



SIEMENS DIGITAL INDUSTRIES SOFTWARE

KSK manufacturing

Using Siemens' advanced wire harness manufacturing engineering solutions to help automotive companies increase profitability

Executive summary

This paper describes the intricacies of KSK wire harness manufacturing, the big data surrounding it and how to make effective use of that data.

The automotive industry faces multiple challenges due to the demand for advanced electronic features, advanced driver-assistance systems (ADAS), autonomous driving and electrification. These megatrends create the need for highly sophisticated automotive electric and electronic (E/E) systems, which emphasize the importance of wire harness manufacturing. Additionally, the surge in demand for mass customization is raising the number of unique vehicle configurations, which increases harness complexity and the number of wire harness variants.

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| Abstract

Modern passenger, recreational and commercial vehicles are built with an abundance of electronic features and components for safety and comfort. These range from air-conditioning, in-vehicle infotainment (IVI) systems and automated features, to electronic control units (ECUs) that manage braking, steering and throttle control. These electric and automated elements significantly influence a vehicle's value. Further, the onset of higher levels of autonomous driving, ADAS and electromobility increases the complexity of wire harness manufacturing.

A significant challenge for automotive original equipment manufacturers (OEMs) and harness manufacturers is effectively managing complex wire harnesses from design, manufacturing to delivery. The most desired solution is the KSK concept, which originates from Germany and translates to customer specific wire harness. While this concept is already proven in the industry, traditional KSK data assimilation approaches could soon become irrelevant as harness manufacturers undergo digital transformation.

Breakdown of wire harness assembly:

The wiring system is a complex assembly, composed of multiple wire harnesses that connect all the E/E components in the vehicle. It transmits power and signals between actuators, sensors and ECUs. Modern wiring systems are designed to support an unimaginable number of configurations due to the level of customization available in today's vehicles.

Furthermore, wiring systems are growing and complexity as automakers incorporate new and more advanced vehicle features. A typical wiring system can contain 10,000 individual part numbers (figure 1). Manufacturers must accommodate all possible vehicle configurations, which can be constructed by millions of combinations. While manufacturing these complex systems, companies must meet very tight timelines, follow precise quality requirements and minimize the harness' cost and weight.

Siemens' advanced electrical systems and wire harness engineering solutions offer companies powerful capabilities, which can help increase profitability in the industrial internet of things (IIoT) era. We can offer OEMs and wire harness manufacturers business-specific solutions and production optimization.

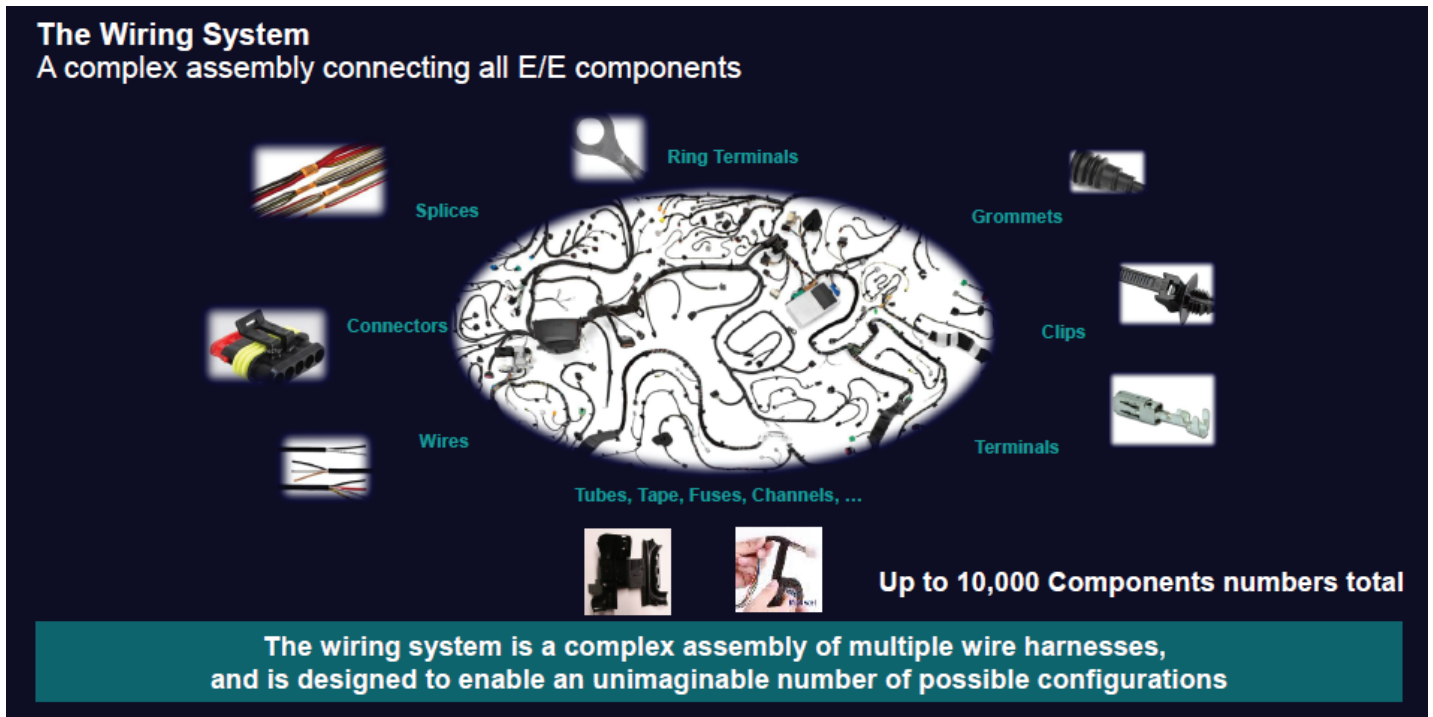


Figure 1. Wiring system components.

There are three common approaches to wire harness manufacturing:

- KSK: Manufactured according to an individual list of modules and has an individual part number
- Variant: Designed with multiple variants of each harness type and has multiple part numbers per type
- Standard: Designed with only one variant of each harness type and has one part number per type

Each of these approaches comes with tradeoffs in content give-away, which refers to unused harness material in the car, and complexity, which refers to the number of variants produced from one harness family. KSK has zero give-away but high complexity, variant has low give-away and standard has high give-away but low complexity.

KSK has grown to be highly successful and has expanded globally in the last 25 years to all car categories and harness types. The KSK manufacturing method is successful due to its high levels of efficiency and flexibility, controlled logistics and planning and it leads to a unique product. Additionally, its zero give-away leads to no wasted materials, which increases its sustainability level — you are producing only what you need. This method also introduces an unlimited number of variants, controlled logistics with optimal work-in-progress (WIP), a flexible sales strategy, a modifiable production program, modular change management and the final customer can change the car content according to the logistics window.

However, due to KSK’s complexity, it requires strong communication, data coherency and a strong data flow between disciplines from the request for quotation (RFQ) stages to production. This is the key success factor in this business — harness manufacturers must seek to eliminate silos between all major business disciplines for a successful KSK manufacturing model/system.

KSK engineering

In a KSK manufacturing approach, wire harnesses are built from modules. There are three categories of modules in KSK manufacturing:

- Basis module: These modules are the same in all harnesses
- Mandatory module: Every harness must contain at least one of these groups
- Optional module: These modules enable flexible car configuration

There are several modularization concepts depending on the OEM strategy. The modularization concept and size of harnesses will drive the number of function modules. Although, each possible vehicle function generally has its own functional module. One of the most important factors is the correct assignment of material for each unique combination of harness modules, without duplication or missing components. Therefore, the accurate and timely delivery of material is a significant challenge in KSK manufacturing.

Figure 2 displays an example of daily harness production. Each harness is unique, and the figure indicates the throughput and assembly time of about 200 of these unique harnesses. The OEM can produce several identical cars, but if there are three cars with three different production numbers, functions and production time, there are three different harnesses. The OEM may also have the same car with the same function content, but different production time and harnesses number. In addition, modern cars contain several harness families such as body, engine and door harnesses,

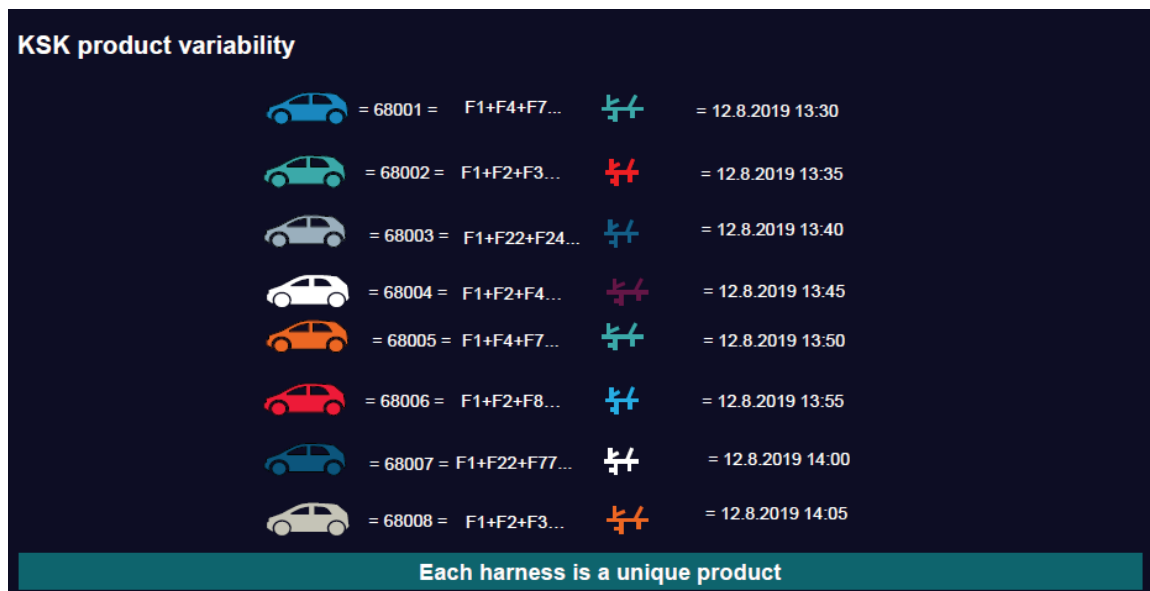


Figure 2. Daily wire harness production.

further complicating the production and delivery of complete and accurate harnesses. The KSK concept ultimately leads to higher product flexibility, but it demands a smart data management solution.

Data-driven KSK production design

The functional modules that are used to construct wire harnesses are usually different sizes and contain complex and can have long routing (figure 3). Therefore, it is not optimal to organize harness production around functional modules. The harness manufacturer can handle this issue by using advanced harness engineering software for production modularization, design rule check (DRC), value analysis and value engineering (VAVE) activities and more to create production modules instead. These production modules support efficient manufacturing without limiting flexibility and feature a strong focus on change management. Software for manufacturing is used to support production modules, harness analysis, bill-of-process (BOP), formboard preparation, work instructions for assembly operators, etc.

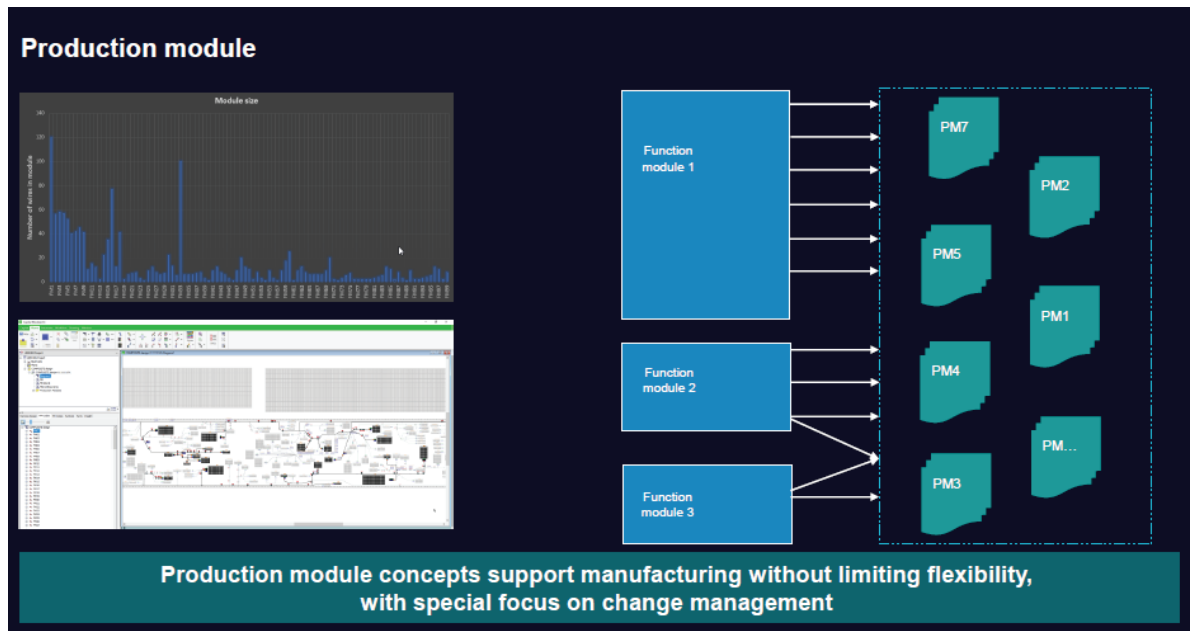


Figure 3. Different sizes of KSK wire harness function modules.

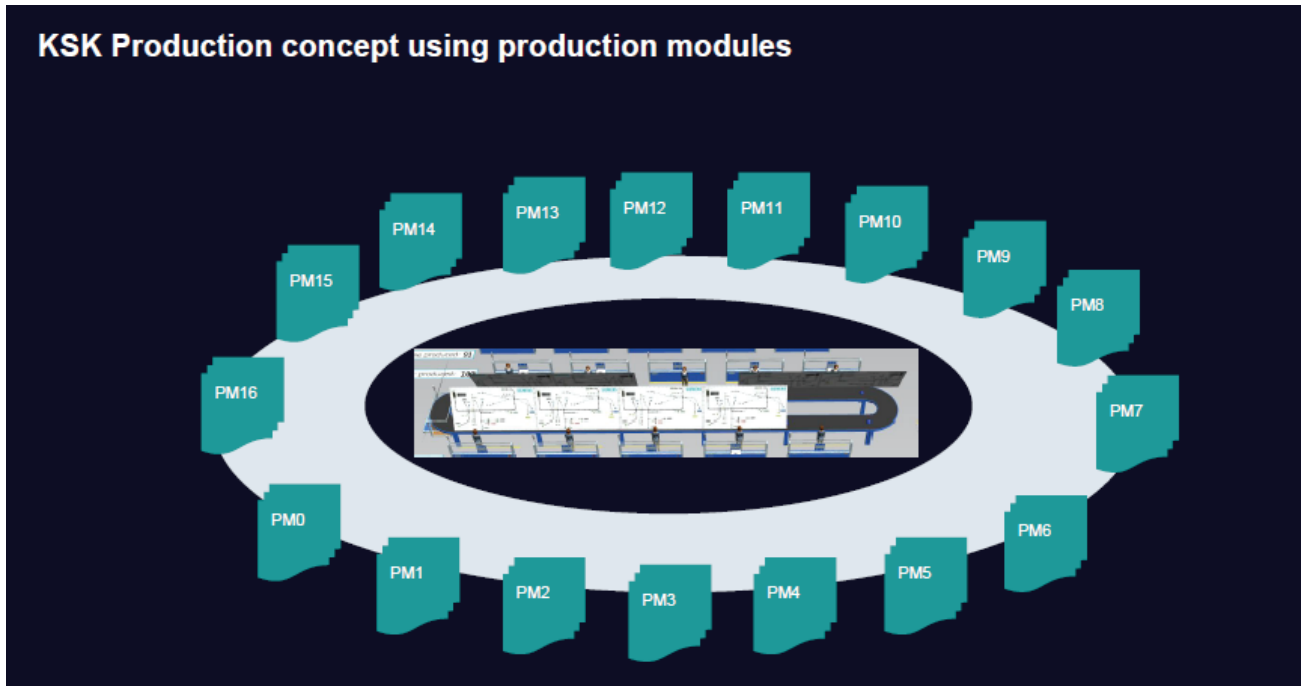


Figure 4. KSK production line concept using production modules.

The production line concept can split production modules across a workstation, making it possible to start production for individual orders without delay. Data and instructions unique to each production module can be displayed, which provide the step-by-step process to the operator according to your production method. At the end of the line, a distinct label and the related finished wire harness will be produced, ready to be passed downstream.

The line balancing process stabilizes the operators' workload at each production line workstation. It provides a guided and intuitive balancing of tasks across a harness production line. Manufacturing engineers can quickly and accurately distribute tasks across workstations to analyze multiple what if scenarios. Wire harness manufacturers maximize production efficiency and minimize costs by using the software to automate previously manual and labor-intensive processes.

Engineers can integrate Line Balancer with the rest of a vehicle's E/E systems and harness engineering flow to create a digital thread from vehicle definition to manufacturing planning and execution. The software can be used to pull required assembly tasks from the BOP, which provides engineers with complete and up-to-date information as they allocate resources and plan production. Once the engineer is satisfied with a balancing scenario, they can push it back to the product BOPs, which automatically update the tasks with the correct workstation assignments. The engineer can then use these BOPs to generate workstation-specific instructions for the manufacturing floor.

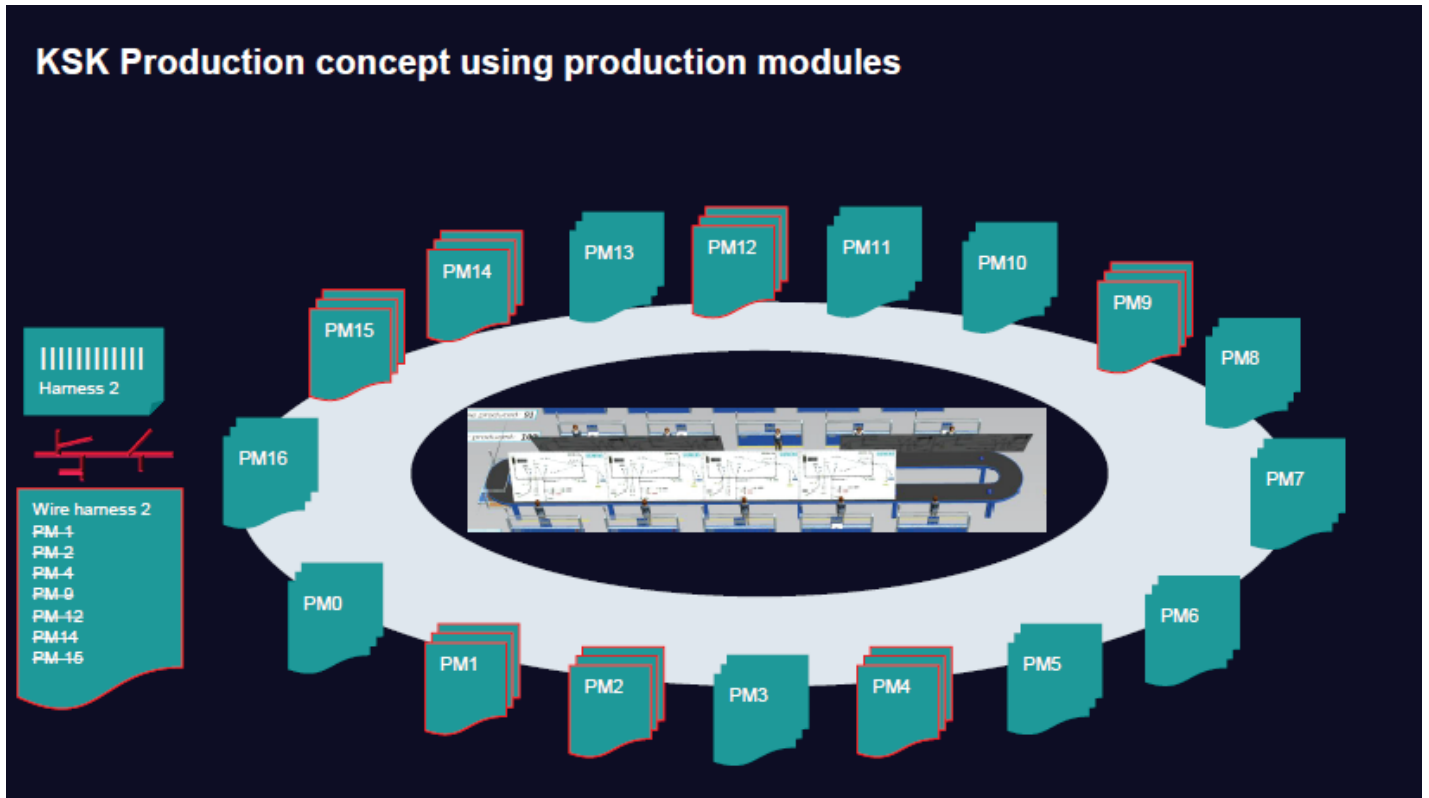


Figure 5. End of the KSK production line.

Although it is complex, KSK production methods can support any number of harness variants. This manufacturing flexibility is the most important element when defining KSK production concepts. Furthermore, KSK methods are flexible and can be adapted to fit the specific needs and conditions of the vehicle program which it will support.

Several production methods can be used for KSK, which include:

- Using only sub-assemblies
- Starting with small connectors
- Starting with big connectors

To choose the best approach, it is important to consider all project conditions when defining the production concept:

- Harness design due to modularization
- Logistic conditions due to production time and volume
- Production country — harness manufacturing is about 80 percent manual labor and not all cultures have the same working style

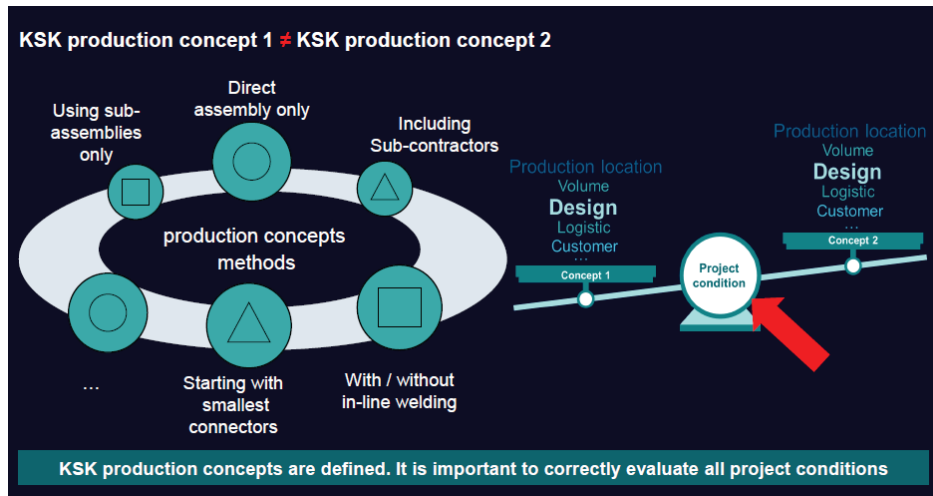


Figure 6. Evaluation of project conditions.

Due to the complexity of KSK manufacturing, it is critical to capture and leverage data in the definition, design, implementation and monitoring of the production system. This includes forecast data on order volume and mix, production time, material delivery and more.

Logistics:

One of the most important planning parameters is the forecast data. The estimated production program is provided to the harness supplier based on the function module forecast. The harness

manufacturer uses this data for material ordering and production set-up. Figure 7 shows there can be significant deviations between forecast data and the final order. Deviations in the quantity of optional modules ordered are more pronounced than that of the base modules.

Thus, there is a prominent need for highly accurate data, which can be regularly controlled for correct production planning. This data can drive production simulations for investment calculation, resource utilization, material flow, request for quote (RFQ)

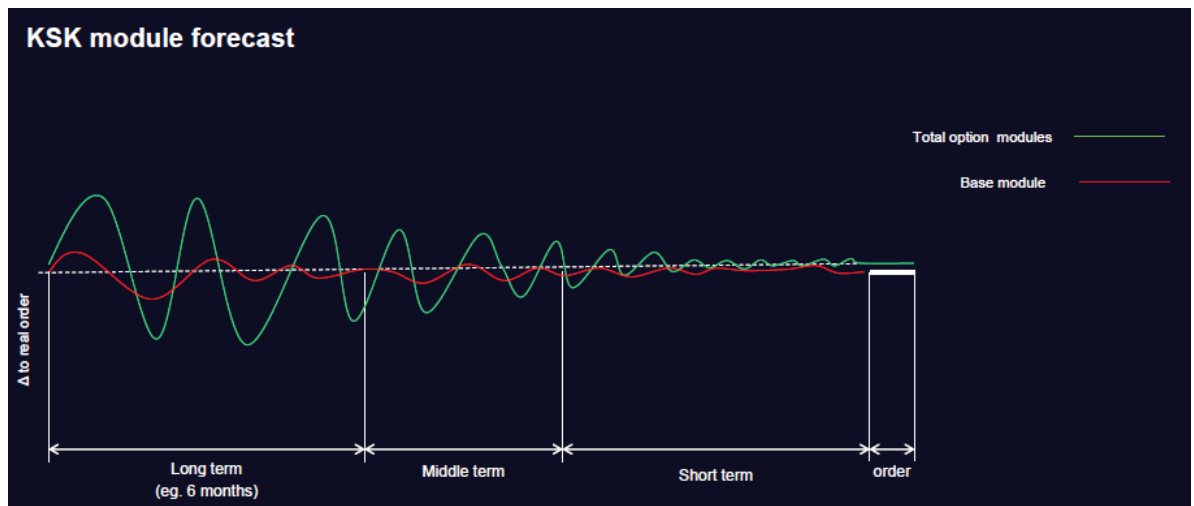


Figure 7. KSK module forecast.

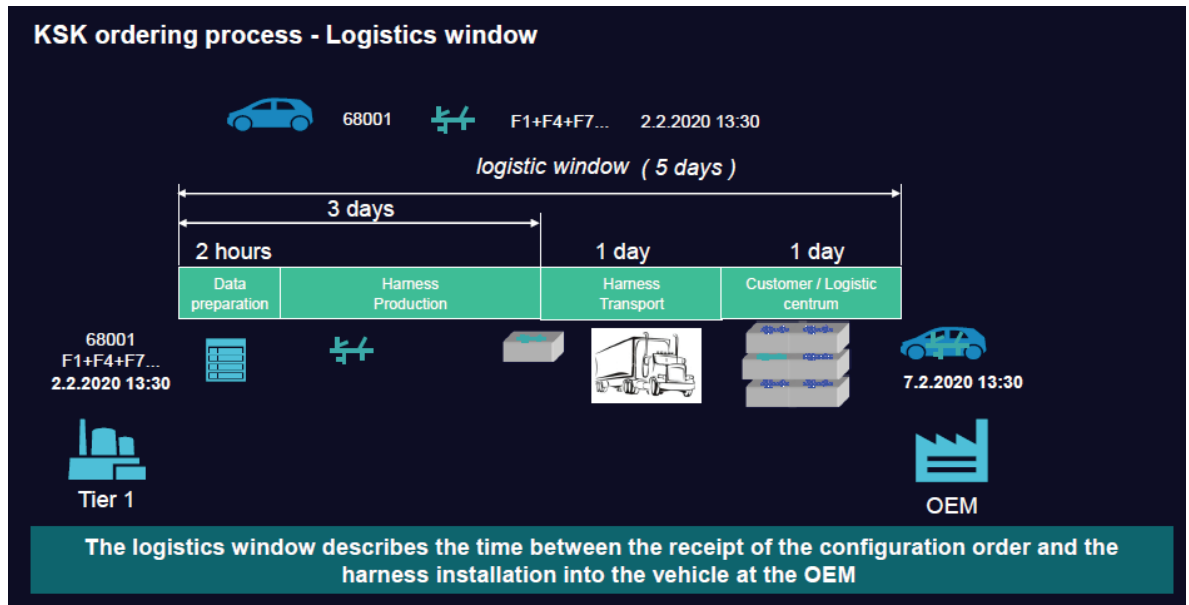


Figure 8. Typical ordering process.

presentation, etc. It can also drive the evaluation of various scenarios to improve production efficiency, provide correct ordering and maintain material delivery schedules.

Figure 8 shows an example of car 68001. The harness supplier receives the order data from the OEM at 1:30 p.m. and the harness production process begins immediately. To maintain the OEM's production schedule, the OEM facility or logistics center must receive the time for production and transport and the harness 24 hours before the car production begins. The time between the receipt of the configuration order and the installation of the harness at the OEM is known as the logistics window. Since each harness is a unique component in a complex manufacturing process, this window can vary greatly between harnesses.

It is critical for harness suppliers to closely manage the logistics window to ensure accurate and on-time delivery. If one component is missing, it can stop the entire car production line. The harness must arrive on-time and in the correct sequence at the customer's plant.

And not all OEMs will request the same logistic conditions. Therefore, It is important for harness suppliers to consider the specific conditions of each customer when designing their production concepts. Suppliers should also communicate their specific situation, with regards to harness production and logistics, with the customer. For example, the supplier should confirm individual logistic conditions with the customer during the implementation of a major engineering change.

IT landscape:

The IT landscape is the foundation of a KSK project and the basis for its success. It is what supports the pillars that we have examined so far (design, engineering, production, logistics, etc.). For a harness manufacturer, the IT landscape is comprised of three data categories:

- Project data — for example, ramp up data, production volume or harness design data
- Standard data — production methods or process time
- Output data — efficiency level or daily output

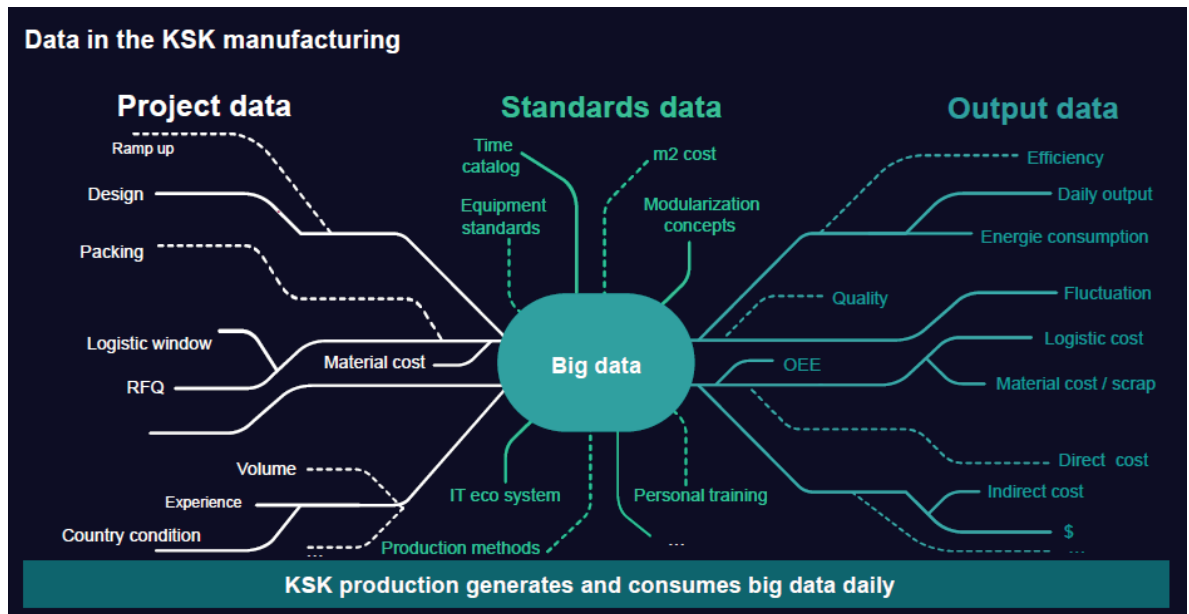


Figure 9. Daily generation and consumption of big data in KSK production.

KSK production generates and consumes large amounts of data, daily. This data is critical to the efficient operation of the production system. However, data alone is not enough. Harness manufacturers must be able to gather data quickly, sort and filter out essential data and analyze to derive insight on the production process.

Siemens’ dedicated software solutions such as CAPITAL™ software enable us to work with OEMs and harness manufacturers to provide design, product and manufacturing engineering. This is a part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens. This software can be used for tasks such as modularization, production module preparation, assembly board optimization, time calculation, line balancing, change management, standard working instruction and production reports.

The Tecnomatix® portfolio is then used to simulate, analyze and visualize production designs virtually. This enables manufacturers to engage in production system optimization before the production line is even built. These simulations can also be used on an active production line without interrupting work, which enable actual operational data to drive the further optimization of the production line or facility.

Furthermore, a product lifecycle management (PLM) solution such as Teamcenter® software, can manage vehicle configurations and their related harnesses and harness modules, which enables a contiguous digital thread throughout the supply chain. The PLM environment also supports fast, accurate and secure data exchange between systems, domains and partner organizations.

| Conclusion

Summary

Meeting today's demand for advanced electronic features ADAS, autonomous driving, electrification and mass customization in the automotive industry requires a solution for efficiently optimizing wire harness manufacturing. The KSK solution enables manufacturers to handle this complexity with a high degree of efficiency and adaptability. Its flexibility, organized planning and sustainability enables manufacturers to follow rapid timelines while still prioritizing quality requirements and minimizing excess costs.

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About the author

Pavel Nosek is a solutions architect for Siemens Digital Industries Software. Previously, as a global manufacturing engineer, he worked on the KSK concept implementation at Yazaki and has many years of experience overseeing customer specific wire harness production.

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