BearingPoint®

Study “Future PLM”

Product Lifecycle Management in the digital age.
The catalyst for IoT, Industry 4.0 and Digital Twins.

Hochschule Karlsruhe
Technik und Wirtschaft
UNIVERSITY OF APPLIED SCIENCES

Steinbeis-Transferzentrum
Rechnereinsatz im
Maschinenbau (STZ-RIM)

Study “Future PLM”

Product Lifecycle Management in the digital age.
The catalyst for IoT, Industry 4.0 and Digital Twins.

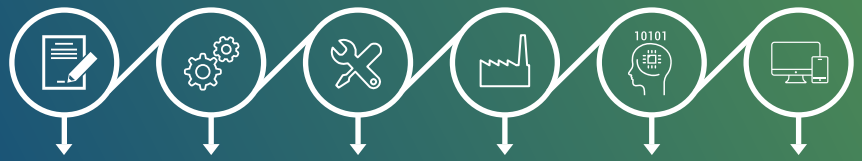


Table of contents

Introduction

“It is not primarily a matter of developing a digitalization strategy for your company. Rather, it is about aligning corporate strategy and processes so that your company can survive and succeed in an increasingly digitized world.”

Prof. Dr.-Ing. Jörg W. Fischer
University of Applied Sciences Karlsruhe – Technology and Economy, as well as Manager/Managing Partner Steinbeis Transfer Center for Computer Applications in Mechanical Engineering.

Current digital trends and technical innovations are transforming the production industry. Companies have to rework their business models due to the increasing demand for individualized products and the rising complexity of "smart products" as a result of the combination of mechanics, electrics, electronics and software are constantly confronting companies with new challenges.

Comparable to data-oriented technology companies, manufacturers need to consider middle- and long-term strategies when developing their digital business models. “Product Lifecycle Management” (PLM) as a concept for the seamless integration of all information that emerges during the lifetime of a product is not new. However, the process-related and technical integration of PLM into business processes still challenges many companies. Tomorrow’s customer’s requirements demand a digital core, an end-to-end digital company by connecting all applications. This is the only way to achieve a continuous and sustainable transformation of the company.

The paradigm shift to Industry 4.0 is often associated with topics such as the Internet of Things (IoT), holistic visions – like the “Digital Twin” of a product, “smart product” or “smart production” , as well as “lot size one”. Even today, however, the real potential of digitalization is still not always transparent or quantitavely measurable in terms of customer benefit. The previous separation of the areas of application into

- PLM (product development until the production release)
- ERP (for the control of the production orders and means)
- MES (Manufacturing execution systems for the control and monitoring of production facilities and machines)
- Digital factory (production planning and simulation of the production)

contradicts of digitalizing the entire value chain. In the digital age, companies in the production industry are not simply assembly line operations: they must have agile, flexible and responsive IT infrastructures. In many cases the overview of the own product emergence process is missing due to grown IT landscapes and solutions.

In the context of the advancing digitalization, the requirements for PLM and the supporting IT systems are dramatically changing.

The systems must be able to quickly capture sensor data from connected (smart) products and to transmit them back to the engineering departments, for example to evaluate them using a “Digital Twin” including big data approaches.

Key facts

71% of the companies are not sufficiently prepared for the increasing product and production complexity

83% of the companies don't have a defined continuous product configuration process

more than 80% of the respondents maintain the variant management manually or with simple tools

67% of the respondents are planning to drive the integration of PLM-ERP-MES to optimize the value chain

78% of the companies consider Digital Twins as a competitive advantage

PLM systems must also support cross-departmental and interdisciplinary product development. The biggest challenges in the production industry are primarily obsolete IT infrastructures and isolated solutions. Only few companies have already integrated data, processes and systems, which are necessary for an efficient and continuous value chain.

In times of ever faster changing or individualized products, various methodical approaches are used to manage product complexity, such as modularization, platform concepts or collaborative engineering.

The data and information collected from the product emergence process to the use in the field (operation) to the "end of life" of a product and its recycling are increasingly helping companies to make the right decisions. The way product descriptive information is documented and managed throughout the process of product development and manufacturing will continue to change dramatically.

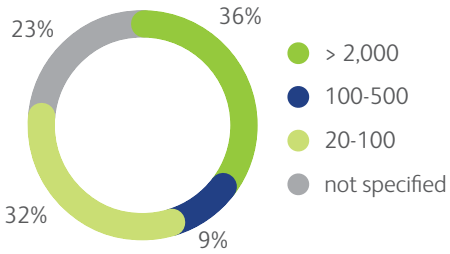
The joint study was conducted by BearingPoint and the Karlsruhe University of Applied Sciences (HsKA), Prof. Dr. Jörg W. Fischer, and the Steinbeis Transfer Center for Computer Applications in Mechanical Engineering (STZ-RIM). The study shows the current status of product development in the digital age and how different companies are dealing with product and production complexity and how they are facing the challenges of digital change.

Complexity within product development

Diversity of variants and product configuration

Participants of the study were manufactures of customized products as well as producers of highly configurable products. The average number of product variants rages from 20 to over 2,000 products per product line.

Product variants



The participants of this study in the **mechanical and industrial engineering are divisible into three groups**. Most of the companies – independently of size or revenue – develop a high or very high share of configurable products (configure-to-order, CTO = 50 to 90 percent). They are covering the remaining demand by the development of customized solutions. An additional group is composed by the generalists, which are equally pronounced in all three development sectors. The third group is built by equipment construction, production engineering and automation technology, which develop a high proportion of standard products which are only configurable in a small proportion (CTO = 5 to 20 percent).

As expected, within the **automotive companies** the **CTO proportion** is **very high**, at the OEMs (> 85 percent) as well as at the suppliers (> 50 percent). Depending on the degree of standardization of the products delivered the latter have also a significant share of "select-to-order" (STO) from 20 to 80 percent of their product development.

The individualized development is not important in the medical device industry (engineer-to-order, ETO < 15 percent). Standard products predominate here, with STO and CTO having roughly the same proportions.

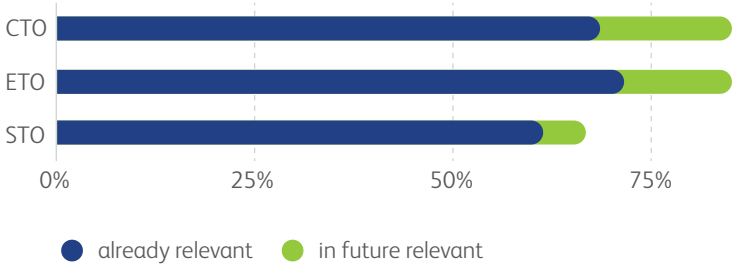
In the electronic industry you could recognize the same division too. While the larger companies have a high proportion of standard products of 80 percent, **small and mid-sized companies tend to deliver customer-specific product developments** (ETO = 50 percent) and have a rather small proportion of standard products in their portfolio.

Independently of the sector **the participants with a high STO-proportion of over 50 percent** could be divided into two groups. Those with a few (20 to 100) variants per product line focus on the STO area and see the other areas – if at all – as future topics. On the other hand, there are companies with a very high amount (> 2,000) of variants per product line. Here, too, the other two kinds of development can already be found in the portfolio and are already considered as relevant today.

The participants with a high or very high CTO-proportion have already today a small level of 5 to 25 percent of the other both product development types respectively. **The participants of this group agree that all three sectors need an elevated attention.** The STO-proportion is seen as irrelevant from some participants. This suggests that product complexity will continue to increase in the following years and that the focus will shift to highly customizable end products.

This observation is also reflected by companies with a high or very high proportion of individualized development, independently of the sector. **Here the STO and CTO are already relevant equally nowadays.**

Which area is becoming increasingly relevant for your competitiveness?



Top 3 challenges in the age of increasing product and production complexity

1. Smart products

2. Demand-driven degree of individualization of products

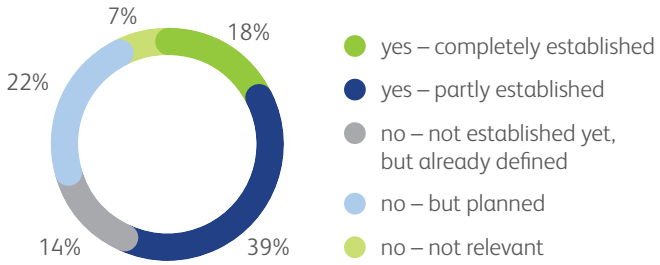
3. Fulfilment of globally differing requirements

Diversity of variants and product configuration – a focus topic in the digitalization strategy

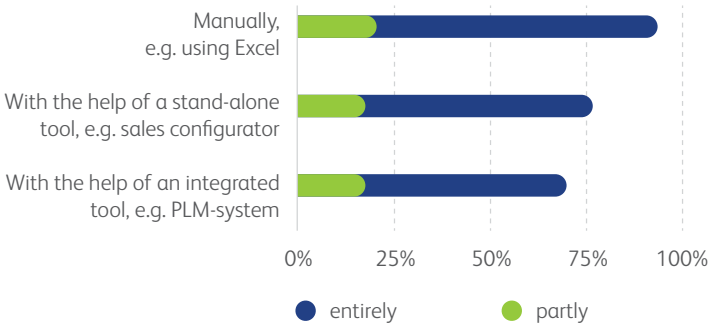
Three-quarters of the study participants have a **process for the definition of product configuration**, though it is only established **completely and consistently in approximately 10 percent of the companies**. These are primarily automotive companies and representatives from aerospace and medical device industry. They each have no or only very small proportions of customized products (ETO) and see their focus in the development of configurable products (CTO). The remaining participants in this group were already able to partially standardize the product configuration, but are working on a holistic integration of the processes within the respective company.

A standardized process for the definition of product configuration is irrelevant for around **20 percent**. Here it refers to producers of customized solutions (ETO), where the **coordination of the orders is completely fulfilled by sales**. By fully integrating the **product development processes** into ERP as well as into CRM, the product configuration can be managed centrally and further processes can be avoided.

Process for defining product configurations



Technical support in the management of variants



Especially automotive companies and partly companies in the machinery and equipment industry with a high proportion of configurable products (CTO) mainly work with existing sales configurators that are used in parallel with the existing PLM systems. At the big automotive manufacturers and suppliers, a profound integration into the PLM system is assumed by the respondents.

In the case of participants whose product portfolio consists to a very large extent of standard products, **variant management** is **often still handled entirely manually**, for example using Microsoft Excel, today even in large companies.

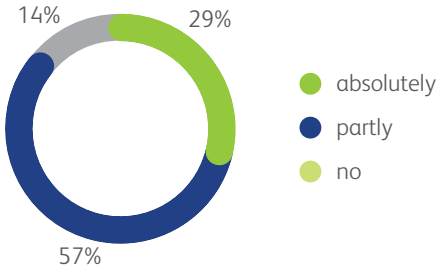
The remaining participants in the study use several approaches in parallel, which – depending on the maturity of the process integration – either communicate directly with the PLM system used or lead to redundant information or process breaks.

Possibilities for special requests or supplements of configured products

14 percent of the study participants **do not allow their customers to make any additional special requests** for their configured products. On the one hand, this is caused by a high proportion of standard products or highly standardized manufacturing processes.

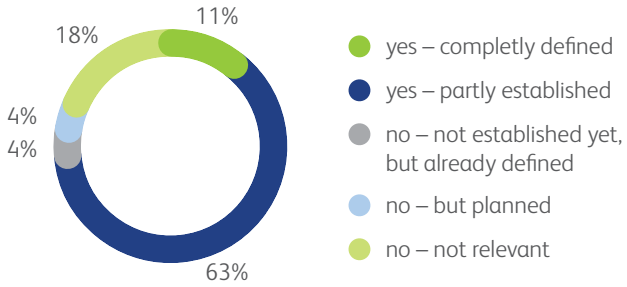
On the other hand, for these participants the responsibility for the implementation of product configuration processes is assigned to the product development with partial involvement of product management. **Sales is not involved in any of these companies** and, consequently, none of these survey participants use a sales configurator to manage product complexity.

Enabling of special customer requests



In contrary, 29 percent of the participants allow entirety special requests for their products. This group of the survey has a medium to high proportion of order-specific engineering products (ETO). Here, the focus is on sales configurators and for the most part on **modularization or a kit strategy** for the product portfolio. The sales department is also rarely or not directly responsible for the product configuration process but better integrated in the processes. **These study participants feel they are organizational well prepared for increasing product and production complexity.**

Process to transfer special customer requests into the existing product emergence process



The task of transferring special customer requests into the existing product emergence process is challenging for participants that allow special requests. Three-quarters of the participants already have defined processes but have yet to establish them completely in daily business.

Only a small proportion of study participants report a continuous implementation of a transfer process of special requests into the existing product emergence process. **For mid-size companies** with approximately 5,000 employees, **only product management is responsible for product emergence**.

Integration of product development

In many companies, there is significant potential for improvement in the process-related integration of the product emergence process (PEP).

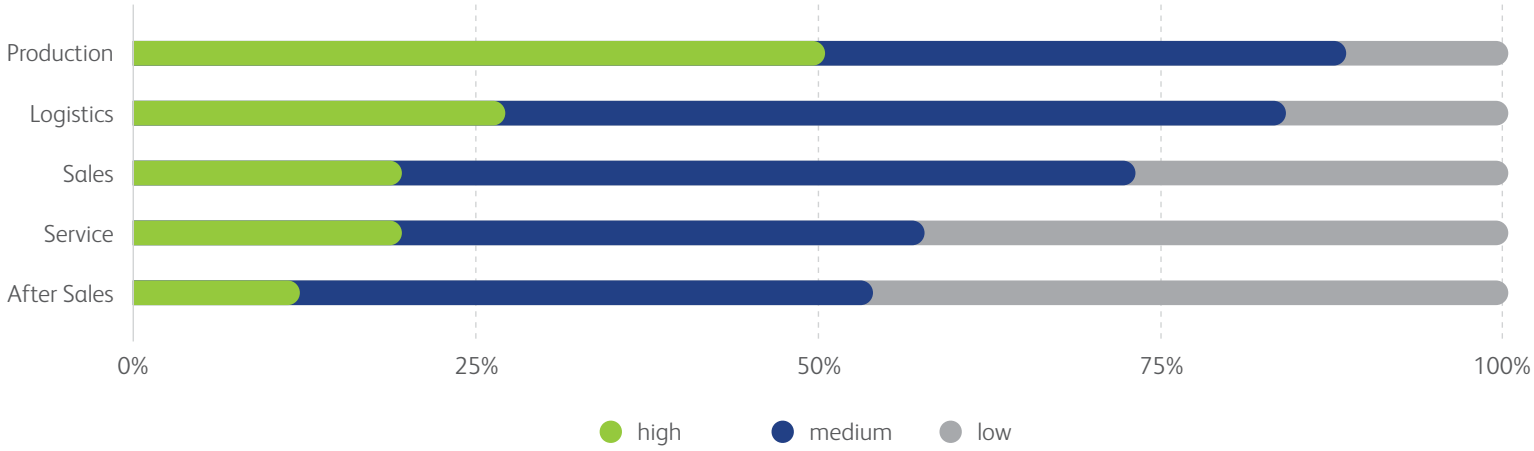
Most of the respondents (> 70 percent) already have a coordinated and documented product emergence process (PEP) established in their company. It is striking that **no study participant indicated that there would be no PEP defined in their company**. This shows that this process is seen nowadays as a pillar within Product Lifecycle Management (PLM).

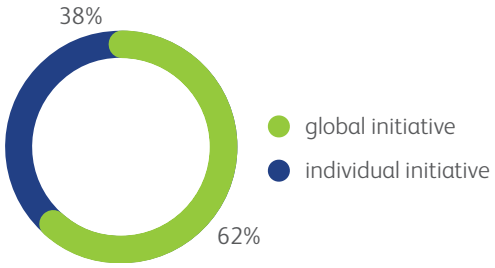
On the one hand, in the sectors of automation engineering technology and automobile manufacturing, this topic is given exceptional importance, and in these sectors all study participants indicated that they have already implemented a coordinated and documented PEP in their companies.

On the other hand, in industries as medical device, machinery and equipment construction as well as the electronics industry, there is a **significant number of companies** that have only partially a coordinated and documented product emergence process.

What is striking, however, is that the process-related integration of the PEP can still be significantly improved in a lot of companies. For example, 100 percent of the respondents from the electronics sector think that their process integration of sales, after sales and service is currently at a low level. Only production stands out, as 50 percent of those surveyed stated that the process-related integration of the product emergence process is at a high level.

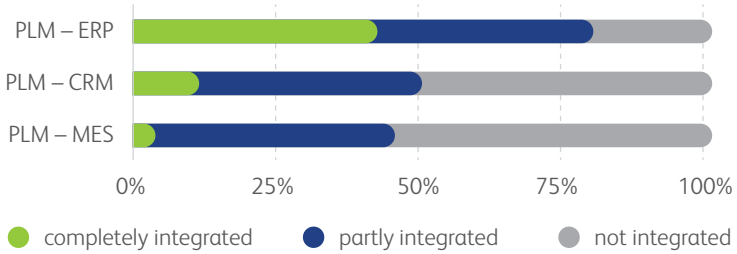
Level of integration of the product emergence process into downstream processes





Approximately two thirds of participants manage the optimization of the value-added chain as a part of a company-wide initiative or in the course of a digitalization strategy.

Integration level of PLM within the system landscape



In the domain of integration of the product emergence process into the remaining system landscape, more than 50 percent of the study participants stated that they do not have full integration of the PLM system into downstream systems.

Nevertheless, the highest level of integration of PLM systems is reached in conjunction with ERP systems. Compared to this, only **a minority have their PLM system integrated into an MES system**. Cross-sectoral, only approximately 40 percent of the respondents indicated that their PLM system would be completely integrated into one of the mentioned systems (CRM, ERP or MES).

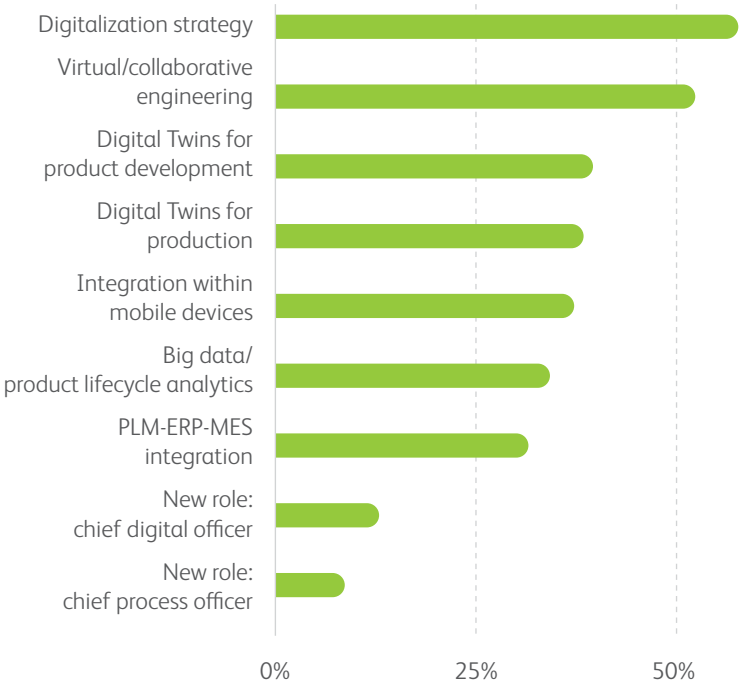
Optimization approaches of the digital value added

In answer to the question of which approaches are currently used the most to optimize digital value creation, two approaches stand out. These are, on the one hand, the "explicit creation of a **company-specific digitalization strategy**", which is particularly prevalent in the electronics industry (100 percent of respondents use this approach), and, on the other hand, "**virtual/collaborative engineering**".

An approach used only by a small minority is the "establishment of the management position: **chief digital officer** (CDO)." The exception of this trend is in the automotive industry, where 65 percent of the respondent companies are using this approach.

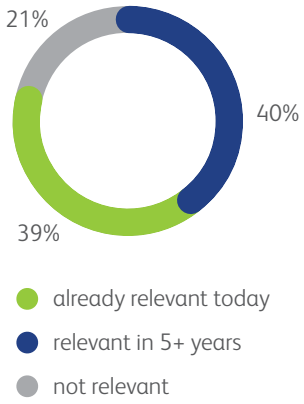
Therefore, sector-specific differentiation must be made in the division of digital value added, though that is not in the scope of this study.

Current approaches to optimizing digital value added



Digital Twins

Digital Twins as a success factor

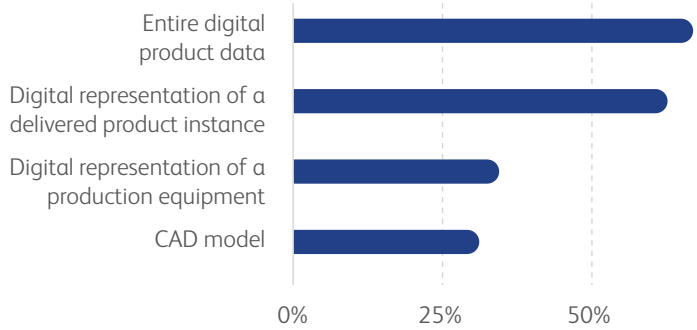


More than two-thirds of the study participants of **all interviewed sectors** interpret the term "Digital Twin" as the **overall scope of the digital product** data. In contrast, approximately one third don't see the actual product in it but only the **illustration of a production facility**. 30 percent also see each CAD model as a Digital Twin of the current product.

Within the **medical device industry** sector they agree that the Digital Twin describes "a digital illustration of a delivered product instance." All responders from this sector indicated that.

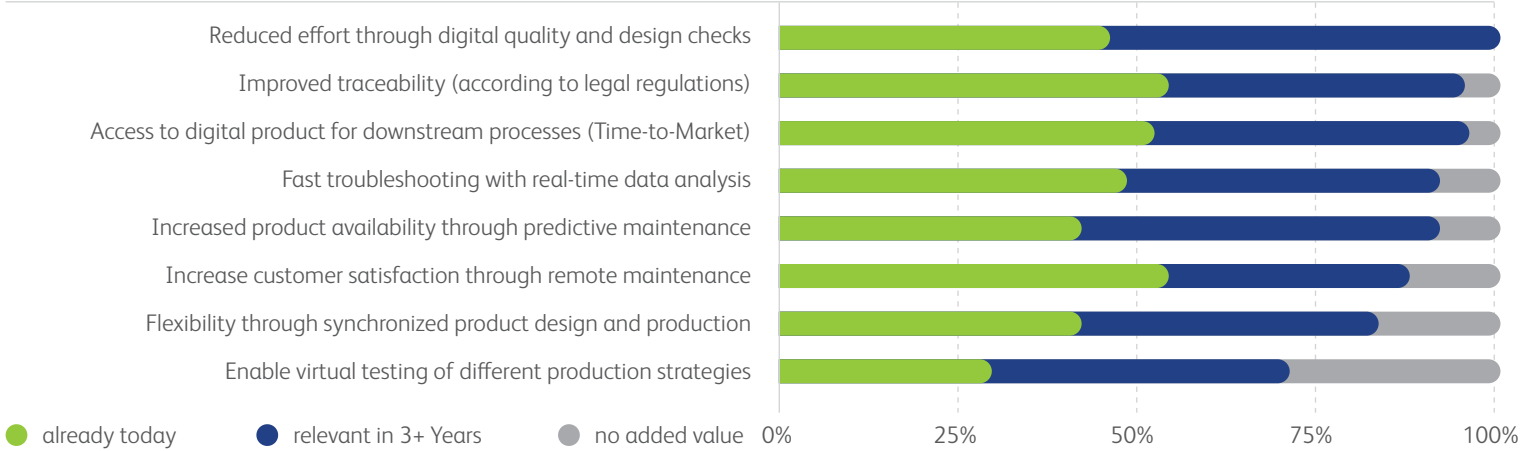
The evaluation of this question is clearer if only **aerospace industry** is considered. In this industry, only the digital product data and the delivered product instances are relevant for a Digital Twin at the time of the survey.

Comprehension of the meaning "Digital Twins"



For the study participants, Digital Twins are seen as a great advantage in **quality assurance**, for example, at the **reduction of expenses in testing** or the **traceability or rather compliance of legal requirements**.

Digital Twin as an enabler for Smart Products



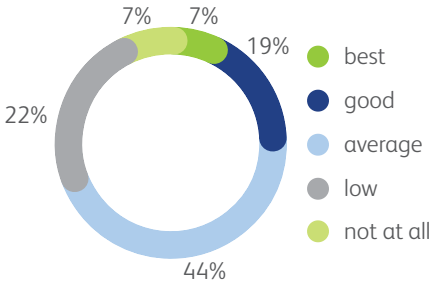
One-third of study participants are already using Digital Twins operatively.

Maintenance is also associated with Digital Twins with almost the same importance. This approach is seen as a supportive measure of trouble-shooting through near real-time data analysis or predictive maintenance. Remote maintenance, and thus the **elimination of travel time and downtime**, can also be supported by digital product twins and thus strongly increase customer satisfaction.

But not only the customer interaction, but also the internal interdisciplinary collaboration can benefit from increased transparency and faster availability of specifications and data. This accelerates product emergence processes, thus time-to-market, and increases the company's competitiveness.

Of the study participants, more than one third already use a Digital Twin for each topic. All others regard Digital Twins as central objects for the further development and improvement of their own product portfolio and are planning short and medium term (within the next three years) implementations in these areas.

Data and system preparation for the future of digitalization



Only about 10 percent of the companies believe they are well-positioned in relation to the data and systems. One third of the participants believe they are not or insufficiently prepared for the coming increase in complexity.

Conclusion and recommendations for action

TOP 3 recommendations for action

- Functional oriented anchoring of the future digitalization approaches within the organization (CDO/CPO)
- Set-up of a centralized, consistent and interdisciplinary PLM data-backbone
- Establishment of consistency, transparency and traceability of the whole product life cycle (closed-loop)

Digitalization requires a consistent, interdisciplinary approach for data continuity from the customer requirement (as-required), development (as-designed), sales (as-ordered), work preparation and production planning (as-planned), production (as-built), logistics (as-delivered) and customer services (as-serviced/as-maintained). Furthermore, transparency, traceability and IT security are moving into the focus of value creation in the production industry. Our study shows that, despite a variety of approaches to manage the ever-increasing product and production complexity, companies still have a lot to adapt. With a focus on PLM and ERP, today's business processes are still heavily dominated by mechanical design and do not take sufficient account of the trend towards smart products and the integration of mechanical, electrical/electronic engineering, software development and service planning. On the one hand, adapted PLM concepts will be necessary and on the other hand agreements, methods and system functions for interdisciplinary collaboration will be required.

The support of collaboration with development partners, suppliers as well as up- and downstream processes is a core requirement for a PLM of the future. Only about 10 percent of companies, however, have already completely established this process. For the realization of an integrated value chain, organizational silos have to be eliminated as well as process and media related discontinuities are resolved. The legal framework as well as the protection of intellectual property (IP) of process partners must be ensured. The results of the study confirm: this organizational change process should be seen in its entirety as part of a digitalization strategy instead of isolated individual initiatives.

The classical "stand alone" PLM solutions are reaching their limits because of immense product and process complexity. There cannot be the "one" system for the entire processes and domains involved in the product life cycle.

PLM architectures must be based on consistent but at the same time expandable master and structural data. They also must be adaptable on independent and flexible processes (for example, ETO, CTO, CTO+ etc.) and organizational structures.

Modular products are a precondition for the reutilization of existing modules. **This study shows that almost 90 percent of the companies allow at least partial individualization of their products.** PLM has to support variant configuration as well as a where-used list of modules and assemblies of various brands, joint-ventures, variants and derivates. Only **continuous complexity management** – from the proposal preparation to the launch and the recycling – is able to realize the success potential of individualized products for customers and the company. **The "Digital Twin of a product" is a crucial competitive factor in the continuous representation of product data**.

Besides the unique described and digitalized processes, data standardization and harmonization are the basis for **digitalization** as well as **the foundation for IoT and Industry 4.0**. Only they will assure competitiveness in this age of increasing product and production complexity.

Are you prepared for the digital future?

BearingPoint's 360° PLM approach is designed to meet the current and future challenges around the product emergence process. We develop demand-oriented strategies, concepts, approaches and procedures for the integration of new technological innovations. We support you in the selection of the right product out of the wide range of innovative solutions and technologies on the market.

Information in relation to the Study

Value-added potential of Industry 4.0

The Frauenhofer Institute estimates that the German production and manufacturing industry will grow by 422 billion Euro based on investments in Industry 4.0 over the next 10 years.

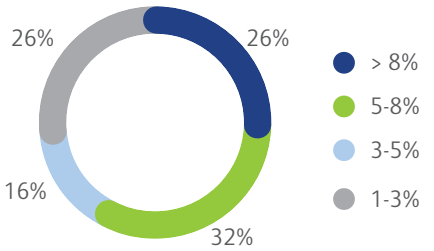
More than 50 experts in Germany, Austria and Switzerland participated in the present study of "Future PLM – Product Lifecycle Management in the digital age". The online survey took place between June and October 2018.

The interviewed experts are from the production sector with a focus on mechanical engineering, in the automotive industry and the automation and process industry as well as adjoining sectors such as medical technology, electronics and semiconductor industry, aviation and military.

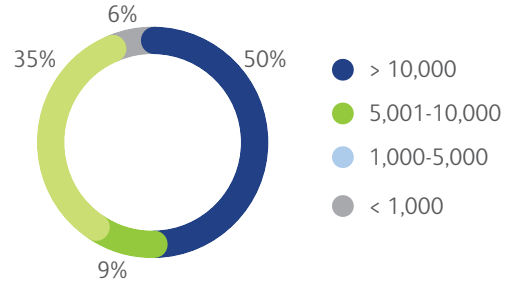
Around 70 percent of the companies generate annual revenue of more than one billion Euro. 50 percent have more than 10,000 employees and 35 percent have between 1,000 and 5,000 employees.

Approximately one third of the interviewed companies invest between five and eight percent of their yearly revenue in the division of research and development and 26 percent invest even more than eight percent.

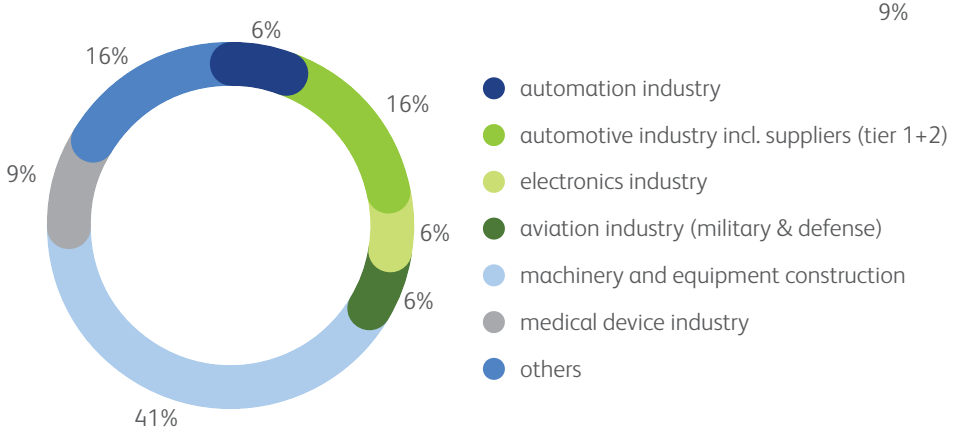
R&D expenses as a percentage of revenues



Number of employees



Industries of the participating companies



Glossary

Production configuration/Configurator
Product configurators are computer programs, by which the specifications of products could be done customer individual for offerings or orders.

Engineer to order (ETO)
Single products as well as assemblies are constructed or manufactured after the order placement. Thereby the end product could include standardized products, but for every order an individual production sequence and a customer specific bill of material is needed.

Configure to order (CTO)
In contrast to ETO the CTO has a defined variant quantity. From this the customer could configurate an individual product at the time of the offering preparation and the order placement. After the order is incomed the production starts in accordance with the configuration.

Select to order (STO)
The product is developed before it is launched into the market. There is no possibility for the customer to configurate the product individually.

Digital Twin
In the Digital Twin an abstract digital model is illustrated, which is available in all product life cycles with all appropriate information. The key features of the Digital Twin are that all available information from the product realization, testing, simulation, service, field information and analytics are used, to forecast the behavior of the product and control, maintain and improve the performance.

Model
A model is a simplified replica of a planned or existing system with its processes in another conceptual or opposing system.

Predictive maintenance
Predictive maintenance enables the companies to detect possible failures, disturbances or breakdowns of production facilities before they happen. For that the production facilities are equipped with sensors, to collect data, which could be analyzed. By anomalies of the data an appropriate reaction could be done, and a proactive measure could be taken. The objective is to prevent expensive repairs and break downs.

Service data
Service data are operating data, which are collected during the customer use of the product and could be used for service purposes.

Smart products
Smart products are linked, intelligent products with embedded informational functions. Recording, processing and transferring of information to surrounding (smart) products belong to these functions.

Options
All possibilities that are given to the costumer to configurate a product. These have to be pre-defined in the product model and evaluated by considering costs, effort and feasibility.

Product model
A figure of all product defining information (data model), which emerge during the product life cycle. That information are collected digitally and are available for all divisions which are involved in the product emergence process for viewing and completing.

Contacts

Stefan Bahrenburg
Partner, BearingPoint
stefan.bahrenburg@bearingpoint.com

Stephan Munk
Senior Manager, BearingPoint
stephan.munk@bearingpoint.com

Prof. Dr.-Ing. Jörg W. Fischer
Manager/Managing Partner
Steinbeis Transfer Center for
Computer Applications in
Mechanical Enigineering (STZ-RIM)
joerg.fischer@stzrim.com

Authors: Harald Rützel, Barbara Fuchs

© 2019 BearingPoint GmbH, Frankfurt/Main. All rights reserved. Printed in the EU. The content of this document is subject to copy right (“Urheberrecht”). Changes, cuts, enlargements and amendments, any publication, translation or commercial use for the purpose of trainings by third parties requires the prior written consent of BearingPoint GmbH, Frankfurt/Main. Any copying for personal use is allowed and only under the condition that this copy right annotation (“Urheberrechtsvermerk”) will be mentioned on the copied documents as well. Photo credits: Adobe Stock, www.stock.adobe.com. BEDE19_1249_EN.

BearingPoint®

About BearingPoint

BearingPoint is an independent management and technology consultancy with European roots and a global reach. The company operates in three business units: The first unit covers the advisory business with a clear focus on five key areas to drive growth across all regions. The second unit provides IP-driven managed services beyond SaaS and offers business critical services to its clients supporting their business success. The third unit provides the software for successful digital transformation and regulatory requirements. It is also designed to explore innovative business models with clients and partners by driving the financing and development of start-ups and leveraging ecosystems. BearingPoint's clients include many of the world's leading companies and organizations. The firm has a global consulting network with more than 10,000 people and supports clients in over 75 countries, engaging with them to achieve measurable and sustainable success.

For more information, please visit: www.bearingpoint.com

About Steinbeis Transfer Center for Computer Applications in Mechanical Enigineering (STZ-RIM)

The Steinbeis Transfer Center for Computer Applications in Mechanical Engineering (STZ-RIM) is one of around 1,000 companies in the Steinbeis Group that operates worldwide. Since 1985, the STZ-RIM in Karlsruhe has been a team of highly experienced experts when it comes to innovative solutions in the areas of internal and external digitalization, smart product development, product life cycle management (PLM), production management or industry 4.0. Professional consulting at the highest level is the basis for successful implementation. The portfolio of the STZ-RIM therefore ranges from consulting to Implementation/ Configuration. The STZ-RIM also offers an extensive range of training and further education. Therefore we are of the STZ-RIM Contact person for small as well as medium-sized and large companies.

For more information, please visit: www.stz-rim.com