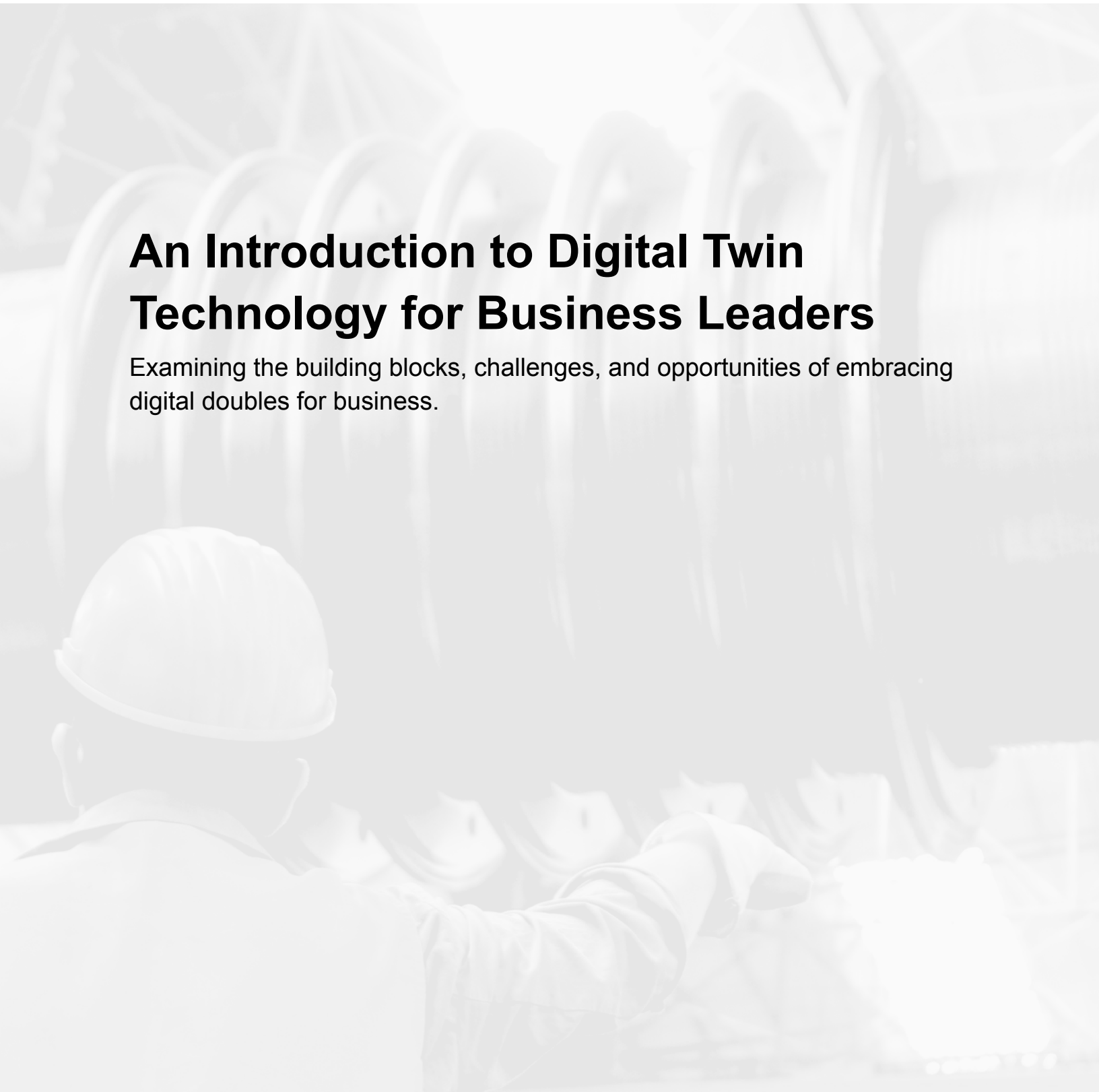

An Introduction to Digital Twin Technology for Business Leaders

Examining the building blocks, challenges, and opportunities of embracing digital doubles for business.

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Introduction

There is something special about the convergence of technologies. When seemingly disparate systems blend together to produce something bursting with potential, it's hard to look away.

And as convergences go, digital twin technology is an explosive display. It includes some of the most exciting technologies today: the cloud, data analytics and artificial intelligence, 3D mapping and modeling, and augmented and virtual reality.

But is digital twin technology all it's lauded to be? What about issues like data privacy and the complexities of working with several data sets to derive value? Can it be integrated into every business, and should you bother trying to kickstart a digital twin project in your business?

What follows is an introduction to digital twin technology. You'll get a clear definition of what it is, what types of digital twins exist, and learn about practical applications of digital twins in nine different industries.

This guide also explores the biggest challenges facing digital twin technology today. And for business leaders keen on kickstarting a digital twin project, you'll find a list of considerations that explore the most important aspects of getting started.

What is digital twin technology?

A digital twin is a virtual representation of a physical product, system, or process that closely mimics its real-world counterpart for various practical purposes. It can mirror the entire lifecycle of the physical entity it represents, from creation and construction to operation and support, and ultimately disposal.[1]

As indistinguishable digital counterparts, digital twins allow for simulation, integration, testing, monitoring, and maintenance activities that otherwise wouldn't be possible.[2]

They also help spearhead research and development. With access to broader insights based on real-life data, product refinement prior to production leads to greater agility. Digital twins can optimize production systems, improve efficiency, and monitor performance throughout the manufacturing process.

And their value doesn't end there. More data aids decision-making. For businesses across the globe, predictive and proactive maintenance, and personalized customer experiences are clear objectives not easily realized.

Digital twins place these gains within arm's reach. It becomes easier to create contingencies, optimize resource allocation, and make accurate revenue projections.

Types of digital twins

There are several kinds of digital twins[1] and they vary based on the level of product magnification -- the extent to which you examine how a product behaves -- and the area of application.

Common types of digital twins include:

1. Component Twins/Parts Twins: These are the basic units of a digital twin, representing the smallest functioning components of a system or product. Component twins focus on individual parts and their behavior.

2. Asset Twins: When multiple components work together to form an asset, asset twins represent the digital counterpart of that asset. They provide insights into the interactions and performance of the components, enabling better understanding and optimization.

3. System or Unit Twins: These digital twins provide a higher level of magnification by representing entire systems or units composed of multiple assets. System twins allow for visibility into the interactions between assets, helping identify potential enhancements for system performance.

4. Process Twins: Process twins represent the digital twin of an entire production facility or a collection of interconnected systems. They provide insights into how these systems work together, identify synchronization issues, and can optimize overall effectiveness.

Digital twins for lifecycle management

Digital twins can also be categorized according to their lifecycle stages:

A Digital Twin Prototype (DTP) is a digital twin at the design and prototyping stage, created before the physical product exists.

A Digital Twin Instance (DTI) is a digital twin that represents an individual physical entity or product after it has been manufactured. DTIs remain linked with their physical counterparts throughout their lifecycle.

A Digital Twin Aggregate (DTA) is an aggregation of multiple digital twin instances (DTIs).

The technologies behind digital twins

Several technologies are used to create digital twins.[1] Together, they work to achieve everything from data gathering to mapping, analysis, visualization, and more. Here are six of the most commonly used to create an accurate, real-time digital representation of a physical asset or system:

1. Internet of Things (IoT)

The Internet of Things collects and transmits crucial data from IoT sensors in real time. In physical/digital doubles use cases, information from physical assets is fed into digital twins. Sensors make monitoring various parameters and performance metrics possible, providing valuable insights for analysis and optimization.[2]

2. 3D Mapping and Modeling

Advanced 3D mapping software is used to create a digital representation of the physical object or environment. Video, images, blueprints, or other data are fed into mapping software tools to generate highly detailed and accurate virtual replicas.

3. Data Analytics and Artificial Intelligence (AI)

Digital twins leverage data analytics and AI techniques to process and analyze vast amounts of data collected from sensors and other sources. Machine learning algorithms are then applied to identify patterns, predict behavior, and optimize performance. Simulations are made possible using AI that's capable of prescribing actions based on real-time data and insights.[2]

4. Visualization and Simulation

Visualization techniques are used to represent the digital twin in an easily understandable format, making user-replica interaction possible. Simulation capabilities allow for testing, scenario modeling, and accelerate the collection of insights into the behavior and performance of the physical asset or system.

5. Cloud Computing

Cloud platforms offer scalability, flexibility, and computational power. The convergence of the cloud and IoT devices has made it easier to collect more data and push it directly into the cloud for analysis and to manage digital twins.

6. Augmented Reality (AR) and Virtual Reality (VR)

AR and VR technologies enhance the visualization and interaction with digital twins. They allow users to immerse themselves in the virtual environment, explore digital twins, and gain a deeper understanding of a physical asset or system.

What digital twin technology can do for businesses today

There is a strong case for digital twin technology in business. As with any other system, businesses thrive when optimized. That's what digital replicas offer -- the opportunity to examine what's not working, strip away the fat, and produce the most lean and effective system.

The list of benefits won't appear as anything new. But the detail about how digital doubles work to improve businesses is undeniable.[4]

1. Improved efficiency and productivity

Digital twins optimize asset performance and provide real-time insights into operations. By simulating the behavior and performance of physical assets or processes, you'll be able to spot potential issues, optimize workflows, and make data-driven decisions to enhance efficiency and productivity.

2. Cost savings

Cost cutting is possible by identifying energy-efficient processes, reducing waste, and avoiding downtime. With the ability to simulate and analyze operations, companies can better manage resource utilization, streamline production, and minimize operational expenses.

3. Improved safety and risk management

Simulating asset behavior helps identify safety hazards and risks. Through virtual testing and simulations, businesses can proactively address potential safety issues, improve product designs, and enhance overall safety compliance.

4. Better decision-making and problem-solving

Organizations that generate a wealth of data and insights are able to make more informed decisions using digital twins. It is possible to leverage stored and real-time data and predictive analytics to anticipate issues, optimize processes, and develop effective strategies.

5. Predictive maintenance

Equipment downtime is costly, making predictive maintenance an attractive proposition. By analyzing real-time data from sensors and identifying potential equipment problems before they occur you can proactively address maintenance needs. Operational performance improves due to less downtime, and businesses can optimize maintenance schedules and realize extended equipment lifespans.

6. Enhanced collaboration and communication

Digital twin technology fosters stronger and more collaborative environments. Stakeholders can visualize scenarios and communicate effectively, identifying system flaws and developing newer, more efficient solutions. Cross-functional collaboration and the option of remote work also allow for better communication between teams, improving business unit efficiency and coordination.

Use Cases

Digital twin technology is active across various industries[5] with gains like improved decision-making and optimized performance cited as common outcomes. Here are nine unique use cases of digital twin technology in different environments:

1. Supply Chain and Logistics

Virtualizing supply chain operations has allowed companies to improve efficiency, reduce costs, and ensure effective distribution. Digital twins are used to predict packaging material performance, enhance shipment protection, optimize warehouse design and operational performance, and create logistics networks.[5]

2. Construction

Construction firms are able to understand real-time building performance and optimize construction efficiency. From planning and designing to prototyping buildings, digital twins help by simulating different scenarios that speed up project delivery.[5]

3. Healthcare

Healthcare is improving operational efficiency and personalized care. With the ability to analyze operational performance of hospitals, everything from staffing schedules to personalized treatments based on individual patient characteristics is enhanced. And these wins translate into improved patient care and reduced costs.[5]

4. Manufacturing

Digital twins are used for product development, design customization, shop floor performance improvement, and predictive maintenance. Manufacturers are streamlining production processes, reducing downtime through predictive and proactive maintenance, and improving overall equipment efficiency.[5]

5. Aerospace

Advanced design and engineering, simulation and training, maintenance and operations are all areas where aerospace manufacturers are realizing drastic improvement today. These capabilities also directly influence how manufacturers streamline maintenance activities, and make it easier to empower buyers with virtual showrooms and product configurators.[6]

6. Utilities

Utilities are driving grid optimization, using digital twins to establish better and smarter energy management and grid resilience. They model and simulate entire grids, optimizing performance, monitoring energy flows, predicting demand, and identifying potential issues in real-time.

And for asset management, digital replicas of power plants, substations, and transmission lines make infrastructure easier to maintain than before. Digital twins provide real-time monitoring, predictive maintenance, and simulation capabilities to optimize asset performance and reduce downtime.[5]

7. Mining

In mining, operational efficiency and productivity are being improved in various ways. Virtual replicas of mining operations allow for real-time monitoring, predictive analytics, and optimization of processes. They help identify bottlenecks and optimize equipment use.

Improved safety and reliability are also simpler to achieve. Digital twins can simulate different scenarios and conditions to assess safety risks, optimize mine design, and improve worker safety.

8. Agriculture

Precision farming using real-time monitoring of crops, soil conditions, and weather data is now possible. Digital doubles enable precision agriculture techniques that optimize irrigation, fertilization, and pest management to improve crop yield, resource efficiency, and support sustainable farming practices.

Livestock management with real-time monitoring of animal behavior, health parameters, and feeding patterns helps farmers take better care of animals. Digital twins track and optimize feeding and track individual animals on site. Data collected is being used to optimize living conditions and detect anomalies for the best animal welfare.

9. Retail

Customer experiences are being improved using virtual replicas of customers. Capturing preferences, behavior patterns, and buying habits helps retailers personalize marketing efforts. With more behavioral data it's easier to optimize store layouts and offer tailored product recommendations to enhance the customer experience and drive sales.

Addressing the biggest challenges facing digital twin technology adoption today

Committing to a digital twin project isn't like buying into a new CRM platform or ERP software. It's bigger. And getting it right could transform every aspect of how you do business. There are several considerations business leaders must make. From the cost of setting a project up to whether it will deliver value, and how their business will respond to it.

Here's a breakdown of these and other key considerations you must address before pulling the trigger.

1. Initial Investment

Initial investment can be a barrier for organizations. While the size of your investment is dependent on an organization's appetite, one thing is certain, without a viable use case, digital twin projects may not deliver immediate returns. And uncertainty often makes justifying any cost to budget holders and decision-makers near impossible.

Investment requires infrastructure like sensors and communication protocols. You'll also need computing and storage infrastructure for analyzing large amounts of collected data. Naturally, the amount you invest is dependent on a business's objectives.

Should you build in-house or buy? Choosing to build your project from scratch in-house will require larger investment. You'll need a complete project team, and that includes additional capital for hiring and onboarding new team members.

Conversely, opting for licensed software is more affordable. You can get away without the need for advanced skills when building and managing digital doubles. You can rely on existing talent familiar with your product or service to plan, design, and maintain your digital twin.

Ongoing costs will include maintenance, data quality control, and security solutions which are crucial to derive value from digital twin technology.[7]

2. Lack of Clear Business Case

Organizations may struggle to identify value-based use cases for digital twins. It's hard for them to demonstrate clear benefits and outcomes. Often, a perceived lack of value is based on little understanding or misconceptions about digital twin technology.[7]

Here are clear rebuttals to four common objections to adopting digital twin technology:

Limited to large-scale companies

Digital twin technology has become more accessible and affordable, allowing businesses of all sizes to tap into its benefits. Digital doubles can be implemented at various levels, focusing on individual processes to streamline and improve operations.

The investment cost is dependent on the scale of your project and whether you chose to build in-house or leverage licensed platforms. You can start small and scale.

Applicable to specific industries

Digital twins are applicable to many industries or sectors. It has diverse applications across industries, including healthcare, distribution, production, agriculture, and more. Digital replicas can support capacity planning, optimization, and simulation-based decision-making.

There are high implementation costs

While there are costs associated with digital twin implementation, accessibility and affordability of underlying technologies have improved. And with the value digital twins can deliver, it's easier to prove significant efficiency gains and cost savings, making them a worthwhile investment.

Only for physical assets

Digital twins can represent processes, systems, and even services. They provide a risk-free environment for testing layouts, optimizing services, and uncovering inefficiencies across various domains.

3. Organizational Silos

Digital twin deployments often need to span multiple departments and organizational boundaries. In siloed organizations, this could prove challenging. Even more so where organizational culture is an issue.

Aligning different teams, such as engineering, operations, sales, and IT, can prove challenging where workflows are poorly defined and communication gaps exist. And should these teams use different platforms, the inability to access or leverage insights could prove problematic.

Overcoming the silo trap is possible, but it will require the introduction and execution of a well-thought-out change management program first. You'll need buy-in at every level to ensure a cohesive implementation of digital twin technology.[7]

5. Complexity and Standardization

Implementing digital twin technology requires integrating various technologies. From the Internet of Things (IoT) sensors to edge computing, artificial intelligence (AI), data analytics, and augmented and virtual reality. In organizations without the know-how or the right systems in place, interoperability and standardization across these technologies can be a challenge.

However, this is starting to change. Digital twins can be created and managed by planners or individuals familiar with the specific processes. By investing in ready-made solutions, you're able leapfrog teething issues and focus on individual processes that can be run by people familiar with your product or service.

You'll be able to find ways to improve efficiency or plan for contingencies and abstract the right data for analysis and derive real business value from your investment.[8]

6. Data Privacy

Data privacy is a significant concern when using digital twin technology. Digital replicas rely on collecting and analyzing vast amounts of data from various sources to create virtual doubles and simulate real-world scenarios.

Data can include personal, sensitive, or proprietary information, depending on the application and industry. And when this data crosses borders, privacy laws are called into question, adding an extra layer of complexity.

Here are five key points that examine and address digital twin technology data privacy concerns:

Collection and Storage of Personal Data

Digital twins may require the collection and storage of personal data to create accurate virtual replicas. Data can include personally identifiable information such as names, addresses, health records, or financial data.

Safeguarding this personal data is crucial to protect individuals' privacy and comply with data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union. The right privacy policies can be developed to align with GDPR regulations.[9]

Consent and Transparency

In cases where data is gathered from individuals, consent mechanisms must exist. There should be transparency about how their data is collected, processed, and shared with third parties.[9]

Data Sharing and Third-Party Involvement

Digital twin ecosystems often involve multiple stakeholders. From manufacturers and service providers to data analytics firms, sharing data between these parties can raise concerns about data ownership, control, and the potential misuse of sensitive information.[9] Developing clear data-sharing agreements and policies that address concerns and ensure that data is used appropriately and only for the intended purposes is essential.[10]

Data Security and Unauthorized Access

As digital twins involve the processing and storage of sensitive data, you'll need a sophisticated security system. Data has and always will be what bad actors are after. It is essential to prevent unauthorized access, data breaches, or cyberattacks. Strong encryption, access controls, and network security protocols should be implemented to protect data from potential threats or malicious actors.[9]

Kickstarting your digital twin technology journey

Digital twins offer tremendous business value. And with a clearer view of the biggest challenges you'll face, you may be wondering how to go about starting your digital twin project.

Here are seven valuable insights on how to get started:

1. Create a blueprint

Start by aligning stakeholders on a clear vision of digital twins and create a blueprint that defines the types of twins your organization will pursue, the order for building them, their capabilities, ownership, and governance structures. This blueprint should maximize value and reusability, ensuring that the digital twin initiatives are aligned with business objectives.[11]

2. Start with basic twin building

Begin by building the basic digital twin over a period of three to six months. Assemble the core data product by engineering structured and unstructured data to ensure quality and usability. Develop visualizations and build initial use cases that generate additional data and insights. Remember, you don't need perfect data or state-of-the-art technology to get started. Focus on laying the foundation and iteratively improving the twin.[11]

3. Start small, think big

Consider starting with a pilot project or a specific use case to demonstrate the value and potential of digital twin technology. Starting small allows you to validate the concept, identify challenges, and gain insights into how digital twins can benefit your business. Once you have proven the value, you can scale up and expand the capabilities of your digital twin.[12]

4. Leverage existing data and technology

Use data and technology assets already available within your organization. While seemingly necessary, you don't have to start from scratch. Identify relevant data sources, systems, and tools that can be integrated into the digital twin. This approach helps accelerate the implementation and reduces costs.[11]

5. Focus on value generation

Clearly define the business value and outcomes you expect to achieve with digital twin technology. Identify specific use cases and metrics that align with your strategic goals. By

focusing on value generation, you can prioritize your efforts and demonstrate the tangible benefits of digital twins to stakeholders.[11]

6. Collaborate and learn from experts

Engage with experts, consultants, or technology partners who have experience in digital twin implementations. Collaborating with knowledgeable professionals can provide valuable insights, best practices, and guidance throughout the process. Leverage their expertise to overcome challenges and accelerate your digital twin journey.[11]

7. Continuously evolve and expand

Digital twin technology is an ongoing journey. Once you have the initial twin in place, focus on expanding its capabilities by adding more data layers, advanced analytics, and AI-driven simulations. Explore different business models enabled by digital twins, such as product-as-a-service, factory-as-a-service, or supply chain-as-a-service, to unlock new opportunities for your business.[12]

Conclusion

Each organization's journey with digital twins will be unique. It's crucial to tailor your adoption process to your specific business needs, industry, and goals. Wins like operational efficiency, improved strategic decision-making, proactive maintenance, personalized customer experiences, risk mitigation, compliance, and innovation are all possible but have to be eased into.

Starting small, focusing on value, and leveraging existing resources, can help your organization start its digital twin initiatives on the right foot. This cautious and calculated approach will help you unlock more value and realize greater success while avoiding pitfalls like underdeveloped use cases or poor planning.

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