Changing Business Information Systems for Innovative Configuration Processes

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Abstract. The dynamic globalized markets cause an increase of competition and require companies to perform strategic changes in their business processes. This is one of the reasons for component manufacturers to offer not only separate products and components but also whole integrated solutions to their customers. However, this requires significant changes both in the business and information management processes that are related to configuration. The paper presents the challenges caused by the above changes and some solutions aimed at achieving higher efficiency of information management processes as well as supporting information systems for delivering standard, customized and custom products and solutions to the customers.

Keywords: product configuration, system configuration, business process, variant management.

1 Introduction

Today, dynamic globalized markets cause an increase of competition and require companies to perform strategic changes in their business processes [1, 2]. Component manufacturers are challenged to offer not only separate products and components but also whole integrated solutions to their customers. Such solutions might consist of multiple physical devices as well as services. One of the consequences of this is appearance of "complex products", which consist of other products (both regular products and complex products) and often include software units using different services [3, 4].

We had a chance to analyse the business and information management processes related to configuration of product combinations and systems at the automation equipment producer Festo AG & Co. It produces pneumatic, electronic automation equipment and products for the process industry and has more than 300 000 customers in 176 countries supported by more than 52 companies worldwide with more than 250 branch offices and authorized agencies in further 36 countries.

The presented work, however, can give significant input to achieve benefits for component manufacturers that tend to become system vendors in general. The major benefit is a guided selling with industry and application specific view, steering of the customers in the e-channels with an easy to use configuration for components, product and system combinations.

Figure 1 shows the intended change in business strategy. The major goals are reducing the effort in producing products and reducing the time-to-delivery to the customer. Both goals should be reached by having less engineering activity (ETO) but more products that can be assembled based on a pre-defined modular system (ATO). In this sense it is intended to make use of the "economies of scale".

Products of different complexity require distinct handling in the process from request to delivery. We differentiate three levels of complexity:

- **PTO – pick to order:** A product is order-neutrally pre-fabricated and sold as a discrete product. This means that no configuration is necessary to identify the correct combination of components. The different combinations already exist and for the user it is a selection process rather than a configuration process. No order-specific production is required.
- **ATO – assemble to order:** The different components a product can be composed of are pre-fabricated but the correct combination of components is left open for order clearing process. The product itself is order-specifically produced from these existing components.
- **ETO – engineer to order:** A product is based on a known set of pre-fabricated components (like in the ATO scenario) but the specific customer need requires additional engineering activity. In this case new components need to be engineered, constructed and fabricated in order to fulfil a customer order and product the order-specific product.

For the logistics processing, this distinction between the levels of product complexity requires different treatment within the process. PTO products should have the shortest delivery time to the customer and therefore are produced to stock. These discrete product variants have an own material number in the ERP system and are pre-fabricated (these products are marked as "FEHA" products in Figure 1). ATO products, on the other hand, are fabricated on-demand, which requires a configuration model for these types of products (these products are marked as "KMAT" products in Figure 1). The same holds for ETO products, which, in addition, require manipulation of the configurator output in order to include the engineering input.

The used "gap analysis"-driven methodology is reflected in the paper structure. First, the analysis of the current organisation of the information management has been carried out (sec. 2). Then, the expert estimation of the company benchmark has been done (sec. 3). Based on this the comparison of the present and future business process and information management organisation has been done resulting in creating corresponding process matrixes (sec. 4). This has made it possible to identify major gaps between the present and the future business organization, analyse these and define steps to overcome these gaps (sec. 5). Major results are summarized in the Conclusion.

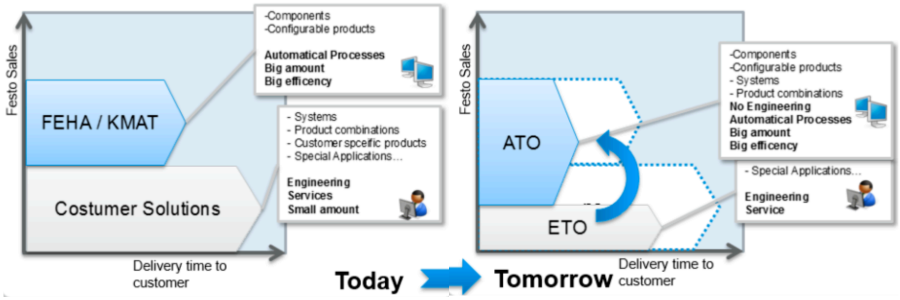

Fig. 1. Sales increase through process optimization and automation from request to delivery

2 Present Information Management Organisation and Drawbacks

The business process reorganization started with the building of a product ontology originally aimed at product codification (order code scheme) [5]. This operation was done automatically based on existing documents and defined rules of the model building. The resulting ontology consists of more than 1000 classes organized into a four level taxonomy, which is based on the VDMA classification [6]. Taxonomical relationships support inheritance that makes it possible to define more common attributes for higher level classes and inherit them for lower level subclasses. The same taxonomy is used in the company's PDM and ERP systems. For each product family (class) a set of properties (attributes) is defined, and for each property, its possible values and their codes are defined as well. The lexicon of properties is ontology-wide, and as a result, the values can be reused for different families. This is a key enabler for modular product structures achieved by the ability to compare product components and their descriptions.

Then, based on the developed ontology, the complex product modelling design and system has been implemented. Complex product description consists of two major parts: product components and rules. Rules of a complex product include the rules of its components and extra rules. Additional product characteristics and requirements (for example, operating temperatures, certification, electrical connection, etc.) are described via auxiliary rules called "Application data". They also affect availability and compatibility of certain components and features. In addition they allow customers to find the right product without any deep knowledge about the company's products. The customers are able to configure an unknown product simply by describing his problem situation (the application of the future product).

The developed so far integrated knowledge management workflow is presented in Figure 2 and is described in detail in [7]. At the first stage, the major product ontology is filled with generic classifications of products and their components. This is done via two tools: NOC and CONCode, since recently developed order code scheme differs from that used before. However, since multiple customers are used to operate with the old classification it has to be maintained.

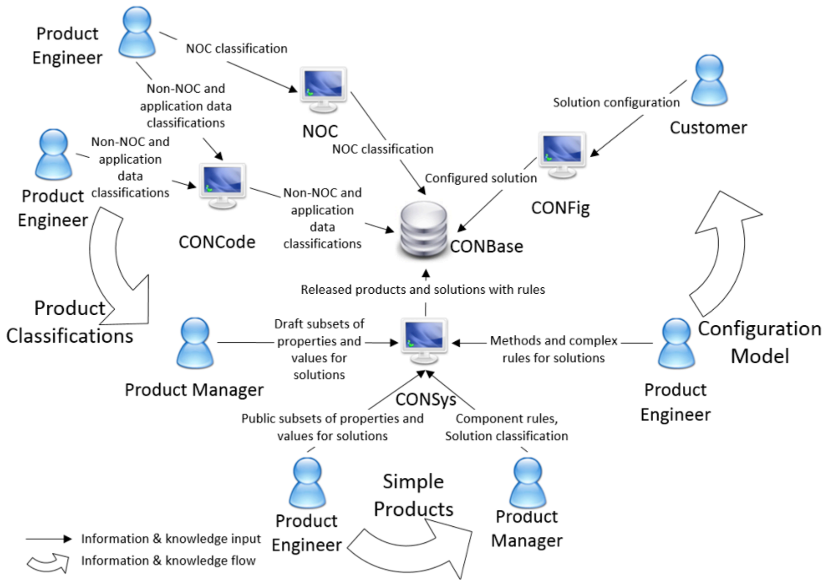

Fig. 2. Developed integrated knowledge management workflow

In addition to the data mentioned in the picture technical data should be used in the configuration process and product selection process. Such data are actually maintained based on the classification in the PDM System. As they are not available in the NOC and CONCode they could not be used in the configuration at the moment. Further there is no process how to handle application data.

For the running configuration application, there is a need to combine these data, sales, technical and application.

At the next stage, the product managers and product engineers design new products and solutions based on existing products and components (the CONSys tool). If a new product or component is needed, its implementation can be requested from the order code structure team. Together with new products and solutions, the appropriate rules and conditions are designed as well (e.g., acceptable load, size, compatibility constraints, etc.).

Based on the built configuration model the process of complex product or solution configuration in accordance with given requirements can be automated. A pilot research project aimed at developing a tool called CONFig was aimed at testing this possibility. The tool supported the configuration process in terms used within the company (company's knowledge level). In reality, the customers are used to operate different terminology (Customer level), which doesn't correspond "one to one" to that used within the company. Besides, customers from different industries can also operate different terms. As a result, there is a need to create configuration tools that can map customers' requirements to those used in the company taking into account the context (customer's industry segment, history of customer's orders, etc.). This is one of the goals of the future research.

3 Comparing Festo to the Competitors

In this Chapter we describe the expert estimation of the company benchmark. An external team of experts has analysed and rated Festo's competitiveness compared to other companies in the same business segments. The results are presented in figures 3 and 4. The white circles denote estimations for the "best" companies for each particular criterion; the black circles denote the estimation of the Festo's competitiveness.

Comparing Festo with other companies in the area of component configuration (Figure 3), the first impression is that Festo is a benchmark in all categories in selling components through the web shop, modelling a configurable product, web interface, automatically generation of CAD models. However, since selling systems and product combinations is now one of the strategic business fields different estimations should be considered (Figure 4). For these use cases Festo is still below the benchmark. The complex products with a very high variety have a complex customer interface, and no industry or customer specific views.

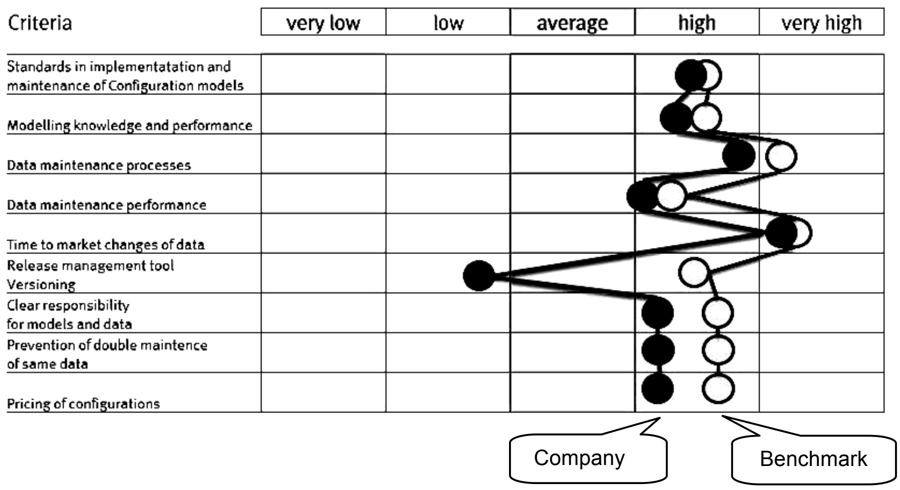

Fig. 3. Festo is benchmark in the area of the component configuration

By today new products and systems need to be implemented by new applications, which results in:

- Enormously multiple expenses (no scaling effect – no standard solution as basis)
- Growing number of projects by limited capacity
- Delay in product releases (Time to Market)
- Permanent, high maintenance costs through higher support efforts

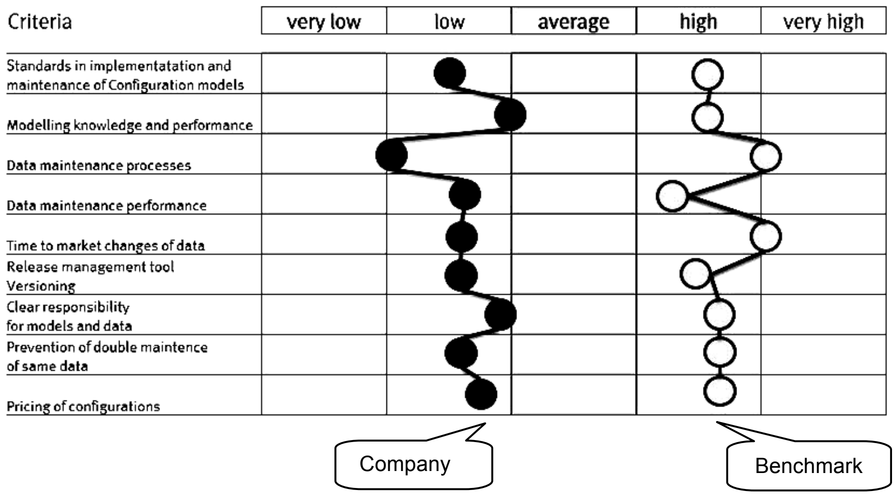

Fig. 4. In the area of system configuration Festo is clearly below the benchmark. Existing solutions are island solutions.

The previously developed workflows and information systems supporting products from the design phase to putting them to the market and further has appeared to be not efficient enough for the new business strategies. As a result, there was a need to design new workflows and supporting software systems to increase efficiency of designing and maintaining new complex product ranges. One of the efficient ways to address the before mentioned aspects is to develop and integrate a configuration platform supporting a modular product architecture (e.g., [8]). Since Festo recognizes that new workflows intelligently supported by information systems is currently a critical and strategic issue [9, 7], long-term research activities have been launched aimed at complex product support at Festo.

4 Future Business Organisation

A joint research aimed at business process review has been carried out. In this review the two major processes "PLM and data management" (with a focus on new product development and the product change process) and "configuration and logistics processing" (including PTO, ATO and ETO strategy scenarios) were analysed. In order to do so all the key company's personnel was interviewed and process matrixes based on the notes were created. These process matrixes describe the current state in the respective processes. The current states were then reviewed together with the company personnel for identifying the most outstanding "pain points". Based on this input process matrixes describing the desired future processes (i.e. a state of the process in 2020) were drawn.

A "process matrix" is a diagram similar to flow charts. In such a diagram the process steps are aligned according to two axes: horizontal swim lanes group the steps that are carried out by a specific person or role (i.e. group of persons with the same tasks) while vertical swim lanes group the steps according to time. For the new product development process, for example, the lanes from the left to the right are product definition, planning, realization, production, series run, and so on. Milestones like "production release" can be mapped to the borders of two adjacent swim lanes.

The whole idea of the desired business organization is presented in Figure 5. It is all centralized around the configuration model. Then, the strategies of the customization levels are shown with corresponding results. The "Material No." here stands for a standardized product available for the "pick to order" (PTO) strategy. The deeper customization strategies require the "bill of material" (BOM) definition either at the stage of assembly, production or engineering. These are followed by activities both internal (for the company) and external (for customers) associated with the strategies. Obviously, for a customer there has to be as little difference as possible in selecting a PTO or configuring ATO or ETO strategy scenario products or systems. The customer should only see the complete product range without a need of understanding what is available PTO and what is available ETO (the only differences could be in lead time).

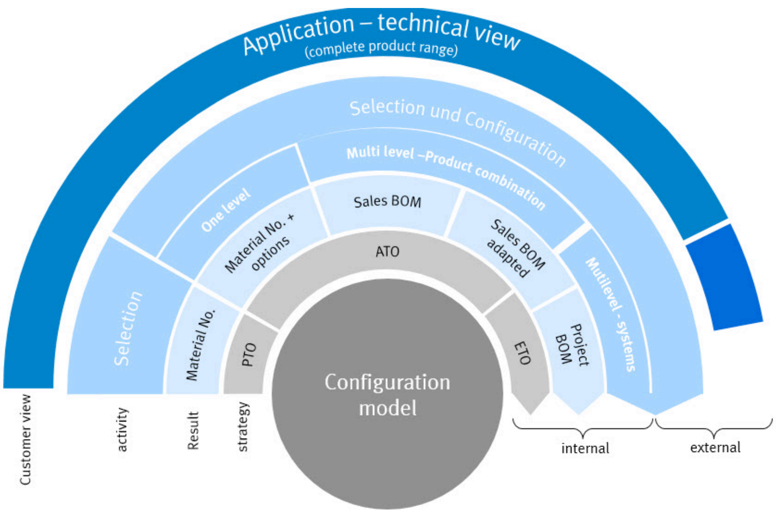

Fig. 5. Layer-based model of the desired business organisation

Variant management [10, 11] is seen as a key activity in the process of business restructuring. The main idea of variant management is to optimize the number of product variants offered to a specific market segment (i.e. "outer variety") while reducing the complexity of product development. Production costs are typically kept low by producing a small amount of modules that are generic and common for multiple products within the same portfolio (i.e. "inner variety"). The interested reader is referred to [12].

In Figure 6 the new product development process is addressed on a high-level by the process steps "product management", "construction", "production / logistics" and "sales / marketing". Within the new product development process the distinction between "inner variety" and "outer variety" can occur multiple times: typically between construction and production, between production and logistics and between logistics and sales. Thus, the main lever of variant management is to compare two different views on a product family (the need / market view with the engineering / construction view) and then improving reuse of modules and eliminating the main variant drivers; which are typically also cost drivers.

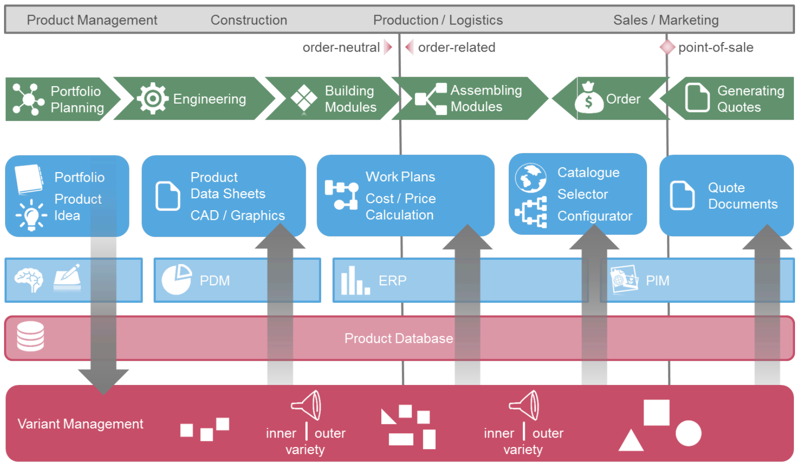

Fig. 6. Variant management and its effects on the major activities and processes around product configuration and order processing.

Having a coherent product database capturing all relevant data from early stages of the new product development process until the sales and marketing stages enables using this data for comparing the different views on the product family. This, in the long run, enables effective variant management. At the same time most of the data required to describe a product for sales is already present, because this data can be extracted from early product specifications. This means that a single coherent product database can be used to reduce redundant work for data creation as a "side-effect".

4 Identified Gaps and Ideas on How to Address Them

In order to gain the desired improvements of the business organization described in the previous chapter – i.e. standardizing the configuration and logistic handling of product combinations and system configurations, still some gaps need to be bridged:

- **(Re-)Structuring the product portfolio** *(understanding which products are important and which are not)*:

  The company offers a wide variety of products all over the world. The products have different complexity and there is regional distinction when it comes to logistic handling and sales numbers. The product portfolio should be segmented according to the importance of products for the different sales areas.

The company is currently defining which products should have the shortest order-to-delivery time and for which products it is acceptable that the production and delivery takes a bit longer. This decision is based on sales regions and market segments such that a product can have different order-to-delivery times in different regions. The implementation of this segmentation has impacts on a production decision: PTO, ATO and ETO products. Vice versa, the production has impacts on delivery-times. This is why the sales view on delivery times is clearly separated from the logistics view on production times. As a result, some complex product combinations or systems are pre-fabricated and sold as PTO products, so that they can have a short delivery time.

- **Designing customer view on product selection, configuration and processing** *(defining user experience, "talking in a customer-understandable language")*:

  Based on the different complexity level, the company's products can be classified as simple discrete components, configurable products or system configurations. Of course, the selection and configuration of these different types needs to be addressed accordingly. But the user should not be aware of this distinction. To the user, the sales process should always "feel" the same.

  There are different types of users, like product managers, sales personnel or customers. These users have different needs when interacting with an application like a product configurator. A product manager, for example, knows about the products and is able to configure by deciding on technical facts. A customer, on the other hand, may not know about the technical details of the company's products or even what kind of product he may use to solve his application problem. This is the reason why technical product details should be hidden under an application layer. In addition, the selection of the right product for solving the application problem can be based on a mapping between the application layer and a (hidden) technical product layer. In the optimal case a user does not notice whether he is selecting a discrete product, configuring a complex system, and so on.

- **Homogenizing and standardizing products and product components** *(less ETO and more ATO products)*:

  One of the main reasons for re-structuring the business organization is to improve sales of product combinations. In order to do so a homogeneous modular system is needed; i.e. the components and products must have the same characteristics, the need to be "comparable".

  This step has mostly been implemented by defining the common ontology. New products are integrated into this ontology and thereby must adhere to the given structure and use the pre-defined characteristics. However, there still are some old products that were developed before the ontology was defined and use a different product structure and naming system. In order to reach "comparability" between the whole product portfolio and with such enable modular product architecture, the description of old products must be transformed to match the new ontology.

- **Increasing product modularity / reusability in larger contexts (i.e. product combinations and systems)** *(less ETO and more ATO products)*:

  In addition to the previous step, the structure of product combinations and systems needs to modularized. "Comparable" modules have the key ability to be used in multiple configuration contexts. General product model architecture needs to be set up.

This is one of the major fields of research in the area of configuration [13-15]. In the coming years we will implement a single product configuration platform that is able to deal with all the different types of products, i.e. selection of simple

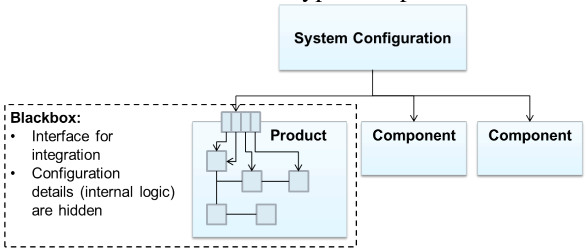

Fig. 7. Reusable products within modular product model architecture are treated as "black boxes".

discrete products, configuration of simple products as well as configuration of product combinations and systems. The configuration model architecture needs to be well-thought out in order to achieve modularity and reusability. This means that on the side of configurator build-time there is a large potential of reducing (redundant) work by reusing the configuration model of a product in the larger context of product combination (Figure 7).

In a modular configuration model architecture the reusable product model is created once and can be included into larger contexts; it is then treated as some sort of “black box”. In order to include “black boxes” into larger system models, the “interface” of this box needs to be well-defined. Talking about product models such an “interface” can be seen as a fixed set of characteristics that are known from the outside. These characteristics need to encapsulate all variability of the product such that selecting values for all interface characteristics results in a complete and consistent configuration of the module (e.g., [16]).

- **Aligning the business processes** *(improving interoperability and avoiding redundant tasks)*:

  When building a new configurator platform, it is important to align business processes like new product development and product lifecycle management together with the desired outcome. Doing so can help improving interoperability and avoiding redundant tasks e.g. in data maintenance.
- **Homogenizing and standardizing product master data** *(increasing master data quality; e.g. for being able to compare product components, which is necessary to build modular product combinations and systems)*:

  In one of the previous steps we already homogenized and standardized products. This means that product descriptions adhere to a given structure and have common characteristics. Designing product model architecture for the configuration platform also requires good product master data quality. The goal here is being able to compare product components, which is necessary to build modular product combinations and systems.

  This step has mostly been implemented by defining the common ontology and forcing the use of globally defined attributes in the NOC tool. This tool enforces the use of globally defined characteristics, which makes product descriptions "comparable". However, currently this is limited to sales-related characteristics (characteristics in the company's ERP system). The approach should be extended to include technical attributes (characteristics in in the company's PDM system) and application attributes (currently not globally pre-defined) as well. After doing so the configuration models are always coherent for all the abstraction levels: i.e. logistics-oriented, sales-oriented or application-oriented. For example, having a global definition of application characteristics allows for generic specification of product applications and "under-the-hood" selection and configuration of different types of products without technical background.

- **Implementing tool support for the changed processes** *(supporting the improved business processes)*:

  Last, but not least, the configuration platform (run-time application) as well as the data supply route (build-time tools) need to be implemented. This includes building configuration models according to the general product model architecture.

  Some tools for the current business organization have been implemented. The productive use of all these tools (except CONFig) proves that the ideas behind the common ontology work well. Currently, there are multiple tools that have to be used within a single business process. In the future prospective a single tool for the different data creation steps is sought, which would support the whole process of building up a well-structured product portfolio and the corresponding product configuration platform. This includes data from new product development (storing structured data from early stages like product specifications) via creating logistics and sales-oriented configuration models up to designing and structuring the configuration workflow within the configuration application (see also Figure 5).

Conclusions

The paper analyses gaps in the major business processes around product configuration that are required for efficient support of new types of products (integrated solutions) for both internal use and for customers. The gaps have been identified in the following areas: product portfolio; customer view on product selection, configuration and processing; products, product components and master data homogenization and standardization; product modularity / reusability; business process alignment; and IT support. The solutions to these gaps have been identified.

Presented work is an ongoing joint research, which is still in an intermediary step of implementation. The future work will include refinement of the achieved so far results, as well as variant management research as a way to optimize the number of product variants offered to a specific market segment while reducing the complexity of product development.

The research is based on the company Festo, however, the results can give significant input to achieve benefits for component manufacturers that tend to become system vendors in general.

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