SIEMENS

White Paper

# Digitalization integrated, not just connected

## Using digital twin technology to accelerate time to market and reduce risks.


### Abstract

This paper describes how manufacturers can use virtual commissioning via digital twin technology enabled by advanced Siemens software to reduce commissioning time and add efficiency. With digital twin technology, mechanical and automation engineering can be done in parallel with the manufacturing readiness process, so companies can identify errors much sooner and with little or no impact or cost. These and other benefits can help manufacturers to better meet rising customer expectations, handle more complex products and variants with mass customization, and become more competitive and profitable.

Manufacturers today face fierce competition amid fast-changing consumer demands. Production speed, flexibility, and agility are crucial to staying competitive and profitable, while maintaining product quality, safety, and compliance.

As the world's leading automation provider, Siemens sees manufacturers facing these core challenges:

1. **Accelerating time to market.** Rising consumer expectations for new features and capabilities require manufacturers to innovatively develop and launch products inside ever-tightening market windows, despite increasing product complexity.
2. **Reducing launch risk.** Getting products launched, especially in highly regulated industries, can be filled with costly pitfalls. Speed cannot compromise quality and safety.
3. **Enhancing flexibility.** Consumers want variety as well as individualized products, and at mass-produced prices. Production has to be extremely flexible and producers need to be more agile.
4. **Increasing quality.** To ensure consistent quality as well as regulatory compliance, closed-loop quality processes with product traceability are needed.
5. **Boosting efficiency.** Not only do products need to be sustainable and environmentally friendly, but material and energy waste also must be minimized and output maximized.
6. **Strengthening security.** As manufacturers increasingly merge OT and IT networks, their vulnerability with cyber security grows. Layered, defense-in-depth safeguards must be put in place, tuned to the deterministic needs of factory production controls and automation.

If well integrated, upgrades can help draw value from existing assets. However, manufacturers need to take into consideration outdated machinery and an aging workforce. Old machinery is often fully depreciated, and while these plant assets might function well enough, companies are incurring opportunity costs in terms of speed, flexibility, reliability, and visibility newer technologies can provide.

The maturing workforce of machine operators, maintenance technicians, and plant engineers, who will retire soon, will take with them decades of factory experience and knowledge, much of it undocumented, needed to keep aging machines and plant machinery operating in top condition.

## Better, faster decision making: Digitalization integrated, not just connected

The good news for manufacturers concerned about staying competitive and ensuring profitability is rapid technology advances in recent years have lowered and, in some cases, eliminated the high capital costs of plant upgrades needed to take advantage of end-to-end factory digitalization.

Consider, for example, external IIoT (Industrial Internet of Things) technologies, such as ultra-fast, highly secure wireless connectivity and economical, cloud-based platforms with advanced analytics, coupled internally with smart sensors and machines, supported by intelligent controls and automation software.

These technologies – if integrated and not just connected – can be employed to streamline production processes, communicate securely with higher-level MES (manufacturing execution systems) and ERP (enterprise resource planning) platforms, and provide everyone from floor personnel to top management with much more operating visibility via advanced HMIs and data-driven dashboards with enhanced graphic representations of KPIs.

This visibility supports better and faster decision making. Before this, data from different sources that might have taken days or weeks to collect and normalize can now be aggregated and securely viewed in real time anytime, anywhere, and on any web-enabled device.

In turn, using cloud platforms, data from a single plant can roll up into enterprise-wide models and provide near real-time reports that can encompass any number of plants, even ones located oceans apart.

For example, Siemens MindSphere, the open, cloud-based IoT operating system, was designed specifically for the industry and serves such a purpose. It also provides manufacturers with access to a growing portfolio of OEM industrial software applications on a flexible pay-as-you-go subscription basis, so they don't have to invest capital in premise-based hardware and software, nor do they have to worry about upgrades or having skilled IT staff to manage it all.

## Faster time to market: Virtual commissioning via digital production twins

Typically, a critical path to any successful product launch is the validation of the manufacturing process. Depending on product complexity and its required variations, the sequence of steps involved in engineering and setting up a new production line (as illustrated in Figure 1) can take many months.

In addition, the interdependencies across these steps can introduce significant risks to a launch. The problem is, unidentified errors that occur in early engineering stages can have huge impacts on cost and time if discovered much later, especially in the manufacturing stages.

According to the Six-Sigma/Quality "Rule of Tens," the costs for an unidentified error can grow by 10 times from one value-added level to the next. So, while an error found in a product's planning stage might cost $100 to fix, the same error discovered once manufacturing has started could cost $100,000 to address.

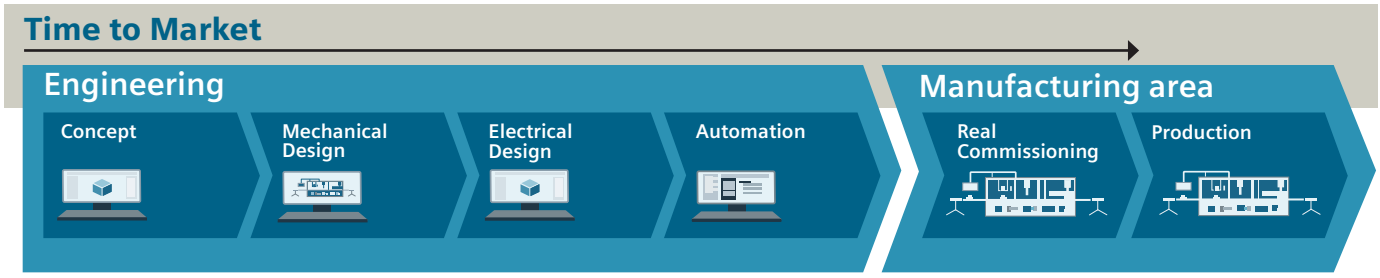


Figure 1. Typical sequence of steps to set up a new product's production line which can take months

Worse, if the product has shipped to market, the impact of an early-stage error emerging – say, in the formulation of a packaged food or pharmaceutical – could be in the millions, not to mention potentially undermining a long-standing brand reputation.

Digital twins modeled in sophisticated software depict physical production systems both in design and operation including controls, automation components, sensors and actuators, PLCs and HMIs. Once a new production line is operating in the physical world, data from its material handling systems, machines, and higher-level systems can constantly update its digital twin to keep the latter current.

Digital twins can illustrate and animate just about every plant dimension: from extremely granular detail of a machine's components and sub-assemblies to larger views of the machine itself, the production cells in which the machine will operate, and entire production lines and plants.

With such a comprehensive virtual representation, engineers can conduct a wide range of simulations to evaluate their various automation approaches to find the best one, much earlier in the process. Using a digital twin, they can validate critical operations including:

- **Control logic and visualization**
- **Interaction between controller and mechatronics of a machine**
- **Interaction of various components in a machine, cell, or plant**

With the digital twin, this validation, through virtual commissioning, can occur in parallel with production engineering (as shown in Figure 2) saving time and reducing the risks of traditional production engineering and set-up.

It can also totally transform the jobs of control and automation engineers, especially those taking part in either of these types of projects.

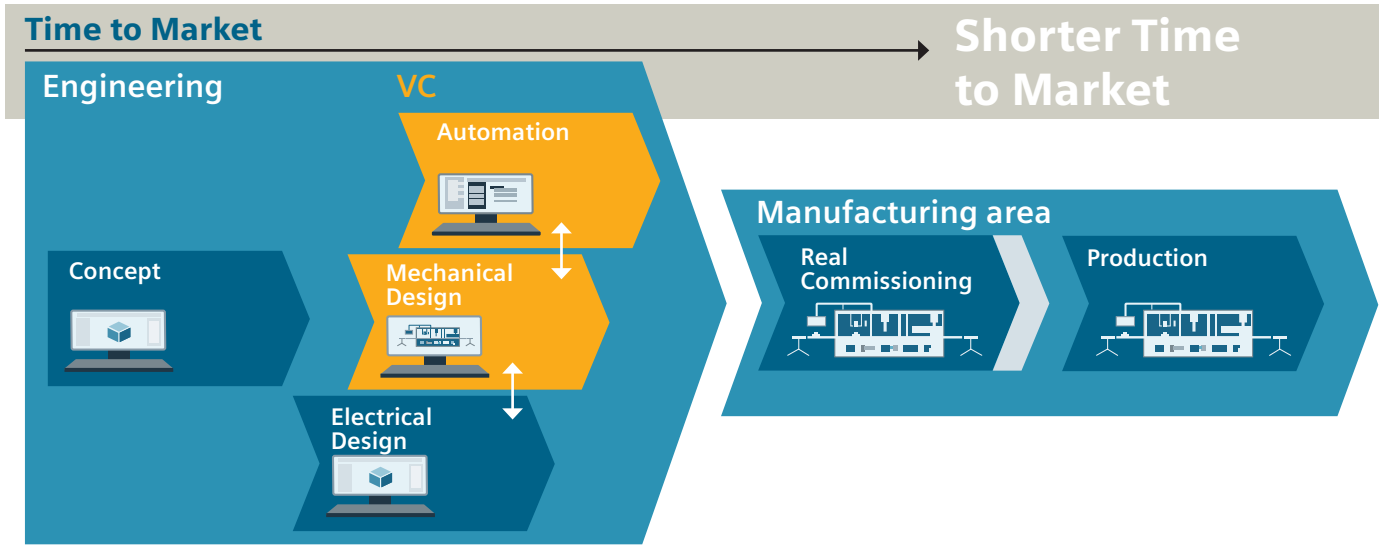


Figure 2. Virtual commissioning (VC) can take place potentially months sooner in the production engineering and set-up sequence, accelerating time to market and reducing risks.

As automation veterans know, an overall product launch timeline may give them a specific number of weeks or months to do work associated with developing and validating the production line's automation and mechatronics. But, if timelines in earlier stages slip, the project's management looks to make up the time in later stages – turning up the pressure and urgency on those responsible for making those later stages happen.

In addition, by using a digital twin to conduct engineering and validation of automation and mechatronics, the completion of these stages can become the basis for both documentation and training of operators and maintenance technicians, Without the digital twin, this can also take weeks or months.

Another important business benefit that comes with virtual commissioning's accelerating time to market is this: Shorter market windows mean shorter profit windows. So, manufacturers who can get their products to market faster –and be able to economically produce and offer more variations during market windows – can gain first-mover market advantage, build greater market share and be more profitable. Figure 3 illustrates this phenomenon.

### How virtual commissioning works

Manufacturers who have already deployed virtual commissioning in their production operations are able to use "software-in-the-loop" (SIL) testing models. Their engineers create these models by employing three powerful and sophisticated yet easy-to-use Siemens software tools:

- **NX Mechatronics Concept Designer (MCD) software**, which enables a multi-disciplinary approach to machine design that facilitates collaboration across electrical, mechanical, and automation engineering teams. With its point-and-click modeling and simulation tools, they can create and validate alternative design concepts early in product development cycles.

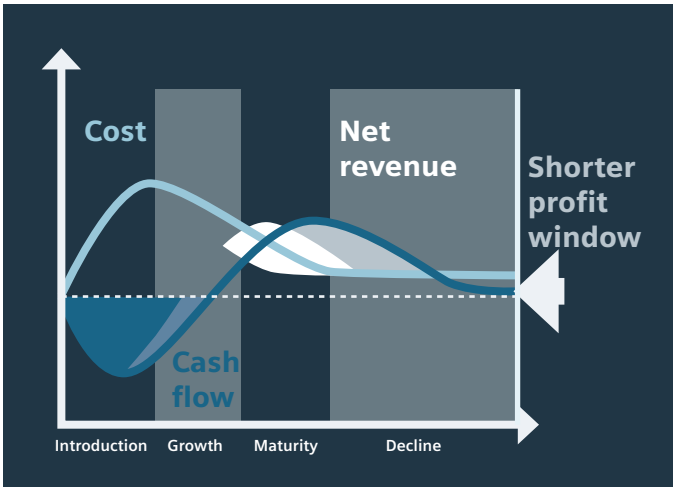


Figure 3. As product lifecycles shorten, so do their profit windows, requiring manufacturers to improve time to market to gain market share and maximize profitability.

Unlike model-based tools, MCD provides engineers not only with 3D machine views, but also with full-motion animations to validate its workings. Simulation data includes joints, motion, sensors, actuators, collision behavior, and other kinematic and dynamic properties for each component. See Figure 4.

Using this physics-based, interactive simulation, engineers can detect and correct errors in the digital twin model before errors manifest themselves in physical manufacturing, when costs can soar.

- **TIA Portal, the all-in-one automation engineering**, which provides a common software engineering framework for the PLC, IO, Safety, Networking, Drives, Motion and the HMI, with automation libraries to support building corporate standards, automatic generation of system and process diagnostics, and open connectivity for data analytics and the IIOT.

- **SIMATIC PLCSIM Advanced**, a virtual PLC in software that allows comprehensive simulations and testing of functions during configuration and engineering with the TIA Portal framework. No physical connections to the hardware S7-1500 PLC or ET 200SP I/O hardware are needed. This capability can help validate functions and detect errors much sooner, limiting their cost impacts.

  The PLCSIM Advanced also includes a documented, public API (application programming interface) for exchanging data with customized, co-simulation or test software. It supports multiple and distributed instances to simulate multiple controllers operating on factory PCs or elsewhere in the OT network.

- **Other Siemens simulation software tools** include: **Tecnomatix Process Simulate**, for validating production feasibility by simulating assembly and tool use simultaneously; **Tecnomatix Plant Simulation**, for building digital models of logistic systems and optimize their performance; and **SIMIT**, for comprehensive testing of automation applications and creating realistic operator training environments before actual startups.

What's more, these software-in-the-loop testing models that support virtual commissioning can be fully animated to simulate real machine behaviors. The MCD software contains a physics engine that can be configured to mimic the effects of gravity, torque, and friction both on the machine and on the parts or products moving through it. The PLCSIM Advanced virtual controller, programmed in the Step 7 TIA Portal, runs the virtual machine's controls and automation code inside the digital twin as if the physical process was underway with actual parts and products.

Taken together, these capabilities provide engineering teams with exceptionally high-quality simulations of their machines and how it works in production modes, so they can identify errors before the machines are built.

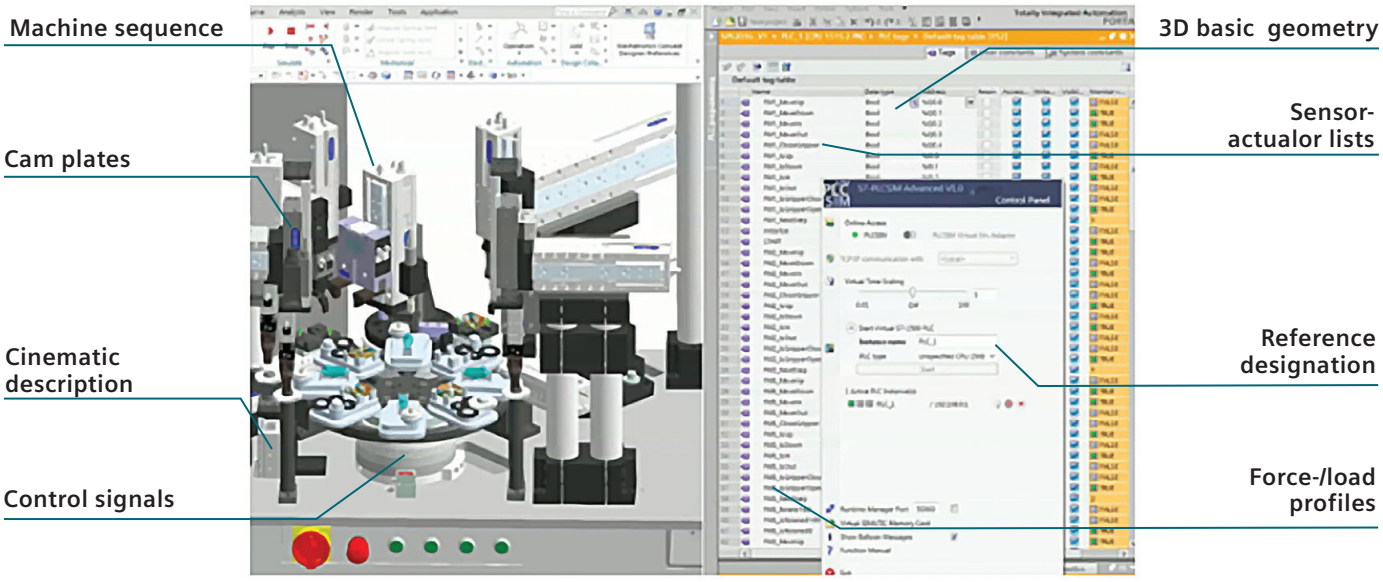


Figure 4. Point-and-click interface of the Siemens NX Mechatronics Concept Designer (MCD) software. It provides users not only with 3D machine views, but also with full-motion animations to validate its workings. Simulation data includes joints, motion, sensors, actuators, collision behavior, and other kinematic and dynamic properties for each component.

This shows how digital production twins operate and enable virtual commissioning. This can deliver many benefits, including:

- **Better quality,** by ensuring both the controller and machine functionality is optimized in advance.
- **Accelerated times to market,** by enabling mechanical and automation engineering to be done in parallel.
- **Faster physical commissioning**, by identifying errors and issues before they manifest at a product's manufacturing site.
- **More innovation flexibility,** by facilitating faster and easier evaluation of alternative control concepts during the design phase.
- **Less cost and fewer risks,** by reducing physical commissioning time.

## How companies are saving time with digital twins and virtual commissioning today

Digitalization in manufacturing is underway around the world and the digital twin concept is emerging not only in product as this paper describes, but also in product development and product performance.

By combining these three digital twin applications, product manufacturers as well as OEMs can take advantage of comprehensive feedback loops to further enhance and take advantage of the benefits listed above.

**SN Maschinenbau,** a 60-year-old German packaging OEM, is using a digital twin they created with Siemens software to conduct virtual commissioning of their machines. This has reduced physical commissioning time on customer sites by a week and cut overall commissioning time by 50 percent. It also allows operator training at the end customer to start much earlier, helping the customer begin seeing a return on their machine investment much sooner.

**Bausch+Stroebel** designs and manufactures packaging and production systems for the pharmaceutical, cosmetic and chemical industries. With operations in Germany, France, Japan and the U.S., it designs and manufactures high-performance packaging machines. These machines cover the entire packaging cycle from purification and sterilization to filling, sealing and validation, to labeling and transporting 1,500 to 60,000 units an hour.

With consultation, sales, production, assembly, service and R&D performed at one location, different project stakeholders needed access to up-to-date information for managing processes ranging from requirements engineering to project and design engineering, as well as production and verification.

### 7 Use Cases for Digitalization in Manufacturing

1. Automatic execution of engineering tasks and code
2. PLM integration of automation engineering
3. Efficient cloud-based engineering
4. Integrated energy management
5. Machine and plant security
6. Data acquisition for cloud services
7. Secure communication networks for transmitting industrial IoT data

To meet these needs, the company deployed a central information platform based on the Siemens Teamcenter® digital lifecycle management solution. This platform includes additional product lifecycle management (PLM) functionality, called PLM-easy, from BCT Technology AG, a Siemens solution partner. The company also acquired Siemens NX MCD software mentioned previously in this paper.

The integration of NX MCD and Teamcenter software simplified information sharing in sophisticated processes such as multi-body simulations and geometry optimization. Information exchange has improved across the company—globally, too. Drawings are no longer needed for final assembly. And depending on their access privileges, stakeholders can directly access CAD data relevant to their jobs.

This Siemens solution has provided many benefits. Processes are more streamlined. CAD models are more detailed and precise. Communication among engineering and other teams is more efficient. Faster model modifications have shortened cycle times. Information is updated online and directly accessible by every department to improve machinery design and verification. In addition, the creation of spare parts

## Integrated means much more than just being connected

Whether large or small, manufacturers know Siemens in many ways. The world's leading automation provider and a large, global manufacturer of automation components, such as PLCs and HMIs, plus motors, drives, turbines, and much more.

However, many don't know that Siemens pioneered not only manufacturing electrification and automation but also digitalization. More than a decade ago, Siemens embarked on a strategy, with $10 billion invested in it so far, to acquire leading industrial software companies whose sophisticated, intelligent applications are still pushing the world's digital frontiers. The Xcelerator portfolio, a suite of services from Siemens Digital Industries Software Solutions, helps manufacturers create the most comprehensive digital twin and integrate simulation within machine design to be flexible, capable and adaptable.

In closing, it's important to note that just connecting industrial systems, as other manufacturing software providers claim they can do, is far from integrating such systems fully.

Accelerating time to market with virtual commissioning via digital twins is just one of many examples of how digitalization can radically transform manufacturing.

While the others may attempt to merge disparate systems and say they can connect design to production to performance via digital twins, as Siemens can, they lack the experience and the highly integrated tools described in this paper to do so.

Our digitalization capabilities didn't come easy. Being able to ensure seamless interoperability of Siemens manufacturing solutions – across plant floors, throughout inbound and outbound logistics, with higher level systems, and even – has been hard earned. Point is, it has taken us many years and many tens of billions of dollars invested in Siemens own R&D as well as in our many acquisitions, which are now key contributors to the digitalization strategy.

The sooner industrial enterprises employ digitalization in their production operations, the sooner they can realize its many benefits. Today, it can provide a competitive advantage, while tomorrow, it will be required just to stay competitive.

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