

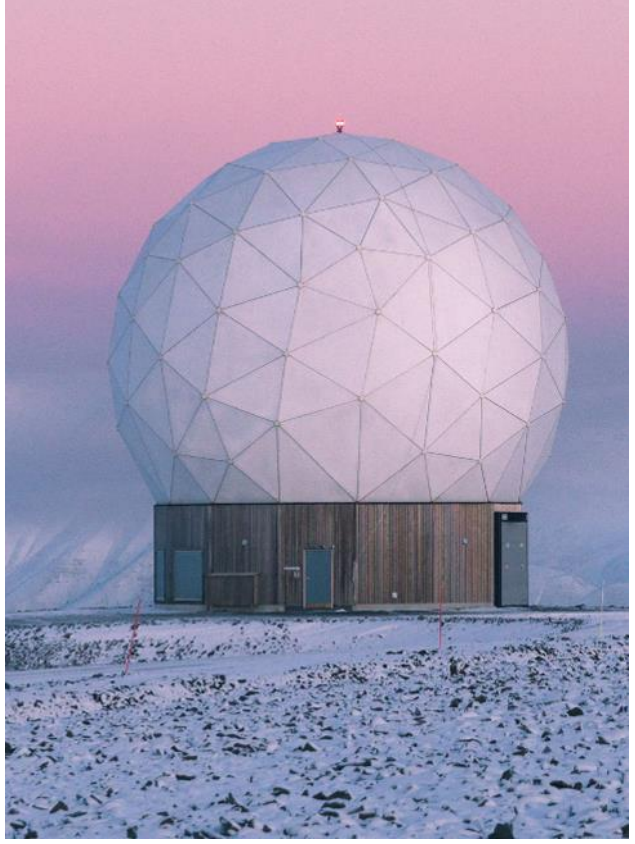


Connecting, Tracing and Managing the Lifecycle of Models, Simulation and Linked Data: Is That Easy?

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Model-Based Digital Thread – Process and Capability Center
Aerospace Technology, Technology & Global Engineering

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Outline

- Product lifecycle digital transformation
- Connecting models, data and simulation for digital twins
- What are the required elements?

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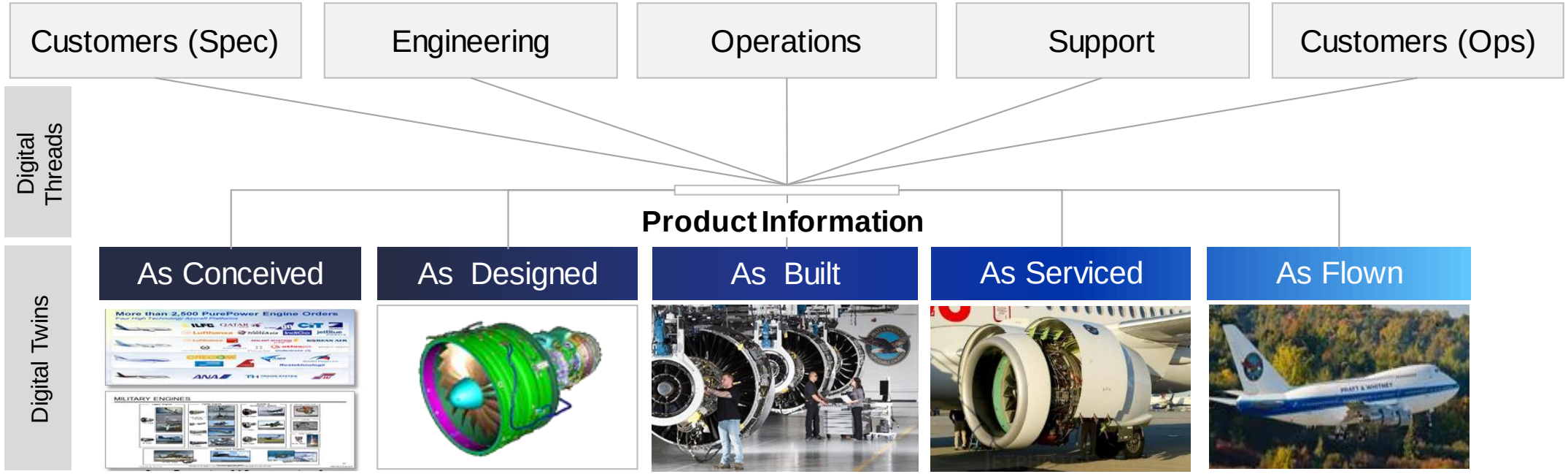
Raytheon Technologies' Model-Based Digital Thread Center

Mission: Accelerating the adoption of model-based & digital thread methods, standards, & tools to help the businesses deliver the next generation of products.



Approach: Applying **models** and **linked data** as authoritative sources of truth to flow **product information** to **stakeholders** throughout the **lifecycle,** driving quality, development productivity and service delivery.

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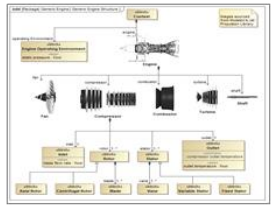
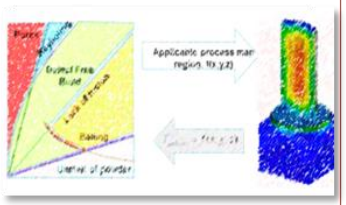
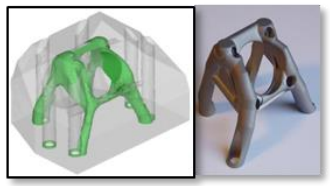
The Business Value of the Model-based Digital Thread



Closure of requirements with customer



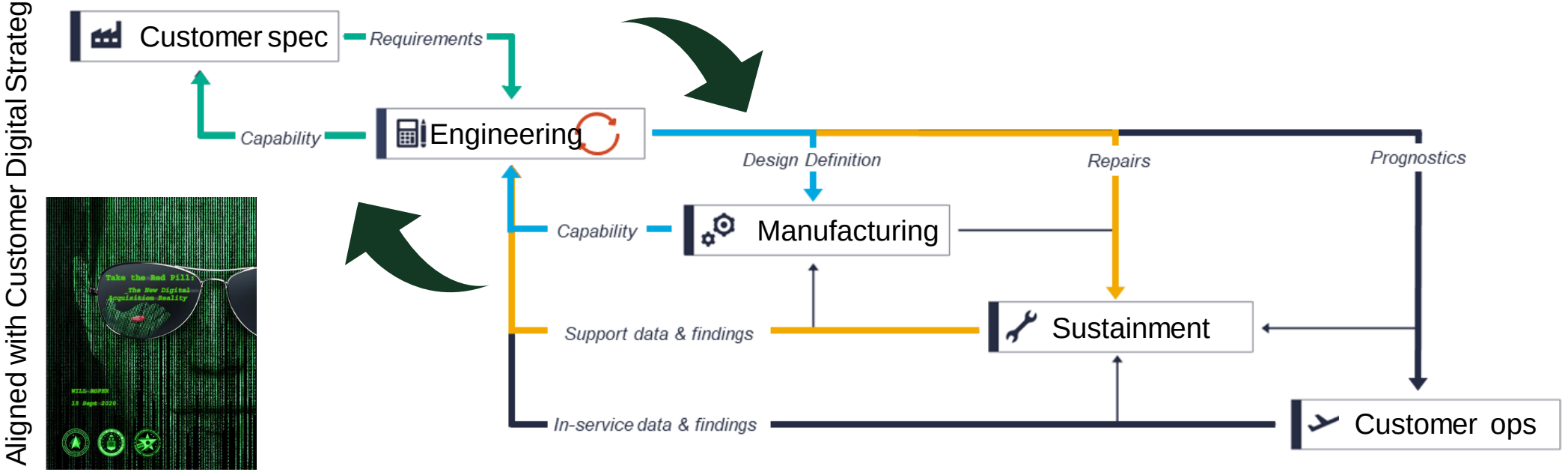
Closure of design to features



Co-design with manufacturing

Enhancement of services

Closure from in-service to design



Take the Red Pill: The New Digital Acquisition Reality, by Will Roper, Air Force
https://www.af.mil/Portals/1/documents/7/Take_the_Red_Pill-Digital_Acquisition.pdf

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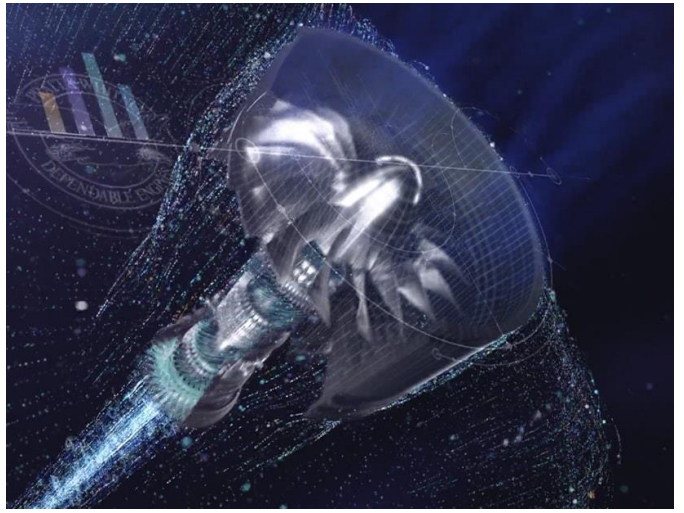
Photo credits: Pratt & Whitney

Defining the Digital Twin and Digital Threads

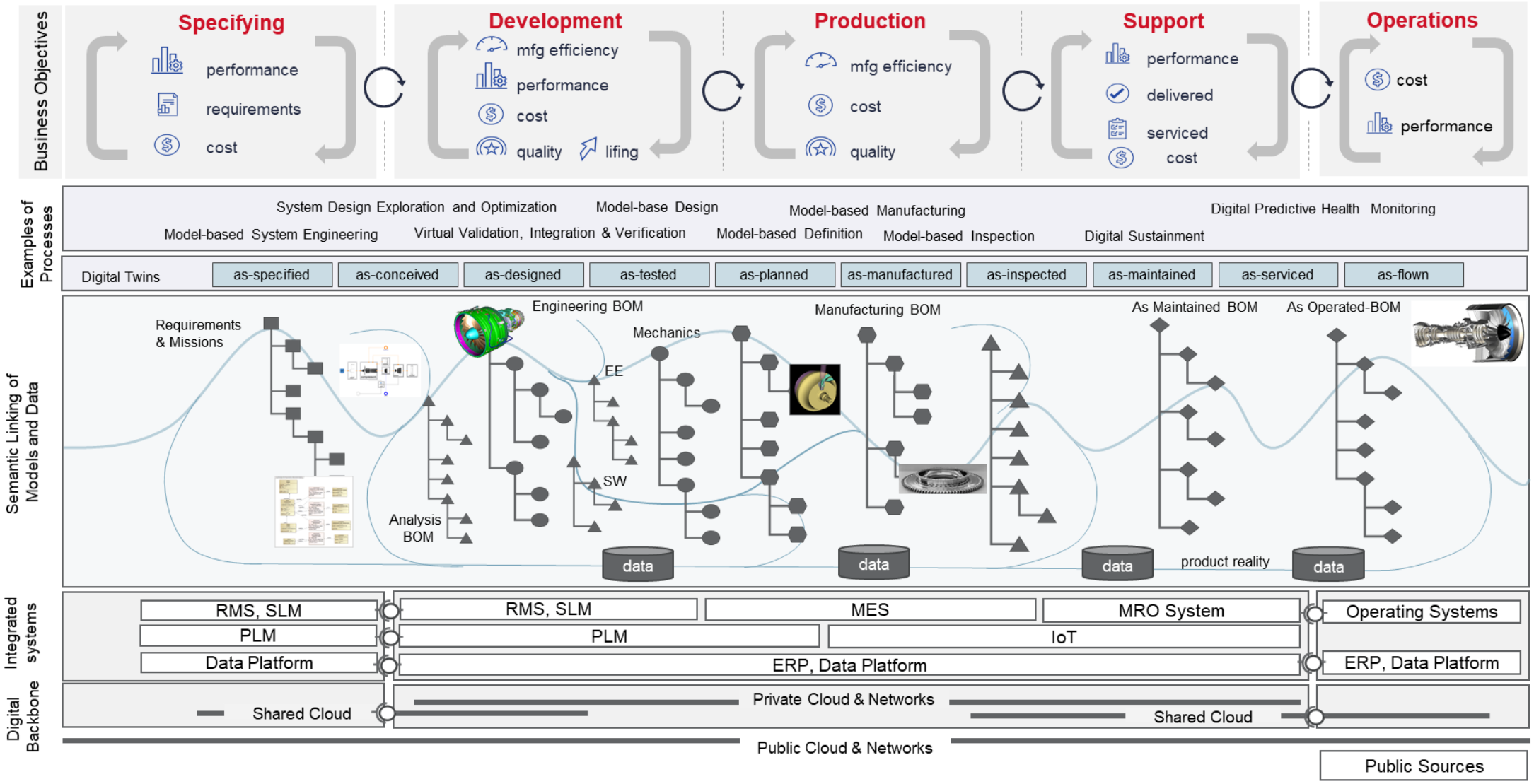
Digital twin: A digital representation of a **physical asset** (or **process)** throughout its lifecycle, **dynamically updated** with data, to enable **learning, prediction** and **reasoning** for **improved decision-making**.



Digital thread: A digital framework that provides a continuous and consistent flow of authoritative product information in the form of models and data throughout the **product lifecycle.** It enables the digital twin.

Source: P&W

Digital Threads Enable Digital Twins



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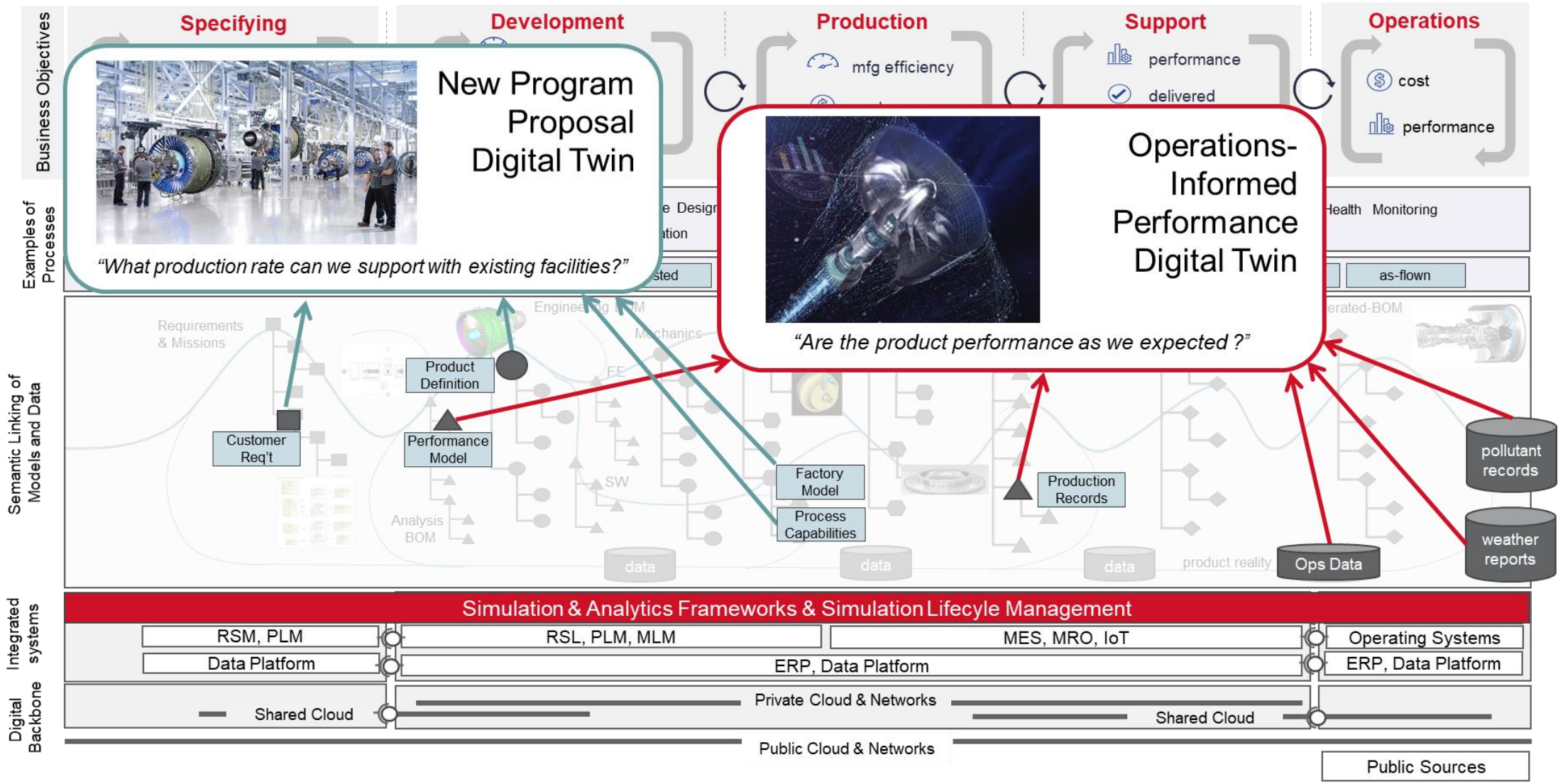
Agility in Building Digital Twins to Unlock Value



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What are the Enablers ?

Information-driven Integration and Mapping

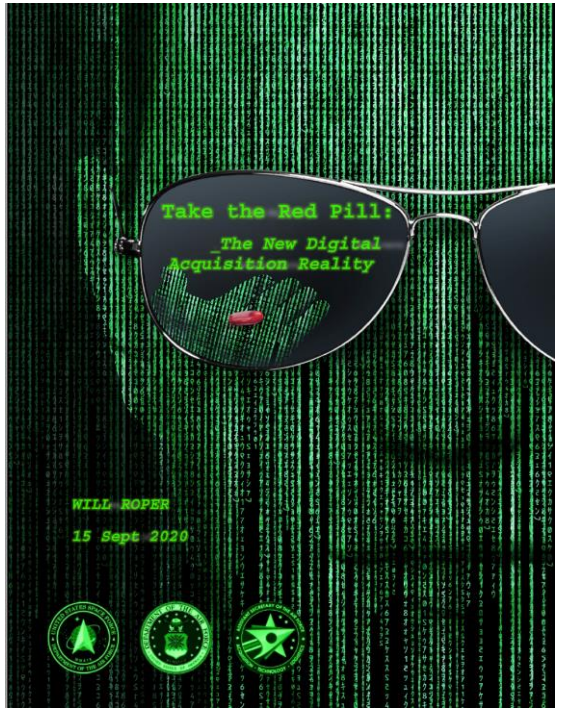
- Semantic integration allows to traverse multiple systems and legacy models and “terminologies” without requiring a single global solution
- Mix of “open-world” with Standards support

Open and service-based architecture for a federated digital integration

- The scope of the integration is so large that not a single solution will cover the entire spectrum of the needs
- Integration via digital service to overcome silos and to enable digital consumption cross traditional system boundaries
  - Simulation-as-a-service enables agile model evaluation across enterprise(s)

Continuous development (DevSecOps) for agile deployment

- Digital twins are “software products” requiring a network of information; they need to be developed, tested and deployed to a fast speed



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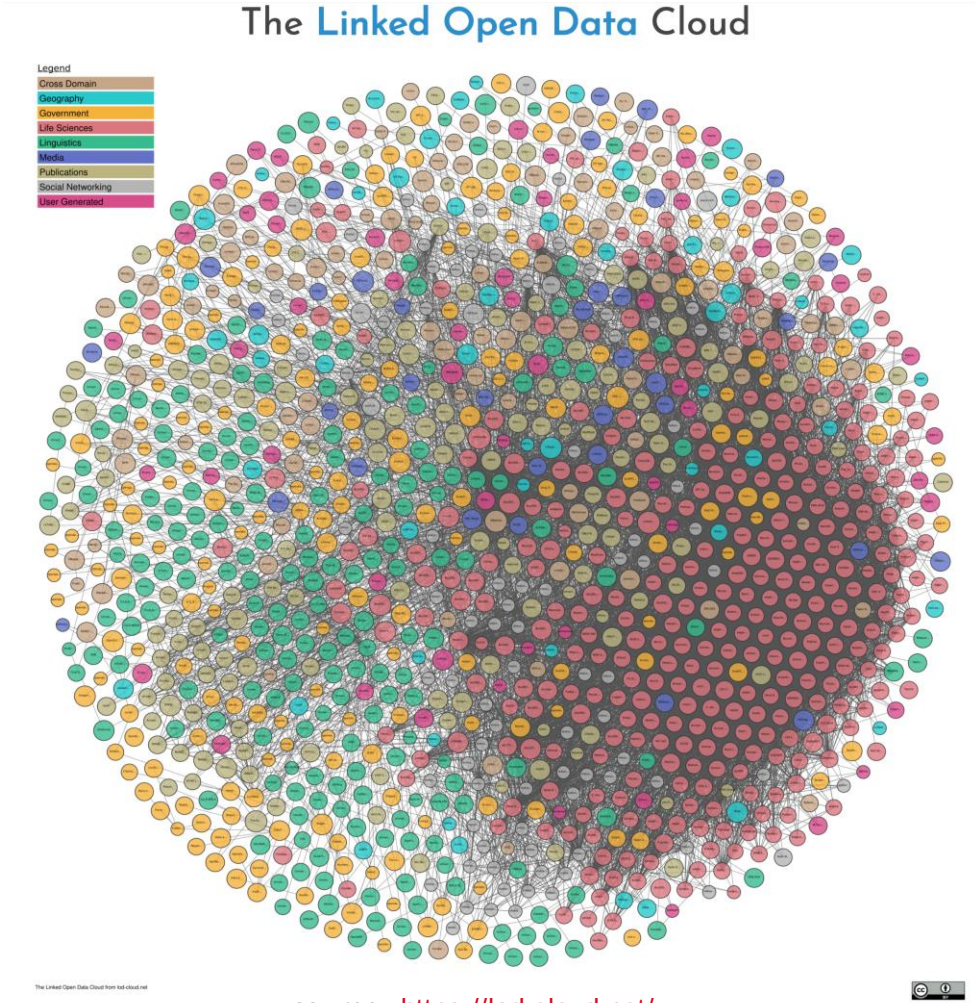
Semantic Integration

Semantic Web Technology

- The Web **clearly scales**
- Embrace **decentralization**, **federation** and **heterogeneity**
- Designed for **irregular structures** and meaningful **relationships**
- Built to be **extensible**
- Ontologies allow **dynamic transformation** and **reasoning** across local languages

Downsides

- Ecosystem still immature to fully serve the engineering space
- IP / Trade Compliance / Access Management at the graph level



source: https://lod-cloud.net/

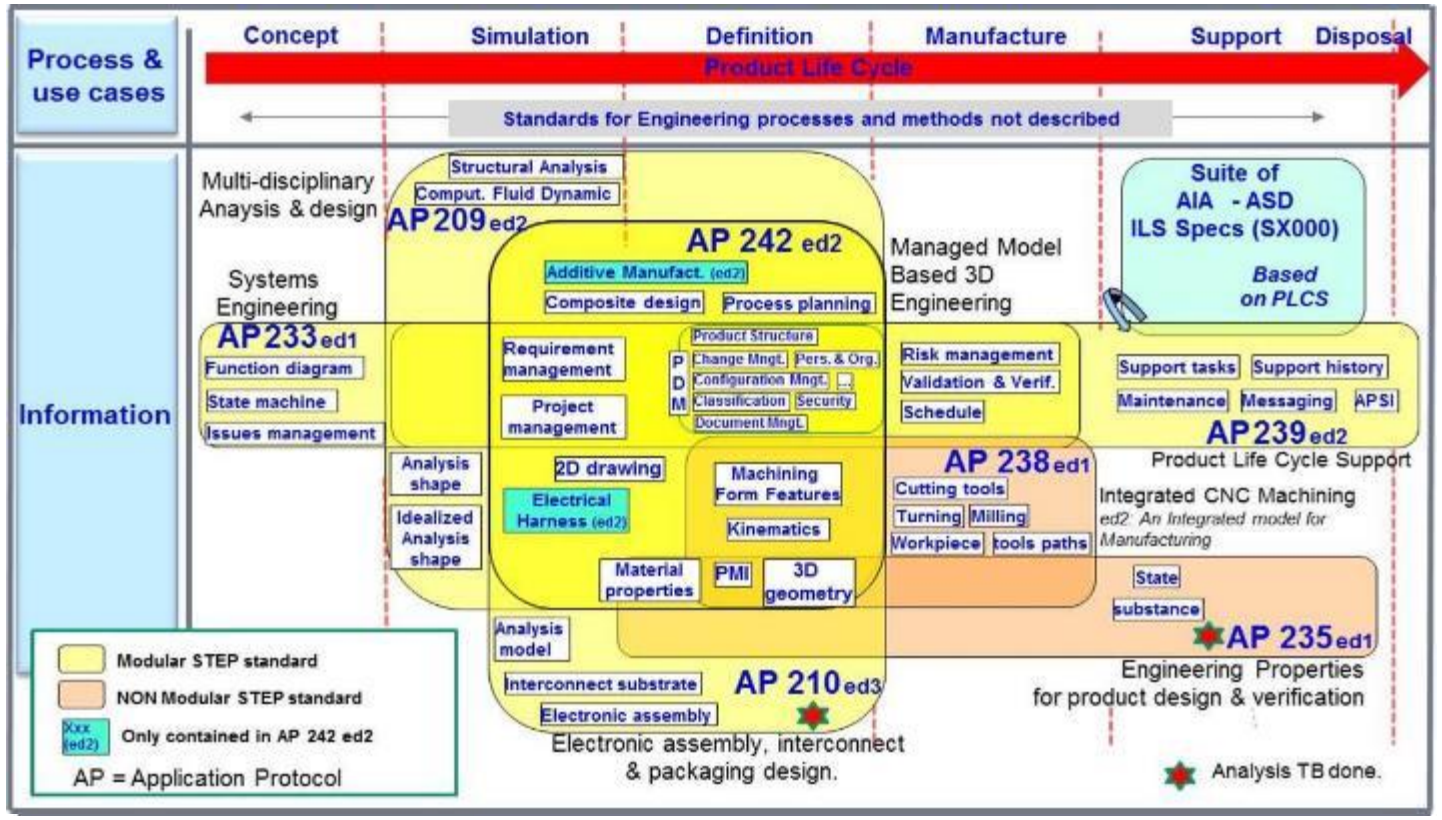
Leveraging Standards is Essential

Standards for Models, Data and Processes

- Enables interoperability
- Foundational for the solution
- Covering a large spectrum of areas

Downsides

- Never enough
- Incompletely supported by tools
- Often must go to native format



the STEP standard landscape

source: http://www.asd-ssg.org/new-step-architecture

Open Service Architecture Example

Open Services for Lifecycle Collaboration (OSLC)

- Built on Semantic Web technologies
- Standardizes both **protocol** and **format**
- Consistent primitives for local and global **configuration management**
- Open and extensible specification and ecosystem

Downsides

- Only mature in ALM/software design space
- Aggregation infrastructure tools dominated by a small number of products

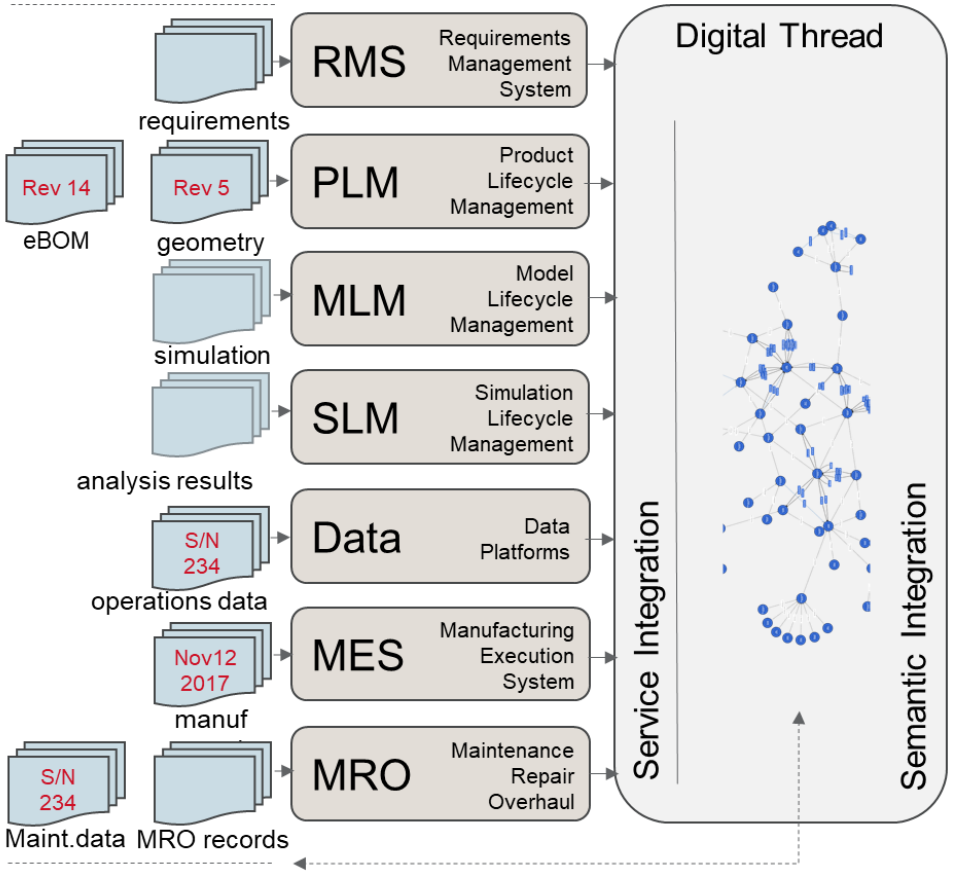
source: https://open-services.net/

OSLC: A promising approach. Why is it not more widely adopted and extended?

Digital Thread Through Federation

Heterogeneity is a fact of life

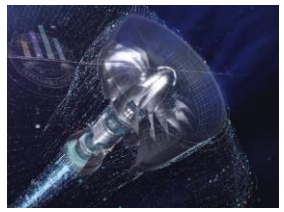
- All models and data sources have **different formats** and **access patterns**
- Not all the models and data needed will live in a single system
- With so many systems, **federation** is the only approach that can work
- To sustain Digital Twins, we must first solve for information integration via **metadata mapping**



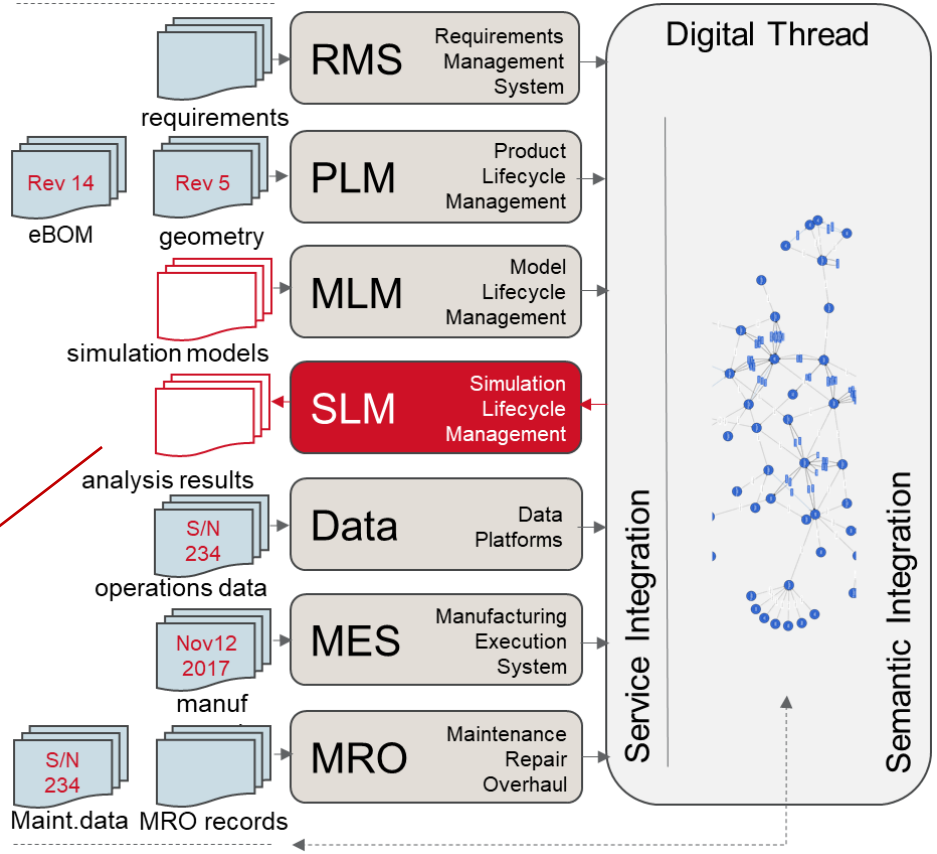
Simulation Lifecycle Management Plays a Key Role

SLM platforms must

- Track simulations and results
- Track **global configuration** of all inputs to the model
- Integrate models and data from **multiple engineering domains**
- Enable managed processes for AI/ML
- Integrate via services to the other systems: **simulation-as-a-service** model
- Expose **metadata** for information integration



Ops-informed Performance Digital Twin



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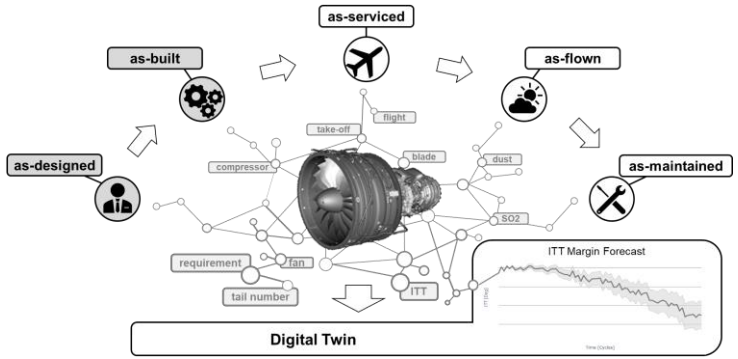
Example of a Digital Twin



Data/Models Sources

Name: Mission Metrics
Description: Mission info (mission and phases time)

Name: Power Usage
Description: Thrust usage at different flight segments

Name: Cruise Snapshots
Description: Timeseries Segment

Name: TakeOff Snapshots
Description: Timeseries Segment

Name: Full Flight Data
Description: Raw Timeseries

Name: Geo-Location
Description: Departure/Arrival of flights

Name: Pollutants
Description: Aerosol concentration on surface

Name: Engine Event Report
Description: Reports from MRO Shop

Name: Design Mission
Description: Requirements on engine usage

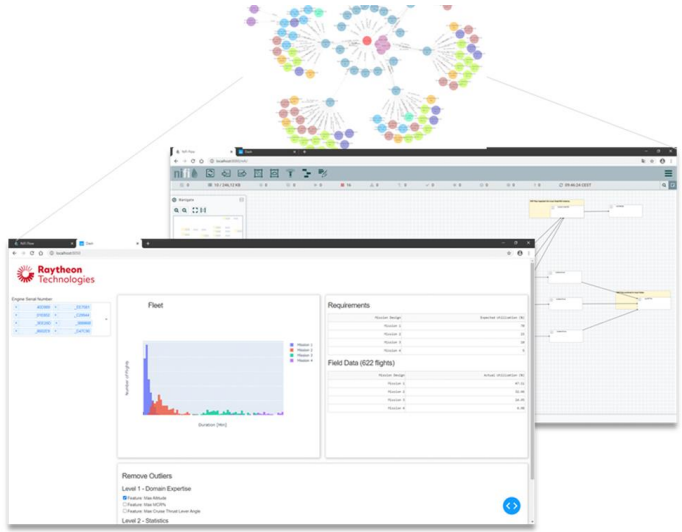
Semantic Integration

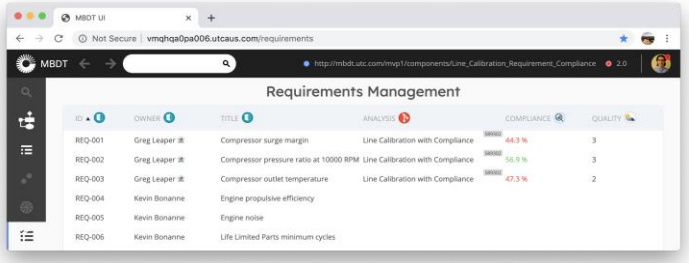
Diagnostics, Prognostics and Health Management Domain

Maintenance Repair and Operations Domain

Product Design Domain

Simulation & Dashboard





Digital twin traversing functional silos by leveraging semantic integration and open service architecture

Conclusions

- Digital twins and digital threads are essential to unlock value in the product lifecycle
- Interoperability at different levels – processes, models, data, tools and infrastructures – is a necessity
- Simulation capability and simulation lifecycle management are key tools to implement digital twins
- Semantic integration, open service architecture and DevSecOps are key ingredients to deliver the needed agility for the digital thread and digital twins

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