TRACEABILITY

Preparing Harness Manufacturing for Autonomous Driving

WHITE PAPER

Di.IT

FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

INTRODUCTION

In the age of electrification and autonomous driving, the safety and quality requirements for harness and E/E components are increasing exponentially. The automotive harness is becoming one of the most expensive and quality critical components of the car. It does not only enable the energy supply for all other components, but also transmits the communication and information signals. It therefore determines a wide range of functionalities including safety-critical tasks such as steering, lane switching and braking. In the last years, the complexity of E/E systems has been continuously rising, bringing up great process challenges concerning their production and design. Problems in the electrical system can result in catastrophic failures, possibly entailing material damage, threats to people's physical integrity and risks to the public or environment. If a problem in the harness occurs, relevant product and process data need to be available in real-time. Using short reaction cycles, the error causes must be found immediately. Harness manufacturing has become too complex to be comprehended and analyzed manually using heterogeneous and incomplete data bases. By establishing interlinked and continuous data, harness manufacturing can be improved in terms of quality, safety and transparency. In a world of electrification and autonomous vehicles, a 100% traceability system is therefore highly recommendable, if not substantial, to prepare harness manufacturing for the new challenges to come.

Traceability describes the ability to reconstruct a product's composition (product history) as well as its value generation (process history) throughout the entire product's life cycle in form of an interlinked and consistent data set.

WHERE ARE WE?

Harnesses are produced in complex multi-partner networks that encompass several companies, production sites and even countries. The countries involved are mostly located in North Africa and Eastern Europe, leading to significant differences in culture, process structure and quality perception. However, the production of a customized harness (KSK), generally follows the same set of overall process steps, as shown in figure 1.

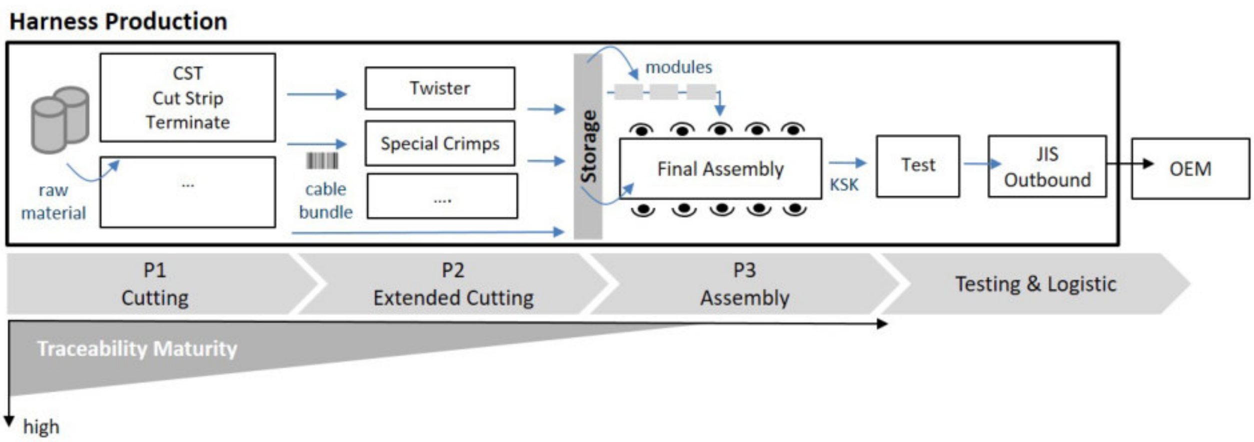

Figure 1. Harness manufacturing process

In the cutting area (P1), orders are assigned and balanced over the machine park using a manufacturing execution system (MES). The raw materials (cables, terminals and seals) are scanned and the cables are then cut and packed into bundles using highly automated machinery. Quality relevant process parameters, like the crimping force, are recorded and stored in the MES. Cable bundles are then transferred to the P2 area, where specialized machines conduct process steps for smaller lot sizes. This could include cable twisting or the attachment of certain crimps, which is normally handled by smaller and semi-automated machines. P1 and P2 products are usually produced in batches based on forecasting data and then stored in a buffer storage. In reference to a customized harness order, those pre-manufactured components and other purchased parts are then picked and transported to the assembly line. The final assembly takes place in the P3 area, where formboards and rotating lines are used to assemble the customized harness. Side lines are also applied to manufacture modules, so called KITs, which are then integrated into the final harness. At the end of line, a 100% electrical quality test is conducted. The final product is then packed and sequenced (Just in Sequence) and shipped to the OEM.

The state-of-the-art process flow is characterized by manual labor, especially in the P3 area, due to its high degree of individualization, complexity and volatility. To this day, traceability can be achieved in the P1 and P2 area, as data is mostly continuous and the necessary data capture technologies are usually installed (scanners, barcodes etc.). However, manual process steps in the P3 area complicate information capture as well as assessment and data is often lost or manually changed at process interfaces. Additionally, frequent changes and alterations hamper standardization and process stability, often leading to fire-fighting and ad-hoc management practices. As harness production becomes increasingly complex, traceability and visibility become a key competitive advantage to improve process quality and to meet the new requirements of increasing safety and documentation. As traceability can only be achieved, when the entire value-stream data is interlinked to a coherent history, the harness can not be traced with the state-of-the-art process flow.

Our analysis showed, that to this day, the harness cannot be traced.

WHAT DO WE NEED TO CHANGE ?

Autonomous driving and electrification now introduces a paradigm shift in the harness industry. Whereby harnesses used to be a cost-driven commodity product in the automotive industry, it is now not only one of the most expensive parts, but the determining module for safety, quality and customer trust. This new role now induces an increasing need for innovation from a product (design) and process (production) perspective, as shown in figure 2.

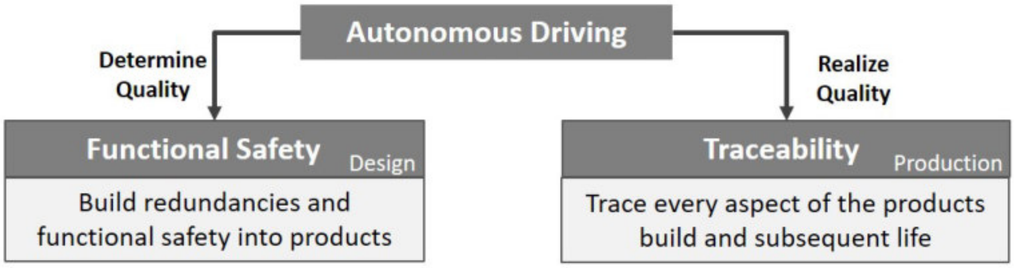

Figure 2. Establishing quality for autonomous vehicles

Accordingly, the harness now needs to fulfill two requirements from a quality management perspective. First, quality needs to be designed into the product according to the requirements of ISO 26262, functional safety and the application of design best-practices. The manufacturing process then has to realize the quality and therefore takes over an equal share of determining the final product quality and safety. This quality can only be realized if the status of the product and the process is documented and made transparent for real-time management and quality assessment. By interlinking all relevant product and process data, traceability can be established, which enables the harness manufacturer to not only locate and correct failures, but use this holistic data for quality improvement, failure prevention and learning.

Autonomous Driving can only be safe, when quality is designed and produced.

Traceability is a requisite for a high quality manufacturing process for autonomous vehicles.

A state-of-the-art traceability system offers multi-dimensional advantages, as depicted in figure 3. One of the most dominant advantages is the case of a product recall. Product recalls in the automotive industry have tripled in the last years.[1] The average costs per recall are around 12 million Euros, but they can easily escalate up to billions (e.g. Takata Airbag with $25bn).[2] A traceability system allows to handle recalls fast and economically, reducing the risk of brand damage and customer churn.

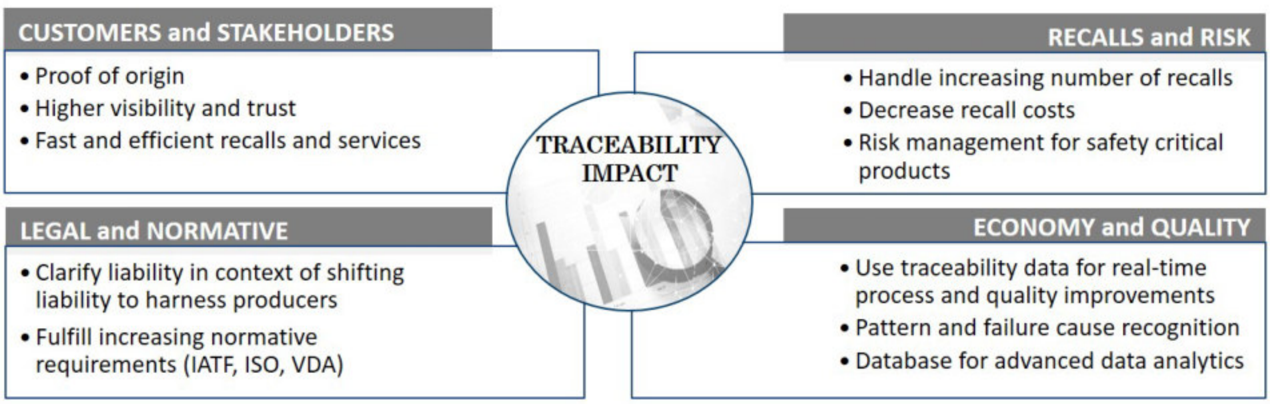

Figure 3. Impact nof state of-the-art traceability system

[1] Kraftfahrt-Bundesamt (KBA), 2017

[2] Allianz Global Corporate Speciality SE, Product recall: managing the Impact of the new risk landscape, 2017

Additionally, a traceability data base can be used to preventively improve process and product quality by determining failure patterns and root causes. An interlinked traceability data set therefore builds the basis for quality-driven improvements and predictive analytics. Moreover, normative and legal requirements also pressure companies to install traceability in their processes. In the context of autonomous driving, the liability question shifts from the vehicle owner to the manufacturer of the car, his suppliers and even individuals in the value chain. If a defective harness in an autonomous vehicle causes an accident, harness producers can expect penalties running into hundreds of millions. This pressure is mirrored by norms now increasingly addressing traceability in more depth, such as the IATF 16949:2016, ISO 26262 as well as various VDA standards (e.g. VDA 5005, 4994, 4958 and 5600).

HOW DOES THE FUTURE LOOK LIKE?

The traceability system should be established to record the product and process history for every KSK. A traceability scheme consists of trace objects, trace references, the traceability technology and the chosen granularity, as shown by figure 4.

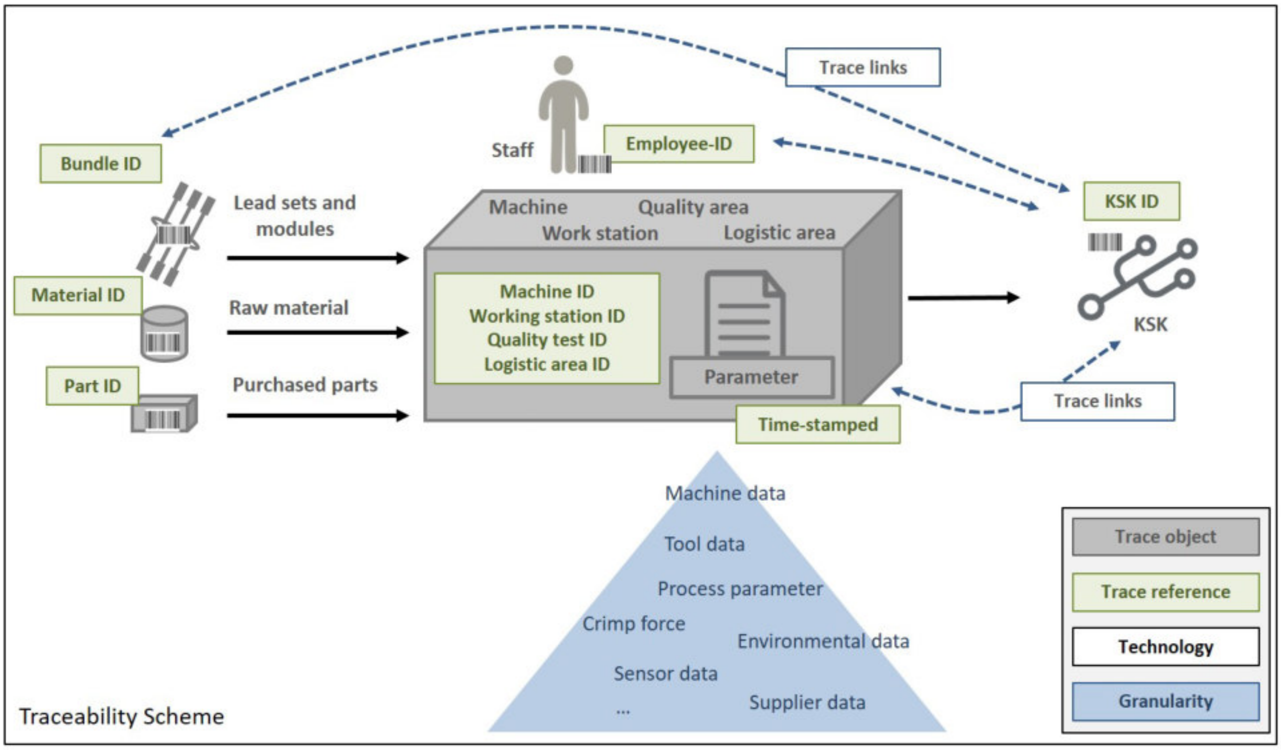

Figure 4. Traceability scheme for harness manufacturing

Trace objects (grey) describe the items of interest like components, material, machines or working stations. Every trace object needs to made uniquely identifiable by applying a so-called trace reference (green), typically by applying unique identifiers (IDs) for physical objects. Those IDs provide the physical object with a virtual representation with the help of a traceability technology (white), such as barcodes, RFID or data matrix. Process parameters can be classified as dynamic trace objects and are therefore referenced by a time stamp instead of a unique identifier.

A traceability system simultaneously builds up two information streams at the same time. The first layer is the product history, which is also called vertical traceability. Within the vertical traceability, product parts, raw material and purchased parts are linked to a final product of interest, in this case the KSK. The vertical traceability allows to comprehend and retrace, which parts and materials were used to build the harness. The second information stream comprises the horizontal traceability, which describes the process history of the KSK and its components, including the process steps and process parameters that were used to fabricate the product. The horizontal traceability therefore reveals relevant process factors, such as crimping force, tool replacement, rework and quality test results. The chosen granularity determines the accuracy and explanatory power of the traceability scheme and can be adapted and designed according to the quality requirements of the product and process. Exemplarily, in the beginning, the system could be fed with the IDs only and then extended with relevant process data such as machine parameters, quality results or sensor data.

The design of a traceability scheme can be adapted modularly according to the external requirements and internal scope of action. In the context of autonomous driving, the vertical traceability should be recorded, consisting of all major purchased parts and sub-components of the KSK. This would include the batch ID of lead sets used, the ID of purchased components (including supplier ID) as well as the unique ID of CPUs and their software version. Additionally, important horizontal traceability data sets have to be included, such as machine and tool ID, production period, quality results and rework. However, it is highly recommendable to extend this data set with quality and safety relevant process parameters to a holistic data base. This data could be analyzed and visualized for the production personnel and management in real-time, allowing them to drive their processes towards business excellence and higher profitability. Additionally, many other applications could be established on top of that data, such as inventory reduction, machine balancing, internal benchmarking or predictive analytics (When and under which conditions will the component fail?).

WHAT ARE THE NEXT STEPS?

A traceability system can be implemented using a MES, which communicates with the machines, workers and ERP system on-site. However, the quality of any traceability system relies on the configuration of the real physical process flow, which feeds the system with the data. This process needs to be adapted on an operational, technical and organizational level to provide the necessary information set. Operationally, the work sequence needs to include work steps like scanning of products or the documentation of quality test results. Ideally, this is designed with the least human intervention and minimum extra work through stationary scanning systems or the automated documentation by machines. Additionally, FIFO principles and Poka Yokes can significantly decrease the amount and complexity of additional process adaptions. However, a traceability system needs appropriate equipment in order to capture traceability relevant data.

On a technical level, this could mean the installation of scanners or updates and configurations to machines. Furthermore, trace objects need to be selected and equipped with a traceability technology, such as barcode or RFID. Lastly, the organizational awareness plays a great role for the quality of the traceability data set. Sometimes, employees scan several products at once and beforehand (instead of when they are assembled) or they scan the same product several times (instead of the actual component used), leading to a faulty and unnecessarily inaccurate data sets.

CONCLUSION

Autonomous driving will change the roles and power structures in the harness industry, as the harness transforms from a customized commodity product to a product highly responsible for differentiation, customer enthusiasm and trust. A failure in the harness in an autonomous vehicle could lead to dramatic consequences, entailing massive recall costs, liability processes and image damage to OEMs and Tier1s alike. The delivery of products of high quality and safety can only be realized through two equally significant pillars; quality needs to be designed into the product and this quality needs to be realized by the manufacturing process. A high quality manufacturing process is transparent and conclusive in regard to the parts, which were used to manufacture the product as well as the process steps and tests, which were conducted to ensure its quality. A traceability system brings visibility to the product history and the process flow. By establishing a 100% traceability, harness producers can develop a system that will not only help them to identify and recall malicious products, but prevent failures in the first place. A cross-functional and continuous traceability data set builds the necessary base for quality analysis and process transparency, leading to significant product and process improvements, which are not only economically desirable, but could even safe human lives.

THE AUTHORS

The Friedrich-Alexander University Erlangen-Nürnberg is one of Germany's leading research institutes. Marlene Kuhn is part of the wiring system engineering team at the Institute of Factory Automation and Production Systems. Her research focuses on process innovations in the harness industry from the perspective of quality management, process digitization and complexity management.

Marlene Kuhn
PhD

DiIT GmbH is the world's leading supplier of manufacturing execution systems for the production of cable sets and wiring harnesses for industries, such as automotive. By digitalizing the value chains, the company's innovative software optimizes and controls complex development, manufacturing and logistics processes and supports quality assurance and traceability.

Bernd Jost
Managing Director