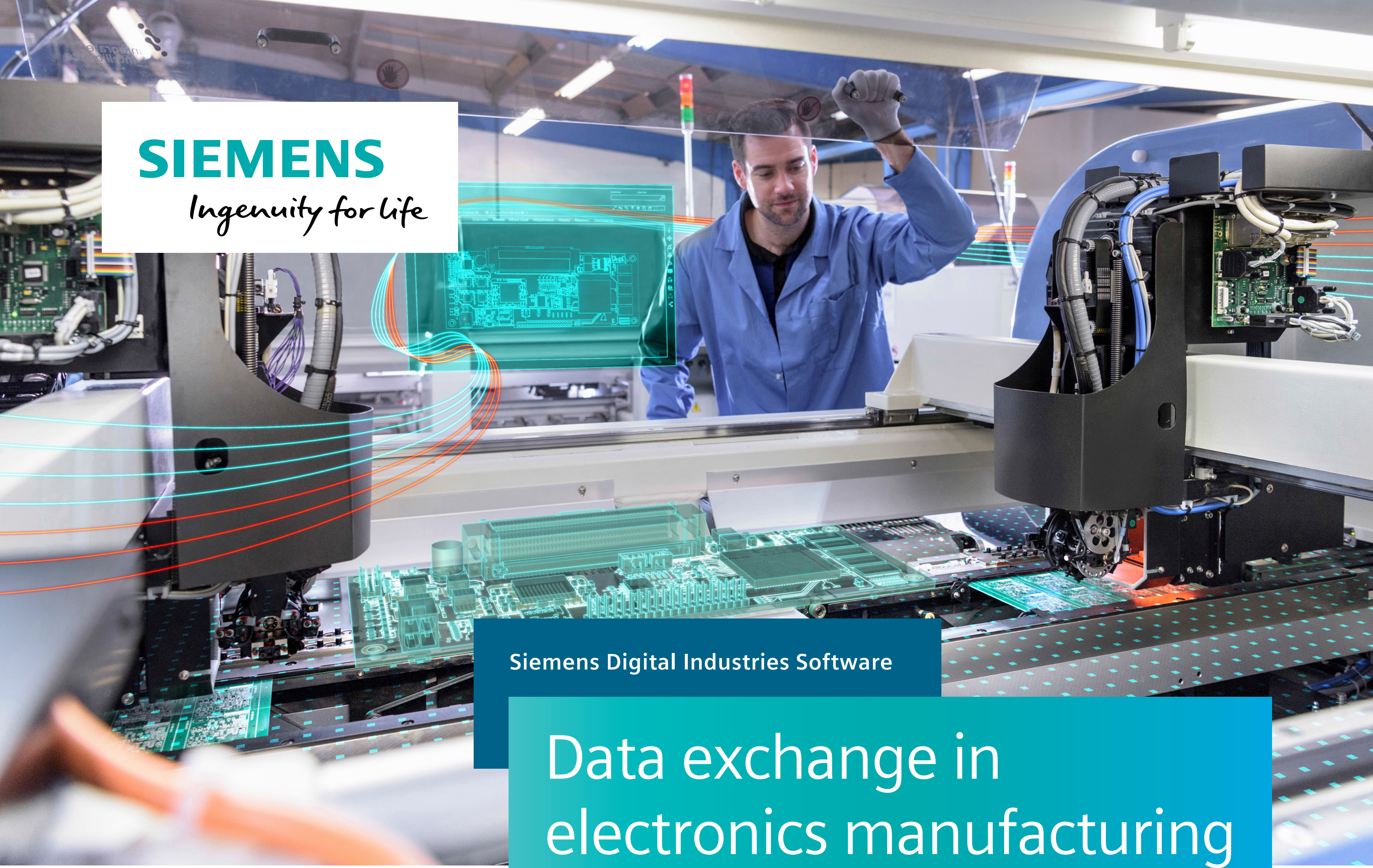

Siemens Digital Industries Software

Data exchange in electronics manufacturing

Standardizing data formats to enable the development of a comprehensive digital twin

Executive summary

This white paper describes how Siemens Digital Industries Software's technology standardizes data formats to enable the development of a comprehensive digital twin for design, process and production, allowing manufacturers to simulate changes in a safe environment without affecting real-life processes or production.

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Abstract

Printed circuit board assembly (PCBA) manufacturing goes from design and process engineering to production. Manufacturers must be able to see and understand all data throughout the process in real time to respond quickly to product changes and meet the demand for new products. Numerous data formats and machine interfaces are available but implementing them often leads to problems such as proprietary and inconsistent data formats, fragmented interfaces, lack of machine control and expenses related to consolidating data into enterprise systems.

An integrated data exchange and communication protocol for design, process and manufacturing becomes critical as manufacturers begin transitioning to smart factory models. Integrated data exchange is vital to harnessing the breakthrough strengths and technologies of the smart factory, including the capacity to create the comprehensive digital twin needed to accurately predict key performance characteristics before investing in physical prototypes and production assets.

Therefore, in order to enable a digital twin and successfully evolve into a smart factory, manufacturers need to rethink how to use standardized data formats and interfaces to maximize their full potential.

Integrated data exchange is vital to harnessing the breakthrough strengths and technologies of the smart factory.

1 The factory of the future

As most industries begin the transition to Industry 4.0, the question arises – what does Industry 4.0 mean for electronics manufacturing in general, and surface-mount technology (SMT) in particular?

Surface-mount technology was developed in the 1960s as part of what became known as the Third Industrial Revolution, which gave birth to the rise of electronics, telecommunications and computers. It was widely implemented by the mid-1980s, and by the late 1990s surface-mount devices dominated high tech electronic printed circuit assemblies.

In the past decade, the real and virtual worlds of electronics manufacturing began to merge as part of the Fourth Industrial Revolution or Industry 4.0, significantly impacting the production of surface-mount devices.

1.1 Digital twin

The comprehensive digital twin is a key enabler of SMT. A digital twin is a virtual representation of a real-world product or process that is used to predict the physical counterpart's performance characteristics. They are used throughout the product lifecycle to simulate, predict and optimize the product and production system before investing in physical prototypes and assets.

Today, the digital twin can act as a unified information thread from design to manufacturing, providing feedback in a continuous flow of information facilitated by languages that communicate between people and machines as well as between machines and processes. By incorporating multi-physics simulation, data analytics and machine learning capabilities, the digital twin is able to demonstrate the impact of design changes, usage scenarios, environmental conditions and other variables, eliminating the need for physical prototypes, reducing development time and improving the quality of the finalized product.

Smart manufacturing technology helps electronics manufacturers develop and maintain a competitive advantage, addressing the demands of an ever-diversifying market where personalization and frequent innovation is driving the need for more flexible, cost-effective and responsive manufacturing.

The digital twin has the potential to revolutionize electronics manufacturing, however, product, process and performance must be synchronized to create a single digital thread across the enterprise.

2 Barriers to Industry 4.0 implementation

Having existed for decades, the electronics industry encompasses a variety of legacy systems and machines, not all of which are ready for Industry 4.0. Additionally, maintaining a complex value chain of suppliers, partners and distributors is difficult when using different data formats. These fragmented systems must work together and communicate normalized data in order to enable a digital twin and improve efficiency and performance.

PCB assembly companies face demand for more product variants with less lead time within the constraints of existing teams and budgets in an increasingly global environment. These impose new demands on manufacturing that make the digital twin and enhanced performance increasingly critical.

PCB manufacturers aim to *produce zero-defect products with high productivity and efficiency*. However, most factories are divided into departments that work in silos. The lack of integration creates the following challenges:

Teams	Challenges
Supply chain	• Low material turnover – difficult to plan material replenishment • High scrap rate • No synchronization with third-party systems
Process planning	• Product data is complex, outdated and hard to access • Lack of standardization across sites causes repetitive work at each site
Shop floor	• Different machines, models and interfaces • Work instructions are not up-to-date due to product variations, engineering change orders (ECOs)/manufacturing change orders (MCOs) • Difficult to track the PCB as it moves through the line and equipment
Quality	• Test plan is not in sync with the assembly plan and product changes • Difficult to assess quality of the entire product • No single traceability record
Information technology	• Outdated legacy information systems • Multiple interfaces to maintain and upgrade

In order to integrate departments and teams, it is essential to have a unified data flow from *design to dispatch* with a closed-loop feedback mechanism. The internet is effective and useful for addressing this because it allows the flow of information over distributed servers and many nonstandard access points. But the internet is not enough.

Because all the various elements and components must be able to “speak” to each other, standardized data exchange throughout the product manufacturing journey is key to achieving a smart factory.

3 The importance of intelligent data exchange

Data exchange is generally classified into three groups:

1. Design data.
2. Process data.
3. Manufacturing data.

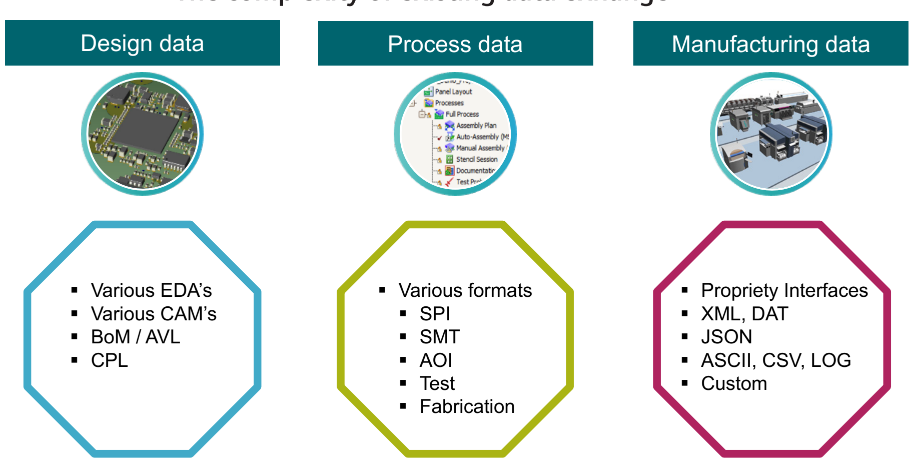
Design data: The electronics industry has evolved beyond manual design for manufacturing (DFM) methods and now offers a variety of electronic design automation (EDA) software options. However, each type of software exports in a different design data format, forcing electronics manufacturers to maintain numerous programs to read the data formats of different customers. Furthermore, design data is not sufficient in and of itself – fabrication information, such as the graphical definition of the layers or mechanical information, is essential to providing a quality DFM hand-off to production.

Process data: A manufacturing shop floor includes automated machines from various manufacturers, which means different data models and formats for each type of machine. Preparing the design data to suit the various formats and individual machine capabilities is labor-intensive. For example, if there are six different machines on the floor, the engineering team is forced to prepare data six separate times to match the format for each machine. The complexity is augmented by the need for custom adjustment of the functional settings of each machine, such as solder paste inspection, pick and place, auto optical inspection and flying probe tester. To shorten the time to new product introduction (NPI), manufacturers must be able to maintain the quality and consistency of data while converting from design to process.

Manufacturing data: PCB assembly lines include a variety of machines such as paste printers, inspection machines, pick-and-place machines, testers, repair and assembly. Today, no single machine vendor can supply the varied requirements of electronics manufacturers for all types of equipment. As a result, there are many communication protocols and interfaces at play, and machine-to-machine or man-to-machine communication becomes difficult. In addition, each machine type generates millions of data points in its native format during the manufacturing process. Each format has barriers and limitations such as proprietary data format, inconsistent data format and protocol, fragmented interface, implementation effort/restrictions and limited controls that make information exchange challenging between machines, production processes, planning, material management, quality management, utilization monitoring and traceability.

An intelligent data exchange methodology is critical to create a digital twin and bridge the gap between the three stages of the PCB assembly data lifecycle (design, process and manufacturing).

The complexity of existing data exhange



4 The ODB++ data format

4.1 Background

The open database (ODB) format was created in 1995. It focuses on intelligent PCB manufacturing content without the restrictions imposed by numerically controlled equipment and without involving a large committee of decision-makers. Instead, it identifies and tackles the needs of its user community.

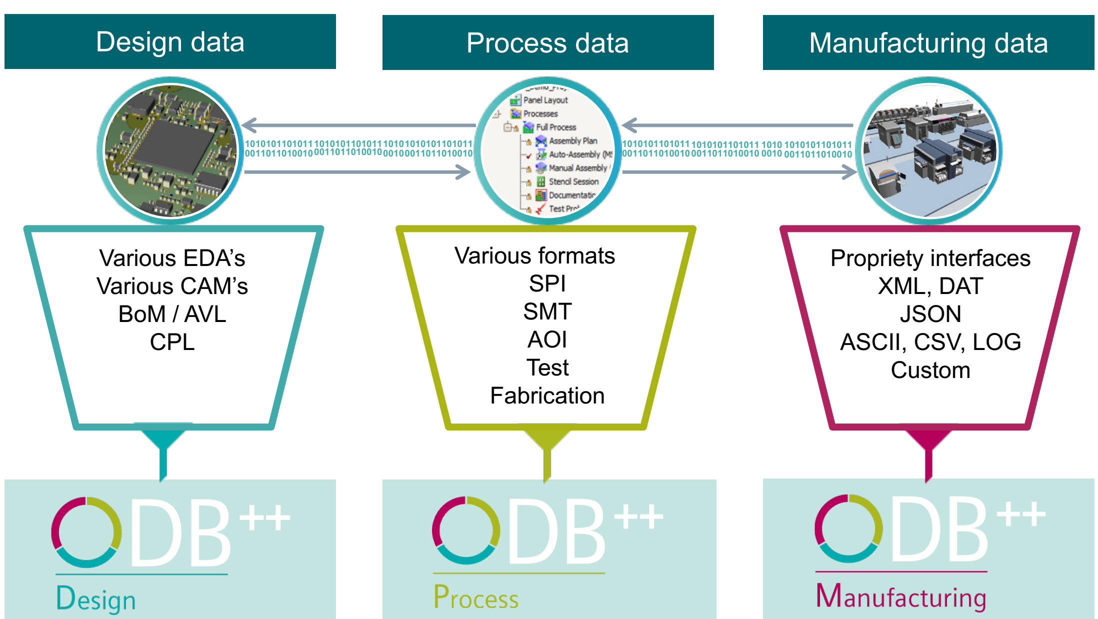
A few years into adopting the ODB format exchange adoption the need expanded to include component information. This gave birth to the ODB++™ data format. Today, with more than 70 partner software companies and over 40,000 users, ODB++ is the oldest and most widely used intelligent design data format. The fundamental objective of ODB++ was to transfer data from the computer-aided design (CAD) system [Virtual Board] to the computer-aided manufacturing (CAM) system [physical PCB], and the format continues to evolve based on user input to bring additional value to the PCB fabrication and assembly industry.

The ODB++ family of specifications has been expanded to provide a complete, end-to-end digital solution covering design, process and manufacturing information flows. The intelligent data exchange modules include ODB++ Design, ODB++ Process and ODB++ Manufacturing. All three modules are designed to be machine and vendor-agnostic, supporting all SMT machine vendors and EDA software providers, enabling a comprehensive digital twin for all stages of PCB manufacturing.

4.2 ODB++ Design

ODB++ Design provides an intelligent, single data structure for transferring PCB designs into fabrication, assembly and test. It saves time and resources used for generating complex collections of files in multiple formats and then reintegrating their data for manufacturing. The intelligent ODB++ design-through-manufacturing flow enables the creation of a comprehensive digital twin and saves time and money while reducing risk to quality across the supply chain.

- Always open source
- Globally adopted for over 20 years
- Supported by leading CAD/CAM software vendors
- Evolves according to market needs



4.3 ODB++ Process

Design data is transformed into the ODB++ Process format so it can be used in any production machine supporting that format. It enables the exchange of intelligent assembly process engineering data between Valor™ Process Preparation software (the advanced programming solution powered by Valor Parts Library), which is part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, and the various electronic manufacturing equipment vendors. The production machines can then adopt and use the assembly process data, supporting the digital thread across the design-through-manufacturing flow.

- Machine-agnostic process data flow
- Product format definition that withstands changes
- Single format, comprehensive process data with ongoing support
- Enables rapid machine programming

4.4 ODB++ Manufacturing

ODB++ Manufacturing (previously known as OML) features bidirectional data flow for shop floor data creation and process control, using a single standard format, language and protocol to support the comprehensive digital twin. It removes the barriers to entry for many companies and allows them to respond to evolving industry business demands by significantly reducing development cost and lead time for PCB assembly shop floor projects with advanced manufacturing computerization.

- Common language for the manufacturing shop floor
- Automated decision-making and intelligence
- Bidirectional data flow for shop floor data creation and process control
- Reduced development cost for advanced manufacturing computerization

Conclusion

Disconnected data formats and information flow silos from design to manufacturing are key roadblocks in the PCB assembly industry. In addition, the lack of standardized data flow increases the cost and complexity of production.

Intelligent data exchange provides the flexibility needed in Industry 4.0 factories. As manufacturing becomes smarter, the data architecture must enable connected and collaborative communication throughout the evolving manufacturing ecosystem. Intelligent data exchange also contributes to ongoing improvement by closing the loop between the virtual (digital twin) and actual product.

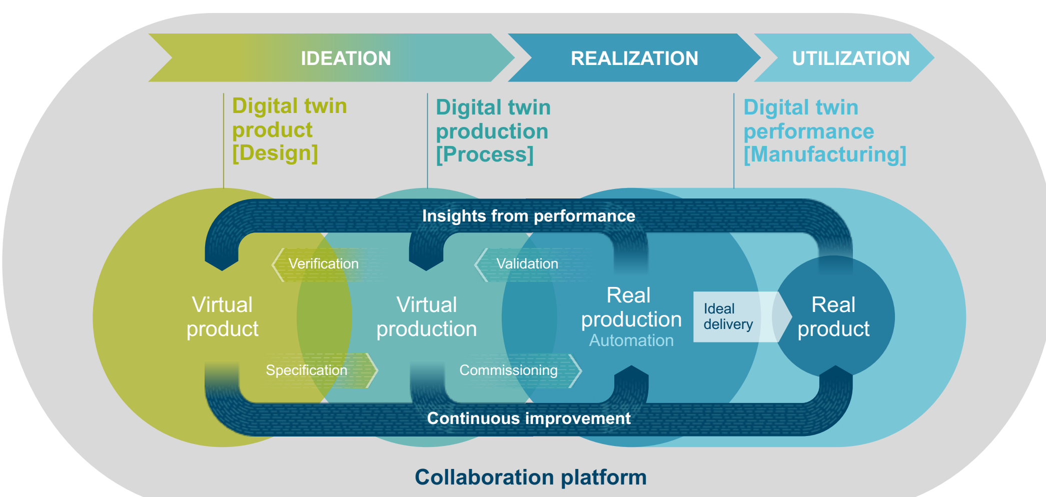
Automated machinery and processes generate large volumes of data. The data needs to be managed, controlled and tracked as it moves along the digital product thread. In the distributed globalized manufacturing ecosystem, the ability to manufacture at the place and time of need is possible only if the data is structured so the right data gets to the right processes/machines at the right time. Furthermore, with intelligent data exchange, producers can simulate changes in a safe digital twin environment without affecting real-life processes or production.

Siemens' comprehensive digital twin creates insights and data analytics in a virtual environment so products can be realized faster and more reliably. Siemens has created technology infrastructure capable of harnessing the power of big data to improve efficiency and quality.

Standardized data format benefits:

- Enables the creation of a comprehensive digital twin for each stage of the PCB assembly using existing software such as CAD, PCB assembly collateral and manufacturing IoT
- Minimizes the need for numerous physical prototypes
- Provides machine-agnostic process planning
- Shop floor connectivity for accurate, reliable, controlled data acquisition
- Optimizes new products and processes at an early stage
- Collects and analyzes real production and product performance data and feeds it back into development

In summary, ODB++ intelligent data exchange enhances the collaboration between design, process and manufacturing to address the challenges of modern manufacturing and deliver higher production volume without compromising quality and time-to-market. Digitalization reduces physical prototypes, disconnected systems, paper-based work instructions and information silos, enabling a continuous, integrated flow from design to planning to production. It supports a more efficient manufacturing process across individual sites as well as for global enterprises.



Siemens Digital Industries Software

Headquarters
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 972 987 3000

Americas
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 314 264 8499

Europe
Stephenson House
Sir William Siemens Square
Frimley, Camberley
Surrey, GU16 8QD
+44 (0) 1276 413200

Asia-Pacific
Unit 901-902, 9/F
Tower B, Manulife Financial Centre
223-231 Wai Yip Street, Kwun Tong
Kowloon, Hong Kong
+852 2230 3333

About Siemens Digital Industries Software

Siemens Digital Industries Software is driving transformation to enable a digital enterprise where engineering, manufacturing and electronics design meet tomorrow. The Xcelerator portfolio helps companies of all sizes create and leverage digital twins that provide 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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