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# The IDS approach for cross-sectorial sovereign data sharing as enabler for extended supply chains: a dive-in into the automotive domain

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# 1 Introduction

Industrial value chains are much more connected than in the past, and companies must think, operate, and execute as part of a greater business ecosystem. This new paradigm is referred to as "**extended enterprise**". The term is believed to have its origin at the Chrysler Corporation in the 1990s to refer to information sharing and cost reduction practices within the supply chain, in order to underline the necessity for a collaborative relationship and draw attention to the competitive advantages that could be gained when suppliers become partners (Post, Preston, and Sachs 2002). The advantages of the extended enterprise are especially evident in the supply chain context, where closer collaboration within suppliers enables to plan and respond to shifting customer demand, requiring that businesses execute real-time material requirements planning (MRP) processes and demand and response planning.

The "extended enterprise" paradigm is also referred to as "**extended supply chain**" when considering the supply chain context (Edwards, Peters, and Sharman 2001). Extended supply chains and, in particular, the ability to connect the value chains, is becoming more and more important because it enables organizations to better face challenges, like current semi-conductor shortages ("The Semiconductor Shortage and Its Implication for Euro Trade, Production and Prices" 2021), and ensure more sustainable processes, tackling e.g. $CO_2$ reduction and circular economy (Tseng et al. 2018) (Busse, Meinlschmidt, and Foerstl 2017) (Mol 2015).

The extended supply chain paradigm is therefore related to a shift from more structured and stiff supply chains to more dynamic, distributed, and resilient one. In particular, supply chain flexibility, collaboration, dynamism, relational capabilities, technology management, transparency and innovation have been identified as performance dimensions responsible for operational excellence to enhance sustainability in supply chains. (Dev, Shankar, and Qaiser 2020) (Mangla et al. 2020).

Information technology, and especially, **inter-organizational information technology, plays an important role** in an extended enterprise scenario, because it eases communication and increases transparency, e.g. providing each member of the supply chain with a common view of data and processes in real or near-real time (Edwards, Peters, and Sharman 2001) (Dev, Shankar, and Qaiser 2020). Nonetheless, the **current landscape of inter-organizational data sharing is far from this transparent ecosystem approach**: not only are companies reluctant to share their data, but the variety of solutions and standards for the data management also holds back interoperability and large-scale adoption. For this reason, inter-organizational data sharing is limited to essential information which is needed to meet contractual commitments and oftentimes this is performed with old-fashioned, unstructured methods (e.g. manual data entry) that are less efficient and more prone to errors (Opriel et al. 2021).

**Being able to tackle the hurdles that are preventing a smoother data sharing is therefore of utmost importance to enable companies to leverage this new paradigm of the extended enterprise, unlocking considerable innovation potential and business opportunities**.

The purpose of this work is to:

- analyze the current state of play of inter-organizational data sharing within of the automotive domain.
- Report the hurdles and challenges that prevents companies to adopt the extended enterprise approach.
- Show some ongoing efforts tackling these hurdles and challenges.

The **paper is structured as follows**: *Section 2* focuses on the *Problematization*: it shows an overview of the complexity of the automotive domain, presents the state of play of inter-organizational data sharing and reports about the value of being connected and the barriers that prevent it. It also explains how the concept of data sovereignty can tackle some major hurdles to be able to embrace the extended enterprise approach. *Section 3* focuses on *Ongoing efforts* in the market that go towards this direction of a collaborative, distributed and dynamic ecosystem approach typical of the extended enterprise: firstly, the holistic approach of IDS is presented as distinctive and unique approach to ensure large-scale interoperability and trust within inter-organizational data sharing; secondly, a pilot in the automotive domain is presented, showing a solution to share sensitive information in the automotive supply chain while maintaining control over the data; thirdly, the recent initiative of Catena-X is presented, as lighthouse project to deliver large scale IT-interoperability and trust within the automotive supply chains building on the work of the most advanced approaches in the context of data management and sharing, like IDS and Gaia-X. *Section 4* draws the *Conclusion* and highlights the need for further research.

The provided insights are a result of literature research based on available publications, articles, and webinars, and they are enriched with the outcomes of three interviews and several email exchanges with reference people from the mentioned initiatives and additional industry-related key actors[1]. The outcome is therefore an academic paper with an industry-driven perspective, enriched with exclusive insights of key practitioners.

# 2 Problematization

## 2.1 Description of the context: the automotive industry

The automotive industry has one of the **most complex supply networks**, with its current trends that go toward vehicle individualization and global supply structures ("Automotive Industry Action Group, The Future of the Automotive Supply Chain: Supply Chain Professionals in the Americas and Europe Share Their Insights and Expectations" 2019) (Opriel 2021).

Among 79.5 million vehicles produced worldwide in 2019, nearly 16 million vehicles were produced by German car manufacturers alone ("Automotive Industry Action Group, The Future of the Automotive Supply Chain: Supply Chain Professionals in the Americas and Europe Share Their Insights and Expectations" 2019) and employ in Germany approximately 833,000 which corresponds to almost 19 percent of the of the working population ("Verband Der Automobilindustrie e.V., Jahresbericht 2020: Die Automobilindustrie" 2020).

Several managerial studies dealing with the future of the automotive industry signal an "increased pressure on cost, individualization, elevated work-load and high level of stress with remarkable effects on employee's physical and mental health" (Opriel 2021).

This situation is very well explained by Ute Burkhardt, project manager at Volkswagen Group

[1] The interviews and exchanges of emails were conducted between December 2021 and January 2022.
In total, 12 stakeholders were involved in this work, belonging to 6 organizations:
Polytechnic University of Milan *(Jacopo Manotti, Supervisor)*;
International Data Spaces Association *(CEO, CTO, CFO, Head of Adoption)*;
Fraunhofer *ISST (Head of Department Logistics, Senior Scientist)*;
TU Dortmund University *(Assistant Professor)*;
GALIA *(Engineering Project Manager, B2B Manager, Logistics Project Manager)*;
NTT Communications *(Director IoT Cloud Strategic Unit)*.

Logistics, referring to the complexity of demand and capacity management activities and the improvement opportunities related to them:

*"In demand and capacity management, colleagues match daily the production planning with capacities of suppliers, they confirm the processes, they make corrections, if necessary, in case of unforeseen incidents and upcoming interruptions, decisions have to be taken, material bypassed, and many measures more. It's a very stressful job every day, and I admire the people working there (...). It's an incredible job to be done. This is the world (...) where we see a noticeable improvement necessary in supply chains, to come to improve (...) sustainability, $CO_2$ footprint and so on"* (Ute Burkhardt, project manager at Volkswagen Group Logistics[2]).

To tackle this situation, sharing information and ensuring a higher supply chain transparency is considered as a valuable solution, because it enables to reduce operational uncertainty (Lotfi et al. 2013) it improves both operational and supplier performance (Waqar and Mohammad 2019), and fosters optimization both within the company and outside the company in collaborative business processes (Zrenner et al. 2019).

## 2.2 State of inter-organisational data sharing within the automotive industry

The current complex scenario of the automotive industry gains further complexity if one starts considering the scope and modalities of the existing data sharing.

The current data sharing interactions in the automotive domain are, in fact, limited to essential information necessary to fulfil contractual commitments, which are normally related to industry services, like supply of material and parts (Opriel et al. 2021).

Moreover, **a standardized data sharing is not to be taken for granted.** Standards, like EDI, are currently available[3] exclusively for simple kinds of data, like order messages and invoices, and adoption of EDI-based solutions is not consistently widespread, even though its adoption has been increasing. In fact, standardised data sharing via EDI is widely used between car manufacturers and direct suppliers, but it is less popular in other tiers. Based on a study by

[2] "Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event on 16/12/2021. Recording available at https://www.youtube.com/watch?v=bIkpyiaC4vI. Min. 42:30 ca.

[3] Europe's EDI standard for data exchange in automotive supply chains is named EDIFACT (United Nations Electronic Data Interchange for Administration, Commerce and Transport) and it is normally combined with the de-facto exchange protocol OFTP (Odette File Transfer Protocol) (Opriel et al. 2021).

(Ostertag 2008) in the early 2000s, 97% of first suppliers was connected to the car manufacturers via EDI, while the usage of EDI between first and second delivery stages was only 20% and reduced to 10% between the second and third delivery stages. The other sharing of information was done via letter or fax. It is reasonable to assume that letters have now most of the times been replaced by emails, which nonetheless still represents an unstructured modality of sharing information, which is time-consuming and error-prone in comparison to direct connection of IT systems, like the EDI approach.

Efforts to improve the exchange of simple information via EDI along different tiers is sometimes done by industry associations, like GALIA[4] in France, which has different projects to foster the adoption of the standard used by OEMs and tier 1 also at subsequent tiers.

In an interview[5], GALIA confirmed that the current situation is still in line with Ostertag's study and that no revolutionary improvement has been achieved so far. From their perspective, the data sharing between OEMs and tier 1 happens via EDI in 97% of the cases, around 40% between tier 1 and 2 and just 10% between tier 2 and 3.

Old-fashioned ways of data sharing like email or phone calls are still widely used, especially to share **sensitive information in the context of bottlenecks**. (Lotz 2014; Tietze, Cirullies, and Otto 2017). A few efforts to standardize such data sharing are currently ongoing, spanning in different directions. One example is the use of collaboration platforms, on which participants manually compile information and thus have access to the latest information (Tietze 2021); other efforts are based on the IDS approach (thoroughly described in Section 3.1), which offers a common framework not only for large-scale technical interoperability, but, originally, also for common agreements and third-party conformity. Two examples of IDS-based solutions to share sensitive information in the context of bottlenecks are respectively

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[4] GALIA is a French non-profit association with 300 stakeholders aiming to foster standardization and best practices for data exchange in automotive supply chains. More information at: https://www.galia.com/en/about/galia-association/

[5] I personally conducted the interview in January 2022.

from (Zrenner 2020) and (Opriel 2021). The first one describes an IOIS[6] for collaborative risk management in automotive supply networks and it was implemented in cooperation with Audi and Robert Bosch; the second one, reported in detail in Section 3.2.1, illustrates another IOIS to share sensitive data for demand and capacity management, which was developed in a collaboration between Volkswagen and thyssenkrupp.

This aspect of large-scale interoperability and easy management of agreements between players in supply chains plays a crucial role nowadays, because more and more companies need to share data with each other in order to create common processes to face challenges (e.g. shortages) and reduce their environmental impact (e.g. $CO_2$ footprint), as also recently highlighted by Oliver Ganser, Head of Programme Data Driven Value Chain at BMW Group[7]. In this context**, one-to-one individual agreements** on technologies, processes, and ontologies **is not a feasible option**, as Klaus Ottradovetz, Vice President of Global Service Delivery at Atos, clearly explains[8]:

*"Use cases which are working across literally thousands of different providers run into a real barrier if you have to make all these agreements and all of the alignments (…) on an individual basis, because (…) this is something that goes exponentially: having an agreement between two parties is easy, for three parties it is manageable, for four parties it is getting complex. For thousands of parties, you cannot do it anymore in a practical way"* (Klaus Ottradovetz, Vice President of Global Service Delivery at Atos)

This aspect becomes even more important considering the **strategical value of being able to connect and share data**. The capability to share data within a specific system or platform can, in fact, become a determining factor for being chosen as a partner (Kersten et al. 2017)

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[6] Interorganizational Information System (IOIS). The term refers to systems that, through their interconnection, can exchange information between companies. Opriel 2021, p.46 offers a good overview of the different types of IOIS, based on a comparison of K. Kumar et al. (1996) and van den Broek et al. (2015).

[7] Gaia-X Summit 2021, November 2021. Specifically: Day 1; Part 2: Gaia-X Creates Business Values - Insights from our International Hubs and Data Spaces; Session "Business Case I: Catena-X and Q&A. The recording of the session is available at https://www.youtube.com/watch?v=P8gyg34K4wE

[8] "Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event on 16/12/2021. Recording available at https://www.youtube.com/watch?v=bIkpyiaC4vI

and, ultimately, it can also become a key success factor (Klug 2018).

Studies clearly show that the ability to share data can **prevent several disadvantages** in the supply chain, as reported by (Opriel 2021, p.4):

- reduced degree of capacity utilization.
- Errors in the allocation of inventories.
- Occurrence of the bullwhip effect, i.e. the phenomenon where order variability increases as the orders move upstream in the supply chain (Wang and Disney 2016).
- Excess inventories leading to inventory costs and capital commitment costs.
- Delays in the process flow with effects on the adherence to schedules.
- Increased use of cost-intensive premium transports.
- Price increases of products.
- Lower customer satisfaction.
- Bottleneck situations with penalty payments in the event of line stoppages.

Fostering adoption of standards and enabling interoperability is therefore a priority for the automotive domain. Nonetheless, **technical interoperability is not enough, because trust among partners is key** in these dynamics. In fact, companies fear that their data could be opportunistically exploited by the data recipient. As (Kerschbaum et al. 2011, p.38) puts it: "companies often do not collaborate due to a lack of trust: they fear that data they share could be used outside its intended purpose." (Opriel 2021) (Opriel et al. 2021) (Otto et al. 2019). The reason for this reluctancy lays in the sensitivity of some information, which could make them worse off later on, e.g. in future price negotiations or in agreements in other networks (Toth 2008, p.144).

For example, a supplier sharing its demand and capacity management information, like inventory levels or production plans to let its customer optimise its production, could fear that these data might be opportunistically leveraged to drive down prices (Klug 2018, p.153). On the other hand, if a customer showed current planned consumption, he or she could be concerned about the supplier's delivery reliability, since the supplier could reschedule his/her production accordingly, causing higher risks of failures in the production. These and other scenarios in customer-supplier relationships complicate data-driven process optimizations, such as the reduction of the bullwhip effect, cost savings, lead time reductions and even to flexibility increases in supply networks (Kumar and Pugazhendhi 2012, p.2151) (Göpfert, Braun, and Schulz 2017, p.31) (Caridi et al. 2014). Moreover, despite tools and principles to support decision-making in the context of process sustainability are available, they are reported to be more easily used in single corporates or single supply chain systems where there is a long history of trust. They could be applied to different corporates in the supply chain or cross-industry networks, but "efforts are often hampered by data discrepancies, gaps, and confidentiality issues" (Tseng et al. 2018, p.146).

This is the reason why **mechanisms to protect sensitive data become more and more important** to overcome these challenges in data sharing. Different approaches go in this direction: for example, access control enables the data provider to decide which data can be accessed by whom, while Secure Multiparty Computation (SMC) enables the data consumer to process the data without having raw access to them. Nonetheless, these approaches have the limitation that they cannot protect how the data (or the results from SMC calculations) are used. For this reason, the **usage control approach** coined by (Park and Sandhu 2002) appears to be a promising one: it consists of a "generalization of access control that covers authorizations, obligations, conditions, continuity (ongoing controls), and mutability", (Park and Sandhu 2004, p.128) which "encompasses traditional access control, trust management, and DRM (Digital Rights Management) and goes beyond them in its scope" (Park and Sandhu 2004, p.172) (Opriel et al. 2021). Specifications for the use and enforcement of usage control can be set by the data owner, but also form governments (e.g., in the context of the GDPR), or by previous data owners (e.g., in case of multiple data sharing) (Pretschner, Hilty, and Basin 2006, p.41).

Despite the term "usage control" was coined already 20 years ago, end-to-end usage control is rarely found in industrial applications, such as management systems at data processing level" (Opriel 2021). In particular, **the standards mentioned above**[9] which are used in the automotive domain currently **do not define or promote any technology-based, trust-gaining mechanisms for data usage**, and they are therefore unable to fulfil this need for trust among partners in the supply chain (Opriel et al. 2021) ("Odette International Ltd, 'Oftp2 Explained,'" 2009).

[9] Cfr. 3 (Europe's standards for data sharing in supply chains).

To refer to the ability of individuals and organizations to self-determine how their data is used, the term **“data sovereignty”** has started to come into use in recent times (Jarke, Otto, and Ram 2019). The ultimate goal of data sovereignty is specified as “enabling ‘‘data richness’’ by clearly negotiated and strictly monitored data usage agreements“ (Jarke, Otto, and Ram 2019, p. 550). Remarkably, this understanding of data sovereignty clearly promotes an active position of the data owner, in contrast with its passive role, which is typical, for example, of the data privacy defined in the GDPR (European General Data Protection Regulation), where citizen passively need to be protected “against powers they cannot confront on an equal footing” (Jarke, Otto, and Ram 2019, p.550).

The following section covers some ongoing efforts to enable data sovereignty in automotive supply chains, while fostering at the same time large-scale interoperability for the creation of dynamic, distributed, and resilient supply chains in this domain.

# 3 Ongoing efforts

Section 3 presents some current initiatives that aim to enable dynamic and resilient supply chains thanks to a distributed approach fostering large scale interoperability and sovereignty over one’s data. Firstly, the IDS approach is presented, which is a unique holistic approach to achieve cross-domain interoperability while ensuring trust among partners as well as control over data usage; secondly, the IDS-based pilot from Volkswagen and thyssenkrupp mentioned on p. 8 is thoroughly described as a success story of implementation of IDS and of data usage policies for demand and capacity management in the automotive domain; lastly, a recent promising initiative based on IDS is presented (i.e. Catena-X Automotive Network), which appears to be a lighthouse project to enable the extended supply chain paradigm in the automotive domain, tackling both the need for standardization and the above-mentioned requirement of trust.

## 3.1 The IDS approach as enabler of trust and cross-domain interoperability

The IDS approach is a **holistic framework** to enable cross-domain interoperability and trust in multi-party data sharing, which is becoming a de-facto standard in different industries. The IDS standard is developed and maintained by a not-for-profit organization called

International Data Spaces Association, which was founded by the will of some research and technology institutions and industry companies back in 2016. The Head Office is located in Dortmund, Germany, and the Association has reached a large international recognition: at the end of 2021, it counted 133 member companies, belonging to 22 countries from Europe and beyond. IDSA members encompass both research and technology institutions, like Fraunhofer, TNO and VTT, and industry companies, like SAP, Microsoft, Engineering, Siemens, PwC, Deutsche Telekom, Atos, NTT[10].

The name "International Data Spaces" refers to **a new paradigm of data sharing called "data spaces"**, which is perfectly aligned with the extended enterprise approach: it holds its basis on the idea that companies are not isolated beings, and they should perform as part of a vital and interconnected ecosystem. According to the data space approach, companies create data-driven ecosystems where data is shared in a decentralized way. Data from different endpoints is therefore shared via common guidelines and standard technologies, so that silos are broken down while avoiding the creation of big data lakes (Nagel and Lycklama 2021).
A data space can be seen as an **intermediate layer** between the soft infrastructure that enables the data sharing and the ecosystem of services offered though it (Nagel and Lycklama 2021). As an example, in the mobility sector there is a first underlaying layer which is the software infrastructure that enables creation, management, and sharing of the digital twins' data. On top of it, there is the layer of the mobility data space, which creates digital twins of real-world objects to deliver innovative mobility services. In this context, data interoperability is key: if we take the example of battery-charging points for electric mobility, in data spaces they must be described by a consistent set of attributes (type, location, charging mode, charging levels, etc.) and attribute values. Lastly, the upper layer represents the mobility data ecosystem, comprising all the actors that provide or consume end-to-end, data-based mobility services (e.g., travelers, public transportation providers, car-sharing companies, etc.).

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[10] The list of members till *December 2020* is available on the IDSA website: https://internationaldataspaces.org/we/members/

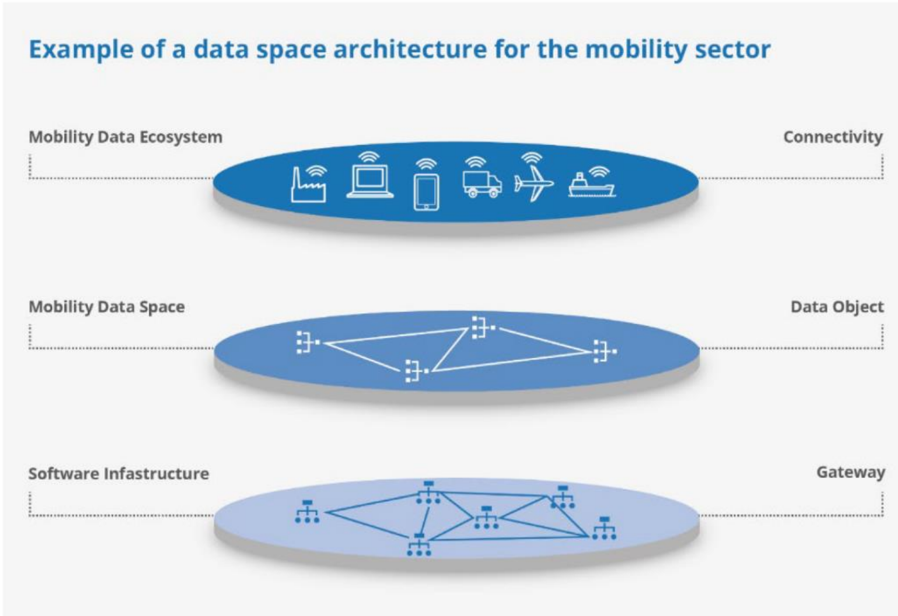


*Figure 1 Example of a data space architecture for the mobility sector it (Nagel and Lycklama 2021)*

The IDS approach is a standard to create data spaces, with the peculiarity that it is also enables the data provider to maintain control over its data: the **unique value proposition of IDS is to ensure large-scale interoperability and data sovereignty**[11], so that people and organizations can leverage the true value of their data as an economic asset and start a new era of the data economy.

Data is currently traded in the market like a commodity (it has a price, and many companies monitor the costs incurred for data management), nonetheless it is an intangible good and, depending on the type of data or what category it can be subsumed under, its value can vary. Therefore, the need for protection of data is not the same across all data types and data categories. Public data, for example, which can be accessed by anyone, requires a lower level of protection than private data (Otto et al. 2019, p.13). For this reason, IDSA promotes the idea of "**data sovereignty as a capability**", i.e. finding a balance between the need for protecting one's data and the need for sharing one's data with others. Since not all data requires the same level of protection, data sovereignty is about mastering this balance

[11] As explained in Section 2.2, data sovereignty refers to the ability of individuals and organizations to self-determine how their data is used (Jarke, Otto, and Ram 2019).

between free data flows and data protection, and it can be seen a key capability that companies have to train in order to be able to leverage the true value of their data as an economic asset and be successful in the data economy (Otto et al. 2019, p.13).

Considering the usual **architecture stack** (depicted in Figure 2), IDS is on an intermediary layer, positioned between the basic data service (e.g. information, aggregation…) and the smart data services (e.g. monitoring, data quality,…)(Otto et al. 2019, p.17).

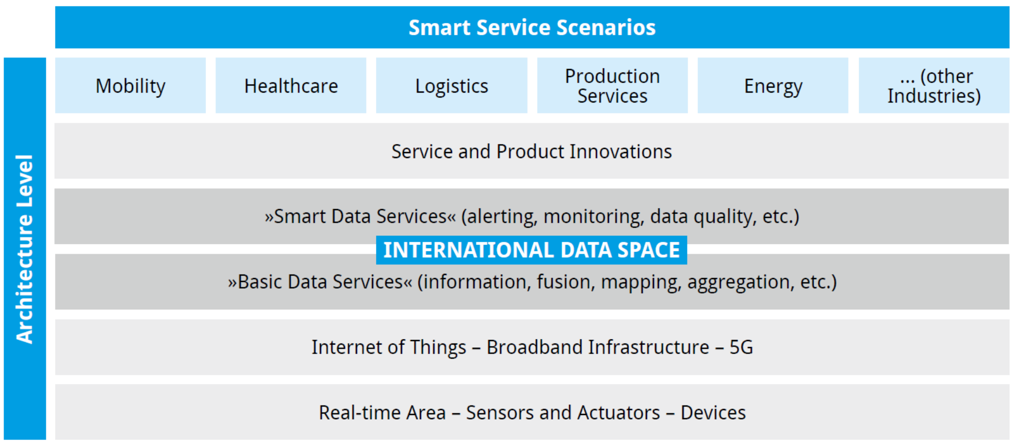


*Figure 2 Typical enterprise architecture stack (Otto et al. 2019, p.17)*

In particular, the IDS standard represents a natural evolution of the technical standards for the data exchange, to enable the sharing of more complex, high value data, like inventory levels in logistics (Otto et al. 2019, p.13).

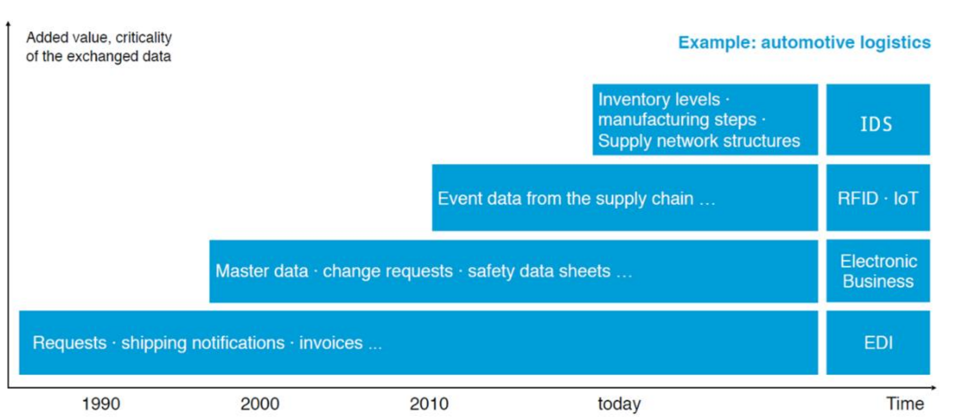


*Figure 3 Evolution of technical standards for data exchange (Otto et al. 2019, p.13)*

Nonetheless, the IDS standard is **more than a technical standard**. It is, indeed, a holistic framework, which offers guidelines for the implementation of data spaces where data sovereignty is ensured. It provides descriptions of the roles needed in a data space, clarifications of their interactions, it tackles key security and interoperability requirements, it promotes best practices regarding the legal side of data sharing, and it also offers a certification process for components and operational environments to make sure that the necessary requirements are met by all participants of the data space.

The IDS approach is based on **three main pillars**:

1. *Unlimited interoperability*: the IDS approach enables large scale, cross-domain interoperability thanks to its Reference Architecture Model and in particular:
    - Its IDS Connector, i.e. a gateway to connect several different endpoints. It is DIN SPEC 27070[12] in Germany and on its way to ISO. It can be developed with different technology stacks, it is, therefore, technology-agnostic. Several open-source implementations are available on the IDSA Github[13].
    - Its IDS Information Model, i.e. an RDFS/OWL-ontology which stands above industry-specific vocabularies to ensures cross-domain interoperability. IDS is therefore domain-agnostic.
    - Large scale usability thanks to IDS open-source components and a Reference Testbed, which are available on GitHub[14].
2. *Trust*: the key priority of the IDS approach is to ensure trust. This is why IDSA offers a certification process[15] to check compliance to the IDS requirements for both components and operational environments and ensure large-scale trustworthy data sharing.
3. *Governance*: the governance pillar refers to two aspects:
    - Governance of the *data space*: the IDS approach ensures that data spaces are

[12] https://internationaldataspaces.org/ids-is-officially-a-standard-din-spec-27070-is-published/
[13] https://github.com/International-Data-Spaces-Association/idsa/
[14] https://github.com/International-Data-Spaces-Association
[15] https://internationaldataspaces.org/use/certification/

properly operated and governed, tackling the technical, functional, operational, and legal implications of data sharing. To this regard the IDS Rule Book plays a crucial role, defining the rules to set-up, operate and govern data spaces in a real-world scenario[16].

- Governance of the *data flows*: the IDS approach offers the possibility to protect the data, thanks to data usage policies attached to the data. Usage control consists in specifying and enforcing restrictions which regulate what must or must not happen to data after access has been granted. It, therefore, enables users to continuously control data flows, rather than accesses to services, and it represents a core building block to ensure transparency and self-determination[17].

These three main pillars reflect the **most important assets of IDSA**: its Reference Architecture Model, which forms the basis of the IDS framework, the IDS Certification Scheme, which defines the certification process and its requirements, the portfolio of open-source building blocks, which help usability and adoption of IDS in commercial solutions, and the IDSA Rule Book, which tackles all technical, operational and legal agreements to make data spaces fully operational in a real-world scenario.

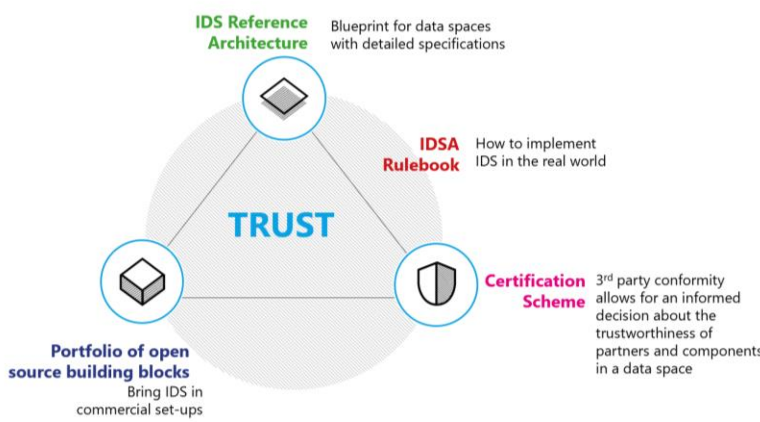


*Figure 4 Visual representation of the main assets of IDSA*

[16] https://internationaldataspaces.org/rule-book-on-structures-and-processes-for-implementing-ids-in-the-real-world/
[17] https://internationaldataspaces.org/data-sovereignty-updated-position-paper-on-data-usage-control-in-the-ids/

A data space based on IDS has several **roles**, going from the data provider and data consumer, to the essential service providers that ensure identity management[18] and trust[19], to additional service providers that enable, for example, meta data search and discovery[20] or the possibility to log and clear the transactions[21]. All roles and interactions are described in detail in the Reference Architecture Model[22].

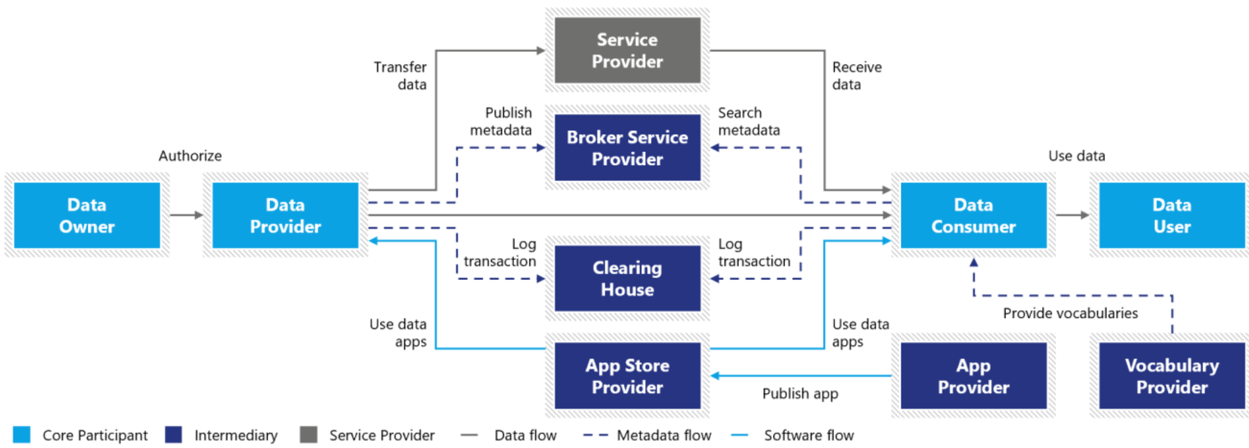


*Figure 5 Simplified representation of the roles and interactions within an IDS-based data space*

It is important to notice that the interactions taking place in a data space and the services that are offered there have an impact on different levels: the identity and trust-enabling providers affect the bottom layer of the essential functionalities of data spaces; providers of meta data brokers or clearing houses refer to the generic functionality layer; on top of them there are, instead, the specific market solutions, which are, then, applied to specific verticals having their own peculiarities, e.g. their own semantic model (Steinbuss et al. 2021, p.6).

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[18] i.e. Certificate Authority issuing X.509 certificates, providers of DAPS (Dynamic Attribute Provisioning Service) and ParIS (Participant Information System).
[19] i.e. roles involved in the IDS Certification process, like the Evaluation Facilities that perform assessment of IDS Components and Operational Environments.
[20] i.e. broker service provider.
[21] i.e. clearing house.
[22] The IDS Reference Architecture Model (RAM) 3.0 is available at the IDSA website: https://internationaldataspaces.org/publications/ids-ram/ The publication of RAM 4.0 is planned for April 2022.

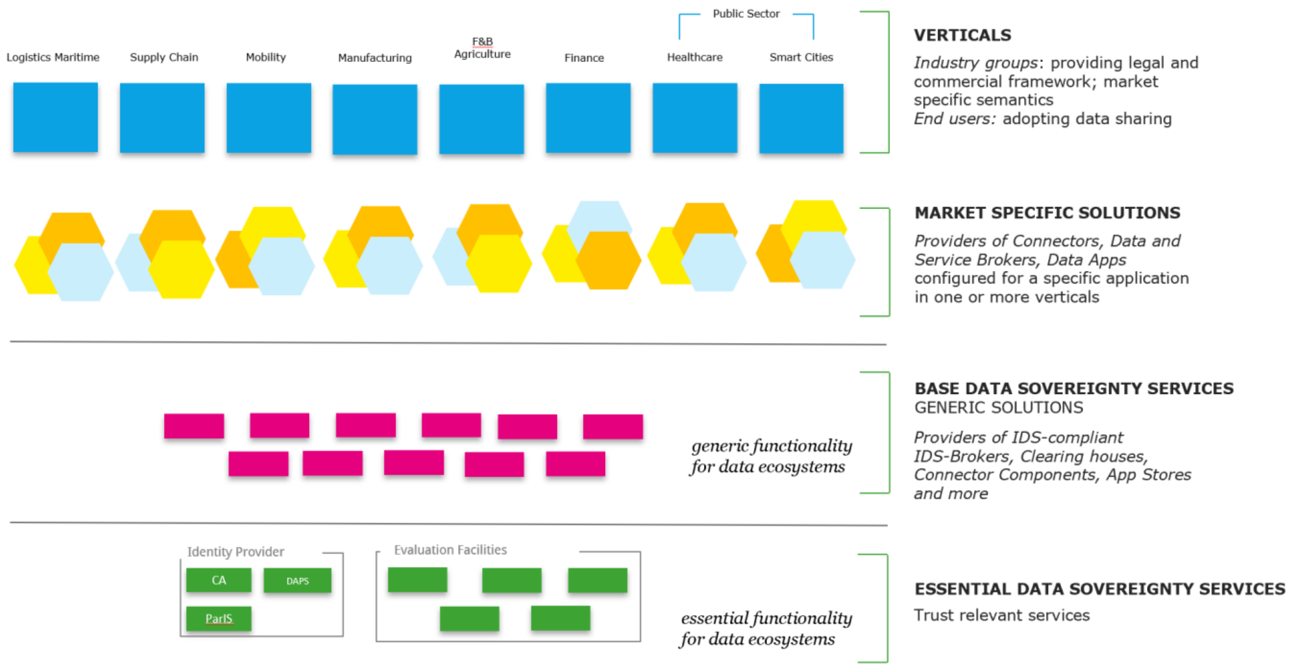


*Figure 6 Representation of the different functionalities and services for the data economy (Steinbuss et al. 2021, p.6).*

The IDS approach benefits from **high adoption potential** thanks to four main elements:

a. *Open source*: IDSA has opted for an open-source strategy, to ensure large scale usability of the IDS components. As mentioned, several implementations of the IDS components, as well as a full testbed, are available on the IDSA Github[23].

b. *Scalability of IDS Certification[24]*: the scalability of the certification process is ensured via a network of approved Evaluation Facilities, which perform the assessment of IDS components and operational environments to ensure compliance to the IDS requirements.

c. *IDS Implementation Partners[25]*: adoption-wise, IDSA leverages a network of IDS experts, that offer trainings and consultancy services to support the creation of data spaces from different perspectives: business, technical or legal.

d. *IDSA Hub Facilitators and Competence Centers[26]*: IDSA ensures a wide reach in different

[23] https://github.com/International-Data-Spaces-Association
[24] https://internationaldataspaces.org/use/certification/
[25] https://internationaldataspaces.org/adopt/implementation-partners/
[26] https://internationaldataspaces.org/make/hubs/

countries leveraging some official Hub Facilitators and Competence Centres, which act as first point of contact of the Association, strengthen it visibility and foster proliferation and adoption of the IDS approach.

IDS currently stands in a **transition phase** between R&D and market-readiness, as depicted in the figure below:

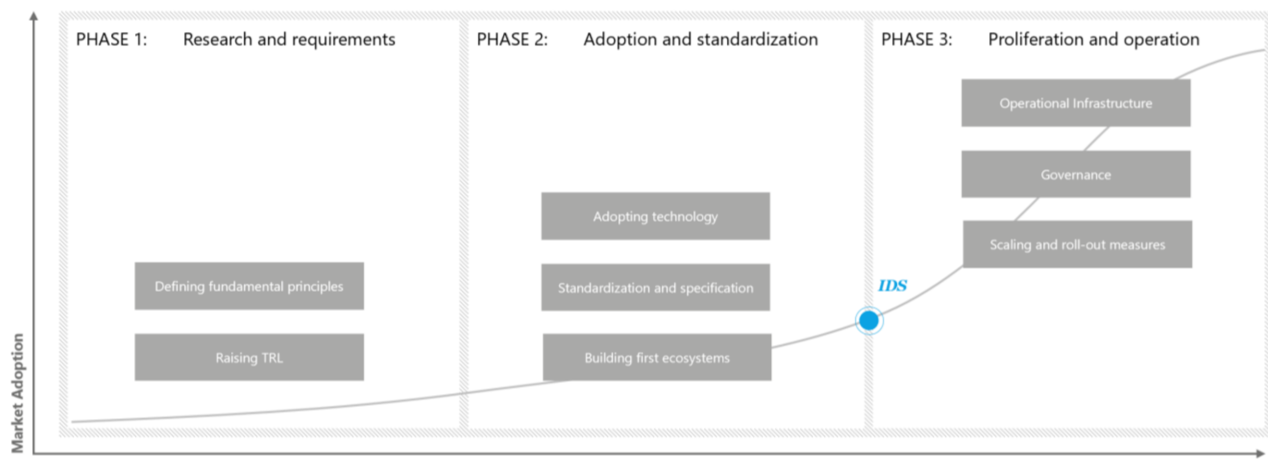


*Figure 7 Current state of the evolution of the IDS approach*

Some **big milestones** have been achieved in the 2021, like the release of the IDS Rule Book[27], the kick-off of graduation scheme[28] for open-source projects and the release of the first open-source Reference Testbed[29], and more are planned for 2022, among which there are the official kick-off of IDS Certification and new releases of the Reference Architecture Model (4.0) and of the Rule Book (2.0).

IDSA is a standardisation organization aiming to find a trade-off between top-down and bottom-up standardization. This is why the IDSA members are highly active in co-creating the standard and in implementing it in several projects, so that the IDS approach is becoming a **de-facto standard** for the creation of data spaces in several domains. The IDS User Group of

[27] https://internationaldataspaces.org/rule-book-on-structures-and-processes-for-implementing-ids-in-the-real-world/
[28] https://internationaldataspaces.org/make/open-source/
[29] https://internationaldataspaces.org/use/reference-testbed/

adopters also appears to be a unique and highly valuable asset of the Association.

Their efforts are given visibility in the **Data Space Radar**[30], an online tool which currently documents 60+ use cases, developed by both IDSA members and non-IDSA members. They are either IDS-based solutions, 1-1 use cases or full data spaces, and are categorised by domain and level of maturity. Among some of the most advanced or promising data space projects, there are the Smart Connected Supplier Network[31] for manufacturing supply chains (fully operating), the Mobility Data Space[32] (pilot phase, more than 200 stakeholders, fully operating in mid-2022) and Catena-X[33] for automotive supply chains (starting phase, more details are provided in Section 3.2.2).

Efforts to test **cross-country interoperability** have also already started, among which one remarkable example is the collaboration between the above mentioned SCSN in the Netherlands and NTT in Japan[34]. The first trials were communicated to be successful: the Japanese factory automation vendor of industrial controllers OMRON and SCSN were able to transfer data between Japan and the Netherlands both ways via NTT's IDS testbed in January 2022. Additional trials are also on their way: NTT Communications is becoming a member of the Catena-X Automotive Network[35] around March 2022, in order to conduct interoperability testing with Catena-X, as well. NTT is also planning to build a prototype of an IDS-compliant data space in Japan in Summer, to allow Japanese companies to share data with SCSN and Catena-X[36].

IDSA's vision is to ensure the creation of interoperable data spaces, reducing any barrier of entry and any hurdle to data space interoperability, regardless of the framework or the technology used. This is why IDSA is also well connected with other initiatives at European

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30 https://internationaldataspaces.org/adopt/data-space-radar/
31 https://internationaldataspaces.org/usecases/smart-connected-supplier-network/; https://smart-connected-supplier-network.gitbook.io/processmanual/
32 https://mobility-dataspace.eu/
33 https://catena-x.net/en/
34 https://internationaldataspaces.org/collaboration-between-idsa-and-ntt-com-to-link-japanese-smart-data-platform-and-europes-gaia-x/
35 Cfr. Section 3.2.2
36 Direct contact with NTT Communications in early February 2022.

and international level, and it recently started a closer collaboration with the other forerunners in the context of data sharing and data spaces: in fact, in September 2021 **IDSA joined efforts with Gaia-X[37], FIWARE[38] and Big Data Value Association (BDVA)[39]** to pursue a formal collaboration under the name of Data Spaces Business Alliance[40]. The aim is to speak with one voice and align their frameworks and architectures, in order to ease the creation of data spaces and avoid ending up in new data silos.

The IDSA represents a paramount success story for co-petitive international collaboration, remarkable private-public bonding, and pooling of forward-looking innovators with the same vision to start a new era of the data economy where the full value of data can be leveraged in a sovereign manner.

## 3.2 A dive-in in the automotive domain: IDS in automotive supply chains

Section 3.2 presents two selected examples of how IDS can be implemented in automotive supply chains. The first one is a prototype developed by Volkswagen and thyssenkrupp, the second one is called Catena-X Automotive Network and it is a larger initiative, which aims to be the first data space for supply chains in automotive.

### *3.2.1 The Volkswagen-thyssenkrupp pilot*

One example of an advanced IDS-based pilot in automotive supply chains is the one

[37] Gaia-X is a lighthouse initiative to create a federated and secure data infrastructure. The goal is "establishing an ecosystem in which data is made available, collated and shared in a trustworthy environment. The users always retain sovereignty over their data. So, what emerges is not a cloud, but a federated system that links many cloud services providers and users together" (https://www.gaia-x.eu/what-is-gaia-x).
Information on the relation between IDS and Gaia-X is available on the IDSA website (https://internationaldataspaces.org/we/gaia-x/) and in the position paper "IDS and Gaia-X" 1.0 available at https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Position-Paper-GAIA-X-and-IDS.pdf

[38] FIWARE is a "curated framework of open-source platform components to accelerate the development of smart solutions" (https://www.fiware.org/about-us/)

[39] BDVA is an industry-driven international organization focusing on enabling the digital transformation of the economy and society through data and artificial intelligence (https://www.bdva.eu/about)

[40] https://internationaldataspaces.org/bdva-fiware-gaia-x-and-idsa-launch-alliance-to-accelerate-business-transformation-in-the-data-economy/

developed by Volkswagen[41] and thyssenkrupp[42] with the support of Fraunhofer ISST, as thoroughly described in (Opriel 2021).

The starting situation of the use case well reflects the status quo of the industry described in section 2:

*"Volkswagen provides thyssenkrupp with a demand forecast of 24 months. Thyssenkrupp allocates monthly capacities though the supplier platform INCA, in line with the supply contracts and agreed quotas. Based on a delivery call-off via EDI (VDA 4984), the single plants announce their needs, which are available for a horizon of 12-24 months. The shipment of the goods is announced with a dispatch advice (EDI message VDA 4987) and the credit note is indicated via VDA 4938"* (Opriel 2021, p.122).

To enhance collaboration, especially in short time-ranges with the help of more detailed information, a collaboration between Volkswagen, thyssenkrupp and Fraunhofer ISST took place between May 2019 and September 2020. The case study was developed from May 2019 till April 2020 while the subsequent piloting until September 2020. The overall work involved more than 90 people from 17 different companies, including the case owners and additional supporting companies (Opriel 2021, p.116).

The result of this collaboration is an **executable prototype of demand and capacity management**, where the industrial partners managed to optimize supply chains in terms of transparency, efficiency, and sustainability, and ensured a high level of trust leveraging technology-based usage control mechanisms. On top of these advantages, the peculiarity of the solution is its potential interoperability with any IDS Connectors, giving the opportunity to connect and share data with any company using the IDS standard and with any IDS-based data space. Such scenario would obviously require additional testing and integration of the latest developments of the IDS concepts, but it is a remarkable showcase of how the IDS guidelines are integrated in a fully working prototype.

The concrete setting of the Volkswagen-thyssenkrupp use case is a well-defined supply

[41] Specifically, Volkswagen Group Logistics

[42] Specifically, thyssenkrupp Presta Ilsenburg

network for a specific component[43] installed in a Volkswagen engine[44]. The component is manufactured by thyssenkrupp and delivered to Volkswagen's engine plant in Salzgitter, where the production of the component is finalized[45].

The aim of the collaboration was to identify requirements, technology limitations and to develop a prototype, which could enlarge the data basis in the context of demand and capacity management, in order to foster a more stable supply network and identify potential risks in a timelier manner. From the technology perspective, the goal of the was to:

1. improve the planning basis and increasing planning reliability.
2. Enable earlier identification of potential bottlenecks in supply networks.
3. Support and improve bottleneck management.

From a research perspective, the aim of the study was to generate design knowledge through the development of an artifact, which could represent a good model for future research and prototypes[46].

In concrete, the prototype is a software solution based on the principles of IDS and designed as a Java application, which contains a backend and a web-based frontend. The backend is developed as IDS Connector and connects internal data sources such as WMS, ERP, etc. In addition, the system is enriched with an IDS API which enables to receive data from another prototype and makes it available to internal systems. This way an end-to-end connection of IT systems can be created: data can be retrieved from one prototype to another one in real time, and it is presented to the user via the frontend in a browser. An overview of the architecture is provided here below.

[43] ACT module5 (Active Cylinder Technology)
[44] EA211 evo
[45] In fact, the Volkswagen Group Logistics, as part of the Volkswagen Group, acts as the central control unit for the component, since it is used in various model series from four brands: Audi, Seat, Škoda and Volkswagen passenger cars
[46] The of research: action design research (ADR)

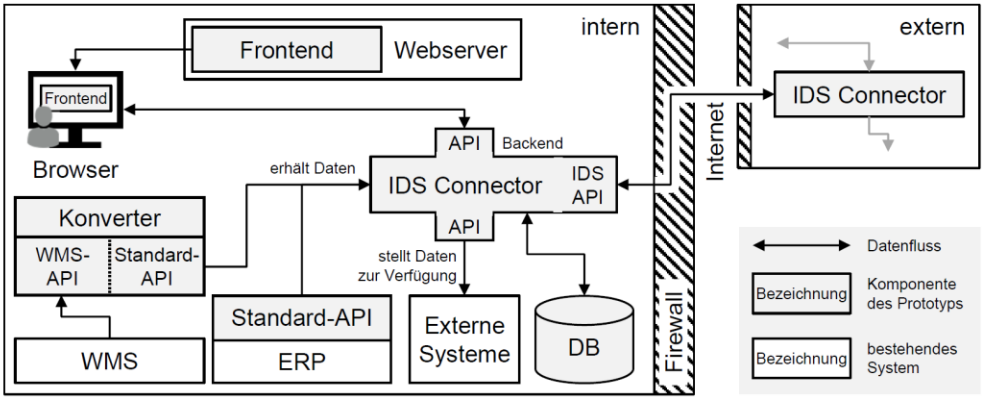


*Figure 8 Technical architecture of the prototype (Opriel 2021). The grey boxes represent the components of the prototype; the white ones are the components of the legacy system; the arrows depict the data flow.*

The purpose of the collaboration was to exchange sensitive information; therefore, **usage control mechanisms** were a requirement of the prototype[47]. In fact, they can increase trust in the software and reduce or prevent potential misuse of data. Unintentional data leaks can also be prevented, for example by conditions of use stipulate that data must be deleted after a defined period or that they may only be used in a restricted manner (Opriel 2021, p.138).

In the prototype, the terms of use are defined at the level of the data connection and are attached to it, so that it is possible at any time to infer the applicable terms of use. Moreover, technical traceability is also implemented, to ensure that it is possible to trace where data comes from, which route it has taken through the IT systems and at what times and under what conditions it was exchanged. This aspect plays a crucial role because "if it is possible to see when and how the business partner uses the provided data (exercise of control), the required trust in the data recipient is reduced", making the data provider less reluctant to share its data (Opriel 2021, p.138).

Usage control policies are a very complex topic for two main reasons:

1. the ownership of data is not fully regulated in Germany and in the European Union("Verband Der Automobilindustrie e.V., Jahresbericht 2020: Die Automobilindustrie" 2020, p.98)

[47] General regulatory requirements such as authentication for access control via an appropriate role and rights management system are implicitly assumed for the prototype.

2. The legally binding nature of technical usage control policies (i.e. if the terms of use are sufficient to make decisions in the event of lawsuit) is currently subject of debate and needs to be clarified (Bader and Pullmann 2020). This open point is currently matter of discussions of the Legal Task Force of IDSA.

To overcome this hurdle and make sure that the terms of use of the prototype are legally binding, the technical usage control policies are combined with a legally binding textual description, which is part of the contract between the business partners (Opriel 2021, p.138, 163).

The enforcement of the terms is managed by a proprietary usage control system, which tackles both access control (authorization or conditions) and the enforcement of the obligations. (Opriel 2021, p.172)

To conclude, the Volkswagen-thyssenkrupp pilot represents an interesting case showing researchers and practitioners how an advanced technical solution can ensure cross-company data exchange in a secure manner protecting the data though data usage control policies and with the potential to open up to n-n data sharing ecosystems based on the IDS standard. It also reinforces the idea that usage control and applied design principles can incentivize companies to share more sensible data, since both were indeed the drivers that fostered the two industry partners to start the collaboration and share sensitive information about demands, production, and stocks from their ERPs.

### *3.2.2 The Catena-X Automotive Network*

As anticipated in Section 1 and Section 2, the current scenario of data exchange in automotive supply chains faces several challenges and, therefore, holds great opportunity of improvement for the creation of distributed, more dynamic, and resilient supply chains.

These issues are also tackled in the Catena-X Automotive Network, an ambitious project aiming to bring the extended supply paradigm into reality for automotive supply chains. The **goal of Catena-X** is to create standardized data flows along the entire automotive value chain, bringing added value for each participant in the network while maintaining data sovereignty[48].

[48] Catena-X website: https://catena-x.net/en/#faq

To achieve this, **small and medium enterprises** play a crucial role: this is why Catena-X will offer "SME-ready" solutions so that they are able participate quickly and with low IT infrastructure investments[49].

The initiative is an industry-driven project, which was then supported by government funding. On December 2020 BMW, Deutsche Telekom, Robert Bosch, SAP, Siemens AG und ZF Friedrichshafen announced the start of the Automotive Alliance at the German Digital Summit 2020 (Digital Gipfel 2020)[50]. Afterwards the name was changed to Catena-X Automotive Network[51], a **concrete project was initiated through a public funding** of 250 million budget (August 2021)[52] and a **formal association** under German law was founded (May 2021)[53] by 28 founding companies, among which there are, for example, BMW, Deutsche Telekom, Robert Bosch, SAP, Siemens and ZF Friedrichshafen, Microsoft, Henkel, Mercedes Benz.[54]. The network has grown considerably and in December 2021 it counted 63 companies[55].

As mentioned, the purpose of the association is to create a uniform standard for information and data-sharing throughout the entire automotive value chain. The ambition is also to build on the current structures of the European automotive industry, e.g. the existing processes in the field of parts logistics, to integrate them and optimise them[56].

The concrete **benefits** unlocked by Catena-X are not limited to a greater efficiency in the supply chain, but they also tackle "more efficient quality and logistics processes, greater transparency in

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49 Cfr. 48 (Catena-X website)
50 The recording of the Digital Summit 2020 is available at: https://www.bmwi.de/Redaktion/DE/Videos/2020/Digital-Gipfel/20201201-panel-gaia-x.html
51 Catena-X LinkedIn post, December 2021: https://www.linkedin.com/posts/catena-x-automotive-network_automotivealliance-catenax-jubilee-activity-6871884570153783296-TZIn/
52 "Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event on 16/12/2021. Recording available at https://www.youtube.com/watch?v=bIkpyiaC4vI
53 The founding meeting of Catena-X Automotive Network e.V. took place on 07.05.2021. Cfr. 46 (Catena-X website)
54 Cfr. 52 ("Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event)
55 Cfr. 51 (Catena-X LinkedIn post, December 2021)
56 Deutsche Telekom news article: https://www.telekom.com/en/media/media-information/archive/catena-x-automotive-network-620638

terms of sustainably reduced $CO_2$ emissions, and simplified master data management[57].

As already highlighted, if we consider the automotive industry today, several of companies need to share data and create shared processes through different tiers, in order to effectively collaborate in supply chains (e.g. to tackle crisis like semiconductor shortages or COVID-19, to foster circular economy…), but individual agreements on technologies, processes and ontologies is no feasible option[58]. This is why Catena-X wants to leverage the common frameworks of Gaia-X[59] and IDS to deliver a concrete solution and allow anyone to easily step into the network.

As highlighted by Oliver Ganser, Head of Programme Data Driven Value Chain at BMW Group, chairman of the Catena-X Automotive Network association & Head of the Catena-X Industry Consortia[60], Catena-X wants to be a "**delivery organization"**:

*"We are a delivery organization, we are not writing standards, we are not discussing, we are writing code. We see ourselves as a delivery organization (…). Within 2-4 months we want you to be able to utilize it. This is our mission and our breakthrough target"* (Oliver Ganser, Head of Programme Data Driven Value Chain at BMW Group, chairman of the Catena-X Automotive Network association & Head of the Catena-X Industry Consortia).

What Catena-X wants to deliver is, precisely, one operating system applied to ten use cases that tackle the current top issues in the European automotive industry, combined with a high-speed transfer approach to be able to activate and onboard users and providers[61].

The Operating System is decentralized, open source and it is based on the frameworks developed by IDSA and Gaia-X[62]. The development of the Operating System is highly collaborative thanks to an open-source Eclipse project[63] and it follows the principles of the agile manifesto.

As mentioned, the **10 use cases** represent the current top issues within automotive supply chains.

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57 Cfr. 56 (Deutsche Telekom news article)
58 Cfr. 8 (quote from K. Ottradovetz, Atos)
59 Cfr. 37 (Gaia-X)
60 Gaia-X Summit 2021, November 2021. Specifically: Day 1; Part 2: Gaia-X Creates Business Values - Insights from our International Hubs and Data Spaces; Session "Business Case I: Catena-X and Q&A. The recording of the session is available at https://www.youtube.com/watch?v=P8gyg34K4wE
61 Cfr. 52 ("Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event)
62 Cfr. 52 ("Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event)
63 E.g. Tractus-X Eclipse project: https://projects.eclipse.org/proposals/eclipse-tractus-x.

They, in fact, aim to tackle the following challenges:

- Traceability of hardware and software components
- Sustainability (proof of CO2 footprint, compliance with social standards)
- Circular economy ($CO_2$ footprint minimization)
- Quality management (real time & collaborative quality management)
- Demand and capacity management (security of supply)
- Business partner database (master data service)
- Data and model-centric development and operations support (Digital Twin)
- Modular production (shared service)
- Manufacturing as a Service (Shared Service)
- Real-time control and simulation (Shared Service)

Currently, Catena-X's Working Groups[64] and development consortium[65] are actively working, and progress has already been done. The **Proof of Concept**, which is normally referred to as "Speedboat", has been performed. The purpose of the Speedboat was to "give an end-to-end journey to Catena with working code"[66], tackling for example the onboarding process (i.e. how to joining the Catena-X with a portal), creating a working company user management, ensuring the use case business partner management (i.e. function to look up and contact business partners), ensuring provisioning and consumption of data thanks to a semantic hub where vocabularies and semantic models can be looked up. The Speedboat also offers a registry where companies can register their digital twin and its specific aspects so that they can be findable by others. It also offers other live services, like the relationship service that helps connecting components to its sub-components to the resources, and the traceability service, which enables to trace components and to manage quality alerts.

For 2022, the focus of Catena-X will be on enlarging the network, developing additional use

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[64] Catena-X LinkedIn post, January 2022: https://www.linkedin.com/posts/catena-x-automotive-network_welcome-2022-what-are-your-new-years-resolutions-activity-6887441803755175936-YTkF
[65] Cfr. 63.
[66] Felix Gerbig, System Architect at the Catena-X Automotive Network. Cfr. 50 ("Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event)

cases, initiate further discussions and networking opportunities, and showcasing the solutions that are market-ready[67].

At a glance, the **roadmap** of the first three years of the project is the following[68]:

- 2021 (project started in August): set-up of the project and Proof of Concept.
- 2022: validation and connection of 1000 partners.
- 2023: scaling and exploitation internationally and in other industries.

To conclude, Catena-X represents a beacon project in the context of value-driven, extended supply chains, because it aims at creating an inclusive network for data exchange for the automotive supply chains, adopting a highly agile, hands-on and result-oriented approach while leveraging the most advanced existing standards, like IDS and Gaia-X.

# 4 Conclusion

In current scenario where companies increasingly need cross-organizational data exchange and shared processes along the whole value chain to better respond to global challenges like shortages and climate change, the IDS approach described in Section 3.1 represents a ground-breaking enabler to make the extended supply chain a reality on a large scale, as shown by the initiatives described in in Section 3.2.

In fact, IDS unique value proposition tackles both major requirements that are identified in Section 2:

1. The need for wide interoperability. Different standards are currently available, even though they only enable the exchange of very simple kinds of data (e.g. EDI) and their adoption is not consistently widespread. IDS offers a sophisticated standard and technology-agnostic framework to connect different endpoints and share any kind of data, also cross-domain.
2. The requirement for trust and data sovereignty. Studies demonstrate that companies

[67] Cfr. 64 (Catena-X LinkedIn post, January 2022)
[68] Cfr. 52 ("Data Spaces Dialogue | Unboxing the Automotive Supply Chain Data Space Catena-X" online event)

are more inclined to share their data if the uncertainty about the potential misuse on behalf of their business partner is reduced. IDS tackle this aspect via a third party-conformity certification process, as well as fostering the most advanced usage control mechanisms.

In addition, the International Data Spaces Association represents a paramount success story for co-petitive international collaboration, remarkable private-public bonding, and pooling of forward-looking pioneers sharing the same vision to start a new era of the data economy.

Big progress has been done in the last years on the topic of data sharing and data sovereignty, nonetheless current literature and ongoing studies are only able to provide partial insight on such complex matters. More research should be, in fact, devoted to shed light on the hidden dynamics behind data sharing, its concrete benefits on global supply chains and on overall social impact (e.g. in the context of circular economy), to better define the archetypes of the different data sharing scenarios and, ultimately, to clarify open points related to the legal side of data exchange, like the legal implications of data usage control mechanisms or the boundaries related to data ethics.

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