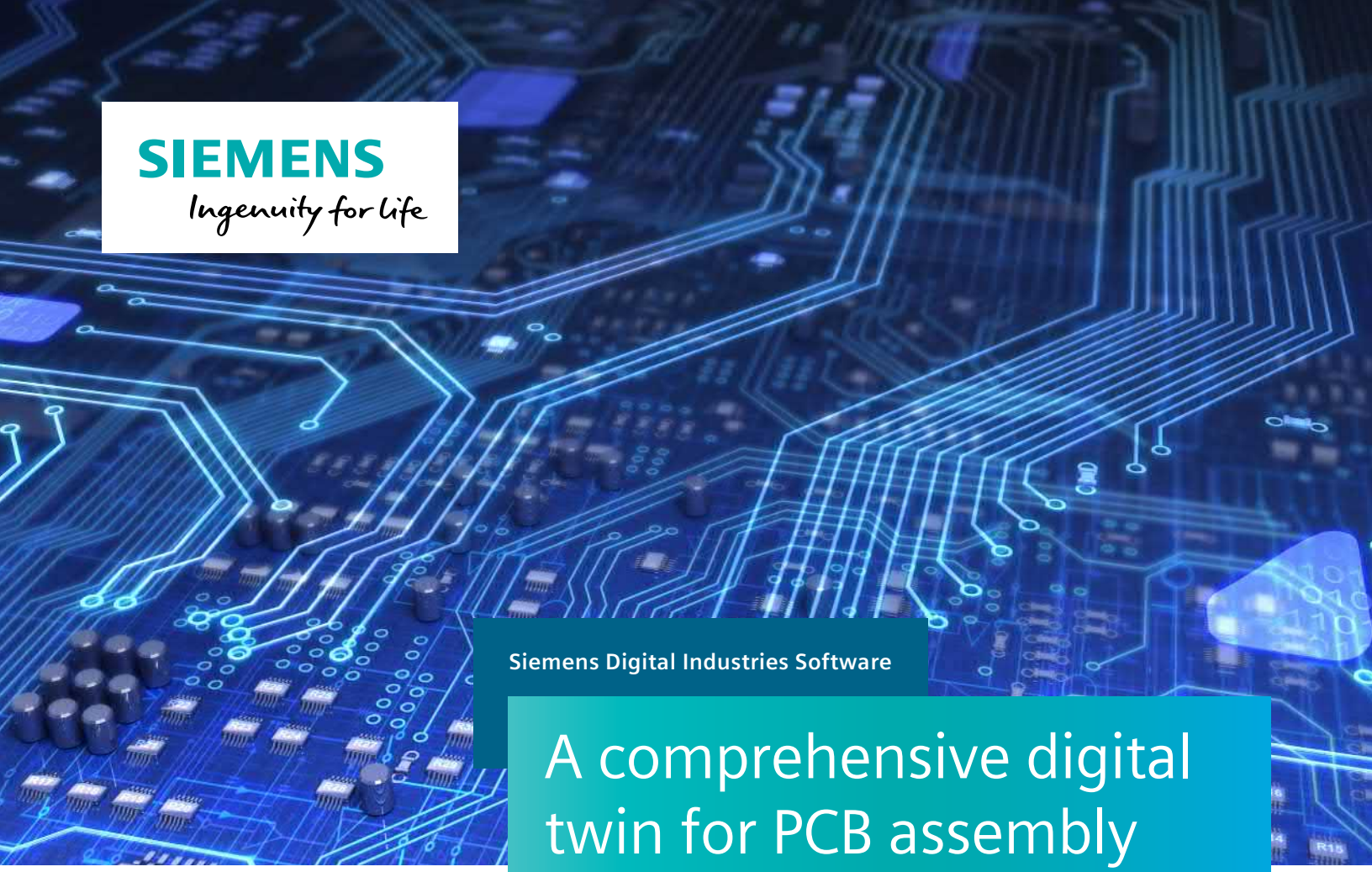

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A comprehensive digital twin for PCB assembly

Reducing errors on the shop floor while improving production yields and the bottom line

Executive summary

A comprehensive digital twin methodology enables the full virtualization of printed circuit board (PCB) assembly, inspection and testing processes, providing access to fully synchronized data across the enterprise. This white paper discusses the necessity of developing a comprehensive digital twin and its implementation and benefits.

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Introduction

The PCB assembly digital twin is a virtual model of the product and production process. It helps preserve the profitability of manufacturing projects in the face of smaller lot sizes, tighter electronic/mechanical integration requirements and the need to quickly move production from site to site.

The digital twin paradigm allows for the early discovery of design and manufacturing errors before the work plan is passed to the shop floor. It involves establishing a synchronized data backbone that provides accurate, up-to-date information to engineers across the manufacturing organization.

What is a digital twin?

As a prologue to this white paper, let's start out with a highly simplified definition of digital twin – "a complete, virtual representation of a real-world product and production process." We'll go into detail later on, but first let's talk about the trends that are making the comprehensive digital twin an imperative in the electronics manufacturing industry:

Industry trends

1. Decreased batch sizes

- Reduced demand for products has been driven in part by the current economic downturn
- Reduced demand has led vendors to issue engineering change orders (ECOs) and revise existing products rather than develop new products from scratch
- Increases in product customization has led to reduced lot sizes. In some industries, the lot size may be as low as one

These changing conditions have compelled even the largest, busiest manufacturers to adapt and take on lower-volume projects.

As project sizes decrease, batches containing a few rejected boards can reduce and even erase a project's profitability. So, as manufacturers realize that they need to get it right the first time, accuracy and proper planning have become more important than ever.

2. Synchronizing the mechanical and electrical domains.

Historically, PCB manufacturers have been focused on the electronic and electromechanical aspects of production. But since electronic and mechanical components are assembled on the same line, it makes sense the design and manufacturing processes should converge as well, requiring use of a holistic, unified data set.

Too often, mechanical design changes don't take electronic characteristics into consideration and vice versa. So without a holistic process, we won't know in advance, for example, how a connector change will affect wiring mechanics, or if additional heat dissipation will influence signaling.

3. Design anywhere, build everywhere.

Recent disruptions in supply chains have challenged product vendors, who have realized the need to quickly shift their manufacturing operations from region to region.

To achieve global production agility, manufacturing processes need to be digitized for easy migration among a variety of regional vendors, each with their own production lines and machine setup. The same goes for migration between differently configured lines at the same site. For this, automated planning tools are required. The tools should allow the manufacturer to enter a board design and receive a production program that is geared to its manufacturing setup, including:

- Assembly machine programs
- Machine libraries
- Electrical test programs
- Automated optical inspection (AOI) and serial peripheral inspection (SPI) programs

As an additional benefit, automation can reduce the time required for program preparation by 90 percent or more, while eliminating human error – thus accelerating the task of shifting production to a new site while preserving quality.

4. Eliminating silo-based inefficiencies and errors.

Since production, testing and inspection machines are usually supplied with their own proprietary software, small self-contained silos have developed around each machine. This requires a manual transfer of critical information from system to system that is both time-consuming and error-prone.

For example, a factory audit may reveal that several employees are performing similar tasks using the same data. Or worse, it may be discovered that two people are using different data to program part of a surface mount technology (SMT) line.

In accordance with Industry 4.0 principles, the manufacturing environment must be re-engineered to ensure these siloed machines are synchronized with each other and with organization strategy as well.

Implementing the comprehensive digital twin

So let's return to our digital twin paradigm, in which the product and the production processes are virtualized in a way that allows for simulation and correction of the processes before they are implemented on the shop floor, improving the probability of a successful first-round batch.

In this paradigm, a holistic product lifecycle management (PLM) tool works with a single, unified data backbone that is used to manage the entire manufacturing workflow. It provides a comprehensive view of the entire process while ensuring subsystems are synchronized.

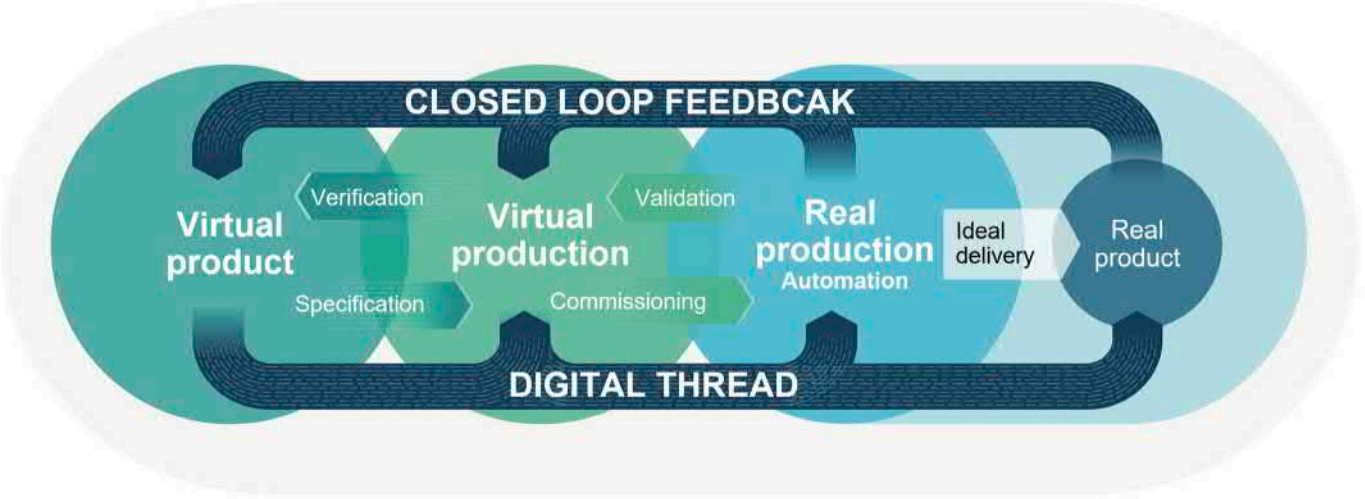
In the backbone framework, the mechanical and electronic designs are verified and submitted for manufacturing planning. The individual processes are then derived, simulated and validated. At each step in the flow, errors can be identified, ensuring corrections can be made to the design. This leftward shift allows problems to be quickly and inexpensively resolved.

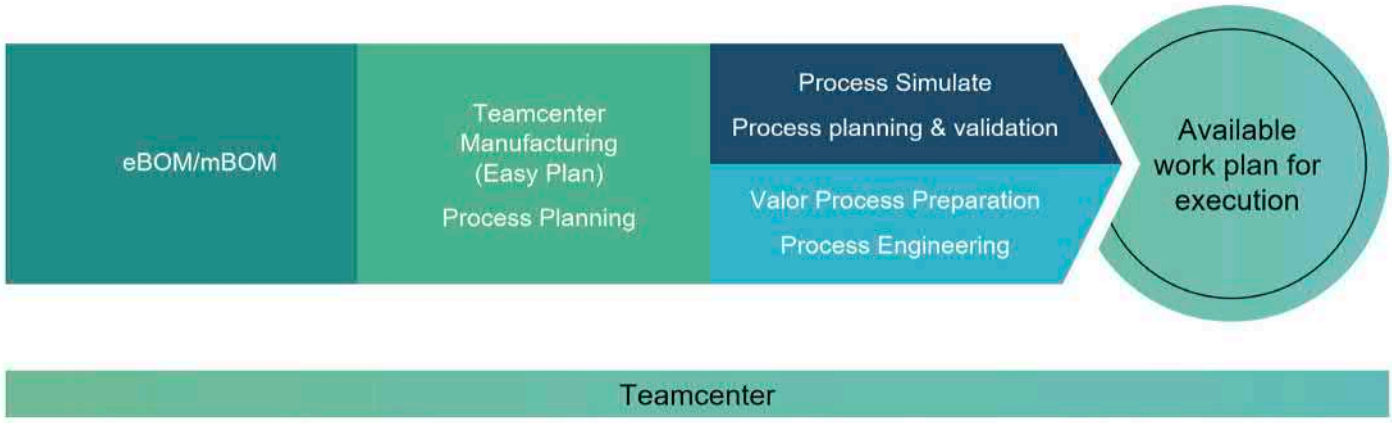
At the end of the holistic planning process, a virtually error-free execution work plan is generated for use on the shop floor. In the end, the process saves time, money and improves time-to-market performance.

The Siemens approach

With such a framework in mind, Siemens developed Teamcenter® software, which serves as an orchestrator for its suite of process planning and engineering tools. For example, Teamcenter is tightly integrated with Valor™ Process Preparation software, a Siemens' process engineering offering. Synchronized with the same in-progress data backbone, Teamcenter and Valor Process Preparation, which are part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, help reduce the occurrence of manufacturing errors that can erase small-batch profitability.

This approach was leveraged by Egicon, an Italian electronics and design house that issues over 200 new product introductions (NPIs) and ECOs each year. By using Valor Process Preparation, Egicon was able to reduce its repair rate from 30 parts per million (ppm) to six ppm and eliminate scrap in 2019.





Benefits

The comprehensive digital twin paradigm offers the following benefits:

- Early discovery of issues allows the decision-making process to be shifted leftward, helping reduce expenses since you get it right the first time
- Data backbone synchronization ensures engineers across the enterprise access to up-to-date, in-process design data
- The centralized knowledgebase of engineering changes is shared among all manufacturing sites
- Improves manufacturing agility, reduces cost and accelerates time-to-market

Conclusion

The digital twin methodology provides a full virtualization of the PCB assembly process, providing access to fully synchronized data across the enterprise, reducing the probability of errors on the shop floor and improving both production yields and the bottom line.

For more information on creating a comprehensive digital twin of your PCB assembly manufacturing operation, contact Kobi Levi at Kobi.levi@siemens.com

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Siemens Digital Industries Software is driving transformation to enable a digital enterprise where engineering, manufacturing and electronics design meet tomorrow. Xcelerator, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, helps companies of all sizes create and leverage a comprehensive digital twin that provides organizations with new insights, opportunities and levels of automation to drive innovation. For more information on Siemens Digital Industries Software products and services, visit siemens.com/software or follow us on LinkedIn, Twitter, Facebook and Instagram. Siemens Digital Industries Software – Where today meets tomorrow.

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