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Digital twin – enabling data-based decision making

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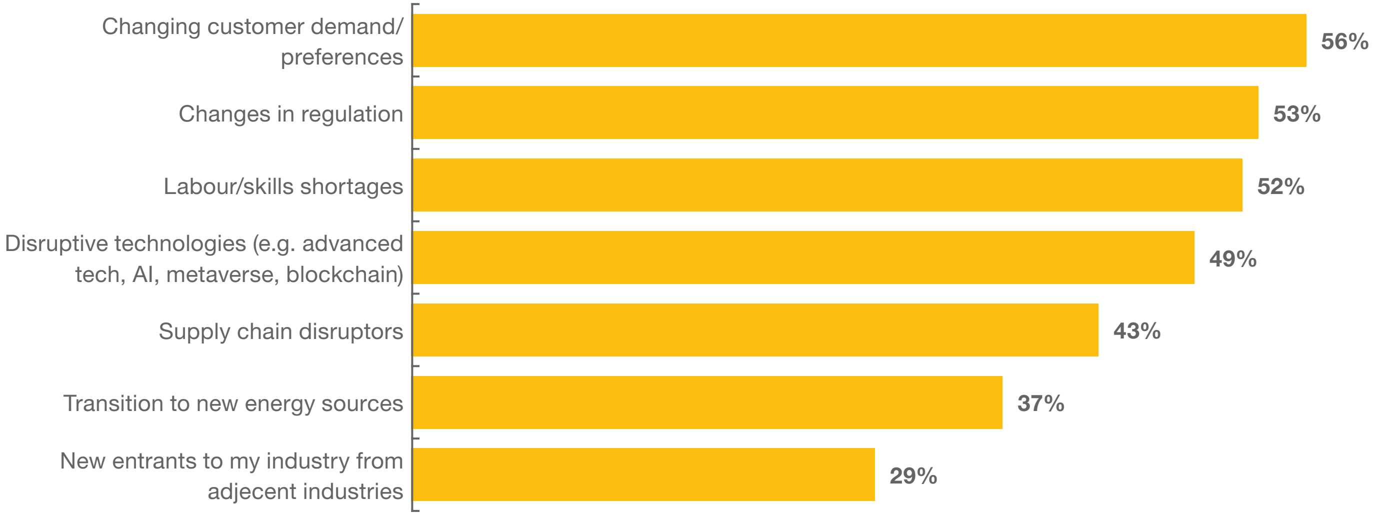
A Digital twin: winning today's race while running tomorrow's

Companies today need to be able to respond to multiple challenges, from increasing customer expectations, new regulations, the skills shortage and technological disruption to global crises and major political tensions. They need to remain competitive while also unlocking new opportunities for growth and innovation.

PwC's latest global CEO survey[1] reveals that 40% of global CEOs think that their organisation will no longer be economically viable in ten years' time if it continues on its current course. The challenges mentioned above are seen as the main driver of this development.

Fig. 1 PwC's 26th Annual Global CEO Survey has revealed multiple perceived threats to profitability

To what extent do you believe the following will impact (i.e. either increase or decrease) profitability in your industry over the next 10 years?



[1] www.pwc.de/de/ceosurvey/2023/pwc-26th-global-ceo-survey.pdf.

Companies must find new ways to stay resilient and to react fast and precisely to this changing business landscape. They must embrace available technologies and adopt new ways of working that enable them to make better data-driven decisions, and work collaboratively across their entire value chains.

One powerful and well-known technology that companies can leverage is the digital twin. This concept has been around for several decades, with its roots in the field of simulation and modelling. However, it was not until the rise of the internet of things that the technology achieved widespread use and recognition.

The concept of the digital twin was introduced in the early 2000s and refers to a virtual replica of a physical product or system. This vision was initially used as a tool for improving product design, reducing costs and enhancing performance.

Fig. 2 **Leveraging digital twins enables new opportunities**

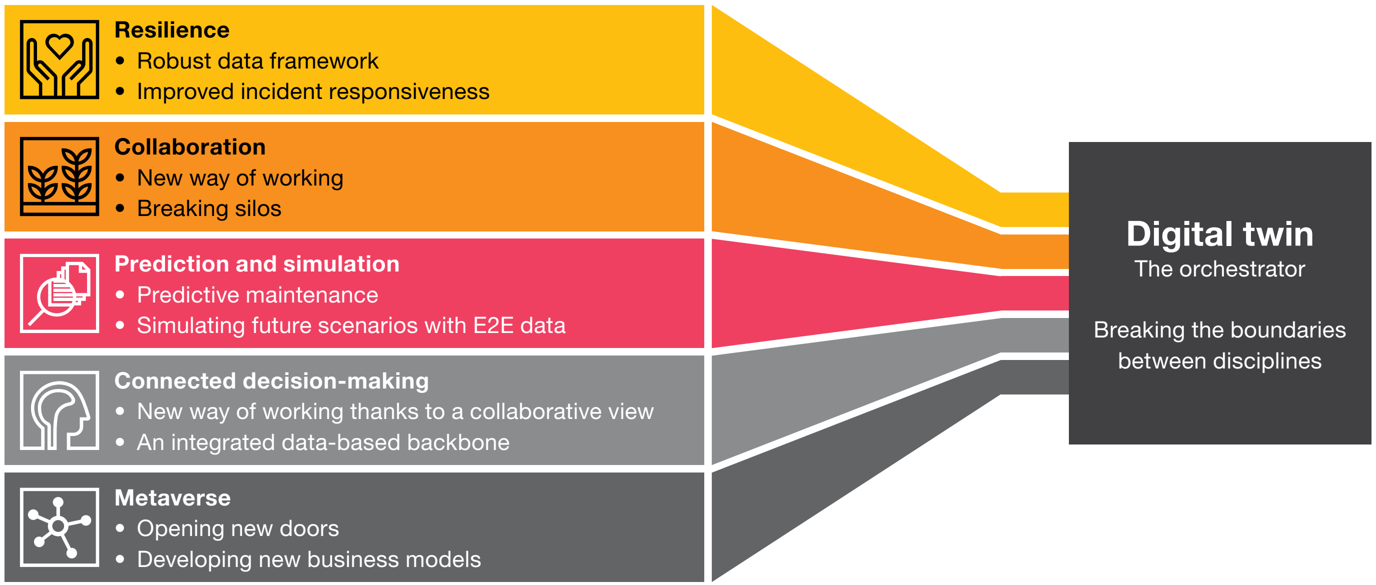
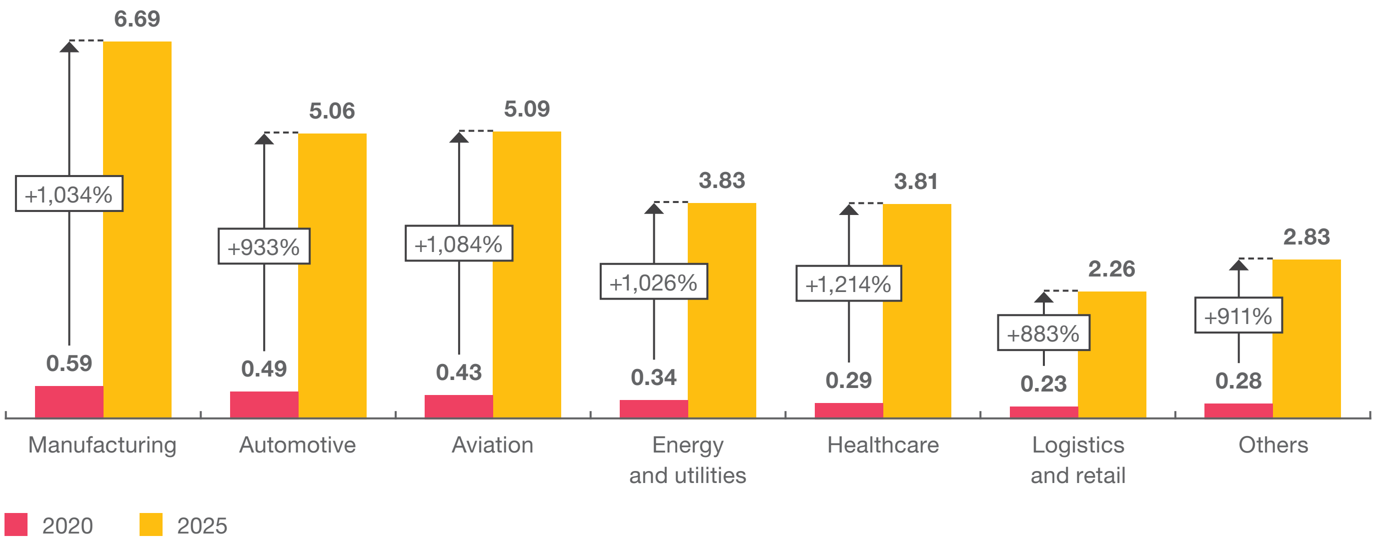


Fig. 3 **The projected explosion of the global market for digital twins between 2020 and 2025 shows the technology's potential in various industries**

Global digital twin market size by industry, in $bn



Today, digital twins are much more than this. They are capable of simulating complex systems and predicting outcomes with a high degree of accuracy. Advances in AI and machine learning have further expanded the capabilities of digital twins, making them more sophisticated and powerful than ever before. As a result, digital twins are indispensable in today's companies and a key technology for facing the future challenges of data-driven businesses.

The manufacturing industry forecasts that the digital twin market will be worth over $6 billion by 2025[2]. There can be no doubt that companies need to invest in digital twins in order to harness the benefits they offer and overcome future challenges.

[2] https://www.statista.com/statistics/1296187/global-digital-twin-market-by-industry/.

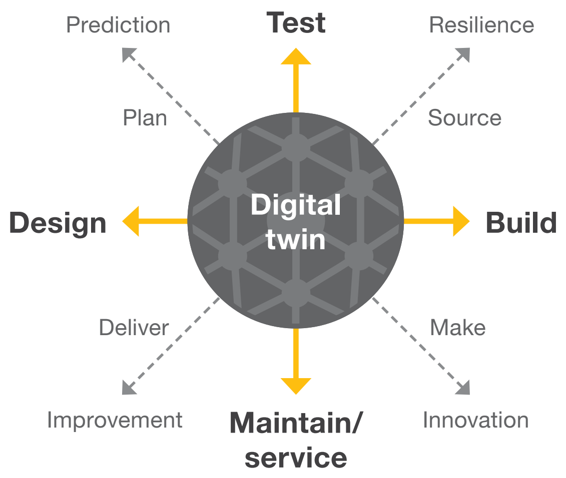
Where to start? Using a digital twin as an orchestrator

Orchestrators are composers or arrangers who transform a musical composition into a score for an orchestra or band. They analyse the original composition and decide which instruments to use in which part of the music to achieve the sound and effect the composer intended.

A digital twin operates in a similar way by analysing and transforming data to provide real-time and predictive information for the company, breaking silos to enable cross-functional teams and facilitating data-driven decision making.

It should be noted that use cases for digital twins can vary depending on the industry, value chain link and the company itself.

Fig. 4 **Digital twins orchestrate data between processes**



Two examples

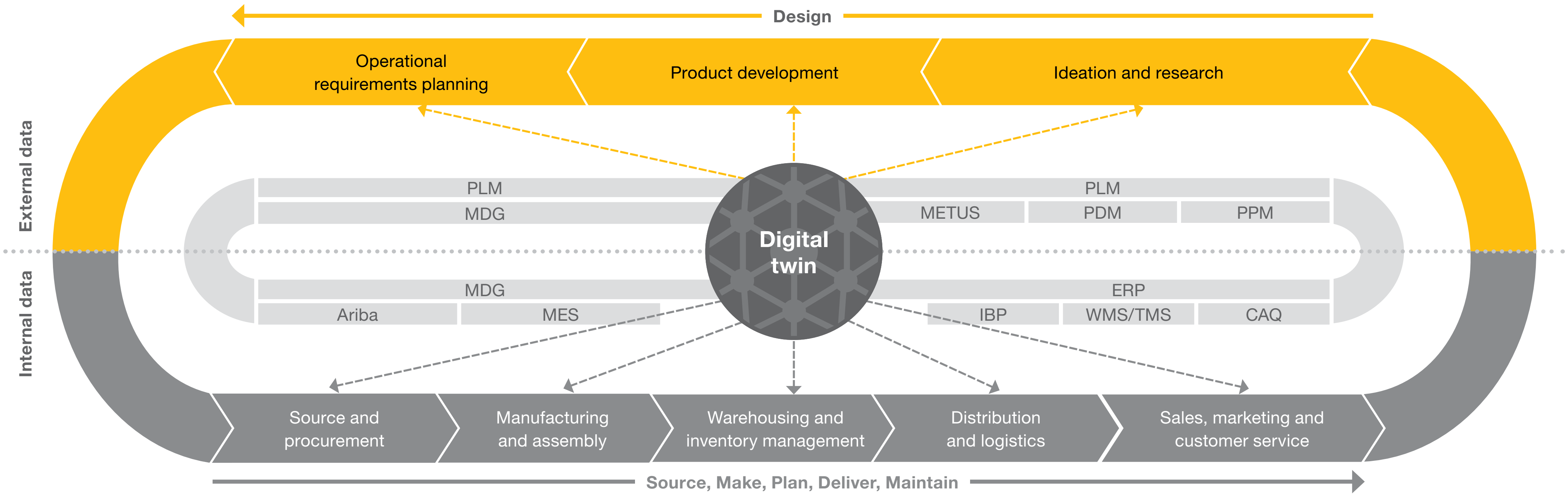
1 Innovation cycle time

In the aviation industry, innovation cycles are often very long and there are many regulatory requirements to meet. Here, a digital twin can help accelerate and simplify the aircraft design and certification process. By contrast, in the electronics industry, innovation cycles are often very short and new products need to be brought to market quickly. A digital twin can help iterate faster and enable quicker development of new products.

2 Value-chain link focus

In the automotive industry, a digital twin can help optimise production and improve quality. In heavy industry, by contrast, it can help optimise machine maintenance and reduce downtime.

Fig. 5 The digital twin connects data along the end-to-end process across systems



There are certain prerequisites for the successful implementation or creation of a digital twin. These include mature data management, flexible IT and system landscapes and infrastructure, and efficient data exchange or an integrated data model across the entire value chain.

Today, companies collect more data than ever before. But despite the wealth of information available, many companies do not use it effectively. There is a large gap between what companies collect and what insights they obtain and exploit. Companies should ensure that they can effectively use and analyse their existing data to generate value by implementing and leveraging a digital twin.

Companies don't have to start from scratch with a digital twin – the data is already there!

PwC: helping to implement digital twins

Company profile – Cybus

Making manufacturing data usable

Data accessibility is vital for the success of a digital twin project. However, many factories struggle to utilise their manufacturing data effectively, as their data infrastructure does not enable seamless data integration with their IT systems. This gap limits their ability to successfully leverage digital twins.

An underlying factory data hub such as Cybus Connectware can address this challenge: Connectware creates a data infrastructure that collects, aggregates, standardises, contextualises and distributes manufacturing data in all directions between IT systems, applications and databases. The result is a seamless flow of data between OT systems and IT applications in real time. Manufacturers can unlock the value of previously inaccessible or underutilised data by directly integrating it into digital twin applications. It's even possible to make operational adjustments and retain control in more complex digital twin scenarios thanks to the data infrastructure allowing data flow in all directions.

Solving the challenge of data reliability

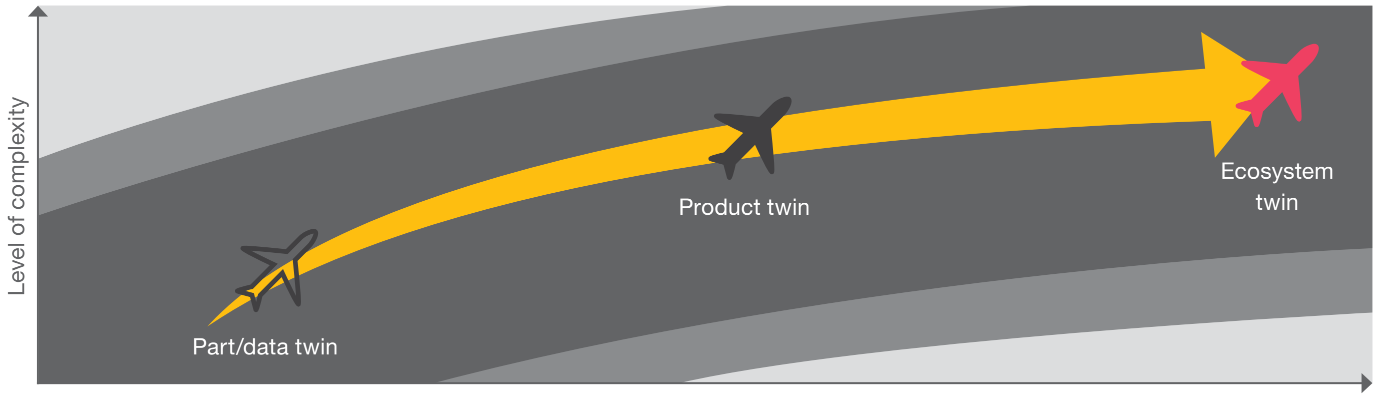
To ensure accuracy and reliability, digital twins need to receive a continuous stream of up-to-date data from their physical counterparts. Any interruption or loss of data can compromise the integrity and effectiveness of the digital twin, rendering it less useful for decision-making and predictive analysis. In short, companies need to guarantee a seamless, uninterrupted data flow to their digital twins – as provided by factory data hubs such as Cybus Connectware.

Cybus is a software company that is part of PwC Germany's IoT portfolio.

B Framework

In both the literature and in industry, there are different definitions, gradations and dimensions of a digital twin. These range from a digital model to a digital shadow or even a digital ecosystem. To help clarify matters, we have developed a simple framework that allows companies to assess and classify each kind of digital twin. We can then help you determine where you are now with your digital twin, and identify activities so that you can progress to the next stage.

Fig. 6 The framework shows that digital twins can be classified and evolved along their complexity as well as their level of data automation and process maturity



Part/data twin

Models of individual components or parts of a larger system. Allows the emulation of real-world conditions for a part/component with defined interfaces.

Product twin

Combines parts and defined materials with manufacturing and in-service data in order to create a digital representation of an intended or real-world physical product.

Ecosystem twin

A complex network of interconnected virtual representations (of products) and different systems that is able to collect, exchange and process data autonomously.

For ease of understanding, we have defined archetypes for low, medium and high complexity. These examples can be used as a guide.

The basic entry level of a digital twin is a (simple) part/data twin. A part/data twin is a virtual representation of a system, process or product. A simple data sheet can be seen as a part/data twin and represents the lowest level of complexity and data automation or process maturity.

With growing complexity and data automation or process maturity, an ecosystem twin is the most developed digital twin class and provides an overview of the stages you can reach in this expansion level. It consists of several product twins with complex interactions and dynamics within one system. Many digital twin use cases are combined in one twin to allow complex evaluation. The metaverse can be seen as the ultimate expression of this kind of expansion.

In a previous white paper by PwC entitled “Digital factories 2020 – Shaping the future of manufacturing”, we defined “digital twin of a product”, “digital twin of a production asset” and “digital twin of the factory”. These descriptions of digital twins can be classified according to complexity.

Level of complexity

Understanding complexity is essential for comprehending a digital twin and its implementation.

The virtual representation of a physical system, process, product or a combination of thereof can be allocated to the assessment framework according to its level of complexity. The level of complexity doesn’t define which artefact we want to reflect with the digital twin, and it doesn’t exclude any type of digital twin – rather, it enables us to classify/allocate all sorts of digital twins.

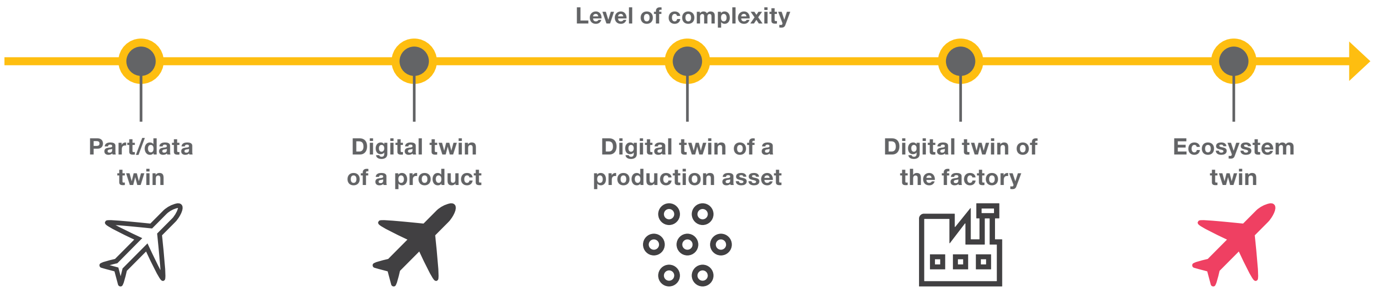
Complexity refers to the state or quality of being intricate, sophisticated or multifaceted, often involving a large number of interconnected elements, processes or factors that can interact in unpredictable or emergent ways. The International Council on Systems Engineering (INCOSE) refers to a complex system as a system that cannot be understood by simply breaking it down into its component parts.

A low level of complexity means that the virtual representation of the object, as well as the object itself as a whole, is easy to understand without breaking it down into its individual components, and that the behaviour of the object is easy to predict. By contrast, a high level of complexity means that, due to synergies, the object and the virtual representation cannot be easily understood, even if it is broken down into its individual parts. Its behaviour is spontaneous and cannot be easily foreseen.

As a simple twin, a digital twin of a product represents one product and a digital twin of a production asset represents one or more production facilities. A digital twin of the factory reflects a complex factory. While the digital twin of a product is the least complex twin in this gradation, there are digital twins that are even less complex, such as a “part digital twin” or a “data digital twin”.

To master complexity, we use an epic/use case approach, starting from a data twin and moving to a highly complex ecosystem. This approach enables companies to set a realistic target and move towards achieving it step by step.

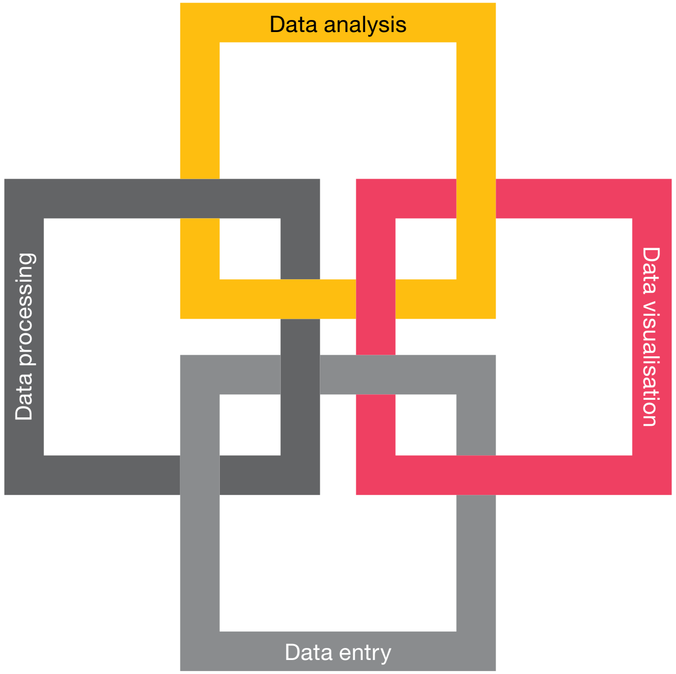
Fig. 7 There are several gradations of complexity between data/part and ecosystem twin



Level of data automation

Data automation refers to the use of technology and software tools to streamline and automate data-related processes, such as data entry, data processing, data analysis or data visualisation. This can include the use of algorithms, scripts or workflows to automatically collect, cleanse, transform and analyse data, as well as to generate reports and visualisations that can help users to understand and interpret the data better. Data automation can help reduce errors, increase efficiency and improve decision-making by enabling users to quickly and easily access accurate, timely and relevant data.

Fig. 8 Interlinking all aspects of data is key for success



Data automation is a critical enabler of digital twin technology and is used, in particular, to collect and process the vast amounts of data needed to create and maintain a digital twin, including data from sensors, simulations and other sources. It involves the use of algorithms or automated workflows to collect, analyse and visualise data in real time, enabling users to monitor and manage the physical system more effectively and efficiently. This can help users to identify and address issues more quickly, improve performance and optimise operations.

Increasing levels of data automation allow greater degrees of complexity to be handled, allowing more efficient use of digital twin technology.

Process maturity

In a corporate environment, process maturity is often assessed using process maturity models. Most process maturity models set out a framework consisting of specific levels that organisations use to assess their own process maturity and to identify areas for improvement. By focusing on process improvement, organisations can improve their efficiency, productivity and overall performance.

In the context of digital twin technology, there is no specific level of process maturity required; however, having a higher degree of process maturity can certainly be beneficial for the successful implementation and management of a digital twin. Having well-defined and standardised processes can help to ensure that the data used to create and operate the digital twin is accurate, consistent and up-to-date.

For example, a higher level of process maturity enables an organisation to have well-defined and standardised processes, which can be used to develop a clear and consistent understanding of the data required for the digital twin. This allows the digital twin to be an accurate representation of the physical system that can be used effectively for analysis, optimisation and data-based decision-making.

At higher levels of process maturity, organisations have a culture of continuous improvement and are more likely to use data and metrics to monitor and optimise the performance of a digital twin.

In summary, the more advanced the digital twin solution, the higher the level of process maturity required in the organisation to fully leverage the potential of this technology.

C What are the main benefits?

Digital twins offer numerous benefits depending on the industry and use case. Broadly speaking, the benefits of a digital twin can be separated into tangible and intangible benefits.

The tangible benefits are the direct impacts associated with digital twin technology which can be measured in terms of time and money. In the manufacturing industry, for example, digital twins help to optimise production lines, reduce downtime and minimise defects. By simulating different scenarios and optimising operations, manufacturers can reduce maintenance costs and downtime. The digital twin also reduces the time required for design and prototyping by simulating physical characteristics of a product in a digital environment before the results are validated in the real world. Another example is the energy industry, where digital twins are used to optimise the performance of power plants, wind turbines and solar panels. By simulating different weather conditions and operational scenarios, energy companies improve efficiency and reduce downtime, resulting in cost savings.

Intangible benefits are impacts that are difficult to quantify or measure in terms of monetary value or physical output. They range from fostering innovation and creativity by enabling the exploration of new ideas and innovative solutions in a cost-effective digital environment, to improving collaboration between different teams and departments by providing shared platforms for visualisation and analysis. This helps to break down silos and improve communication.

Overall, the benefits, especially cost and time savings, depend on the specific use case and industry. However, the benefits are clear, and digital twins are being used to transform various industries by enabling data-based decision-making, improving efficiency, decreasing time to market and reducing costs and risks.

To further illustrate these benefits, four real-life use cases from various industries are listed below. In all of these cases, the use of a digital twin provided measurable benefits.

Fig. 9 Real life digital twin applications show measurable improvements

Use case	Industry	Challenge	Digital twin task	Benefits
Speed up innovation and time to market	Consumer products	Developing products taking mechanics, fluid dynamics and thermodynamics into account	Developing/optimising products within the digital twin, simulating machine behaviour, optimising the machines' energy efficiency, thermal sizing, and further physics modelling before doing physical tests	• Development cycle shortened by 30% • Reduced number of prototypes • Reduced development cost
Advanced product development	Industrial manufacturing	System development of a drone to autonomously capture data	Virtual testing of full system including structural, control and mechatronic subsystems	• Shorter development cycles • Fewer prototypes • Less physical testing • Cost saving • Virtual commissioning of the control system
Manufacturing process improvement	Food and beverages	Streamlining processes in 160 production facilities	By relying on software simulations leveraging the digital twin, the company was able to strengthen capacity management and process control	• Improved machine runtime and reduced error-related rejects • Cost reduction • Efficiency improvement
Predictive maintenance	Industrial manufacturing	Without information on the condition of the equipment, producers do not know how or when equipment is defective or not working properly	Introduction of live data access for remote inspections and programming of tests, for checking cooling, monitoring energy consumption etc. This enables predictive maintenance and preventive maintenance	• 13% fewer system failures • 27% better product performance • 10% lower service costs

D How do I implement a digital twin?

The use of digital twin technology starts either with a generic vision, or with a specific use case and a planned area of application.

The following section shows an approach to implementation, including a structured guide to manoeuvring towards a beneficial and achievable digital twin.

Fig. 10 Five step approach to tackle digital twin implementation

Vision
- Why digital twin?
- What can be achieved?

As-is assessment
- Current state
- Capabilities

Scope and target state
- Epics and use cases
- Potential/value

Fit-gap analysis
- Identify gaps
- Determine functions

Roadmap and way forward
- Prioritise
- Determine tasks

1 Vision

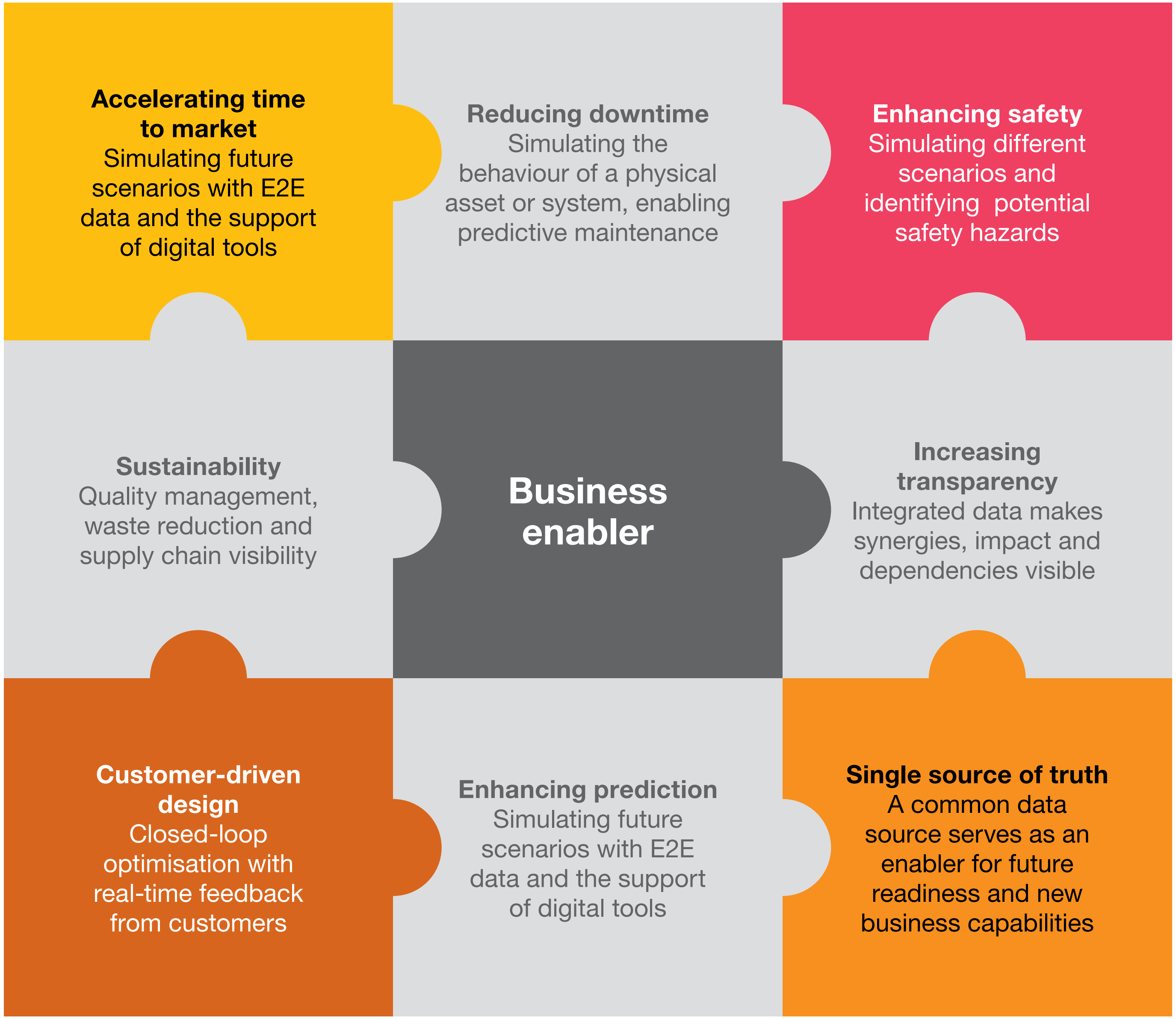
The first step towards a digital twin is to state or refine a vision of why digital twin technology should be implemented and what benefits it will offer.

To create a vision, it is first necessary to identify the specific business challenges that a digital twin could help to solve and the opportunities it could open up. Alternatively, this can be a specific use case for which the digital twin is intended.

The cornerstone of the vision is defining how the digital twin will work as a business enabler. This includes the benefits that implementing a digital twin will deliver for your company.

Key performance indicators to be optimised can also be determined at this stage. These will later serve as measures of success.

Fig. 11 High impact benefits through digital twin implementation work as business enabler



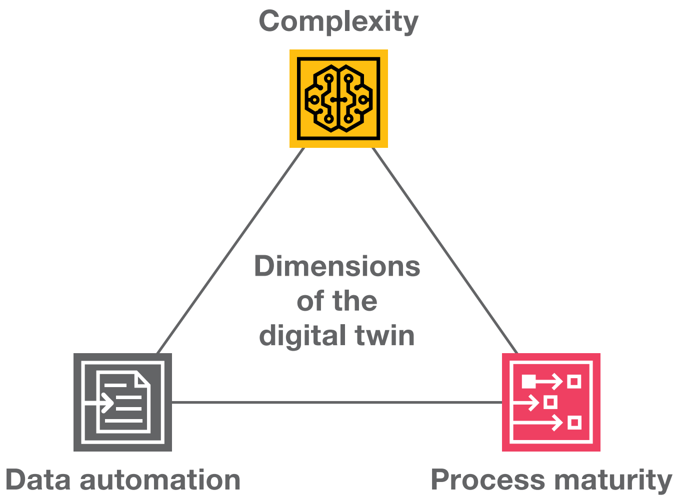
2 As-is assessment

Once you have your vision, the next step is to carry out a thorough as-is assessment. This will provide a baseline for the digital twin project, and will help to determine the effort required and the tasks which must be performed in order to achieve your vision. The assessment should focus on your current process landscape, the data model in place, your system landscape, including tools and interfaces between them, and, if applicable, your current digital twin or digital twin activities.

This assessment allows you to gauge your level of process maturity, your degree of data automation and data continuity, and the degree of complexity of your digital twin.

This will then allow the state of the digital twin capabilities to be mapped onto the framework described in chapter B.

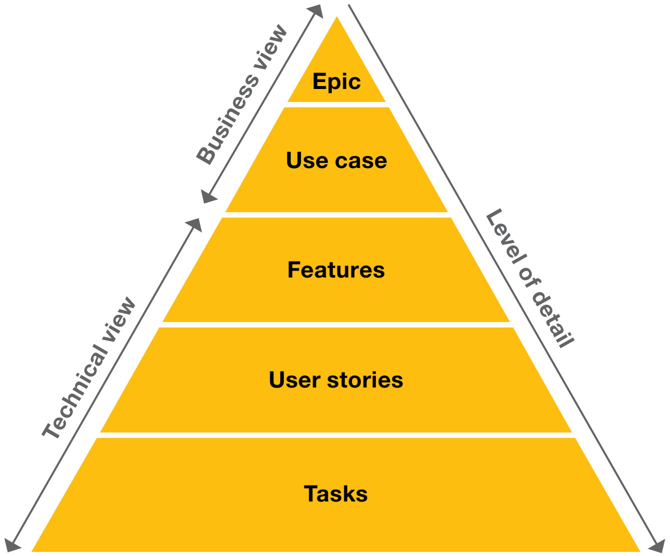
Fig. 12 The state of the digital twin is categorized in three dimensions



3 Determine your scope and target state

To achieve your vision, you need to settle on the scope and target state of your digital twin by specifying the desired future state of the aforementioned dimensions: process maturity, level of data automation and level of complexity.

Fig. 13 High level epics are broken down into detailed items for implementation



We set a clear scope by using an agile methodology and formulating specific epics with detailed use cases. These epics and use cases are developed by combining best-practice examples from the PwC library with bespoke additions, tailored to your needs. It is not always necessary to start with epics; in some cases, a dedicated use case can be the sole starting point and target for digital twin activities.

The value of these epics or use cases needs to be individually quantified for your company to support the necessary business case.

The target state is visualised by mapping the scope onto the assessment framework, highlighting the difference between your current state and the desired end result.

4 Fit-gap analysis

Next, a fit-gap analysis is conducted to identify gaps between the as-is assessment and the target state. This involves taking the epics and use cases within the scope of the project and mapping them onto your existing system landscape, data model and process landscape. The gaps identified in this manner are then translated into features and functions.

5 Roadmap and way forward

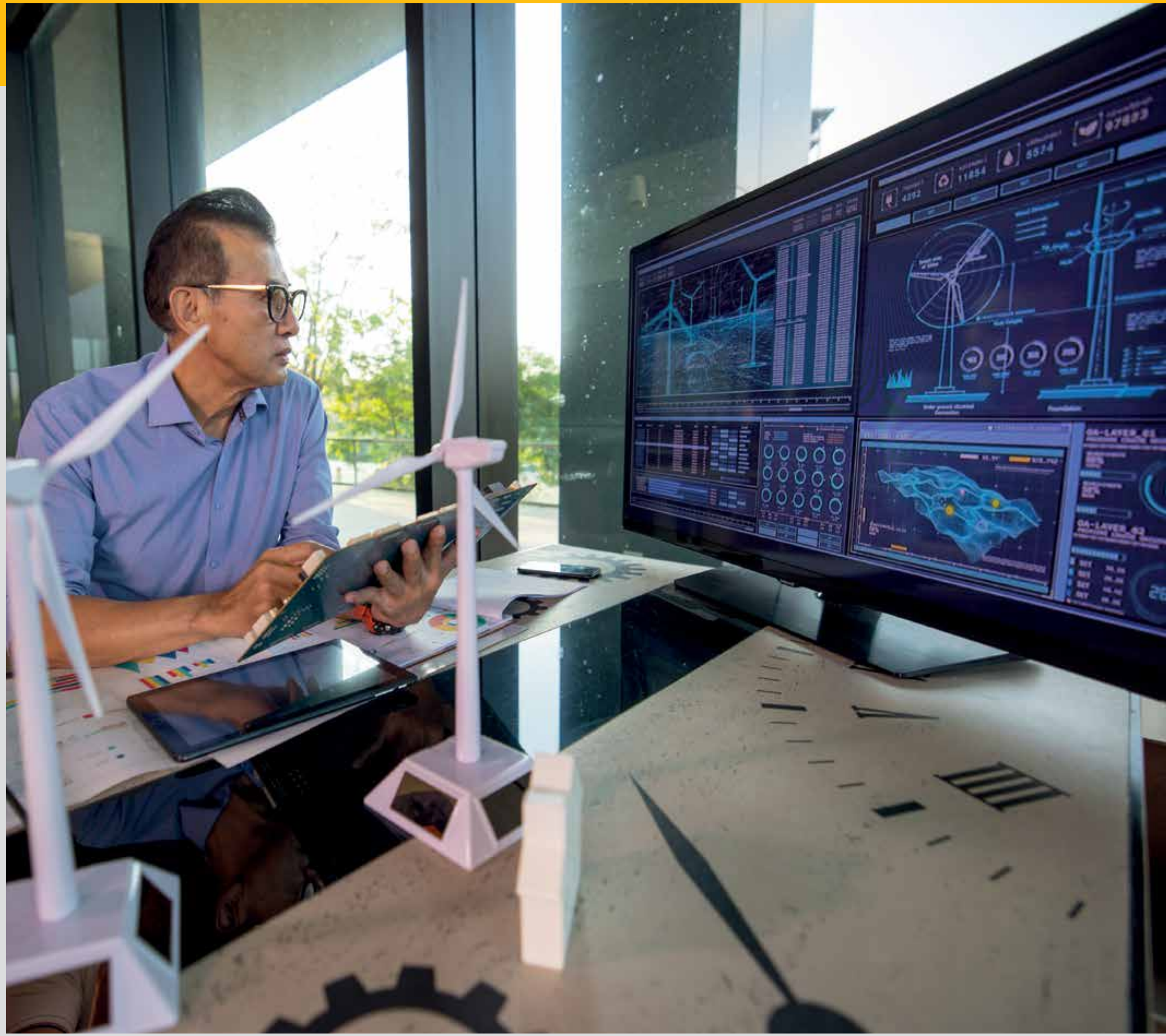
Once the target state of the digital twin has been defined and the gaps that need to be closed have been identified, the epics – consisting of use cases and formulated features and functions – need to be prioritised in terms of impact, value and effort required. A roadmap can then be drawn up by placing these priorities onto a chronological chart. Overall implementation can be clustered into separate waves that lead towards the vision and highlight quick wins.

For the more detailed project plan, all items within the waves are broken down into specific and tangible user stories and tasks. This requires the necessary resources to be determined in order to complete the plan and create a timetable.

In addition to the roadmap, a risk mitigation strategy should be in place to identify potential risks that could impact the project.

Identifying the right technology and system vendors to support your digital twin transformation, creating and aligning your implementation roadmap and then beginning the actual blueprinting and implementation will kick-start your journey into a digital future.

E Conclusion



In the face of global crises and major political tensions, companies need to find new ways of staying resilient and reacting fast to the changing business landscape. The Covid-19 pandemic has disrupted businesses worldwide and highlighted the need for digitalisation and agility. Digital twins are an important tool which businesses can use to tackle challenges. Companies can benefit from digital twins in various ways depending on their maturity and specific industry requirements. Digital twins can help improve operational efficiency, reduce downtime, optimise performance, enhance safety and reduce time to market. In these days of uncertainty with international challenges and crises, it's more important than ever for executives to adopt an active mindset and get in the driving seat. Implementing a digital twin requires careful planning and execution to ensure that the desired benefits are realised.

There is no one-size-fits-all solution to implementing digital twins, and each company must tailor their approach to their individual needs. Our five-step approach to implementing specific digital twin use cases according to the client's individual needs will help to cover current and future business, process, system and organisational needs.

In order to use digital twins effectively, companies must understand their own maturity level in terms of data automation and process maturity. As companies increase their level of data automation, they can adopt a higher degree of complexity to get the most out of their digital twins. There will be different focus points for companies at different maturity levels. Organisations with a lower level of maturity should focus on building a foundation for data automation and process maturity, while advanced companies should use the potential of digital twins to drive innovation and seize new opportunities.

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