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EBOOK

Drive Innovation with Digital Twin Technology

Your Guide to Powering Limitless Digital Twin Projects

Introduction

From product design to factory optimization, cutting-edge teams across industries use **digital twin technology** to drive innovation. They leverage digital twins for prototyping, testing, predictive maintenance, collaboration, customer experience, and more. With a predicted **annual growth rate of 61%**, digital twins are no longer an option, they are a competitive necessity.

This eBook explores the latest developments in digital twin technology with industry examples. It also outlines the benefits of implementing digital twin technology, and the steps to get started. Finally, we examine the obstacles companies face managing the large data sets needed to run digital twins across dispersed global teams and how to overcome these challenges.

Digital Twin vs. Digital Replica

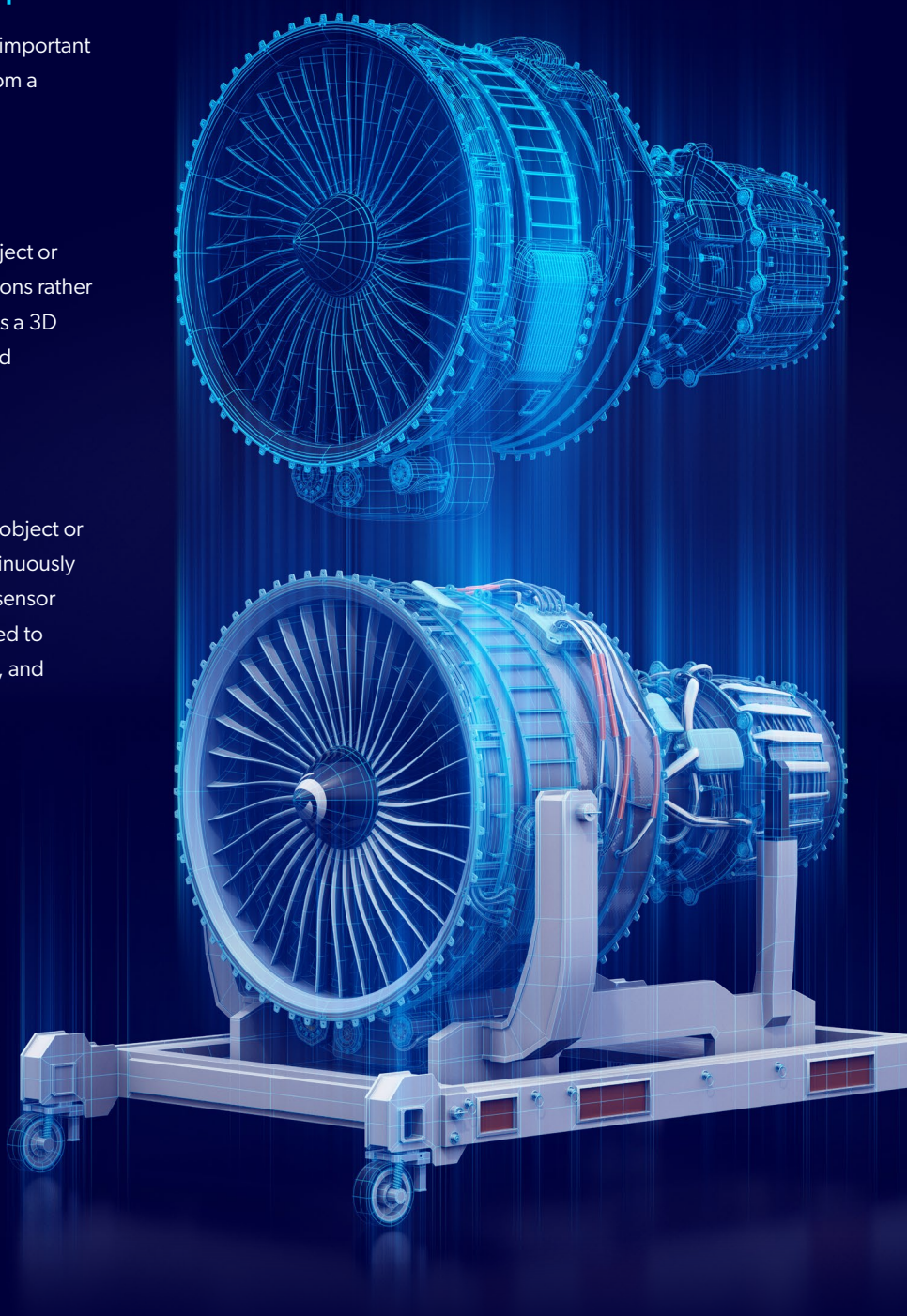
Before diving into industry use cases and first steps, it's important to understand what a digital twin is and how it differs from a digital replica:

Digital Replica

A digital replica is a digital recreation of a real-world object or system. It typically refers to highly accurate representations rather than simplified models. An example of a digital replica is a 3D model of an office building, complete with electrical and plumbing systems.

Digital Twin

A digital twin is a dynamic digital model of a real-world object or system. Unlike a static digital replica, a digital twin continuously evolves with its physical counterpart through real-time sensor data, simulation models, and control logic. It can be used to accurately replicate and predict behavior, performance, and system interactions under varying conditions.



The Digital Twin Advantage

According to Research and Markets, the global digital twin market size is expected to reach $63.5 billion by 2027. This rapid growth is no surprise given the immense value digital twins have proven in companies already leveraging them:

Cost Reductions

Digital twins can save teams time and money through virtual prototyping, issue prediction, and optimized operations. For example: General Electric used digital twin technology to identify a supply leak on a gas turbine and saved $9 million. It also used the technology to detect increased suction temperature on a centrifugal compressor, saving $3.2 million.

Improved Prototyping & Testing

Digital twins, paired with advanced physics engines like the kinds found in game engines, allow teams to replicate complex testing scenarios without costly prototypes and time-consuming live runs. GM designed and tested its new Corvette, the fastest American production car ever, using digital twins. The engineering team even predicted its top speed within 1.09 mph.

Accelerated Development & Time-to-Market

By using digital prototypes, teams can make changes and test updates faster. This accelerated development process speeds up time-to-market without compromising quality or safety. Just ask Renault, who used digital twins to slash a year off their design time.

Predictive Maintenance

Digital twins give companies like Caterpillar the ability to monitor machine health in real time and predict maintenance before breakdowns occur. Internet of Things (IoT) devices collect data on systems and feed them into the digital twin, where teams can easily review outliers, spikes in usage, or unexpected behaviors.

Better Decision Making

Digital twins allow teams to incorporate real-time data from sensors and the environment for better decision-making. Lowe's, for example, uses digital twins of its stores to make key decisions around shelf layouts, stock management, and in-store operations to optimize customer experience.

The Industries Growing with Digital Twins

Automotive

Automotive companies like Porsche and BMW use digital twins to transform static CAD models into dynamic prototypes with real-time rendering. They save money by simulating crash tests on different terrain and in unique situations. Engineers also use game engines to train driver assistance systems. Watch the Perforce webinar, Leveraging Game Engines for Design, Development, and Manufacturing, for a full discussion around the applications of digital twins for automotive manufacturers.

Manufacturing

From process optimization to product lifecycle management, there are numerous digital twin applications. Manufacturers use augmented reality (AR), virtual reality (VR), and mixed reality (MR) applications for training and maintenance. Through AR headsets, technicians can view the most up-to-date models of a machine laid over the one in front of them. Digital twins can enhance this process even more by overlaying real-time data and simulations. Watch our webinar discussing NASA's use of digital twins to prepare its assembly facility for travel to Mars.

Aerospace

Boeing uses digital twins to test different components and predict engine performance. They even achieved a 40% improvement rate in first-time quality, saving development time and money. They have also used IoT sensors to determine the ideal cargo load balance.

Architecture & Construction

Architecture firm Foster + Partners used digital twin technology to oversee development on a site in London. They used a robot dog to collect data around the site, which was fed into their digital twin of the building. The digital twin could then be used to compare the design to its built reality.

The 4 Challenges of Digital Twins

High Initial Costs

While strategic digital twin use provides extensive long-term savings, the cost of implementation can be high, especially for small and medium-sized businesses. It requires a large technology investment upfront and ongoing maintenance costs to ensure your system performs and scales with your needs.

Complexity

Building and maintaining digital twins is inherently complex. Fragmented tech stacks or proprietary systems that can't communicate or integrate with other tools slow down development. A lack of unified version control can lead to errors and rework.

Data Integration & Management

Digital twins require large, reliable, high-quality, and real-time data streams. Data silos, inconsistent formats, and the use of outdated files can undermine your capabilities, particularly when it comes to rapid iteration. You need a data management solution that can centralize, manage, and version high volumes of data while providing full traceability as your digital twin evolves.

Security & Compliance Risks

Digital twins mirror sensitive product data like source code, firmware, and design IP. Fine-grained access controls are critical to protect assets and ensure team members, contractors, and partners have access to only the files they need. If you operate in a regulated industry, you'll need careful data governance to track change history and meet compliance requirements.

6 Tips for Developing a Digital Twin Strategy

The guidelines below will help your team mitigate the obstacles outlined on the previous page and pave the way for a successful digital twin implementation:

1. Identify Use Cases & Set Measurable Outcomes

Common objectives include monitoring operational performance, improving predictive maintenance, or testing new product designs in virtual environments. Once you know your intended use, set specific goals such as, "reduce production downtime by 20%."

2. Create & Communicate Standards

When working with a variety of design and development tools, it is important to create standards and set naming conventions across your project early to prevent issues down the line. Align conventions to the tools you're using. For example, Unreal Engine has a **recommended naming structure** that helps users quickly identify file types and uses.

3. Store Data Securely & Efficiently

Between the initial design of your digital twin and its continuous iterations, you will need to process and store huge amounts of data. All this data needs to be **versioned and tracked** in such a way that each iteration is clearly labeled and identifiable.

Preplanning your data flow practices early on can save you the work of changing your project structures later. This includes your branching strategy, **stream graph**, and even your review and approval processes. Setting up the correct **filetype behaviors** in your server's typemap will prevent merge issues from arising. If you're using Unreal Engine, see their **guide on setting up a workflow using Perforce P4**.

4. Start Small and Scale

Building a digital twin is a complex process. **Start small** with an initial use case and expand your capabilities by adding data and analytics to develop additional uses. Breaking up your project into easily replicable components will allow you to build (and potentially **reuse**) as you go. Where possible, use automation to make processes as seamless as possible.

For many teams, **component-based development** (allowing different teams to bring various aspects of the project together) lends well to building digital twins.

5. Iterate and Test Often

Digital twins and replicas rely on data, but not all data is the same. Human error and duplications can throw off a model. If something feels off, it is important to look at the source data and iterate/test often. This goes back to storing and versioning both your data and prototypes the right way.

6. Get Buy-In Early

Buy-in at every level is critical for resource allocation and smooth execution. The goals, capabilities, and limitations of your project should be clearly communicated early on to ensure buy-in and continued support throughout its development. Ensure all stake-holders have proper visibility and access to the project's tools.

Build with the Right Digital Twin Tools

CAD or 3D Modeling Tools

CAD designs can be exported into other tools in the pipeline, preventing the need to make the same changes in two different tools. Streamline the process with workflows that optimize CAD data for simulation, such as reducing file complexity or converting detailed designs into mesh-based models suitable for real-time analysis.

Examples of popular CAD tools include Siemens NX, Dassault CATIA, and Rhino. Commonly used modeling tools include Autodesk 3DS Max or Maya, and Blender.

Design Transformation & Optimization Tools

Before CAD models can be used in simulations or game engines, they must be transformed for real-time performance. This process reduces complexity, converts formats (e.g., FBX, USD, glTF), generates levels of detail (LOD), and preserves essential metadata. It also removes or obscures sensitive geometry to protect IP.

Common tools include PiXYZ, Blender, Simplygon, NVIDIA Omniverse, and Autodesk FBX Converter. Configure your data management solution to store both original CAD files and optimized assets and maintain traceability, version history, and secure, role-based access.

Game Engines / 3D Engines

Because of their powerful rendering abilities and advanced physics engines, game engines like **Unreal Engine** and **Unity** create highly detailed and immersive virtual environments that mirror real-world systems. Game engines, also referred to as 3D engines, are where the digital twin comes to life through photorealistic visualization, interactive exploration, and simulation capabilities. They also support the integration of IoT and sensor data in real-time, allowing users to monitor, analyze, and optimize performance within a virtual setting.

IOT/Connected Devices & Sensor Data

IoT & connected devices and sensors can supply continuous, real-time data from the real-world object that is emulated in the digital twin. Data collected from IoT devices or sensors is transferred via the internet or edge servers to IoT platforms, where it is organized, processed, and managed based on the team's needs. This processed data can then be fed into the game engine through various integration points. To fully leverage IoT and connected devices, it is critical to establish a robust infrastructure capable of securely transmitting and processing large amounts of data.

Version Control

Version control, also referred to as data management or source control, is the foundation of your digital twin pipeline. The high volumes of large files collected and created in the digital twin process must be securely managed using the right tool. Your version control platform must scale to handle the massive file sizes involved in digital twin development, as well as properly manage frequent changes from multiple team members as you rapidly iterate on your digital twin. Without these capabilities, you won't be able to leverage the full benefits of digital twin technology.

For teams in heavily regulated industries, a traceable version control platform is critical for compliance and streamlining the audit process. It should provide a complete audit history of all changes made within your digital twin project, including who made them, and when. Plus, the right data management solution (like **Perforce P4**) protects your proprietary data with enterprise security features and granular permissions.

You'll also want to ensure that your version control system can easily integrate and communicate with the rest of your toolchain, so your team can easily access and version files directly within their digital twin tools and workflow.

The Future of Digital Twins

Today's digital twins are the tip of the iceberg. As this technology unfolds, new innovations will completely change how companies develop products, perform predictive analysis, and optimize operations. Here are a few emerging trends to get in front of:

AI Integrations

Modern digital twins increasingly integrate machine learning and advanced analytics to automate predictions, detect anomalies, accelerate testing and validation, and optimize performance. These self-improving systems are poised to further reduce the development cycle and bring products to market significantly faster.

IoT & Edge Computing

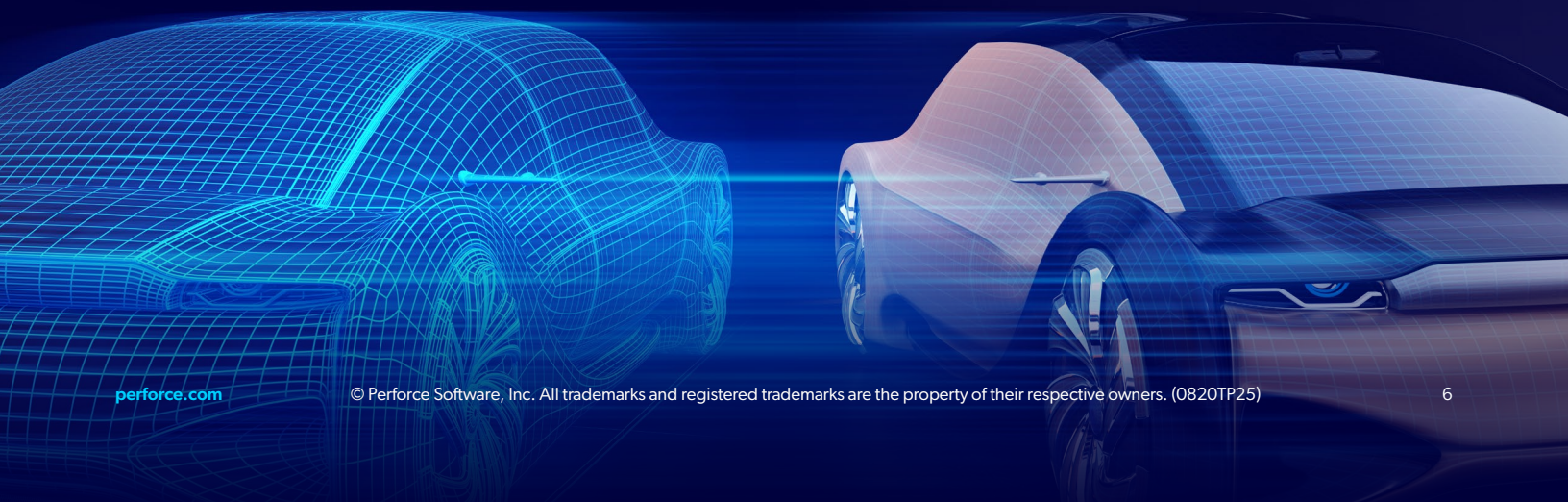
The expansion of IoT sensors and edge computing allows digital twins to process data closer to the source. This reduces latency and cloud dependency and enables real-time responses in remote or time-sensitive environments such as autonomous vehicles or smart factories.

Smart Manufacturing & Industry 4.0

In manufacturing, digital twins underpin smart factory initiatives with real-time process monitoring, predictive maintenance, and closed-loop control. They create a unified view of production to improve uptime, quality, and throughput.

Sustainability & Lifecycle Optimization

Digital twins support environmental goals by modeling energy consumption, emissions, and material usage across the full product lifecycle. They enable manufacturers, builders, and infrastructure owners to track, predict, and improve environmental, social, and governance (ESG) performance.



Conclusion: The Road Ahead

Digital twin technology can revolutionize your team's processes by making them faster, more efficient, and more cost-effective. However, to build digital twins, your team will need to manage massive quantities of data. Doing so efficiently and securely requires a robust version control system.

Perforce P4

Your Foundation for Digital Twin Development

Perforce P4 is a scalable, high performance version control solution that is ideal for digital twin development. It integrates with your existing toolset to manage, store, and version all digital assets.

Limitless Scalability

With an unrivaled ability to handle the expanding size and complexity of today's digital twin projects, P4 can store and track changes to all your digital assets, from massive binaries to source code.

High Performance

P4 delivers files at lightning speed, even when managing complex digital twins with remote teams across the globe. Its federated architecture supports advanced server topologies—including proxy and edge servers—so collaborators worldwide can access assets quickly and securely.

Seamless Integration

What sets P4 apart is its extensibility. It can connect to virtually any tool in your workflow or pipeline through a vast **ecosystem** of APIs and integrations, including seamless integration with **Unreal Engine** and **Unity**. Through these integrations, teams can automate, scale, and evolve their digital twin infrastructure as projects become larger and more complex.

Functional Safety Compliance

Perforce P4 is ISO 26262 certified for functional safety to ensure your digital twin adheres to the highest safety and quality standards. A complete audit history allows you to trace every change for compliance with industry regulations.

Enterprise Security

P4 is known for its iron-clad security. Unlike Git where collaborators have to share entire repositories, P4 allows you to control access down to the individual file level and by IP address, so team members, partners, and contractors have access to only the files they need.

Watch the Demo ▶

perforce.com/products/helix-core/demo

Watch: Mission to Mars

"[P4] has been a great addition to our software development suite. The advanced mapping features have greatly sped up our development workflows."

– Greg Porter,
Senior Systems Architect, Sev1Tech

Sev1Tech used P4 when they teamed up with Louisiana State University (LSU) to build a digital twin of NASA's Michoud Assembly Facility in New Orleans. The goal was to create a data-driven model that would replace costly and time-consuming real-world prototypes so that NASA could fast track its plans to send humans to Mars.

You can **watch the entire video** to hear how the team:

- Leveraged the digital twin for real time component location, environmental condition testing, and AR-based job instruction.
- Used Unreal Engine to build real-time 3D environments, integrated with P4 as a scalable foundation for iterating on these environments.
- Maintained secure collaboration across multiple teams while handling large amounts of sensitive data.

"[P4's] ability to fine tune access and permissions has given us new ways to collaborate on secure and highly sensitive IP."

– Marc Aubanel,
Director of Digital Media Arts & Engineering, LSU

Power Your Digital Twin Projects with P4

Building a digital twin requires a significant investment in time and resources. Be sure that you're using the right version control platform to handle your digital twin assets safely and efficiently. With P4, you can:

- Scale without limits as your digital twin capabilities evolve.
- Maintain speed, traceability, and integration flexibility.
- Ensure your infrastructure is secure, compliant, and future-proof.
- Deploy your way: on-premise or in the cloud.

Connect with a Perforce expert today to learn how your team can benefit from the version control platform trusted by gaming, automotive, aerospace, architectural, and manufacturing leaders around the globe.

Talk to a Digital Twin Expert ▶

perforce.com/products/helix-core/contact-us