Asset Administration Shell for The Wiring Harness System

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Abstract. The wiring harness is one of the most expensive components of the automobile. It is still a custom-made product despite the high-volume production in the automotive industry. However, various trends such as increasing fragility of supply chains and functional safety demands for autonomous driving are forcing the automation of the value creation processes. But in mass customization, automation needs the digitalization of all information flows. Machines and processes must be able to gather all required information automatically.

In the wiring harness industry, much of the information has been geared toward processing by humans and has hardly been digitized at all. One of the foundations for Industrie 4.0-oriented automation is therefore the existence of complete digital information of each wiring harness. A digital twin of the wiring harness is required. The asset administration shell is the technical concept for interoperating transparently with the digital twin.

The project “Asset Administration Shell for the Wiring Harness” (VWS4LS) creates the first complete digital description of the wiring harness based on the asset administration shell. As a result, all actors in the value network can access complete and consistent data ("single point of truth"), enrich it, and control its application through authorizations. To achieve this goal, a consortium from all levels of the value network was assembled for VWS4LS. Starting with the OEM, through the suppliers at the various levels of the value chain, to the software suppliers and machine manufacturers. This publication presents the project and its initial results.

Keywords: Digital Twin, wiring harness, asset administration shell.

1 Introduction

The wiring harness is the is the electrical and communication backbone of the automobile. As a key element of the vehicle electrical system, it is fundamental to enabling the future trends electromobility and autonomous driving. [1] Automotive industry is high-volume production but as a car with the same equipment is usually built only a few times, the complete wiring harness with its complexity is a customized product [2]. As a result, the wiring harness is not only one of the most expensive components in the automobile but is also associated with a high degree of manual work delivered by several hundred thousand jobs worldwide.

Aside the currently still heavily manual production the wiring harness is facing further challenges by the vulnerabilities of the supply chains posed by geopolitical conflicts, natural disasters, or pandemics. Another very important technical aspect is missing of continuous digital data chains along the value chain. Software solutions are offered in proprietary silos and the digital flow of information is interrupted in many places.

From the point of view of the industry, the automation of information flows within the value chain will be a critical success factor in overcoming these challenges. So far, however, a lot of information has been geared towards human processing and has therefore only been minimally digitized. A possible approach could be the implementation of the administration shell in the wiring harness industry.

This publication first describes the value chain of the wiring harness and the associated challenges and developments. A special focus is on the aspect of the availability of wiring harness-related data over the entire life cycle. Subsequently, the concept of an Asset Administration Shell (AAS) is presented. The AAS will be used for the digital representations of all components of the wiring harness. Afterwards, the project “Asset Administration Shell for the Wiring Harness” (VWS4LS) is introduced. One major task of VWS4LS will be the creation of the model description as part of the AAS. In the second part, the current project status is presented and a brief outlook on further activities is given.

2 Changing the Value Chains for Wiring Harness

2.1 Wiring Harness in Current Value Chains

Whereas in the 1960s and 1970s, wiring harnesses tended to have the character of a series component due to the low level of electrification in automobiles, the paradigm of the so-called KSK - the "customer-specific wiring harness" - has dominated since the 1990s. This term alone shows that this is no longer a mass-produced product, but a batch size of 1. Due to the drastic customization of equipment in vehicles, German OEMs are installing KSK without exception. Up to now, this requirement has been met mainly by highly manual production processes in so-called "best cost countries" (low-wage countries). At the same time, the complexity of the wiring harness and the associated value chain continues to increase.

In the meantime, however, various trends in the automotive sector are forcing the automation of value creation processes. The resilience of value chains is thus becoming increasingly important. Events such as the Corona pandemic, the grounding of the Ever Given in the Suez Canal and the war in Ukraine show the fragility of value chains. Without automation, greater regionalization of production is inconceivable. However, a pure focus on the development of means of production with which manual activities can be replaced by automation will not be sufficient. Rather, in addition to the means of production, it is also necessary to consider their informational linkage in the sense of a continuously automated production value chain - each work step must be completely recorded in terms of information technology.

In addition, new challenges are arising around traceability of automotive components, partly caused by new regulations like the German Supply Chain Compliance Act. Identifying human rights violations at all levels of their own supply chain will be the responsibility of each company. New regulations regarding sustainability will require to record and aggregate the CO2 footprint of each individual process step in the value chain, with the purpose of initiating targeted improvements. Another important trend is the development of autonomous driving towards Level 4 and 5, which entails increasing data rates and higher requirements in functional safety [1].

2.2 Vision – Uniform Data Representation Along the Complete Life Cycle

One of the foundations for Industrie 4.0-oriented automation of the wiring harness is the availability of complete digital information on each wiring harness, based on which development and optimization can be realized along the entire life cycle from a wide variety of perspectives.

The data on the wiring harness can be used, enriched, and further developed by a wide variety of players. It is not only important that everyone has access to the same database during the engineering phase, but also during the subsequent (distributed) production and assembly process, right through to service if necessary. All relevant components of both the product "wiring harness" and the respective production components (e.g. production equipment and processes with parameters) thus require a comprehensive digital description ("digital twin"). The decisive factor is not only the description itself, but also its automated interpretation, so that all subsequent processes can be automated as far as possible, especially in the case of changes.

This means that, based on a complete digital description, the systems of all the players in a value network can access complete and consistent data ("single point of truth"), enrich it, and control its use by means of authorizations. The digital twin is a fundamental prerequisite for end-to-end digital process chains horizontally and vertically. The AAS, in turn, is the technical concept of the interoperable digital twin of the wiring harness. The AAS therefore provides a comprehensive conceptual basis that can make a significant contribution to the solution.

2.3 The Asset Administration Shell

When the final report of the Industrie 4.0 working group was published in April 2013, the question “What will the future look like under Industrie 4.0?” was responded with the following statement: “Industrie 4.0 will deliver greater flexibility and robustness together with the highest quality standards in engineering, planning, manufacturing, operational and logistics processes. It will lead to the emergence of dynamic, real time optimised, self-organising value chains that can be optimised based on a variety of criteria such as cost, availability and resource consumption. This will require an appropriate regulatory framework as well as standardised interfaces and harmonised business processes.” [3]

By developing the concept of Reference Architecture Model Industry 4.0 (RAMI4.0) and the related Industry 4.0 component the basis for the implementation as the Asset

Administration Shell (ASS) was set [4]. Primarily the AAS is the digital representation of an asset. The concept supports the description of complex assets with all their components by using a hierarchical structure of ASS and further allows to link ASS of different assets. While current implementations of the AAS focus on the description of real physical assets, we expect in near future that also information, functions, as well as contracts are represented within an Administration Shell. [5] The AAS thus represents an approach to realise many of the ideas written down back in 2013.

2.4 Potentials by Using Digital Twins

By using the digital twin, numerous use cases can be realized over the life cycle of the wiring harness. For example, requirements can be transmitted digitally between OEMs and suppliers and components can be selected automatically in engineering. In addition, change management can be made much more efficient. With the help of the resulting database, new applications for simulation are emerging. As a result, optimization potential in engineering, manufacturing, and recycling can be uncovered.

However, the digital twin can be used not only in the development and production of the wiring harnesses. The data can also be used in repair shops to find faults more quickly, procure spare parts and carry out repairs. In recycling, the data from the digital twin is valuable for quickly identifying which wiring harness is installed in the vehicle. This information can be used to quickly decide whether the wiring harness can be offered as a spare part or sent directly for recycling.

3 Asset Administration Shell for the Wiring Harness (VWS4LS)

The project “Asset Administration Shell for the Wiring Harness” (VWS4LS) has set the goal of developing a consistent representation of the Asset Administration Shell (AAS) for the wiring harness as a digital twin across all stages of the value chain, from its initial specification to its disassembly.

The basis is formed by comprehensive information models of product, production process and means of production, which are uniformly designed throughout the industry. The norms and standards common in the industry are adhered to and extended as required. Uniform formats and protocols are required for the exchange of data so that the participants in the value chain can understand each other in terms of data technology. The starting point is the already known and used data types of the Cable Harness List (KBL) and the Vehicle Electric Container (VEC).

Another aspect is the infrastructure for data storage and data exchange for automated production control. The company-wide and cross-company exchange of data will increasingly take place in the cloud in the future. Group-specific industrial cloud-based platforms are currently being established by the OEMs (e.g. BMW Open Manufacturing Platform, Mercedes-Benz Cars Operations 360 (MO360), Volkswagen Industrial Cloud). In the first step, the focus is initially on internal group platforms for data exchange. In further steps, suppliers and service providers will also be integrated into these platforms.

While the concept supports hierarchical structure, today the AAS is mainly used for describing individual components applying different types of sub-models and protocols, such as OPC UA and E-Class. In the future, however, combined AAS for assemblies will gain in relevance. The AAS for the wiring harness will generate a first example illustrating the effects on and the associated advantages of the concept of a hierarchical structure and the possibility describe relations of ASS via links.

Figure 1 shows a real wiring harness of a Mercedes Benz C-Class (demonstrator is 3m high and 2m wide). The wiring harness seen there gives an idea of how many individual components make up the product "wiring harness". Depending on the perspective of the value-adding company, the composite component or assembly can be defined differently. For the assembler, for example, the product is "the wiring harness" itself. The component manufacturer may already see a connector and connector housing as a composite component.

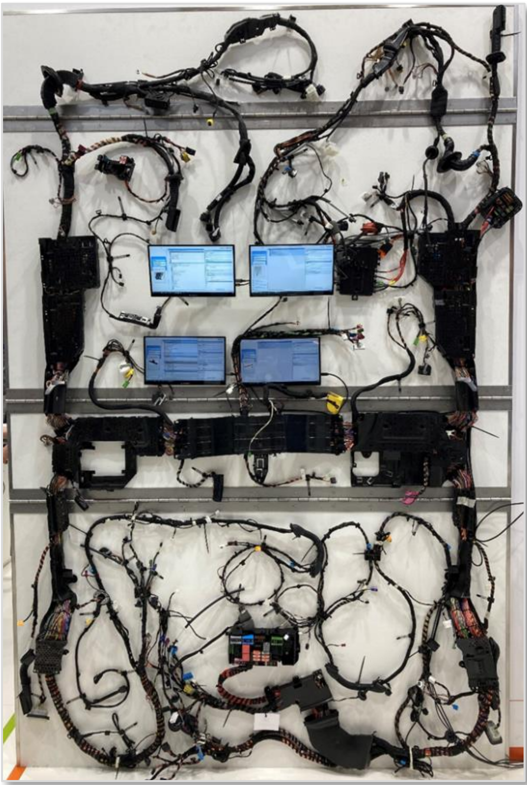

Fig. 1. Wiring Harness of a Mercedes Benz C-Class

Furthermore, the goal of VWS4LS is to generate the AAS not only for the product wiring harness, but also for the machines used during production. The next step is the mapping of production processes in the AAS by linking the product and the production equipment. Doing so allows to collect data for example on the quality produced and the costs incurred. Those data can be supplemented by further information collected over the entire life cycle. The combined information can be used in planning to achieve the required quality within the given costs.

4 Status of Development

The project is divided into ten subprojects and five use cases. In addition to the main areas of the value chain (development, production, and assembly), the subprojects include an information model and innovative topics such as automated negotiation processes, data governance concepts and the connection to Catena-X. The start-up phases of the sub-projects are timed sequentially. This is to integrate the experience and content from the value-added areas into the more innovative topics.

Figure 1 shows a wiring harness from a Mercedes C-Class. In total, several thousand individual components and, depending on the angle of view, different composite components can be seen there.

The development of the information model is an important basis for the rest of the project. Since the digitization of an entire value chain, with the goal of automation, is in focus. The product, process and resource model (PPR model) were used as a basis. The breakdown is intended to identify digitalization gaps in the various areas of the value chain that are not yet covered by established data standards such as KBL, VEC or OPC-UA. Simultaneously to the analysis of the current state of the value chain, the partners defined requirements for an end-to-end digitalized and automated value chain process. These requirements are considered as further input for both the data model and the individual value creation areas.

The development process of the wire harness is basically collaborative between different value creation partners. The resulting challenge is to develop a concept that supports the collaborative (shared digital twin) working method in the development of the control set, while maintaining data sovereignty and access. The basis for this was a reference process developed jointly in the project, which was supplemented with standardized inputs and outputs of the process steps. The known inputs and outputs are now to be converted into partial models and thus digitally and automatically retrievable by means of a unique reference ID.

Like the development process, a reference process was also developed for manufacturing and assembly of a wire harness. The aim was to obtain an overview of the information provided and required in the individual process steps. The reduction of manual activities and the information required for this form the central element here. The current focus of work is to convert the reference process and its information into submodels and then to make them available across companies through the AAS.

The development of the AAS and completion with data, shown in Figure 2, is currently still carried out manually. The basis is formed by the submodels standardized and published by the Industrial Digital Twin Organization (IDTA). A standardized range of information for the most diverse application areas can be covered. For the digital continuity of the wiring harness value chain, this is not sufficient jet. For this purpose, own submodels will be developed at a later stage to meet the industry-specific data requirements. The implemented product data was provided by partners of the project VWS4LS and ARENA2036. The semantic to be able to interpret data and information unambiguously is ECLASS. ECLASS is a cross-industry classification standard that can uniquely describe information by a value. [6]

Figure 2 shows the composite component in the AASX package explorer of a line set section. The left side of the figure represents the I4.0 component, which consists of the asset (gray) and the AAS (blue). The lower left third depicts the repository, through which the AASs of the individual components of the composite component can be selected. The middle third shows a hierarchical structure from the AAS, through various sub-models (SM) to the sub-model element (carries the respective information). The right third shows the information stored in the sub-model element and much more. In this case the hierarchical structure of a Bill-of-Material (BOM) can be seen there. The composite component shown there consists of five individual components (tape, cable, clip, connector, and flat connector housing), which all have an entity. The individual entities are then related to each other by the "Relationship Element" sub-model element.

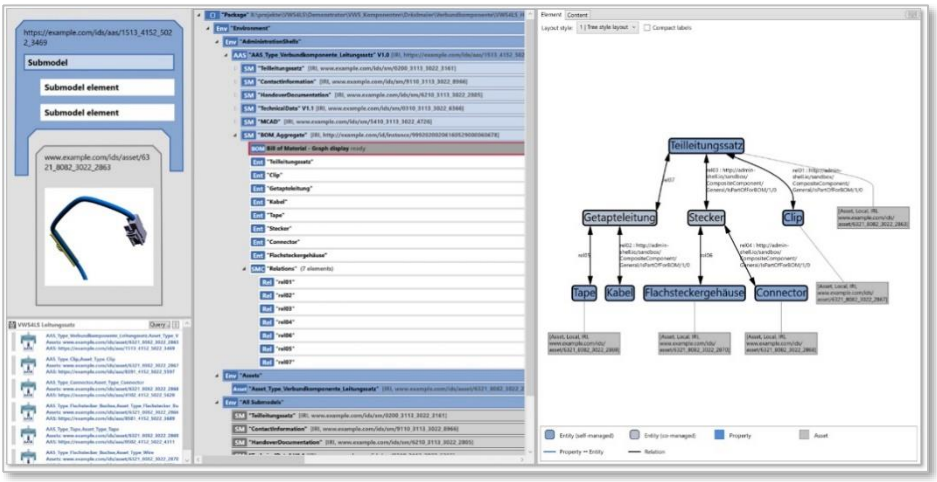

Fig. 2. AAS of a composite component

5 Conclusion and Further Development

The VWS4LS project has successfully completed the first steps. But there is more to come. New use cases become possible. The creation of the complete wiring harness will enable the continues access to all data of the related supply chain. Based on the complete information the system engineering will be a lot more efficient, even may use automated processes. Integrated information, such as the carbon footprint of the complete wiring harness assets including manufacturing can be determined. The data will

be available over the complete life cycle allowing use case like re-use and recycling (Circular economy).
In the future, also numerous further technical topics need to be addressed. One important aspect is the automated merging of ASS. The wiring harness consists of numerous individual components from different suppliers that are combined to form an assembly. Today, this is done with a great deal of manual effort. Within the project, the possibilities for automated production are to be investigated. An important aspect is change management. E.g., what happens to data when components change? How can traceability still be guaranteed?

A particularly important topic in VWS4LS is the monetisation of data. Within the framework of the project, considerations on new business models and their implementation with the ASS have to be developed. In this context, a data storage policy needs to be developed that defines who has access to what data and under what conditions. Another important aspect are automated negotiation processes. Here, negotiation scenarios and strategies need to be explored.

A very important aspect that is not covered in VWS4LS is how the data gets into the AAS. As currently the generation of new ASS is still a manual process, supported by tools, we see a great benefit by semi-automating the generation of assets by using semantic interoperability based on neural language model. [7].

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