Siemens PLM Software: The Actionable, Holistic Digital Twin

CIMdata Commentary

Key takeaways:

- *Actionable, holistic Digital Twins are living models fed by analytics and exercised by math-based simulations.*
- *Digital Twins create a predictive engineering analytics function that enables companies to improve their product design, process design, warranty, and maintenance approaches.*
- *Siemens PLM Software defines an actionable, holistic digital twin composed of multiple functional twins, including product, performance, and production digital twins—one of the broadest digital twin strategies in the industry.*
- *As a developer of technology as well as a manufacturer and user of products and systems, Siemens AG and Siemens PLM Software are leveraging the breadth of their solutions to offer actionable, holistic digital twin solutions that can deliver enhanced business value.*

Introduction

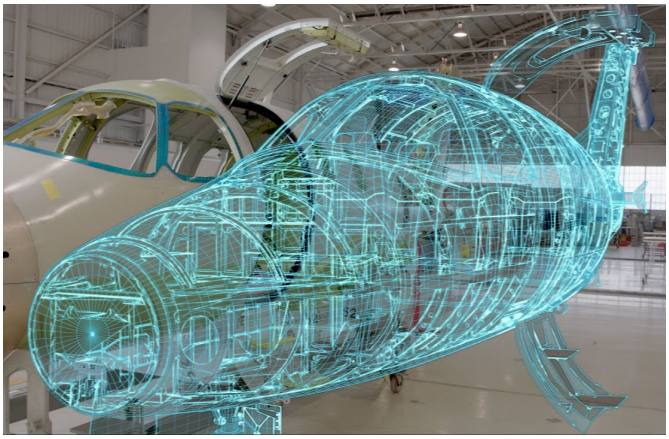
NASA was the first to dabble with "pairing technology"—the precursor to today's digital twin—as far back as the early days of space exploration. The concept of a digital twin has been around for a long time, but only recently has it become cost-effective to implement with improvements in 3D modeling and related technologies. It is so imperative to business today that it is considered one of the top technology trends in 2017.

CIMdata defines a digital twin as a smart (dynamic), virtual representation (model) of the physical product, production process, or product's utilization. It has the required accuracy and fidelity to predict actual, physical performance. The twin accompanies its real-world companion throughout its lifecycle—being changed in tandem with the physical version, and is continuously updated to reflect improvements in product and process development.

While most companies talk about and define a product digital twin, there are in fact at least three lifecycle stages that require a digital twin, each of which needs to be created and connected to the others. These include the:

- Digital Product Twin—used during product development
- Digital Production Twin—used during manufacturing engineering and production operations
- Digital Performance Twin—used for product simulation and during the utilization life of the product

Together, these digital twins make up the actionable, holistic digital twin and enable the digital thread that can be used to make faster, more informed decisions. By closing the loop between R&D, simulation and test, manufacturing, and service the digital twins enable insight and action, which result in value-added impact on a company's core business goals. Siemens PLM Software offers their customers an actionable, holistic digital twin that understands and models the entire value chain process and helps create a digital thread across the product and process lifecycle. CIMdata agrees that to get maximum value and productivity an



Uses of Three Types of Digital Twins
(Courtesy of Siemens PLM Software)

enterprise that creates complex products or processes can benefit from an actionable, holistic digital twin concept.

Actionable, Holistic Digital Twins

An actionable, holistic digital twin is a living model fed by analytics and exercised by math-based simulations. These are multi-function simulations involving mechanics, electronics, and embedded software that are combined to create a predictive engineering analytics function that inform companies how to improve their product and process design, and production and maintenance approaches. This provides business value well beyond simple predictive maintenance use cases common in digital twin discussions today.

An actionable, holistic digital twin can enable a company to completely duplicate and predict, in the virtual world, the properties and performance features of a physical product, product line, manufacturing process, or complete plant, before a single item needs to be physically acquired or produced. When used to close the loops between the physical and digital worlds across all the lifecycle stages, the actionable, holistic digital twin has great potential to improve lifecycle processes.

Using Digital Twins

The **digital product twin** can be used in the creation and/or modification of a product, forming the basic digital model in which geometry and other product attributes are managed. This is the most familiar form of the digital twin used today. But such information alone is not sufficient to form actionable insights that improve a product throughout its entire lifecycle. It is imperative to enhance the model from a product development management, retrieval, and revision environment to an interactive management environment across the entire lifecycle of the product. This extension includes managing the other digital twin representations and their interactions with one another.

Industry example: A motorized equipment manufacturer used Big Data and Analytics as part of its enterprise-wide initiative to improve corporate decision-making by transforming data into actionable insight. They used these capabilities to accurately predict failure modes to reduce, if not eliminate, unplanned downtime of equipment while in service. This manufacturer analyzed 16 months of service data to develop predictive models for, and key performance indicators of, machine failures. The company knew the causes of some of the failures, but wanted to uncover additional patterns to identify causal factors of failure. A pilot

project was able to develop models to accurately predict one third of machine failures occurring during production time more than 8 hours in advance of the event and 7% of machine failures occurring during production within 2 to 8 hours in advance of the event. This data was then used by the design team to improve the product.

The **performance digital twin** can be used in several ways. One is to use today's standard practice finite element modeling techniques combined with the physical performance characteristics of the parts to stimulate the actual product. There should also be data associated with test and results that is looped back into the product to refine the FEM simulation. This becomes an essential part of the validation and verification process. The next logical extension is to include product reliability data as it is captured in service. The technology exits to monitor many products in service via Industrial Internet of Things (IIoT) strategies, but companies need to capture and then act upon this data. Once captured the data can be analyzed and predictive analytics can be incorporated and the results acted upon for continuous product and production design improvements—not just service process efficiencies. These new data elements need to be stored and managed by an enterprise's PLM solution. The performance twin is also a key element in validating that products and systems meet their stated requirements and appropriate safety regulations.

Industry example: A mining equipment manufacturer needed to find a way to enable its field engineers to implement preventive, rather than reactive, maintenance. Downtime from unexpected equipment failure or unnecessary scheduled maintenance is costly to mining companies—equipment failures and associated production downtime can cost the company thousands of dollars a minute. A new predictive asset optimization solution that models equipment performance enabled the mining equipment manufacturer to help its operators spot potential maintenance problems before equipment might fail, thus avoiding unnecessary downtime for unneeded maintenance. The solution identified anomalies in the data collected from sensors on the heavy equipment that might indicate imminent or future problems, giving operators time to perform preventive maintenance.

The **production digital twin** concept has been maturing for many years, starting in the form of NC models and more recently using production process simulation to enable manufacturers to efficiently plan, manage, and optimize their global industrial operations. Now through IIoT and Industry 4.0 practices companies can capture actual production data and use it to drive and validate simulations that continuously refine the production digital twin. With the implementation of predictive analytics those companies can also predict when a process is about to go out of specification and make preventive corrections, and even production changes. These corrections must also be stored and included in a feedback loop to the product value chain increasing the intellectual capital of the production processes to the organization. By doing so, a company's production process and associated IP is continuously improved and enhanced.

Industry example: A global auto manufacturer used predictive models to make appropriate production adjustments to meet tight tolerances. This company's managers had an anecdotal understanding of which variables were tied to product-quality issues in the company's cylinder-head production line, but not enough information to change it. What they needed was a way to more precisely identify the complex patterns in machine settings, material temperatures, and equipment maintenance activities that adversely affected product quality so they could take preventive steps to minimize production line waste. Now, using digital twins of the production lines and associated processes, production quality analysts can run more than 500 production-line variables through predictive models. This solution identifies which specific processes of the line need to be adjusted to ensure that products remain within

their tight tolerances. The solution also provides predictive insights about which production assets should be preventively maintained to avoid future problems.

Conclusion

CIMdata sees a need for an actionable, holistic digital twin that is managed by the PLM or digital innovation platform solution as the single source of record and the starting point for interrogation, prediction, validation, and continuous product and process improvement and innovation. Expanding and combining multiple digital twin views will enable companies to better manage products and processes over their entire lifecycle, bringing value to the companies and their customers. Implementing an actionable, holistic digital twin requires the collaboration of the software providers, service providers, and end customers. This transformation can take place in a step-by-step payback scenario where specific use cases are identified and collaborative projects are architected and implemented.

Siemens has leading offerings in PLM, IIoT, and predictive analytics and solution services. As they also develop, manufacture, and operate smart, connected products, CIMdata believes that this combination of digital twin enabling technology, and extensive manufacturing and product expertise gives them extensive real-world knowledge of the problems at hand and how to solve them by employing an actionable, holistic digital twin approach.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM). CIMdata provides world-class knowledge, expertise, and best-practice methods on PLM. CIMdata also offers research, subscription services, publications, and education through international conferences. To learn more about CIMdata's services, visit our website at http://www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.