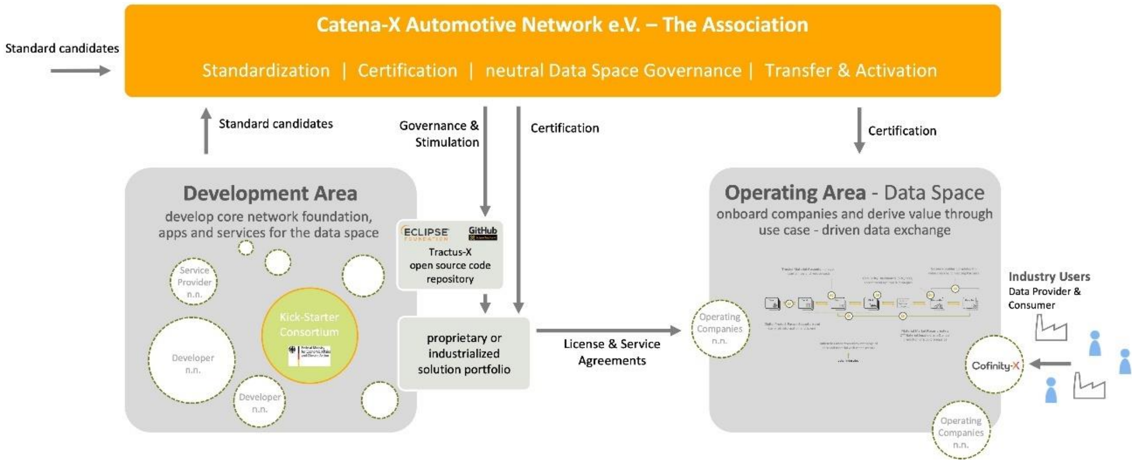

Figure 5 – Catena-X areas

As shown in the Figure 2 and Figure 3 above, the Data Space roadmap should consider both Core infrastructure and shared Data Space service development as well as Common Data Space Federation services.

The Data Space 4.0 Roadmap hence is organized in the following 3 layers.

- Data Space 4.0 Open – Open source environment for development of core and common data space and federation services. This is a fundamental element of the support of the development area. (Development Area)
- Data Space 4.0 Lab – Playground and sandboxing environment for testing and evaluating compliance and interoperability of data space and federation core, shared and common services. (Association & Development Area)

- Data Space 4.0 Live – Instances of data spaces and business applications certified and operated. Data Platforms and Business Applications can be operated in relevant marketplaces. (Operating Area)

2.4.2 Data Space Roapmap Steps

Taking these elements into consideration we have divided the roadmapping activities in two steps (1) deployment (2) operationalisation, which correspond to phases 2-3 and 4-5 respectively based on the data space maturity model. It is worth noting that the level of maturity of data spaces such as SCSN or Catena-x differs from more embryonic implementation endeavors such as BAIDATA, UNDERPIN, SM4RTENANCE, Factory-X, Aerospace-X or Data4Industry-X to name a few.

The chronological layout of the roadmap is crucial, especially for the deployment phase. The project analysis outlines the various sequences required for constructing the Data Space 4.0 in a feasible manner, with the understanding that the roadmap should consider the individual development of the data space and its ecosystem as well as the federation of various manufacturing ecosystems that will naturally co-exist and co-operate data spaces; e.g. vertical and horizontal integrations of machine tools, factories and supply chains for instance.

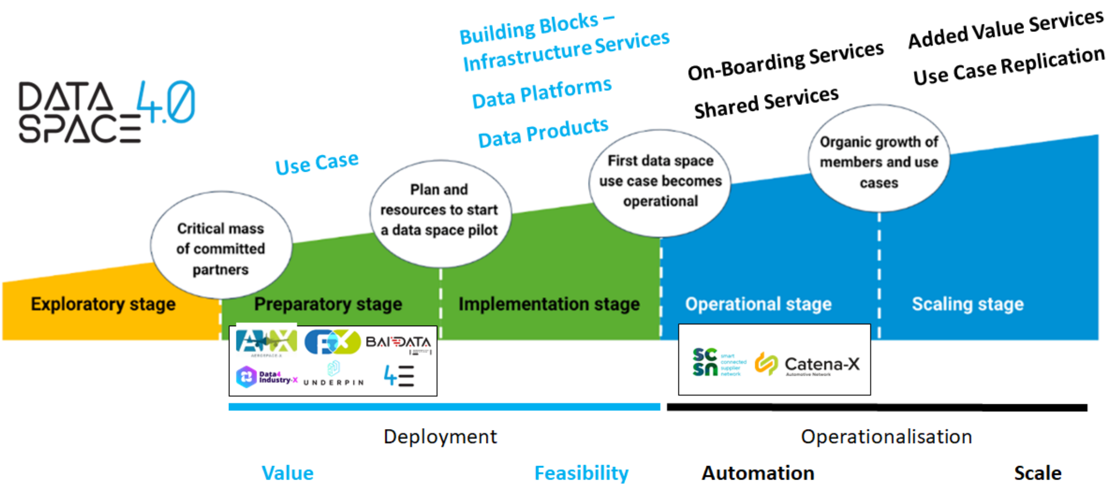

Figure 6 – Data Space 4.0 Landscape and Evolutionary Roadmap

2.4.2.1Preparatory Phase of Existing Data Space Initiatives

The Data Space 4.0 preparatory stage commences with a critical mass of dedicated partners united to develop their individual business cases taking advantage of the individual data space services as well as the data space federation services. In this initial phase the ecosystem is focused on:

- Selection of individual and collective business cases.
- Proposal of governance framework (individual data space as well as federation).
- Selection and preparation of essential technical building blocks (BB) for each individual data space as well as basic data space federation services.
- Continuous revision and update of data space blueprint and technical implementations of BB.

It is worth noting that preparatory projects will not start in the blue and that the deployment actions should and will take advantage of the ongoing operational activities and scaling activities of more mature data spaces; e.g. Catena-X and SCSN. Hence, the technical selection of building blocks can be performed supported by already available open source artefacts provided by key open source initiatives such as Tractus-X and in the next moths/years SIMPL middleware. These initiatives (tractus-X and SIMPL) play a key role in accelerating deployment, since they provide already a solid foundation for setting up robust basic shared services across data spaces and on the other hand allow the deployment projects to focus on the added value services that need to be instantiated to operate services in each of their domains.

On the legal and governance dimension of the data spaces, the road-mapping activities need to take into consideration that new governance models for new emerging data spaces will require that a harmonization exists, since data spaces will not work in isolation and use case transferability across sectors for instance for machine tool builders should be somehow facilitated. The focus of this phase should be on value and feasibility to ensure solid development of data space operations in a second stage. The focus of this stage is on adapting at 3 levels current brownfield operations (1) Data Products to allow successful and valuable data exchange, (2) Data Platforms for acquisition, curation and exploitation of data products and (3) business processes to the essential services of the data space.

2.4.2.2 Operationalization of Existing Data Space Initiatives

Only through a sufficiently large utilization of data spaces can the high costs for the establishment and operation of basic services be distributed among the participants of the data space without imposing excessive burdens. If the costs for individuals to participate in the data space are too high, the economic potential is quickly called into question (see 3.1).

In addition, a large number of participants in the data spaces promises economic potential through the provision of corresponding services (e.g., data analysis, condition monitoring, etc., see 3.2 Data Ecosystem level). A wide range of services in the data ecosystem, in turn, motivates more companies to participate in the data space.

To initiate this upward spiral, public funding for the specification of basic services in the respective application context and an initial operating company that first operationalizes the specified basic services and enables initial traffic in the data space can be considered. Alternatively, cooperatives or associations of participating companies in the data space can be possible organizational forms for operating companies. In this case, companies must invest in the establishment of the operating company, or consortia can be tasked or funded by the public sector to establish an operating company to take on or mitigate the risk due to the unpredictable return on investment.

If the use of the data space increases sufficiently based on these developments, this can encourage other organizations to also offer basic services in the data space that comply with the specifications. In this way, the decentralization of the data space network can be realized, which is necessary, among other things, to achieve sovereignty and competitive design of the offerings.

To enable a practical European data space for the manufacturing industry, it may be a path, against the background described, to only include data space initiatives that have already operationalized with a sufficient number of participants and thus demonstrated the applicability of the approaches implemented there in the industrial environment. Examples here could include Catena-X or the Mobility Data Space.

In the operationalization phase the main focus of the roadmap should be on ensuring automation and scaling of the services implemented in the previous phase. Such service automation and scaling is mandatory if the required economies of scale are to be reached. Here one should notice that the use cases implemented at this stage will lack critical mass and would still be implemented by a reduced number of companies, so the focus of this phase will be on increasing the depth and width of such use case implementation. Replicability of use case in different regions and by different stakeholders will be the focus of this second phase of the roadmap.

2.4.3 Specification of the basic services and definition of the governance for the development process as well as for the subsequent operation.

The initiation of a comprehensive development process for basic services in the manufacturing industry requires a structured approach, ensured by various key aspects:

Firstly, the formation of an initial group is crucial. This group should consist of influential actors such as the Data Space Support Center (DSSC), the Big Data Value Association (BDV), or the International Manufacturing-X Council and initiate the development process by building the consortium. The formed body will henceforth be referred to as the "Governance Organization" (see Figure 5). Involving various organizations and initiatives brings diverse perspectives and expertise into the process, favoring the holistic development of specifications for basic services.

For the selection and engagement of relevant data space initiatives (see 3.4.1), existing data space catalogs, especially those of the IDSA and DSSC, can be valuable resources. Linking with suitable initiatives according to Section 3.5 allows broader participation and integration of different approaches into the development.

The development of governance is another indispensable step in the process. This governance should not only guide the development of specifications for basic services but also regulate the operation of these services. The groups, tasks, guidelines, and rules outlined in Section 3.1 are crucial to ensuring a structured and efficient process.

The specification of basic services must be carefully done, considering the specific requirements and peculiarities of the manufacturing industry. Existing studies [3] and project reports like D4.2 of the EU Data Sp4ce project serve as valuable guidelines. In particular, the ambition of the manufacturing industry to exchange data not only vertically but also horizontally across companies in the long term should be considered. This involves both the direct exchange of information between different levels of the automation pyramid (as marked by path 1 in Figure 4 from the Field Device in Company A to the Field Device in Company B across all levels of the automation pyramid) and direct exchanges between the Field Devices of companies or on other levels (as marked by path 2 in Figure 4).

Horizontal communication offers significant advantages for the manufacturing industry:

- Horizontal communication facilitates direct exchange of information between different levels of the automation pyramid. This contributes to increased efficiency, as relevant data can be quickly and directly transferred between different process levels.
- Through horizontal communication, events or anomalies can be detected and transmitted in real-time, allowing for a faster response to changes or issues in production processes.
- Horizontal communication enables better coordination between participating companies, ensuring that different processes work together smoothly and align with common goals.
- Direct information exchange allows for better monitoring and optimization of production processes, leading to more efficient use of resources and improved overall performance of the involved partners.

However, these benefits are accompanied by challenges to the security of the participating companies:

- Increased horizontal communication can raise the risk of cyber-attacks, as a broader attack surface may emerge. Cybercriminals may attempt to exploit vulnerabilities in communication channels.
- With growing integration and networking of systems, the complexity of security measures increases. It becomes more challenging to develop a comprehensive understanding of all communication processes and implement appropriate security controls.

- Intensive horizontal communication may raise privacy concerns, especially when sensitive information is exchanged between different areas. It is essential to ensure compliance with data protection policies and practices.
- Different systems and protocols can lead to interoperability issues, creating security gaps. It is crucial to ensure that communication interfaces are secure and standardized.

To ensure security in horizontal communication, companies should develop a comprehensive security strategy that includes aspects such as access control, encryption, monitoring, and regular security audits. Moreover, a clear policy for secure communication and training for employees are crucial to raise awareness of security risks.

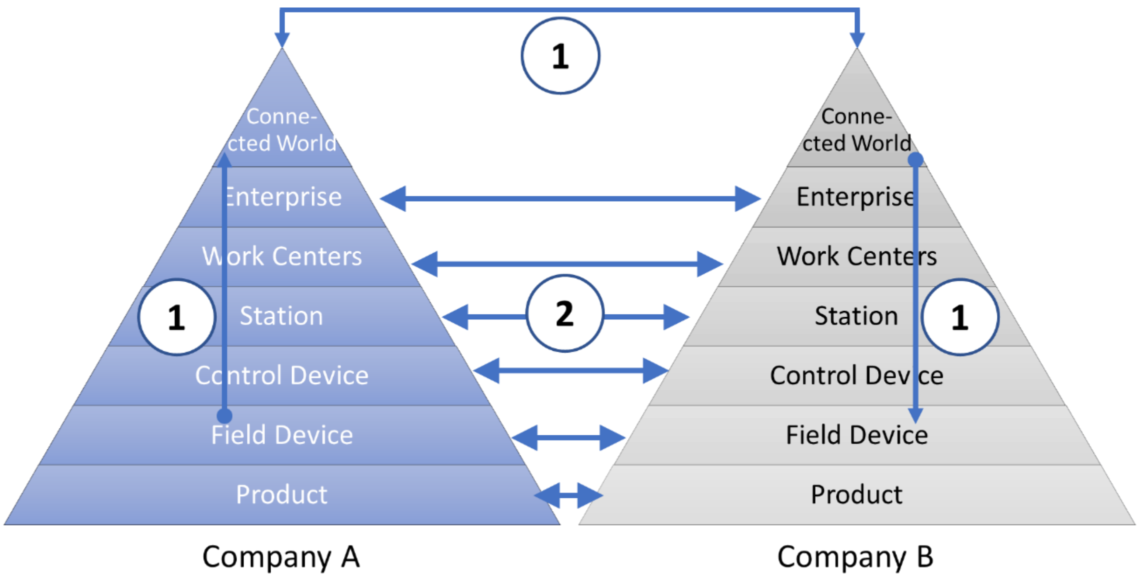

Figure 7 Vertical and horizontal Communication according to IEC 62264 / IEC 61512

As communication in the European data space for the manufacturing industry is expected to handle crucial aspects of data exchange, these challenges must be considered in the development of Basic Services. Key elements in this context include Identity and Authentication Management (IAM), Access Control (e.g., Attribute-Based Access Control (ABAC)), and secure communication.

Another peculiarity of the manufacturing industry is that the vast majority of companies in this sector are small and medium-sized enterprises (SMEs). Therefore, it is essential for the success of the European data space for the manufacturing industry to develop convincing migration concepts for SMEs. This is the only way to enable their easy participation in data spaces. Additionally, business models supporting broad user access should be developed. Transparent cost models, allowing for a fair distribution of expenses among participants, are also crucial for acceptance in the medium-sized business sector.

Considering these peculiarities enables the development of Basic Services that are optimally tailored to the needs of the manufacturing industry.

The publication of specifications marks a crucial milestone. This step promotes transparency and enables the broad use of the developed Basic Services by making them accessible to the public and potential users. This not only drives the further development but also enhances the acceptance of these services in the manufacturing industry.

The final accreditation of operator companies is of great importance given the central role these companies play in coordinating, operating, and managing the services. This ensures that operator companies have the necessary resources, expertise, and governance mechanisms to meet the required quality standards and ensure the integrity of Basic Services.

The continuous evolution of specifications for Basic Services is a dynamic process extending beyond the initial development stages. This step allows adaptation to changing requirements, technological advances, and industry-specific developments. Continuous improvements ensure that Basic Services are aligned with the evolving landscape, maintaining their relevance and effectiveness. This iterative approach promotes agility and innovation and requires a transparent, open process to maintain the trust of all stakeholders.

In summary, the following steps should be taken:

1. Establishment of an initial group initiating the development process for Basic Service specifications and setting the governance for the development process and later operation (e.g., DSSC, BDA, International MX-Council, etc.)

2. Onboarding of relevant data space initiatives for co-creation (see 3.4.1, numerous catalogs already exist, e.g., at IDSA, DSSC, also refer to initiatives in 3.0)
3. Development of governance for the specification of Basic Services (see 3.1: Groups, Tasks, Policies, and Rules)
4. Development of governance for the operation of Basic Services
5. Specification of Basic Services considering the peculiarities of the manufacturing industry (see [3], D4.2 EU Data Sp4ce Project, etc.)
6. Publication of specifications for Basic Services
7. Accreditation of operator companies
8. Maintenance and continuous improvement of Basic Services and certification requirements.

2.4.4 Certification and Operation of Business Applications

Business applications are the services that provide actual benefits. There have been numerous attempts to offer these services in proprietary ways, but these offerings, particularly due to a lack of scalability and the fear of vendor-lock-in-effects by the customers, could not be successfully positioned in the market. The aim is to address this deficiency without vendor lock-in effects by offering these value-added services independently of providers through operator companies. Business applications (see Domain Specific Services in Figure 2) should be certified by the Governance Organization in favor of uniform standards.

2.4.5 Operation of the European Data Space for the Manufacturing Industry

2.4.5.1 Establishment of a Robust Infrastructure and a Dynamic Process for the Accreditation of Data Space Initiatives

The establishment of a solid accreditation infrastructure for data space initiatives based on the published specifications of Basic Services is a fundamental component in the pursuit of quality and reliability. This infrastructure ensures that participating initiatives meet the necessary quality standards to actively participate in the European data space for the manufacturing industry. Clear testing procedures are essential to enable accreditation on a uniform basis.

In the context of accreditation, the accreditation of testing facilities is also a possibility to increase the scalability of the approach. Setting clear criteria and standards for such facilities not only ensures the integrity of the certification process but also strengthens confidence in the results.

The description of admission and exclusion processes is another essential step in the accreditation infrastructure. Clear guidelines are established, governing the admission process for data space initiatives while providing mechanisms for exclusion in cases of non-compliance or other serious violations. This not only promotes the integrity of the initiative but also contributes to ensuring high-quality and trustworthy collaboration.

2.4.5.2 Seamless Implementation and Operation of Basic Services: From the Establishment of the First Operator Company to Supporting New Data Space Initiatives

The establishment of an initial operator company is a crucial step in the creation of the European data space for the manufacturing industry. This company will play a central role in the operational accreditation of existing data space initiatives and the operation of Basic Services.

In the initial operator company, the first development and implementation of Basic Services are carried out based on the developed specifications. This includes the detailed design of services and their technical implementation. A precise implementation of specifications ensures that Basic Services meet the defined requirements and can be effectively integrated into existing infrastructure. At this stage, it is essential that the operator company is motivated to make its results freely available, for example, as open source, to enable a European data space for the manufacturing industry that aligns with European values, ensures sovereignty, and avoids vendor lock-in effects (see 3.4.1).

However, the free provision of Basic Services is only possible if the necessary investments for the development of Basic Services are not borne by the operator company itself, as otherwise, a return on investment (ROI) would be required. A possible instrument to achieve this could be a publicly funded project in which Basic Services are developed and then provided as open source. The differentiation of different operator companies can then occur at higher service levels, for example, through the design of the user experience and the offering of additional services in the data space or data ecosystem layer (see 3.2).

The operation of central services by the initial operator company is of great importance for smooth operation. This includes responsibility for admission and exclusion processes of data spaces as well as the provision of discovery services for data spaces, data, and services. These central services ensure a consistent, efficient, and transparent administration of offerings in the connected data spaces.

The initial operator company actively supports new data space initiatives by providing the developed Basic Services and offering to operate the Basic Services for new data spaces. This support promotes the spread of Basic Services and allows new initiatives to benefit from established structures and experiences. This cooperative approach facilitates the scalability and applicability of Basic Services across different contexts.

2.4.5.3 Roles and Tasks at a Glance

Figure 5 summarizes the roles and tasks described above.

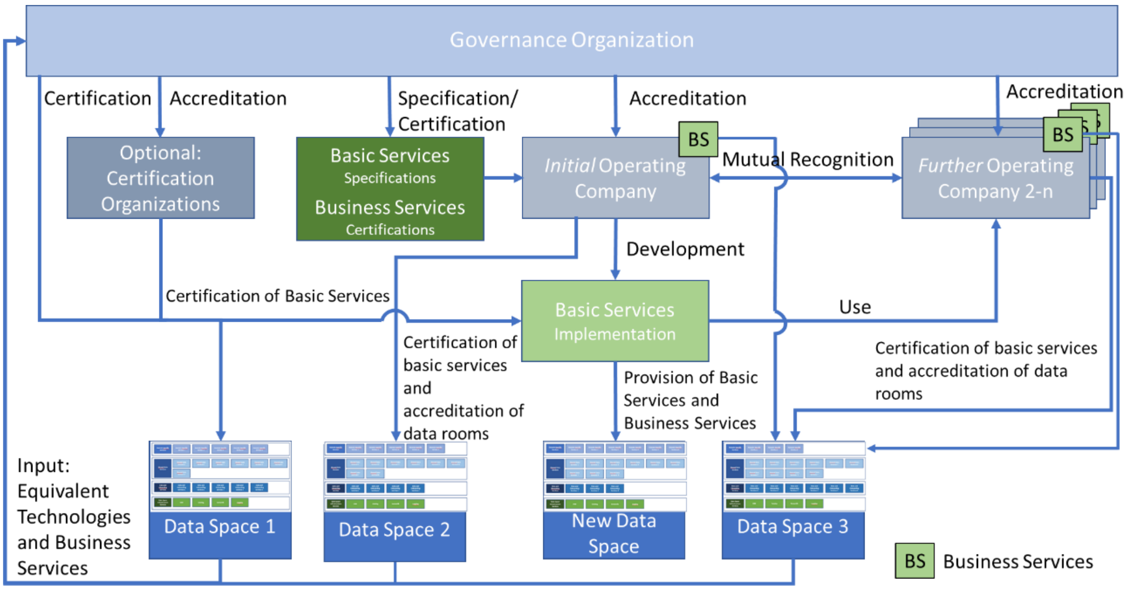

Figure 8 Roles and Tasks for European Data Space 4.0 Federation Roadmapping

2.5 Timeline

This section summarises in a timeline the inputs considered in the previous Sections. The timeline can be adapted based on the different maturity level of the existing data spaces as well as the evolution of the different ecosystems supported by the data space technologies.

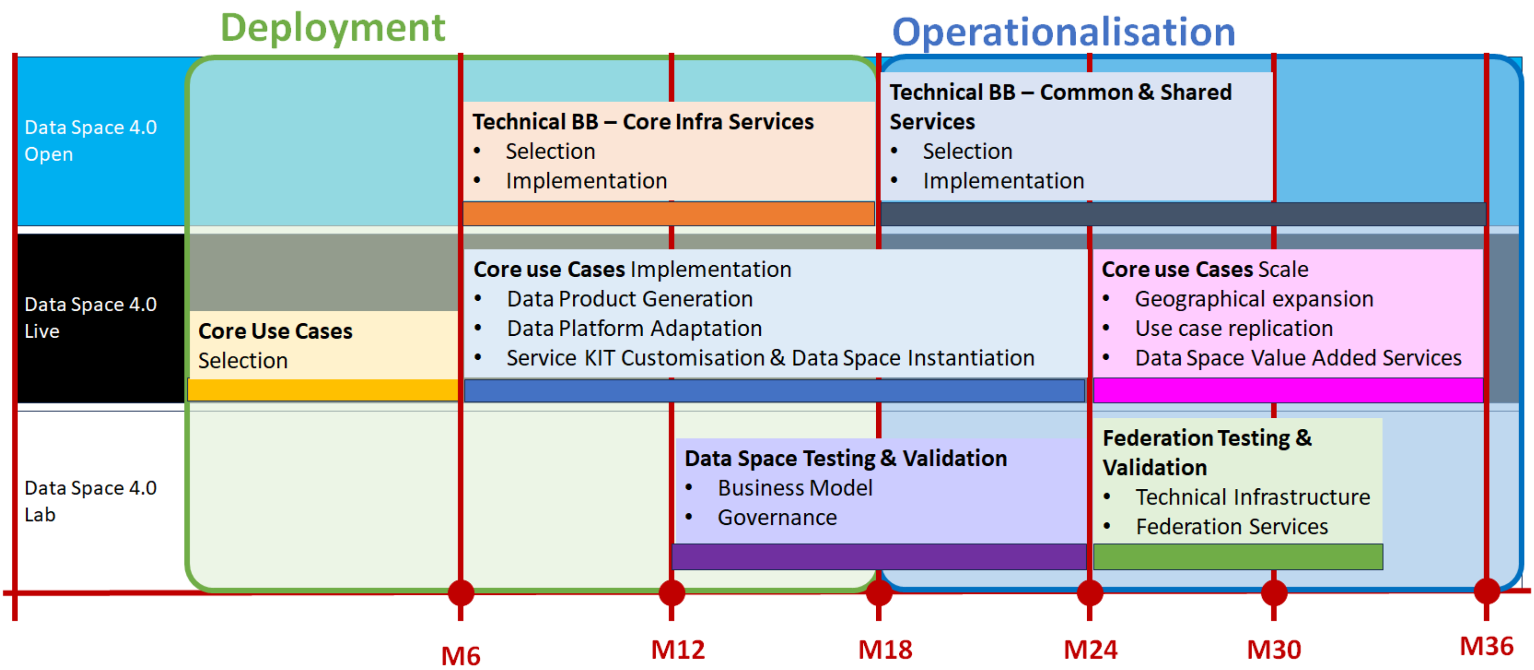

Figure 9 – Data Space 4.0 roadmap timeline

The Data space 4.0 is divided in two main steps ;i.e. deployment and operationalization.

In the *preparatory stage* the selection of the Core Use Cases that drive the development of the data space. The selection of the data spaces that will contribute to the federation is also key in this preparatory phase. This is mainly implemented in the Data Space 4.0 Live area.

In the *implementation phase* , activities will span across Data Space 4.0 Open, Live and Lab. In the Data Space 4.0 Open, the selection and implementation of the Core Services for the Data Space Infrastructure services to support the use cases is a key activity. This includes integration with and contribution to reference Open Source data space development initiatives (SIMPL, Tractus-X).

In the Data Space 4.0 Lab is necessary to agree on the business model and governance of the implementation of the use cases at the level of individual data spaces. The business model to support the individual applications and the access to the common data space federation services is also scope of this stage. The main portal services supporting the federation is also fundamental activity during the phase.

In the Data space 4.0 Live it is necessary the preparation of the Data Products with clear definition of vocabularies and data formats to support the use cases. In the implementation of the Core Use Cases it is also necessary to adapt the data platforms to acquire, curate and storage the data that will conform the data products. It is also necessary that data space are instantiated with upgraded data space services and final applications of the use cases developed as application/extension of data space KITs.

On the *operationalization stage*, at the Data Space 4.0 Open, the selection and implementation of the shared and common services from the data space Federation should be the focus. The services should be focused on Data Space interoperability common services.

In the Data Space 4.0 Lab, the design and agreement on the legal form and governance process that will support the data space federation with clear roles and groups. At this stage the definition of the process to on-boarding new data space operators.

In the Data Space 4.0 Live level the focus should be on the operation of added value services that build on the core services provided and on increasing the width and depth of data spaces increasing both the participants in the use cases rolled out (potential geographical expansion) as well as on replication of use cases supported by a wider variety of data space operators and companies. Hence, scale up in terms of users as well as applications/solutions implemented in the data space will take place. At this stage new and additional cases can be identified and incorporated into the Development area of the data space ecosystem.

These roadmapping activities can be further connected with the deployment of the Data Space 4.0 blueprint building blocks. As shown in the Figure below

		DATA SPACE ECOSYSTEM INDUSTRY COMMONS	DATA PLATFORMS CORE SERVICES DEFINED	DATA SPACE PORTAL INFRASTRUCTURE AVAILABLE FOR DATA PLATFORMS	MINIMUM VIABLE DATA SPACE ECOSYSTEM DEPLOYMENT	DATA SPACE FEDERATED INFRASTRUCTURE AVAILABLE	DATA SPACE FEDERATED INFRASTRUCTURE OPERATIVE
		M01-M06	M06-M12	M12-M18	M18-M24	M24-M30	M30-M36
Organisational & Business Building Blocks	Business	Data Value Chain (DVC) analysis Business applications requirements professional needs & design	Data ecosystem incentive model Business framework design	**Business portal ready (release one)** Business application inventory Data Space users & dev. guides Data space business strategy Application KIT inventory (design)	Collaborative maintenance and circular business application needs & design Data ecosystem scale up strategies	Data ecosystem incentive model Business framework extension Business application KITs inventory	**Business portal ready** Data ecosystem scale up strategies Data Space & Dev users guide update Data space business strategy
	Governance		Data room governance framework design	Data space exchange services Management services	Data space rule book Data space service operational terms & conditions Data governance & onboarding-offboarding lifecycle management		Data space federation service operational terms & conditions Data governance & onboarding-offboarding lifecycle management
	Legal		Data room legal framework design		Data room governance framework design Data exchange certification		Data room governance framework design Data exchange certification
Technical Building Blocks	Data Interoperability		Common industry 4.0 vocabularies Information Modelling Framework (IMF) design	Data space infrastructure Data space interconnection services Asset OEM adaptation Data platforms adaptation	Continuous integration environment Data room trials Data Space Interoperability Trials Federated Data Space Trials	Common industry 4.0 vocabularies Asset OEM federation Data platforms federation	International data rooms
	Data Sovereign. & Trust			User management Technical implementation of certification Data usage control Identity management solutions		Distributed identity management for partners and data space network Data usage control Data space protocol	
	Data Value Creation		Data spaces blueprint	Digital twin model registry (design) Data Space AI services (design) IMF semantic hub (design)	Data Space Federation blueprint	Data Product quality	Digital twin model registry Data Space AI services Marketplace services (Apps/Solutions) IMF Semantic Hub

3 Conclusions

This document has presented a roadmapping approach to the development of a manufacturing sector that will build upon the best practices and lessons learned from the deployment and operationalisation of the Catena-X project.

The document propose a roadmap to allow both the deployment of additional data spaces in other sectors beyond automotive and at the same time addressed the needs for a roadmap that ensures federation and interoperability across data space operators and manufacturing sectors.

The document provides clear identification of Tasks and roles as well as provides a clear mapping of the different tasks to be implemented in terms of blueprint building blocks as well as the availability of different concurrent environments for the preparation, implementation, operatinalisation and scaling stages.

The document has also proposed different activities at 3 different levels that integrate the main elements of a data space ecosystems; i.e. development environment, operational environment and association for legal and governance structure management.

The roadmap considers the need for development of specific Data Products, adaptation of data platforms, evolution and potential extensions of applications development KITs as well as formalization of business portal to govern and facilitate the business transaction across the federation.

4 References

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