Digitalization potential for battery production and value chain

Options for greater efficiency, speed and quality

T Systems

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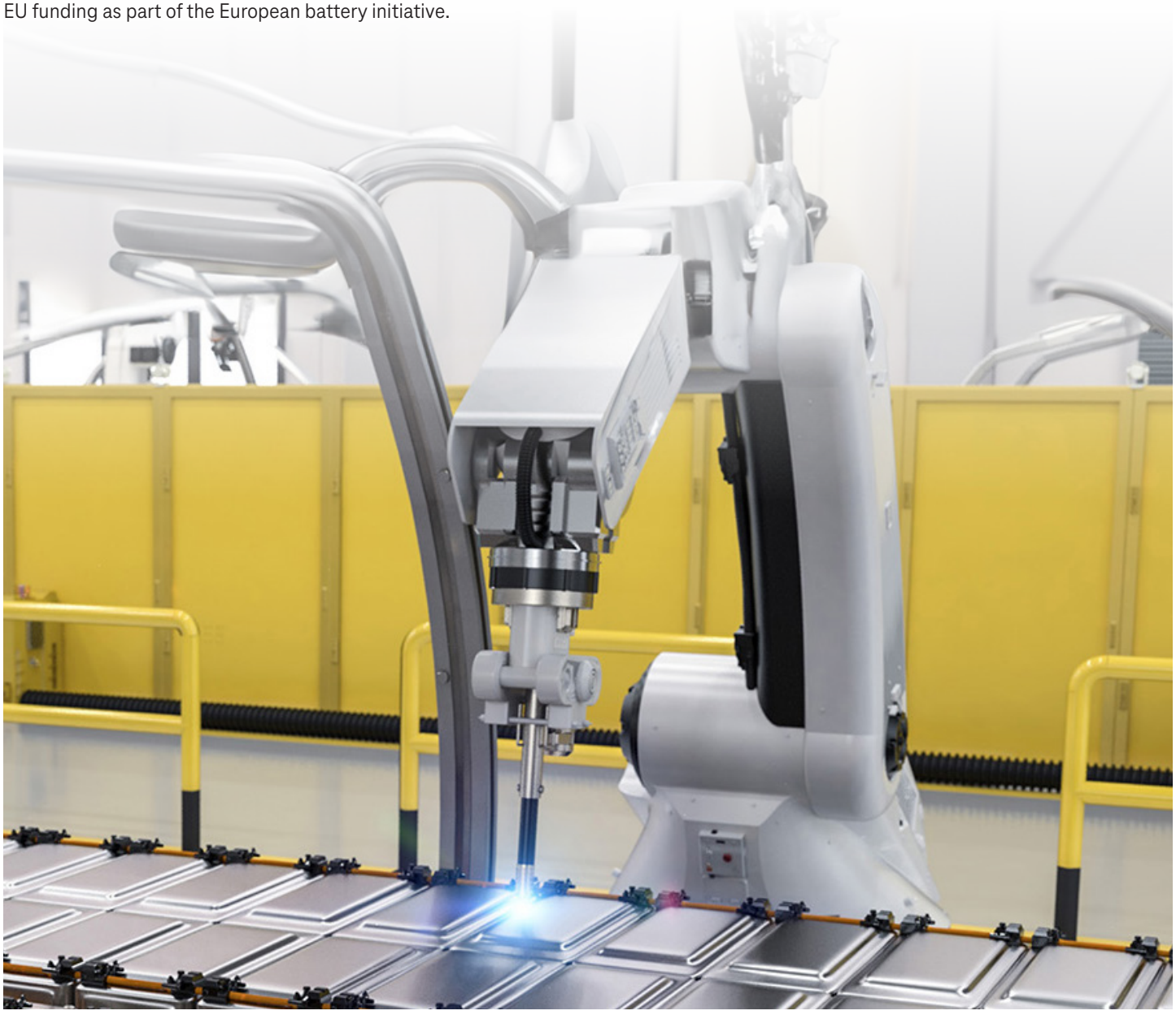
Battery production as the driver of mobility transition

The availability of battery capacity is one of the decisive factors if the mobility transition to electromobility is to succeed. At the same time, the battery represents around 40 percent of the added value of electric cars. To date, the lion's share of batteries for electric vehicles has been manufactured in China. This is set to change.

Many manufacturers, established automotive companies as well as start-ups, but also Asian manufacturers, are recognizing the business opportunities for battery production "made in Europe": Added value is created in the "green continent" of Europe, supply chains are shorter, dependencies are reduced and sustainability aspects are given greater consideration. The establishment of production capacities in Europe is even being supported with EU funding as part of the European battery initiative.

In 2022, the Fraunhofer Institute for Systems and Innovation Research (ISI) analyzed the European battery market and came to the conclusion that production capacities are expected to increase tenfold from 124 GWh in 2022 to between 1,300 and 1,500 GWh in 2030[1]. Manufacturers want to increase capacities to over 500 GWh as early as 2025 – this is an increase of the existing capabilities by four times within just three years.

A vibrant market with extremely strong competition, in which companies that act faster secure market shares for a booming future segment! Incidentally, a quarter of Europe's total production capacity is to be built in Germany.



1. BEMA 2020 II - Europäische Batteriezellfertigung: Verzehnfachung der Produktionskapazitäten bis 2030, Fraunhofer-Institut für System- und Innovationsforschung ISI, 2022, https://www.isi.fraunhofer.de/de/presse/2022/presseinfo-17-Batteriezellfertigung-Verzehnfachung-2030.html

Challenges along the lifecycle

Anyone who wants to get seriously involved in battery production, has to think about the entire battery life cycle. This begins with development, continues through production and ends with the use and recycling of the battery. Challenges for battery manufacturers arise along the entire life cycle (see Figure 1).

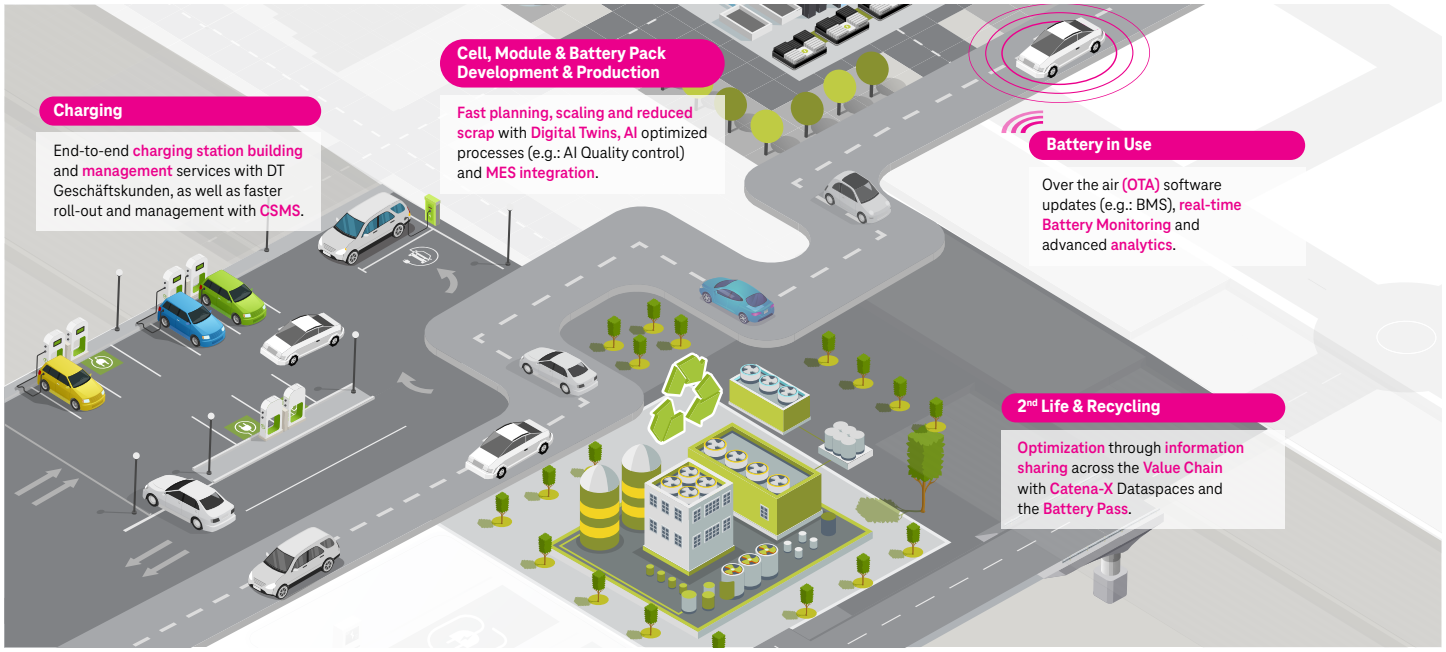


Figure 1

Engineering capacities for battery products are relevant in a highly competitive segment so that suppliers can differentiate themselves from the **competition with innovations**. This includes in particular the technical (further) development of batteries, e.g. to increase energy density and reduce the weight or space requirements of batteries. Efficient collaboration methods are essential for this.

In production, the focus is primarily on **operating costs and quality**. The maintenance and operation of battery production facilities require considerable resources and expertise. A key characteristic is the high energy consumption, which is not only a major cost driver, but also affects **sustainability aspects**. Against this background, efficient production processes are essential. With a current reject rate of over ten percent, increasing production quality also plays an important role in manufacturing. At the same time, production must be able to scale. The rapid expansion of additional production capacities to meet the demand for batteries is also a decisive competitive criterion for battery manufacturers. This also includes the opening of new sites.

Last but not least, battery manufacturers must keep an eye on regulatory requirements. These go beyond the direct requirements for production. For example, the EU Battery Pass will be introduced in 2026[2]. It will be mandatory for all newly purchased batteries in vehicles, stationary storage systems and larger industrial batteries in Europe. It will make the entire life cycle of batteries transparent for consumers. It will include components such as the CO_2 footprint, social sustainability, the health status of the battery and the proportion of recycled/recyclable materials.

Battery manufacturers also benefit from the recycling of the raw materials and components used at the end of the life cycle, giving them access to additional production components – essential in view of the current shortage of raw materials. According to a recent report by the World Bank (December 2022)[3], even in Europe, the pioneer of the circular economy, 87% of resource consumption comes from primary materials. Not even ten percent comes from recycling (8.6%).

2. Darum geht's beim Batteriepass für Elektroautos, Bundesministerium für Wirtschaft und Klimaschutz, 2022, https://www.bmwk.de/Redaktion/DE/Artikel/Industrie/Batteriezellfertigung/batteriepass.html
3. Squaring the Circle: Policies from Europe's Circular Economy Transition, The World Bank, 2022, https://www.worldbank.org/en/region/eca/publication/squaring-circle-europe-circular-economy-transition

Digital solutions create more efficiency, higher transparency and reduce costs

Collaboration and efficient use of data for better development

Many development teams in the manufacturing and automotive industries report immense pressure to innovate. Development cycles are becoming shorter and shorter. This development faces a rampant shortage of skilled workers and an increasing division of labor with many partners.

Against the backdrop of business requirements, it is clear that decision-makers have to deal with the consequences and opportunities of digitalization more than ever before. Be honest: do you currently see technology more as an enabler for new opportunities or a necessary evil? Or even as a nuisance whose limitations even prevent innovations and burden employees? Use digitalization as a booster.

PLM (Product Lifecycle Management) systems are crucial for the processes involved in battery development. These are generally proprietary, self-contained siloes. Different data formats and little ability to exchange information with other systems (even beyond the PLM world) are the result of this insular thinking on the part of manufacturers – not an uncommon phenomenon in the engineering tool landscape.

Harmonious collaboration within the company requires **cross-system and cross-divisional processes.** An optimal working environment can only be created by eliminating data and process breaks. This enables **efficient data exchange** between the systems, for example for data supply to downstream systems or parts list synchronization between PLM and SAP. External partners can also be seamlessly integrated into this data exchange.

Ideally, battery manufacturers should use tools that provide industry-specific processes and use cases as ready-made templates for such integration solutions. In this way, costly and time-consuming new implementations can be avoided and the company can benefit from mature solutions instead.

One such tool is the PDM WebConnector. It acts as PLM middleware that reduces the complexity of data in the background, a kind of central data hub that enables bidirectional exchange between a wide variety of systems. It also comes with a wealth of interfaces and conversion functions as standard. It can also be used as part of Catena-X for the standardization of data. The bottom line for engineering teams (and other company units) is consolidated data pools with an up-to-date database. Other important topics beyond data integration are the **semantic interpretation of data** and the introduction of **digital twins.**

Semantic data layers generate contextual knowledge. They interpret the data collected from the various sources from a business perspective and answer business questions such as:

How do I achieve traceability across all artifacts in my engineering process?

What impact does this change request have?

Which components, configurations or tests can I reuse for similar requirements?

The future of engineering also includes relieving employees with specialist expertise in the best possible way and taking collaboration to a new level. **Digital twins,** virtual images of physical objects, play a decisive role in this. They allow to work “directly on the object”. Changes to a battery can be modeled virtually and the effects of the changes on battery performance can be simulated. Information from the use of batteries can also be incorporated into the digital twin. This can provide engineering with valuable impetus for the development of new battery generations.

Just-in-time production, quality improvement, efficient use of energy

One of the key challenges in battery production is the combination of two different manufacturing approaches: The slurry for electrode production is created in batch production, cells as the smallest battery units and their combination into modules and packs in discrete production. Hybrid production creates a complex and challenging production environment.

In addition, electrode production is still in its infancy: a holistic production design and the measurement of data along the production process to identify optimization potential have not yet been established.

The respective **production processes must be harmonized and integrated.** Only seamless cooperation ensures efficient production. In particular, adapting to fluctuations in demand or changes in production processes has a direct impact on efficiency.

In addition to integrating the two production approaches (within the company), battery manufacturers must also think along the **supply chain** and plan the efficient **just-in-time provision** of the initial components and raw materials as well as coordinate the batteries to be supplied with the needs of the OEM as a customer. Supply chain coordination and production planning can now be more closely interlinked and analyzed using IoT solutions and artificial intelligence (AI). IoT solutions create a high level of transparency regarding the location and quantity of raw materials and products across the supply chain; AI helps with the planning, analysis and optimization of processes. Efficiency potential is identified, production costs are reduced.

In view of the high energy requirements, battery manufacturers are also focusing on **measures to optimize energy consumption.** Precise recording of energy consumption and collection of energy data is essential for this. This data can not only be collected and visualized in energy dashboards, but can also serve as the basis for simulation models. These in turn allow various optimization measures to be determined – AIs can also be used for this. Last but not least, the **transparency of energy consumption** enables reporting as part of sustainability reports.

In terms of the **quality of battery production,** Europe is still in its infancy. As of today (2023), 40 percent of the cells produced are defective or need to be reworked[4]. Twelve percent of production is scrap on average.

The production costs, but also the carbon footprint of production, correlate very strongly with the quality of the batteries. The predictability of product quality – including in various preliminary production stages such as electrode production – plays an important role in this[5].

The random sample inspection that has been common today can also be optimized with the help of AI. Cameras work together with established AI methods for object recognition. Many car manufacturers use such processes to automatically check the quality of weld seams, for example. The AI performs a comprehensive **quality check for each workpiece.** This process can be used directly to check safety-critical weld seams during the consolidation of battery packs, for example. However, AIs can also be trained for quality control in other phases of production: Machine learning algorithms[6] allow research and production to evaluate production data in order to predict and, if necessary, optimize the characteristics of battery cells in early production phases (in situ).

AI-based quality control for welds at OEMs

Welding processes are central to automotive production. High-quality welded joints are a hallmark of high-quality products. However, welded joints offer a wide range of possible defects: incorrect weld seam dimensions, pores or interruptions , for example. Quality control is complex and requires specialized personnel. As a rule, only spot checks are possible in series production.

Several car manufacturers rely on an AI-based solution from T-Systems to check weld seams. It uses AI-based object recognition and links this with sensor data from the welding robots. The result is a real-time analysis of the quality of each individual workpiece. Quality control also allows root cause analyses to permanently eliminate sources of error. The AI basis alsupports the solution to continuously evolve (self-learning) and automatically reconfigure welding robots to improve product quality.

4. Battery production design using multi-output machine learning models, *Energy Storage Mater.* **38** 93–112, Turetskyy A, Wessel J, Herrmann C and Thiede S, 2021, https://www.sciencedirect.com/science/article/pii/S2405829721001008
5. Roadmap on Li-ion battery manufacturing research, J. Phys. Energy 4 042006, Patrick S Grant et al., 2022, https://iopscience.iop.org/article/10.1088/2515–7655/ac8e30
6. Artificial intelligence applied to battery research: hype or reality?, Chem. Rev., Lombardo T et al., *Chem. Rev.* 2022, 122, 12, 10899–10969, 2021, https://pubs.acs.org/doi/10.1021/acs.chemrev.1c00108

Finally, industrial metaverse (IM) approaches can make outstanding contributions to **factory and production planning.** Complete factories with all components such as robots, lasers, machines, equipment, components, workpieces, etc. are not created on the drawing board, but as a collection of various digital twins. Planning approaches and simulations in the Industrial Metaverse (IM) significantly accelerate factory planning and thus reduce project costs. But the digital twins of factories in IM also allow simulations to optimize production processes. In addition, IM platforms are often also able to train AIs.

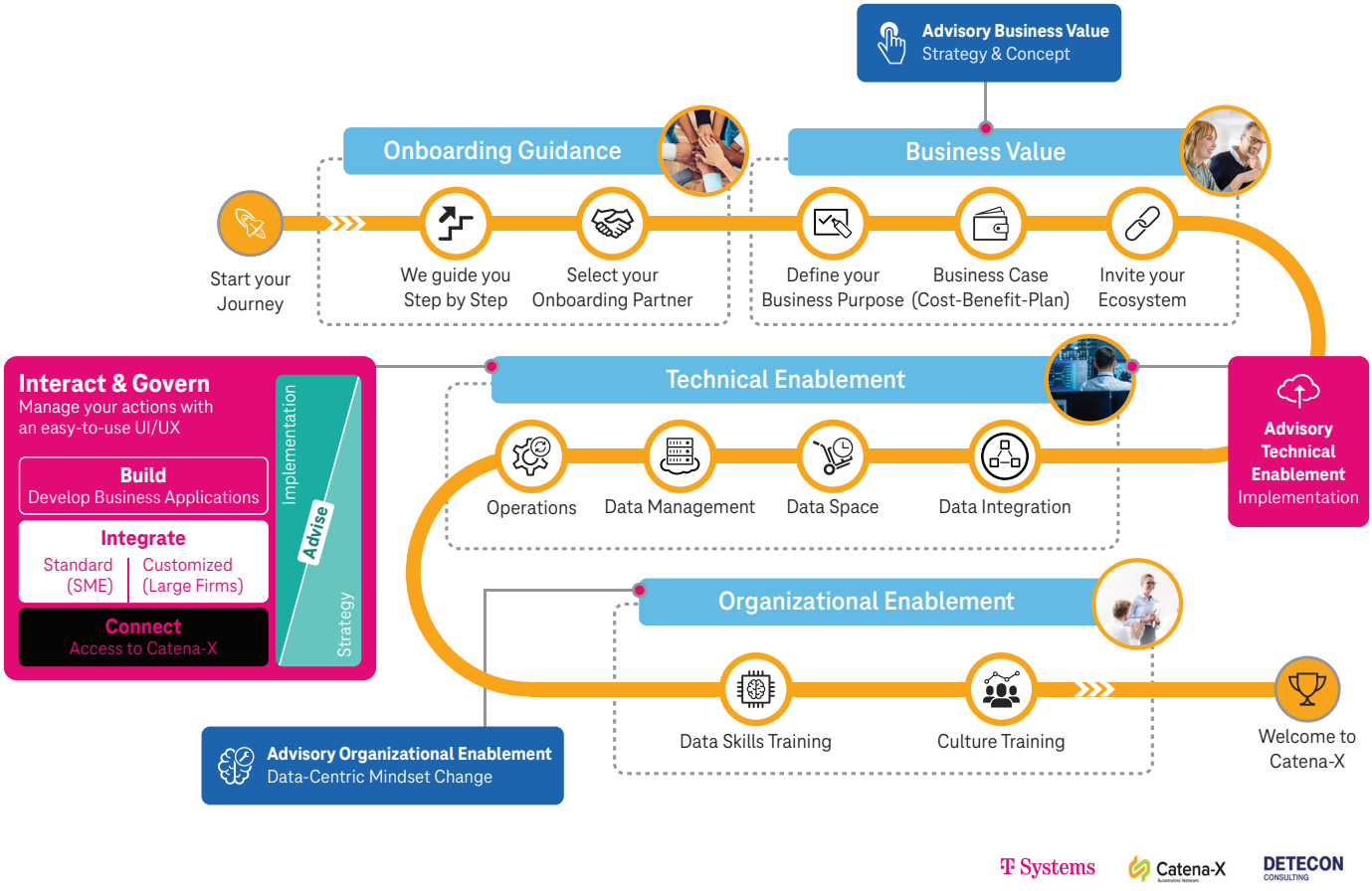
Factory planning in the Industrial Metaverse

The advantages of 3-dimensional factory planning over 2-dimensional planning are well-known for quite a while. But until now, 3-dimensional models have tended to be static. They could only depict reality to a limited degree. A European OEM uses an Industrial Metaverse to create a virtual image of a complete factory with all its elements, including its processes. T-Systems supports the OEM with comprehensive integration services that enable the creation and interaction of the digital twins. The digital factory image provides the OEM with answers to “what if” questions in real time. The 3D model, which examines the introduction of changes and their impact on the subsequent production process, provides the OEM with a helpful tool for identifying errors at an early stage. Planning errors, time delays, costly corrections and workarounds can be avoided.

Perspectives through data rooms and Catena-X

The collection and provision of data during the production and use of batteries can significantly improve development and production. However, the collection and provision of data will also be important in the future in order to meet **external requirements.** These include **regulatory** requirements (such as the Battery Pass described above) as well as **industry-specific requirements** in the value creation network. Catena-X, for example, is establishing itself as a new standard for data exchange – and an ecosystem of services, including for the circular economy. Battery manufacturers should therefore also take precautions to connect to the network.

Closely linked to Catena-X is the sovereign handling of data. Sovereign data rooms are available for this purpose – both within Catena-X and separately. Companies can collect scalable data in these and share it with partners as required – with full control over the data. The availability of the data also ensures compliance with regulatory requirements.



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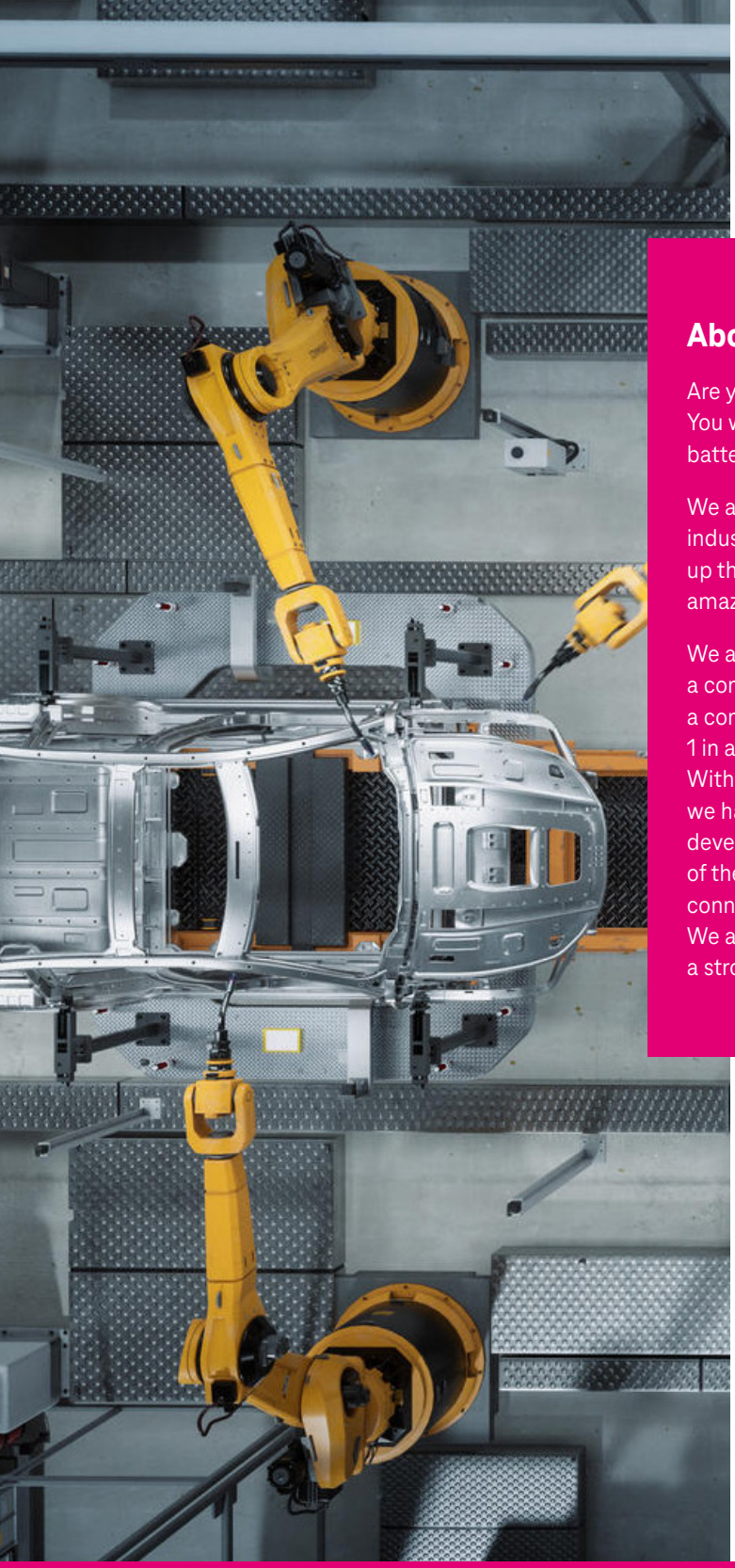
Source: https://catena-x.net/de/catena-x-einfuehren-umsetzen/einfuehrung-von-catena-x

Catena-X – Data provision in the data ecosystem

Many different parties are involved in the automotive value chain. Small companies, medium-sized tier 1 and tier 2 suppliers as well as large companies. What they all have in common is the challenge of integrating their data into the new automotive data ecosystem. T-Systems supports companies of all sizes with their entry into Catena-X. The range of solutions includes consulting services and the technical implementation of connections. For large companies, T-Systems realizes specific integrations and data transformations of data from legacy systems. For SMEs, T-Systems offers standardized solutions for data upload and download as well as data transformation.

For a medium-sized Tier 1 supplier, T-Systems realized a connection solution that combines the in-house Semantic Integration Assistant (SIA) with the Catena-X standard tool for data transfer, the Simple Data Exchanger. The SIA supplements the transfer and necessary transformation of data so that it meets the requirements for digital twins and semantic data interpretation. The medium-sized company thus became an early adopter of Catena-X.



About T-Systems

Are your goals improved efficiency, speed, resilience and competitiveness? You want to be flexible and master the challenges of sustainability in battery development and production?

We are a long-standing partner to the automotive and manufacturing industries with expertise in the process and chemical industries. We open up the potential of digitalization in battery production for you. You will be amazed at what is possible today and the results for battery production!

We are a reliable partner with experience in implementation. We bring a combination of unique process and technology expertise and offer a comprehensive portfolio of ready-to-use solutions. We are the number 1 in automotive IT and can look back on more than 25 years of experience. With an international community of over 3,000 automotive experts, we have realized over 5,000 projects for the digital future of automotive development and production in 2022. We are experts in the digital future of the automotive industry with know-how in process solutions, machine connectivity, artificial intelligence, digital twins and industrial metaverse. We are quick to adopt the latest methods and technologies. We have a strong sustainability agenda and are a founding member of Catena-X.

Would you like to get to know us and our capacities? Contact us.

Andreas Valtl
Senior Business Development Manager Automotive
andreas.valtl@t-systems.com
automotive@t-systems.com

Contact

www.t-systems.com/contact
E-Mail: info@t-systems.com
00800 33 090300*

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