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Taking a close look at successful digitalization

PROSTEP

Understanding and implementing the digital twin and mastering its complexity

Taking a close look at successful digitalization

The digital transformation is far from being merely an IT-specific topic; it is shaking the foundations of companies. The use of digital tools permanently changes the way users work and at the same time wakes expectations regarding how they should be used in the future. Companies need redesigned business processes and self-learning systems if they are to be able to respond agilely to the challenges posed by a high level of volatility. They need to work together more closely both internally and in the supply chain in the context of an extended enterprise. This means that the relationships and interfaces between OEMs and their suppliers will have to be rethought to a certain extent. At the same time, companies need to rethink their existing business models so that they can supplement their products with additional value-added services or even take a holistic approach and offer them as a service. The digital champions, whose business models no longer focus primarily on products but instead on the data they collect, serve as role models.

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At the heart of successful digital transformation lies the core data and the ability to handle this data efficiently and use it for new services or the transition from a product-oriented to a service-oriented business model. In the context under consideration, core data refers to the data in its "atomic" form, i.e. in the form it is generated by the original authoring systems. This represents a significant expansion compared with the metadata that a large number of existing PLM systems currently limit themselves to managing. Core data can include requirements, architectural models, functional descriptions, electrics/electronics (E/E) and hardware models. The challenge when developing a digital twin is storing this data in a clearly structured manner and linking it in order to make interrelationships transparent. Mastering core data and ensuring its availability are not only prerequisites for using digital twins but also for the use of intelligent assistance systems and the evaluation of data with the help of (big) data analytics.

In complex systems, there is usually no single digital twin. Instead, a large number of digital representations exist or are created throughout the entire lifecycle. They build on each other, include overlapping data, and work closely with each other via conceptual data models and other shared services.

PLM capabilities in the context of digitalization

Existing PLM infrastructures cover primarily conventional product data management (PDM), with functions for version and configuration management as well as the management of formal PLM processes such as release, change management, certification and verifying compliance. In sustainable concepts, the two lower levels must be supplemented by two additional layers with shared digital services. These make it possible to access certain core data and thus ensure a better understanding of the data content. It became clear during concept development that every company has to decide for itself on the granularity of the core data required for the digital twin.

A new term for these extended PLM capabilities, shared digital enterprise services (SdES), was coined to prevent confusion with the traditional term "PLM ".

End-to-end digitalization plays a key role in the context of process efficiency. For example, users need to be able to exchange core data from initial systems engineering, such as the requirements, with the individual domains mechanics, E/E and software, using different authoring systems. They also need to be able to use this core data consistently in simulation applications or to fill the authoring systems with a consistent data set for a new project or program. This requires additional PLM capabilities, which Airbus, for example, has been working on intensively for ten years.

At the same time, digitalization paves the way for new capabilities that make it possible to derive additional knowledge from the core data using systematic semantic evaluations. This is important when it comes to calibrating digital simulation models using data from the real world. It might, for example, be that manufacturing tolerances in product assembly prevent highly sensitive electronic measurement equipment from being calibrated as precisely as the underlying 3D model of the product requires. The measurement or calibration of the real-life product could thus be fed back into the digital 3D model and reproduced in order to define permitted tolerances or perform digital effects analyses. Shared digital enterprise services not only allow the end-to-end digitalization of business processes and the creation of networked process chains but also new, data-driven business models. They provide the basis for implementing a sustainable and scalable digital twin concept that can support different use cases.

Quelle: earn.g2.com/immersive-experience

The digital twin as an expression of reality

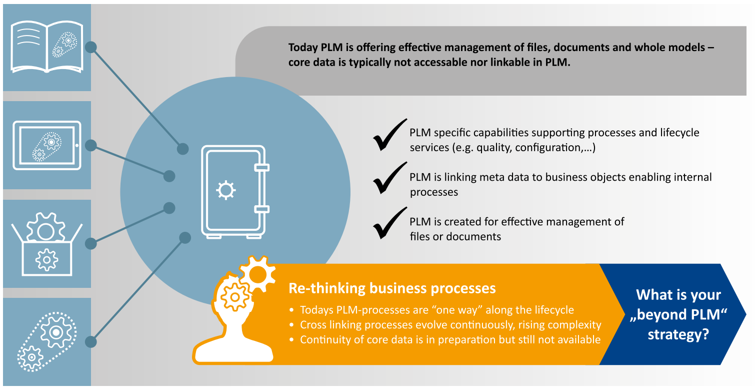
The digital twin is generally defined as a virtual representation of an entity that actually exists. This can be a product, service, process or even a person or organization. Every search performed using Google, every music track streamed and every purchase made online rounds out our digital profile in the background. We have learned from the digital champions that these digital avatars represent added value because knowledge that allows predictions about our behavior to be made can be derived from them. Digital twins can interact not only with their real-life counterparts but also with other digital twins, like entities in the real world. In the world of complex technical systems, on the other hand, the virtual outline of the digital twin begins to take shape before the real-life object exists. This means that at the beginning of the product development process, the digital twin is more like a prediction about a future system or system behavior. The digital twin of a technical system comprises the core data generated by the authoring tools in the form of descriptive models. These are expanded as required to include additional data that is used to initialize analytical models, as well as time series (results) from certain tests. These three types of data (descriptive data, analytical data, results data) have been around for a number of years. What is new as digitalization gathers pace is their interlinking, either automatically or by specialized data scientists.

Constant companion to the product lifecycle

The digital twin takes shape during the process of creating a product or system. It initially exists as an as-designed representation. This twin is largely identical to what other authors refer to as the digital master, i. e. a complete description of the later product including all the information about how it should look and behave. Accordingly, an as-planned twin of the production systems and production logistics needed to manufacture and assemble the systems also exists. Information from both twins can be combined in the as-built twins of the systems actually built. In addition to the actual configuration, these twins also include information from production, such as the production equipment and processes used or deviations during assembly that are within the tolerance range but which may have an impact on later behavior. At the same time, they provide the basis for the as-operated twins, which record operating data and information about service activities, components that have been replaced or upgrades. It is important that the digital twins build on each other, or originate from one another, and are linked to together without exception.

Information flows between different digital twins

The web of relations between the digital technical systems with a large number of possible use cases is highly complex. Information needs to flow between the different representations throughout the lifecycle in order to synchronize the idealized properties of the as-designed



Where PLM stands today

Source: 3DSE Management Consultants GmbH

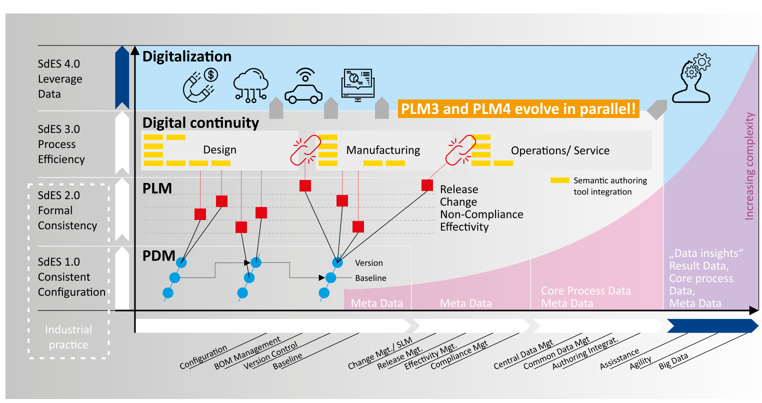
state with manufacturing information and, for example, to enter the precise position of a sensor in the as-built twin – a position that may differ from the ideal position in the as-designed twin. The aim is to establish end-to-end digitalization and constant interplay between the real and digital worlds. Which specific properties are fed back depends on the use case that the digital twin is intended to support. This however has no impact on the basic concept.

It is also important to feed back information gathered during operation, for example when an aircraft is measured following a hard landing to determine what has bent or been deformed and to simulate the impact on flight behavior. This means that it must be possible to track the properties specific to the serial number. In the context of closed-loop engineering, it must also be possible to guarantee that potential problems in a delivered product configuration can be traced back to a design baseline. The link between the different digital twins is a prerequisite for ensuring traceability.

Suppliers account for the majority of the value added in the aerospace industry and other industries. How efficiently the digital twin can be used for which use cases depends on whether and how suppliers make their digital twin available. Suppliers must therefore be included in this calculation. This may mean that the digital twin ends up living in a federated architecture in the cloud, where everything can be traced but not everything is visible to all those involved.

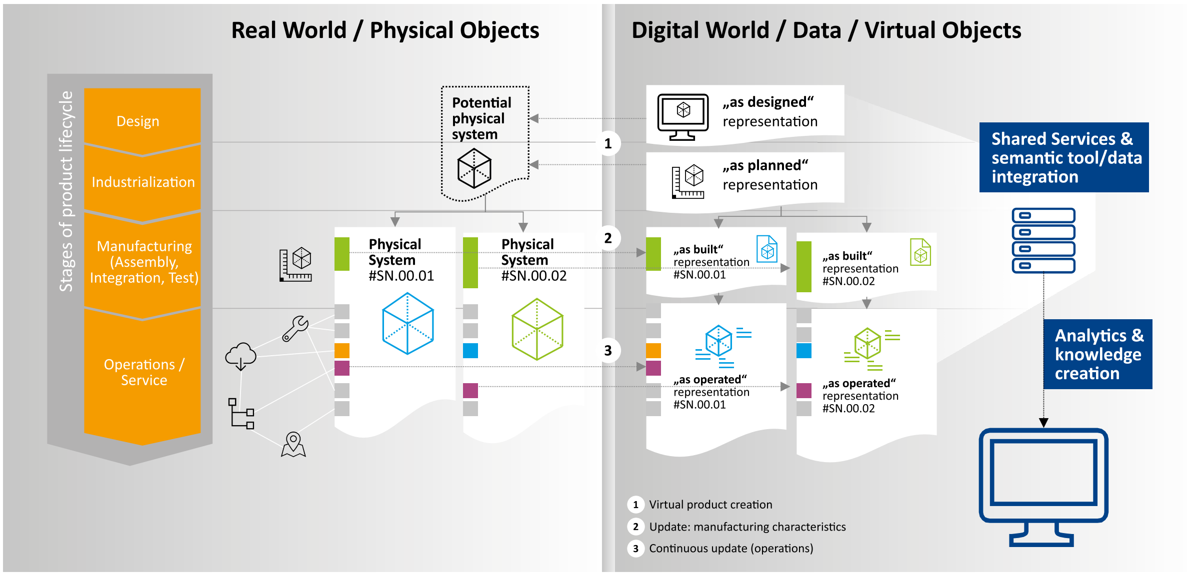
Reference model for shared digital enterprise services

A reference model for the shared digital enterprise services was developed together with the experts from Airbus on the basis of the findings from the various use cases and ensures the convergence of existing and new PLM capabilities. It makes the core data accessible in an integrated viewer independently of the authoring systems. The bottom layer of these shared services is semantic application integration, which ensures end-to-end digitalization of core data and not only establishes the relationships between all the phases of a product's



The further evolution of PLM will give rise to digital services and provide the basis for the digital twin

Source: Airbus Defence ans Space / Airbus Group



Shared digital enterprise services – operational framework and functionality of the digital twin
Source: 3DSE Management Consultants GmbH

lifecycle but also across multiple use cases. The relationships between the core data from different authoring systems are mapped in system-neutral data models that also include functions for filling the models with content. There is a central database in which the data used across different systems is maintained.

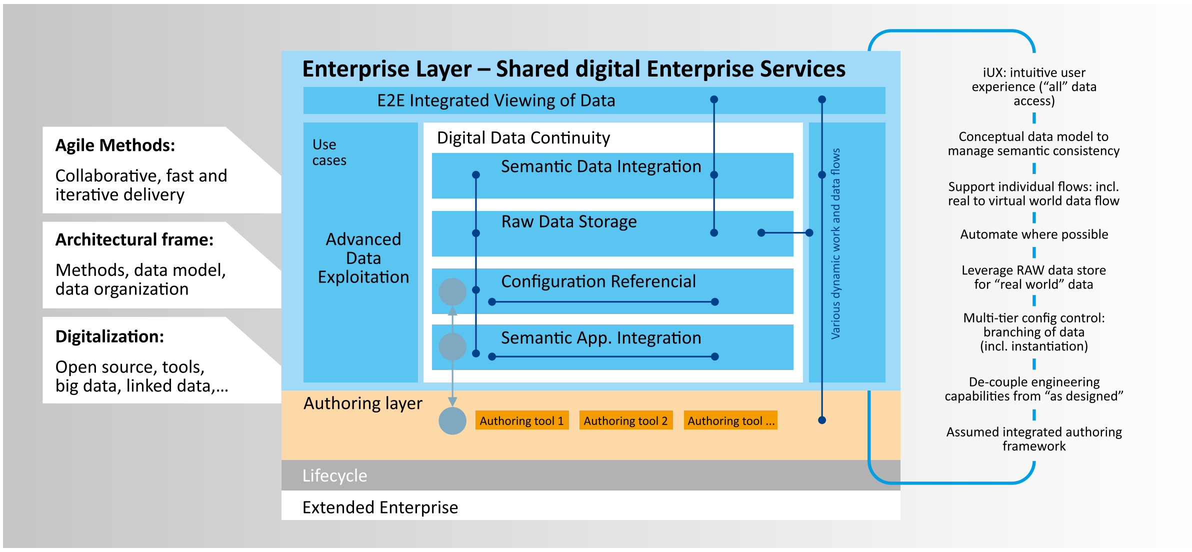
The Configuration Referencial layer essentially comprises existing PDM/PLM functions that ensure the consistency of the configurations at file and document level. The Raw Data Storage layer is used to support digitalization and collects all the data from engineering, testing, manufacturing and operation. The Semantic Data Integration layer can then be used to establish relationships between the data for specific use cases. The reference model also provides tools and methods for a more detailed, AI-based analysis of the data. The workflows for using shared services should take into account the fact that agile methods are being used to an increasing extent in product development.

The digital twin "lives" as an information structure in the different layers of the shared digital enterprise services, while the actual information is distributed across different authors and management systems and is used as needed. If the engineering data was stored only in the authoring systems, it would not be possible, for example, to establish references to manufacturing information that might have an impact on system behavior. Different PLM capabilities are required, depending on the purpose of the digital twin. Today, these capabilities are closely linked to specific systems, which makes it impossible to use the digital twin of a system that has already been manufactured or is in operation to perform an analysis in a simple and straightforward way.

Consistent access to the data in this federated system architecture is of great importance. The key to this is the end-to-end viewing layer. Its clear organizational structure and Google-like search functions make it easy to use. It is not merely a cockpit but also a very powerful search engine that allows each person and role to choose a different entry point according to their preferences.

Shared services provide a framework

A certain organizational structure for the different activities is required if a digital twin is to be made available for complex technical systems. In some cases, new or alternative data exchange process will need to be established to ensure that the digital representations remain up to date. The framework for this organizational structure is provided by the shared digital enterprise services



The digital twin is based on data generated from a specific perspective

Source: Airbus Defence and Space / Airbus Group

described in the white paper. They form a complex infrastructure that supplements the authoring tools. Read more in the joint whitepaper by 3DSE and PROSTEP at www.prostep.com/whitepaper.

A key issue when it comes to the acceptance of digital tools is the user experience, i.e. the question of how the required information can be presented in a simple and attractive manner in particular. Conceptual data models are the key to maintaining semantic consistency. Getting to grips with them is a task that cannot be left to the vendors of the authoring systems. As a configuration reference, the PLM systems have a permanent place in this framework, at least as far as the users of the authoring systems are concerned.

The digital twin: gateway to a new age

The white paper drawn up by 3DSE Management Consultants GmbH (Munich) and PROSTEP AG (Darmstadt) makes it clear that the digital twin is a highly complex, company-specific task. It requires new concepts for a digital enterprise architecture that links business strategy and the application level with each other. Shared digital enterprise services extend the conventional PLM Infrastructure and make available the capabilities needed to support different use cases for the digital twin throughout the product lifecycle.

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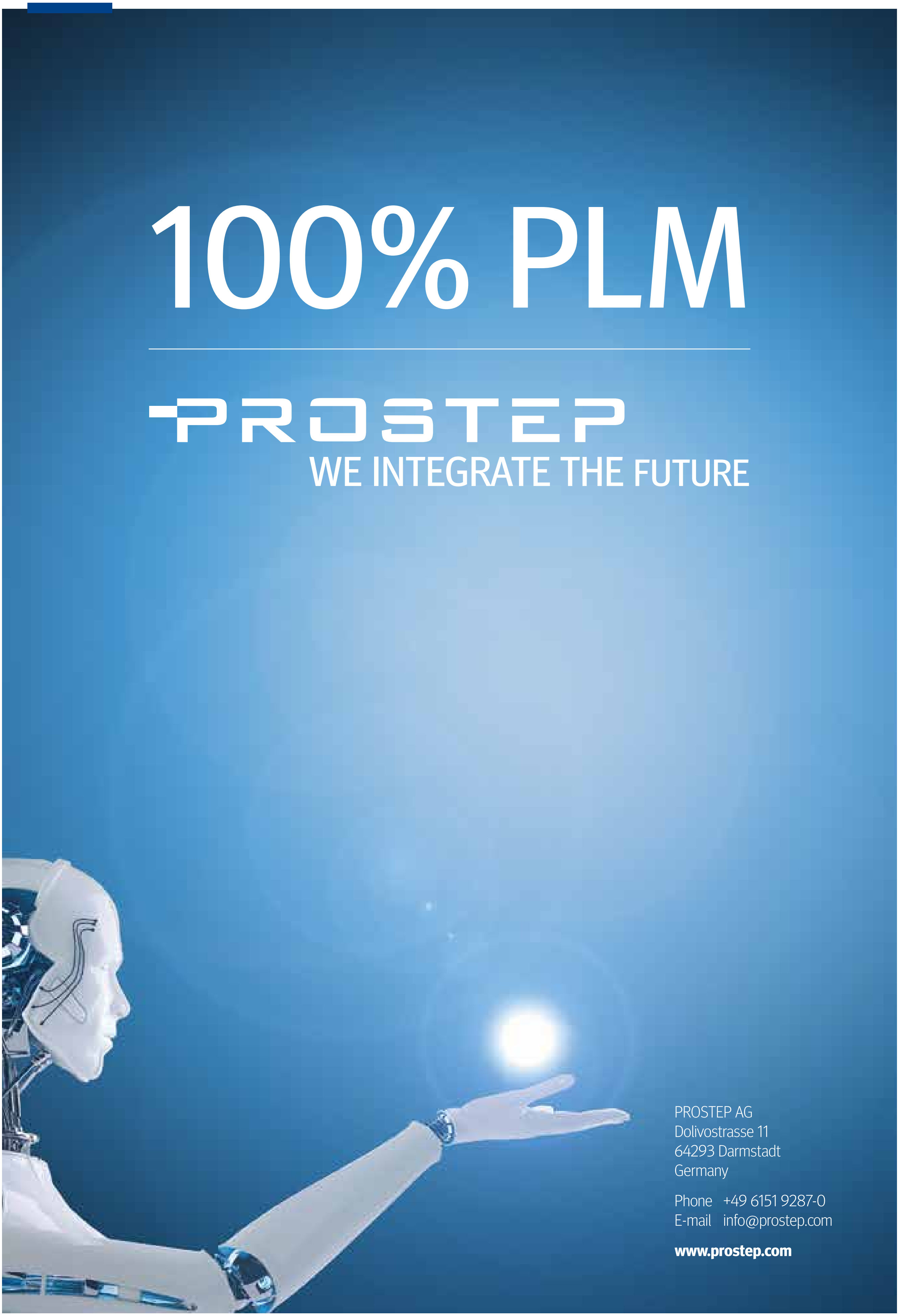
100% PLM
PROSTEP
WE INTEGRATE THE FUTURE
PROSTEP AG
Dolivostrasse 11
64293 Darmstadt
Germany
Phone +49 6151 9287-0
E-mail info@prostep.com
www.prostep.com