PLATTFORM INDUSTRIE 4.0

RESULT PAPER

Multilateral data sharing in industry

Concept using "Collaborative Condition Monitoring" as a basis for new business models

Imprint

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Contents

Aim of the publication:

Collaborative Condition Monitoring (CCM) represents an innovative approach to multilateral data sharing.

This approach is shown here in connection with a “three-point fractal”, which consists of a component supplier, a machine supplier and a factory operator, and aims to generate economic added value for all stakeholders.

This publication aims to make the idea of the “CCM three-point fractal” accessible.

The necessary legal, technical and economic framework conditions are highlighted and discussed with reference to various scenarios.

1 Introduction

The German economy is facing major challenges in the form of sustainability and climate neutrality. Although the process of transforming the economy and society has already started, it will continue well beyond 2045.

Meanwhile, value chains must become more competitive and more resilient. The natural disasters, pandemics and wars currently in the headlines clearly illustrate the fragility of global value chains.

Today, the digital transformation of industrial value creation is generating ever greater volumes of data and creating a need for greater transparency. Data is used and shared, providing valuable input for existing and new business models. The paradigm shift underway is changing the world of work and the shape of communication. How and where value is created is also changing.

As a result of these changes, the use and handling of data has inevitably moved centre stage. Collaborative Condition Monitoring (CCM) shows potential for multilateral data sharing. The transparency it offers also lays the foundation for improving resilience.

Due to the globally networked nature of information and companies, interdependencies in value chains will continue to exist, despite the accelerated trend towards decoupling driven by geopolitical tensions.

The information carried by a single record is straightforward. It could be a temperature, a person's age, the result of a quality check, or the number of orders processed by a company in one day. Analysts can only draw relevant conclusions, that is conclusions about economic relationships or human behaviour, by combining various pieces of data or by considering data histories. In either case, the information concerned is information over which companies or individuals should retain sovereignty. It must therefore be in our interest to create a secure environment for data, similar to the secure environment we have created for our currency, especially in areas where information replaces currency. For example, we have secure depots in addition to secure and largely traceable routes for our currency. There are insurance policies against misuse for payment system users. Set rules also exist for the exchange and valuation of currencies with respect to each other. For example, market participants positioned along a value chain such as component suppliers, machine suppliers and factory operators require, on the one hand, sovereignty and secure data spaces in order to collaborate across company boundaries. On the other, they need to be able to assess and secure the value of the information is also a prerequisite.

Europe is already well on the way to achieving this goal: In addition to a large number of contract-based corporate collaborations on the market, initiatives such as Gaia-X and industry projects based on these, such as Catena-X, are also currently emerging to develop a "network of networks" approach for the automotive industry across the entire value chain. The foundations are thus being laid for making the added value of cross-company data exchange compatible with values such as data sovereignty.[1] In B2B business, data sovereignty means that companies have their own control over access to and use of their data. They can therefore decide themselves who receives data and for what purpose.

The Gaia-X approach reflects European values such as liberality and multilateralism. It positions data and the secure exchange of data as a "currency" and thus allows participating institutions and companies to use data to shape business models, in the same way as goods and services are purchased and sold today. Furthermore, by combining traditional and data-based business models under the umbrella of a legal framework that safeguards all stakeholders, the approach establishes mutual trust. It will therefore be able to rival provider-specific approaches in the long term. This mutual trust is crucial to success.

To create a vision of collaborative data-based business models in manufacturing and thus pave the way for these business models, we outline sample concepts of multilateral data sharing on the basis of CCM.

1 Data sovereignty in the sense of complete control over stored and processed data as well as the independent decision on who may access it. (Source: "The Project Gaia-X")

2 Status quo: What is the situation today?

2.1 From bilateral to multilateral data sharing

At present, business models or activities designed to improve efficiency in many manufacturing companies often involve bilateral data exchange between two participating companies. However, for additional efficiency or market potential in the manufacturing industry to be leveraged, there needs to be a change in mindset from purely bilateral data exchange to holistic, standardised and multilateral sharing of data from multiple stakeholders.

Working hypothesis of the CCM project group of Plattform Industrie 4.0:

"Multilateral data sharing offers enhanced opportunities for B2B data-driven business models and value creation for all stakeholders."

For multilateral data sharing to take place, stakeholders must create an infrastructure with the appropriate framework conditions (technical, legal and economic) as a foundation within the context of a jointly defined constellation.

With this in mind, the CCM project group of Plattform Industrie 4.0 plans to initiate a discourse with stakeholders in the manufacturing industry:

Core question addressed by the CCM project group of Plattform Industrie 4.0:

"What frameworks and innovations are needed to enable multilateral data sharing and thereby create cross-enterprise, data-driven business models?"

2.2 What is the situation today?

At present, value chains are formed mainly on the basis of a sequence of bilateral contractual relationships between the delivery recipient (customer) and the supplier (vendor). In complex value chains, there are no overarching contractual relationships, particularly in industries that have very high supply volumes on occasion. As a result, customers have no knowledge of what further supplier relationships their suppliers have with other companies, i.e. what they receive from their own suppliers. For the supplier part, this is not necessarily relevant for the customer. However, once data-driven business models are involved, data from the suppliers of the customer's own supplier also becomes important.

Market trends and socio-political developments are increasingly converging in terms of requiring traceability of the origin of products and their components along the value chain. For example, as of January 2023, the Supply Chain Due Diligence Act ("Supply Chain Act") requires companies to provide the necessary transparency regarding data and processes from the value chain and to make the origin of their supplier products traceable. From a sustainability perspective, the emissions required to produce all supplier parts along the entire value chain are also relevant for calculating the carbon footprint of a product. The concept of the circular economy will only be feasible in practice with the creation of traceability and transparency about the origin and use of raw materials.

The digital transformation of business processes in manufacturing industry is the basis for creating transparency and efficient cross-company collaboration along value chains. Small and medium-sized companies in particular often find themselves weighing up the conflicting demands of investment and costs required for digitalisation and the associated benefits and economic added value. The German Federal Ministry for Economic Affairs and Climate Action (BMWK) has recognised this challenge and is supporting German industry with extensive funding measures to build cross-company value networks, for example as part of the German government's economic stimulus package. Other funded initiatives such as Catena-X[2], Gaia-X[3] and IPCEI-CIS[4] are also promoting the establishment and expansion of digital ecosystems with the aim of cross-company and collaborative value creation. Many industry experts agree that in the next developmental stage of Industrie 4.0, cross-company, multilateral data sharing will play a key role in leveraging potential efficiencies and creating innovative added value.

2 See https://catena-x.net/en/

3 Gaia-X: A Federated Secure Data Infrastructure

4 BMWK - IPCEI Next Generation Cloud Infrastructures and Services (bmwk.de)

3 Motivation for multilateral data sharing

It is often the case that data generated in industry remains unused in individual departments or production sites, resulting in the formation of fragmented data silos. However, many experts and users in industry agree that a significant contribution to the digital transformation of industry is made by further processing and linking these unused data silos within the context of collaborative use between the companies involved in industrial value creation.

The reasons motivating companies to participate in multilateral data sharing may be weighted differently, depending on the specific considerations of the business field in question. In general, however, it is in the interest of companies to share data if this results in an economic improvement or a competitive advantage.

In principle, the (cross-company) use of data can serve to improve existing products or processes and to optimise business processes *(motive 1)*. This factor will also usually be the primary reason that motivates companies to tap into data sources.

Moreover, the use of data can also lead to the further development of existing business models or the development of new business models *(motive 2)*. This has been the case to a large extent in B2C markets. In these markets, the use of consumer data or creation of profiles during this process has sparked brand new opportunities for value creation and thus also the formation of new, sometimes disruptive business models. In the industrial B2B context, the starting position must be assessed differently with regard to the heterogeneity of the data and the associated integration efforts. Nevertheless, it is clear that here, too, existing business models will be further developed and new business models established, some of which are expected to be disruptive.

Another reason motivating companies is that they are facing growing legislative and social pressure to take environmental and social criteria into account in their product portfolio (motive 3). This may require using data and sharing it across the value chain, e.g. the German Electrical and Electronic Manufacturers' Association (ZVEI) showcase for determining the "Product Carbon Footprint"[5].

Multilateral data sharing is essential to meet these requirements. This has already been recognised by the automotive industry. Initiatives such as Catena-X are laying the initial foundations for secure multilateral data sharing between

5 Automatisierung entscheidend für Klimaschutzziele – zvei.org ("Automation decisive for climate protection goals"; available in German only)

market participants along the automotive value chain. The focus is on the development of data exchange frameworks that guarantee data sovereignty and thus create a basis of trust between the partners. Based on three ideal types of motives, the motivation for multilateral data sharing is described below and illustrated by selected practical examples. Basic technical, legal, and economic conditions of data sharing are considered in each case.

What are the ideal motive types for companies to share their data with other companies?

Motive 1:
Improve existing processes and products

The cross-company availability of data along the value chain can make a significant contribution to the transparency of value chains. End-to-end value chain transparency should not only enable traceability, but also represent all of the externalities associated with the value chain. The advantages of end-to-end value chain transparency are manifold, as illustrated by the following examples:

- Data transmitted in real time enables companies to respond to fluctuations in demand in a timely manner, adjust supply inventories, and thus optimise risk management in their supplies.
- Value chain transparency can highlight, quantify and exploit potential for cost savings.
- Quality costs can be significantly reduced by means of information on the manufacturing history of product components and data-driven root cause analysis (see box).

When data from the usage phase of products is shared multilaterally, new opportunities can arise in the area of analysing product usage and application, which can then be used to further develop and optimise products. Transparency with regard to product usage data helps manufacturers to identify weak points and potential areas for improvement in products more quickly and thus implement more efficient product maintenance.

For example, when a component supplier supplies a machine supplier, the return flow of information from the use phase is of increased interest not only to the machine supplier, but also to the component supplier. For the component supplier, operating data can help, for example, to identify design errors and production faults and to correct these promptly. The following example shows the potential of multilateral data sharing between market participants in automotive manufacturing:

> Nowadays, if vehicle malfunctions occur during operation, the root cause analysis is often carried out in the form of a parts-driven quality management process: After the faulty component has been replaced, the causes of the malfunction are only reported back to the vehicle manufacturer and component supplier by the workshop on a random basis. Relevant details and contextual information regarding the malfunction are often missing completely. This is mostly due to the use of isolated, proprietary IT system solutions by the parties involved (workshop, vehicle manufacturer and component supplier), which hinder cross-company collaboration. Switching to a data-driven quality management process, where relevant root cause information is shared in a structured way between all parties involved, enables faster root cause analysis and targeted traceability in the value network (for example, instead of a manufacturer having to recall 100,000 cars due to a fault, the actual number might only be 50 because the fault can be pinpointed more precisely).

Motive 2:
Further develop existing business models and develop new business models

Multilateral data sharing can also be a key driver behind the further development of existing business models and the establishment of new business models. Taking machinery and plant engineering as an example, this results in a wide range of opportunities for the individual partners in the value chain.

In addition to selling production equipment, marketing a service bundle for remote maintenance of production equipment based on the usage data is already common practice among companies today.

Alternatively, the machine supplier may no longer be able to sell the production equipment to the factory operator, but may receive an ongoing payment from the factory operator instead based, for example, on the usable output ("pay-per-use"). This would allow a service bundle to be combined in various forms or expansion stages, e.g. remote maintenance/service on site or data provision (production data, Q data, etc.) via standardised application programming interfaces (APIs) or in blockchains for application scenarios. The ongoing payment then scales according to the "add-on services" ordered. It is conceivable that in a similar set-up the factory operator would receive a bonus in the form of credits, discounts or cash: the factory operator would allow the machine supplier to access the usage data of the production equipment and thus spot potential opportunities for optimising its future products.

The multilateral expansion in this example extends data sharing to additional participants in the value chain, thus extending the previous bilateral, point-by-point approach to other relevant elements of the value chain. In the above business model (pay-per-use for the quantity of machine output of parts), data on the supply of raw material for the machine would add value, as well as data on the quantity, quality and demand in further processing of the parts produced by the machine. In this context, the machine can always be considered as part of the value chain. Therefore, the consideration and thus the data sharing can also include larger parts of the value chain, such as a complete production line or even an entire factory with suppliers and customers. Environmental parameters such as room temperatures or weather could also be added, especially in data-driven use cases for energy optimisation.

Data collected at the machine, store floor and factory levels can be used in a variety of ways as new business models are developed. For a factory operator, the collection of data from data sources (sensors, controls, IT systems) can be priced using a value per data point and the volume of the data collected. This business model is currently only used in a bilateral business relationship. However, it could also conceivably be extended to multilateral business relationships. Furthermore, this data could also be used to create common pools of data sets from different companies and industries, which could then be used in R&D as training data sets for the development of algorithms. For example, optical inspection systems based on artificial intelligence (AI) require large volumes of image data for the teaching process. The provision of neutralised data from different production companies generates a larger data pool and can thus accelerate the AI process to generate meaningful results[6].

Motive 3:
Support in the consideration of ecological and social goals as well as regulatory requirements

Future regulatory requirements for a climate-friendly and resource-efficient economy will also make new forms of collaborative data collection and use necessary. An important element of this will be digital product passports across all companies in the value chain, in order to fulfil the extension of the "Ecodesign Directive" in a "Sustainable Product Initiative" of the European Commission, as defined in the Green Deal.

One barrier to data sharing for companies is often the initial investment cost. This applies in particular to small and medium-sized enterprises (SMEs): According to the Federal Statistical Office, these approximately 2.6 million companies account for 42% of gross value added in the Federal Republic.[7] The question is not simply that of investing in technical infrastructure, it is also about investing in developing the relevant expertise and checking the legal permissibility of data sharing.

6 Wie KI die Qualitätssicherung im Schweißprozess verbessert (produktion.de) ("How AI impoves quality control in the welding process"; available in German only)

7 See Federal Statistical Office: Small and medium-sized enterprises

However, if the industry is already obliged to make such investments in order to comply with regulatory requirements, the investments made in this regard can also be used more widely. Again, an example of this is the Supply Chain Due Diligence Act ("Supply Chain Act"). As of 1 January 2023, this law obliges companies with at least 3,000 employees in Germany (and as of 1 January 2024, companies with at least 1,000 employees in Germany) to make reasonable efforts to ensure no violations of human rights occur in their own business operations and in the value chain. Comprehensive monitoring and documentation obligations are regulated in the law. These obligations would be greatly simplified if IT-based collaboration structures allowing the necessary data to be shared in the value chain were available for this purpose.[8] The requirements could be imposed by the companies at the end of the value chain on their suppliers. If investments in data-sharing capability must be made in any case, it would make sense to use this potential for other value-creating purposes as well.

Ultimately, companies must balance conflicting interests within their own field and their business activities are therefore guided not only by policymakers, but also by other institutions. Non-governmental and non-profit organisations set standards and norms, creating product transparency through certifications and labels. As a result, there is more pressure on customers to gain a greater insight into the origin and sustainability criteria of products.

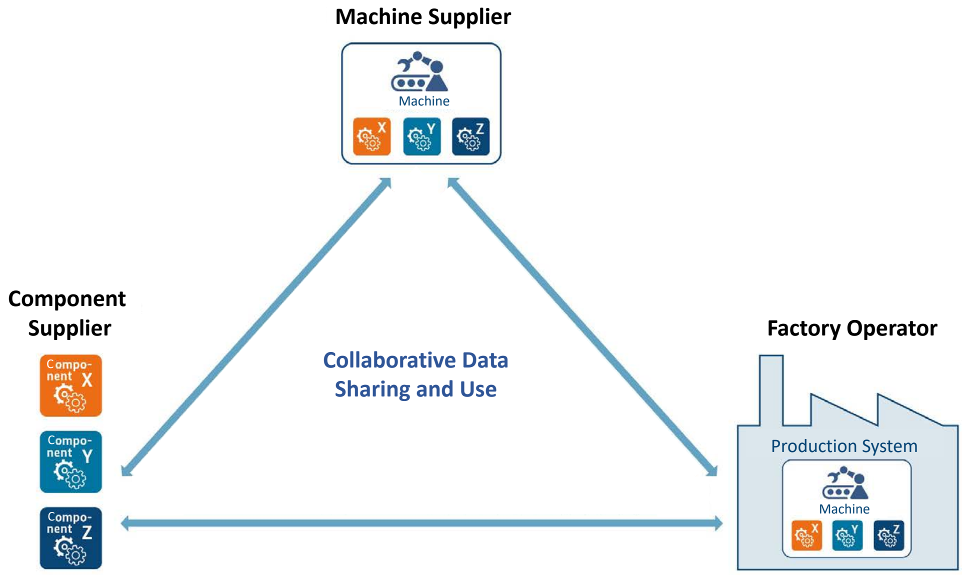
This trend can be taken into account through cross-company data exchange, e.g. in order to be able to determine the product carbon footprint of a product across the value chain in a methodically reliable way.

8 With Gaia-X and the Federation Services, a decentralised, federated infrastructure will be available for this purpose in the future.

4 Concept of multilateral data sharing using CCM as an example

To further elaborate the concept of multilateral data sharing, the CCM three-point fractal, that is, the smallest possible unit for multilateral data sharing, is first introduced as a reference model. Second, the potential market participant roles within the reference model are explained. Finally, the reference model is presented in detail on the basis of a "coopetitive"[9] approach.

Figure 1: Reference model



Source: Plattform Industrie 4.0

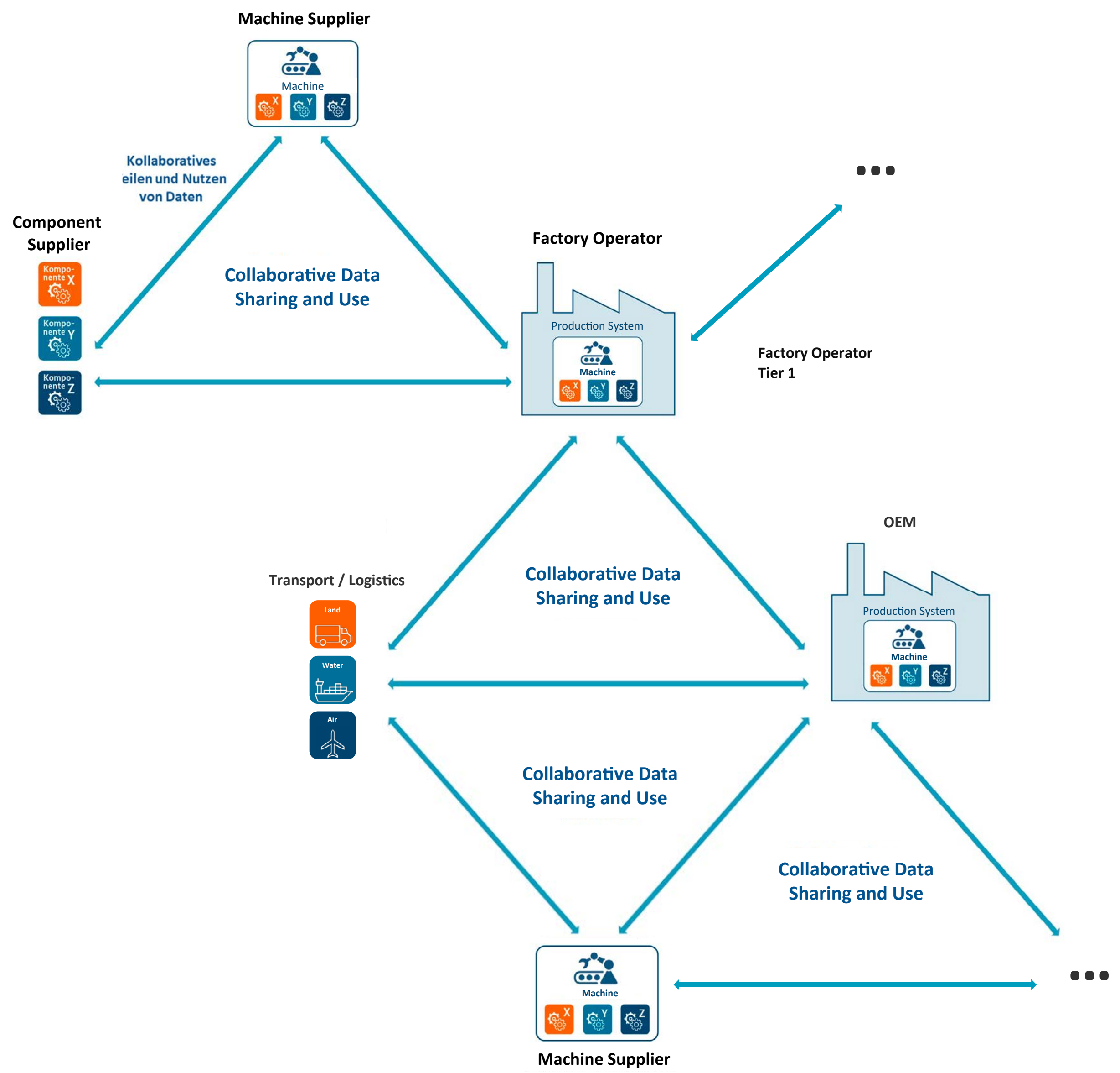
9 Coopetition: https://www.investopedia.com/terms/c/coopetition.asp; Coopetition is a neologism coined to describe the act of cooperation between companies that compete with each other. The term is a portmanteau of cooperation and competition.

4.1 The CCM three-point fractal as a reference model

CCM is based on cross-company cooperation within the framework of the “three-point fractal” consisting of a component supplier, a machine supplier (integrator) and a factory operator, with the aim of generating economic added value for all parties involved (cf. Figure 1).

Nowadays, productive value creation in industrial applications often takes place in globally distributed value networks. Such a value network includes a variety of companies, such as OEMs (original equipment manufacturers), suppliers at various tier levels, machine suppliers, system integrators and IT system solution providers. These companies are accompanied by providers of additional services for the organisation and execution of global logistics and

Figure 2: Modelling of cross-company collaboration in a production value network based on the scaled reference model



Source: Plattform Industrie 4.0

service processes. All of these entities in the global value network of production have a variety of different bilateral relationships with their partners in the value chain. The complexity of these value networks can be modelled by scaling the three-point fractal (cf. Figure 2).

4.2 Roles in the CCM concept

With regard to the creation and use of data, a basic distinction can be made between the stakeholders according to (i) who creates the data or at whose site is the data created ("data producer"), (ii) who is authorised to decide on the handling or use of this data ("data controller"), (iii) who offers the data to third parties ("data provider"), and (iv) who uses or evaluates the data ("data user").

These roles are not mutually exclusive; one participant may take on multiple roles. With regard to the CCM triple-point fractal, one participant may even assume all roles in the case of a factory operator. A factory operator generates the data, has control over the data, can offer the data to third parties for their use and also evaluates some of the data in order to monitor the factory's own production.

1 | Data producer:

The data is generated by the data producer or at the data producer's site. With respect to the CCM three-point fractal, we assume that only the factory operator can be the data generator. The component supplier or the machine supplier could also possibly be considered as the data generator. After all, they install the hardware by means of which the data is generated. However, a piece of hardware only records information that is generated by the factory operator's use of the production equipment. No one would think that the manufacturer of a video camera is also its user, i.e. the person who is the "data producer" of videos and who then possibly trades with these recordings.

2 | Data controller:

A data controller is anyone who can factually access data without violating legal provisions, such as in particular Sections 202a ff. and 303a of the German Criminal Code (StGB) or the Law on the Protection of Trade Secrets (GeschGehG).[10] In the CCM three-point fractal, this can be all participants. Since data is not subject to an exclusive right, there are hardly any restrictions on the role of data controller.[11] Exclusive rights are, for example, ownership or copyright. An exclusive right protects the holder against any third party; i.e., no one may use the thing or copyright work in relation to which the exclusive right exists without the express permission of the right holder. The situation is different for data. If the data controller passes on data to a third party, the third party may use this data freely. This applies in all cases except where third parties come to a contractual arrangement with the data controller to restrict their use of the data. However, this contractual restriction of use – usually referred to as a data licence[12] – is only binding between the contracting parties. If the licensee discloses the data to another third party in breach of the contractual restrictions, the original data controller cannot prohibit this third party from using the data.[13] The data controller may only claim damages from the licensee due to the breach of the contractual restrictions or, if agreed, the payment of a contractual penalty.

The data controller is therefore anyone who has access to the data. If the data controller breaches contractual restrictions, such as prohibitions on disclosure, this remains irrelevant for a third party; the restriction is not transferred.

3 | Data provider:

The data provider makes the data available to third parties. In the CCM three-point fractal, the data provider is the factory operator who communicates the data to the machine supplier or the component supplier. It is also conceivable

10 This does not apply to personal data as defined by the General Data Protection Regulation (GDPR); such data may only be processed to the extent that the controller can invoke a legal justification as defined by the GDPR.

11 See "Digitaler Neustart" ("Digital Reset"; available in German only) Working Group of the Conference of Ministers of Justice of the Federal States, Report from 15 May 2017

12 The term is misleading, since the licence originates from the field of industrial property rights. A licensor grants the licensee rights to an exclusive right. In contrast, under a data license, the licensor restricts the licensee's otherwise free control over the data.

13 Even the mere willingness of a third party to take advantage of the licensee's breach of contract known to him does not, as a rule, lead to claims by the data controller against the third party (cf. Grüneberg/Sprau, German Civil Code (BGB), 81st edition, Section 826 point 23).

that the machine supplier may communicate data to the component supplier. In addition, disclosure of data by participants in the three-point fractal to third parties is possible either directly or through an intermediary, such as a data trustee.

Since there is no such thing as an "exclusive right" to data,[14] data providers are regularly confronted with the issue that the data they have provided may be disclosed to unauthorised third parties. If, for example, the three-point fractal only comprises data being communicated by the factory operator to the component supplier and if the data in question is only, for example, generated by sensors installed by the component supplier, this is less relevant for the factory operator. However, if the data can be used to indicate how the factory operator controls production, which customers the factory operator works for or even whether production capacity utilisation is high, this is data that competitors can use to draw conclusions about the future behaviour of the factory operator in competition.

Such risks are usually countered by having the data provider only disclose the data to the recipient if the recipient commits to a data use agreement, a data licence,[15] to limited use and to confidential handling of the data. The problem here is that the protective effect of such contractual prohibitions is actually very weak. It is only possible in exceptional cases for the data provider to prove that a licensee has violated the prohibitions on disclosure regulated in the data use agreement. Contractually bound data recipients can always claim that they did not release the data and that the data must have been accessed directly from the data provider without authorisation. There are currently no suitable contractual means to increase the de facto protective effect of prohibitions on disclosure and confidentiality obligations in data use agreements. A technical solution such as a technically unchangeable recipient identifier for the data concerned would make it easier to prove who disclosed the data.

4 | Data user:

The data user evaluates either self-generated data or data received from a data provider. If the component supplier wants to access the data for its components during the machine operating phases, it is considered to be a data user. If the component supplier has received the data from the data provider under a data licence, the component supplier is under a contractual obligation to the data provider to comply with the scope of use regulated in the data licence. In fact, however, the data user is a data controller just like the data provider, i.e., third parties have free control over the data obtained from the data user.[16]

4.3 Coopetitive granularity of the reference model

The granularity of the three-point fractal as a reference model of the CCM use case with respect to multilateral data sharing is discussed at three levels of consideration.

4.3.1 Data set

The first level of consideration is the *data set*, i.e. the particular data objects that are exchanged across companies.

To illustrate the key challenges and issues that arise in cross-company collaboration from technical and market viewpoints, the exchange and use of temperature data is envisioned as a potential use case in relation to the three-point fractal. Here, the temperature data only serve as a representative application example for a data object; other data objects could also be used, e.g. carbon emission data against the background of an integrated sustainability consideration.

14 See previous Chapter 4.2 Roles in the CCM concept, under "2 | Data controller".

15 On misunderstanding the term, see above footnote 12.

16 See previous Chapter 4.2 Roles in the CCM concept, under "2 | Data controller".

4.3.2 Data business policy

The second level of consideration, *Data Business Policy*, comprises essential aspects that must be taken into account when modelling data for cross-company data use (see Figure 3). Issues relating to data handling are addressed in the data business policy, e.g. the agreement on data use rights (analogous to the description of use rights in bilateral contracts).

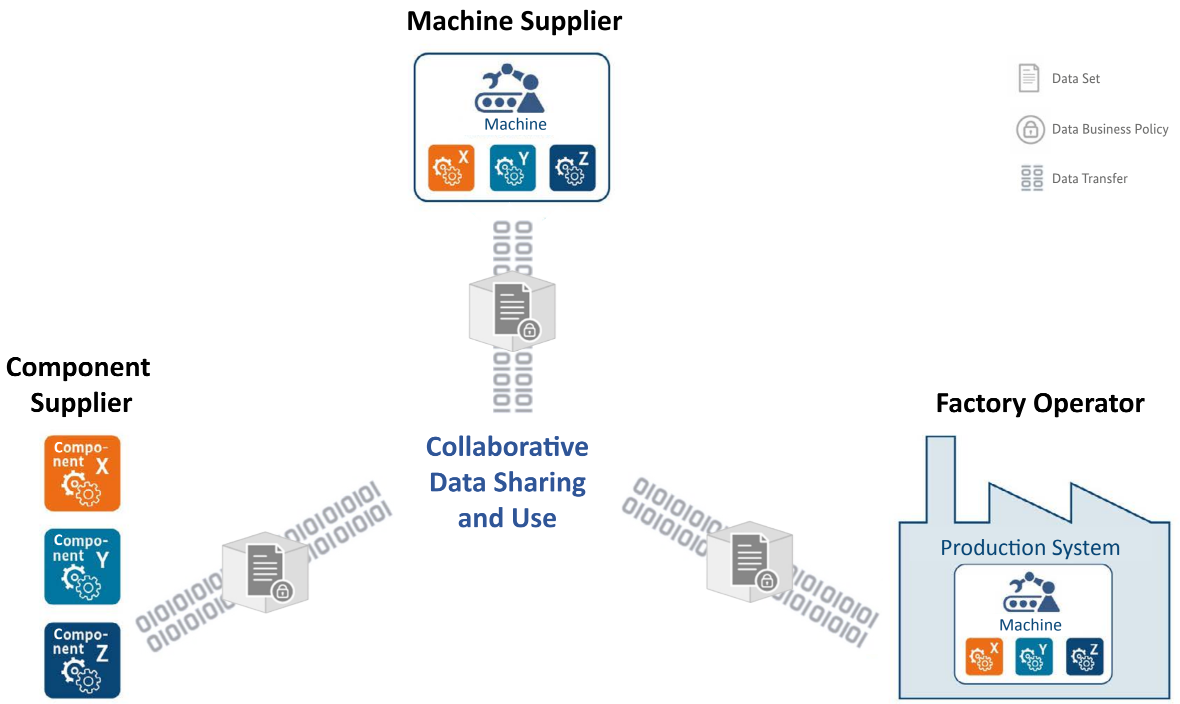
Every piece of data (e.g. piece of temperature data) that is to be used and exchanged across companies must comply with a data business policy that regulates data usage by defining different parameters for the specific piece of data. This metadata describes essential properties of the piece of data, such as usage or application, covering both technical and economic aspects of date usage.

Table 1 shows examples of the possible regulatory content of a data business policy:

Table 1: Examples of the regulatory content of a data business policy

Regulatory object	Explanation
Authorised to access	Who is allowed to access/disclose a piece of data (e.g. for benchmarks)?
Access purpose/use	For what purpose may a piece of data be accessed?
Access duration	When/how often/for how long may a piece of data be accessed?
Access mode	Is the data accessed directly or is the algorithm sent to the data for evaluation?
Licence	On which licence model is the data use based? According to which IP policies may the piece of data be used? What are the requirements for legally compliant use of the piece of data? On which regulatory/legal framework is the data use based?
Price	How much does the piece of data "cost" the individual market participant? What do revenue sharing models look like for the market participants involved?
History	
• Origin of the data	Where and under what circumstances was the piece of data created (e.g. operating condition, measuring equipment, tolerances, etc.)?
• Data producer	Who generated the data?
• …	…

Figure 3: Data set and data business policy in the reference model



Source: Plattform Industrie 4.0

4.3.3 Data exchange framework

The third level of consideration *Data exchange framework* plays an important role here. It is used to establish the framework conditions (technical, legal, and economic) for cross-company data exchange (see Figure 4). In the same way as for a road network, the infrastructural components of the data exchange framework are to be built on the basis of a collaborative/cooperative approach among all stakeholders and users, with appropriate fees paid for use.

Care must be taken in the design of all three levels of consideration to ensure that data is handled responsibly. Therefore, further development of the reference model should be based on the five basic principles of the ZVEI for using data and platforms[17]:

1. Ensure data sovereignty: The data generator is responsible for determining access to and use of the data generated.

2. Establish transparency: The use of data follows clear rules agreed among all partners involved.

3. Protect trade secrets and intellectual property: If trade secrets or intellectual property can be derived from data, these are subject to the corresponding property rights.

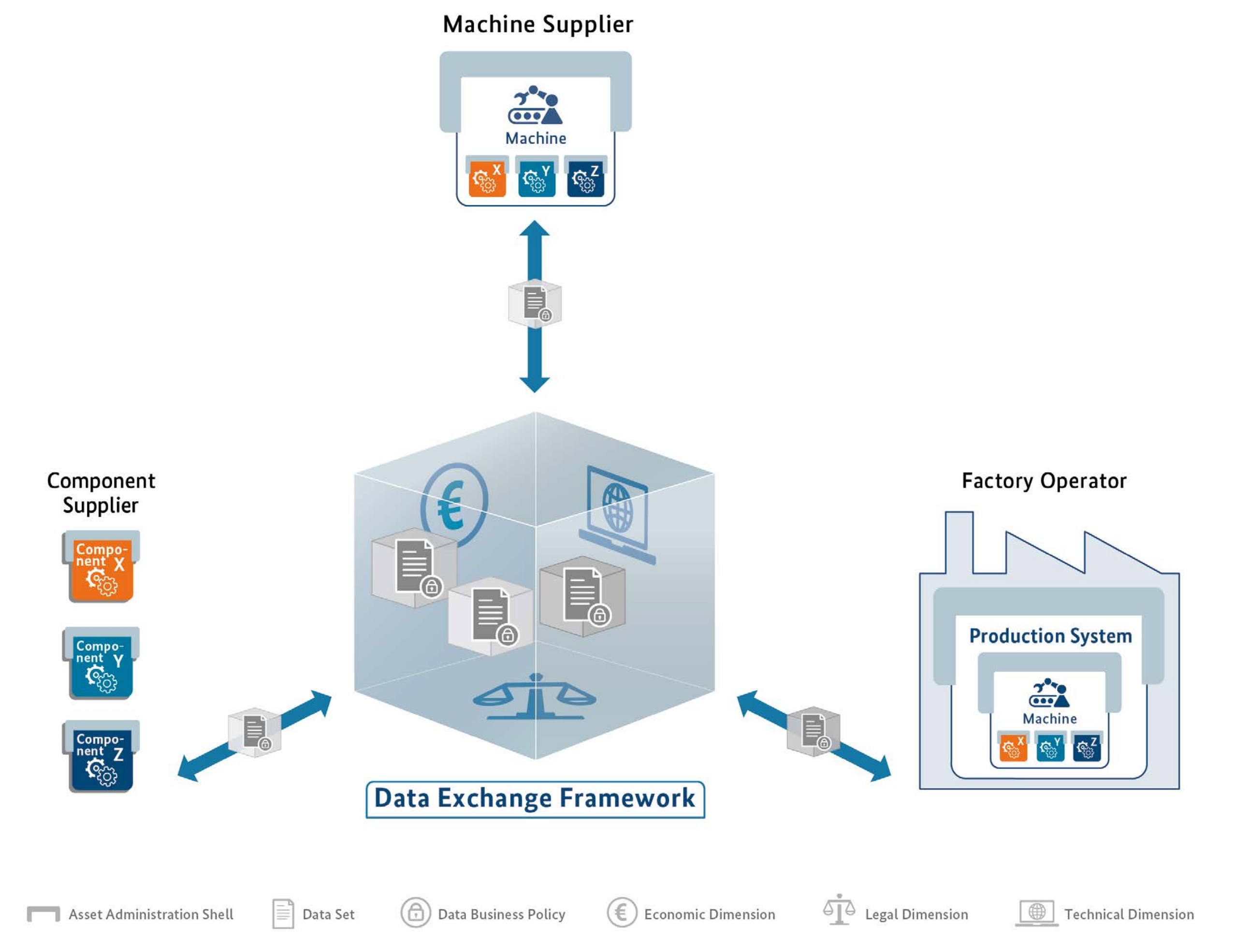
4. Data security has top priority: Security by design and state-of-the-art security lifecycle management ensure that data access, processing, storage and evaluation meet the highest possible security standards.

17 See ZVEI: Guidelines of the electrical industry for the responsible use of data and platforms (2020); Digital Europe (DMEC): Data Governance Principles (2020)

5. Ensure data portability: The use of interoperable data formats ensures that data can be used across different generation and application contexts.

For the technical and organisational implementation of data sharing and storage, a tool is required that is trusted by all market participants involved and guarantees secure, data provision according to demand. The main challenge of this type of tool is to establish a framework that enables all participating companies to make even large amounts of data available for further use without worrying about sacrificing their expertise as market competitors.

Figure 4: Data exchange framework in the reference model



Source: Plattform Industrie 4.0

Core features of a data exchange framework

Based on the five characteristics of cloud computing according to NIST[18], four core characteristics are initially defined for a data exchange framework to be used for the technical implementation of the CCM use case:

- On-demand data selection and access: Under existing “framework agreements” between parties, data can be selected at will and data access granted. Data can be selected before being accessed, e.g. via a search function. Data access takes place automatically, i.e. without additional approval by humans.
- Interoperable data access: Data is annotated in a machine-readable manner and is available in open formats. This allows heterogeneous usage scenarios (platforms, applications, devices) to be realised.
- Provider elasticity: A provider of data uses an infrastructure that potentially enables any number of consumers. Once legal issues have been settled, there are therefore hardly any technical obstacles to data sharing.
- Measured and traceable usage: Access to data can be implemented and logged in a fine-grained manner. This logging enables pay-per-use business models.

Key organisational or non-functional issues for setting up a data exchange framework include:

- Does the data exchange framework support the desired data business policy?
- What are the requirements for the processing/storage of the data (e.g. trustworthiness, security requirements, etc.)?
- What regulatory requirements apply to storage?
- On which technology should the physical data storage be based (e.g. edge, cloud, etc.)?
- Who is the owner/operator (data broker) of the data storage system?
- Who acts as “super admin” for piece of data? What rights and obligations are associated with the “super admin” role?

With its Labelling Framework[19] and Labelling Criteria[20], Gaia-X provides a solid set of requirements for services within a data exchange framework.

18 See The NIST Definition of Cloud Computing
19 Gaia-X Labelling Framework_0.pdf
20 Gaia-X Labelling Criteria

5 Design aspects of collaborative data sharing

5.1 Data spaces as a scaling factor

The three design aspects of a data exchange framework highlighted in the CCM example can be implemented in individual application examples (see Annex) or incorporated in larger collaborative contexts, which can also be referred to as "data spaces".

A single, uniform definition of "data space" does not exist. The European Commission defines data spaces as follows (European Strategy for data[21]): "The European strategy for data aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. Common European data spaces will ensure that more data becomes available for use in the economy and society, while keeping the companies and individuals who generate the data in control."

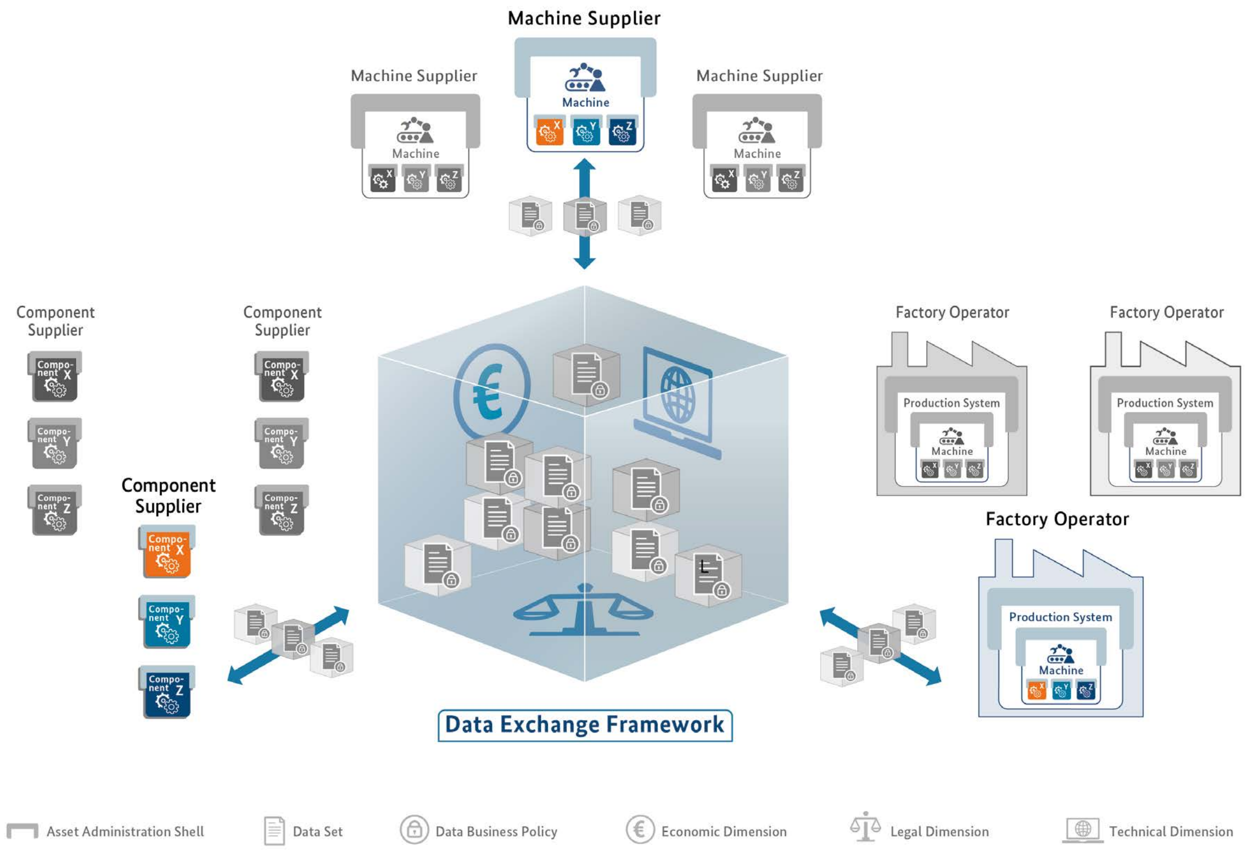
In the Federal Government's[22] 2021 data strategy, data spaces are characterised as follows in terms of function: "Data spaces are key elements (...). They provide users with shared trusted spaces for transactions in which data can be provided, analysed and managed in collaboration. Contrary to what the term suggests, data in data spaces does not have to be consolidated centrally. There are lots of ways in which data spaces can be designed both technically and legally."

Against the background of the CCM three-point fractal, we understand data spaces to be characterised by a uniform data exchange framework and thus by common technical, legal and economic frameworks. In this sense, a data space does not specify individual business processes, particular technologies or use cases. Instead, it provides frameworks, routines, standards, and guidelines that can be used as a basis to initiate efficient cross-company collaboration and data sharing.

From the user's perspective, a data space provides a trusted environment for multilateral collaboration between companies, e.g., from the integration of data sources, through storage and data access management, to data analysis and value-added services based on data analysis, taking into account the three design aspects.

21 A European Strategy for data
22 Data Strategy of the Federal German Government

Figure 5: Concept of the Industrie 4.0 data space



Source: Plattform Industrie 4.0

In abstract terms, a data space is characterised by the concrete definition of the above-mentioned five basic principles of the data exchange framework (see Chapter 4.3.3).

Data spaces allow additional partners to be included and thus support scaling beyond individual use cases. Due to this scaling function (which is relevant for developing an industrial data economy), the establishment of data spaces is currently also the focus of economic and political initiatives at different stages of maturity. Current (and partly overlapping) examples are the Common European Data Spaces in eight application fields, the implementation of Gaia-X, Catena-X or Manufacturing X/Data Space Industrie 4.0.

Figure 5 provides an example of how a data space spans the technical, legal and economic dimensionsand how this data space grows dynamically as more and more data space participants are connected. The market participants from the CCM reference model are used for this purpose: component suppliers, machine suppliers, factory operators. Many other stakeholders could also possibly join: legal services, customs authorities, public administration, port authorities, logisticians, etc. could contribute to or benefit from a data space.

Crucially, a data space is not a free data lake in which everything is available to everyone. On the contrary, it provides all participants with the agreed standards necessary to organise data exchange between dedicated parties in a targeted and easy way – technically, legally and economically.

The core principle of data spaces therefore to provide connectivity, in a technical, legal and economic context. This necessary connectivity represents an obligation on both sides: First, the data space should be designed to minimise the hurdles and effort on the part of participants to connect. Second, interested potential participants must be prepared to establish this connectivity on their own end. This then applies to all participant roles.

For participants in multiple data spaces, there may a greater connectivity challenge, since we cannot yet assume that different data spaces define the same connections. Anyone wishing to participate in the Industrie 4.0 data space, Catena-X and the Mobility data space will most likely have to address the issue of connectivity three times. Cross-industry and cross-vendor initiatives such as Gaia-X are working to provide data space building blocks that enable the same connectivity capabilities for different data spaces.

Design features of data spaces should therefore make the connection of data space participants to each other reliable and simple, especially the connection of data providers and data users – in a technical, legal and economic context.

From a technical perspective, data spaces generally use different concepts for sovereign data exchange (e.g. International Data Spaces Association[23], Eclipse Dataspace Connector[24] or decentralised technologies such as Ocean Protocol[25]).

The legal and also regulatory frameworks are just emerging and are therefore subject to significant changes and regional differentiation.

Connecting data spaces/exchanges between data spaces: As described previously, it can be assumed that data spaces will initially be constructed around the standards and practices of individual industries and sectors. For example, discrete industry, process industry, finance, retail, mobility, and logistics have many economic/specialist requirements of their own to define data spaces with good and easy connectivity in each case. There are also many valuable cross-connections and dependencies that make cross-cutting data exchange attractive.

Data spaces therefore offer a construct to overcome the obstacles to multilateral data sharing outlined above. Considering the postulated major economic benefits that are also to be expected from multilateral data sharing, the designers of data spaces bear a great economic responsibility.

The requirements for functioning data spaces for multilateral data sharing are therefore:

1. Simple, secure, cost-effective connectivity for data space participants

2. Use of standard technologies and concepts, use of cross-industry federated infrastructures if necessary

3. Clear, compatible regulations/general terms and conditions at the legal level for data space participants. A technical platform on its own is not enough.

4. Clear, compatible economic options for data space participants

5. The data space itself must be provided and operated in a way that is legally binding and also creates trust among participants.

23 Home - International Data Spaces

24 Eclipse Dataspace Connector | projects.eclipse.org

25 Tools for the Web3 Data Economy – Ocean Protocol

Specific examples of data spaces currently being implemented:

- MDS[26] - Mobility Data Space spans a data ecosystem for all manufacturers, suppliers, service providers and users of all conceivable mobility assets and services.
- Catena-X is a data space for all participants in value chains in the automotive industry.

5.2 Technical design aspect

In technological terms, there are two basic requirements for the CCM approach. The first of these is technical and semantic interoperability. This includes a common understanding of the rights of use and access to the data. Data providers decide themselves which data (data sets) to share with which users and with which access rights (data business policy) and for what purpose the data is to be processed.

To restrict access and use of the data to the authorised group, the semantically interoperable attributes to be assigned to the data must be defined.

International standards which are vendor and domain-neutral are required for this purpose. They must be able to map all forms of assets (components, machines etc.), including non-intelligent assets, and enable the storage and processing of their data.

The subject of connectivity is also relevant. This means in principle that all market participants can participate in CCM and that there are no technological or competitive barriers. It also means that data usage should ideally be based on neutral standards.

The Asset Administration Shell (AAS)[27] provides a cross-industry and cross-technology approach for this purpose. It is used to digitally map assets in the form of a digital twin.

The AAS metamodel defines the possible elements for modelling the AAS metamodel instances, e.g., asset, asset administration shell (AAS), submodel (SM), submodel element collection (SMEC), property, and other submodel elements. The technology-neutral AAS metamodel as a UML class diagram (UML = Unified Modeling Language) is serialised and saved as a schema file for XML, JSON and RDF. AAS instance data uses the elements described in the metamodel to describe asset types or asset instances. AAS instance data can be populated in a variety of ways and can be loaded into AAS server applications and instantiated as a storage object. The AAS instance data can be accessed via the AAS API of the AAS server applications. The AAS instance data can be accessed and used following authentication and authorisation according to the participant's access rights. The AAS registry provides a directory service for AAS instance data.

Using the AAS for the CCM use case, as shown in Figure 5, enables multilateral data sharing. It is assumed that each AAS contains a submodel SM T "Temperature data" (data set) and a submodel for "Use and application of temperature data" (data business policy). In its role as data generator, the factory operator opens up the data sets and associated data business policies to the Industrie 4.0 data space (data exchange framework). The component supplier can find the data sets for its components via the AAS registry and gain access to the data via the AAS API.

In this context, the AAS provides the interface for integration into data spaces as a single point of entry. This type of data exchange based on the AAS is available in the form of an open-source implementation[28]. Authentication can be performed both via X.509 certificates[29] and via self-sovereign identities (SSI)[30].

26 Mobility Data Space – acatech; available in German only

27 Plattform Industrie 4.0: What is the administration shell in technical terms?

28 Home of AAS (admin-shell-io.com)

29 Industrial Digital Twin: AAS security; demo in German only

30 Update 6 AAS Security with SSI IDunion Lissi

5.3 Legal design aspect

In the CCM use case, data sharing also needs to be legally compliant. However, many legal issues essential to the use and sharing of data have not yet been resolved. This is already true at the national level and even more so in international situations. It is another reason why companies have widespread reservations about sharing data.

The European Commission wishes to counteract this uncertainty, at least within the European Union (EU), with a large number of legislative acts as part of the European Data Strategy . The cross-sectoral use of data in business and the public sector is to be specifically regulated and promoted. Examples of such legislation include the Data Act (a bill to promote data access and exchange), the Data Governance Act (which aims to promote the availability of data for use), and the Digital Markets Act and Digital Services Act (which regulates online platforms). Although these legislative acts are likely to be controversial in the short term, they can contribute to the desired legal certainty in the medium term.

However, it must be stated that legal uncertainty still exists even within the scope of application of established legal standards. For example, uncertainty about what is permitted under data protection law in Europe in accordance with the provisions of the General Data Protection Regulation (GDPR) is cited by companies as a major obstacle to data sharing (see Section 5.3.1 below) There is also a fear that an exchange of data could be qualified as an exchange of competitively sensitive information between competitors and, under certain conditions, could violate German and European bans on restrictive practices (German Act against Restraints on Competition (GWB), Section 1; Treaty on the Functioning of the European Union (TFEU), Article 101 (1) TFEU) and lead to fines (see Section 5.3.2 below).

5.3.1 Data protection law

The CCM use case concerns data generated by sensors installed in machines that is to be shared by the participating companies. This data is not obviously considered to be personal in the sense of Article 4 No. 1 GDPR. However, personal references in this data can arise in the context of the CCM use case, for example through time stamps and the additional information about which employee used a machine and when. In this respect, it must also be assumed with regard to machine-generated data in Industrie 4.0 that a personal reference in this data is an "... undesirable but factually unavoidable side effect".[31]

The importance of anonymising data, especially in the context of Industrie 4.0, is therefore repeatedly underscored.[32]

If personal references are removed from the data, the GDPR no longer applies to the anonymous information then available.[33] The option of reliably anonymising data would therefore greatly help the legally permissible sharing of machine-generated data, also in relation to the CCM use case. However, both the legal and the actual requirements for reliable anonymisation are currently the subject of debate.[34]

As long as the prerequisites and requirements for anonymisation remain unclear, another option is available, which is described as "confidential computing".[35] It is essential that the data does not leave the area under the control of the data provider, i.e. evaluation of the data takes place without transferring the data and without extracting the personal information. Whether this is then carried out directly by the data provider or, for reasons of convenience, by a data trustee who, as a processor within the meaning of the GDPR, takes over the technical set-up of data provision for the provider of the data and ensures that no personal

31 For more details, see the European Commission website, last accessed 28 March 2022: European Data Strategy – Making the EU a role model for a society empowered by data

32 See the publication by Plattform Industrie 4.0: Anonymisierung im Datenschutz als Chance für Wirtschaft und Innovationen ("Anonymisation in data protection as an opportunity for business and innovation"; available in German only)

33 This is logically necessary, but is made clear in recital 26 pp. 5 and 6 GDPR.

34 See e.g. Federal Commissioner for Data Protection and Freedom of Information (BfDI): Position paper on anonymisation under the GDPR with special reference to the telecommunications industry (2020, available in German only); and as a counter-position Schweinoch/ Peintinger, Anonymisierung im Datenschutz - terra incognita? ("Anonymisation in data protection - terra incognita?"), CR 2020, p. 643 ff. (available in German only)

35 See the presentation by the LINUX Foundation, available at: https://confidentialcomputing.io/; in this respect, however, it does not matter whether data confidentiality is achieved by a hardware solution ("trusted execution environment"), or by a software solution, e.g. the Ocean Protocol, a solution based on blockchain technology.

data is extracted when the data is evaluated by third parties, is ultimately irrelevant. Either route is possible under the GDPR. At first glance, the route via a data trustee seems more promising, since not every data provider has to set up their IT systems accordingly. Software-as-a-Service (SaaS) or Hardware-as-a-Service (HaaS) solutions are just as easy to set up.

5.3.2 Antitrust law

Sharing data as part of the CCM use case may also violate antitrust law.[36] It may constitute coordination of competitive behaviour by the participants in the information exchange in violation of antitrust law. So-called anticompetitive market foreclosure, in which companies not participating in the exchange are significantly worse off competitively than the participants,[37] is less likely. However, a claim for access to the data exchanged within the scope of the CCM use case is conceivable on the basis of data-related unilateral dependence and relative market power within the meaning of Section 20 (1a) of the Act against Restraints of Competition (GWB).

1 | Antitrust coordination:

An exchange of information between companies can be both pro-competitive and anti-competitive; only in the latter case can coordination in violation of antitrust law be considered. It is harmful to competition if the information directly or indirectly provides information about competitors' future market strategies. The component supplier and machine supplier could compete with each other in the area of maintenance, for example. In the CCM use case, a (potential) competitive relationship is therefore not excluded from the outset. However, coordination in violation of antitrust law can only be a consideration if the origin of the data is identifiable and if confidential, current and strategic information is concerned; i.e., information that allows conclusions to be drawn about the competitor's future market strategy. This is, for example, information about prices, delivery quantities or stock levels. However, it cannot simply be assumed that the operating data relevant in the CCM use case allows conclusions to be drawn about specific infringements of competition law by the participants. This may nevertheless be the case for data that provides information about the service life of competitor products or about the competitor's capacity utilisation.

Consequently, coordination in violation of antitrust law does not generally apply in the CCM use case; nor is it excluded.

2 | Anti-competitive foreclosure:

A violation of antitrust law can also be considered if companies not involved in the exchange of information are in a significantly worse competitive position than those involved in the exchange of information. For anti-competitive foreclosure to apply in this case, however, the data in question would have to be of significant strategic relevance and also have to affect a substantial part of the relevant market. Such a scenario seems highly unlikely in the context of the CCM use case; all the more so because the CCM use case is designed to include rather than exclude potential additional participants. Such participation, however, excludes the possibility of market foreclosure.

3 | Abuse of market power:

A claim for access to data under the so-called "essential facilities" doctrine set out in Section 19 (2) No. 4 GWB is probably ruled out, since the absolute market dominance of the opposing party required for this is likely to be the absolute exception in the CCM use case. A claim for access on the basis of data-related unilateral dependence and relative market power within the meaning of Section 20 (1a) GWB is more likely. The regulation was newly introduced when the 10th GWB amendment came into force at the beginning of 2021. Data-related unilateral dependence exists, for example, when a company depends on access to data controlled by another company for its own operations. According to the explanatory memorandum to the law, a contractual relationship between the companies involved is not required for this. Data-related unilateral dependence is

36 See for more details Polley, C&R 2021, p. 701 ff.

37 See Komm., Horizontal-LL („Horizontal guidelines"), paragraph 127; Wagner-von Papp in MüKo WettbR, 3rd ed. 2020, TFEU Art. 101, paragraph 339.

said to exist when there are insufficient reasonable fallback options open to third parties for data use. Refusal of access for a reasonable fee may then constitute an unreasonable impediment - even if the data has not yet been made available to a third party. Ultimately, it will be necessary to observe how the case law on Section 20 (1a) GWB develops in order to be able to assess the eligibility requirements and the relevance of the provision for the CCM use case more precisely.

5.3.3 Challenges for cross-regional data exchange

The legal challenges relating to data exchange are substantial. Solutions are currently being developed to address these challenges for Europe and are expected to become established in the medium term. However, such European legal solutions do not apply globally, or even across different regions. For cross-regional or global data sharing, the challenge is to merge or share data from differently regulated regions. In Europe, Gaia-X is also being used as a legal model here, in which European "external data relations" are also considered.

At the same time, the chief information officers (CIOs) of many companies whose increasingly smart products (e.g. cars, refrigerators, machines, wind turbines) are being shipped around the world are developing and testing viable solutions for cross-regional or global data sharing, thus generating data worldwide.

5.4 Economic design aspect

5.4.1 Company processes

The economic design aspect includes the process landscape of a company, which can be divided into different types of processes: management processes, processes for creating goods and services, and support processes.

Management processes:
In particular, this involves target planning for a collaborative data exchange scenario, e.g. shortening delivery times (Key Performance Indicator (KPI) time), reducing quality costs (KPI profit), increasing production output by increasing throughput times or reducing downtimes (KPI quantity), or increasing production flexibility (KPI product type). With regard to management processes, common, coordinated target definitions are crucial (e.g. cost reduction versus quality improvement versus delivery speed).

Processes for creating goods and services:
Operationalised KPIs (derived from the management processes) are then applied to the processes for creating goods and services (procurement, production, logistics, sales), and become actual values via economic decisions in the processes for creating goods and services (e.g. procurement timing and quantity or production flow planning or warehousing/minimum inventory quantities). These actual values are fed back into the target planning. This is where a cross-company controlling approach is needed (controlling = planning, management, coordination and control of corporate activities).

In the processes for creating goods and services, the Enterprise Resource Planning (ERP) systems must communicate with each other via business networks and ensure inter-company controlling.

Support processes:
The support processes (human resources, marketing, legal, finance, IT, etc.) build the framework for economic interoperability. These support processes also need to be adapted to collaborative data sharing scenarios (e.g., networking IT in a three-point fractal or common calculation schemes for a revenue sharing model in the area of finance). In the support processes, IT system compatibility and coordinated calculation of the benefit (price) of the data must be achieved in particular.

Management processes and processes for creating goods and services are responsible for directly creating added value through the creation and commercialisation of products and services. The support processes enable the direct value-added processes.

5.4.2 Business model modelling for multilateral data sharing

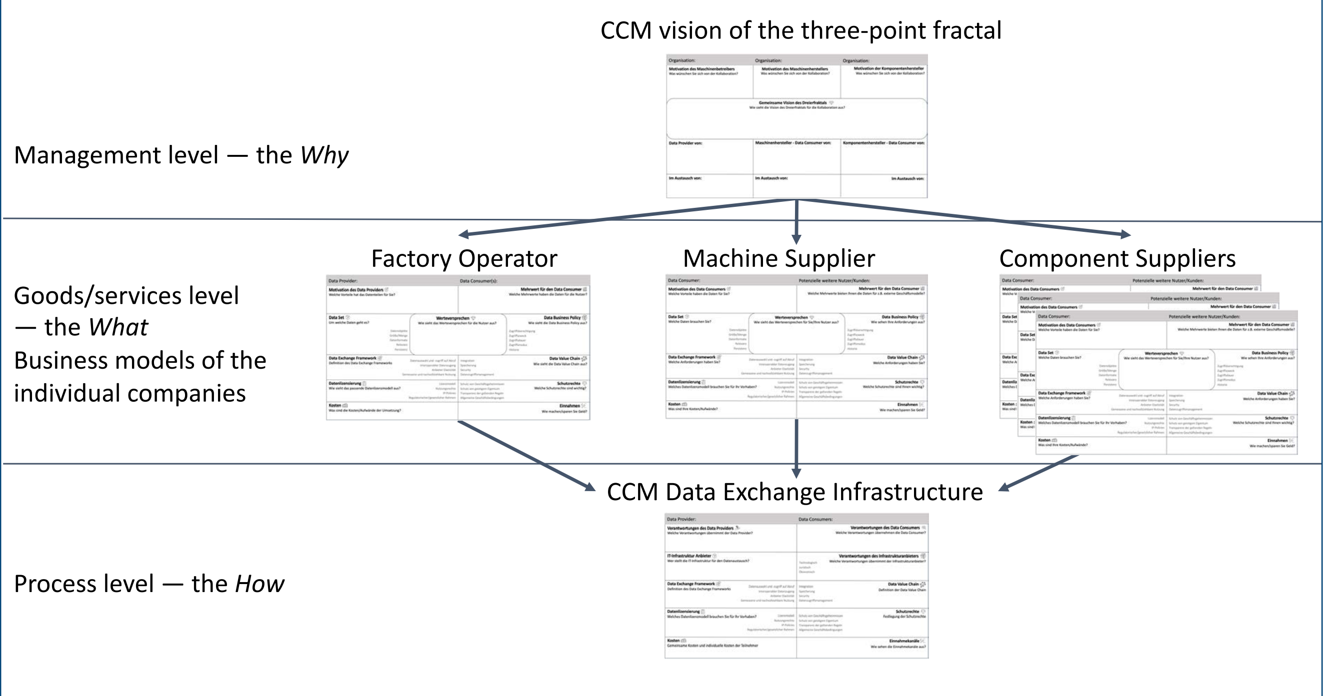
Chapter 3 outlines the reasons for multilateral data sharing based on three motives. All of the motives have a particular influence on the management processes. The management processes in turn influence the processes for creating goods and services. All of the motives are driven by clear economic considerations such as increasing efficiency, optimising across company boundaries, reducing carbon emissions or tapping into new business areas. Economic success is measured by corresponding KPIs.

Four CCM-specific canvases were created to support this economic perspective and incorporate the different business models in the context of a three-point fractal. The advantage of canvases is that they allow complex projects to be defined, which are structured and tailored to each collaboration partner.

The four CCM canvases enable the collaboration partners in a three-point fractal to align themselves comprehensively and hierarchically from the management level through the goods/services level to the process level (see Figure 6): The first canvas captures the shared vision of the three-point fractal (the "Why") at the management level. In contrast, the goods/services level, the specific business model targeted (the "What") is defined individually by each collaboration partner in the three-point fractal. Role-specific canvases were created to help define the goods/service level as well as possible and the concrete added values. A distinction is made here between the data provider and the data consumers. The fourth canvas defines the necessary infrastructural requirements (the "How") at the process level for the entire three-point fractal.

Once the partners, their roles, the management level, goods/service level and process level have been defined, it is ensured that the relevant conditions for successful col-

Figure 6: CCM – the business models in the three-point fractal



Source: Plattform Industrie 4.0

laboration are present: In the context of the three-point fractal, it is known why the individual companies are interested in collaboration, what they want to exchange, and under what conditions the exchange can take place. It should be emphasised that canvases, with their simple, transparent structure, are ideally suited to adapting this knowledge to potentially changing conditions. In this way, the progress of a collaborative initiative can be documented and the current actual status can be tracked in an agile manner.

If the goals of the participants in the three-point fractal are comparable at the level of leadership processes, the initial hypothesis is likely to be confirmed. However, if the participants pursue different goals, such as reducing costs versus increasing quality, no economic interoperability is apparent and thus the hypothesis is unlikely to be confirmed. Although support processes only provide a framework in which a company operates, these processes are critical in relation to collaboration. If the prerequisite is satisfied, one of the questions is how to distribute the savings among the participants.

Economic interoperability
The economic processes of the partners in the fractal can exchange data via their respective ERP systems and each access KPIs from the other partners. Such approaches are available, for example, with business networks (e.g., SAP Ariba). Economic interoperability is only present if there is the same formulation of goals, alignment of KPIs in the processes for creating goods and services (networked via ERP systems), compatibility of the support processes and an aligned pricing model/revenue sharing model.

5.4.3 Possible pricing models

The companies within the three-point fractal have the goal of commercialising data from the processes for creating goods and services and will define corresponding pricing models for this purpose.

1. Status of pricing models today: A component supplier delivers hardware (e.g. sensors) and embedded software to a machine supplier and, in the case of maintenance or retrofitting, also to the factory operator. Data generated by these components during operation of the plant is not subject to any price. This means that the raw data is not priced by the component supplier. Today, however, factory operators often find it difficult to acquire all the raw data. They therefore need connectivity products and data agents that collect the raw data and provide applications to interpret the data and share the results. There are different pricing models for this purpose: pay-per-data-point, data volume-based models, pay-per-use models and also flat pricing models.

2. In future, however, the factory operator's information (data populated with semantics) will be shared with machine suppliers and component suppliers. Commercialisation is almost always the factory operator's motivation. Future pricing models will be based on the benefits of the data for the machine supplier and the component supplier. In addition, IT and analytics companies will be added as potential buyers of the data in the future. They want to refine the data again (e.g. predictive maintenance forecasts, etc.) and in turn market it to other factory operators. These future pricing models in a data sharing economy will likely be neither data point-based nor volume-based. Instead, benefit-based pricing models will be the preferred model.

3. Another approach discussed in practice comprises revenue and profit sharing models from the commercialisation of interpreted data. Such models can already be found in business software systems. In principle, these models can also be transferred to Industrie 4.0 scenarios. However, there is still a lot of work to be done in this field. Interoperability of the calculation schemes is an important prerequisite here, comparable to interoperability of the data sets.

In the data sharing economy in the context of Industrie 4.0, the topics of data confidentiality and data security will play a central role (see also Gaia-X). This confidentiality will also be subject to pricing in the future, most likely through a price to be paid to a data trustee.

6 Conclusion

This paper outlines an approach to data sharing using the example of CCM and demonstrates the economic relevance of multilateral data sharing. It proves that multilateral data sharing is both lucrative and feasible and that, with the establishment of data spaces in some sectors of the economy, it is already underway.

The technical, legal and economic design aspects are shown to be vital for multilateral data sharing.

Using the "three-point fractal" as the "minimum viable multilateral construct", the particular features and challenges of multilateral data sharing are elaborated in a structured way. The technical, legal and economic issues are raised.

By taking a closer look at data sets, data business policies and data exchange frameworks, we were able to develop an essentially shared vision and understanding of data and the tools used to handle data.

Actual implementations of these approaches to handling multilateral data exchange can be found today in data spaces such as Catena-X, DSM (Data Space Mobility) or Data Space Industrie 4.0, among others. These data spaces are capable of organising multilateral data exchange and thus represent best practices in this area today.

Based on the findings of this paper, functioning data spaces should meet the following expectations:

1. The guiding principle must be good connectivity to the data space, on both sides: The data space must offer easy connectivity and participants must be able to establish a connection easily.

2. It must allow for the organisation of technical, legal and economic dimensions. The assumed good connectivity applies to all three dimensions.

Cross-regional and even global areas of activity present a particular challenge for data spaces. Different regulations will presumably need to be mapped in dedicated data space subsets.

The requirements for functioning data spaces for multilateral data sharing are therefore:

1. Simple, secure, cost-effective connectivity for data space participants

2. Use of standard technologies and concepts, use of cross-industry federated infrastructures if necessary

3. Clear, compatible regulations/general terms and conditions at the legal level for data space participants. A technical platform on its own is not enough.

4. Clear, compatible economic options for data space participants

5. The data space itself must be provided and operated in a way that is legally binding and also creates trust among participants.

7 Outlook

This publication provides an introduction to multilateral data sharing, including its advantages and requirements, based on the example of CCM. To facilitate the introduction, defining CCM-based business models that are tailored to individual needs is key (see the examples in the annex).

A further publication (in planning) will specify the canvas-based approach in more detail for interested companies and/or triple-point fractals that support the step from theoretical planning to practical implementation. In particular, the four CCM-specific canvases and their hierarchical dependencies and overlaps are described here using a practical example, which makes the method's advantages immediately tangible to users.

The systematic collection and processing of usage data for multilateral data sharing therefore has significant potential, far beyond the CCM use case. The acquired data of the CCM use case could therefore be used for other parties and use cases, such as:

- The circular economy (see Industrie 4.0 Use Cases)
- Insurance industry (e.g. business interruption insurance)
- State and other certification bodies
- Lease providers

These use cases require a targeted networking of stakeholders, as has been widely achieved in other areas, such as global logistics.

Appendix: Practical examples of multilateral sharing of data similar to CCM

The following practical examples of multilateral sharing of data were compiled using a questionnaire. The results were then transferred to a canvas for simplified presentation and improved further processing.

Collaborative Quality Management (Robert Bosch GmbH)

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Outline of your CCM model

1. Who are the participants (parties sharing or receiving data)?

Stakeholders:
- Vehicle owners
- Workshops
- OEM (car manufacturers)
- Suppliers

Today's quality management and complaints process is almost entirely parts-driven. If a vehicle owner encounters a problem (e.g. dashboard warning light), the part causing the fault is typically replaced following diagnosis in the workshop.

Only in the so-called "reference market" is a small percentage of the rejected/replaced parts sent to the OEM (car manufacturer) and then to the supplier for investigation. The reference market for German OEMs is typically Germany, for French OEMs it is France, and so on.

If the problem mainly occurs in hot countries, it may take some time for OEMs to notice it.

Nowadays, the data is transmitted to the various participants in proprietary systems. Only sparse information is given to suppliers in the event of damage. Contextual information, e.g. what triggered the fault or what happened in the vehicle before the malfunction occurred, is not available to the investigation team.

Therefore, the team may come to the wrong conclusions and the real cause may not be found.

2. What data is shared?
- Vehicle diagnostic data
- Control unit fault path
- Data pattern of known faults

3. What added value is generated by your collaborative approach?
- Detection of emerging faults six months earlier
- 20 % reduction in external failure costs (OEM/supplier)

4. In your experience, what are the key success factors?
- Determination of the data sets
- Data marketplace with data trustee

Figure 7: Collaborative Quality Management canvas

Motivation – Vehicle Owners	**Motivation – Workshops**	**Motivation – OEM**	**Motivation – Suppliers**
• Better and more targeted service • Cheaper repairs	• Draw the right conclusions • Closer relationship with OEM	• Early error messages • Discover causes and draw conclusions • Enable troubleshooting	Early error messages • Discover causes and draw conclusions • Enable troubleshooting

Shared vision of multilateral collaboration

Motive 1 | Improve existing processes Using multilateral data exchange, ensure that all relevant companies/partners receive the information that is relevant to them	Based on the context information, the faults that have occurred can be analysed and understood more rapidly/better in order to initiate appropriate solutions or future fault prevention

Data exchanged

Vehicle diagnostic data	Control unit fault path	Data pattern of known faults

Targeted results

Detection of emerging faults six months earlier	20% reduction in external failure costs (OEM/supplier)

Success factors

Determination of the data sets	Data marketplace with data trustees

Production Progress Monitoring (SupplyOn AG)

Contact

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Company: SupplyOn AG
E-mail: thomas.huebsch@supplyon.com

Outline of your CCM model

1. Who are the participants (parties sharing or receiving data)?

The scenario involves a supplier ("Tier 1") in turn having a supplier ("Tier 2") as a sub-supplier. "Tier 1" and "Tier 2" are both data suppliers and data users, i.e. both "share and receive data" in the sense mentioned above. "Tier 2" is also the plant operator or component supplier for "Tier 1" (Note: "Tier 1" in turn is a component supplier for the "OEM"). The data is provided by a platform provider on a fiduciary basis, i.e. the data is received bidirectionally from the platform provider via standardised interfaces and made available or visualised in corresponding dashboards.

2. What data is shared?

First, demand data provided by "Tier 1" to "Tier 2" via the platform (essentially product identifier, product name, quantity, delivery date). Second, feedback from "Tier 2", which provides information from its production on the stock of required raw materials, production equipment and the corresponding progress (i.e. virtually all of the above-mentioned parameters). This provides the greatest possible transparency for both parties with regard to the demand and delivery situation.

3. What added value is generated by your collaborative approach?

In our experience, having the above-mentioned information available for machine processing at all in this constellation is perceived as added value, especially by "Tier 1". In addition to the continuous visibility of the entire process, it is quickly apparent that the actual added value comes from system-supported exception management and also from predictive analytics, based on historical data, which means that future case scenarios in the area of follow-up support can be predicted. Predictive analytics is considered as added value especially for both parties involved because it is not supported by traditional planning or ERP systems (->planning errors, e.g. bull-whip effect) because the other party's situation is not known/transparent (silos).

4. In your experience, what are the key success factors?

1. "Tier 1" and "Tier 2" must mutually agree on the data to be exchanged and the analysis scenarios to be implemented based on this data. This must also be contractually regulated because, especially in the case of breaks in the supply chain, the question of how to handle any delivery delays or even failures that may have been forecast in advance must be clearly regulated.
2. As a rule, "Tier 1" has not one "Tier 2", but several. Tier 1 must therefore consider a technological approach that optimally positions it to meet the requirements regarding security of supply/resilience and also enables it to realise the added value described above with smaller suppliers having little IT expertise and knowledge of implementing IT solutions.
3. It is therefore advisable for Tier 2 to commission a platform operator with implementing and operating the corresponding solutions: first, a high degree of IT and process competence is required in this regard and second, a sustainable solution should be used that is based on a valid operating model.

Figure 8: "Production Progress Monitoring" canvas

Motivation —Suppliers (Tier 1)	Motivation —Platform Provider	Motivation – Suppliers (Tier 2)
• Optimisation via Predictive Maintenance • Better quality components in the long term	New customers/users for: • Standardised interfaces or UIs • Visualization of data in dashboards	• Wants to collect data to optimize own components and, for example, to offer services such as Predictive Maintenance

Shared vision of multilateral collaboration

Motive 1 | Improvement of existing processes

Highest possible transparency regarding demand and supply situation

Data exchanged

Demand data:
Product ID, product name, quantity, delivery date

Tier 2 feedback:
required starting materials, manufacturing equipment, progress

Targeted results

Expectation Management:
System-supported handling of exceptional situations

Constant visibility of the entire process

Breaking down silos:
Cross-company access

Information is available in a maschnically processable format

New possibilities that the classic (ERP tools) do not support

Predictive maintenance: predicting case constellations and follow-up care based on historical data

Success factors

Contractual regulation regarding the data set and permitted analysis scenarios

Use of platform operators as IT infrastructure providers (sustainable and valid operating model)

Tier 1 must position itself optimally in terms of technology in order to ensure security of supply/resilience across multiple suppliers (of any size/IT competence)

DB Cargo Innovation Collaboration (Siemens AG)

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Outline of your CCM model

1. Who are the participants (parties sharing or receiving data)?

- DB Cargo vehicles generate data. Some fleets send data to DB Cargo, some fleets to Siemens Mobility.
- DB Cargo sends/shares data with Siemens Mobility GmbH and vice versa.
- DB Cargo and Siemens Mobility jointly provide an analysis team that works together on current use cases.
- In this case, DB Cargo assumes the role of operator, maintainer and owner. Siemens provides support as an OEM with its experience in data analysis and maintenance as well as manufacturer knowledge.

2. What data is shared?

- Vehicle data (diagnostics and continuous data) relevant for maintenance
- Continuous data: Temperatures, voltages, pressures that occur during operation
- Operating data: operating data from daily operations
- Data is used to assess the condition of a wide range of components.

3. What added value is generated by your collaborative approach?

- Potential savings in single-digit millions
- in the area of corrective and preventive maintenance
- Development of new innovative algorithms for condition monitoring by merging manufacturer knowledge and operator knowledge

4. In your experience, what are the key success factors?

- From a technical point of view: Bringing together the necessary expertise (and identifying the necessary expertise)
- Data: Combination of data from operation, diagnostic messages and feedback from maintenance on actual faults
- From a business management point of view: Measurability of targets, especially when evaluating potential savings
- From a legal point of view: Clarification of IP rights
- Mindset: Trust, common goal, collegial relationship (flat hierarchies)

Figure 9: "DB Cargo innovation collaboration" canvas

Motivation – Siemens Mobility
- Supported with own data analysis experience, Maintenance and manufacturer knowledge

Motivation – DB Cargo
- DB Cargo vehicles generate data

Shared vision of multilateral collaboration

Motive 1 | Improve existing processes
Joint analysis team working together on current use cases
Data is used to assess the condition of a wide range of components

Data exchanged

Vehicle data: • Diagnosis • Continuous data
Operating data: • Temperatures • Voltages • Pressures

Targeted results

Potential savings in single-digit millions in the area of corrective and preventive maintenance
Development of new innovative algorithms for condition monitoring by merging manufacturer knowledge and operator knowledge

Success factors

Identifying and bundling the necessary expertise:
e.g. operating data, diagnostic message and feedback about actual faults
Trust
Measurable targets/KPIs
Clarified IP rights

Collaborative Condition Monitoring (KI Reallabor)

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Outline of your CCM model

1. Who are the participants (parties sharing or receiving data)?

- Component supplier receives and shares data
- Plant operator shares data
- Analytical service provider receives data
- The general goal is to find a generic solution in which each stakeholder can share and receive data on a self-determined basis.

2. What data is shared?

- Data from operations that is relevant in the context of (collaborative) condition monitoring. This includes, for example, time series data from the temperature and electric current measurements of integrated conveyor belt drive motors.

3. What added value is generated by your collaborative approach?

- The component manufacturer is able to collect operational data for the components that are located and installed in the field. This data can then provide the basis for AI/ML/analytics procedures. These procedures can in turn be used by the operator for optimisation purposes (e.g. predictive maintenance).

4. In your experience, what are the key success factors?

- From a technical point of view: IT (data) security: sovereign digital identities that scale across organisations. Solutions for managing and implementing access control Interoperable exchange formats at information level
- From a legal point of view: Implementation of GDPR-compliant software solutions
- From a business management point of view: Provision of key open-source software components or SaaS for SMEs

Figure 10: “Collaborative Condition Monitoring“ canvas

Motivation – Factory Owners	**Motivation – Analytical Service Providers**	**Motivation – Component Suppliers**
• Optimisation via predictive maintenance • Long-term improvement in quality of components	• Contributing company’s own skills in a • profitable way	• Wants to collect data in order to optimise its own components and, for example, offer services such as predictive maintenance

Shared vision of multilateral collaboration

Motive 1 | Improve existing processes
Potential for Motive 2 | Further develop existing business models and develop new business models via additional services such as predictive maintenance

Find a generic solution together in which each stakeholder can share and receive data on a self-determined basis

Data exchanged

Data from operations
• e.g. time series data from the temperature measurements
• e.g. time series data from measurements of the electrical current of integrated conveyor belt drive motors

Targeted results

Access to operational data of installed components
Enables knowledge gain through AI/ML/analytics processes
Product optimisation through predictive maintenance
Expansion/new business models via e.g. new service offerings
Product optimisation through fault source transparency

Success factors

Interoperable exchange formats at information level
Provision of key open source software components
IT (data) security
Solutions for managing and implementing access control
Provision of SaaS for SMEs
Sovereign, digital identities that scale across companies boundaries
Implementation of GDPR-compliant software solutions

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