Catena-X
THE FIRST OPEN AND COLLABORATIVE DATA ECOSYSTEM

Digital Product Passports as the enabler for the Circular Economy

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Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Catena-X

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Catena-X

1 STRUCTURAL CHANGES IN THE AUTOMOTIVE INDUSTRY

Current challenges in the automotive industry

The automotive industry, often hailed as one of the most innovative and transformative sectors globally, plays a pivotal role in shaping modern society. Beyond simply providing transportation, it influences economic growth, technological advancement, and environmental impact. The automotive industry is currently undergoing its biggest transformation seen since the beginning of the last century. The shift from internal combustion engines towards electric vehicles, as well as the focus on software platforms for driving assistants and new mobility solutions, are two enablers for this automotive industry of the future.

The European automotive industry and its whole value chain are significant pillars of the European economy, all together representing more than 13 million jobs for Europeans, 8% of Europe's GDP, and more than 374 billion € in tax revenues for European governments in 2022[1]. The geopolitical tensions, the technological transformation, and the negative environmental impact represent some of the biggest challenges the industry is currently facing.

Geopolitical and market changes

Geopolitical and market changes have introduced a new layer of complexity to the automotive sector. Trade policies, international relations and regulatory frameworks have a significant impact on the industry's supply chains and market access. For example, recent trade tensions between major economies have led to fluctuations in tariffs and trade barriers, resulting in disruptions to the procurement of key materials and components. In addition, market changes, such as the growing demand for electric vehicles in response to environmental regulations and changing consumer preferences, require car manufacturers to adapt quickly. These factors are forcing the industry to navigate a complex landscape of global interdependencies while striving to maintain competitive advantage and meet changing market demands.

Technological transformation

The availability and adoption of advanced technology solutions are major drivers in the automotive industry. Connected cars, autonomous driving systems, sensors, electrification, and new business models all leverage these technologies. The entire industry, from suppliers to automobile manufacturers, faces the challenge of maintaining profitability in current operations while simultaneously expanding capacity to embrace these innovations.[2]

Modern technologies have increased the importance of vehicle software and data, e.g. for autonomous driving. This disruption has intensified competition, elevating the role of Information Technology (IT) and electronic manufacturing services companies. In addition to this, greener consumer preferences force technological disruptive changes throughout the entire automotive global value chain, as it remains uncertain to what extent the transformation of the automotive industry can maximize inclusive and

[1] ACEA – European Automobile Manufacturers´ Association (11.2022)
[2] Forbes – The future of Automotive and Mobility

sustainable economic benefits in areas such as jobs, innovation, value-added, entrepreneurship, trade, investment, eco-friendliness, and gender balance.[3]

Environmental and social impact of linear value chains and their products

The automotive industry operates predominantly on a linear value chain model. This traditional approach, characterized by a straightforward trajectory from raw material extraction to product disposal, presents significant challenges both environmentally and socially. As the world grapples with the pressing need for sustainability, the environmental and social impacts of linear value chains in the automotive sector have come under increased scrutiny. Linear value chains in the automotive industry are heavily resource-intensive. The extraction of raw materials such as metals, minerals, and fossil fuels incurs substantial ecological costs, including habitat destruction, biodiversity loss, and soil and water pollution. The manufacturing processes that follow are energy-intensive, relying predominantly on non-renewable energy sources, which contribute to greenhouse gas emissions and exacerbate climate change. End-of-life disposal of automotive products further compounds the environmental burden. Vehicles and their components, loaded with hazardous substances, often end up in landfills or incineration facilities, releasing toxins into the environment and wasting valuable resources that could otherwise be recovered and reused. This linear approach not only depletes finite natural resources but also generates significant waste and emissions, posing a serious threat to ecological balance and sustainability.

The social impact of linear value chains is just as profound. The extraction and processing of raw materials often takes place in regions with loose environmental regulations and poor working conditions, leading to exploitation and human rights violations. Workers in these regions often face hazardous working conditions, low wages and limited access to healthcare and education. In addition, the communities surrounding the extraction and production sites bear the burden of environmental degradation, as pollution of air, water and soil leads to health problems and reduced quality of life. The economic benefits of the automotive industry are disproportionately distributed and often bypass the communities that supply the raw materials and labor, exacerbating social inequalities.

European manufacturers are demonstrating a strong commitment to developing more efficient and sustainable production. Notable progress within the European Union includes a total waste reduction by 2,2%[4], CO_2 emissions from car production decreased by 31,4%[5], and the energy consumption for production by 30% since 2005[6]. To further improve current results in the future, the industry is increasingly embracing solutions such as decarbonization and circular economy[7]. These approaches focus on waste reduction, material efficiency, and emissions reduction. The transition from a linear economy to a circular economy is seen as a critical strategy for meeting future sustainability goals.

[3] The future of the EU Automotive sector – European Parliament
[4] ACEA – Waste from car production in the EU
[5] ACEA – Key Figures on the EU auto industry
[6] ACEA – The Auto industry Pocket Guide 2023/2024
[7] European Parliament

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Figure 1: Information flow and losses in a linear economy

Regulatory compliance as additional driver for sustainability in the industry

Regulatory compliance is becoming a key driver of change in the automotive industry. Amid increasing global environmental concerns, governments and regulators are introducing stringent regulations to mitigate the environmental and social impact of the sector. These regulations are not only challenges to be overcome, but also catalysts for innovation, driving the industry towards more sustainable and efficient practices.

The European Union currently offers fifteen different environmental regulations for the automotive industry.[8] In terms of the relevance for circular economy initiatives, the End-of-Life (EOL) Vehicles Regulation, the Battery Regulation, and the Eco Design for sustainable products Regulation have the most significance.

End-of-Life Vehicles[9]:

The EOL Vehicles Regulation maximizes the efficient use of resources. The directive sets clear targets for the reuse, recycling, and recovery of electric vehicles, aims to prevent and limit waste from electric vehicles and their components, and improves the environmental performance of all economic operators.

Battery Regulation[10]:

The Battery Regulation, first draft proposed in July 2023, aims to create a harmonized legislation for the sustainability and safety of batteries. It introduces new battery categories and specific new limitations. In particular, it states that by 2027 industrial, electric vehicle (EV), and light means of transport (LMT)

[8] ACEA – The Automotive Regulatory Guide
[9] European Commission
[10] TÜV Süd – Understanding the new EU Battery Regulation

batteries with a capacity bigger than 2kWh will be required to be electronically registered with a battery passport including information on sustainability requirements, battery handling data and repurposing efforts. It also sets recycled content targets for elements like cobalt, lead, lithium and nickel starting from 2024. Finally, the regulation includes provisions for calculating the carbon footprint of batteries, as well as delegated acts and implementation acts specifying methodologies for recycled content calculation.

Eco Design for Sustainable Products[11]:

The Eco Design proposal, published in March 2022, establishes a framework to set eco-design requirements for specific product groups to improve their circularity, energy performance, and other sustainability aspects. It enables the setting of performance and information requirements for almost all categories of physical goods placed on the EU market. According to the EU Commission, this new sustainable products framework could lead to savings of 132 mtoe by 2030.

To comply with these challenges, the European automotive industry must ensure data transparency along its value chain. To do so, information about products and materials at all stages of the value chain must be shared among trusted partners. Data exchange networks can enhance collaboration, efficiency, and innovation in the automotive sector by enabling to share and use data in a secure and standardized manner across different organizations.[12]

[11] European Commission
[12] World Economy Forum

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2 DATA ECOSYSTEMS: CATENA-X

The automotive industry is currently developing different data exchange solutions to enable partnerships and collaboration within the value chain and help overcome these challenges. 73% of business leaders are willing to collaborate with competitors to achieve sustainability goals, as collaboration fosters innovation, solves problems, and sets higher industry standards.[13]

Data ecosystems across the entire value chain

As legislators demand greater transparency, digital traceability of material flows becomes crucial. Data ecosystems aim to enable digital data flow across the entire value chain, addressing the uncertainty and risks associated with data sharing among suppliers[14], driving innovation and aiming to solve complex challenges that single entities might struggle to tackle alone.

Data ecosystems can provide transparency and traceability, ensure comprehensive visibility into each stage of the value chain and compliance with the increasing regulatory requirements. They allow stakeholders to track materials, components, and products from origin to end-of-life. Additionally, data ecosystems enhance efficiency and optimization by enabling precise resource management, minimizing waste, and optimizing the use of materials and energy. Real-time data allows for continuous monitoring and improvement of supply chain processes, leading to reduced costs and a better risk management [15]. By supporting predictive analytics, it enables quick identification and response to disruptions caused by geopolitical tensions, natural disasters, or other crises, and allow companies to take proactive measures to mitigate risks.

To function effectively, data ecosystems require different key components.

- Interoperability is crucial and requires standardized data formats and communication protocols to ensure seamless data exchange between different systems and platforms.
- Integration with existing technologies and adaptability to new technologies are necessary, as is data sovereignty and security to ensure that participants maintain control over their data and ensure solid protection against breaches and unauthorized access[16].
- Scalable digital infrastructures are required to handle growing data volumes and provide reliable high-speed connections for real-time data exchange.
- Governance and trust mechanisms such as clear regulations, certification policies and audits are key to maintaining the trust of participants.
- Advanced technologies and tools such as data analytics, blockchain, and digital twins are instrumental to process and analyze large data sets, ensure data integrity, and optimize asset lifecycles. [17]

[13] Baker-McKenzie, The Race to net-zero, https://view.ceros.com/baker-mckenzie/race-to-net-zero/p/1
[14]World Economic Forum (2023), Why industry collaboration is necessary for a sustainable future, https://www.weforum.org/agenda/2023/03/radical-collaboration-for-a-sustainable-future-the-case-for-sustainability-collaboration/
[15] Catena-X (2024) Benefits Circular Economy, https://catena-x.net/en/benefits-pros/circular-economy
[16] Catena-X (2024) An Overview of the Data Space (https://youtu.be/BXMc3BMyTWw)
[17] Catena-X (2024) An Overview of Data Sovereignty (https://youtu.be/XeJScMk3nwc)

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Through these components, data ecosystems also offer diverse benefits[18]:

- Enhanced decision-making, as monitoring of comprehensive real-time data allows for informed decisions, improving operational efficiency and strategic planning.
- Improved resilience through predictive analytics, as warnings about potential issues are detected early and the value chain becomes more adaptable to changes and disruptions.
- Improved sustainability, as optimizing resource use and reducing waste contribute to sustainable goals and support the tracking and reuse of materials.
- Cost reduction, as improved efficiency and reduced waste lead to lower operational costs.

The automotive data ecosystem Catena-X

Catena-X is a data ecosystem with an automotive focus. Its vision is based on the technologies and ideas of Gaia-X and the International Data Space Association (IDSA). Catena-X Automotive Network e.V. aims to provide an environment for the creation, operation, and collaborative utilization of end-to-end data chains along the entire automotive value chain. Based on an innovative infrastructure, this data ecosystem aims to ensure secure exchange and high-quality data. The provision of a resilient and flexible supply chain management system is intended for use by both small and medium-sized enterprises as well as global corporations.

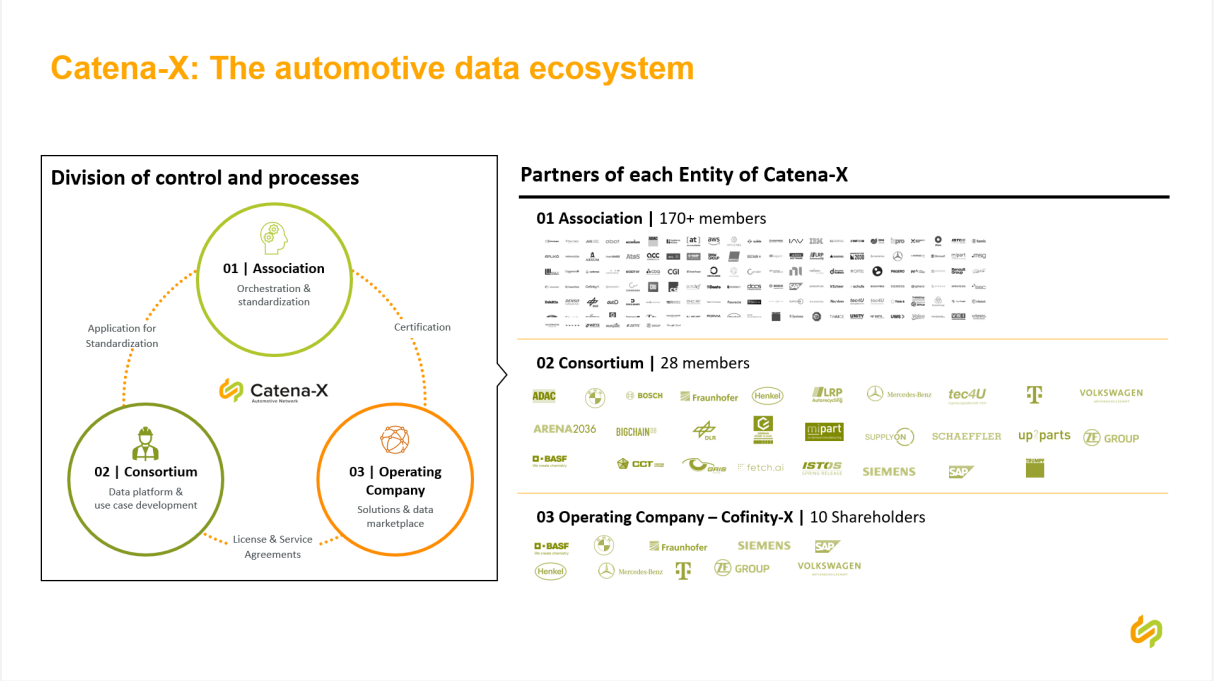

Figure 2: The automotive data ecosystem Catena-X

[18] Johannes Lohmöller, Jan Pennekamp, Roman Matzutt, and Klaus Wehrle. On the Need for Strong Sovereignty in Data Ecosystems. PVLDB, 15(1): XXX-XXX, 2022.

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The structure of Catena-X is presented in Figure 2. 28 consortium partners collaborate to establish an initial data ecosystem, forming the Catena-X workbench. The current project is set to run until July 31, 2024, with the expectation that additional consortia will join and continue the development in the future. Within the consortium, the core development work takes place, creating concrete solutions that will later be implemented by relevant users. The focus is on developing technological foundations such as the data space connector ("Eclipse Dataspace Connector") and the Catena-X portal, along with specific pilot applications. This is realized across use cases, for which the consortium develops service offerings that enable companies to quickly derive tangible benefits for their production or services. The results of the workbench undergo certification by the Catena-X Association before being put into operation. Additionally, the consortium's results are candidates for standardization by the association.[19]

Catena-X aims to become the leading standardized data exchange platform for the automotive industry. Its main objectives are:

- to develop standardized data formats and interfaces to enable seamless data exchange between different participants in the automotive value chain,
- to ensure interoperability of systems and processes so that various stakeholders can effectively communicate and connect,
- to increase transparency and traceability throughout the entire value chain from manufacturing to end-of-life,
- to implement robust security and privacy measures to protect sensitive data and ensure compliance with relevant regulations,
- to foster innovation and collaboration by creating an open ecosystem where participants can share data, insights, and best practices.

[19] Catena-X (2024) – The Development Environment (https://catena-x.net/en/about-us/)

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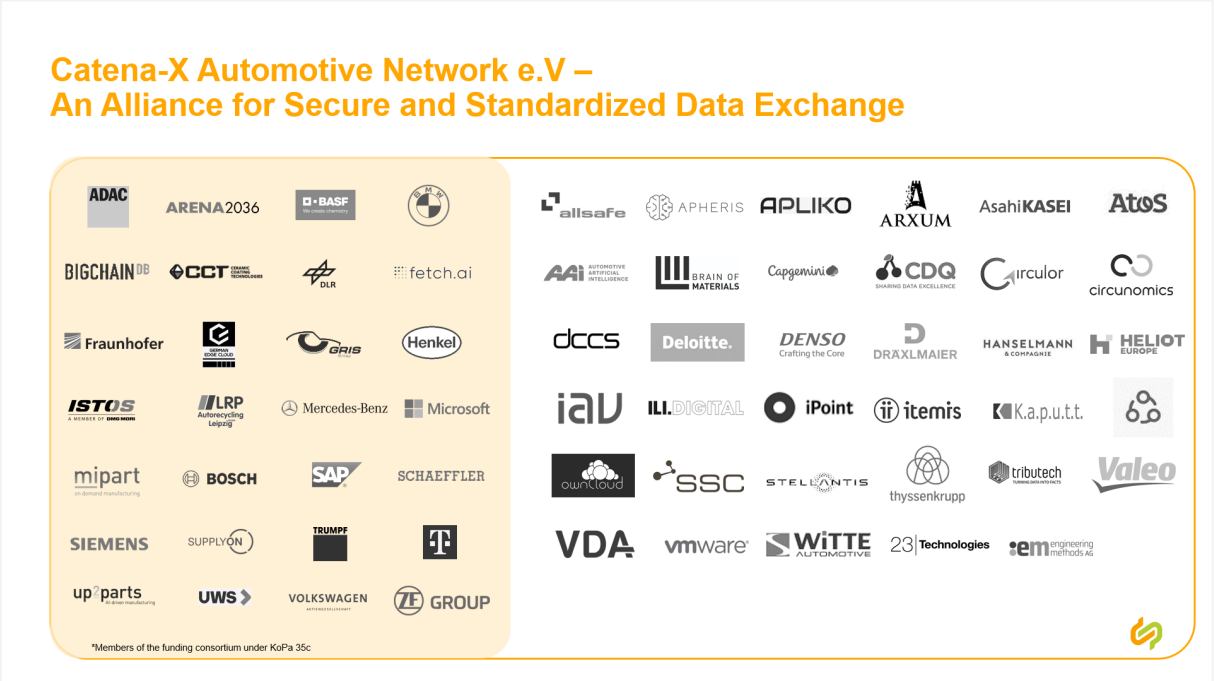

Figure 3: Catena-X Automotive Network e.V. - An alliance for Secure and Standardized Data Exchange

In a project funded by the Ministry of Economic Affairs under Catena-X, ten specific use cases have been defined (Figure 4), and standards have been developed for each to guide their implementation. These use cases cover topics such as Digital Twin, Manufacturing as a Service, and Modular Production to optimize collaborative industrial manufacturing. They also address traceability and quality management of end-to-end data chains. The focus on sustainability is incorporated through work packages including Circular Economy and CO_2 Footprint.

Examining the Circular Economy in greater detail, the project has identified and is advancing eight key topics during the consortium phase. These include Material Accounting, Secondary Material Content, Asset Tracking, End-of-Life/Dismantling, Secondary Marketplace, CE Assistant, Circular Economy Guideline, and the Digital Product Passport. Since the beginning of the year, the outcomes of these efforts have been handed over to the association, where they continue to be pursued or adopted by newly formed expert groups. Notably, the Digital Product Passport has been fully embraced as a central focus, underscoring its importance in the transition to a circular economy.

The Digital Product Passport will be a key element in achieving the goals of Catena-X. By providing standardized and interoperable data formats, it enhances transparency and traceability across the value chain. It also meets stringent security and privacy requirements, fostering a collaborative and innovative environment within the industry. This initiative lays the groundwork for a seamless transition into a detailed explanation of the Digital Product Passport, demonstrating its critical function in driving the automotive sector towards sustainability and circularity.

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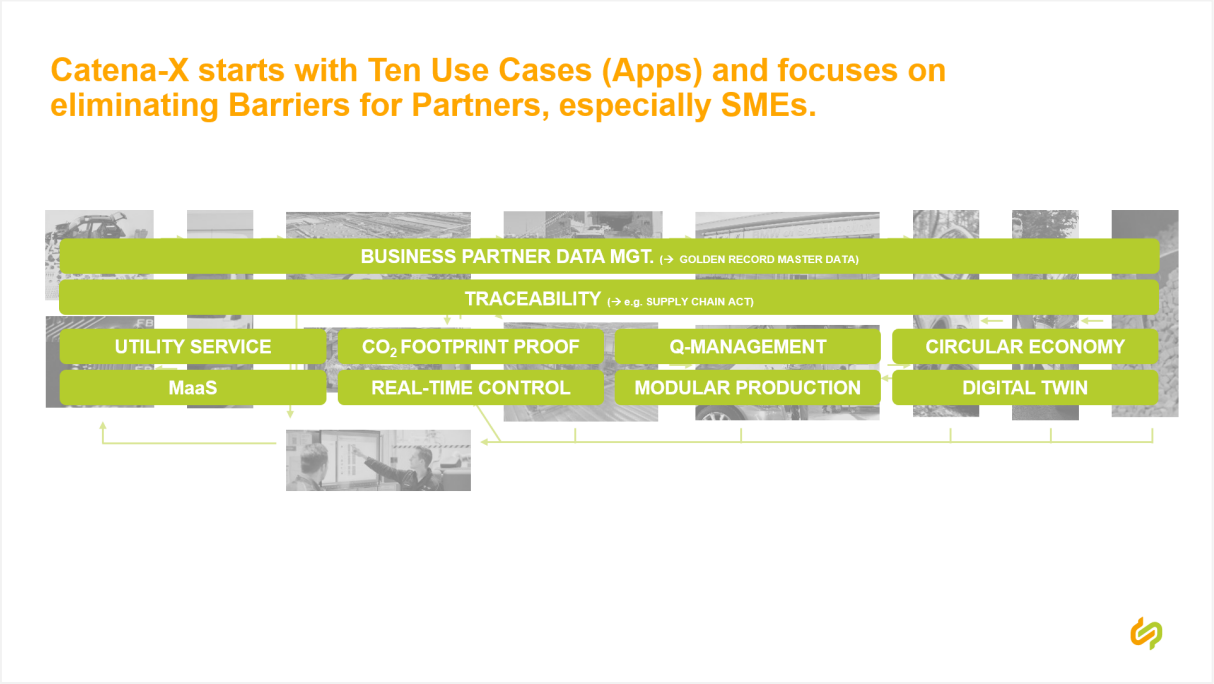

Figure 4: Catena-X Ten Use Cases

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3 DIGITAL PRODUCT PASSPORT

The European Commission is developing sustainability principles to regulate various aspects of product life cycles as part of its Circular Economy Action Plan. This includes "mobilizing the potential of digitalization of product information, including solutions such as digital product passports, tagging and watermarks" for all products placed on the European market. An early example of a digital product passport is the battery passport, included in the EU battery regulation. [20]

An introduction to the digital product passport and circular economy

The Digital Product Passport (DPP) describes a comprehensive data set summarizing the components, materials, and chemical substances in a product, along with details on reparability, spare parts, and proper disposal instructions. The data in the DPP is gathered from all phases of the product life cycle, allowing for the possibility to optimize design, production, use, and disposal. [21]

A DPP should include information across the entire value chain of the product. An initial categorization of the necessary information can be structured based on the different phases of a product lifecycle, as depicted in Figure 5.

- Component data from suppliers, such as the materials used in each component, their physical and chemical properties, their structure and origin, and information regarding non-hazardousness or hazardousness to human health or to the environment.
- Production data from manufacturers, such as the product composition, the details of manufacturing processes (e.g., joining technique, binder), and the environmental and social impact assessment of both production and transformation processes.
- Usage data from consumers, such as the documentation of any parts of a product that have been replaced or repaired.
- End-of-life data from dismantlers, such as the documentation on collection, sorting, and treatment during the End-of-Life phase of a product. [22]

[20] European Commission, 2020
[21] Wuppertal Institut, 2021
[22] Jansen, et al., 2023

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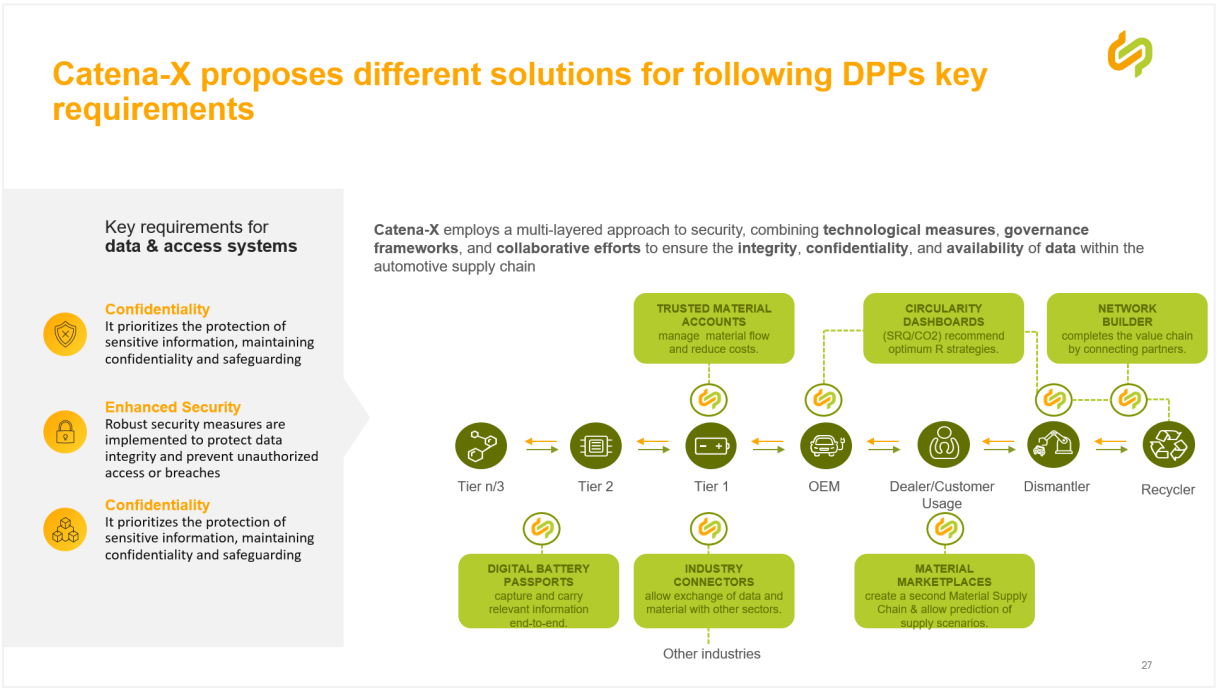

Figure 5: Catena-X proposes different solutions for following DPPs key requirements

The automotive industry and Circular Economy

The automotive industry is moving towards circular economy practices, as circular economy can keep resources in use for as long as possible at their highest level and eliminate waste. In 2015, the EU adopted the Action Plan for the Circular Economy intending to "boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming." This requires a de-coupling of economic growth from the consumption of finite resources, as shown in Figure 6.[23]

The European Parliament defines the Circular Economy as a "model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended."

[23] Catena-X

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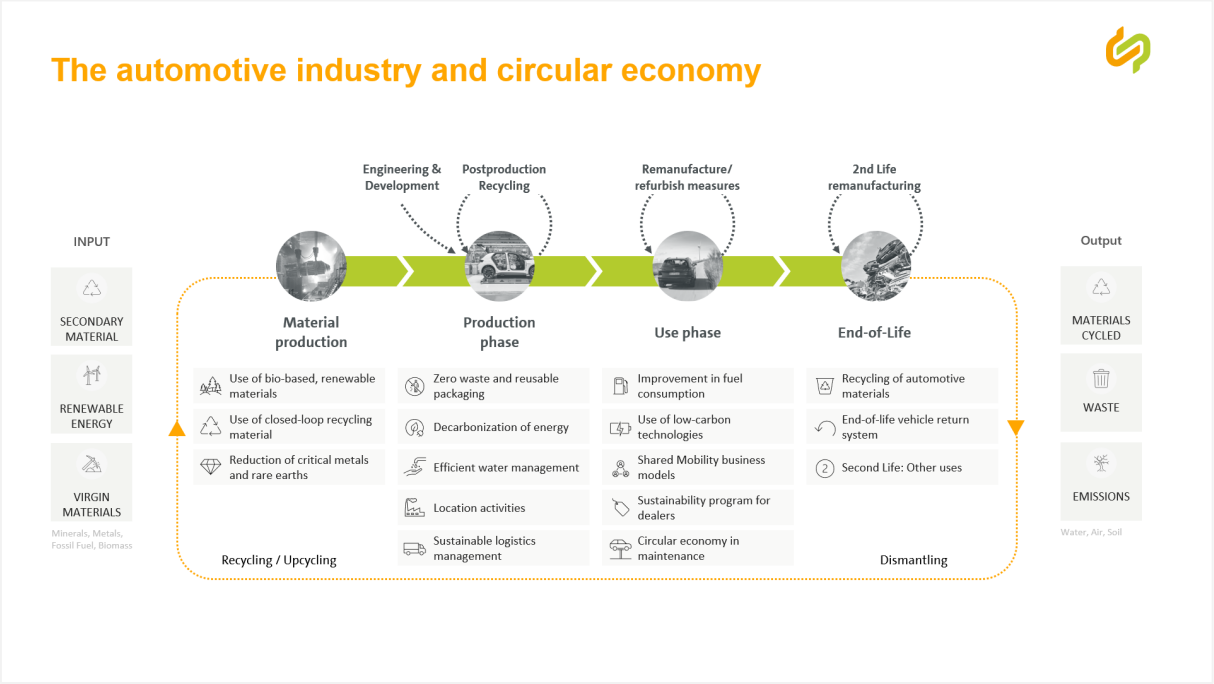

Figure 6: The automotive industry and circular economy

To ensure the successful operation of a circular economy, certain requirements must be met throughout the value chain. These requirements, facilitated by the Digital Product Passport (DPP), cover various aspects of transparency, traceability, recycling, reuse, sustainable design, resource efficiency, and predictive maintenance.

Transparency and Traceability: For a circular economy to function effectively, both consumers and companies need precise information about the origin and composition of products. The DPP enables this by providing detailed data on materials and production processes. Consumers can choose products based on their sustainability credentials, while companies can ensure compliance with ethical standards and improve supply chain management.

Recycling and Material Recovery: The DPP plays a crucial role in optimizing recycling and material recovery processes. Recyclers can access comprehensive information about the materials used in products, enabling more efficient and environmentally friendly recycling practices. This data helps optimize the dismantling process, ensuring that valuable materials are recovered and reused, thereby reducing waste and environmental impact.

Reuse and Repair: Through the DPP, the condition and repair history of products can be meticulously tracked. This information is invaluable for assessing the longevity and quality of components and the product as a whole. It supports initiatives aimed at extending product lifespans through reuse and repair, ensuring that products remain in circulation for as long as possible before reaching the end of their life cycle.

Sustainable Design: The insights gained from the DPP throughout the product lifecycle can significantly enhance sustainable design practices. Data from recycling and usage phases can inform better product design, emphasizing the principles of Design for Circularity. Each iteration of the product lifecycle can highlight particularly durable materials and design features that enhance circular economy practices, leading to the development of more sustainable and long-lasting products.

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Resource and Energy Efficiency: Resource and energy efficiency are critical components of a circular economy. The DPP allows companies to monitor and optimize these efficiencies through detailed data interfaces. For instance, tracking CO_2 emissions across the value chain enables companies to identify areas for improvement and reduce their overall carbon footprint.

Predictive Maintenance and IoT Integration: Integrating predictive maintenance and Internet of Things (IoT) technologies with the DPP can prevent damage and other issues before they occur. By utilizing real-time data, companies can anticipate maintenance needs and address potential problems proactively. This not only extends the life of products but also ensures their efficient operation, further supporting the goals of a circular economy.

Within the CE framework, Digital Product Passports offer a transformative approach to managing the environmental impact of products by making this information visible and readily accessible. Given the extensive scope of the regulation and the large EU market, DPPs hold considerable potential to enhance the circularity of products and materials on a significant scale, even beyond EU boundaries. The European Commission intends to enforce DPP regulations on imported products, components, and intermediary goods, making importers responsible for compliance. This will substantially affect global value chains, requiring suppliers and producers worldwide to gather and report the necessary DPP data. This global enforcement ensures that products entering the EU market align with rigorous circular economy standards, promoting sustainable practices. [24]

Because of the scale of its relevance, the benefits of DPP include many aspects of future circular economies, ranging from data management to regulatory advantages.

- The enhanced traceability and transparency of products and materials throughout their lifecycle, which support a better decision-making and monitoring of materials, a reduction of waste and a promotion of sustainable practices. [21]
- The detailed information on product architecture and disassembly methods, coupled with integration of smart technology, which optimizes sorting, disassembly, and recycling processes, leading to higher quality recycling and more efficient resource use. [25]
- The access to product-related data made possible to all stakeholders in the product lifecycle, which enhances collaboration across the value chain and ensures industry alignment towards common circular economy goals, facilitating better coordination and more sustainable outcomes. [21]
- The facilitation in compliance checks and certification processes by providing necessary data to verify that products meet regulatory standards, which support the assessment and benchmarking of the sustainable impact of different products and encourages continuous improvement. [26]
- The enforcement of and market surveillance mechanisms for authorities by improving the ability to enforce tariffs, taxes, and trade rules, which ensures that products adhere to sustainability standards, thereby supporting the overall circular economy framework. [26]

[24] Beanland, A., 2023
[25] Neligan, et al., 2023
[26] Walden et al., 2021

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What does the DPP need for its successful implementation?

Since the DPP guideline should cover different industry sectors and products, the definite steps for a successful implementation can be difficult for companies to identify. A definition of the main functions of the DPP can be helpful to identify its technical requirements:

- Clear identification and description of the product, its characteristics, and the transparent presentation of environmentally relevant information.
- Standardized and uniform data management for companies along the entire value chain (manufacturers, suppliers, retailers, etc.) and for consumers. [26]

The Eco-Design Regulation planned by the European Commission in 2022 provides for the following five data- and digitalization specific requirements. [27]

Technical interoperability for seamless collaboration between different systems:

Shared common semantics, such as standardized product data schemes, allow all relevant stakeholders to understand the content of the DPP information. The goal is to reach an autonomous interaction between different systems and organizations [28]. In this regard, technical interoperability is not limited to interoperability between different members of a DPP system, but also relates to interoperability within the IT and data infrastructure of a single member.

Free access to the product passport for all relevant stakeholders:

Certain information about a product is a well-guarded company secret. Nevertheless, DPP information should be accessible to all relevant stakeholders, consumers, and economic operators. For this reason, access rules for the DPP system need to be determined, so that system members only have access to the information they need. Their respective access rights can be set out in delegated acts. [22]

Secure data storage and data processing:

The establishment of the DPP system cannot hinder existing value chain processes. Because of this, the actors in a value chain must be able to provide product information through secure data storage and data processing technologies. The DPP system must enable this decentralized collection of information, and at the same time allow the members of the value chain to determine the storage location of their data themselves. [22]

Authenticity, reliability, and integrity of the data:

IT systems can be easily modified, which is why the DPP information needs to be verified with regards to its origin and integrity, so that trust and confidentiality can be ensured along the entire value chain [29]. The relevant members should not be able to add, change, or delete information about the product unnoticed, and all alterations should be tracked and recorded. Data sovereignty of the data provider should be ensured through direct control over the provided data. [22]

Data security and data protection:

Data access should also be monitored for reasons of data security and protection. In this regard, companies need to comply with the legal requirements of data protection, as well as protect their

[27] European Commission, 2022
[28] DIN & DKE, 2020
[29] Berg, et al., 2022

sensitive product information. Data governance and data management strategies should be implemented. However, this aspect does not seem to already have a definitive solution, with 46% of companies declaring in a 2022 Fraunhofer survey that they do not hand over data because of technical concerns about data security [30]. [26]

In conclusion, digital product passports are pivotal for enhancing transparency, traceability, and sustainability within supply chains. They provide comprehensive insights into a product's lifecycle, from raw materials to disposal, fostering informed consumer choices and responsible manufacturing. By detailing a product's origin, composition, and environmental impact, digital passports support regulatory compliance, mitigate counterfeiting, and facilitate recycling and reuse. These passports enable businesses to identify inefficiencies and improve resource management, thus promoting a circular economy. Ultimately, digital product passports empower consumers and companies to make environmentally and ethically conscious decisions, paving the way for a more sustainable future.

[30] Fraunhofer, 2023

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4 THE DPP IN CATENA-X

As we transition from the broader implications and benefits of digital product passports, it is crucial to explore practical implementations and real-world applications of these technologies. One such initiative that exemplifies the advancement of digital product passports is Catena-X. This section delves into how Catena-X is enabling an advanced DPP system, highlighting the platform's approach to meeting regulatory requirements and enhancing data transparency. By examining the centralized and decentralized solutions proposed by Catena-X, we can better understand the practical aspects of deploying digital product passports and their potential impact on the industry. In particular, we will conduct a deep dive into the first implementation of the DPP in Catena-X: the Battery Passport, to illustrate the practical application and benefits of this innovative technology and the data ecosystem Catena-X.

How Catena-X is enabling an advanced DPP?

Although the European Commission's guidelines favor a decentralized structure for future DPPs, the conditions required to meet the regulations can also be fulfilled in the form of platform-based, centralized solutions. For reasons of practicability, the first commercial solutions comparable to the DPP rely on central data repositories where the copies of the required data sets are bundled and then made available online (Figure 7). Another available variant is the link to distributed ledger/blockchain-based solutions, in which the respective information is written immutably to a blockchain and is generally publicly available via the distributed systems. A combination of both variants is also possible and can be found on the market.

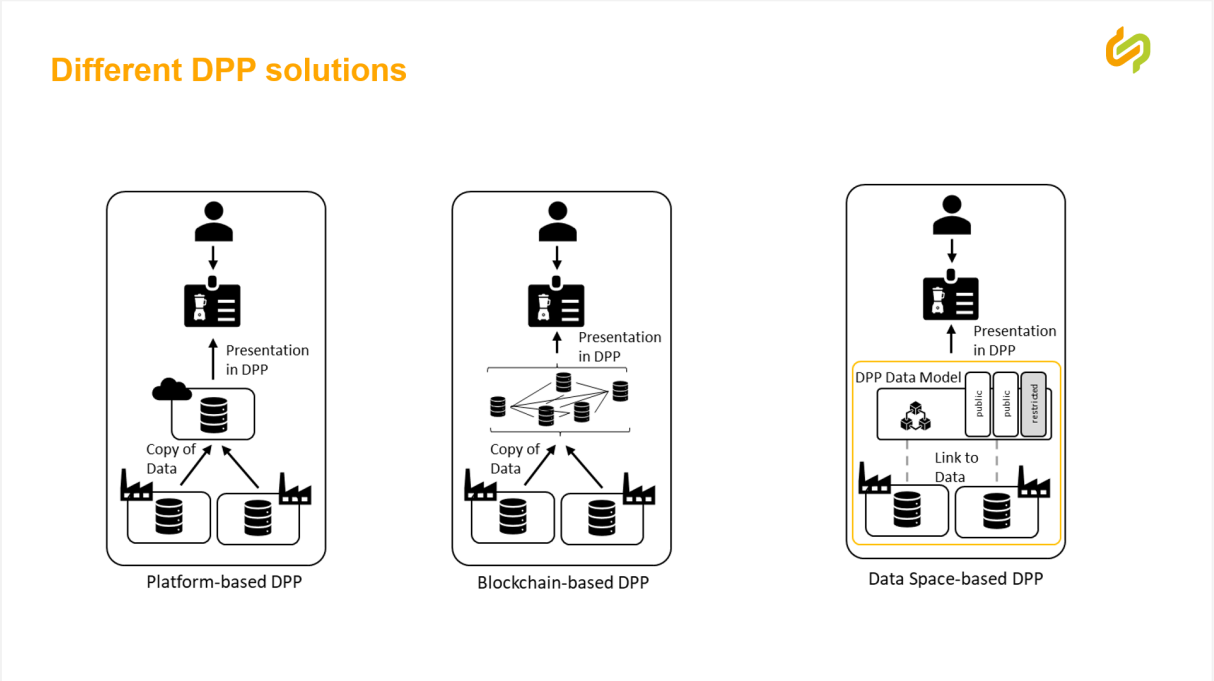

Figure 7: Different DPP solutions

As a data ecosystem, Catena-X chooses a much more far-reaching and connecting approach. Catena-X offers an excellent basis for the creation, data integration and provision of the DPP, as numerous

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regulatory requirements are already inherently covered by the existing Catena-X policies and the core services of the live data space. The European Commission plans to operate back-up systems to ensure the long-term availability of the data, which take over this function in extreme cases in which the economic provider can no longer guarantee the data availability of the DPP, for example due to insolvency.

As the Catena-X Data Space is a multi-use case approach, existing information/data paths can be used to enable the enrichment of the DPP in an automated and always up-to-date form.

In addition, with the Semantic Hub, the Digital Twin Registry and the integration and use of the AAS standard (IEC 63278) (Asset Administration Shell), important components for the interoperability of the DPP across application and company boundaries have already been implemented and will continue to be adapted to the latest guidelines in partnership with the IDTA.

The Catena-X DPP can make use of the AAS system of nested information levels and, as a data economy approach, can enable the integration of data assets across company boundaries without having to rely on duplicated data and at the same time ensure data sovereignty using the already established Catena-X principles. This enables economic providers to easily integrate their suppliers' DPPs into their own DPPs without losing the original data paths and to add the additional information of the value creation steps they have carried out themselves to the DPP. This composition of the DPPs represents an essential logic, which must be recomposed during the stages of partial reuse and re-manufacturing in accordance with the CE.

In the medium term, however, the Catena-X DPP is about more than just satisfying EC regulations or other emerging regulations. It is about establishing and designing the DPP as a central entry point for product-related data over the entire life cycle. The Catena-X-based DPP addresses the following principles:

- Public provision of product and production data - in accordance with regulatory requirements and enabled by the Catena-X access rules
- Dynamic enrichment of data over the life cycle (upstream & downstream) and adaptability to future requirements
- Additional data and information restricted/protected by the Catena-X access mechanisms, which exceed the required regulatory information and at the same time contain relevant information about the product for specific partners (e.g. detailed instructions, coordinates or entire CNC programs for automated disassembly)
- Possibility of monetization by using the already existing Catena-X policies of such data in the course of future negotiation processes with new partners and users that arise in the course of establishing the CE.

The first implementation of the DPP in Catena-X: The Battery Passport

In the automotive industry, the Battery Passport or Digital Product Passport for batteries plays a crucial role in ensuring transparency, traceability and sustainability throughout the battery supply chain. Catena-X integrates various semantic models that structure and utilize data effectively, facilitating interoperability across different datasets. These models, including digital product passports, aim to establish unified frameworks adaptable across the automotive sector.

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The EcoPass KIT within Catena-X addresses challenges by providing standardized solutions for creating and managing digital product passports, specifically tailored to enhance battery traceability and sustainability. The Battery Passport serves as a secure, centralized repository of information accessible to stakeholders such as vehicle manufacturers, suppliers, regulators, and recyclers.

Components of the Battery Passport Data Model

The Battery Passport is a tool, a standardized semantic data model for the exchange of information and enables tracking and tracing of batteries usage information. Serves as a single, secure, and easily accessible source of information for various stakeholders, such as vehicle manufacturers, suppliers, service providers, regulators, vehicle owners, recyclers and dismantlers.

The Battery Passport data model encompasses comprehensive information crucial for regulatory compliance (EU 2023/1542) and effective lifecycle management: Passport metadata, Product identification, Product operation, Product handling, Product characteristic, Sustainability information, Material information, Commercial information, Sources (documents), Conformity information, Safety information and Performance information.

Data sharing within Catena-X relies on decentralized technologies, respecting individual provider decisions, thereby ensuring data security and privacy.

Implementation in Electric Vehicles

1. Battery Manufacturing: During production, manufacturers record critical data such as unique identifiers, manufacturing details, technical specifications, and material compositions.

2. Supply Chain Transparency: Information regarding sourcing, manufacturing processes, and distribution is documented, ensuring compliance with environmental and social standards.

3. Vehicle Integration: The Battery Passport links to the vehicle's VIN upon integration, facilitating seamless communication and tracking between the battery, vehicle, and stakeholders.

4. In-Use Performance Tracking: Throughout the vehicle's lifecycle, the Battery Passport continuously monitors performance metrics like state of charge, charging cycles, and degradation, enabling proactive maintenance and optimization.

5. End-of-Life Management: At end-of-life, the Battery Passport provides instructions for proper disposal and recycling, aiding recycling facilities in efficiently processing batteries and promoting circular economy practices.

The Battery Pass Viewer App

Developed under the Catena-X initiative, the Battery Pass Viewer App is a pioneering application for visualizing product passports. It simplifies access to digital product passports via QR code scanning or unique ID entry, consolidating comprehensive product information in one accessible tool. The Battery Pass Viewer App, provided as a Free and Open-Source Software (FOSS) application, ensures cost-effective implementation and compliance with Catena-X principles. It guarantees secure data retrieval, quality assurance, and interoperability with existing infrastructures, making it the operational choice for large-scale digital product passport applications within the automotive industry.

In summary, the Battery Passport in Catena-X exemplifies a transformative approach to enhancing battery traceability, sustainability, and efficiency across the automotive sector. By leveraging

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standardized data models and advanced digital tools like the Battery Pass Viewer App, Catena-X paves the way for a future where transparency, sustainability, and innovation converge seamlessly in automotive manufacturing and beyond.

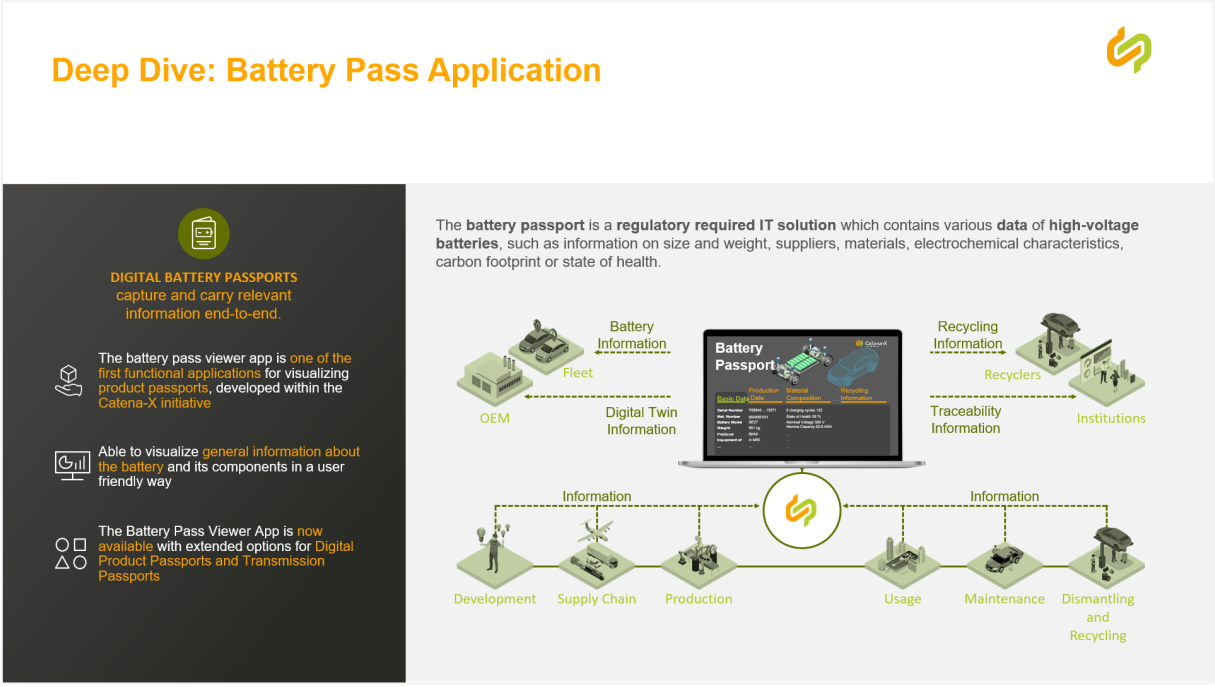

Figure 8: Deep Dive: Battery Pass Application

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5 CONCLUSION

The Digital Product Passport (DPP) initiative within Catena-X represents a transformative approach to realizing the vision of the circular economy in the automotive industry. By integrating standardized data models and promoting collaboration between stakeholders, Catena-X enables comprehensive traceability and sustainability across the entire life cycle of automotive products. Catena-X has made significant progress in promoting DPP technologies, particularly through initiatives such as the Battery Passport, which standardizes data exchange protocols. This enables a seamless flow of information from manufacturing to end-of-life management, supporting efficient use of resources and minimizing environmental impact. These efforts not only serve to comply with legal regulations, but also promote innovation in the areas of product design, manufacturing processes and material recovery.

The prospects for DPP and the integration of the circular economy in the automotive sector are promising. Catena-X continues to expand its ecosystem to enable wider adoption of DPP technologies across the industry. The development of tools such as the Battery Pass Viewer app is an example of Catena-X's commitment to accessibility and scalability to ensure that all stakeholders can reap the benefits of digitalization without major financial or technological barriers. Looking to the future, Catena-X's initiatives are able to drive significant advances in sustainable practices in the automotive industry. By improving data transparency and promoting the principles of the circular economy, Catena-X is setting a precedent for global automotive manufacturers and suppliers. As these technologies evolve and take hold, they promise to redefine industry standards and promote efficiency, resilience, and environmental sustainability.

In summary, Catena-X is positioned as a leader in digital innovation within the automotive industry, advocating for sustainable solutions through the adoption of DPP technologies. Through collaborative efforts and the deployment of advanced digital tools, Catena-X is driving towards a future where economic growth and environmental stewardship can coexist harmoniously. With a focus on continuous partnership and innovation, Catena-X plays a crucial role in advancing a more sustainable ecosystem within the automotive sector, aiming to benefit future generations.

APPENDIX

List of figures

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Verfasser: Name Name (optional: Redaktion v. i. S. d. P.)

Druck: Name, Anschrift

Bildnachweise: entsprechend AGB/ Nutzungsbedingungen

Erschienen: 2/2023