Defining & Managing the Digital Twin throughout the Lifecycle
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Our Mission...

Strategic management consulting for competitive advantage in global markets

CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on the PLM market.

We are dedicated to maximizing our clients’ ability to design and deliver innovative products and services through the application of PLM.
Key Takeaways

Defining and Managing the Digital Twin throughout the lifecycle

- “Digital Twin” isn’t a new concept, but our ability to enable it from an end-to-end perspective is
- PLM’s vision isn’t changing, but our ability to enable it is
- The Digital Twin must include the virtual product and the virtual process definitions to maximize benefit
- The Digital Twin is a key enabler of new business models
- Defining the Digital Twin is relatively easy, but it does require end-to-end connectivity and physics-based simulation, which isn’t easy
- IoT, big data, and other technologies and initiatives are furthering the economic enablement of the Digital Twin
“Digital twins refer to computerized companions of physical assets that can be used for various purposes. Digital twins use data from sensors installed on physical objects to represent their near real-time status, working condition or position.”

“Digital surrogate (i.e., the digital twin) is a physics-based description of the system resulting from the generation, management, and application of data, models, and information from authoritative sources across the system’s lifecycle.”

“The digital twin refers to a digital model of a particular asset that includes design specifications and engineering models describing its geometry, materials, components and behavior, but more importantly it also includes the as-built and operational data unique to the specific physical asset which it represents.”
Creating & Maintaining the Digital Twin

The Digital Twin vision cannot achieved without PLM (1 of 2)


Creating & Maintaining the Digital Twin

The Digital Twin vision cannot achieved without PLM (2 of 2)

(Courtesy of Mevea)
CIMdata, Circa 1994

PDM: ALL product-related information and managing the ENTIRE product lifecycle

Introduction to PDM

PDM Definition
A Productivity Tool for manufacturing

- Manages all product-related information
  (Including digital files and database records)
  - Part information
  - Configuration information
  - Specifications
  - CAD drawings & models
  - FEM/FEA
  - Process plans
  - NC
  - Hard-copy documents
  - Images

- Manages the entire product life cycle
  - Product release
  - Change management
  - Approval process
Today’s Definition of PLM

*Defined by CIMdata & enabled by a innovation platform*

- **Strategic business approach**
  - *NOT* just technologies
  - Consistent set of business solutions

- **Collaborative creation, use, management & dissemination of product related **intellectual assets**
  - All product/plant definition information – the virtual product
    - MCAD, AEC, EDA, CASE, analysis, formulas, specifications, portfolio, docs, ...
  - All product/plant process definitions – the virtual processes
    - Processes that plan, design, produce, operate, support, decommission, recycle, ...

- **An innovation platform that supports the extended enterprise**

- **Spans full the lifecycle, from idea/concept through life**
Defining Intellectual Assets

Intellectual assets are key to innovation

Intellectual Assets are comprised of all the components of the enterprise’s product and process definition:

All mechanical, electronic, software, formulas, recipes, specifications, and documentation components; and

All business & manufacturing process definitions within the scope of the lifecycle.
The Virtual & Physical Product

Intellectual vs. deliverable asset management

Customers

Portfolio/Rqmts. Management

Orders/Service Forecasting

Virtual Product

Deliverable Assets

Physical Product

CRM

PLM

ERP

SCM

Design Chain Collaboration

Supply Chain Logistics

Partners

Intellectual Assets
Today’s Major Business Domains

*Intellectual vs. deliverable asset management*

- **Customers**
- **Deliverable Assets**
  - *Physical Product*
- **Orders/Service Forecasting**
- **Portfolio/Rqmts. Management**
- **Supply Chain Logistics**
- **Design Chain Collaboration**
- **Intellectual Assets**
  - *Virtual Product*

**PLM**

**ERP**
PLM Provides a Single Source of Truth: E-to-E

A single source for multiple structures (e.g., multiple BOMs)—enabling the Digital Thread
PLM Delivers End-to-End Connectivity

PLM touches all phases of a product’s life—the digital twin requires it

PLM Solutions—Information Management across Media, Process, Time, Geography, & Enterprise
The Product Innovation Platform Enabled It

End-to-end connectivity & lifecycle optimization of the virtual product & process

A set of evolving Functional Domains orchestrated by an enterprise level “systems of systems” approach
Companies gather incredible amounts of data about every stage of a product’s lifecycle and then ignore most of it
- Some of this data comes directly from the product itself
- Other data arrives via social media and multiple loosely structured formats

To be useful the data needs to be understood in the appropriate contexts, formats, ...
- Just having the data available doesn’t mean that it is useful and actionable
- Data analytics is important, but only part of the solution, the ability predict future issues, requirements, etc. is also required

Steady progress has been made over many years in data interoperability, the transparency of workflows & processes, & collaboration among ever more diverse groups
- But it hasn’t proven to be enough to close all the lifecycle loops
But remaining open loops (not to mention the new ones) often hamstring the development and support of game-changing, globally competitive products

- These loops take the form of unanswered or unasked questions
- These disconnects undermine collaboration among the increasingly diverse teams throughout today’s extended enterprises

Closing these loops and eliminating the workflow disconnects may be a never-ending battle

- Due to the dynamics of product lifecycle, for every loop that’s identified and closed, new disconnects appear
The Circular Economy & Its Multiple Loops

New challenges offer new opportunities

How will these loops be closed?

The *Industrial Internet* encompasses intelligent sensors and instrumented industrial machines, accessed via networks that provide high-level data visualization and use sophisticated software applications to provide advanced analytics.
Closing the Loops: An Industry Example

GE’s “Brilliant Factory” initiative implemented a perpetual data-sharing loop (2 of 4)
HOW SOFTWARE AND TECHNOLOGY ARE DIGITIZING THE MANUFACTURING INDUSTRY, AND THE BENEFITS TO BUSINESS LEADERS

Data, Digital Threads and Industry 4.0

https://www.protolabs.com/resources/whitepapers/2016/industry-40/
Closing the Loops: An Industry Example

E-to-E connectivity & traceability required in non-discrete industries as well (4 of 4)
• PLM enables users to close loops more tightly than ever before, with less time and effort, and fewer frustrations
  ▪ From the top-floor to the shop-floor
  ▪ From the design center to the field
  ▪ From the top-floor to end of useful life
  ▪ Etc.

• The rapidly maturing PLM solutions and strategies are driven by two growing realizations about data shortcomings:
  1. Nearly all the digital information we collect so obsessively is useless
  2. Hidden in what some analysts call “data debris” are a myriad of insights, trends and correlations
Knowledge and insights are built up from countless data points, which means measurement

- So how can the PLM industry help?

Industrial companies must understand...

- What measurements are needed to design more competitive products?
- What are the best ways to retrieve these measurements?
- How can the IoT can help (i.e., smart connected products)?
- How can measurements—data in the raw—be placed in their proper informational contexts, e.g. trends and correlations?
- What predictive analysts can be applied in support of closing the loops more quickly and efficiently?

There are a lot of questions that need answers.
“The ultimate vision for the digital twin is to create, test, and build our equipment in a virtual environment. Only when we get it to where it performs to our requirements do we physically manufacture it. We then want that physical build to tie back to its digital twin through sensors so that the digital twin contains all the information that we could have by inspecting the physical build.”

John Vickers, Manager
National Center for Advanced Manufacturing, NASA
“The real advantage of the digital twin, …materializes when all aspects, from design to real-time data feed, are brought together to optimize over the lifetime of the asset. An accurate digital description of a physical asset, for example, does not just cut prototyping or construction costs, it also enables to predict failure more easily once real-time data is fed into the model, thus reducing both maintenance costs and downtime.”
“A digital twin is a virtual model of a process, product or service. This pairing of the virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations.”

Bernard Marr, March 6, 2017

What Is Digital Twin Technology - And Why Is It So Important?
Enabling New Business Models

“The jet engines with digital twins”—Erin Biba, 14 February 2017, BBC (1 of 2)

Anthony Dean, head of combustion systems General Electric’s Global Research Center, in Niskayuna, New York, gave us a rundown of how the company is re-imagining a technology that hasn’t had an upgrade in the basic science it’s based on for the last 50 years. And that is the “digital twin” of each jet engine on its performance on the

So GE recently introduced a new method to monitor their engines once they are in use and attempt to predict how and when they will need repair. The first part of the new system is to create what they call a “digital twin” of every engine they build. During the design and manufacturing phase of the engine, engineers compile thousands of data points specific to each engine, which they use to build a digital model. This allows them to know exactly how hot that engine should be in each of its modules, what the pressure should be, and how fast the airflow should be moving.

http://www.bbc.com/autos/story/20170214-how-jet-engines-are-made
"That overall understanding of how each different engine lives out its life helps them tweak and change future engine designs."

One of the most useful parts of the digital twin is that it measures a huge number of factors that the engine faces throughout its lifetime — some flights have more people on them then others (that will put more strain on the engine), some cities (like Abu Dhabi) have a lot of sand in their air, and some pilots push their engines harder than others.

"With the twin...I can learn that the pilot is a cowboy and pushes the engine. The fuel burn we see will be different with different pilot. The digital twin remembers every one of those events. You can start to separate the fleet. Each engine has a different life experience," he says. And that overall understanding of how each different engine lives out its life helps them tweak and change future engine designs. "It’s like personalized medicine. You can start to classify and see what works best for an engine that has a similar life. We’re beginning to use this to inform how we build new engines."
What’s Required to be Successful

The key capabilities required to define and manage the digital twin

- **End-to-end data and process connectivity**
  - The virtual product and virtual process definitions must always be clear, concise, and valid
  - Through-life configuration management & traceability, i.e., the ability to manage a product’s configuration from concept through its entire lifecycle, as well as provide bi-directional traceability (i.e., the digital thread)

- **Lifecycle optimization of all systems**
  - Including the product, and its support processes and systems (e.g., manufacturing, logistics, and support)
  - This must include data capture, management, and analytics

- **Connection & associativity between the virtual & physical**
  - Connecting the left side with the right side of the “V”

This cannot be accomplished without PLM…
Final Thoughts

Defining and managing the Digital Twin throughout the lifecycle (1 of 2)

- “Digital Twin” isn’t a new concept
  - Our ability to enable it from an end-to-end perspective is possible and much more practical today
- PLM’s enablement through the implementation of a true product innovation platform is key to defining and managing the digital twin
- The Digital Twin must include the virtual product and the virtual process definitions to maximize benefit, without it, sub-optimization is the name of the game
- The Digital Twin is a key enabler of new business models
  - It allows data to be and/or enable the what is being sold
Final Thoughts

Defining and managing the Digital Twin throughout the lifecycle (2 of 2)

- We have defined the Digital Twin as the set of product-related data for years, but the connectivity, associativity, and traceability isn’t easy
  - Just ask those who have tried doing so

- IoT, big data, analytics, and other technologies and initiatives are furthering the economic enablement of the Digital Twin
  - Bringing it all together has taken time, but all the elements are available, but companies will fail to maximize their benefits because of people and processes

Significant opportunities lie ahead…
“WITHIN five years you could have a ‘digital twin’ capable of making decisions for you and even interacting with loved ones after you die, a technology expert says.”

John Smart, Acceleration Studies Foundation
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