Supercharging the industry transformation with the comprehensive Digital Twin

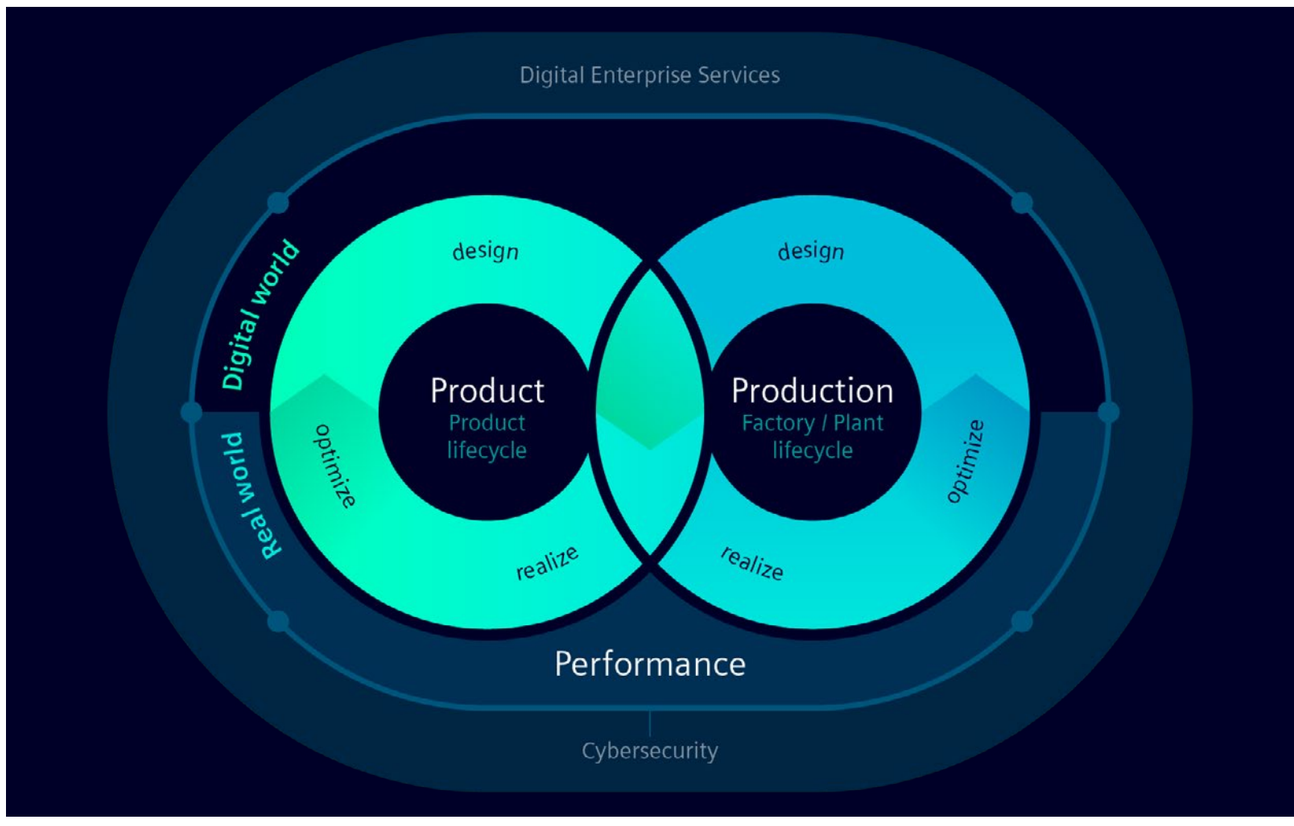
SIEMENS

Physicist William Pollard famously said, “Those who initiate change will have a better opportunity to manage the change that is inevitable”. And these words are more relevant now than ever. Our current industrial landscape is a minefield of challenges that include cost pressure, efficiency demands, faster innovation cycles, workforce shortages and above all, the need for more sustainable practices. Rather than viewing these hurdles as potential setbacks, it’s time for organizations to embrace innovations and recognize them for what they really are – opportunities.

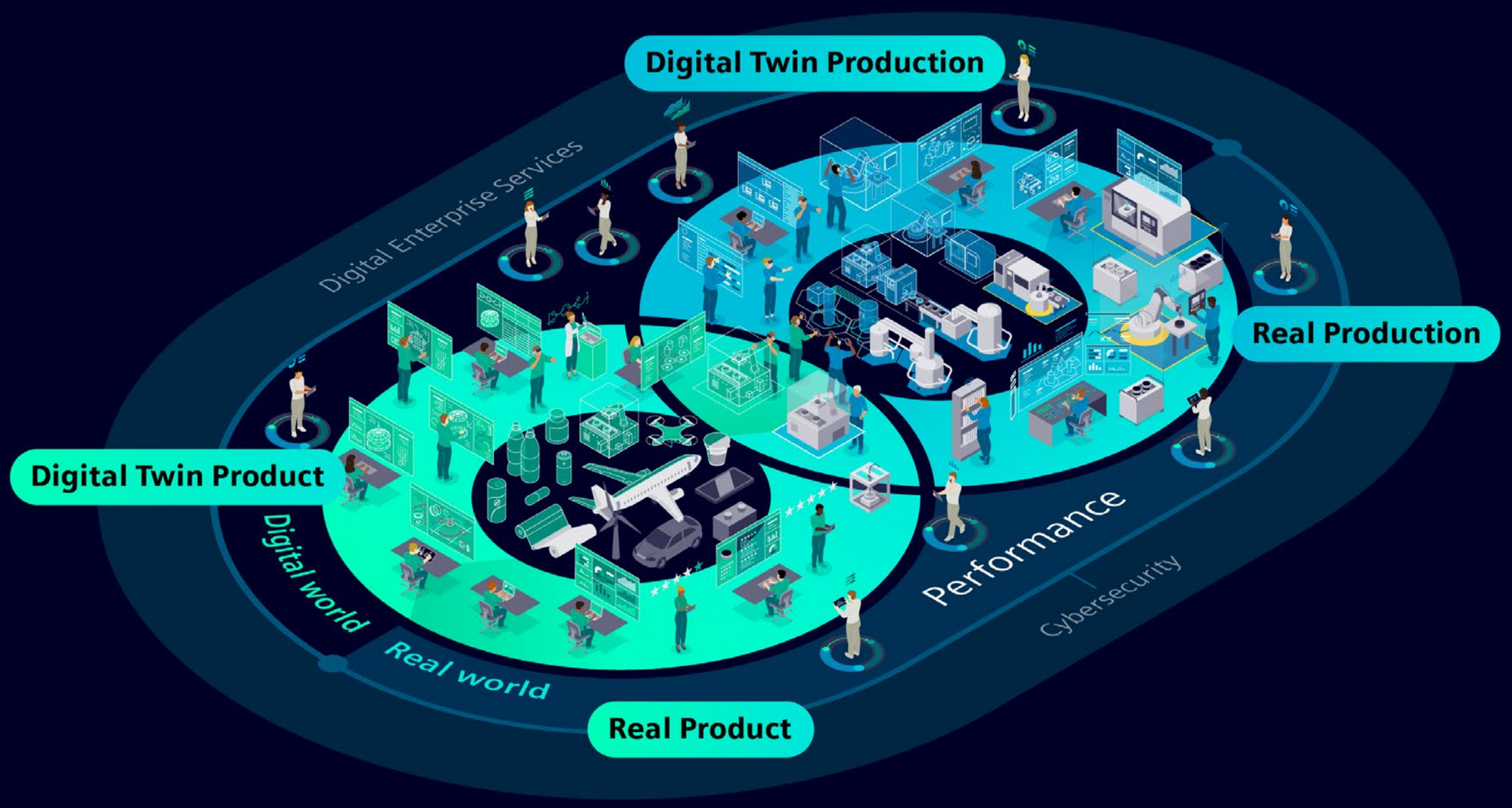
Our production systems need to be very flexible to ensure that they can be operated efficiently. Lean methods in combination with the Digital Twin and simulations help us achieve optimal timing and optimal system operation.”

Lars Schreiber,
Expert for Simulation and Digital Twin,
Siemens Electronics Factory Erlangen

Simulation capabilities have emerged as the key to adapting to the changes of today’s environment. Companies can leverage this technology to remain competitive through managing industry challenges. This brings about true digital transformation where the Digital Twin plays a key role. As a Digital Enterprise, companies can seamlessly integrate the real and digital worlds with Siemens’ comprehensive Digital Twin approach, enabling them to integrate their entire product and production lifecycles to make critical decisions with confidence, optimize the overall performance of their organizations, and ultimately capitalize on and overcome adversities.



Siemens’ unique approach of combining the real and digital worlds with the Digital Twin enables industrial companies to become Digital Enterprises.



The comprehensive Digital Twin is a unique approach from Siemens that enables users to derive maximum value from Digital Twins for products and production.

New opportunities with the Digital Twin

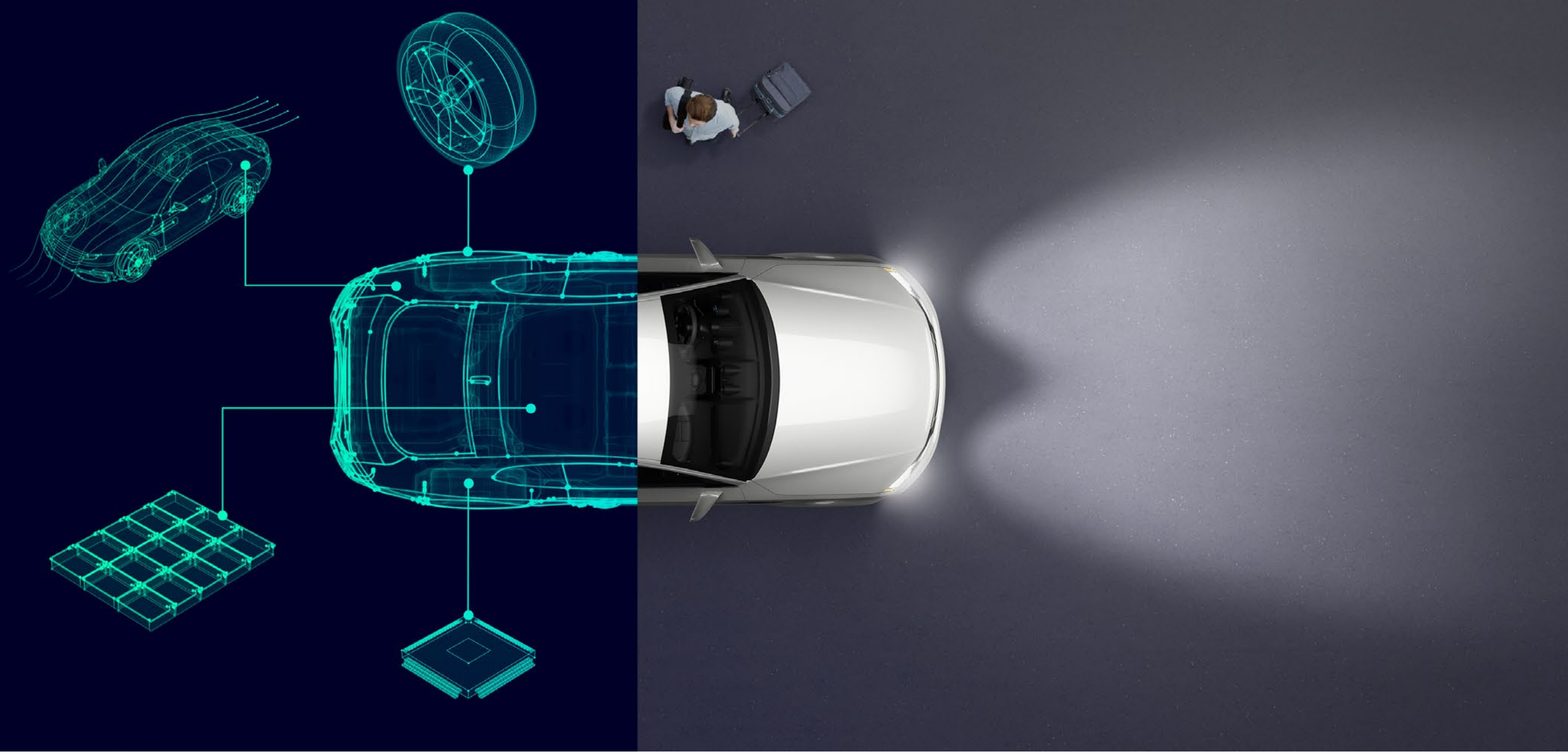
A Digital Twin is a digital representation of a physical asset or process based on powerful physics-based simulation. This can range from small products to large machines or even entire plants. The Digital Twin helps define and optimize products and production systems, thus significantly reducing the need for physical prototypes before investing in physical assets and contributing to saving valuable resources. Moreover, the Digital Twin continuously updates to reflect any change to its physical counterpart throughout the product lifecycle, creating a closed loop of feedback in a virtual environment. This enables companies to continuously optimize their products, production and supply chain processes at minimal cost.

There are as many Digital Twin models for a technical system as there are different use cases. In general, the models grow with their requirements.

Users can start small by creating additional facets of the Digital Twin when needed and expand their capabilities with more data over time as their experience and ambitions grow.

Siemens' unique comprehensive and physics-based Digital Twin approach incorporates mechanical, electronic and electrical software and manufacturing to fully capture today's smart products and processes. It comprises a set of consistent digital models representing different aspects that can be used throughout the entire product and production lifecycle and the supply chain.

The Digital Twin also offers an essential level of traceability and forensics that is crucial to regulated industries. The comprehensive Digital Twin ensures consistency throughout the lifecycle and minimizes the effort required to create and maintain it.

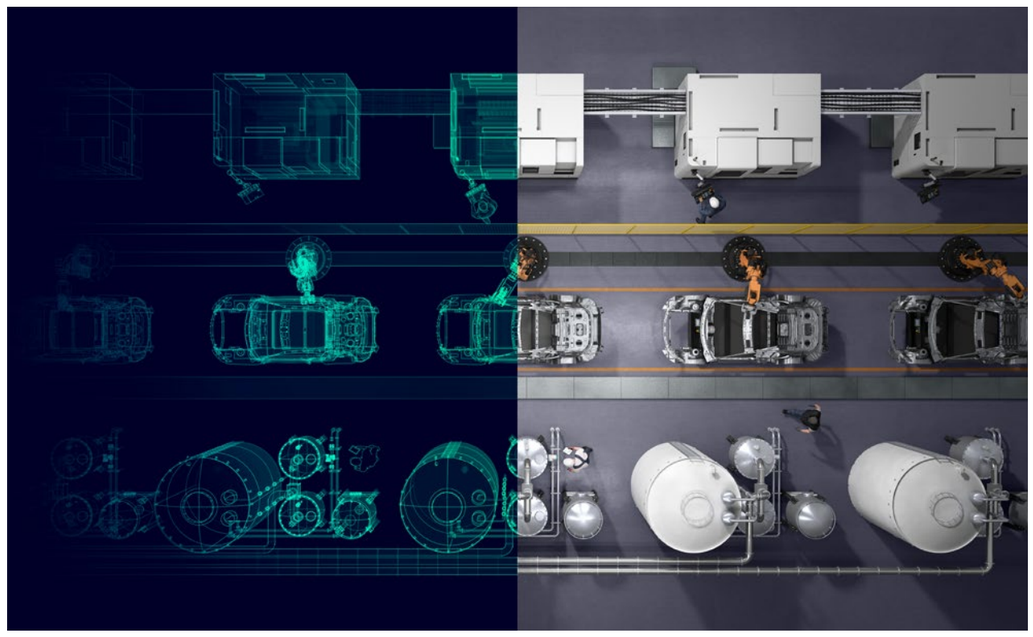


The Digital Twin for Products helps to virtually design, simulate, and verify products, including mechanics and multiphysics, electronics, and software.

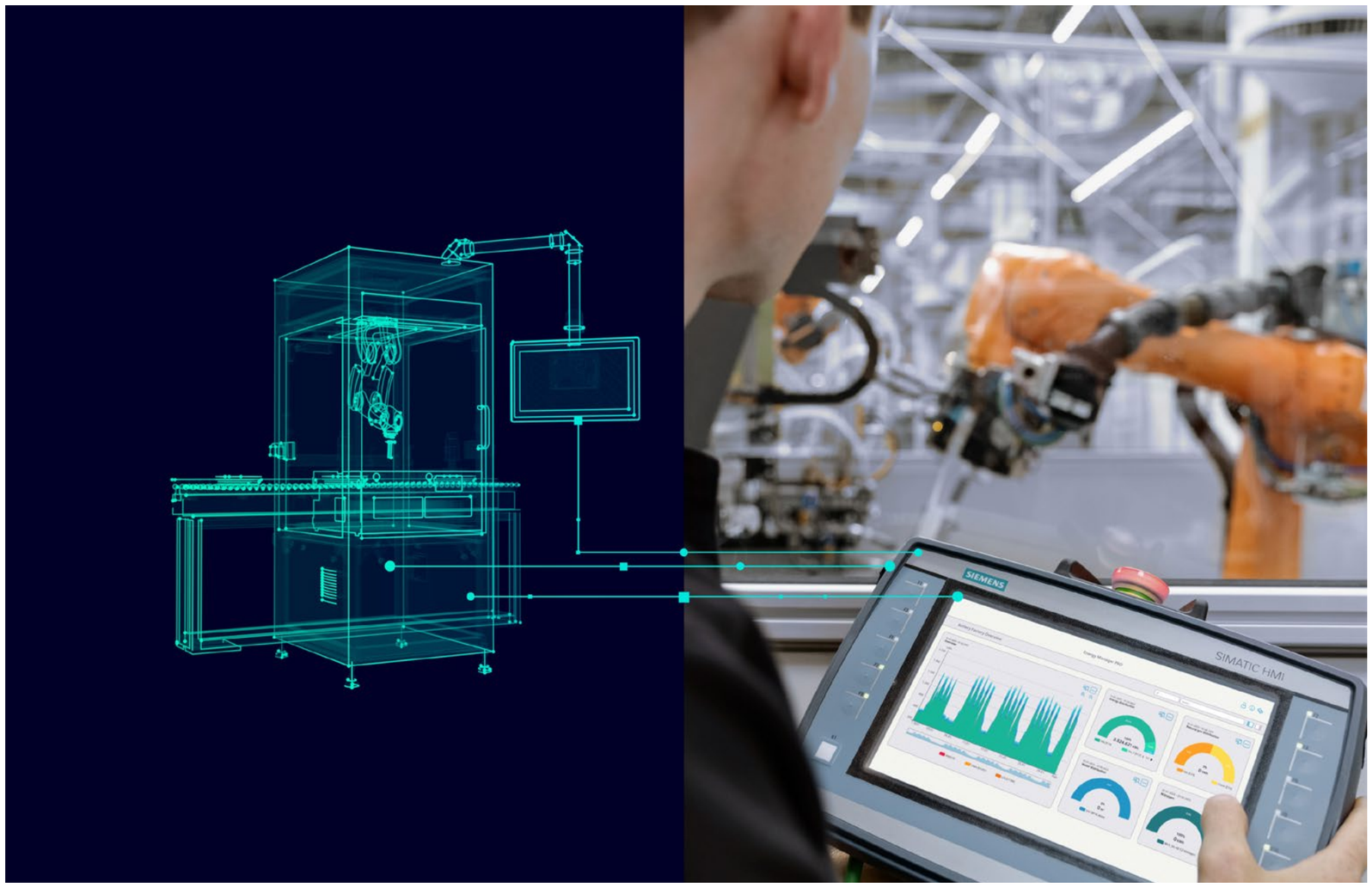
End-to-end optimization

The comprehensive Digital Twin enables the seamless integration of the product and production lifecycles, including software and automation. It allows manufacturing companies to design, simulate, test, improve and validate products with the Digital Twin for Products, including mechanics, multiphysics, electronics and software. All of this can be achieved in a virtual environment using robust simulation tools to enhance the quality of the final product while shortening the overall design cycle.

Another facet of the Digital Twin is the Digital Twin for Production. It enables the design and optimization of machines, production lines, entire factories and plants in the digital world to make them faster, more efficient and sustainable. From the design, engineering and simulation of the machine, line, factory or plant to virtual commissioning, the Digital Twin for Production can identify areas of improvement. It can correctly determine the most efficient sequence for processing or executing tasks in the production system, proving itself invaluable when optimizing production scheduling.



The Digital Twin for Production helps to plan, simulate, predict, and optimize all production processes, optimize machines, lines, and even complete factories and plants throughout their lifecycle.



Performance data from real production or real products is collected, analyzed and fed back into development. The result is a continuous loop of optimization.

Moreover, using the Digital Twin to streamline production scheduling enables the collection of information such as tracking processed orders, monitoring materials, or accurately measuring process times, including the validation and optimization of the material flow throughout the entire system.

When extended to the supply chain, the comprehensive Digital Twin can unlock major efficiencies by sharing insights between inbound logistics and the Advanced Planning and Scheduling role of MES systems. Furthermore, logistical roles can be connected between external and intra-plant logistics for similar business efficiencies and gains.

One of the most beneficial aspects of the Digital Twin is its ability to evolve throughout the lifecycle. This starts during the initial stage of developing a product or process, where designers can benefit from digital representations supporting the simulation of behavioral aspects. In the operational phase, the physical asset and the Digital Twin coexist with the performance data of the real product and process being collected, analyzed, and fed back into development.

This results in closed-loop optimization using performance data through the Digital Twin of Performance. Actionable insights derived from this data can facilitate confident decision making, allowing for productivity and process improvements. Armed with these insights, the Digital Twin can generate value by running “what-if” scenarios that analyze the past, reflect the present, and even predict future states or behaviors.

When combined with Siemens Xcelerator, the Digital Twin can also help users act on their insights, making the Digital Twin invaluable to the future success of organizations. Users obtain direct feedback on their actions – and when changing any settings or creating new scenarios, this allows them to directly experience the impact of their changes in real time.

Turning possibilities into reality

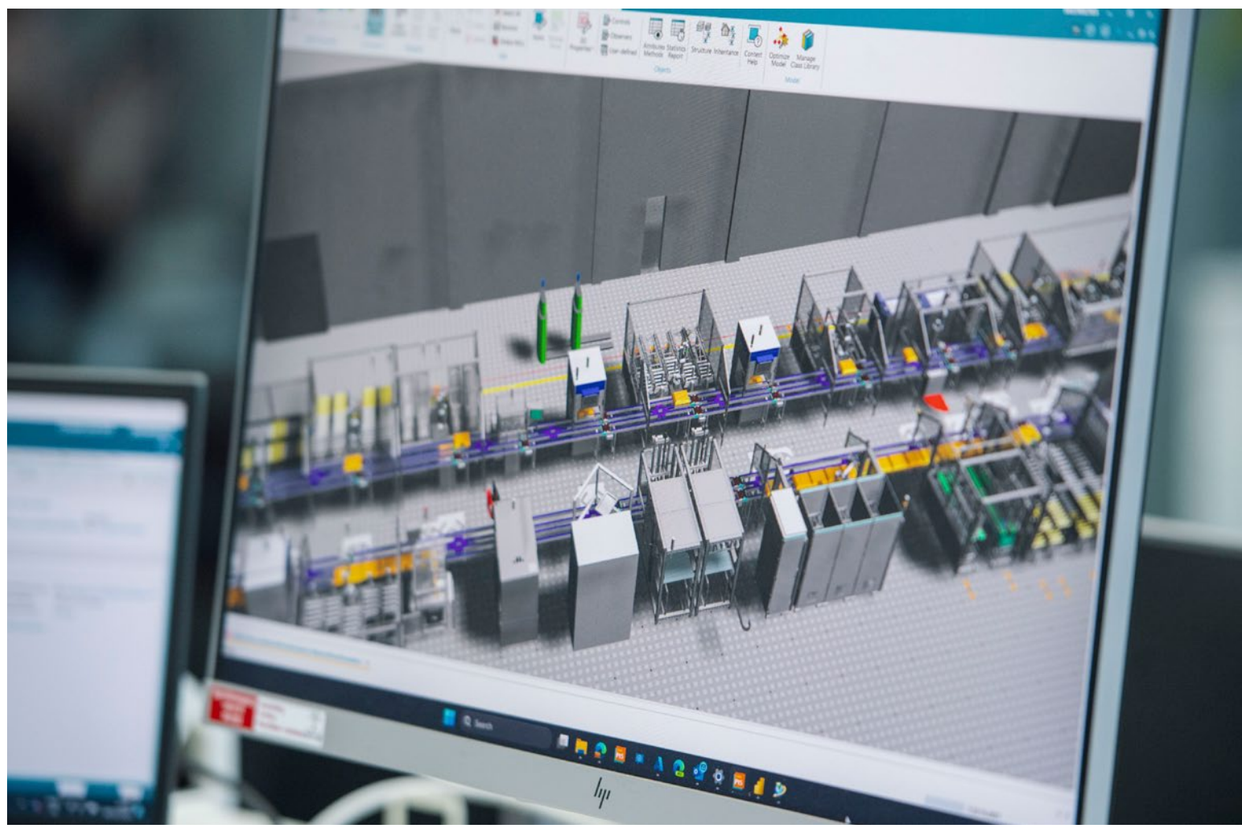
The possibilities of a Digital Twin are virtually limitless. Today, our customers, i.e. product designers, machine and line builders and plant operators, are already generating value with this technology.

Here are just a few examples of use cases:

- Validate designs with simulation models to optimize a product or production
- Optimize the cooling airflow without having to create expensive prototypes
- Simulate the kinematics of a machine virtually before building it in reality
- Find the perfect AGV route based on the Digital Twin of the shop floor
- Determine the best plant layout after simulating thousands of possible scenarios
- Run the Digital Twin on Industrial Edge devices to analyze and optimize real-time performance
- Combine a Digital Twin with AI to intelligently optimize production with the help of analytics
- Utilize operational data to create a closed-loop Digital Twin and improve next-generation designs

Furthermore, the Digital Twin greatly enhances the concept of the Digital Thread which is a digitalized and automated sequence of specific business workflows within the product or production lifecycle. The Digital Thread requires a common understanding (semantic integration) of data related to objects or processes. It significantly facilitates the comprehensive Digital Twin by providing a seamless data flow between product and production lifecycles.

Working with a Digital Twin provides freedom from constraints or costly consequences. If something does not work out in the digital world, companies can reset the simulation and try again with different parameters. Our comprehensive Digital Twin approach inspires both creators and innovators and sparks new ideas on how to optimize products and production, reduce costs and the carbon footprint, and create new business models and revenue streams.



At the Siemens Electronics Factory in Erlangen, the Digital Twin is used to continuously optimize production.

Enter the Industrial Metaverse with the comprehensive Digital Twin and collaborate at new levels of efficiency.

Continuous innovation lies ahead

The comprehensive Digital Twin, software-defined automation and production work together to lay the foundation for the Industrial Metaverse. This will further extend the Digital Twin's reach, ultimately leading to even faster and improved judgments.

The Industrial Metaverse is an immersive, synergistic space, allowing users around the world to easily collaborate by interacting with digital representations of physical assets in real time. This digital space is where Digital Twins from multiple sources reside in an interoperable way so that users can creatively experiment and innovate.

The Industrial Metaverse will not only supply the necessary computing power to operate a larger number of Digital Twins in parallel, but it will also provide effective means to manage user access, ensure IP protection, and will finally provide a new level of usability that allows non-experts to derive even more value from Digital Twins.

The Digital Twin enables to analyze countless scenarios and optimize material flows, reduce energy consumption, and increase productivity.

The Digital Twin can dynamically reflect the status of its real-world counterpart, allowing developers and designers to optimize their work in the virtual world before committing it to the real world.

Getting started with the Digital Twin

But how does an engineering group create a Digital Twin? Picture the Digital Twin process as two distinct lanes – one as the virtual world and the other as the real-world system. This can be a physical production system or a specialized machine. It is the virtual lane that initiates the lifecycle by creating a Digital Twin of the yet-to-be-built system.

But the Digital Twin isn't just a static representation of the intended design or system. It serves as a detailed, dynamic description of how the system should be built, illustrating how it should behave. Then, through simulations, engineers can refine the parameters of their intended system to feed even more information into the Digital Twin, thus optimizing the proposed system before committing to a physical build. As the engineering process unfolds, the physical build of the system starts. This is when the physical lane reflecting the real world begins to run in parallel with the Digital Twin. From now on, the Digital Twin is continuously updated to reflect the progress of the future physical system as it is being built and assembled.

During this crucial period, multiple teams can use the Digital Twin to run, simulate and validate its code well before the actual physical build of the system is completed. This approach is called virtual commissioning. As a result, engineers are empowered to debug, refine and enhance the design of a product or production process before the system is even built, leading to substantial cost savings. This is a game-changing solution for machine builders that leads to additional benefits, such as a drastic reduction of the time required for physical commissioning and a decrease in waste, and can even give manufacturers an early start on operator training.

Capturing data to improve factory operations

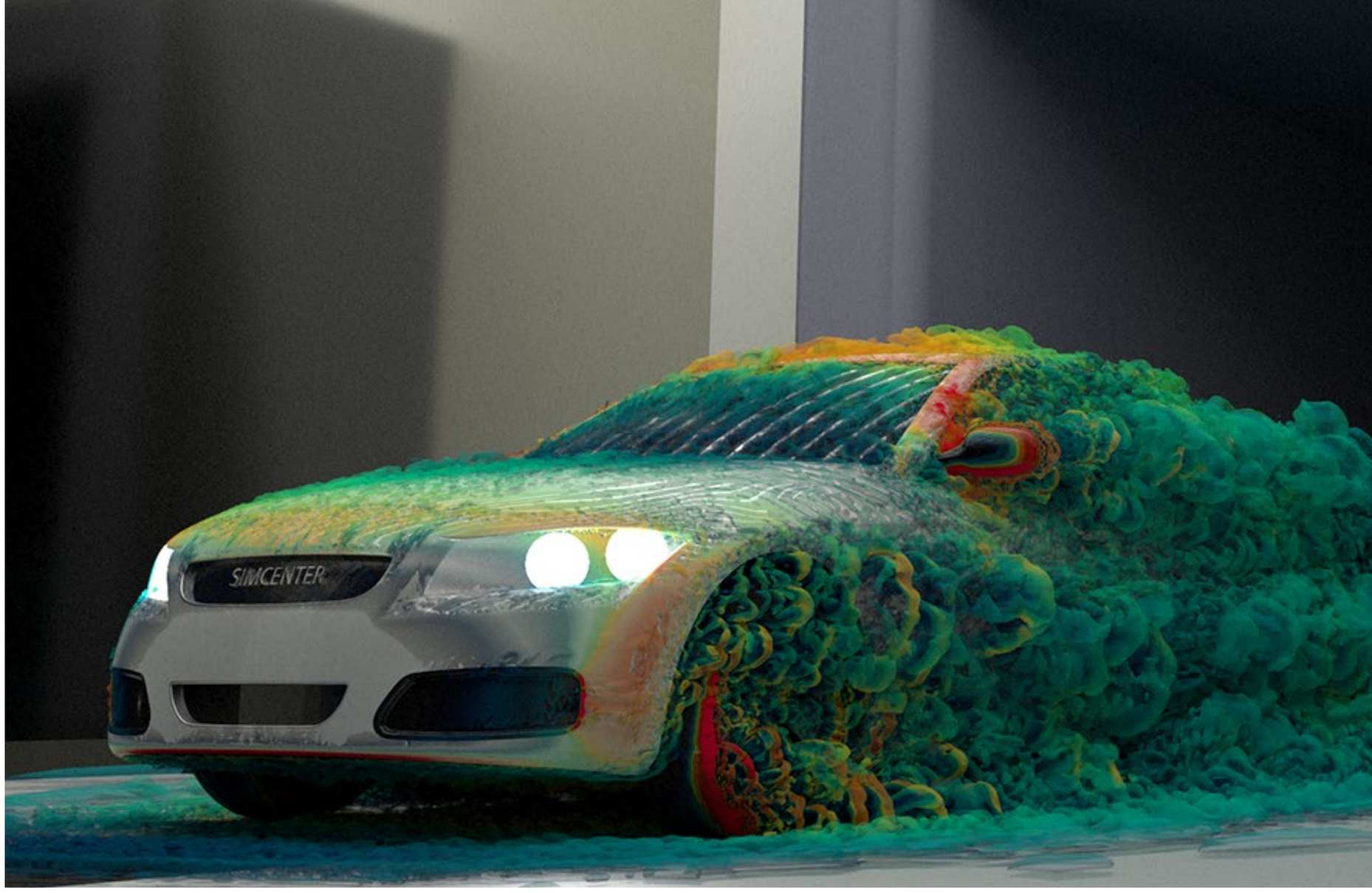
IT/OT convergence enables companies to connect information and operations, increasing transparency and access to data throughout the product and production lifecycle and across the supply ecosystem.

In addition to enhancing machine design, the Digital Twin offers a cutting-edge approach to improving factory operations. Whether it is a single machine, a production line or an entire factory: the Digital Twin can help manufacturers understand whether potential changes will actually improve their system. How is this achieved? Through the collection of real-time data.

There are several ways to capture this data, including:

- **IT/OT convergence:**
  The combination of Information Technology (IT) and Operational Technology (OT) drives the performance of the Digital Twin. IT/OT convergence enables the communication and integration between traditionally siloed IT systems, focused on data processing and business applications, OT systems, as well as on reliable physical processes. This convergence provides the necessary infrastructure for the Digital Twin by unlocking previously untapped data, thus facilitating a holistic view of factory operations.
- **Sensors and machine data:**
  Sensors capture real-time data from machines and equipment on the factory floor. This data is crucial for creating an accurate and up-to-date representation within the Digital Twin, reflecting the actual state of physical assets in the factory.
- **Artificial Intelligence (AI):**
  When working in tandem with a Digital Twin, AI can generate tremendous value. For example, robotic arms for bin picking would normally be trained on physical systems to assess the parts in different conditions. However, this is costly in terms of time, space and equipment. But now, AI-based control algorithms can be trained with the Digital Twin, causing no interruption to production.

With these data capturing methods, the Digital Twin can create a dynamic and accurate representation of machines and factory operations.



Collaborative CFD simulation helps to optimize aerodynamic performance for improved energy efficiency, range and comfort.

Different Digital Twins for individual needs

In light of the expansive Digital Twin landscape, the need for tailored solutions becomes more and more evident. Different applications demand distinct types of Digital Twins, with a strategic focus on specific information that aligns with its intended use. There are situations where all-encompassing information may be unnecessary. For instance, in scenarios where optimization is the primary goal, a streamlined Digital Twin focused on software modifications may work more efficiently.

Predictive maintenance, on the other hand, may require a distinct Digital Twin to monitor and understand the wear and tear of a machine's individual components, without the need for information about the machine's overall purpose. A specialized Digital Twin thus ensures efficiency and relevance in addressing targeted objectives.

The most compact and efficient form is the executable Digital Twin. This practical and lean Digital Twin is a self-contained, easily adaptable and reusable simulation component. Executable Digital Twins leverage the data collected by a set of sensors integrated into the physical product to conduct realtime simulations using reduced order models. These Digital Twins come with an integrated simulation environment so that they can use local computing resources to generate insights efficiently without requiring simulation expertise or large, remote computing resources. The insights derived from these sensors then provide the basis for real-time analysis and informed decision-making in order to optimize operational processes.

The benefits of the Digital Twin

Here are some additional benefits that a Digital Twin brings to manufacturing:

- **Improved training:**
  The Digital Twin allows operators and staff to familiarize themselves with equipment operations in a virtual setting before working with physical machinery, fostering skill development, reducing training time and improving workforce proficiency.

- **Optimized throughput and quality:**
  The Digital Twin enables manufacturers to optimize production processes by simulating scenarios. By analyzing real-time data from the physical product, adjustments can be made to improve throughput. For example, a machining operation that takes 5 hours for titanium could be shortened by analyzing the feed rates or the spindle, saving both time and resources.

- **Sustainability support:**
  By monitoring energy consumption, resource utilization and the environmental impact, the Digital Twin can help manufacturers reach their sustainability targets. Additionally, the Digital Twin for Disassembly can help sustainably disassemble a product or machine at its end of life.

- **Efficient troubleshooting:**
  When discrepancies or malfunctions occur in the physical system, the Digital Twin can assist in diagnosing problems by analyzing data or software in ways that cannot be easily done on a physical machine. This accelerates the resolution process, minimizes downtime and reduces the need for manual intervention.

- **Predictive maintenance:**
  In manufacturing, downtime equals financial loss. Having a Digital Twin of a machine or a production line can help manufacturers predict maintenance needs proactively, preventing unnecessary planned maintenance.

We use our software for design, simulation and optimization in our own plants, for example in our Electronics Factory in Erlangen, Germany.

Create your comprehensive Digital Twin faster with Siemens Xcelerator

The best solution for Siemens customers is a consistent end-to-end approach combined with deep industry know-how and profound experience. We offer customers a broad range of integrated software, automation solutions, and services to align with their individual needs across all industries. Thus, we help create their comprehensive Digital Twin that interoperates with Siemens and 3rd party hardware and software solutions: thanks to Siemens Xcelerator, our open digital business platform.

The Digital Twin helps you become a sustainable Digital Enterprise

Becoming a sustainable Digital Enterprise adds another level of complexity to the entire value chain of a manufacturing company. Product design should support eco-friendly use. Up to 80% of all product-related environmental impacts are already determined in the design phase.

Production must become more sustainable as well. In both cases, the Digital Twin can unfold huge potential, helping to avoid emissions and save energy and other valuable resources. Leveraging the Digital Twin, companies can virtually model, optimize, and identify inefficiencies prior to physical prototyping and production. All of this minimizes waste, energy and resource consumption.

Powerful product carbon footprint (PCF) tools, AI, and automation can help businesses manage the energy transition, increase carbon footprint transparency, drive recycling and circularity, and implement smart energy and asset management. As a result, manufacturers can accelerate transformation with the Digital Twin to reduce the CO_2 footprint, save valuable resources, improve energy efficiency, increase resilience, and speed up processes and finally become a sustainable Digital Enterprise.

To learn more, visit us at
www.siemens.com/digital-twin