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No digital twin without end-to-end digitalization

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No digital twin without end-to-end digitalization

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Digital twins make it possible to simulate the behavior of physical assets, whether they be ships, cars or plant equipment, to monitor them during operation and to continuously improve them by feeding back operational data. The data and models from development provide the context in which the operating data can be correctly interpreted. Preparation and provision of this data in a way that is twin-compliant is therefore an essential prerequisite for the deployment of digital twin applications.

A digital twin is understood as the digital image of a physical object or system, which can be a product or production plant, but also a process. It links the world of digital planning with that of real products and production using a theoretical data construct, without the need to combine all data in a centralized database structure. Today, the digital twin is primarily used to give people a better insight into the system and its status or behavior. However, the longer term vision is to use digital algorithms to achieve an autonomous control system as understood by Industry 4.0.

The extent to which the digital twin has to fully reflect reality will depend on the actual use case. In fact, there is not just one digital twin. Instead, there are many versions depending on the use case and the lifecycle phase, and all these versions can ideally be derived from one digital thread. The lines of demarcation between versions are fluid. While the digital service twin is the direct, digital representation of a real object or asset in order to allow support for services such as maintenance, predictive maintenance, updates or retrofitting measures, the digital product twin is the digital representation of all product instances and is used to analyze product-related optimization potential for the purposes of product development and the improvement of all existing and future product instances. The digital manufacturing twin is primarily a tool for planning, controlling and optimizing the mapped production processes (Figure 1).

The functional relationships of a product or a production plant are defined during product planning and development on the basis of customer requirements, while taking into account a wide range of legal requirements. Without knowledge of these interrelationships, it is not possible to correctly interpret the operating data that the real asset records and provides in its later product life. If you do not know how a machine or system is actually supposed to work, it is impossible to unambiguously identify the causes of any deviations from the nominal status or behavior and take appropriate countermeasures, whether these be preventive maintenance or optimization of the affected components on the basis of closed loop engineering.

Of course, capturing and evaluating the signals from a sensor measuring the vibrations on an axle, for example, makes it possible to predict the wear on a bearing and initiate maintenance even without knowledge of the development history. However, it would be interesting to know why the bearing failed, whether the design was not strong enough for the stresses and why, what other machines could be affected by the problem or whether components from a particular supplier are tending to fail. A direct link to the digital planning data allows correlations of this kind to be identified immediately without having to laboriously reconstruct this data using mostly paper-based documents. This direct link to the development and planning data that describes the history of the real asset is called a digital thread. The digital thread is thus synonymous with the end-to-end digitalization of product information.

The centrality of the digital thread

PROSTEP sees the digital thread as the thing that digitally links the information that belongs to a real product instance across all processes and IT systems (Figure 2). It can be seen as describing the creation of this product instance, including all the relevant decisions and events. On the one hand, this makes it possible to bring together all the information from the life cycle of the product instance or the real asset and thus forms the basis for the creation of a digital twin.

It is possible to manually rebuild the digital twin without the digital thread, but it is difficult or impossible to keep it up to date. On the other hand, traceability along the digital thread allows decisions during development and production to be questioned and optimization potential to be identified in conjunction with the opera-

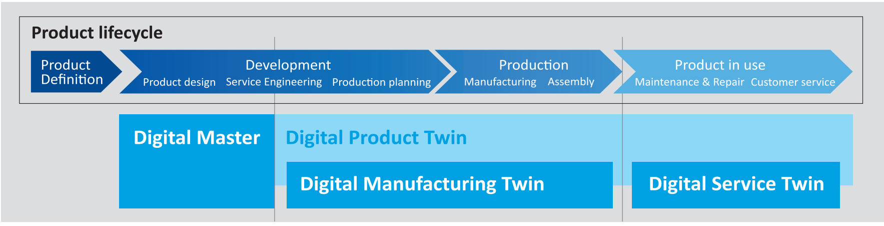

Figure 1. Use cases for the digital twin (source: PROSTEP)

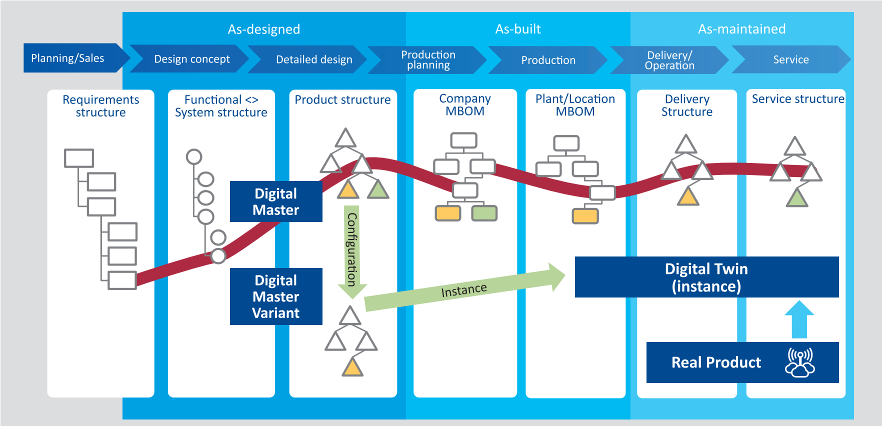

Figure 2. The digital thread (source: PROSTEP)

ting data from the real life of the asset.

Automatic merging of information requires the creation of an information model that represents all relevant information objects and their connections. This should be seen as a map that can be used to identify and eliminate interruptions to the information flows. The information model is created independently of the current IT environment, but can then be mapped to the existing IT systems. At the same time, it provides orientation in the event that the PLM architectures need to be modified in respect of the digital thread.

Currently, end-to-end digitalization is made more difficult by the fact that the product data from the individual disciplines is distributed across a large number of data silos (e.g. TDM, PDM, ALM, ERP systems) and managed in different structures. Design, production and service BOMs represent different, often independent, views of the product, which must be merged without media discontinuity. One essential aspect of the information model must therefore be to describe the required product structures in a uniform product structure model.

This uniform product structure model is used to support processes involving different IT systems and their information flows in order to avoid redundancies and information discontinuity.

Management of the product configurations

From the perspective of PLM, the starting point of the digital twin is a specific configuration of the product or production system, for example the asset in its delivered state. This includes not only mechanical, electrical/electronic and software components, but perhaps also information relevant for service, such as the service life of certain components. Bringing this information together and maintaining it manually is time-consuming and error-prone, especially as the configuration changes over the course of the product's life, whether through software updates or other measures in the context of asset maintenance or further development. It is expected of today's PLM systems that they should be able to automatically extract the configuration for the digital twin and keep it up to date.

In order to generate one configuration of the product throughout the product structure model, which spans different IT systems, it is necessary to use a powerful PLM integration platform that has connectors to all participating IT systems and that supports structure mapping. As a system-neutral intermediate layer, it enables the coexistence of different IT systems and creates the prerequisite for bringing together the information from the individual IT systems in a way compliant with the digital thread concept.

In this context, PROSTEP talks about the concept of configuration lifecycle management (CLM), which makes it possible to generate views of the product that cross IT system boundaries and are valid at a given time and to manage product configurations across all phases of the product lifecycle (Figure 3).

The main function of CLM is to generate the various views of the digital product model during the lifecycle, to keep them consistent, and to document their validity over time. To do this, it uses cross-system, interdisciplinary baselines. These baselines document the status of the configuration at a certain point in time or maturity level and thus also control the representation of the Digital Twin. They enable companies to immediately and reliably answer the following questions at any point in the process: whether and how the product or asset meets the requirements placed on it and in what state the asset was at a given point in time, for example, which product configuration was delivered to the customer.

CLM makes use of the product structure and the classification and configuration of the product data, for example on the basis of attributes and calculated values such as the date of deployment or expiry, the serial number or logical conditions, to sort, filter and combine the product data. The information from the authoring systems and data management systems used are combined in a virtual data model using existing integration facilities and modern data linking

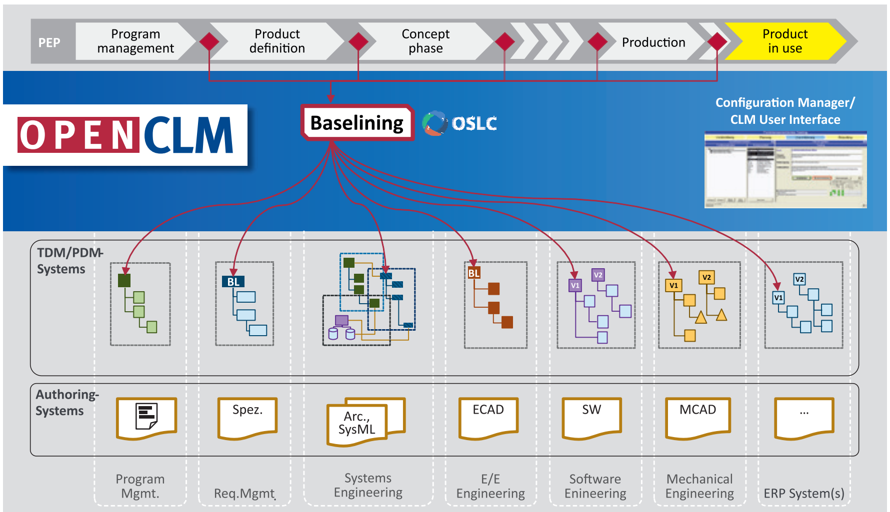

Figure 3. Configuration Lifecycle Management (source: PROSTEP)

(source: PROSTEP)

techniques. Depending on which criteria users select, different results will be provided in their baselines. They can be linked directly to the information in the data sources, so that they can be displayed together with the required properties such as maturity level, date of last change, responsibilities, and be compared with other deliverables from the project.

Cross-Company collaboration

In industries such as mechanical and plant engineering or shipbuilding, companies are presented with the challenge that the manufacturer who builds and provides the digital twin is not necessarily the operator/user who feeds it with operational data. Both the digital data and the operating data, or at least some of it, therefore has to be exchanged and synchronized across companies in order to keep the digital twin up to date and to allow the operating data to be used for the continuous improvement of real assets. Issues around such things as data security, protection of intellectual property and ownership of the data therefore play a crucial role when setting up and using a digital twin application.

Today, customers are increasingly requiring their suppliers to deliver digital data and models to support digital twin applications along with the physical assets. CLM allows you to control not only the amount of information provided, but also the level of detail of the information and the formats in which it is delivered. The information can be compiled largely automatically and made available to the customer as a data package, for example in 3D PDF format.

In order to maintain the digital thread for cooperation across company boundaries, the exchange partners must first agree on the scope of the information to be exchanged and set down common standards for handling this information. But the key issue is where the digital twin should reside. PROSTEP is of the opinion that it is appropriate to set up a joint collaboration platform for this purpose. This platform will become part of the information model. It offers customers the opportunity to have access to the information they need to build their digital twin application while the development process is still underway and to synchronize changes to the master models during operation as required. If the digital thread is to be reconstructed, it is essential that the customer has not made any changes to the underlying information model. The common platform can also be used to link some of the operating data that the manufacturer needs for new service offerings such as predictive maintenance or product improvements to the digital thread

Three building blocks for the digital twin

The foundations for the digital twin are laid during product development and production planning. To bring it to life and keep it alive, the digital umbilical cord must not be cut. This is why an integration platform is needed to make the digital information from the various authoring and data management systems available at all times. A powerful configuration management system that manages the relationships between the various scopes of information and the extent of their validity is essential for building a digital twin. However, end-to-end digitalization is not a one-way street. In order to derive maximum benefit from the product twin in terms of closed loop engineering, traceability must be ensured between the digital twin and the digital thread. The creation of a collaboration platform upholds end-to-end digitalization even beyond company boundaries.

About the author

Dr. Lars Wagner was born in 1977 and has worked in the shipbuilding sector at PROSTEP's Hamburg office since 2012. He has headed up the "Digital Twin" technical consulting cluster as Processes & Methods manager in the Strategy & Processes business unit since 2017. Born in Bonn, he studied mechanical engineering at the Hamburg University of Technology, specializing in production technology, where he wrote his doctoral thesis on the subject of production organization and material flow simulation.

Summary

Digital twins make it possible to simulate the behavior of physical assets, whether they be ships, cars or plant equipment, to monitor them during operation and to continuously improve them by feeding back operational data. The data and models from development provide the context in which the operating data can be correctly interpreted. Preparation and provision of this data in a way that is twin-compliant is therefore an essential prerequisite for the deployment of digital twin applications.

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