LNI4.0 LABS NETWORK INDUSTRIE 4.0

CESMII THE SMART MANUFACTURING INSTITUTE

PLATTFORM INDUSTRIE 4.0

US-German Digital Product Passport Demonstration

Purpose

Recently, there has been growing recognition of the critical importance of supply chain resilience and carbon/GHG tracking and reporting on a global scale. Addressing these global challenges necessitates robust solutions that enhance internationally coordinated efforts. The concept of a Digital Product Passport (DPP) plays a pivotal role in achieving this goal, particularly for manufacturers in supply chains that sell products to consumers in Europe. By ensuring secure and well-managed industrial data interoperability across both inter- and intra-company manufacturing platforms, the DPP unlocks significant opportunities for enhancing end-to-end industry process optimization. Specifically, it contributes to sustainability, streamlines supply chain processes, and boosts overall productivity.

Motivated by these global business needs, Plattform Industrie 4.0 and its US partner CESMII – The Smart Manufacturing Institute (CESMII), along with Labs Network Industrie 4.0 (LNI 4.0) and the ZVEI, developed a joint demonstrator. Last year, this demonstrator showcased international multivendor solutions for supply chain resilience and carbon/GHG tracking and reporting, all based on the international industrial standards AAS and CESMII SMP. This year's demonstrator extents the previous showcase and adds an exemplary DPP solution and introduces an additional DPP use case to provide information on the end-to-end provenance of a battery.

First, this document aims at informing interested readers about the challenges and opportunities of the DPP, displaying two different prototypical exemplary demonstrations. These examples highlight how the DPP can be part of the solution for innovative businesses and economies to adept to the global multi-crisis. Further-more, the DPP is contextualized in the digital ecosystem demonstrating the needs and benefits of international cooperation – presented by the US-German collaboration. Additionally, technical insights of the demonstrators are shown. Finally, the paper gives an outlook on what next steps are needed

History of a US-German partnership

The fruitful collaboration between Plattform Industrie 4.0 and CESMII – The Smart Manufacturing Institute thrives.

It has been 5 years, in 2019, since the first meetings on smart manufacturing were held at the Chicago fair. Since then, it has been a fruitful collaboration: The sustainable manufacturing cooperation was initiated in 2020. As the pandemic changed the way businesses worked, Plattform Industrie 4.0 and CESMII jointly developed a COVID relief action plan for manufacturing. During Hannover Messe 2021, it was finally time to make the cooperation public: In their joint press release, the two organizations declared their intent to cooperate on shaping the future of manufacturing. Consequently, a first discussion paper on sustainable manufacturing was launched.

The momentum of the year 2021 also led to the agreement to build a joint demonstrator for carbon/GHG tracking and reporting leveraging IEC industrial standards OPC UA and Asset Admin Shell (AAS). Linking interoperability of standards with sustainable use cases proved to be a successful strategy to involve major companies in the development of the demonstrator. Work commenced with Festo (Didactic and SE & Co. KG), Siemens and Microsoft. Shortly after, GE Digital was onboarded. CESMII's Smart Manufacturing Innovation Plattform (SMIP) was integrated into the demonstrator and connected to AAS interoperability. After its virtual launch at the Big Data Value Forum 2021 it was showcased at different fairs around the globe in 2022. Continuously, the demonstrator was significantly expanded to include Product Carbon Footprint (PCF) Calculation of a ballpoint pen. Several new companies (SAP, Eviden and SMEs) were onboarded into the PCF demonstrator. The launch of the updated PCF demonstrator at Hannover Messe 2023 was a highlight for CESMII and Plattform Industrie 4.0 as the German Minister for economy and climate action Robert Habeck visited the demonstrator.

The participation at mutual events in the US and Germany, such as the CESMII Annual Summit and Hannover Messe, strengthened the trusted relationship between the partners. Both organizations collaborate actively in the international multi-stakeholder initiative, IMX, to foster an interoperable, sustainable, resilient, and competitive industrial ecosystem.

Global challenges

The design of open, digital ecosystems

While the value creation of our industries remains globally interconnected, the modern world is facing a myriad of industrial and environmental challenges. These challenges, if not addressed promptly and effectively, could have far-reaching impacts on our societies, economies, and the planet: Industries worldwide are grappling with resource scarcity, driven by increasing demand and finite natural resources. The complexity of global supply chains further exacerbates this issue, making it difficult to track the origin and journey of products and their components. At the same time, we know that industrial activities contribute significantly to greenhouse gas emissions, driving climate change. Thus, the mitigation of these emissions is key. Additionally, industrial activities can lead to habitat destruction and pollution, contributing to biodiversity loss. Balancing industrial development with the preservation of ecosystems is another key environmental challenge.

As these changes affect all our lives, policymakers are in search for incentives to foster the transformation of our societies. Industries must comply with a growing body of regulations aimed at promoting sustainability and protecting consumer rights. Ensuring compliance, particularly in a global market with varying regulations, is a significant challenge for businesses.

Nevertheless, several new technologies create new opportunities to overcome these challenges and lay the foundations for new business models to arise. Considering all these challenges, businesses and economies have the chance to manage the twin transition: On the one hand, this two-fold change refers to the joint efforts to make the global economy more ecologically sustainable and supply chains more resilient. On the other hand, the digitalization of production and work processes is intended to strengthen local economies. Through international collaboration, businesses and industries can jointly shape open, digital ecosystems that build on the three pillars of autonomy, interoperability and sustainability.

Challenges on the path towards a circular economy

As we know, in traditional models of linear economic growth based on a 'make, take and dispose' production leads to significant waste, contributing to environmental degradation. This has initiated a transitioning to a circular economy, where waste is minimized, and resources are reused and recycled. For any industry to shift to a low-carbon footing, interests must be aligned in policy, financial markets and the real economy. Systemic approaches are critical to transition towards a circular economy. To achieve this, data enabled circular businesses require an interoperable and resilient infrastructure. Therefore, it is necessary to facilitate data sharing to ensure that the material composition of components remains within the cycle. Suppliers will need to aggregate their data and provide it to customers upon request.[1]

> "The circular economy is 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."

However, using data for environmental benefits has been a challenge for a long time: It is necessary to allow the mapping of information along the value chain to enable data acquisition as well as data analysis and data use. Additionally, a technical infrastructure for the exchange of collected product-related life-cycle data is needed.

The figure below showcases an exemplary product and its global value network. It underlines that data exchange points during a product-life cycle are global, thus requiring interoperable services to ensure low-cost product life cycle management. Therefore, Plattform Industrie 4.0, CESMII and LNI 4.0 focus on showcasing interoperability of the international industrial standards AAS and CESMII SMP.

1 https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

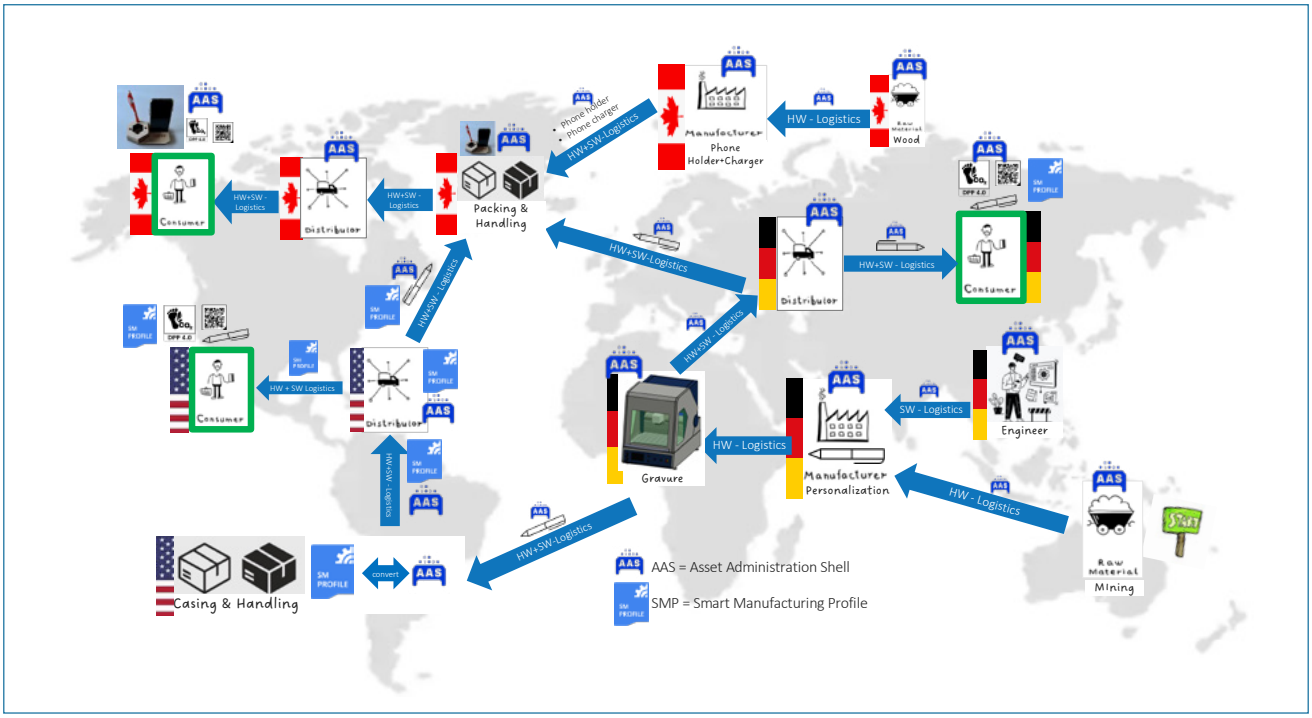


Figure: Demonstration of exemplary data exchange points in a global value network

Compliance or innovation – to respond or to create?

The Digital Product Passport is an innovative solution

The DPP activities around the world offer the opportunity to further link the OT industry to the data economy in. While enabling the use of mandatory sector-specific sustainability and circularity information, it also creates a vast amount of non-mandatory business opportunities to innovate the digital ecosystem and to help businesses to develop new business models.

Our US and German DPP demonstration is based on a decentralized approach for data storage. It is envisioned to enable a decentralized soft infrastructure that is mainly operated by the participating stakeholders, using interoperable implementations that are based on a set of agreements among all actors.[2] Also, the DPP shall be uniquely linked to a product. For a more detailed view on how the architecture of a DPP system could look like, please refer to the ZVEI discussion paper (link paper).

Systemic benefits can be drawn from the DPP as a solution. The benefits of the DPP include:

- **Enabling the circular economy:**
  - Through the DPP life cycle data becomes available.
  - It allows engineers to provide standardized product information during product development (i.e., on how to manufacture, operate and later dispose of the product).
  - To replace products globally at low-cost if needed.
  - Information on use, repair, maintenance, and disposal become available and can therefore be used internationally.
- **Creating data transparency for new business models**
- **Being future-proof at the lowest possible cost to comply with global regulations (regulatory compliance)**
- **Ensuring a global operational capability for companies today and in the future**

2 *ZVEI Discussion Paper: "DPP 4.0: An Architecture Proposal for a DPP-System to implement the EU Digital Product Passport for Industrial Products"*

This creates an opportunity for next steps in international harmonization processes and is an example of how data can be shared across a supply chain, enabled by this same approach to interoperability and standards-based information models.

The demonstrator realizes several business cases based on AAS (Asset Administration Shell) and SMP (CESMII Smart Manufacturing Profile)

The demonstrator is designed around the production of a pen. The product (ballpen) has several variants and is personalized. The supply chain of the product is configurable. The configuration enables transparent and educated business decisions based on carbon/GHG footprint and supply chain information being provided to the customer during the design phase of the pen. The demonstrator configuration options cover the following product lifecycle steps:

- Engineering and development (with personalization)
- Production
- Finishing
- Casing and shipment

The configuration options that affect the carbon/GHG footprint for the product include:

- Material selection (aluminum or plastic pen)
- Engraving of the pen
- Finishing and casing of the pen (USA and/or Germany)
- Shipping (truck, train, ship or air cargo)

These options include the prediction of the expected carbon/GHG emissions. Therefore, the carbon transparency of the engineering process is ensured. International supply chain alternatives (including alternative components) strengthen the resilience of the production process. These configuration options are selected by the customer.

A closer look at the AAS and SMP implementation

The product is more than just a pen: It is the physical pen with a digital twin and a product passport.

As illustrated on the left-hand side of the figure below, the engineering and development step yields the instantiation of a new product AAS. One for every product. They are stored in a repository with an API and discovery functionality for the AAS instances.

The data for each product AAS instance of the pen has multiple sources and several interoperability technologies are involved. These technologies are:

- AAS Digital Nameplate sub-model (with the main information of the product and its manufacturer) provided by Industrial Digital Twin Association (IDTA)
- CESMII SM Profile data containing energy and carbon/GHG related information
- CESMII Dashboard showing live data bound to the Sub-Model Template as an OPC-UA Connected Profile
- OPC UA time-series data collection of energy measurements per configuration step (live energy consumption measurements as well as offline measurements)

- AAS Time Series Data sub-model (energy measurements) provided by IDTA
- AAS Product Carbon/GHG Footprint sub-model to converge all carbon/GHG reporting data into the digital twin of the product provided by IDTA
- OPC UA 40501-1 companion specification for engraving (personalization process step)
- QR-code by Identification Link IEC 61406-1 for tracing the product pen over its life-cycle

Technical challenges for the DPP implementation

The interoperability technologies being discussed in the previous section are our base set for the prototypic, exemplary reference demonstration of the DPP. Therefore, a global alignment of related topics is needed. The main challenges are:

a. Will we be able to align globally to develop standardized DPP criteria, descriptions and semantics?

b. Will already existing solutions be interoperable?

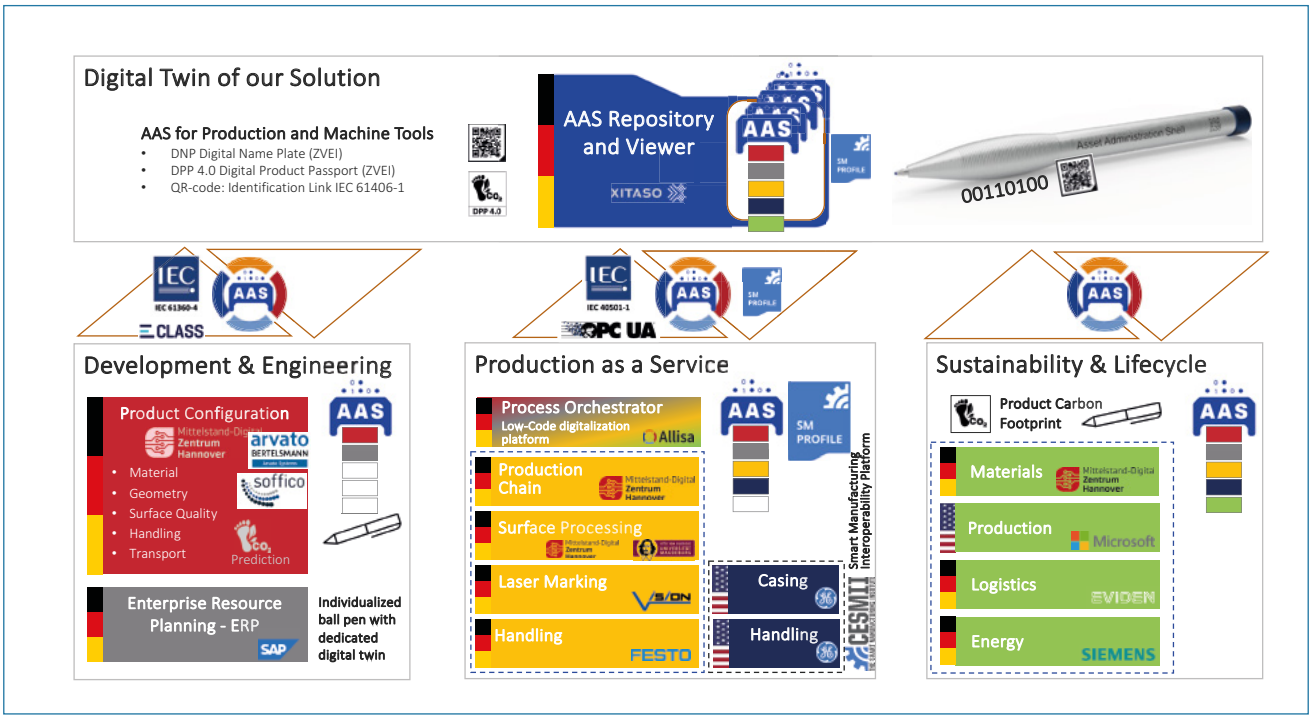


Figure: Demonstrator Architecture

International Manufacturing-X Council

The International Manufacturing-X Council supports the international alignment of all DPP related initiatives in the countries of the IMX. This alignment covers the areas of

- International standards synchronization together with the international standardization bodies
- Interoperability of the different technical solutions
- Alignment on nation programs to foster decentralized data economy for industry and specifically manufacturing.

The presented prototypic DPP demonstrator follows these goals and shows an exemplary realization jointly with CESMII and Plattform Industrie 4.0.

The demonstrator covers two different products. A battery as well as the pen demonstrator. The battery DPP is covered by several parties that actively work on data economy and DPP standards. Catena-X is an important stakeholder and contributor in this context. Also the International Manufacturing-X Council (IMX) supports the activities and the standardization alignments globally.

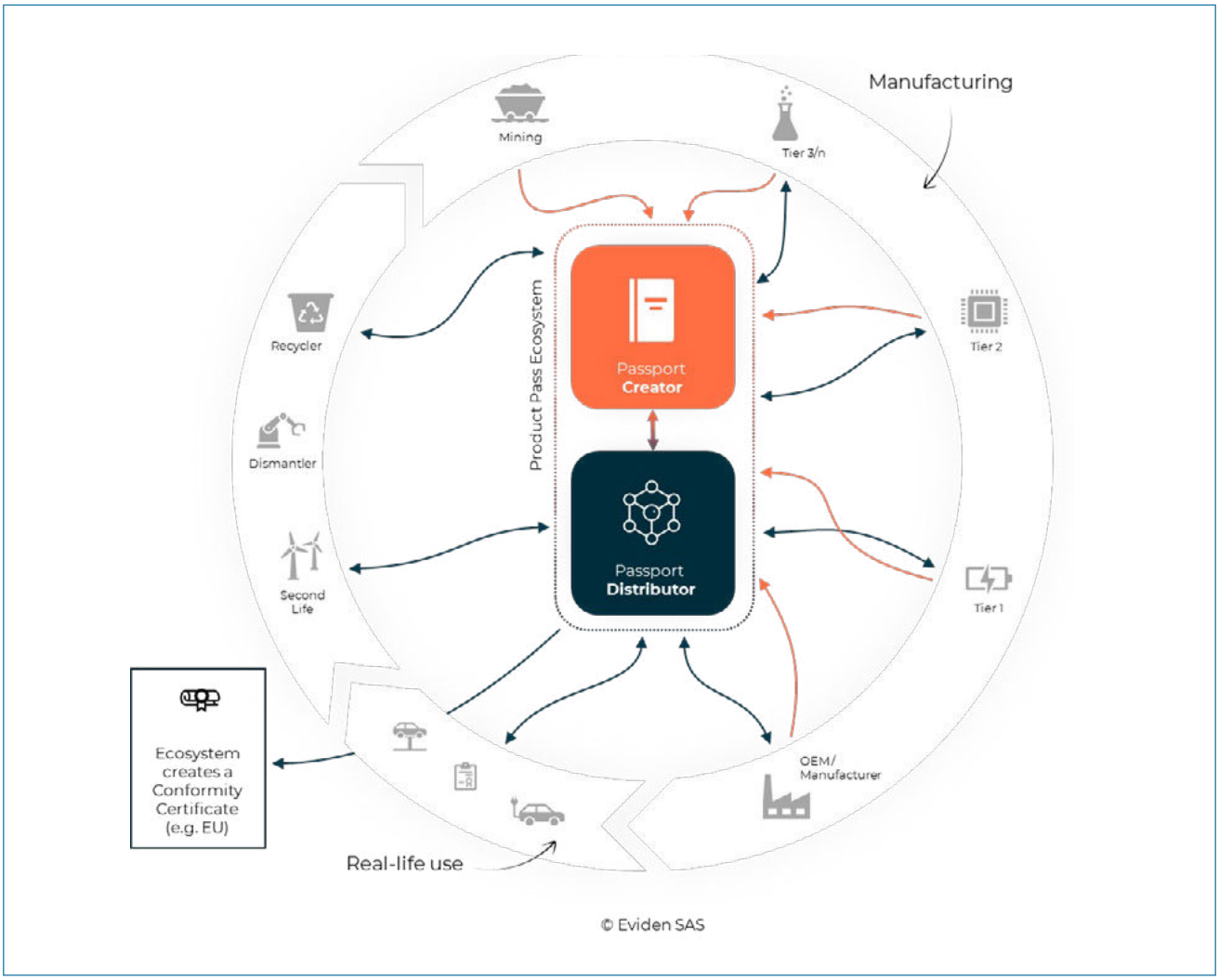
Demonstration of a Digital Product Passport

DPP provides a comprehensive view on attributes of a product and, thus, has to extend the view we have shown in the original demonstrator with information outside the manufacturing realm. As it requires data contribution from different data sources using interoperable technologies, it should provide an easy, extensible way to define the passport and individual attributes, which on the other side must be controlled and enforced across a distributed system:

The DPP demonstrator shows how we can provide such a flexible extension with additional attributes as we expect them to be defined by regulatory bodies and industry associations.

We show new use case which addresses not only PCF across the production and assembly of an asset with a solution which is tracking products lifecycle from raw materials all the way to the across the full lifecycle including usage and recycling of the product and its components using the example of a battery and a pen.

We'll demonstrate a decentralized approach to the management and storage of the DPP, which will address the need for adaption across different industrial domains and types of business – from SME to large industrial players.



Outlook

The challenges and benefits of the DPP display the importance of international collaboration to foster interoperable, sustainable, resilient, and productive ecosystems. As its implementation is global, the DPP seems to be the ideal global use case to strengthen collaboration across borders. This need to collaborate to create international interoperability in the data ecosystem becomes evident as everyone is affected. The international multi-stakeholder International Manufacturing-X Council will arise as an important platform for global alignment and to build up a positive momentum for international cooperation.

References

[1] CESMII SMP

[2] OPC UA Companion Specifications

[3] IDTA

[4] Standardization Council Industrie 4.0 (SCI 4.0)

[5] ZVEI DPP 4.0 Discussion Paper

[6] LNI 4.0 AAS Demonstrator from Hannover Fair 2023

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