3DSE Management Consultants

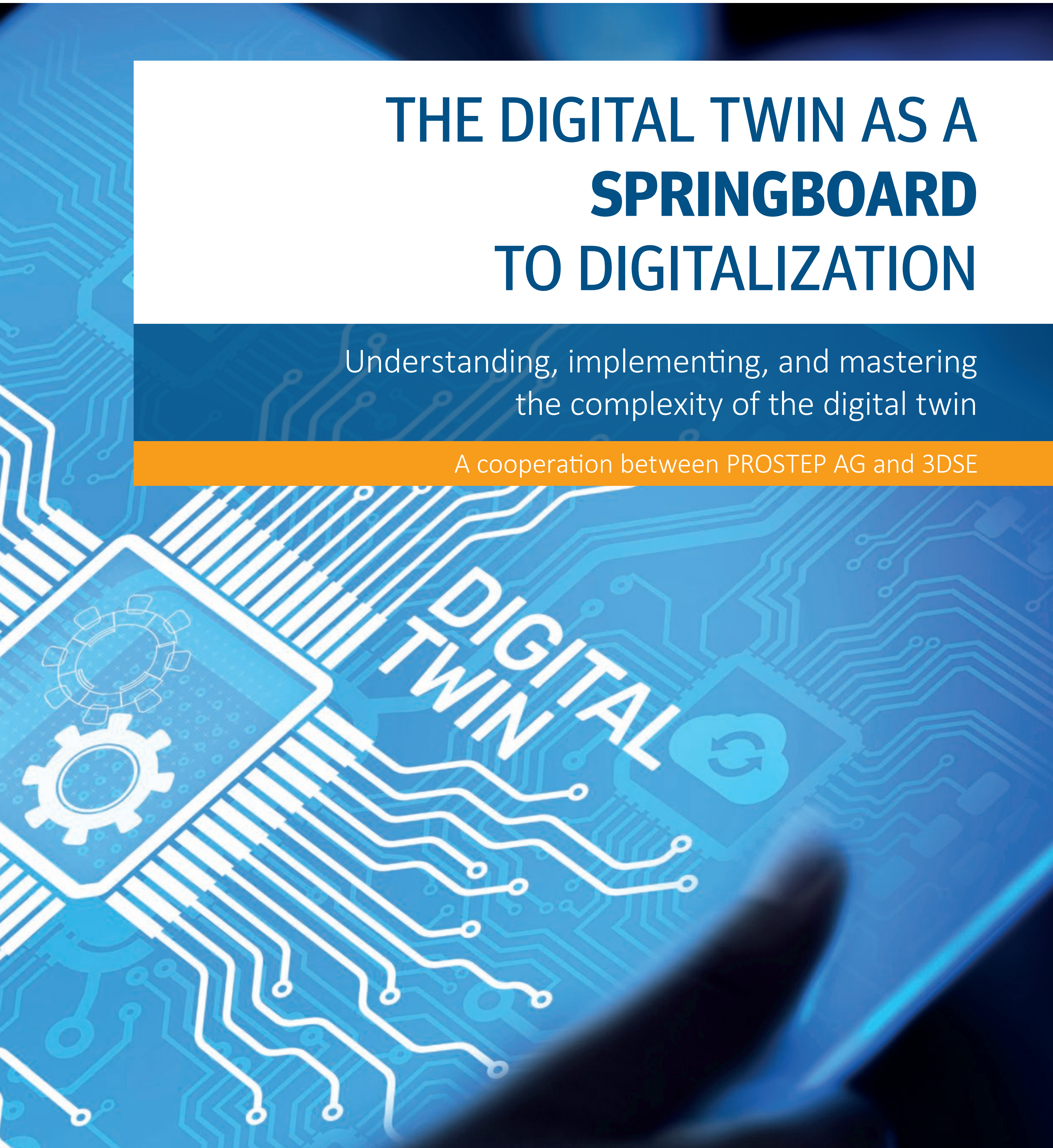
PROSTEP integrate the future

WHITEPAPER

THE DIGITAL TWIN AS A **SPRINGBOARD** TO DIGITALIZATION

Understanding, implementing, and mastering the complexity of the digital twin

A cooperation between PROSTEP AG and 3DSE

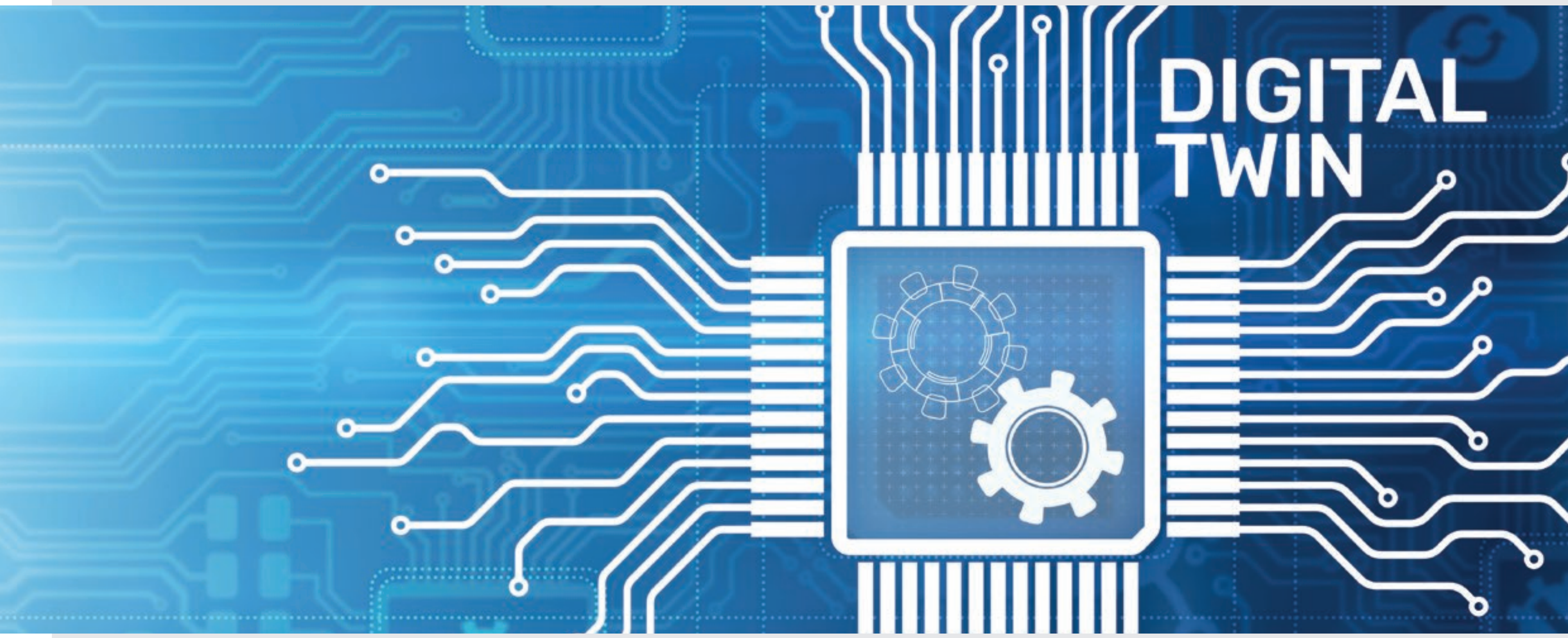


Content

The digital twin as a springboard to digitalization

Companies in every sector of industry need to digitally transform their business to remain competitive in an increasingly digital world. Positioning the appropriate mindset to enable systematic use of digital technologies to increase operational efficiency using the inherent potential of the data with the aim of developing new business models provides the basis for this digital transformation. One such mechanism for increasing added value is the digital twin, which connects the digital world of product development and production planning with the real world of production and operation. Digital twins today are the focus of numerous digitalization initiatives across all sectors of industry.

This white paper outlines the organizational and technical foundation of a sustainable digital twin concept. It summarizes the key findings of a comprehensive concept study on the digital twin, which the consultancies 3DSE and PROSTEP prepared together with Airbus Defence & Space. The starting point was the idea of placing the digital twin in the existing PLM landscape. However, the study indicated that a different type of IT environment with additional PLM capabilities is required to make available and manage the different configurations of the digital twin. Requirements relating to the digital twin may seem more complex in the aerospace and defense industry, yet can be applied broadly to any industry.



Rethinking business processes and models

The digital transformation is far from being a purely IT-specific topic. It is rocking the foundations of companies. The use of digital tools permanently changes the way users work and at the same time creates new expectations regarding how they should be used in the future. Digitalization is raising questions about business processes and practices in development, production, and service. Companies need lean innovative processes and self-learning systems if they are to be able to respond quickly to the challenges posed by the volatility of complexity. They need to work more closely together both internally and in the supply chain (extended enterprise). This means that the relationships and interfaces between OEMs and suppliers must be redefined.

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. Digital champions whose business models no longer focus primarily on (their) products but instead on the data they collect serve as role models throughout their verticals. When it comes to smart connected products, the traditional boundary between development/production and operation has to be eliminated. In particular, sovereignty over the data that accumulates during development/production and operation needs to be strategically managed and organized.

The digital economy is defined as the digital connection of people, devices, processes and systems across all areas of the global economy. Companies worldwide are forced to challenge their

RE-THINKING BUSINESS MODELS

Drive competitive advantage by expanding beyond traditional industry boundaries

- Outcome based model
- Expand to new industries
- Digital distribution channel
- Compete as an ecosystem
- Shared economy
- Digitalization of products & services

RE-THINKING BUSINESS PROCESSES

Innovate or eliminate fundamental business processes due to digitization

- Real time processes
- Predictive processes
- Collaboration processes
- Lean processes
- Content rich business processes
- Self learning processes

RE-THINKING WORK

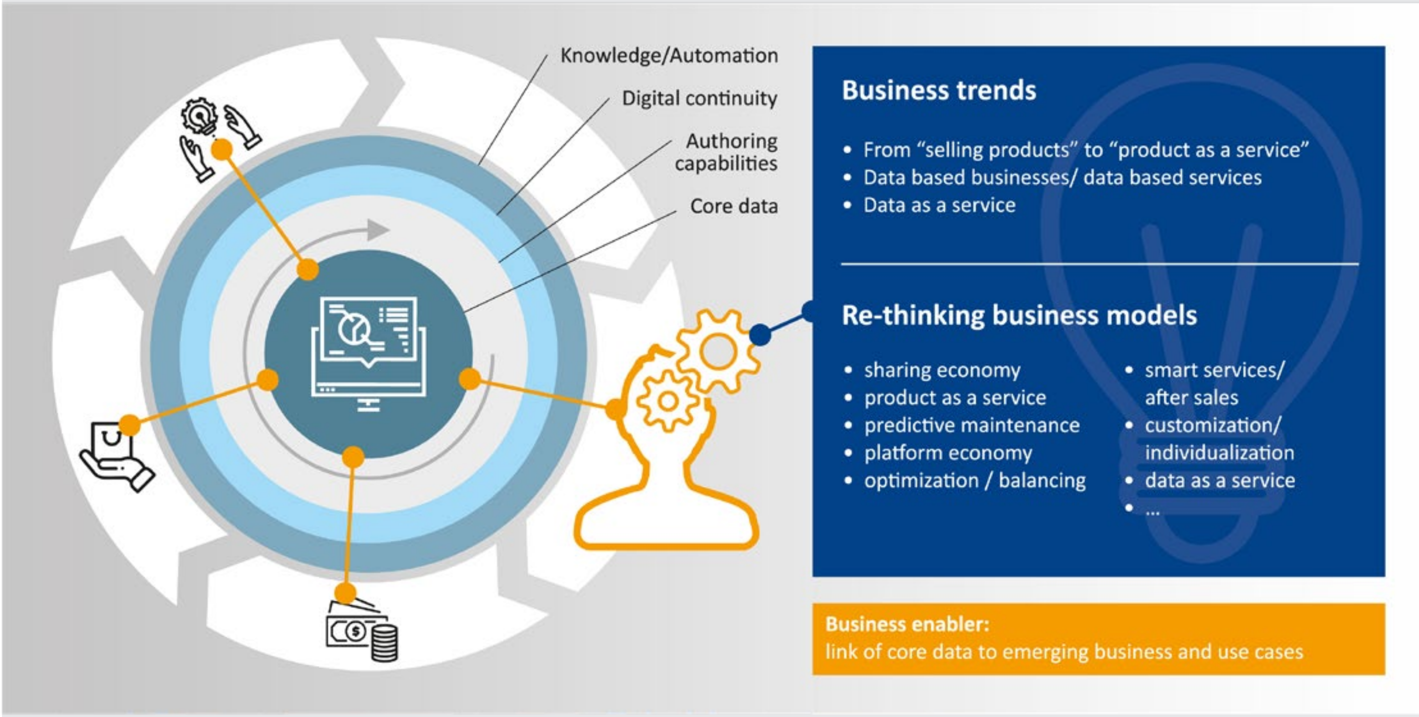
Real-time information given to make the right decisions and drive immediate impact

- Consumer grade user experience
- Self service
- Real tim collaboration
- People-machine collaboration
- Natural languague interaction
- Cognitive world and AI

Core data at the heart of the digital transformation

At the heart of 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 generated by the original authoring systems. This represents a significant expansion compared with the metadata that many existing PLM infrastructures currently limit themselves to managing. Core data can include requirements, architectural models, functional descriptions, electrics/electronics (E/E), hardware models, and more. The challenge when developing a digital twin is storing this data in a clearly structured manner and linking it to make interrelationships transparent. Mastering core data and ensuring its availability are not only prerequisites for digital twin applications, but also for the use of intelligent assistance systems and the evaluation of data with the help of (big) data analytics.

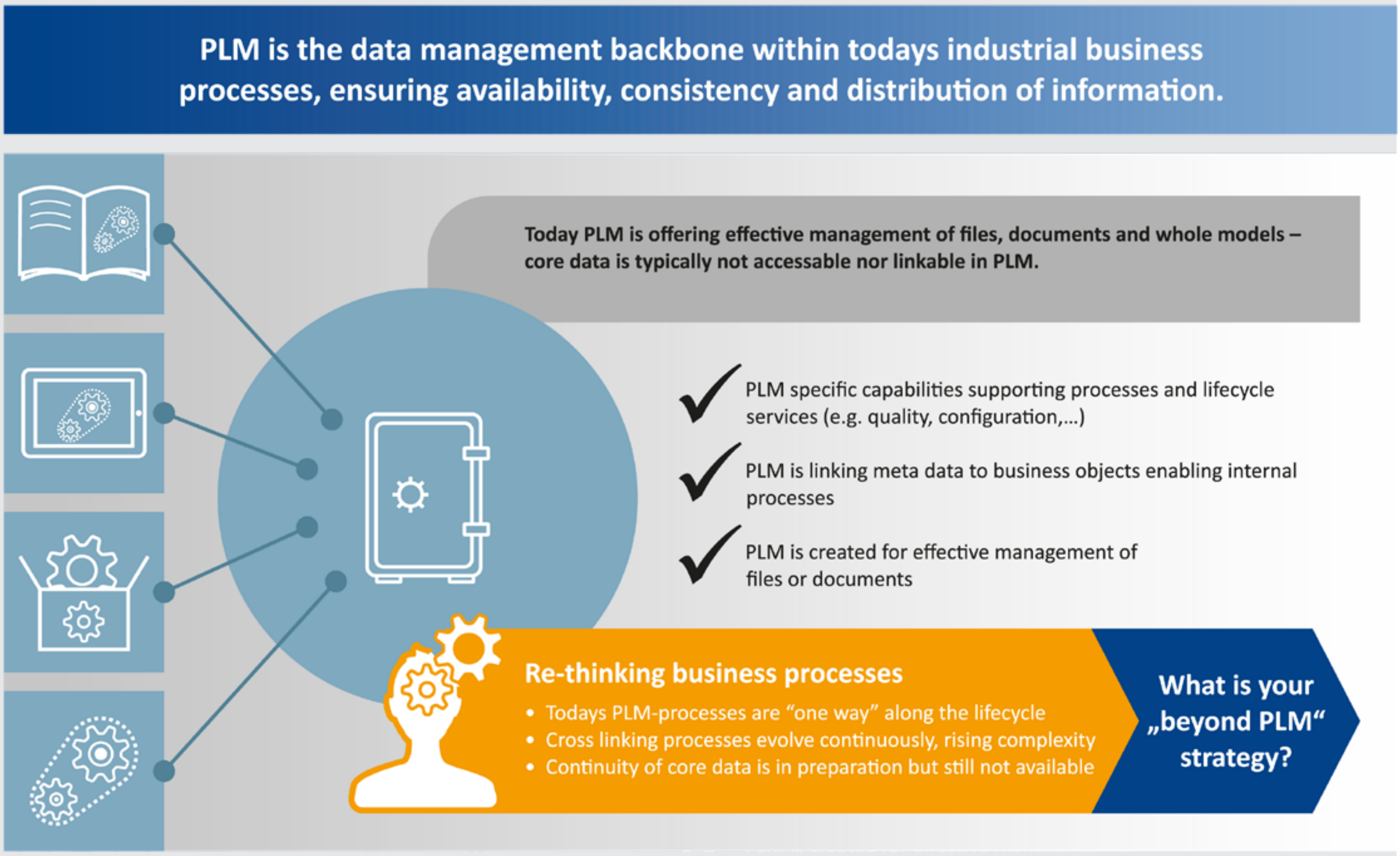
Within Digitalization core data is in scope – supported by powerful data handling structures and framework to enable digital business.



File management in today's PLM infrastructures

Although today's PLM infrastructures claim to manage the data generated by the various engineering disciplines, they barely do justice to the extended requirements relating to management of the core data. Many manage only files, documents, and monolithic models, thus supporting core processes such as version management, configuration management, and enterprise-wide provision. The actual core data, however, cannot be accessed or can only be accessed using the respective authoring system. This means that it cannot be linked across systems or used throughout the processes. To do this, PLM infrastructures would need to look deeper into the files, i.e. not only manage the container (file) but also understand its contents.

Another problem is that current IT infrastructures usually support PLM processes throughout the product lifecycle in one direction only. In addition to the support established for product development through to the operational phase, industry today needs a higher level of cross-linking between processes and feeding data from later lifecycle phases and process steps back into earlier phases. The pressing question is whether or not established PLM landscapes are capable of making the digital twin available and, if so, how?



PLM capabilities in the context of digitalization

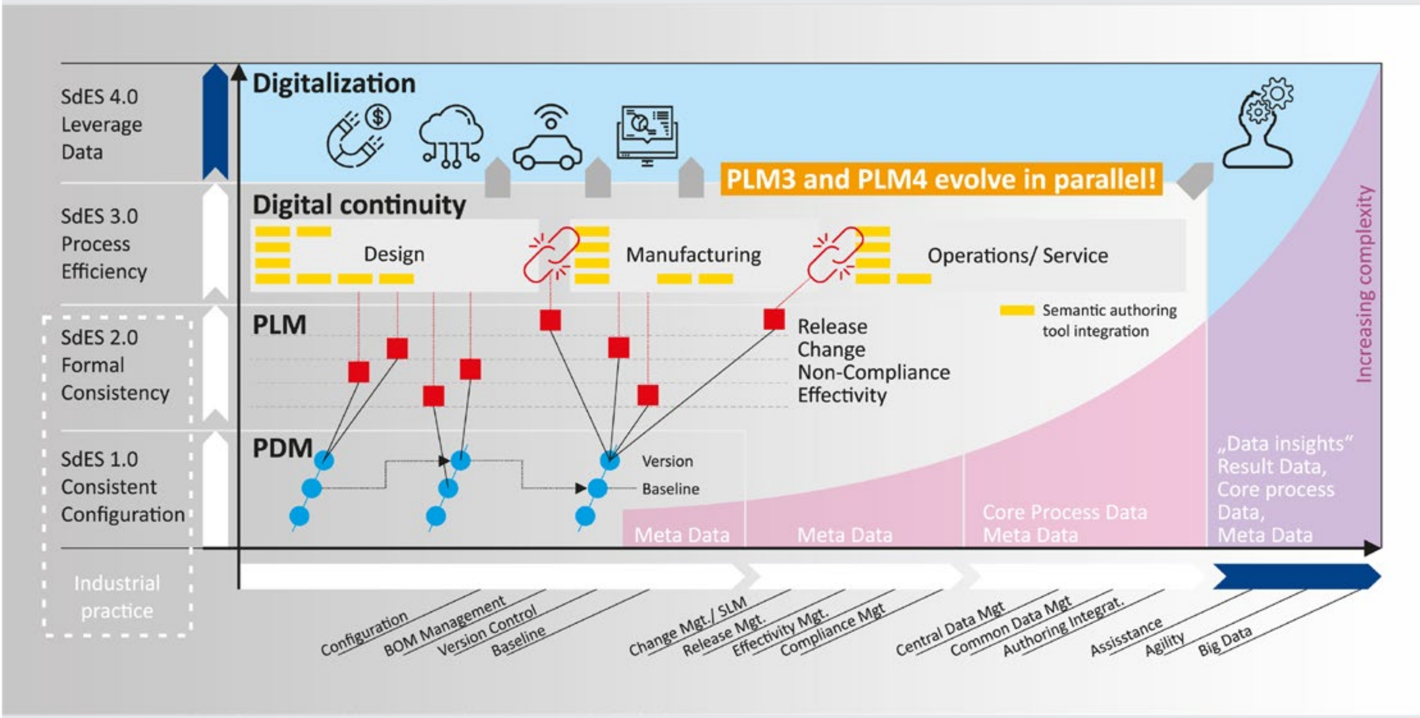
Existing PLM landscapes cover primarily conventional product data management (PDM) with functions for version and configuration management. Today's systems enable the management of formal PLM processes such as release, change management, certification and verifying compliance. In sustainable concepts, these two lower levels must be supplemented by two additional layers with shared digital services (PLM 3 and 4). These make it possible to access to certain core data and thus ensure a better understanding of the data content. It became clear during concept development that each company must choose for itself the granularity level 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 avoid weighing down the traditional term "PLM" and prevent confusion.

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 relating to the individual domains mechanics, E/E and software, via different authoring systems, use this core data consistently in simulation applications or fill the authoring systems with a consistent data set for a new project or program. This requires additional PLM capabilities which Airbus 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. Manufacturing tolerances in product assembly might 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 product could thus be fed back into the digital 3D model and reproduced in order to define permitted tolerances or perform digital impact analyses.

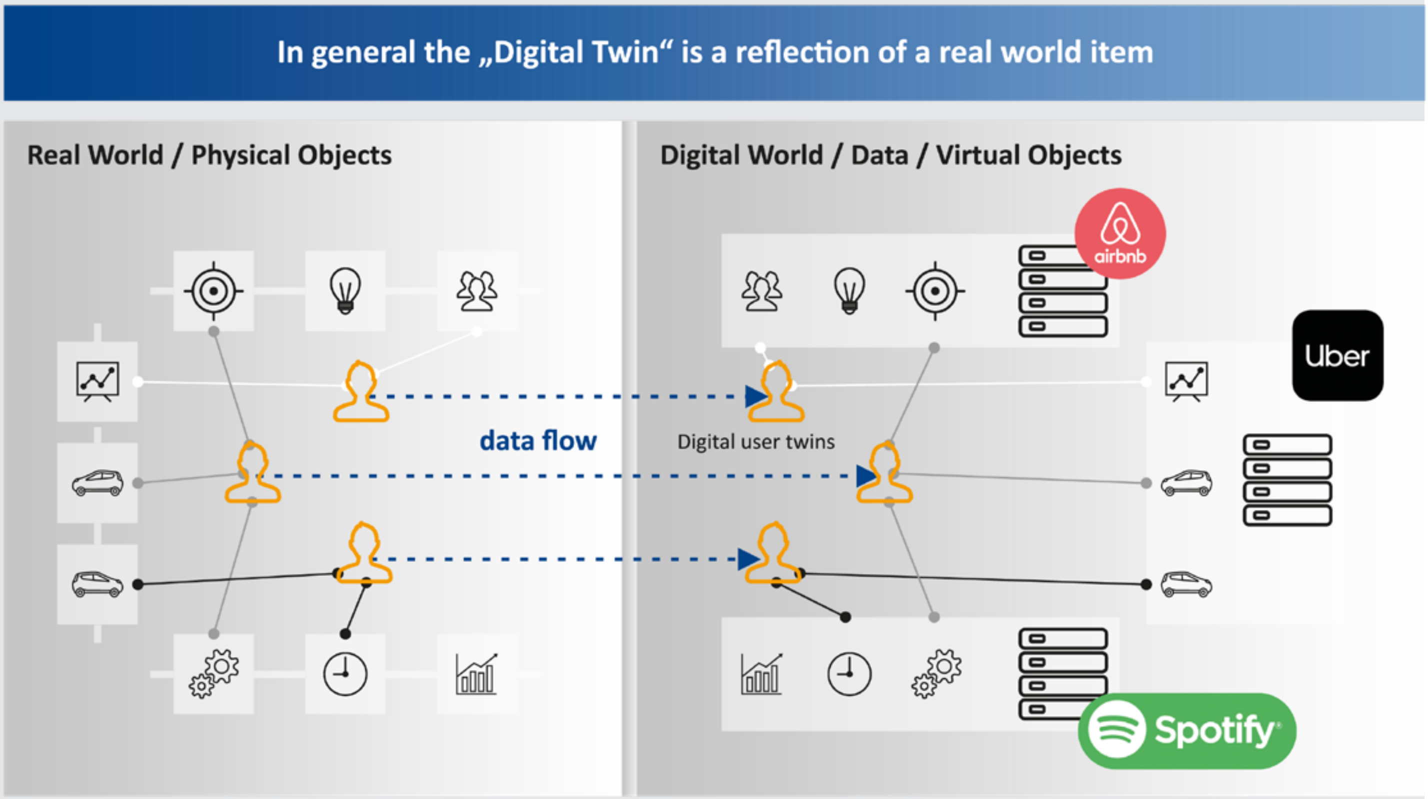
Evolution of PLM provided digital services and provides the underlying basis of the digital twin



Quelle: Airbus Defence & Space, Airbus Group

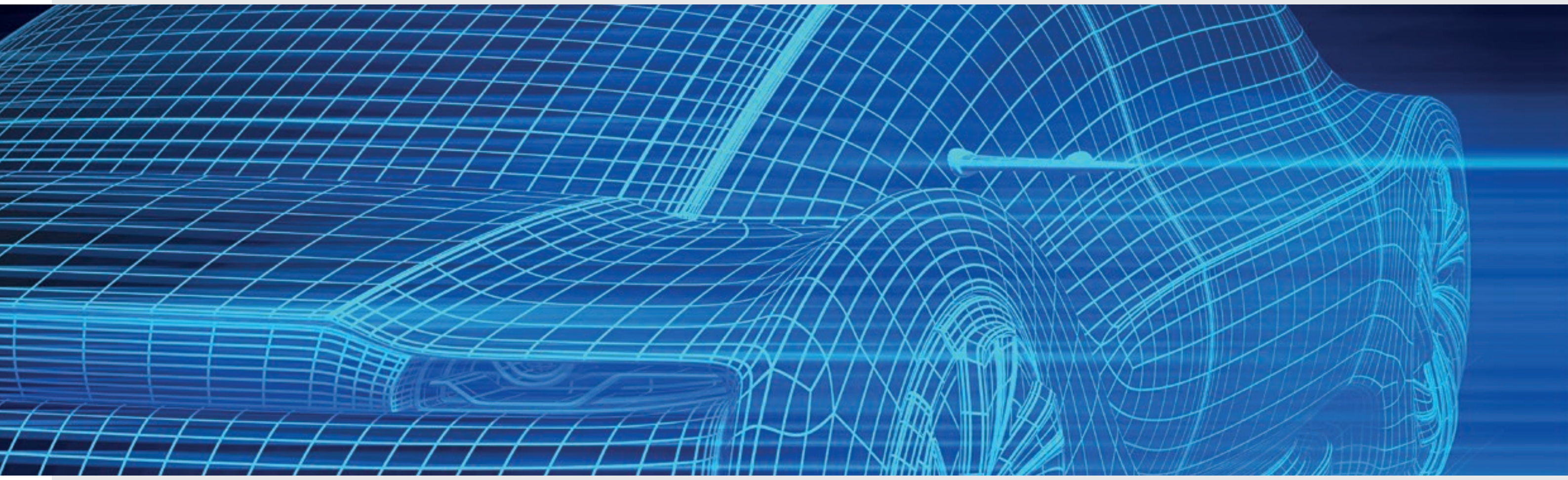
Shared digital enterprise services not only allow the end-to-end digitalization of business processes and the creation of networked process chains but also new data-driven business models. They provide the basis for implementing a sustainable and scalable digital twin concept that can support a wide range of shared digital enterprise use cases.

The digital twin represents a real entity



The digital twin is generally defined as a digital or virtual representation of a real entity which can be a product, service, process, or even a person or organization. In the consumer world of Amazon and Co., this reality usually already exists and is merely extended or mapped digitally. Every search performed using Google, every music track streamed and every purchase made online allows our digital profile to be rounded out in the background. We have learned from the data champions that these digital avatars represent added value because we can derive knowledge from them that allows predictions about our behavior. Digital twins can interact not only with their real-world 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 object exists. This means that at the beginning of product development the digital twin is more like a prediction about a future system or system behavior.

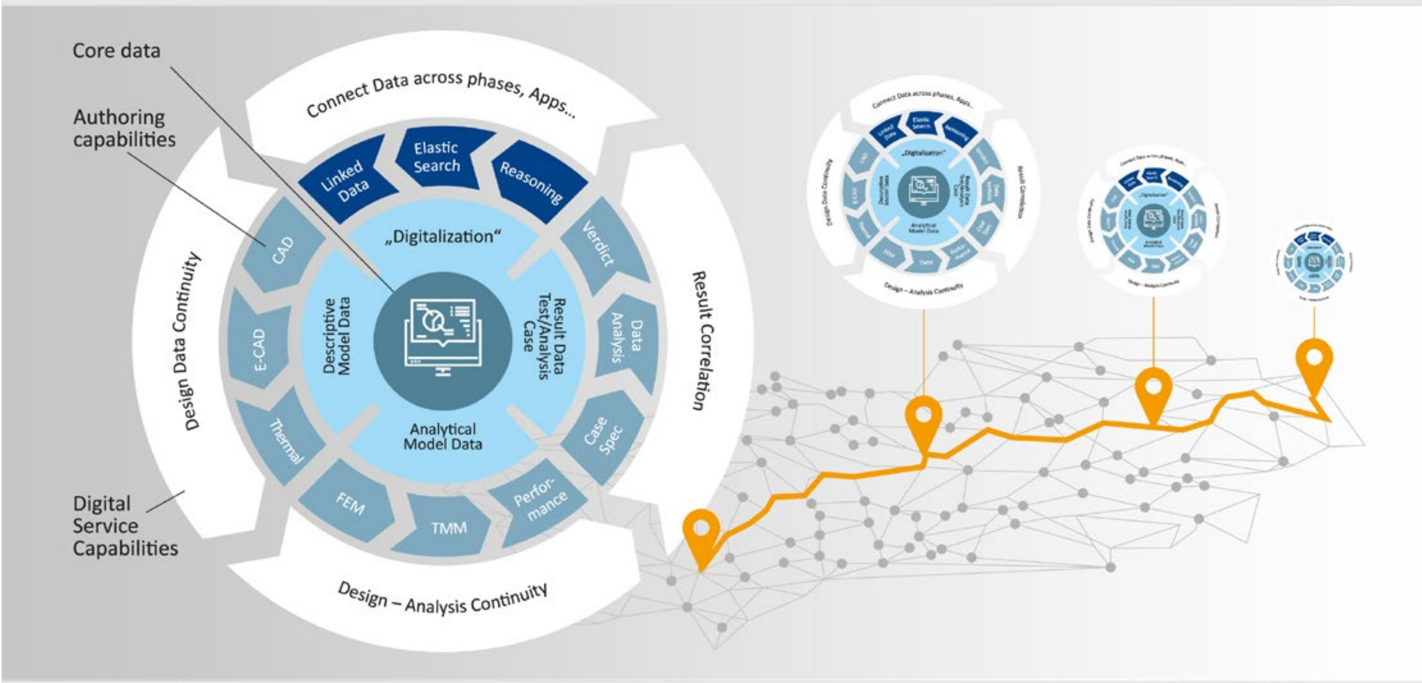


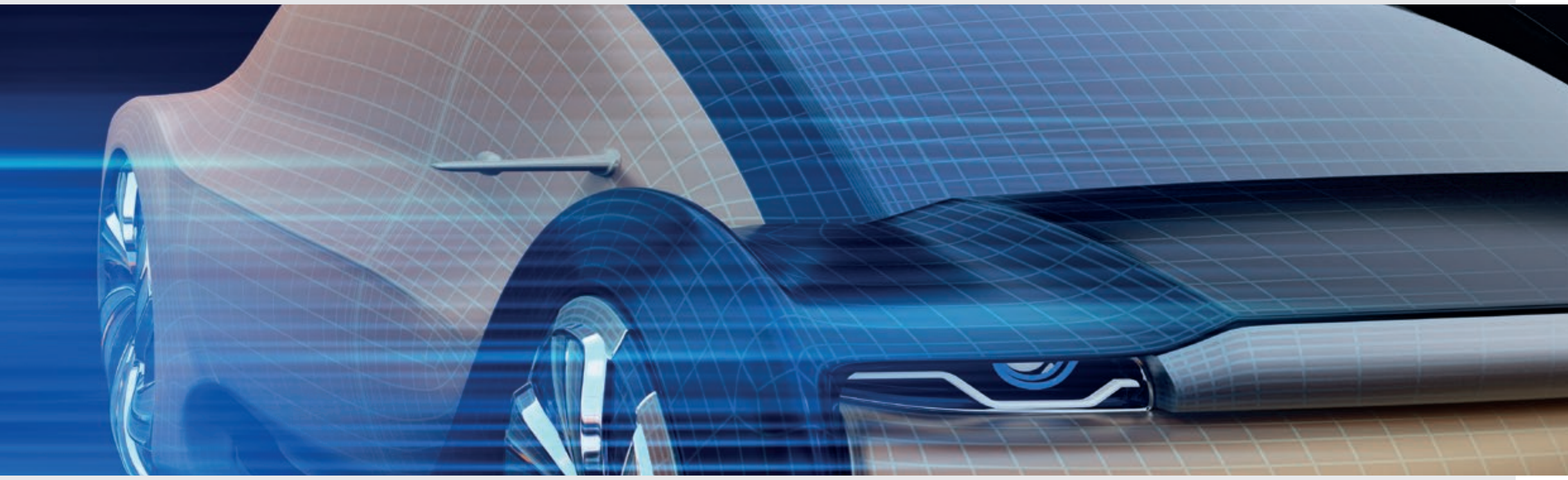
There is no single digital twin

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 momentum is their interlinking, either automatically or by specialized data scientists.

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 are bound together by the conceptual data models and other shared services.

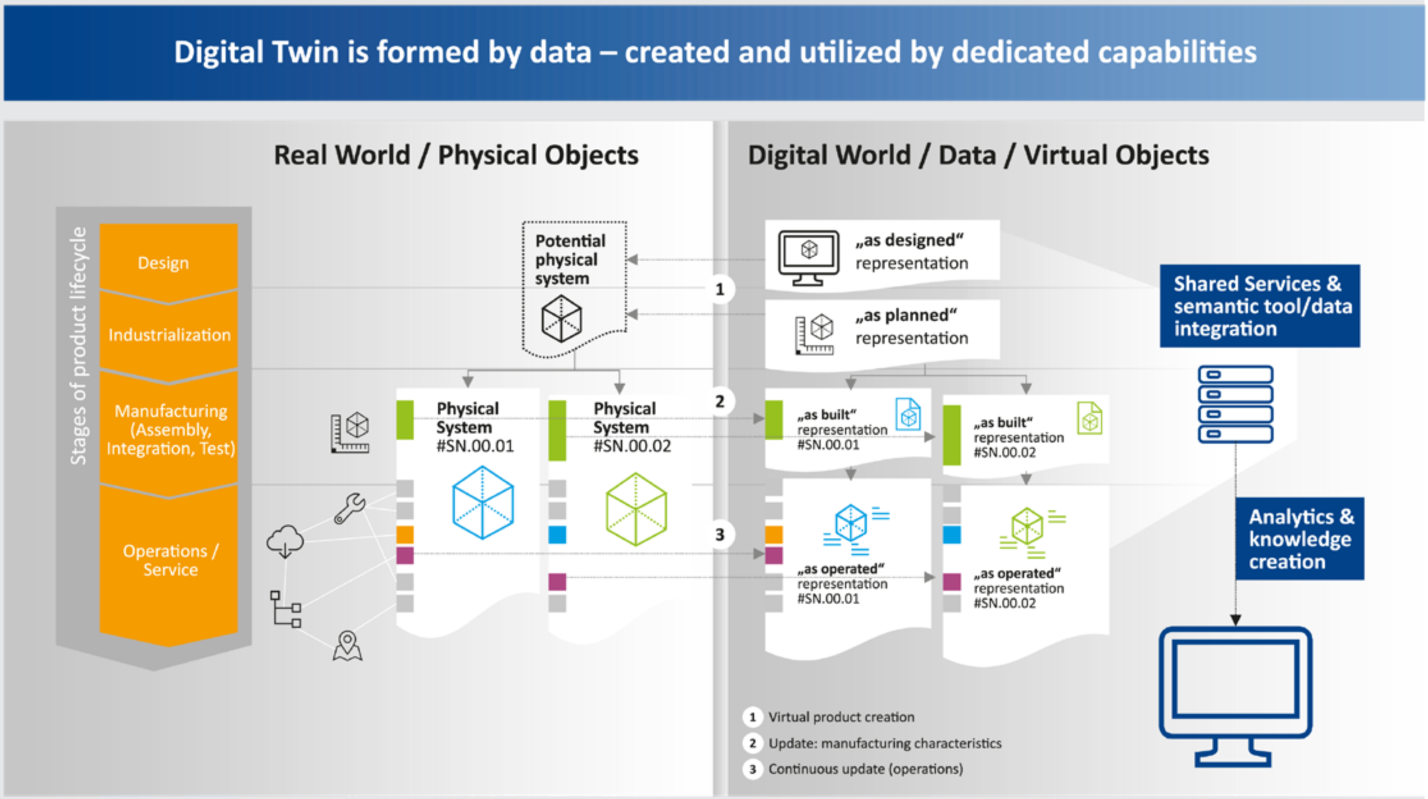
Digital Twin is formed by data – created and utilized by dedicated capabilities





The digital twin accompanies a product throughout its lifecycle

The digital twin takes shape during the product development process. It initially exists as an as-designed representation of a future physical system. This initial 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, there is also the as-planned twin of the production systems and production logistics needed to manufacture and assemble the systems. Information flows from both twins into 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 form 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 together without exception.



Different use cases involving the digital twin

Aside from the different phase-specific phenotypes of the digital twin there are also different configurations of the digital twin within the context of the supported use cases. It is important to stress that these are configurations of a generic digital twin and not digital twin applications that exist separately from one another. The study examined different use cases at Airbus and other companies to develop a better understanding of how the data needs to flow and what capabilities are required to make this flow of data possible. The use cases examined range from product-as-a-service applications in which the digital twin in combination with the operating data ensures maximum availability and reliability of the systems, to the optimization of production lines and over-the-air updates of vehicle functions through to the collection of as-manufactured data and data-driven factory management. The findings from the analysis of the individual use cases were validated on the basis of the potential integration and support provided by the overall architecture. The shared digital enterprise services need to be set up in such a way that all relevant cases are supported and further scaling is possible.

Serveral use cases have been investigated to understand the specific nature of the digital twin phenotypes

Cross industrial cases

1. Product as a service applications
2. Over the air updates (focus automotive)
3. Manufacturing line optimization
4. Platform & variant management
5. Retrofit: smart devices machine upgrades
6. Greenflield E2E PLM approach

Specific internal cases

7. E2E digital engineering approach
8. Extended Enterprise – seamless supply chain management
9. „as manufactured“ data set – capture real world properties
10. Data driven factory management
11. Overcome document based processes
12. „as operated“ representation for service optimization

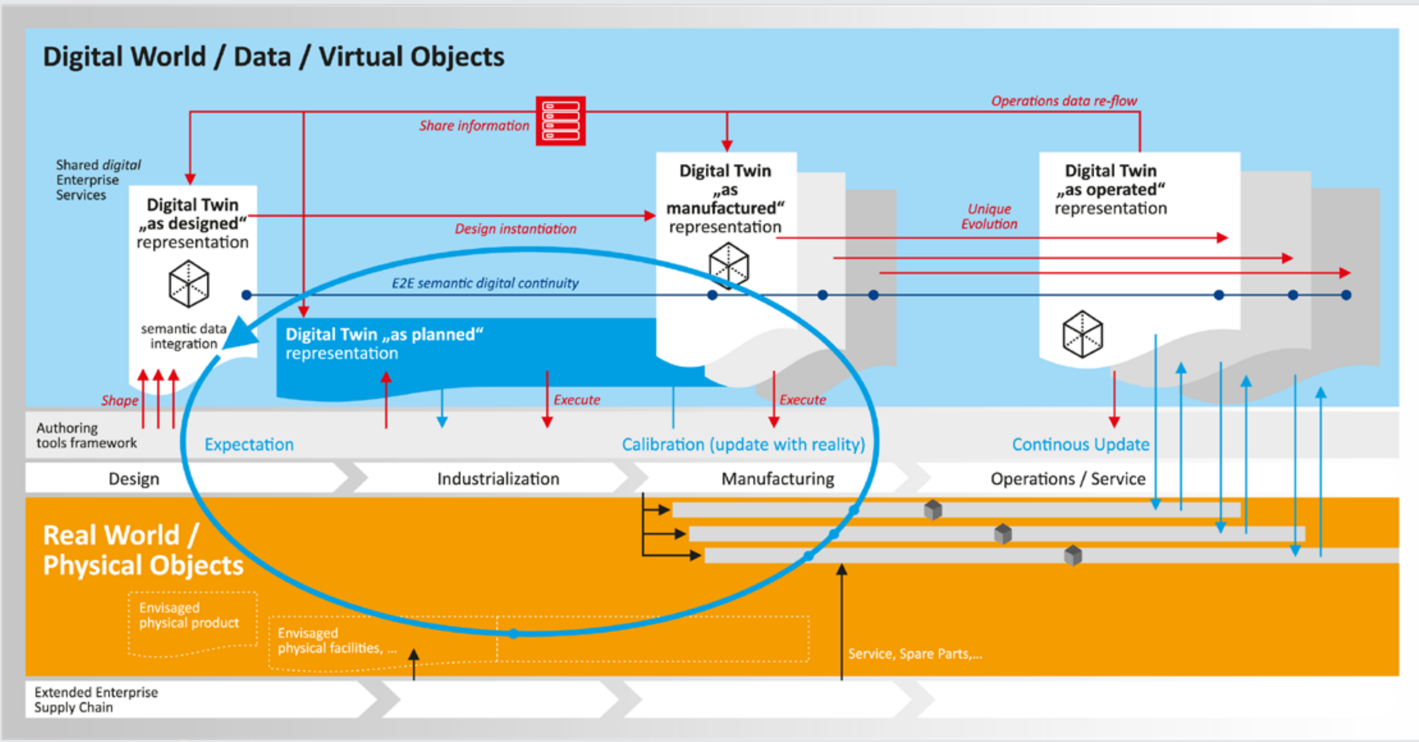
Information flows between the digital twins

The web of relations between the digital twins of technical systems with a large number of possible use cases is highly complex. Information needs to flow between the different twins throughout the lifecycle in order to synchronize the idealized properties of as-designed 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 inter-play between the real and digital worlds. Which specific properties are fed back depends on the use case that is to be supported with the digital twin. This however has no impact on the basic concept.

It is also important to feed back information gathered during operation. For example, an aircraft is mea-sured following a hard landing to determine what has bent or been deformed in order 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.

The majority of the value added in the aerospace industry and other industries can be found in the supply chain. How efficiently the digital twin can be used for which use cases depends on whether and how sup-pliers make their digital data available. Suppliers must therefore be integrated in the digital twin strategy. 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.

Digital Twin of technical Systems are far more complex with a huge quantity of individual use cases and complex relations along the lifecycle

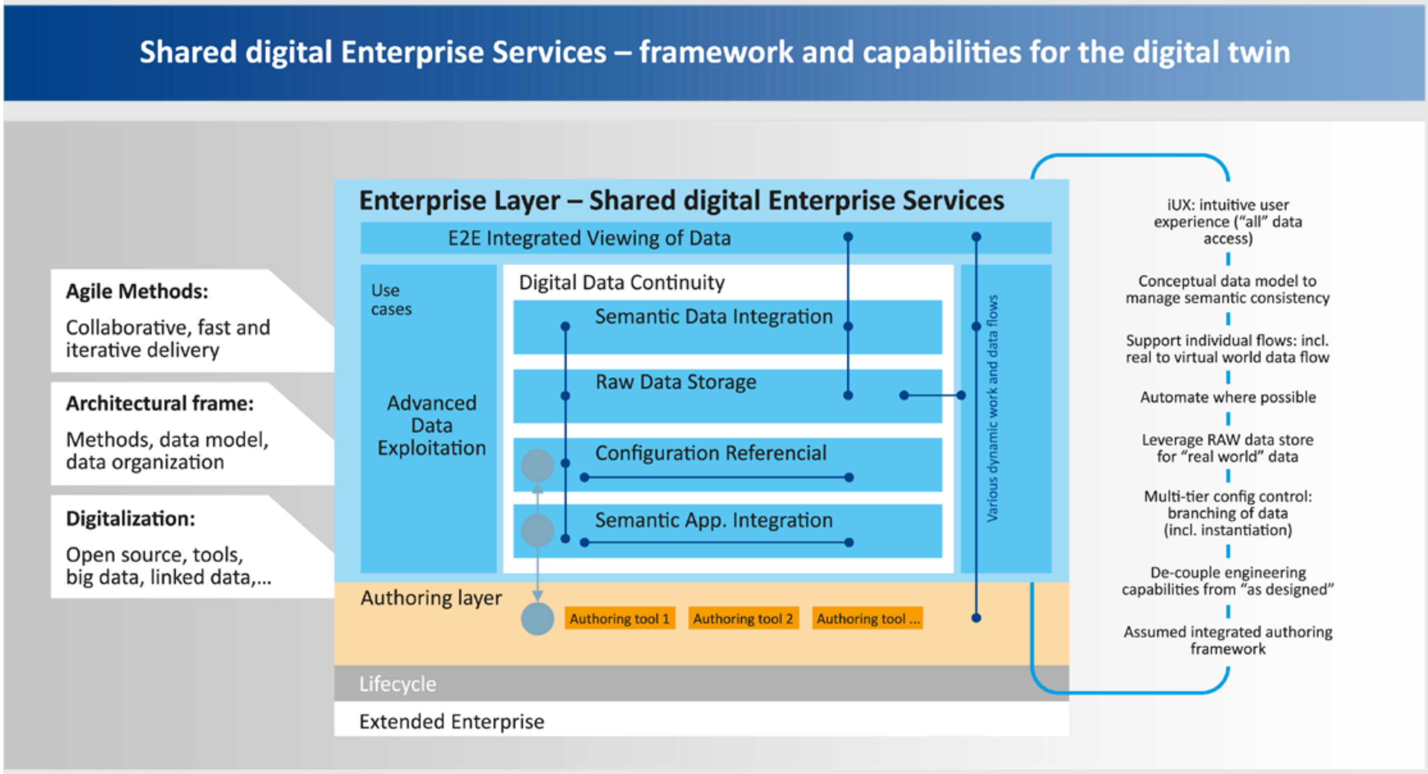


Reference model for shared digital enterprise services

A reference model for the shared digital enterprise services was developed with the experts from Airbus on the basis of the findings from the various case studies. It ensures the convergence of existing and new PLM capabilities. It makes the core data accessible independently of the authoring systems (yellow layer) in an integrated viewer. The bottom layer of these shared services involves semantic application integration which enables end-to-end digitalization of core data and not only establishes the relationships between all the phases of a product's lifecycle but also across multiple products/programs. 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 Reference 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, operations, and more. 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 account for the fact that agile methods are being used to an increasing extent in product development.

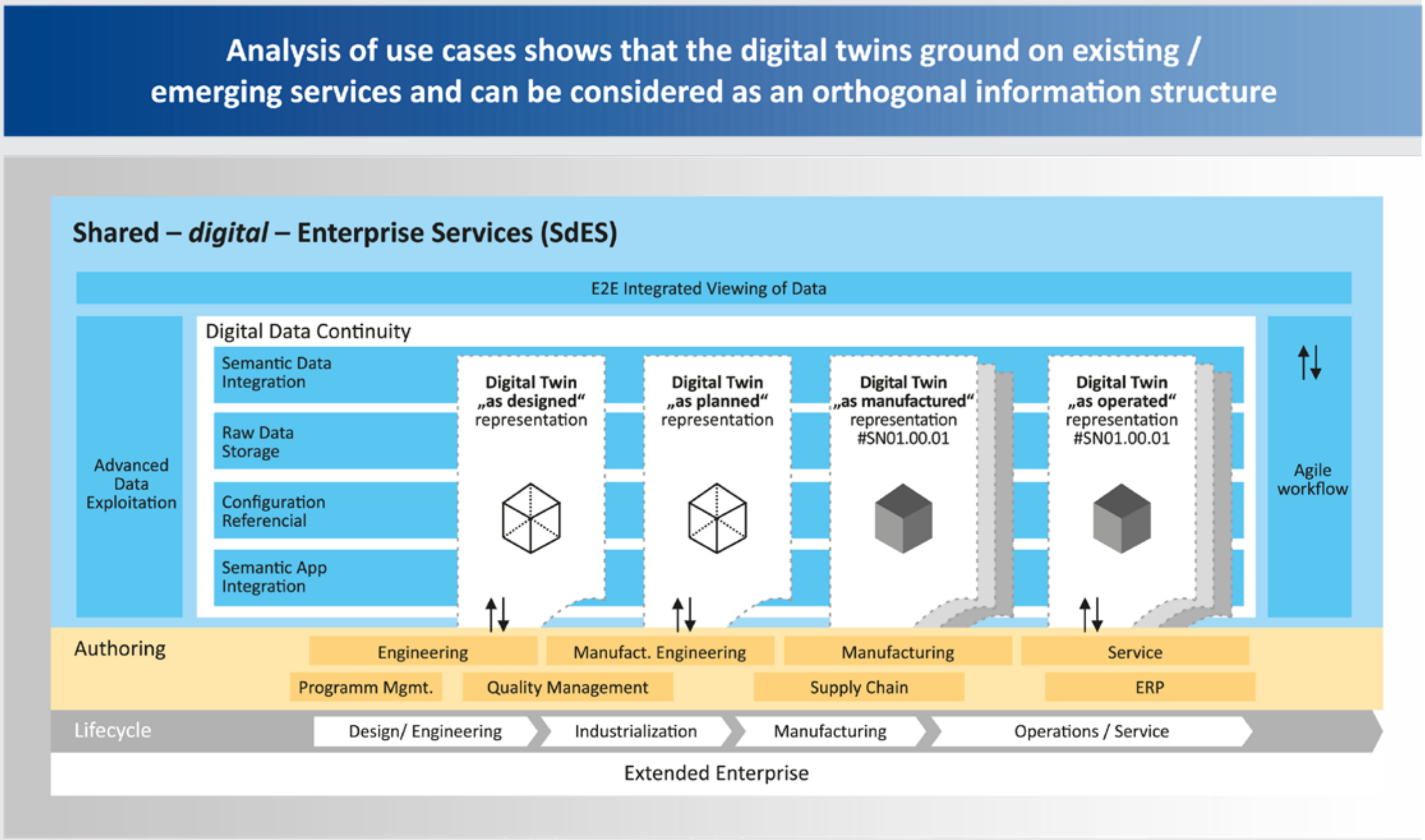
The digital twin "lives" as an information structure in the different layers of the shared digital enterprise services model, while the actual information is distributed across different authors and management systems and is used as needed. If the engineering data was stored only in the authoring systems, it would not be possible to establish references to 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 in most cases 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.



Quelle: Airbus Defence & Space, Airbus Group

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 as a framework for the digital twin



Quelle: Airbus Defence & Space, Airbus Group

An 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 flows will need to be established to ensure that the digital representations remain up to date. The framework for this organizational structure is the shared digital enterprise services presented in this white paper. They form the complex infrastructure behind the authoring tools. Their main components and properties are shown in the right-hand part of the diagram above.

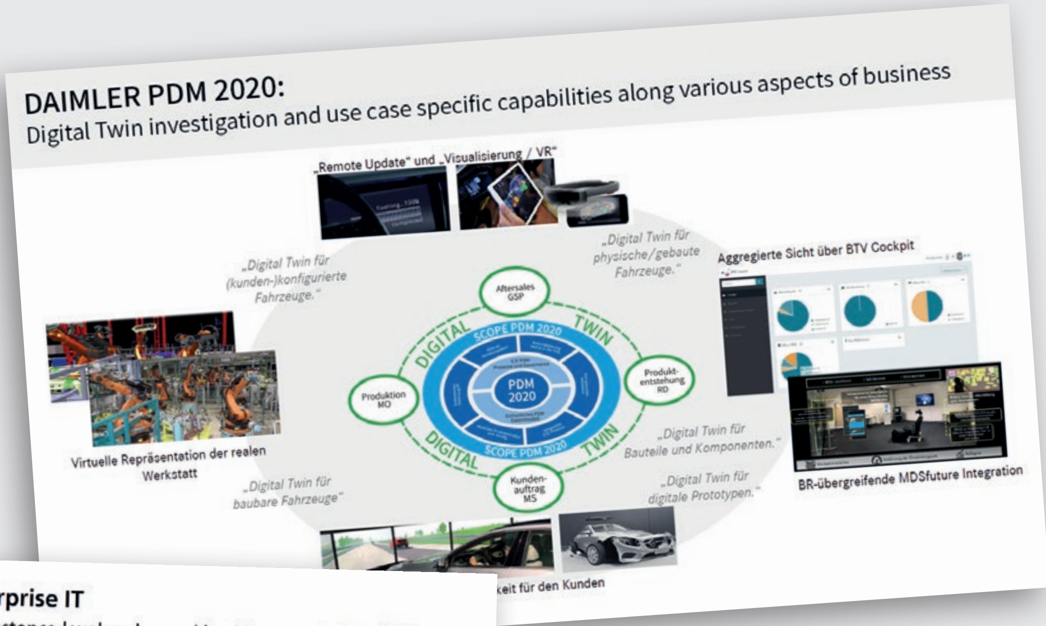
A key issue with the acceptance of digital tools is the user experience, specifically the question of how the required information can be presented in a simple and attractive manner. Standardized conceptual data models are the key to maintaining semantic consistency. Coming to grips with them is a task 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 becomes the dominant topic

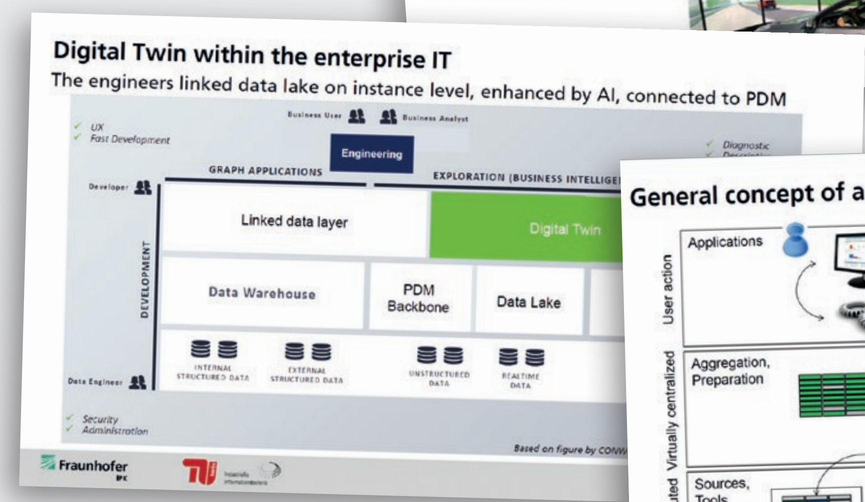
Making the digital twin available is a key objective of many digitalization initiatives not only in the aerospace industry but also in the automotive and other industries. Siegmar Haasis, CIO R&D at the carmaker Daimler, once called it the supreme discipline of digitalization. Not all companies are pursuing a digital twin concept as comprehensive as the one at Airbus. At an early stage, companies often try to generate added value with individual use cases. Without an overall concept, however, there is a risk that these individual digital twin applications will remain isolated solutions and diverge regarding the data involved.

When developing an overall concept, the requirements of different use cases should be taken into consideration from the beginning, even if they are implemented step-by-step and on an iterative basis. Companies need to be able to prepare and aggregate data from numerous different source systems in order to make it available in a generic digital twin. For this to happen, the question of data sovereignty within the company and the extended corporate network also needs to be addressed.

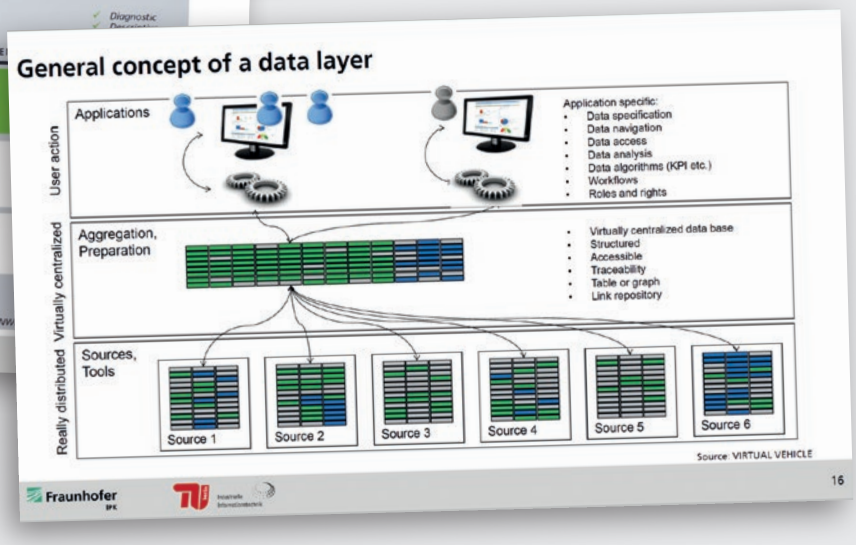
Outside-In view: Digital twin is a core topic in industries and industrial research institutes worldwide



Source: Daimler AG, Hr. Oliver Markovic, 5th Linked Data Day organized by CONWEAVER GmbH, Darmstadt on 17.05.2019



Source: Fraunhofer IPK/Technical University Berlin, Prof. Dr.-Ing. Rainer Stark, 5th Linked Data Day organized by CONWEAVER GmbH, Darmstadt on 17.05.2019



3DSE and PROSTEP: partners for the digital twin

Strategy level

- Business model analysis
- R&D capabilities
- Portfolio, organization, and processes
- Derivation of a digital twin business strategy

Shared digital Enterprise Services

- PLM capabilities and architecture
- Concept of a digital enterprise architecture
- Representation of the solution platform

Application level

- Concrete use cases for the digital twin
- Analysis of suitable technologies
- Data analysis in development, production, and operation

The white paper makes it clear that the digital twin is a highly complex, company-specific topic. It requires new concepts for a digital enterprise architecture that links business strategy with the application level. Shared digital enterprise services extend the conventional PLM landscape and make available the capabilities needed to support different use cases for the digital twin throughout the product lifecycle. The specific capabilities required will depend on the digital twin concept and the priorities of the company in question.

Digital twins increase operational efficiency in development, manufacturing, sales, and service. They make it possible to develop new business models thanks to innovative product-as-a-service offerings. All vendors of complex products should therefore think about how they can use digital twins to support their products and processes. Even component suppliers will not be able to avoid developing digital twins of their components in the long run because their customers want to integrate them in the overall product.

The development of a sustainable digital twin concept is a challenge that business departments and IT should ideally tackle together. On the one hand, companies need to be drivers of innovation and understand technologies such as artificial intelligence, cloud computing, augmented reality, and the like, which today are making a growing variety of digital twin applications possible. On the other hand, they need to address the question of which specific use cases promise the greatest benefit for their business model and product, and which requirements regarding digital twins will in the future be communicated to them by the market and their customers.

Not all companies have the resources to develop an overall concept of the digital enterprise architecture as comprehensive as the one we developed for Airbus. Despite this, they should not overlook the strategic dimension of the digital twin. We recommend that this topic be addressed from two different perspectives. On the one hand, from the perspective of the business models and business requirements, which may change under the influence of the digital twin. On the other hand, from the perspective of the user or possible use cases. Many companies are already collecting vast amounts of data in development, manufacturing, and operations, but without enabling it to be used for the digital twin. We help them to exploit this potential using a transparent and clearly structured approach.

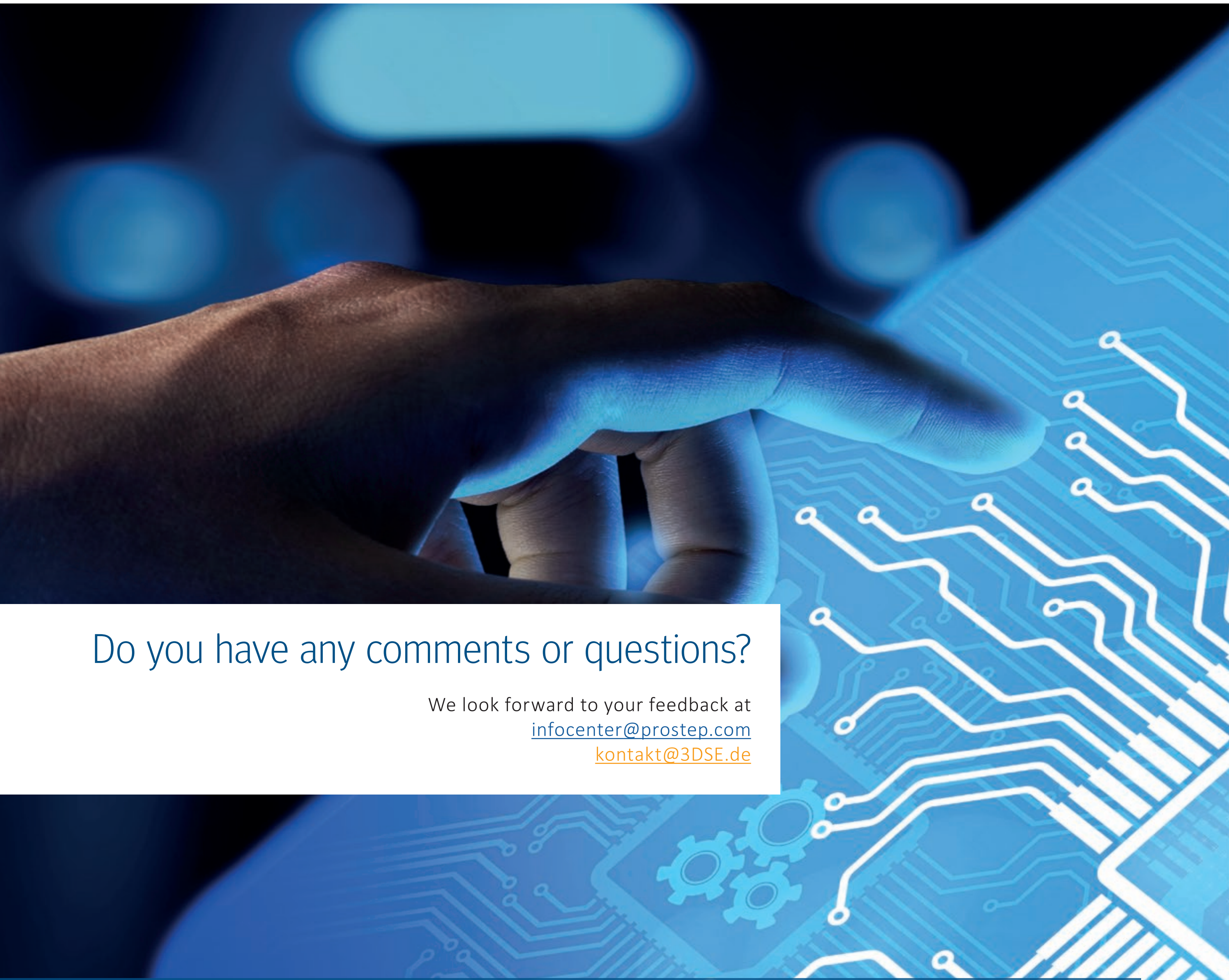
As external consultants, 3DSE Management Consultants and PROSTEP AG help companies develop a digital enterprise architecture for implementing specific use cases that is best suited to the organization, processes, and product portfolio. Implementation and rollout of the concepts are supported by professional, strategic change management throughout the company to ensure that it has the maximum ability to implement, the highest possible level of acceptance, and fast added value.

Numerous successful projects mean that we are familiar with how both established companies and innovative start-ups approach the topic of the digital twin. Process knowledge, organizational development, and many years of expertise in the field of digital transformation are now brought to bear on joint customer projects.

Joint offering

- Create digital twins by analyzing strategy and use cases and use them as the basis for deriving an appropriate digital enterprise architecture.
- 3DSE and PROSTEP are familiar with the concepts and approaches used at a wide range of companies and can develop an appropriate concept for your company.
- The digital twin is one of the key topics of the future that is critical to success. We will help you create a viable overall concept, develop initial concrete applications, and gradually exploit the benefits.

PDF version of the white paper:
www.prostep.com/whitepapers
or scan the QR Code



Do you have any comments or questions?

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