

2017 MIT Europe Conference in Vienna



Digital Twins:

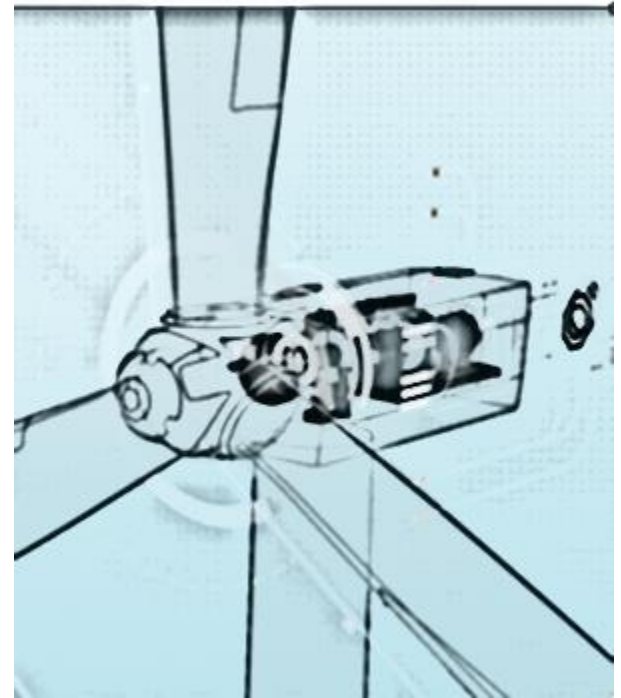
do you have ghosts in your portfolio?

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Are physical products and models of product two separate things?



Business portfolio



“ghost in the machine” – Ryle (1949) used the term to denote the view (with which he disagreed) of the human mind as being completely separate from and independent of the physical body.

What is a Digital Twin?

A digital replica of a product or system, maintained as a virtual equivalent throughout the lifespan of the physical product.



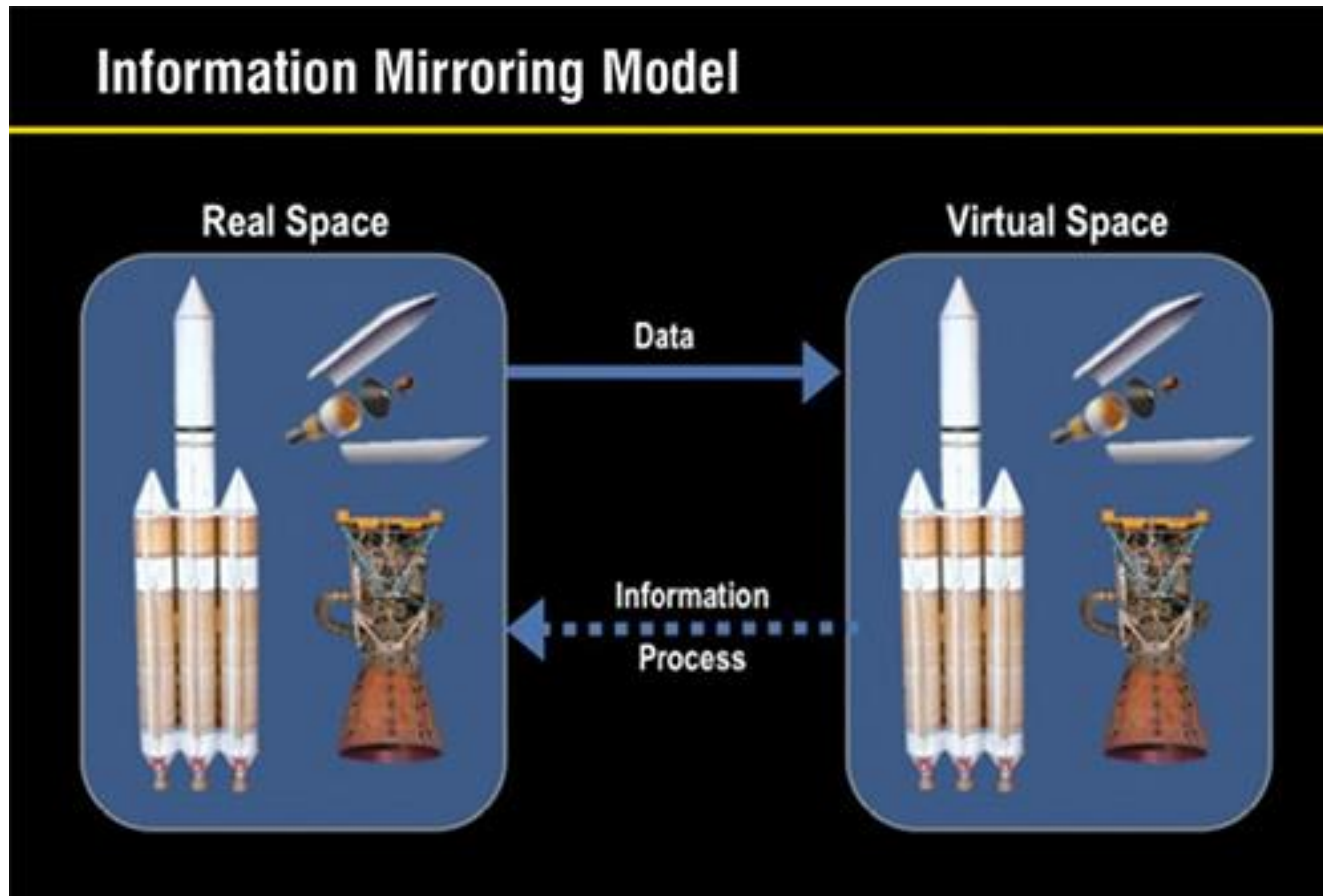
Image credit: GE Power & Water

A dynamic software model that uses sensors and other data to analyze its state, respond to changes, and improve operations.

NASA – Pairing digital and physical

- Pairing of digital objects and physical objects pioneered by NASA in early days of space exploration.
- Motivated by challenge of designing things that travel beyond ability to immediately see, monitor or modify them.
- Objective was a complete digital model that can be used to operate, simulate and analyze an underlying system governed by physics.

Mirrored Spaces (Grieves, 2002)



Digital Twin Definitions (Grieves)

Digital Twin Prototype: information necessary to describe and produce a physical version that duplicates the virtual version

Digital Twin Instance: describes a specific corresponding physical product, remaining linked to it throughout its lifespan

Digital Twin Aggregate: aggregation of all DTIs for a set of products

Purposes of the Digital Twin

- Descriptive
- Interrogative
- Analytic
- Diagnostic
- Predictive
- Anticipatory

Digital thread

- ***digital thread*** refers to the communication framework that allows a connected data flow and integrated view of the asset's data throughout its lifecycle
 - raises the bar for delivering “the right information to the right place at the right time”

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.

GE Look ahead Posted September 30, 2015, from The Economist

Digital Twins Across Sectors

Digital Twin in Energy Sector

GE Digital Wind Farm



As data streams in, the twin evolves to reflect how the physical product has been altered and used and the environmental conditions to which it has been exposed

Photo credit: <https://www.gerenewableenergy.com/wind-energy/>

Digital Twin in Aerospace Sector



Image credit: Siemens

The full value of the digital twin can be realized through support for digital twins in product design, manufacturing process planning and production. Feuer and Weissman, 2017

Digital Twin in Maritime Sector

*The **digital twin** is a virtual image of your asset, maintained throughout the lifecycle and easily accessible at any time. One platform brings all the experts together, bringing powerful analysis, insight and diagnostics.*

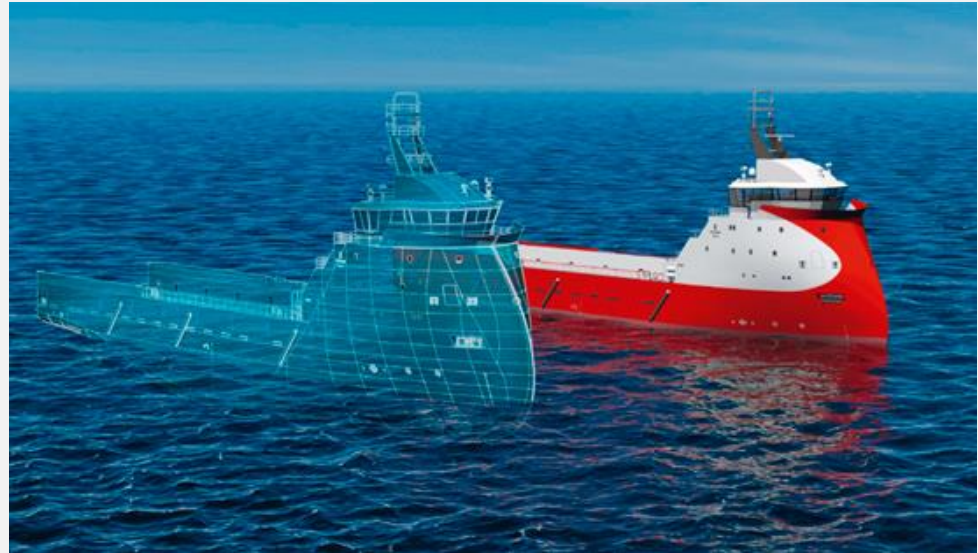


Image Credit: DNV GL Annual Report, 2015

Like an avatar for the actual product, the digital twin allows the company to visualize the status and condition of a product that may be thousands of miles away.

Porter and Hepplelmann, Oct 2015

Digital Twin in Health Care Sector



Image credit: GE



GE Wall of Analytics™ in Johns Hopkins Hospital Command Center

Digital Twin in Power Plant Operations

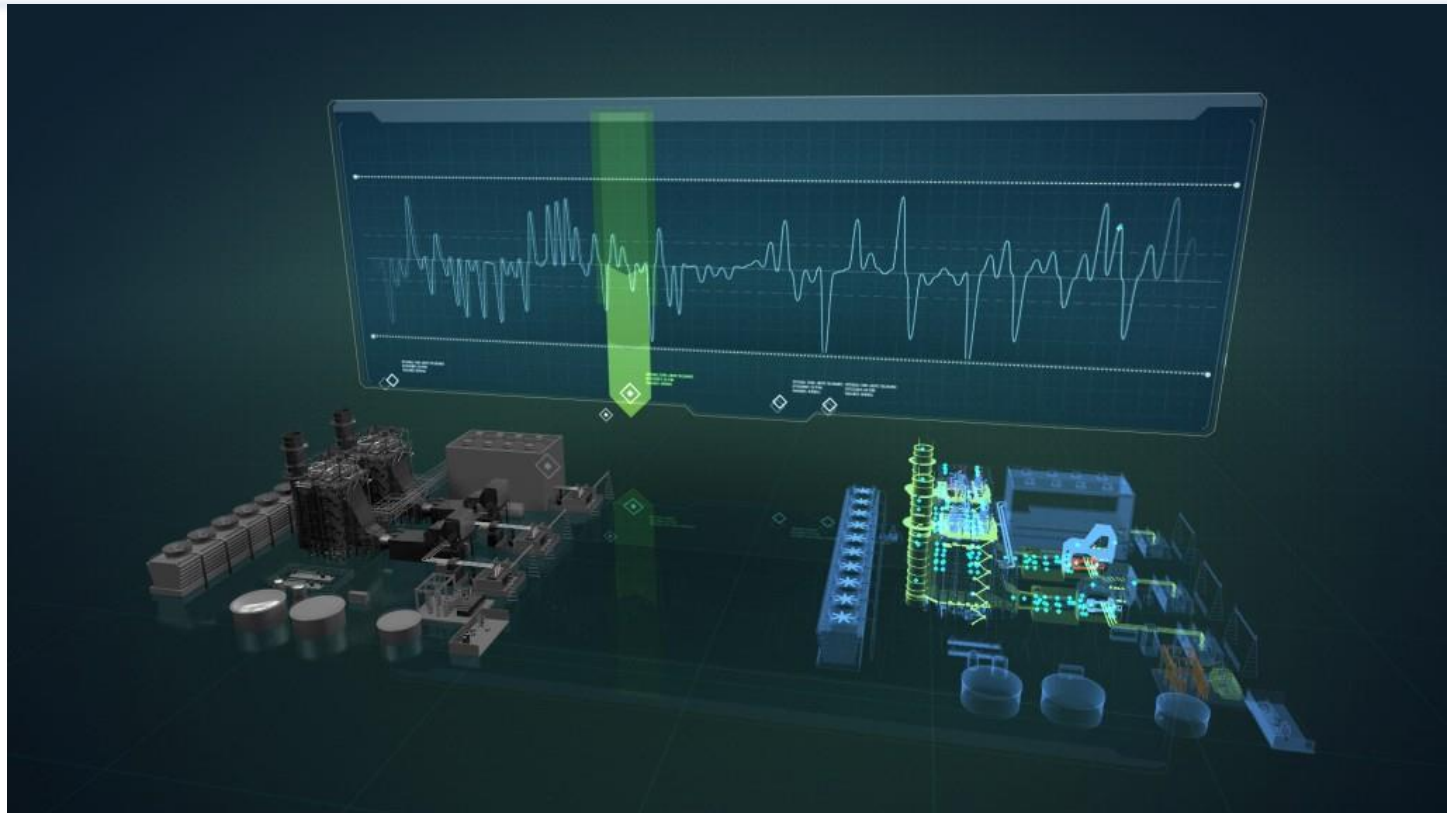


Image credit: GE Power

The digital twin essentially creates a digital model of the operations of an asset, say, a power plant and continually updates the performance model with feedback from real life operations

Pomerantz, D. 2016

Enablers and Challenges

Enablers



Image credit: Siemens

- Hyperscale computing
- Cloud computing and storage
- Commoditization of sensor equipment
- Augmented reality/virtual reality
- Data science, visual analytics, digital platforms
- New suppliers of digital toolsets and services

Technical challenges

- Model composability
 - Magnitude and complexity of combining models
 - Need for interoperability standards
- Digitalizing legacy products is resource intensive and difficult due to lack of information

... in this forthcoming shift, objects and things may not be baptized after birth to follow the digital persuasion but will be born free of the analog baggage and will not need a path to digital transformation because they will be born digital.

(Datta, 2016)

Workforce challenges

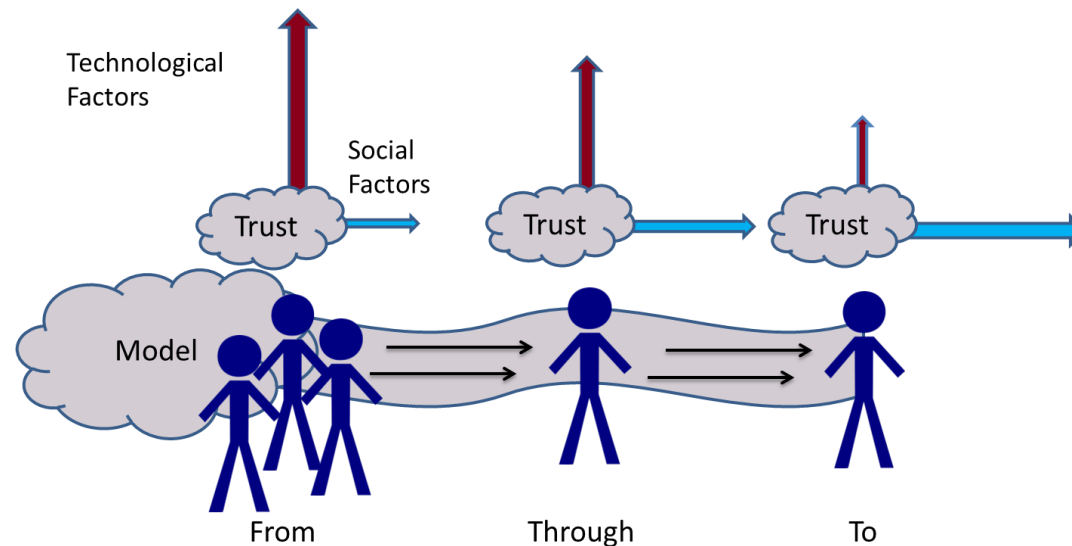
- Digitalizing legacy products puts extra demand on the experts involved in creating them
- Lack of knowledge and skills in current workforce for digital engineering
 - Digital experts may be least experienced in business domain and products
- High demand for talent makes hiring difficult
- Organization structures typically not suited for creating the digital thread

Business challenges

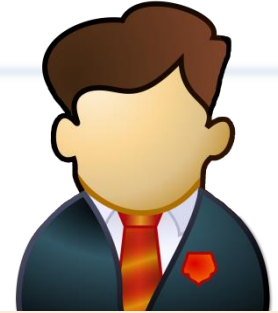
- Inversion of value of product and model
 - Valuation of models
 - IP strategies
- Changing the traditional business model
 - Sell product + twin
 - Sell product + “black box” service
 - Micro-transactions each time accessed
 - Open source digital twin
 - Basic access free, pay to unlock features

Social challenges

- Sometime difficult to get people to ‘give up’ their models and data
- Willingness to accept models as “primary source of truth”



Preference for Direct Human Knowledge over Encoded Knowledge



Why did I name my model “Fred”?

No, it’s not an acronym... I named it Fred because whenever I built this model everybody still said go ask Fred, we trust Fred to have the right answer.

I was tired of people questioning my model, so I named it Fred.

Now I say “well, Fred says” and people stopped asking questions about the information, but I was really taking about my model.

Cognitive challenges



- Humans are an integral element
 - our digital twins will be only as useful as humans have capacity to use them.
- Velocity of decision making may exceed what is necessary for thoughtful deliberation.

Emerging Ecosystem

Garner Top Ten Strategic Technology Trends 2017 -- Trend No. 5: Digital Twin

- *Within three to five years, billions of things will be represented by digital twins...*

New Ecosystem

- Suppose you are a company that manufactures the engine for an automobile
- Your customer will have a digital twin for each of its automobiles
- They will expect you to deliver the engine along with the digital model that is an exact replica of the engine to plug into their digital twin
- Your engine includes component parts made by a supplier, who must deliver the part and its digital model to you.

In the present...

- Foster a digital culture
- Establish/maintain model pedigree
- Tighten coupling of products and models
- Digital twin experiments/demo case
- Active surveillance of your ecosystem

Envision a future where every product has a digital equivalent ...



Image credit: ANSYS

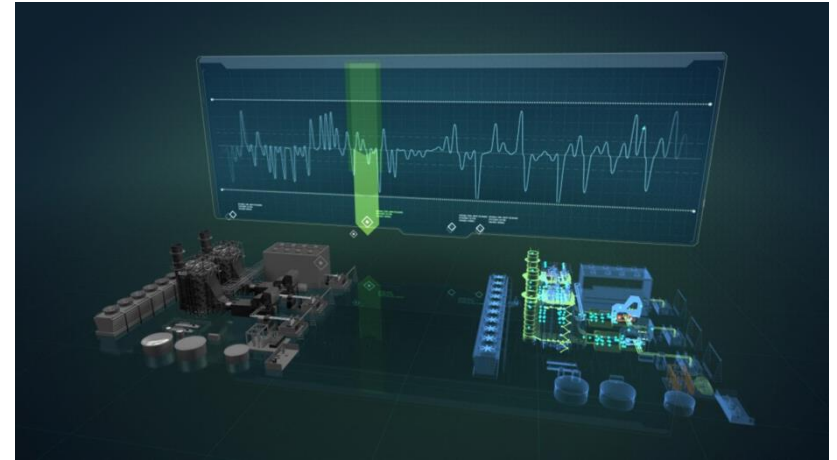


Image credit: GE Power



Image credit: GE

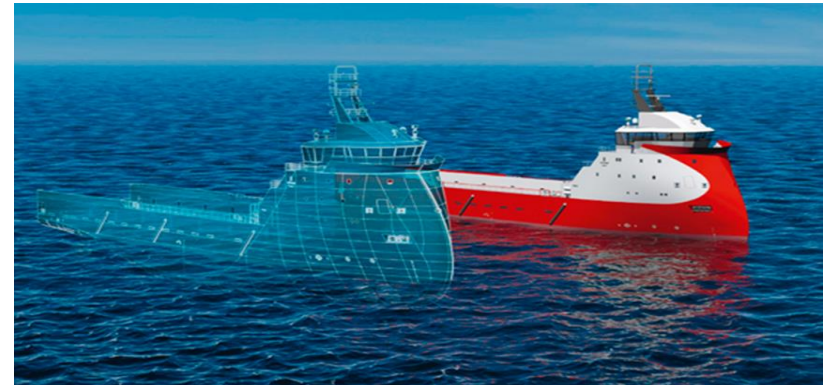


Image credit: DNV GL