Digital Thread Enabled Through Semantic Approach

Presented by:

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Chief Technology Officer, GeometricPLM
HCL Technologies

GLOBAL PRODUCT DATA INTEROPERABILITY

SUMMIT 2017

ELYSIUM Parker Aerospace NORTHROP GRUMMAN BOEING

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Louis Pascarella *Chief Technology Officer, HCL Geometric PLM*

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Louis Pascarella is CTO of HCL's Geometric PLM organization focused on Product Creation Methodologies, Product Lifecycle Management and Digitalization of Enterprise Ecosystems, including Digital Thread/Twin enablement.

He has been working with global Automotive, Aerospace and Software Vendors for over 35 years in the areas of Visualization, CAD, PLM and Software Lifecycle Management with a focus on strategy, planning, consulting, systems engineering, and knowledge capture & management.

Mr. Pascarella has a leadership background (CTO, VP R&D) in PLM & Manufacturing technology development and implementation (Teamcenter, Windchill, & ENOVIA), solution architecture, enterprise middleware technologies (EAI, SOA), and Industrial Internet of Things (IIOT/IOT).

Currently, he is providing thought leadership and strategic guidance for large customer Digital transformation initiatives.

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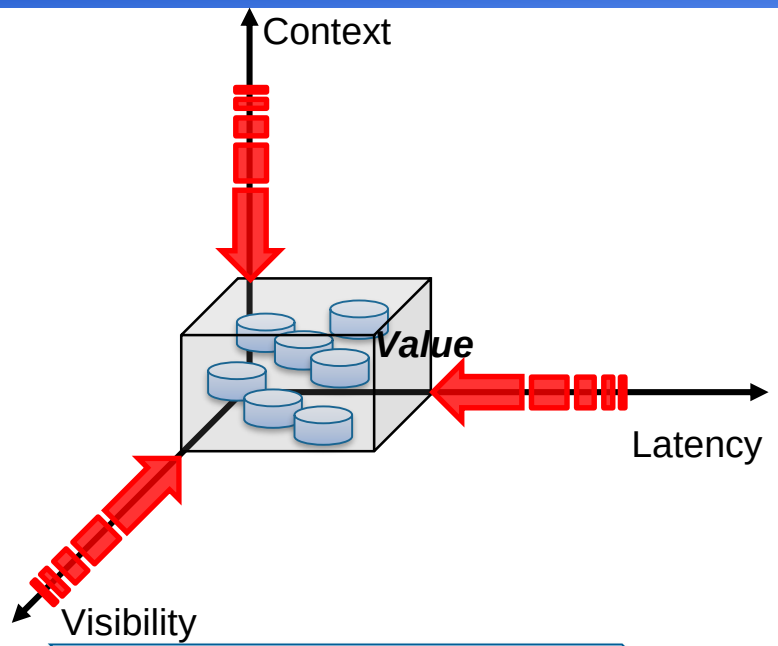
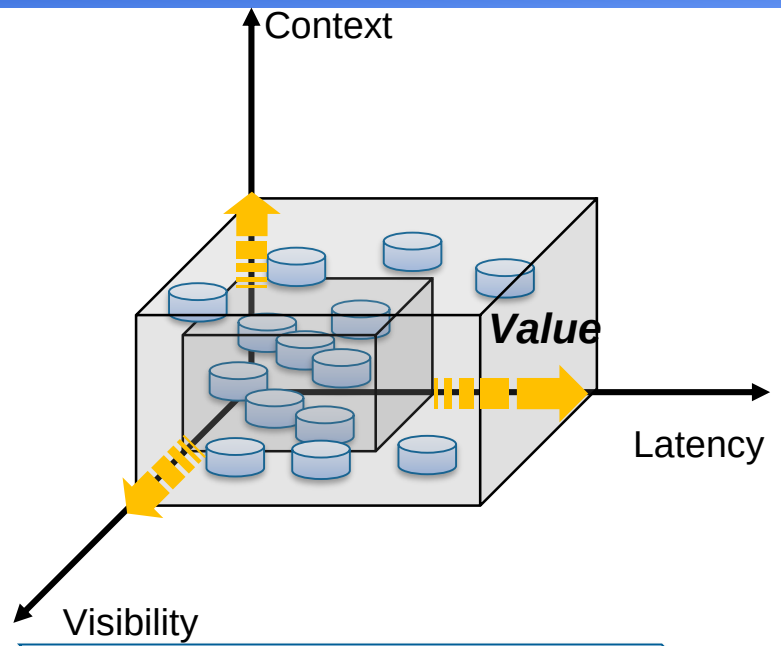
We Struggle to Improve the Value of our Digital Assets



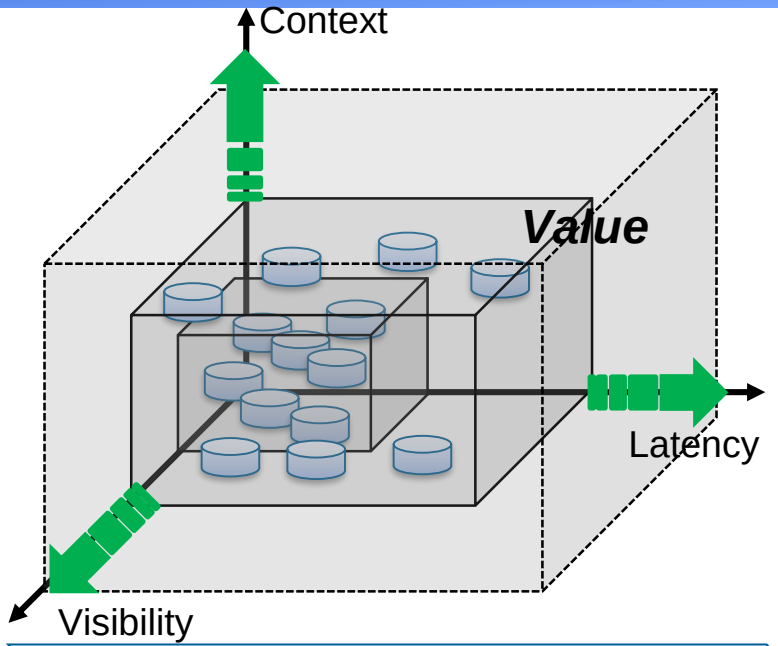
Data Authoring Focus

- "Data Authors" enabled with applications
- "Data Consumers" struggle with
  - Stale data → Latency
  - Why? → Context
  - Data access → Visibility



Enable Data Consumption

- "Data Consumers" enablement
- Application Integration
- EAI and Middleware
- Reporting and Dashboards
- Mixed Results
  - Latency Improved, but
  - Data Quality → Context
  - Integration Complexity → Visibility



Data → Information → Knowledge

- Synthesize data to information
- Collection
- Aggregation
- Normalization
- Assign Context for global understanding
- Increase availability to 'Consumers'
- Reduce latency
- Increase data transparency (visibility)

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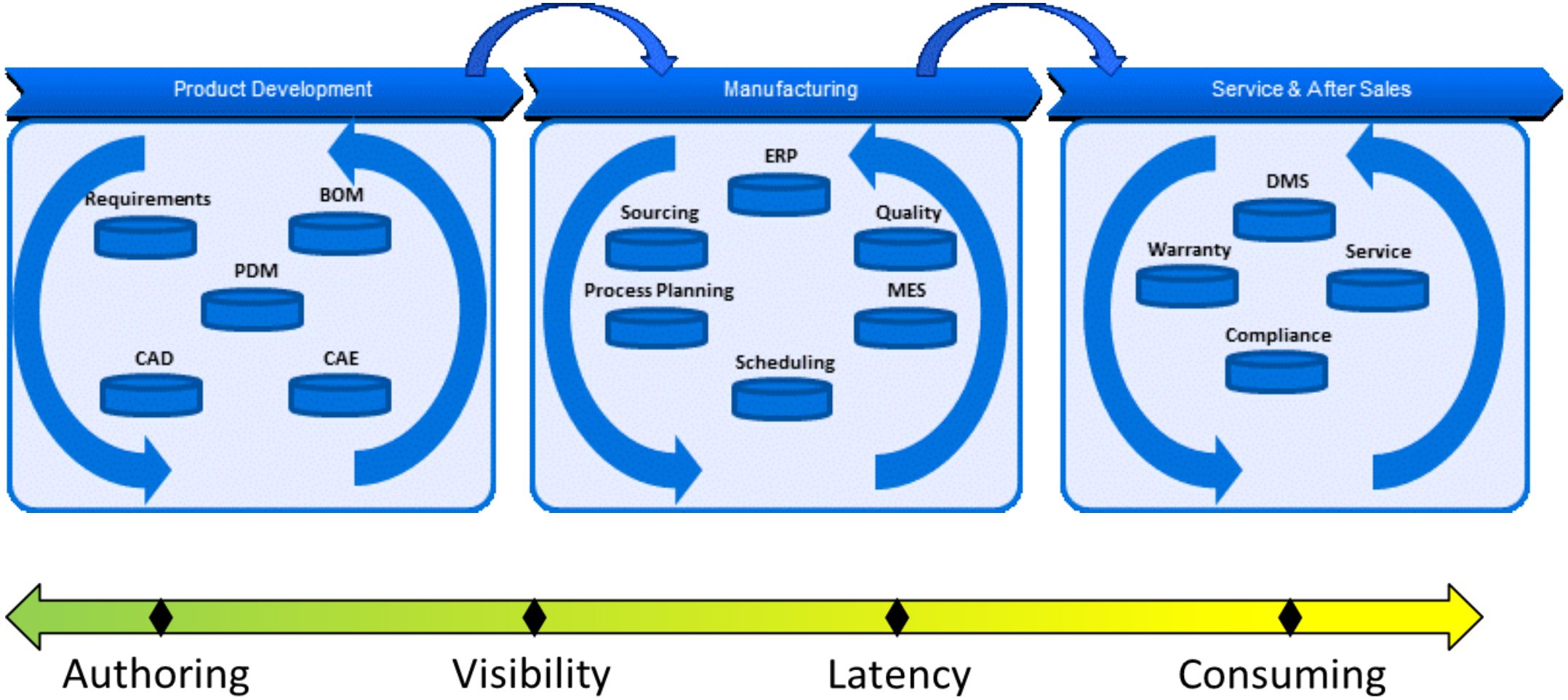
What We Built ➔ An Application Footprint Focused on Authoring…



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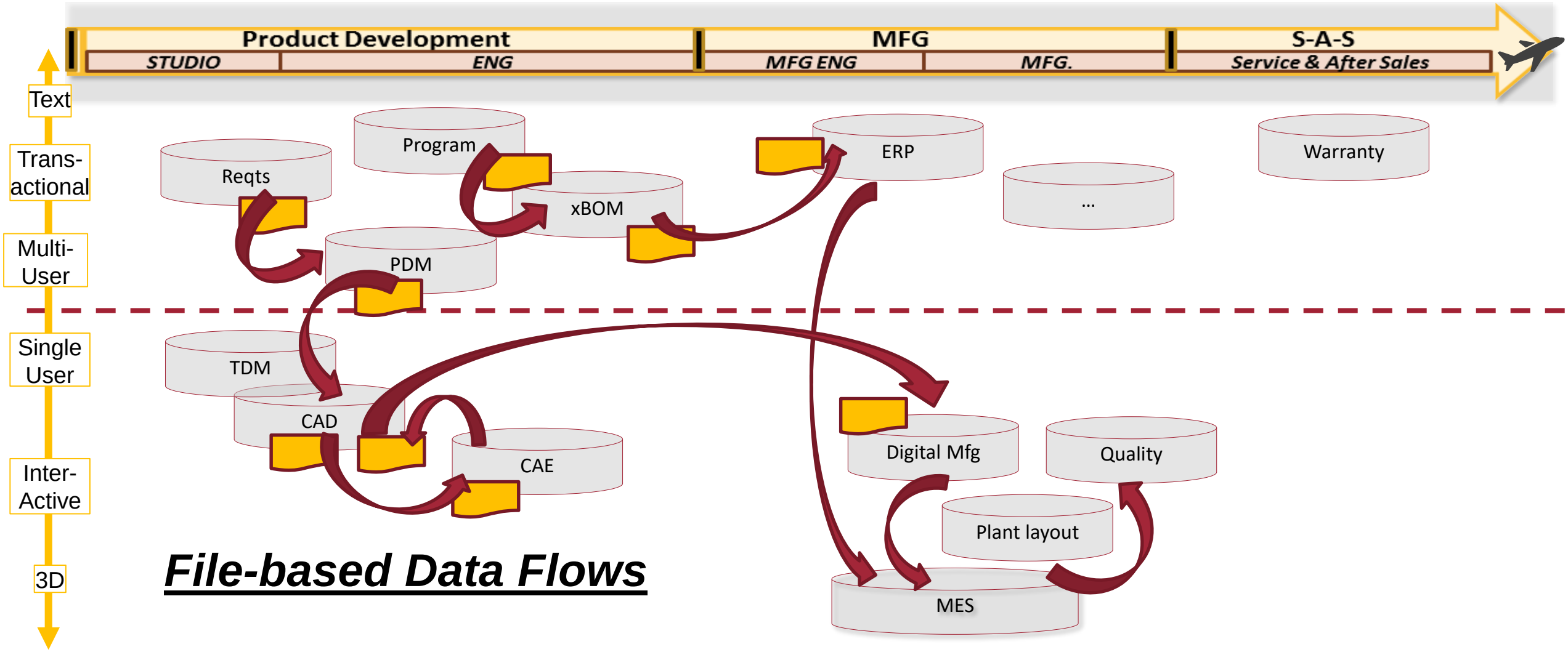
But We Tried to "Consume"… and Built Semantic based Point-Point Integratiions



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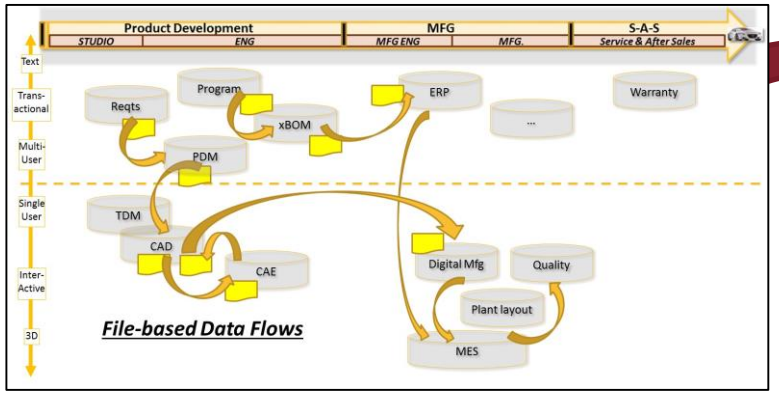
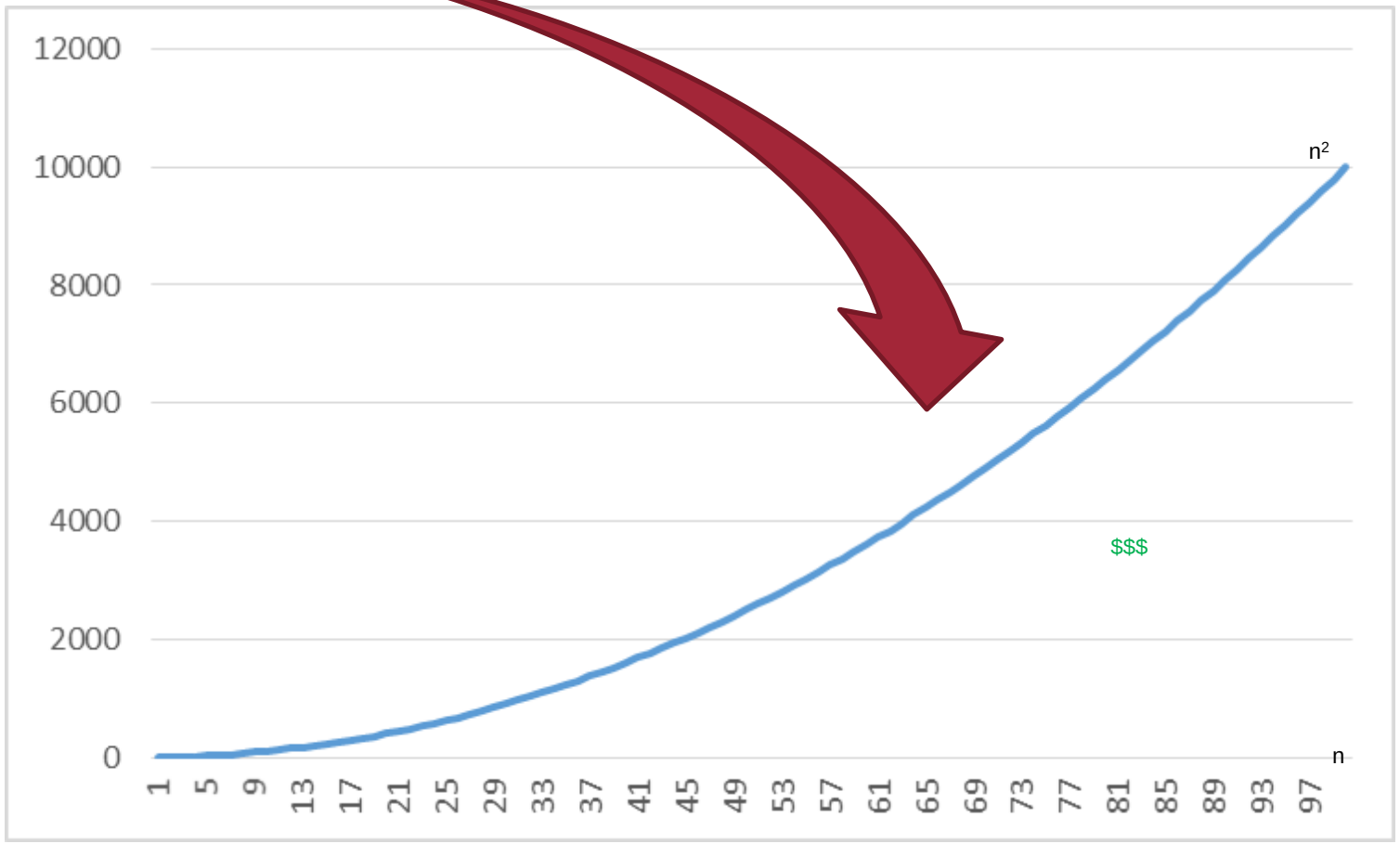
And Hit a Wall…. File-Based Links Scalability Barrier





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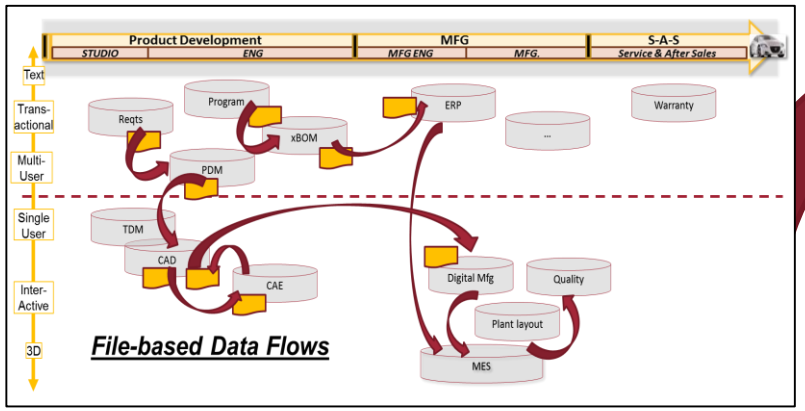
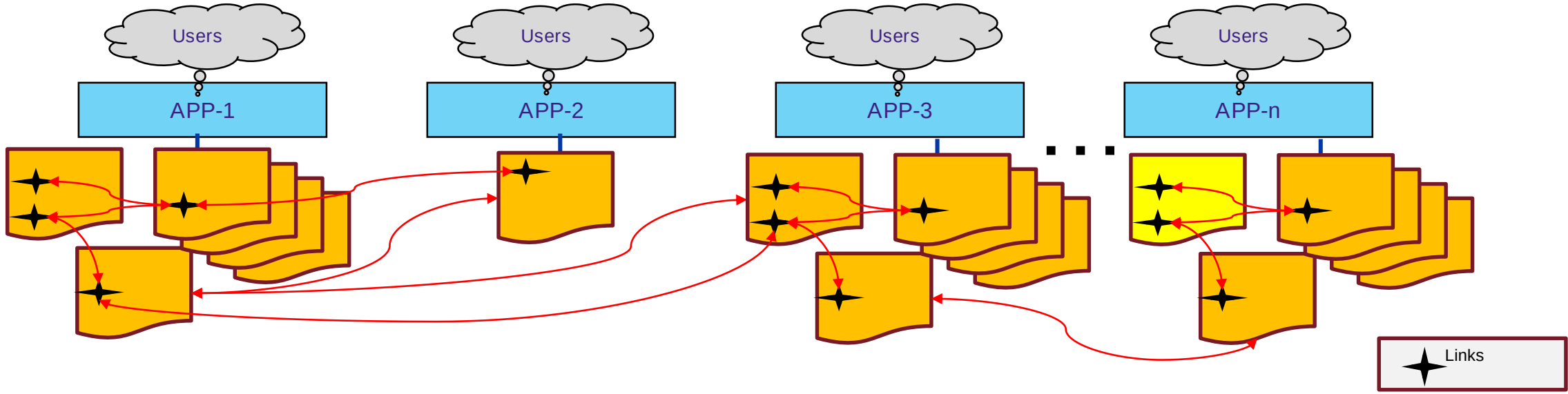
The Challenge is now greater : Inter-file & Intra-file attribute Linkage





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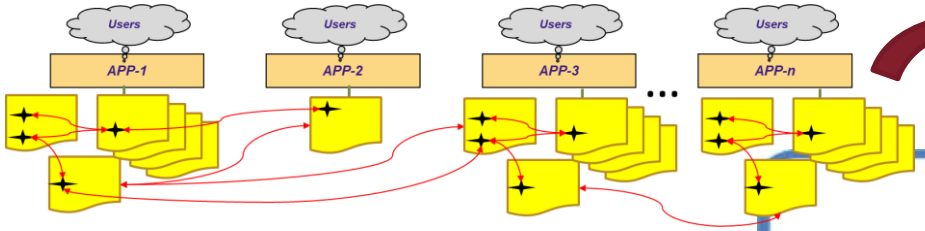
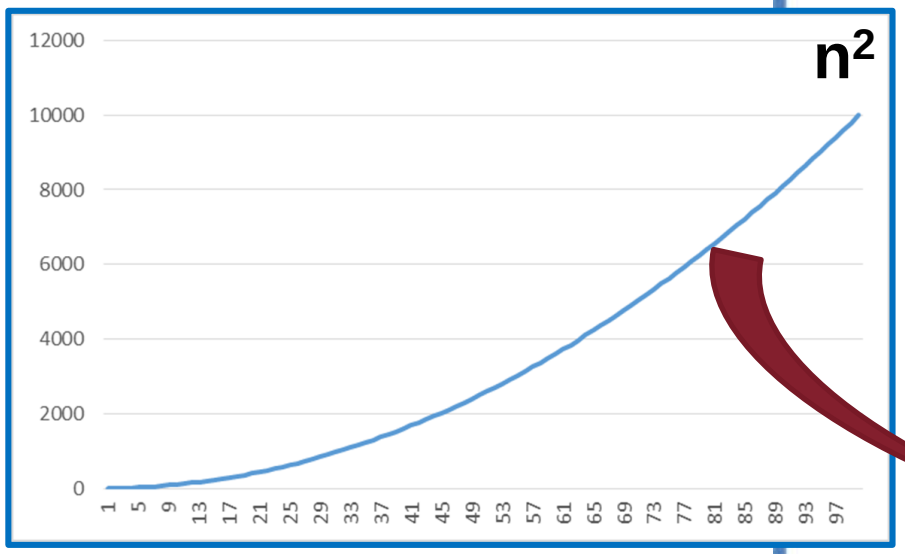
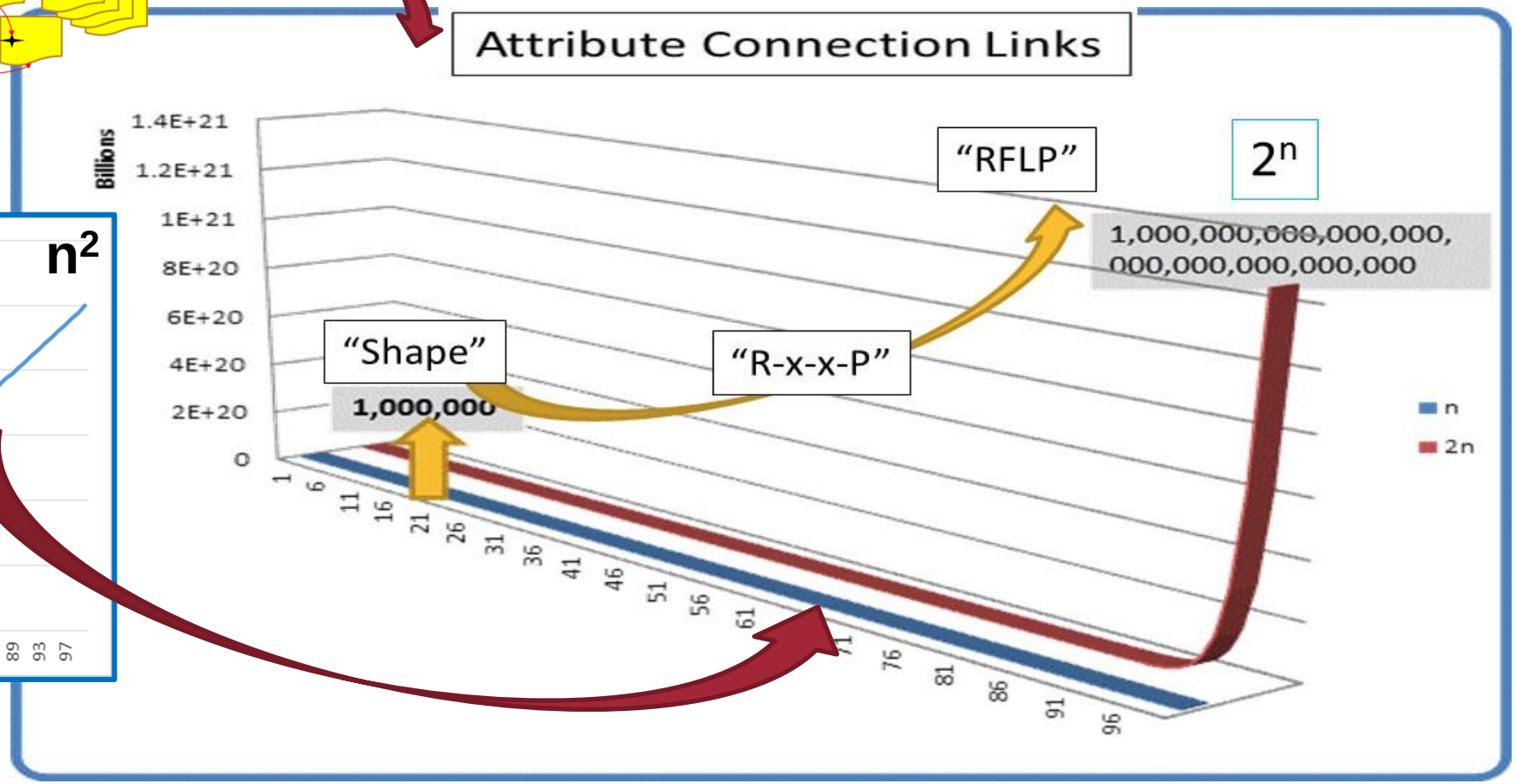
And Now the Wall is Higher!!!! Attribute Linkage & Traceability Scalability Barriers







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Product Complexity - Authoring & Consumption

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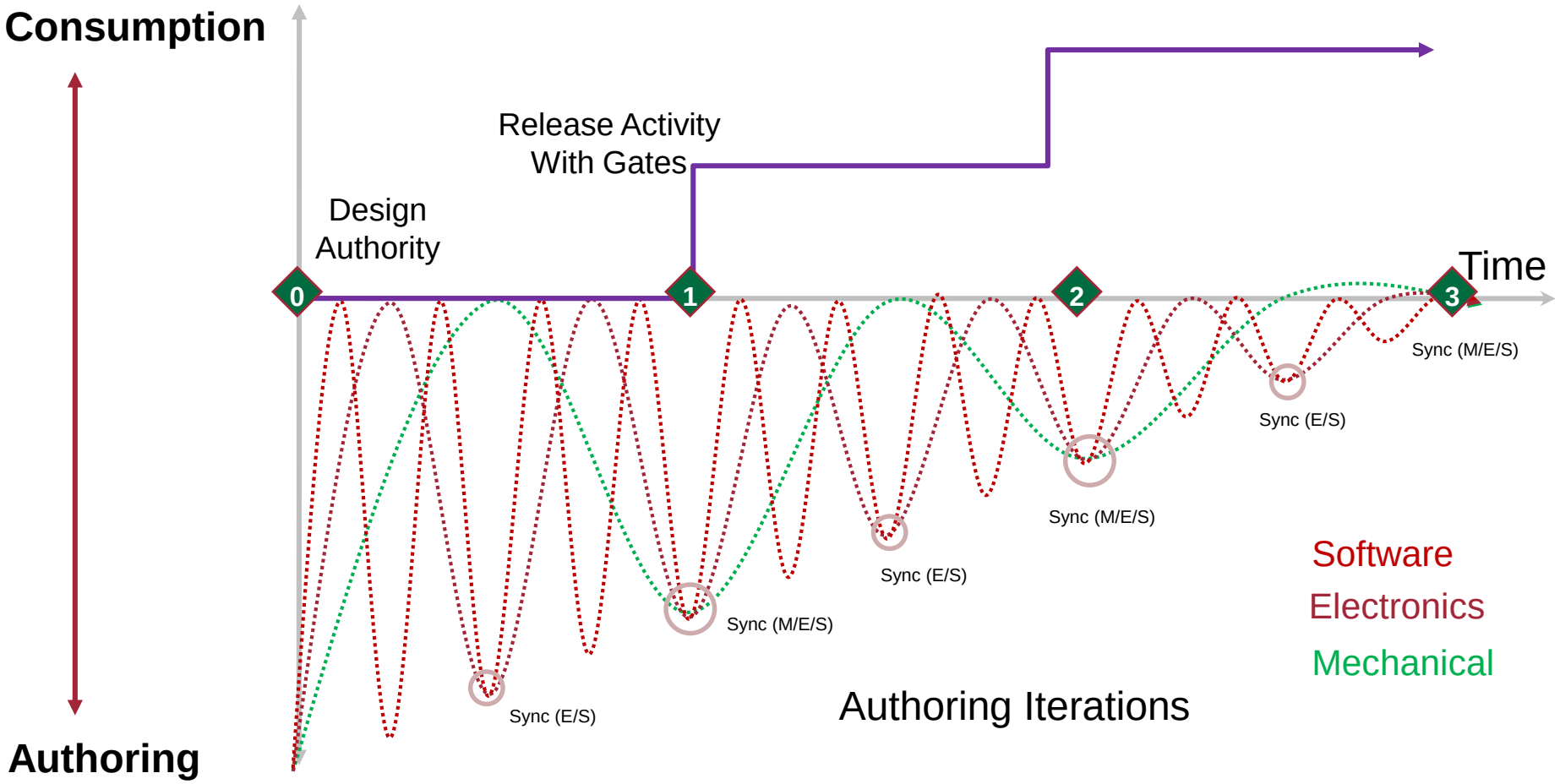

Consumption

- Bills of Material (BOMs)
- Configuration Management
- Release Management
- Change Management
- Project Management
- Product & Portfolio Mgmt
- Cost, Compliance & Quality

Authoring

- User Workspaces
- Team Collaboration
- Integration
- Simulation
- Verification & Validation
- Supplier Collaboration

Mechanical, Electronics and Software streams attain maturity in different cycles. Managing these streams individually is essential to retain their flexibility. However they need to be integrated horizontally and vertically (Enterprise systems) based on maturity of data.

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Corporate Ecosystem Application Footprint → Macro Semantic view

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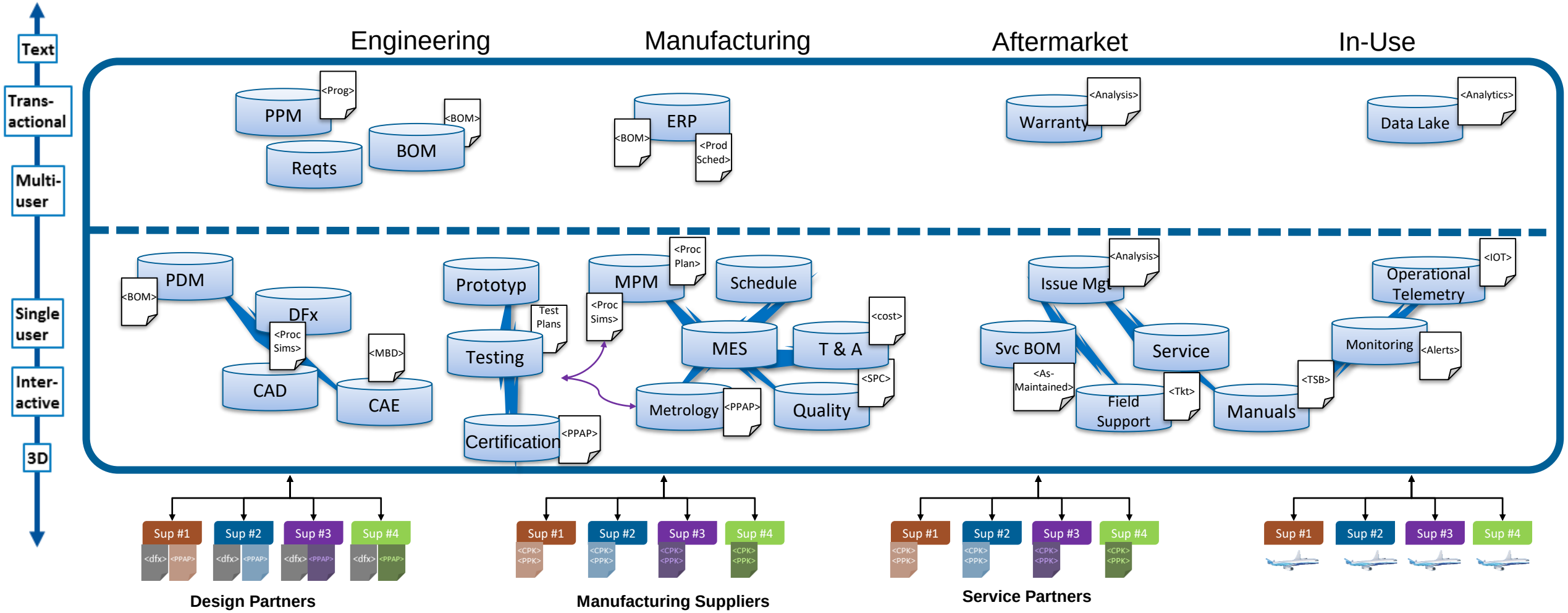

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Corporate Ecosystem Application Footprint → Macro Semantic view

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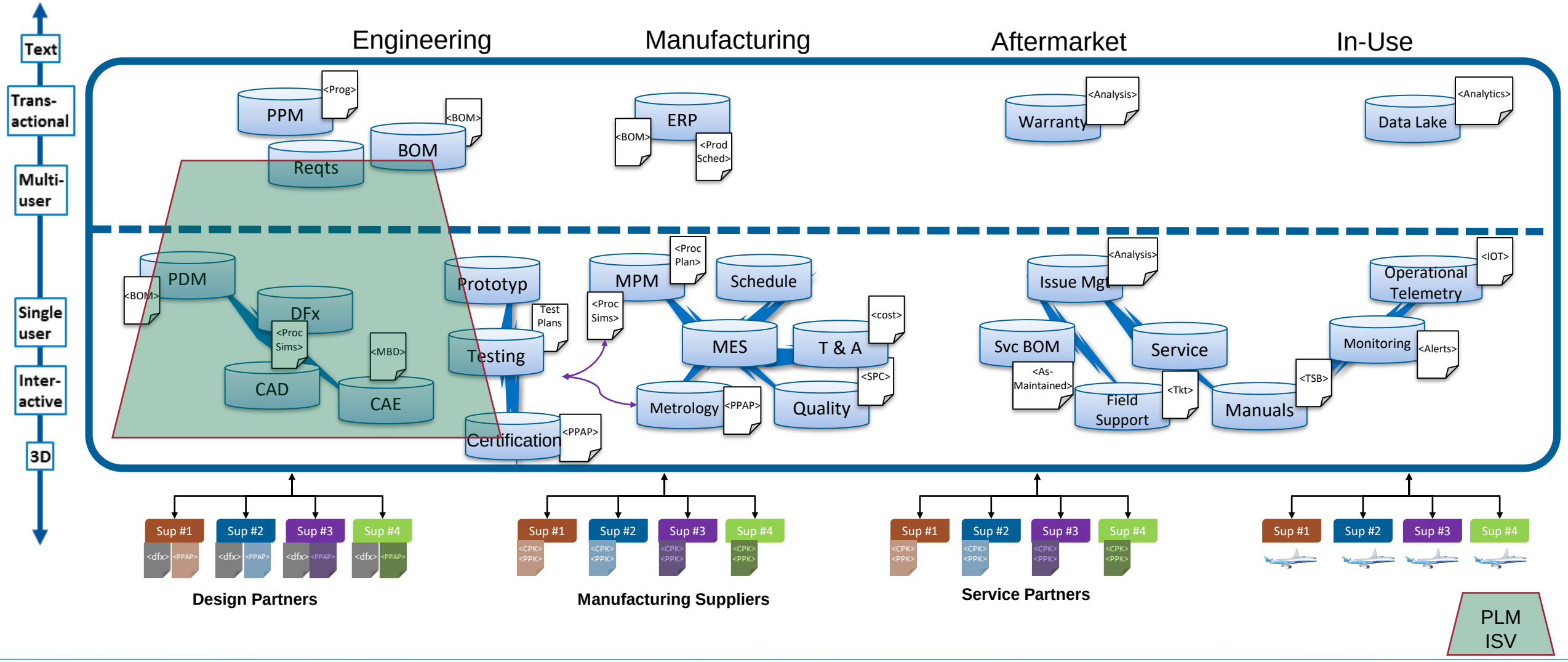

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Corporate Ecosystem application footprint → Micro Semantic view

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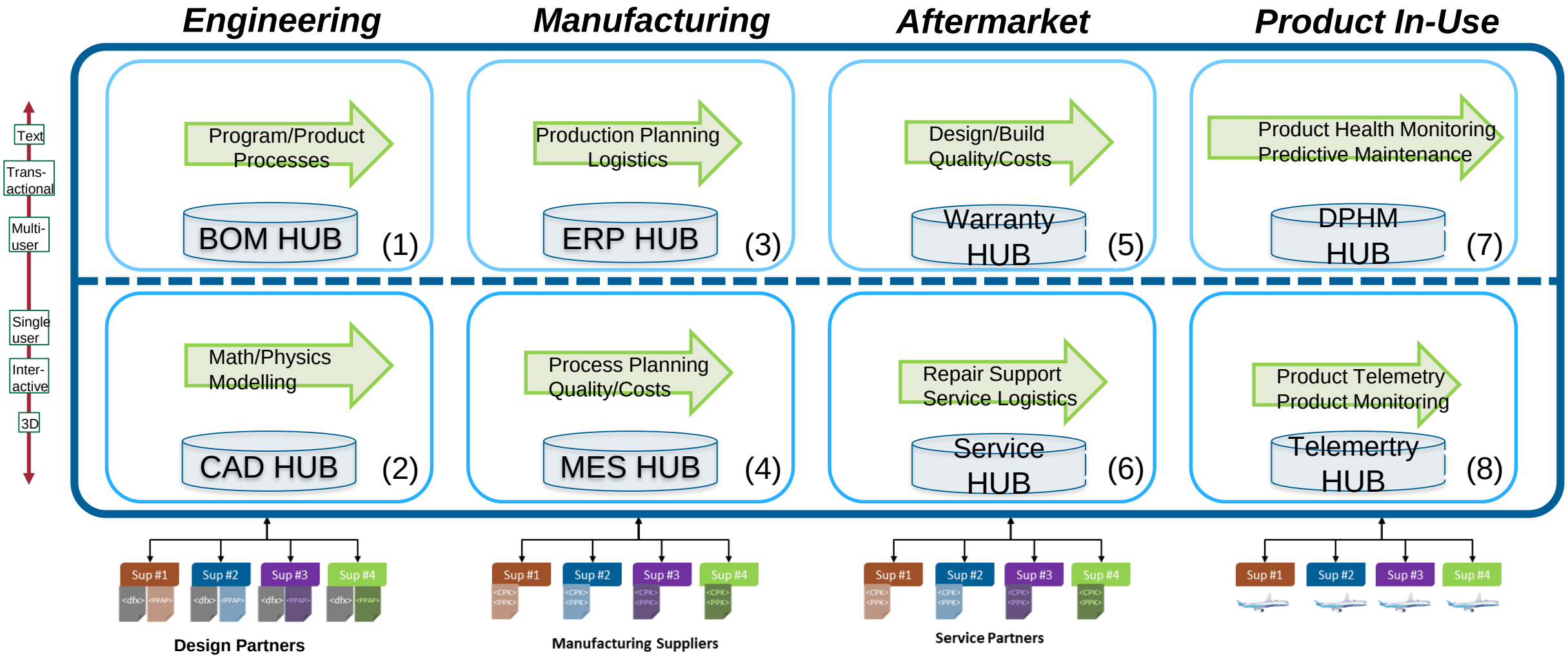

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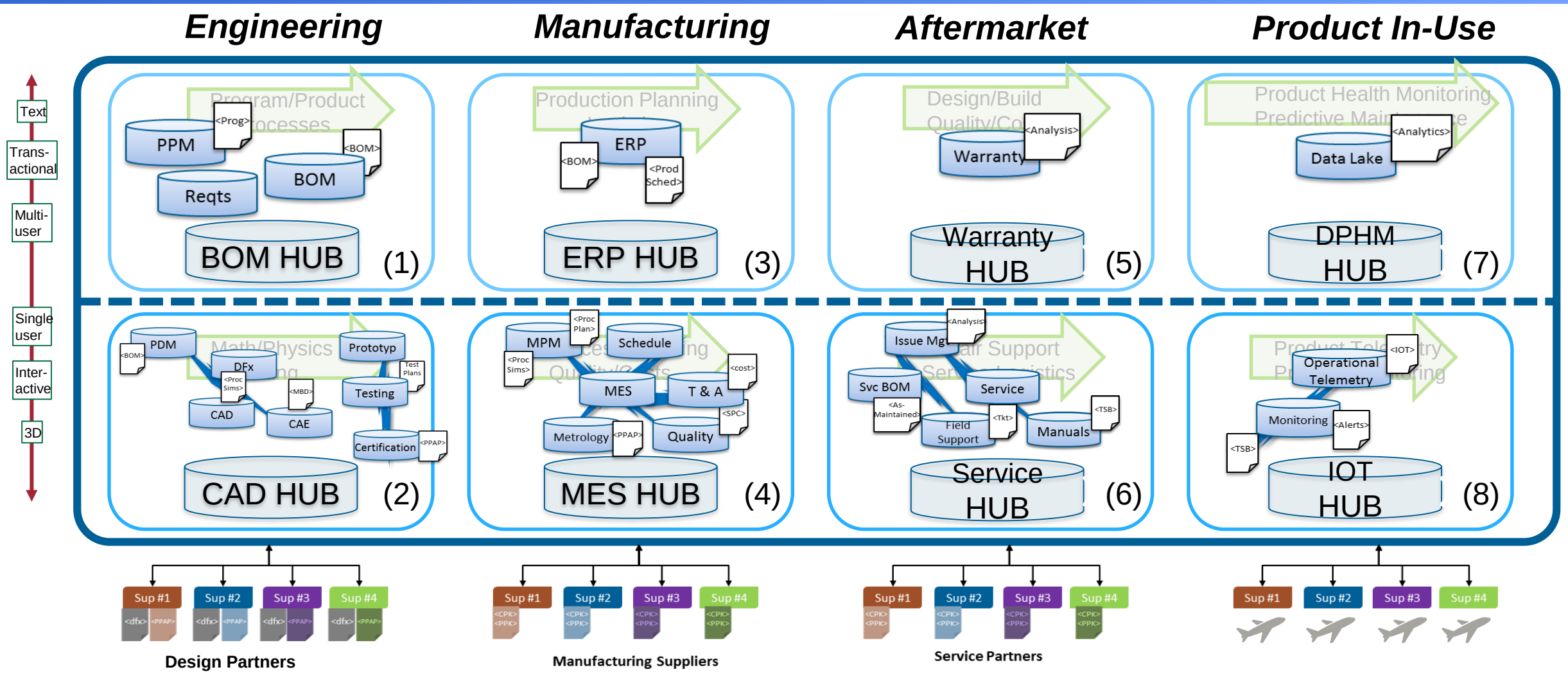
Corporate Ecosystem application footprint → Micro Semantic view



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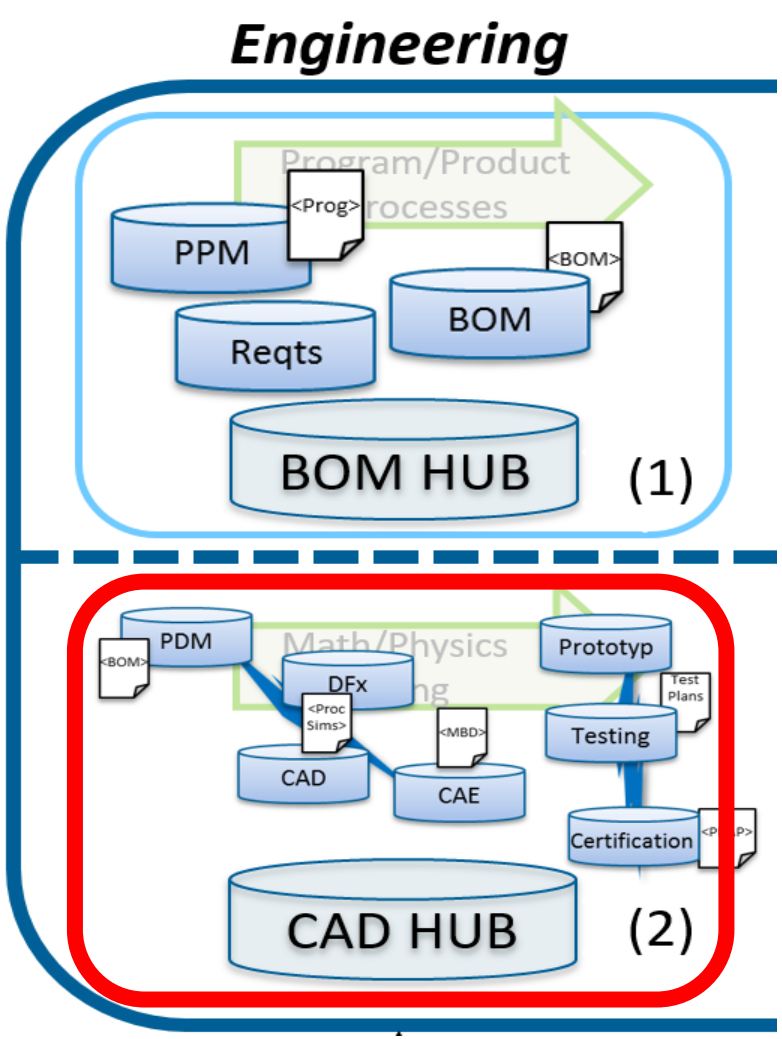
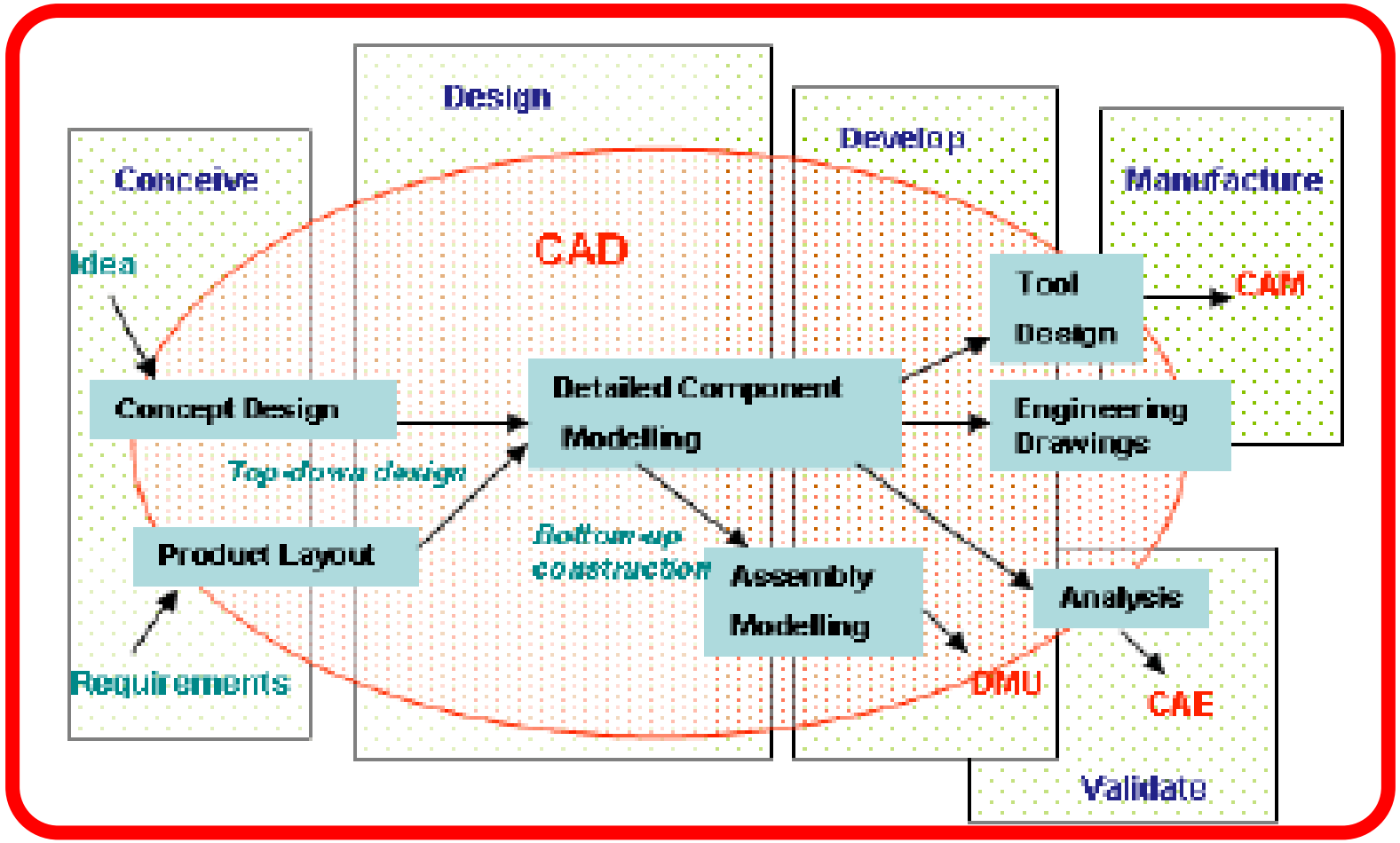
What is Inside the CAD Hub…..



Formalized Process….



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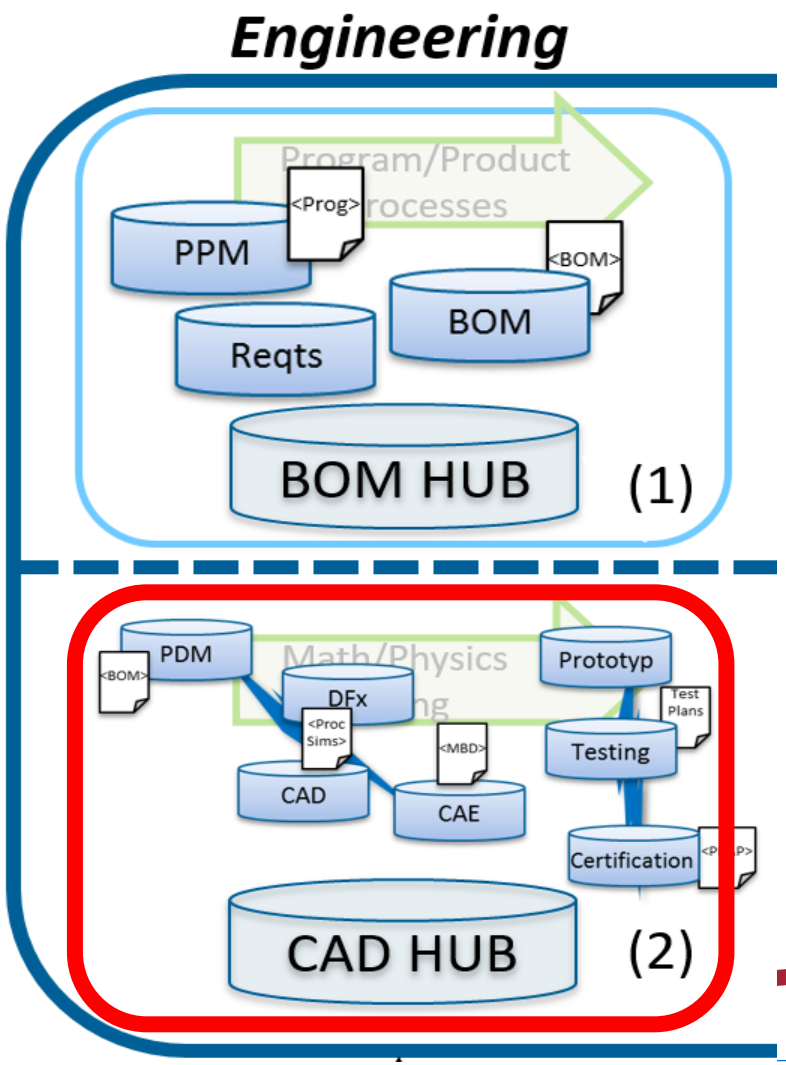
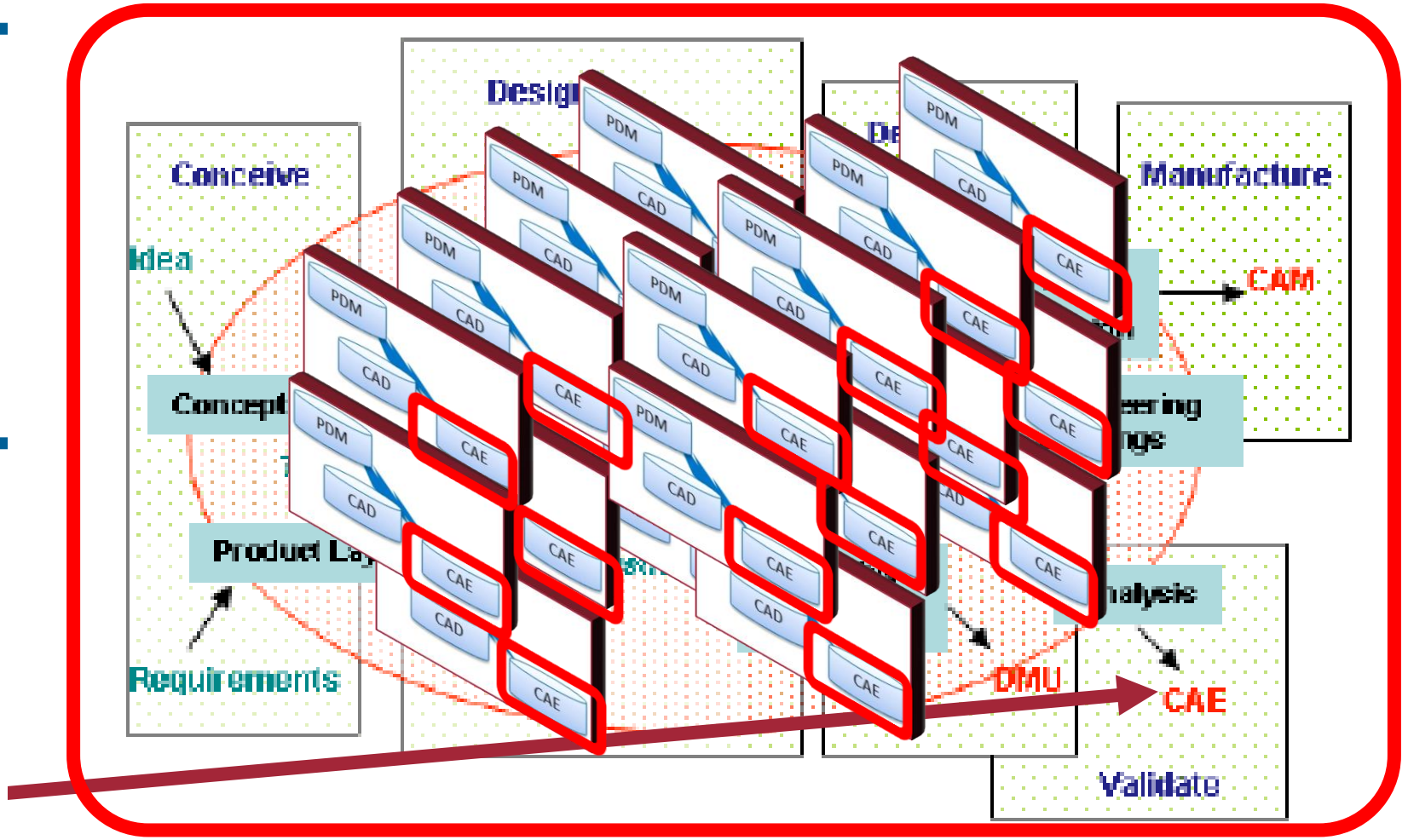
What is “REALLY” Inside the CAD Hub…..



Ad Hoc Process….



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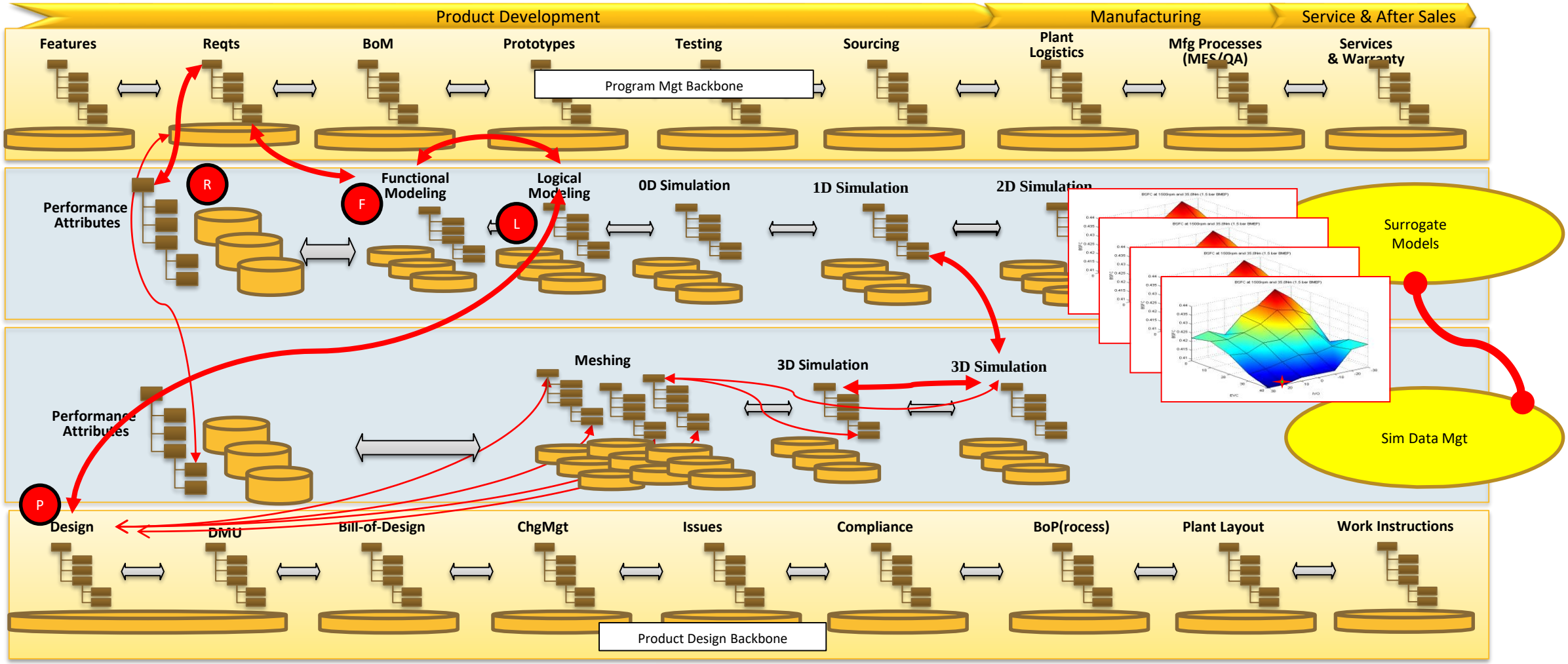
The need to mange a Formalized Simulation Backbone….



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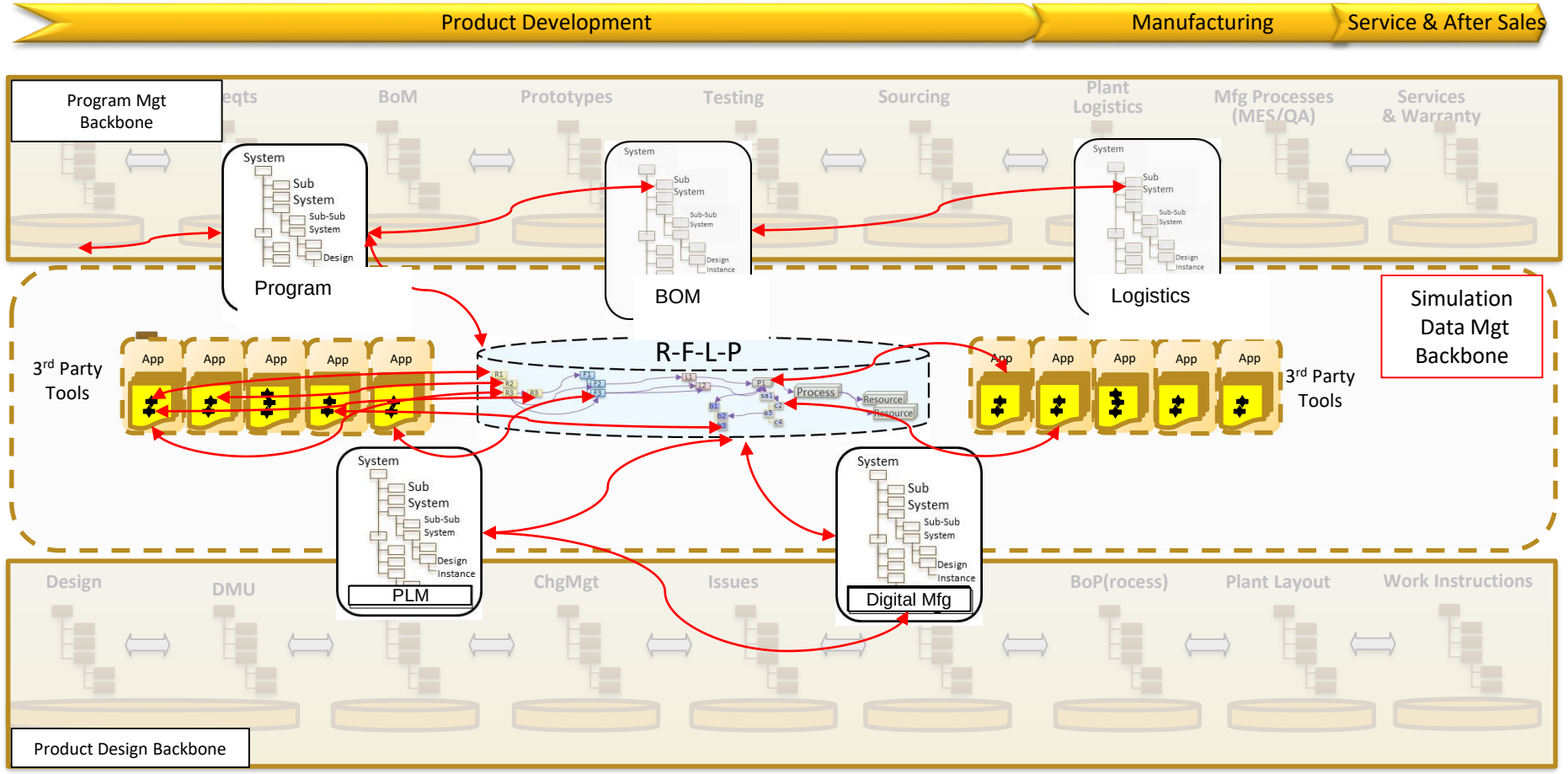
And…. must manage massive heterogeneity



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Fueled by Linked Data & Semantics

A PATH FORWARD…..

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Enabling the Model Based Enterprise

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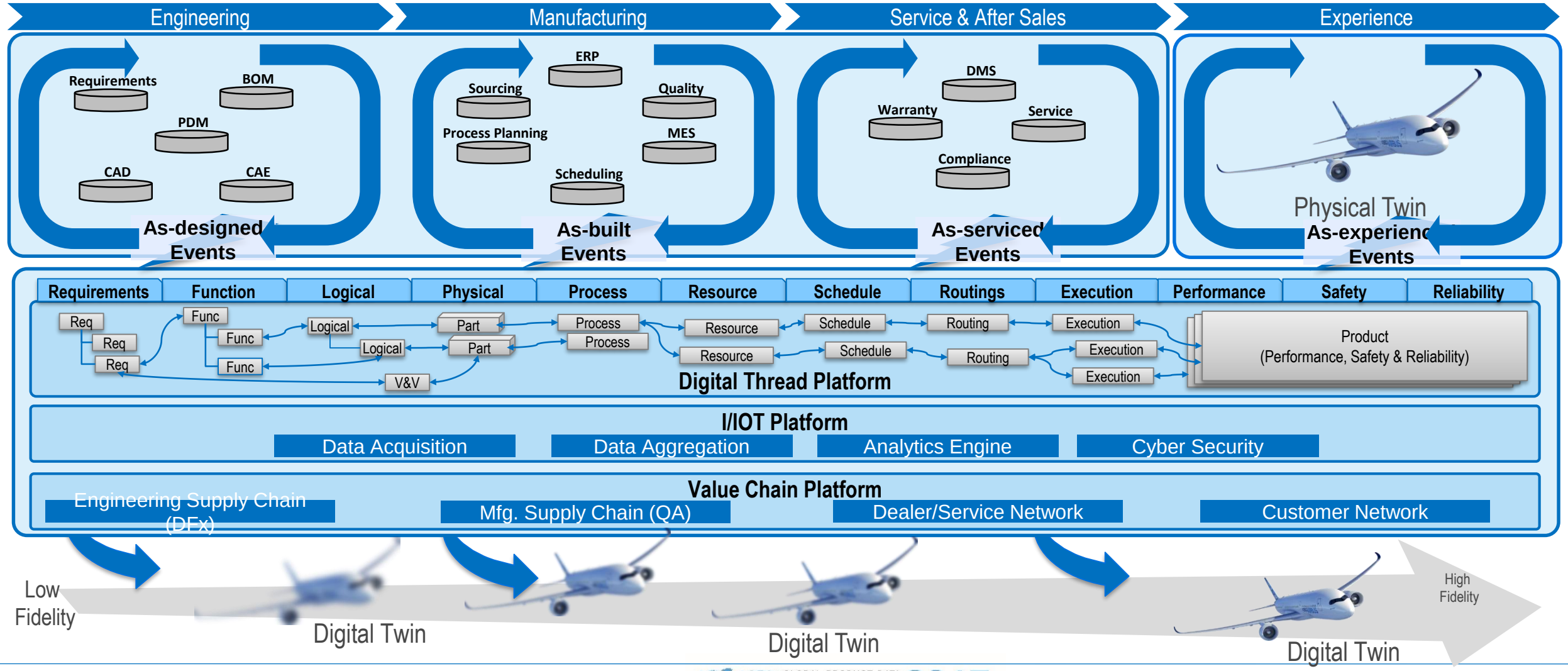

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Digital Thread Consumption……..

Predictive Models

- Statistical Methodologies
- Sparse data sets
- Massive variability/correlations

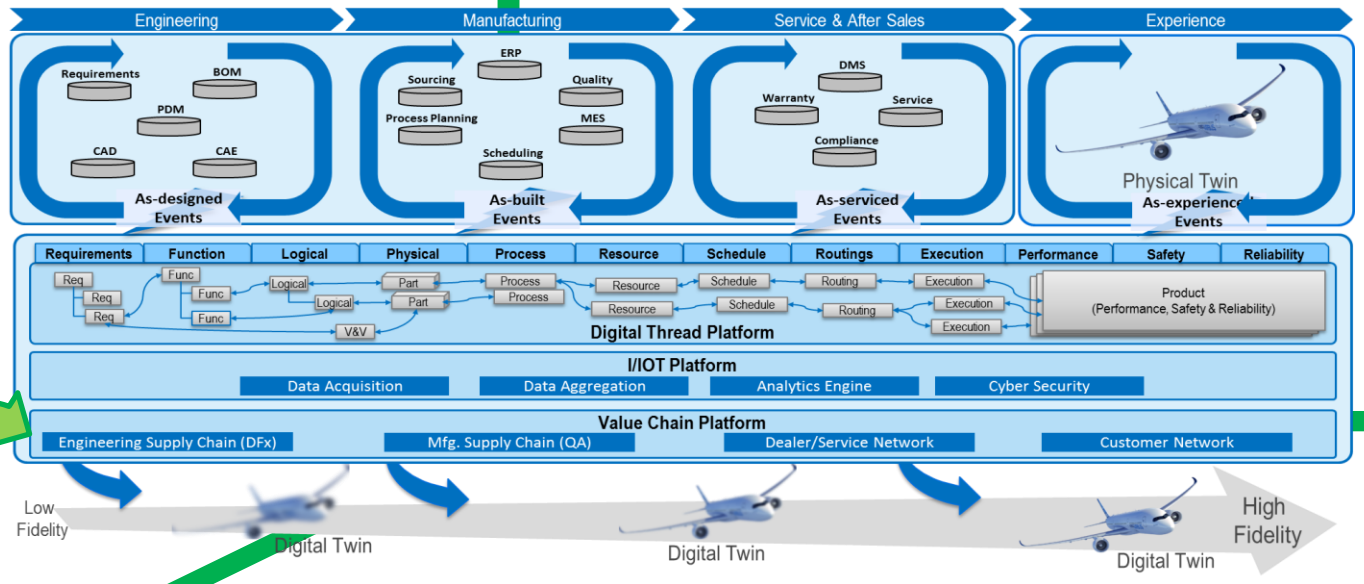
Big Data

Context

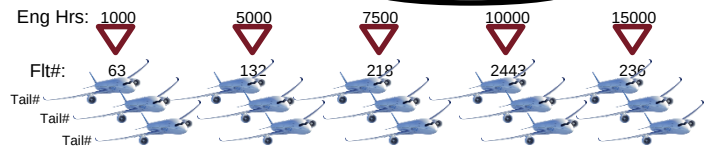
RCA

Trends/Patterns

Rules/Stds



Operations



Big Data

Explanatory Models

- Enabling prescriptive analysis

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Digital Enterprise : Solution Topology

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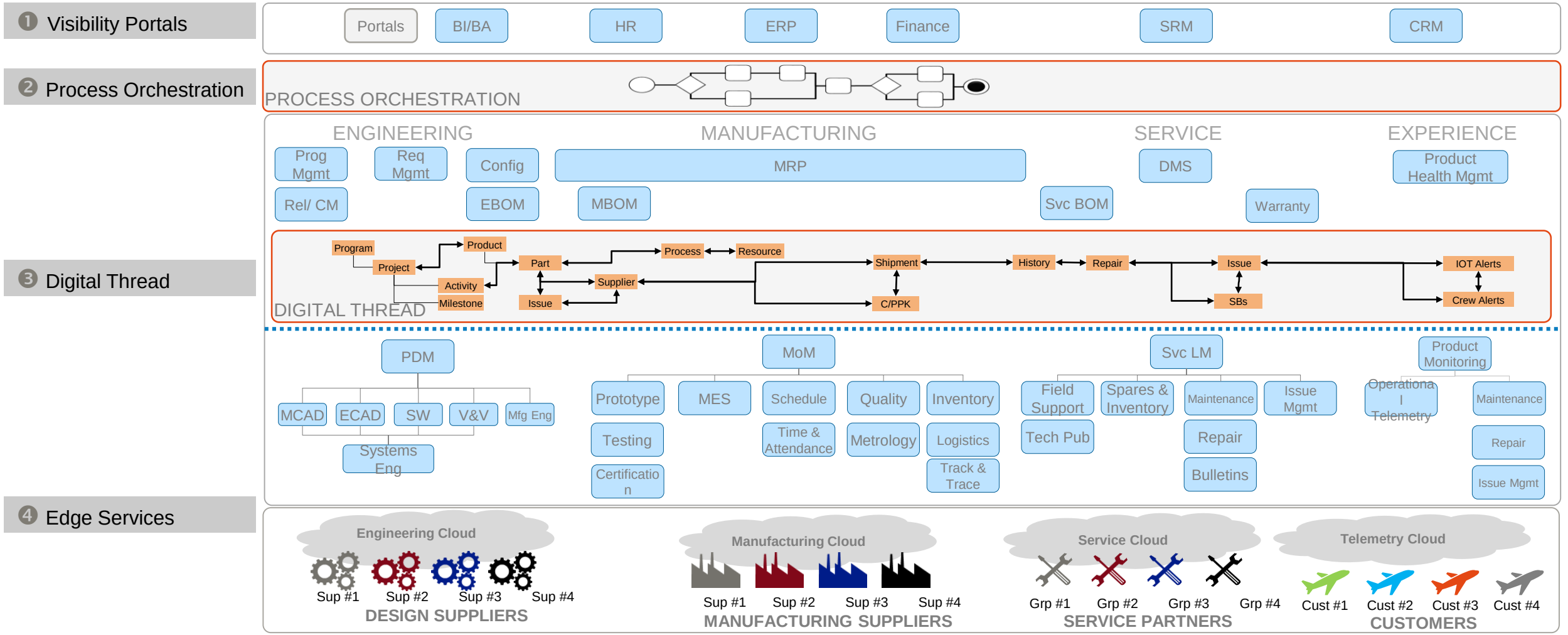

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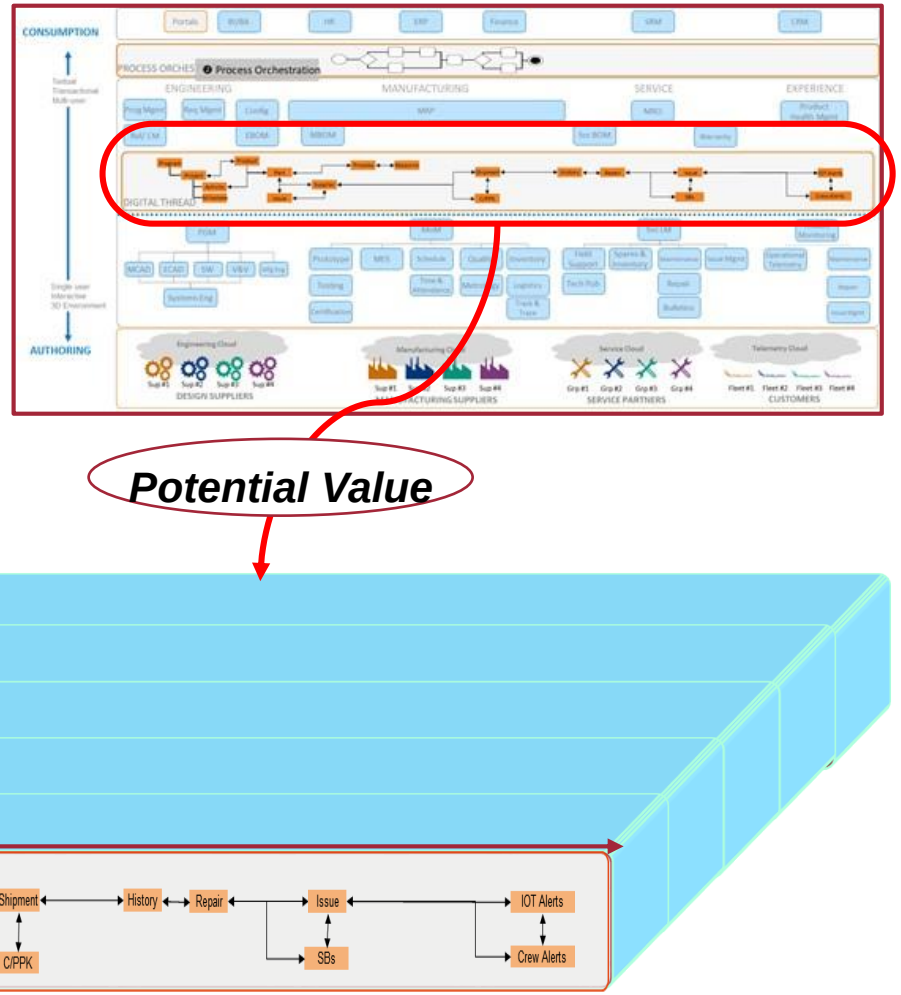
Digital Thread : Potential Value

- **Digital Thread Value Prop**
  - **Provide bi-directional traceability to improve the context and impact analysis across the domains (horizontal/breadth) and in a domain (vertical/depth)**
  - **Make key information available to all stake holder thus improving visibility**
  - **Provide information in near real-time thus reducing latency**



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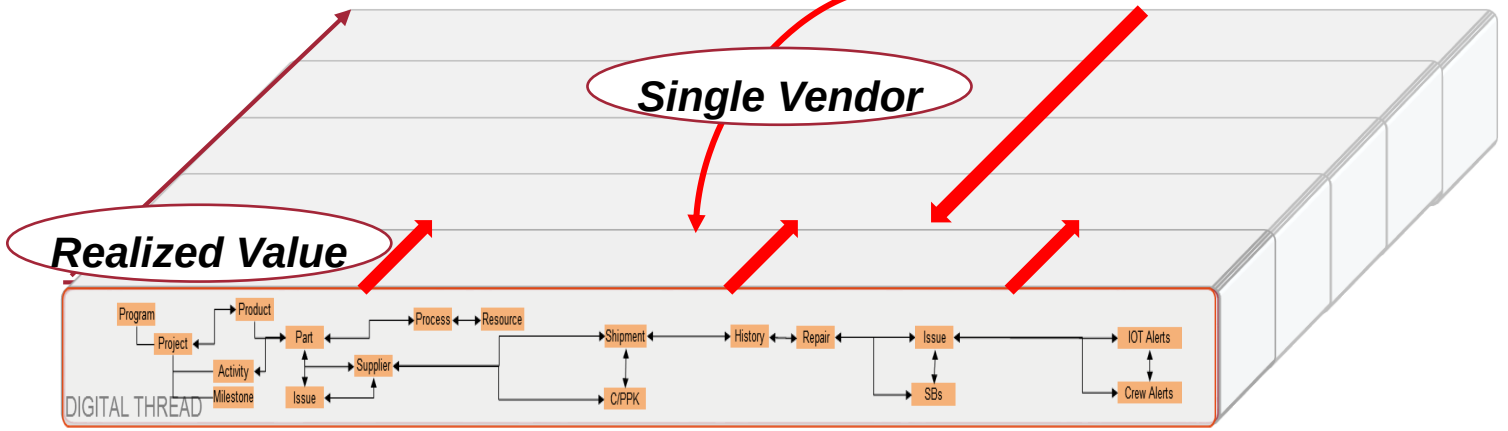
Digital Thread : Single Vendor Value

- **In a single vendor system the value of a Digital Thread is constrained by**
  - **Functional nature of the systems**
  - **Domain specific interpretation of data and elements**
  - **The value is reduced to a common minimum subset**



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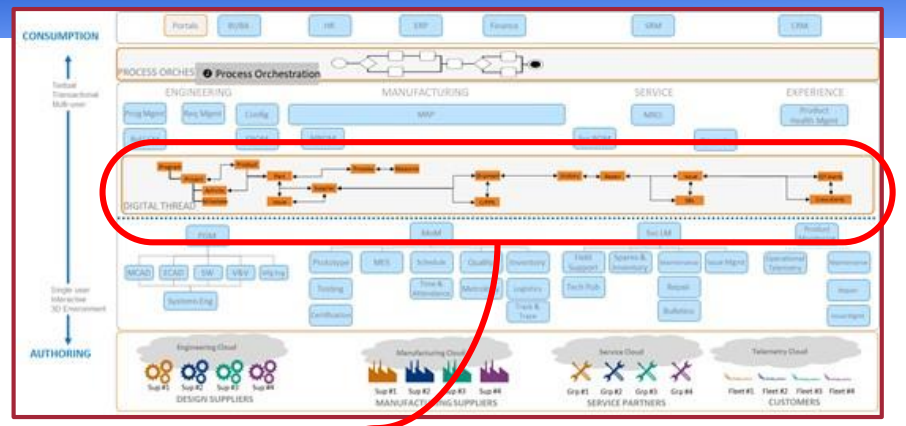
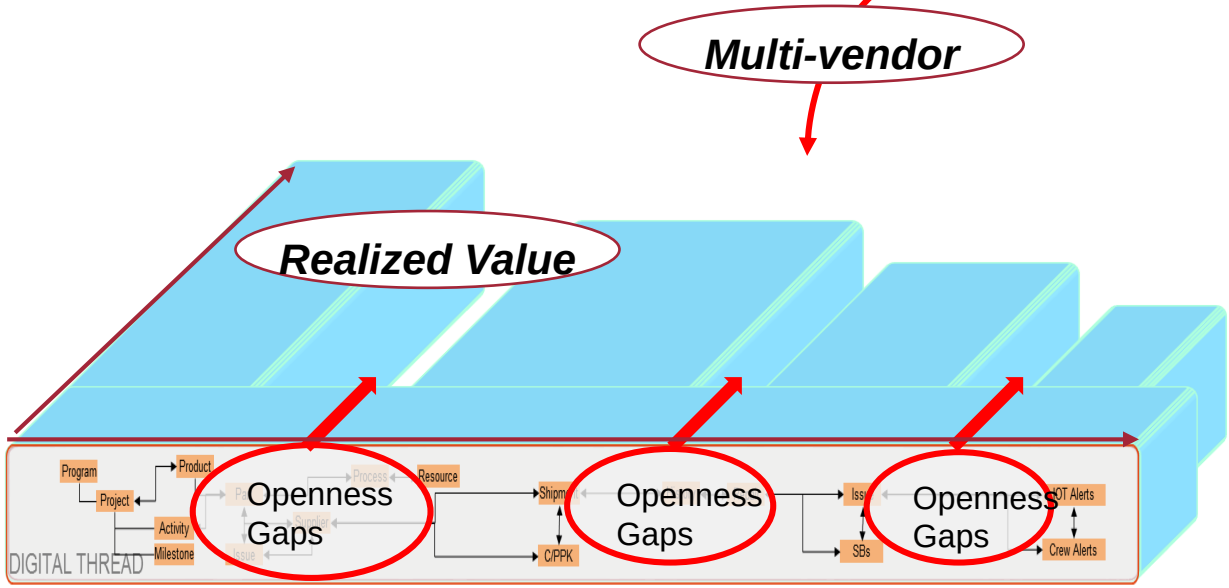
Digital Thread : Multi-vendor with “openness” constraints

- **In a multi-vendor environment the value is constrained by**
  - **Domain specific interpretation of data and elements (different semantics)**
  - **Lack of Access in systems for users in other domains**
  - **Quality of Data**
  - **Openness constraints**
- **The value in few systems will be high and across the systems will be low**





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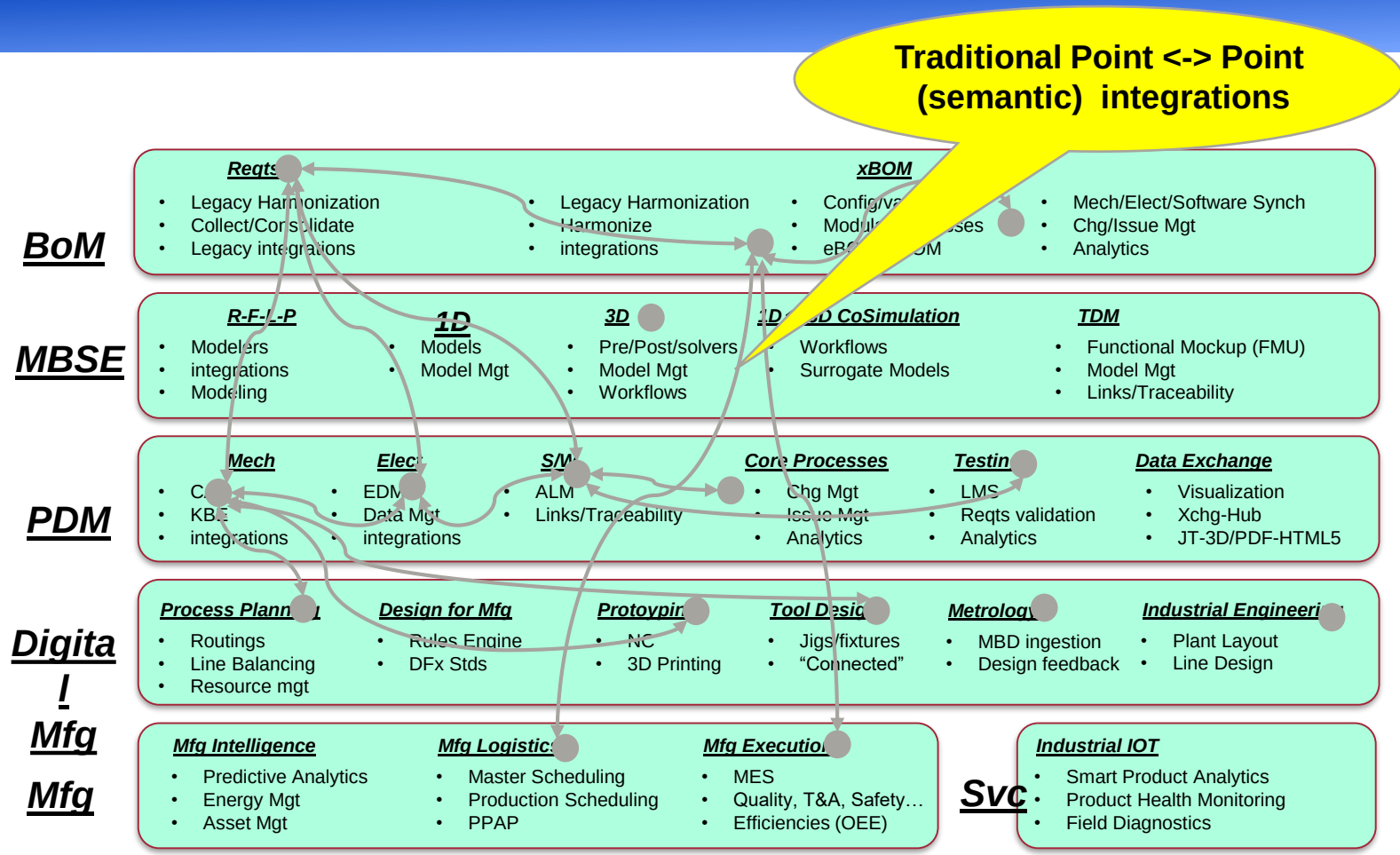
Enterprise Application Footprint with Traditional Integrations (Fixed Mappings)

- **While traditional integrations provide data to different systems – are not ideal as**
  - **Traceability is still distributed across system impeding visibility and context**
  - **Re-work required for adding new objects and relations (due to fixed object mapping)**
  - **Assuring data quality (data master vs. data consumer) is difficult**
- **These integrations can also be though as "semantic" but with fixed mapping**



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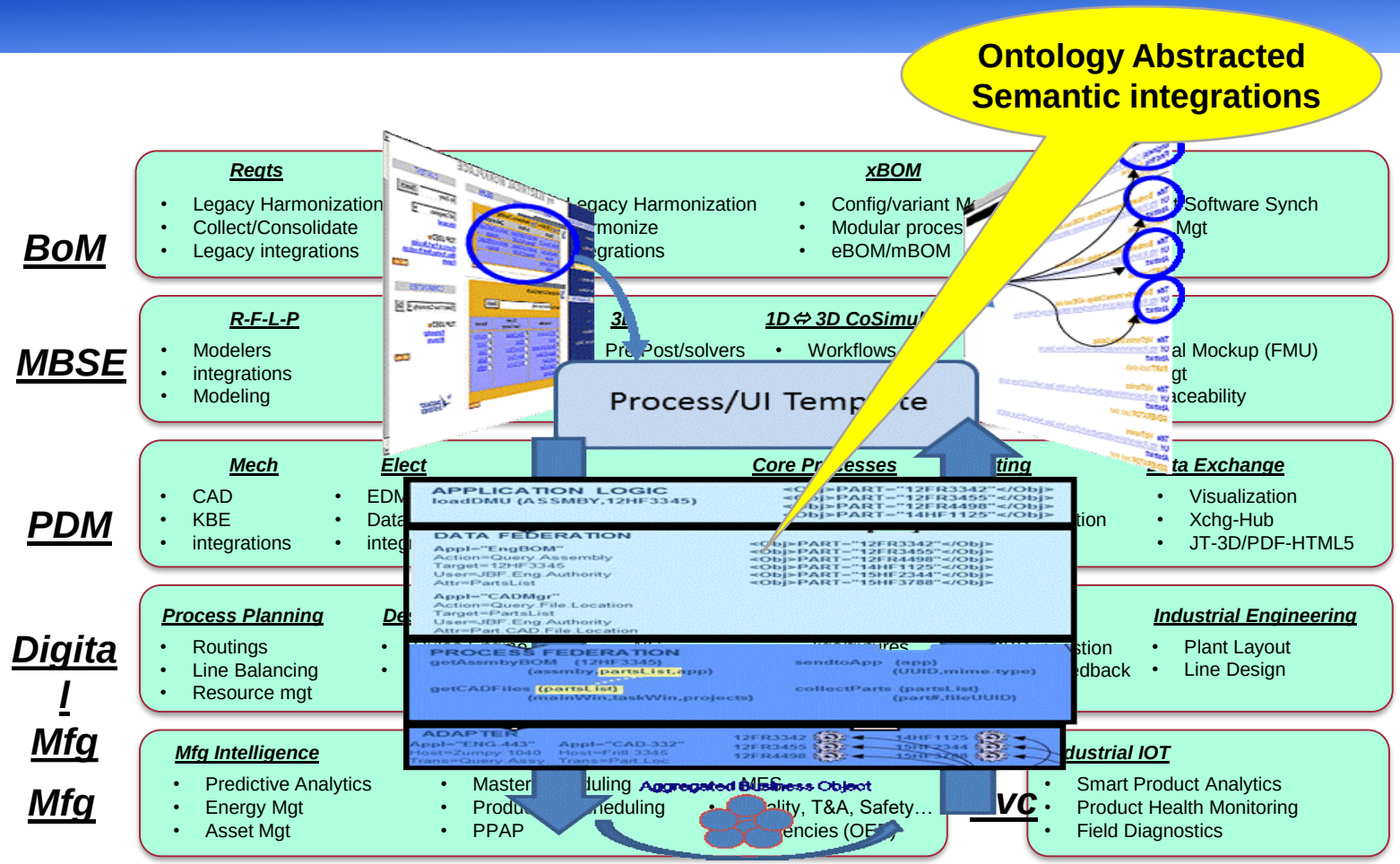
Ontologically Abstracted Semantic Integrations

- **Ontologically Abstracted Semantic Integrations help**
  - **Domain Specific (Local) and Domain Neutral (Global) Ontologies to bridge across domain specific applications**
  - **Federate data thus providing always the latest data without duplication**
  - **Provides a neutral way to represent bi-directional traceability**



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N-Dimensional Mappings (FUNCTIONAL) → with Associativity → Vertically & Horizontally

BoM

Reqts
- Legacy Harmonization
- Collect/Consolidate
- Legacy integrations

- Legacy Harmonization
- Harmonize
- integrations

xBOM
- Config/variant Mgt
- Modular processes
- eBOM/mBOM

- Mech/Elect/Software Synch
- Chg/Issue Mgt
- Analytics

MBSE

R-F-L-P
- Modelers
- integrations
- Modeling

1D
- Models
- Model Mgt

3D
- Pre/Post/solvers
- Model Mgt
- Workflows

1D ⇔ 3D CoSimulation
- Workflows
- Surrogate Models

TDM
- Functional Mockup (FMU)
- Model Mgt
- Links/Traceability

PDM

Mech
- CAD
- KBE
- integrations

Elect
- EDM
- Data Mgt
- integrations

S/W
- ALM
- Links/Traceability

Core Processes
- Chg Mgt
- Issue Mgt
- Analytics

Testing
- LMS
- Reqts validation
- Analytics

Data Exchange
- Visualization
- Xchg-Hub
- JT-3D/PDF-HTML5

Digital Mfg

Process Planning
- Routings
- Line Balancing
- Resource mgt

Design for Mfg
- Rules Engine
- DFx Stds

Protoyping
- NC
- 3D Printing

Tool Design
- Jigs/fixtures
- “Connected”

Metrology
- MBD ingestion
- Design feedback

Industrial Engineering
- Plant Layout
- Line Design

Mfg

Mfg Intelligence
- Predictive Analytics
- Energy Mgt
- Asset Mgt

Mfg Logistics
- Master Scheduling
- Production Scheduling
- PPAP

Mfg Execution
- MES
- Quality, T&A, Safety…
- Efficiencies (OEE)

Svc

Industrial IOT
- Smart Product Analytics
- Product Health Monitoring
- Field Diagnostics

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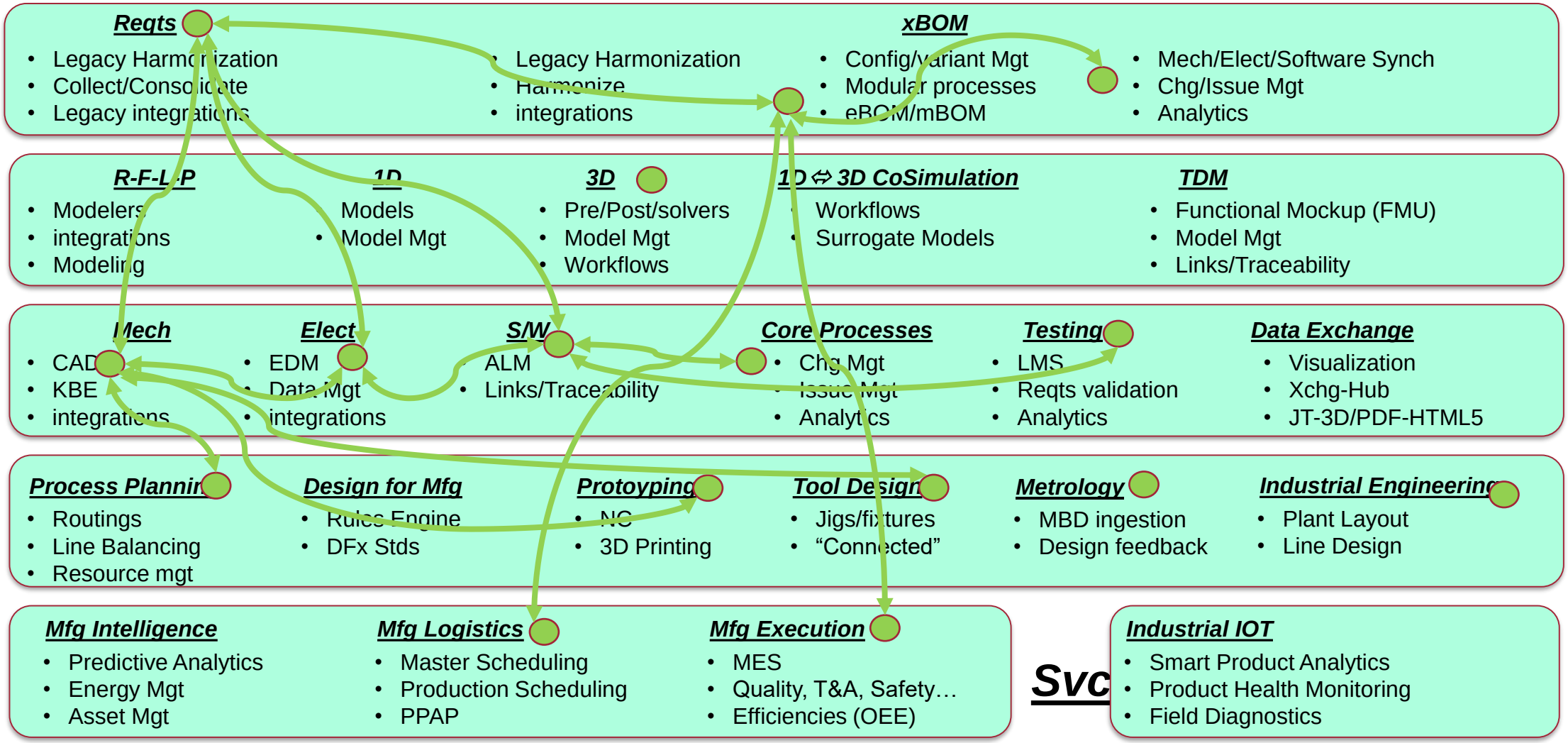
Semantic Integrations (Mappings → with Associativity → Vertically & Horizontally)



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N-Dimensional Mappings (FUNCTIONAL) → with Associativity → Vertically & Horizontally

BoM

Reqts
- Legacy Harmonization
- Collect/Consolidate
- Legacy integration

xBOM

…are Synch

MBSE

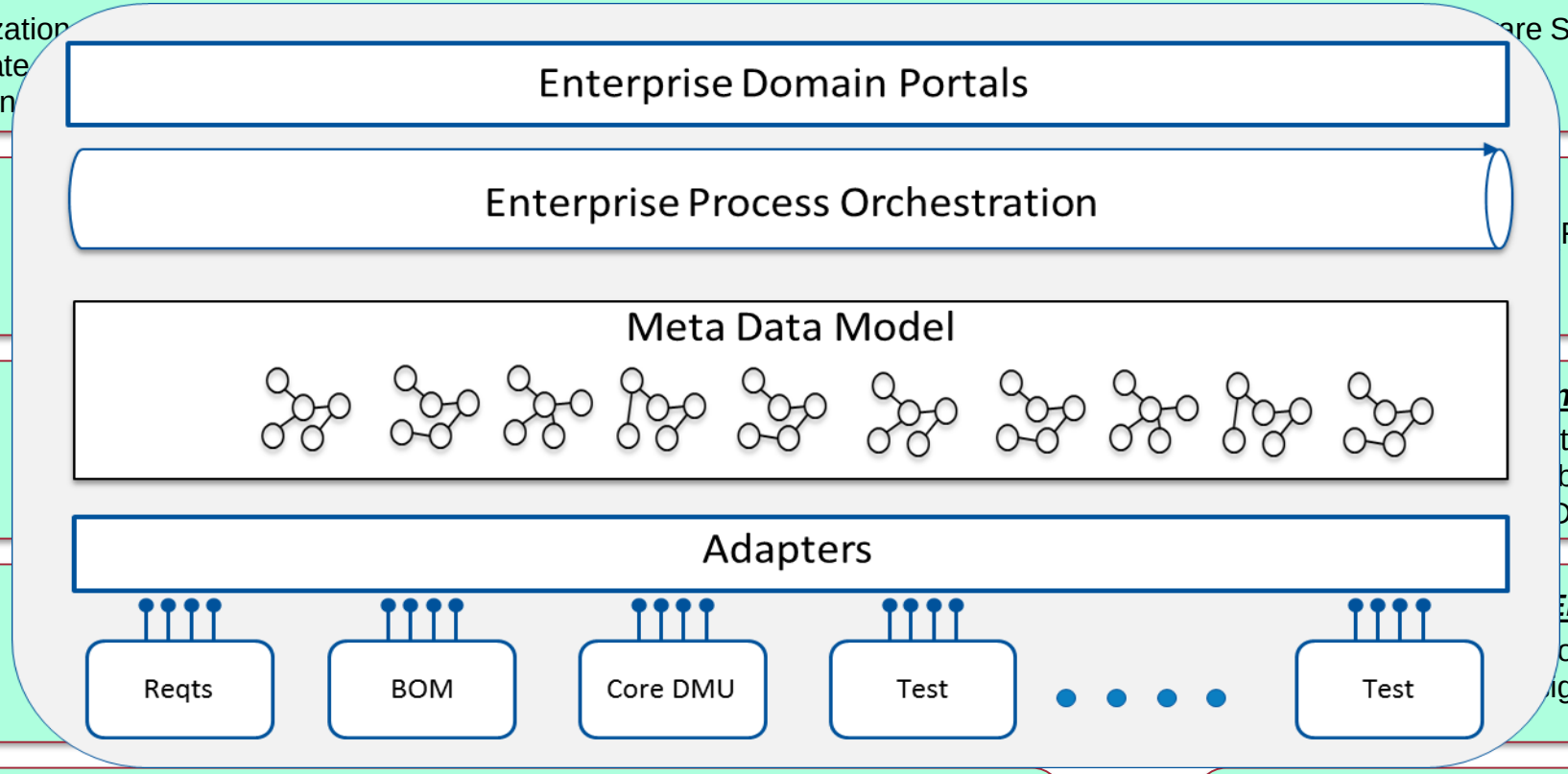
R-F-L-P
- Modelers
- integrations
- Modeling

…FMU)

PDM

Mech
- CAD
- KBE
- integrations

…nge
- …tion
- …b
- …DF-HTML5



Digital Mfg

Process Planning
- Routings
- Line Balancing
- Resource mgt

…Engineering
- …out
- …ign

Mfg

Mfg Intelligence
- Predictive Analytics
- Energy Mgt
- Asset Mgt

Mfg Logistics
- Master Scheduling
- Production Scheduling
- PPAP

Mfg Execution
- MES
- Quality, T&A, Safety…
- Efficiencies (OEE)

Svc

Industrial IOT
- Smart Product Analytics
- Product Health Monitoring
- Field Diagnostics

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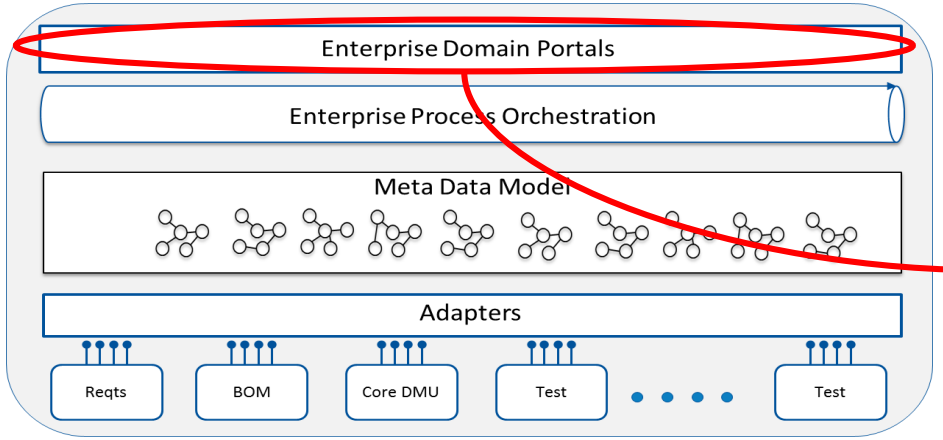
Digital Thread: Template UI & Process (Define)



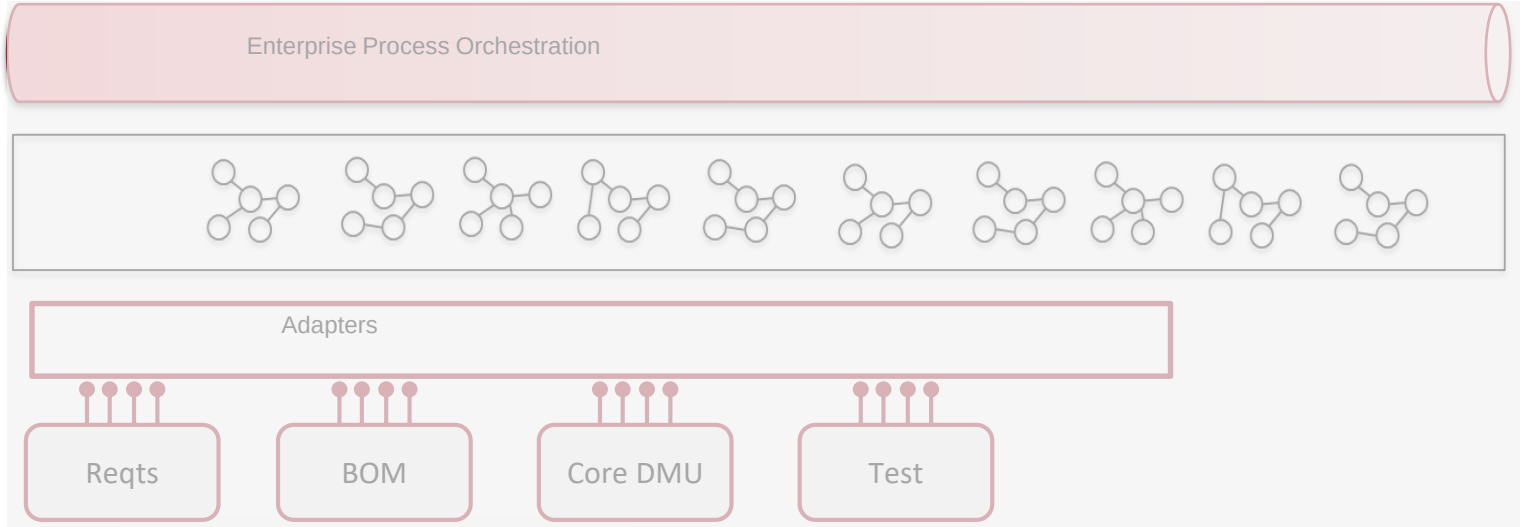
Process Template

```
<Actions>
<Query> object="part, *123*", result= out1
<Save> output = out1
<Query> object="dwg, *123*", result= out2
<Join> object="out1,out2", result= out3
<Sort> object="out3"
<Save> output= "out3"
<GoTo> Template="UI1"
```

UI Template

```
Template = UI1
<Display>
<GET> input="out3"
<Show> UI Widget= "list", out3
```

Enterprise Portal



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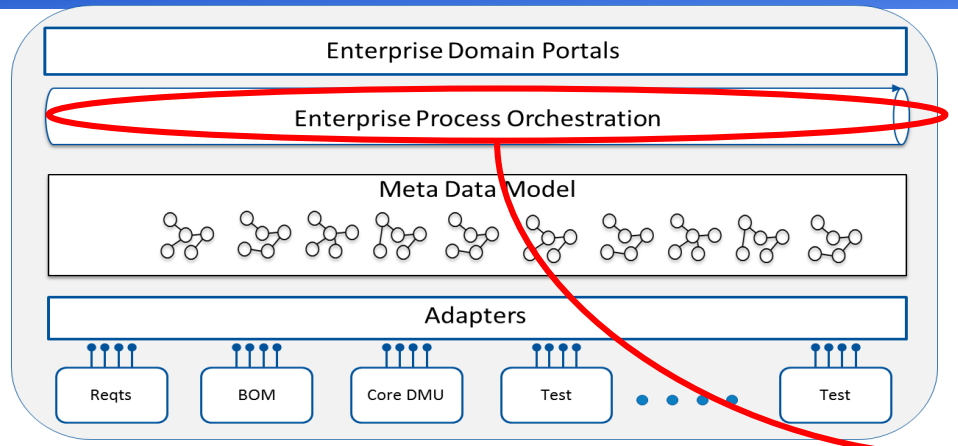
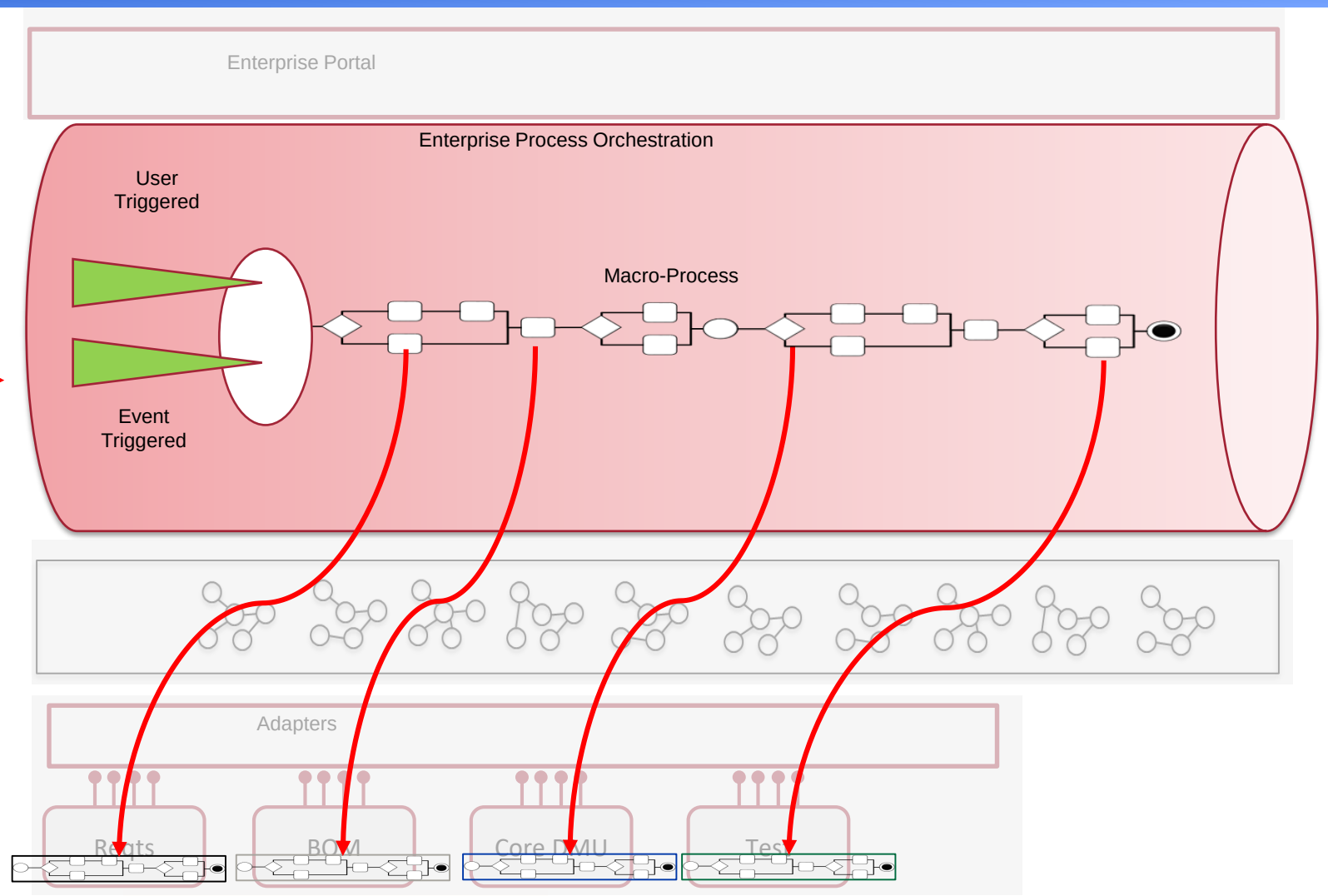
Digital Thread: Process Orchestration (Define)





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Digital Thread: Meta Data Model (Define)

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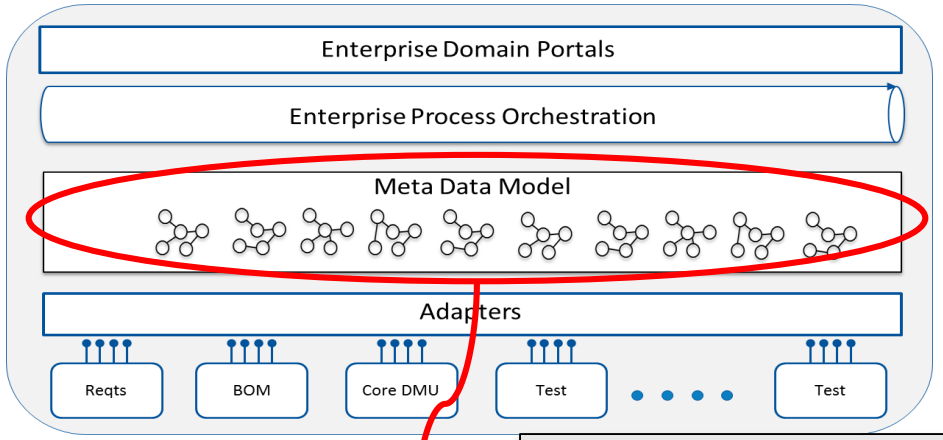
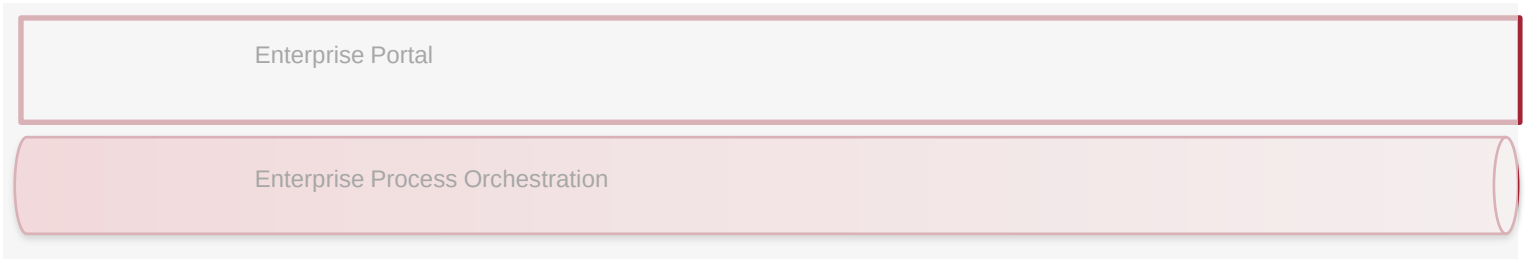
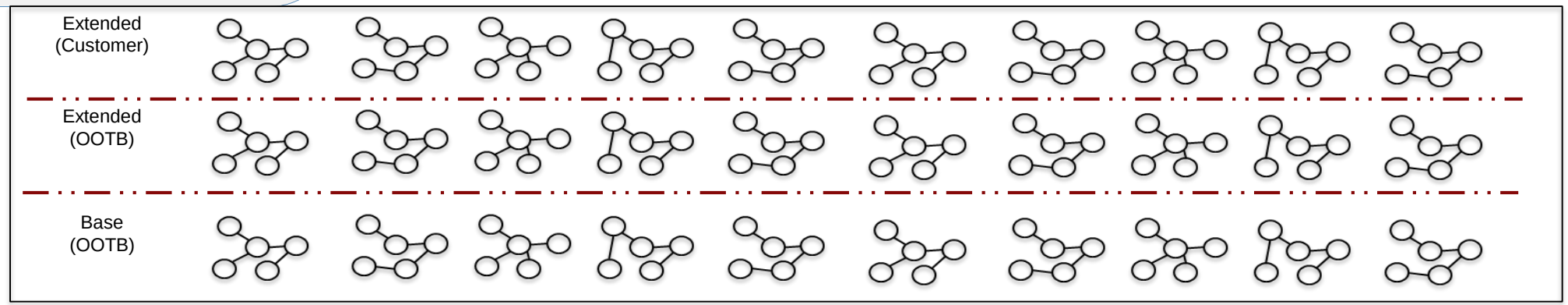
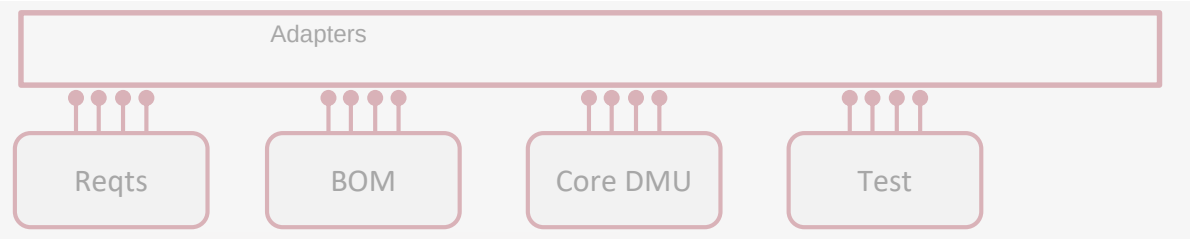


Meta Data Model







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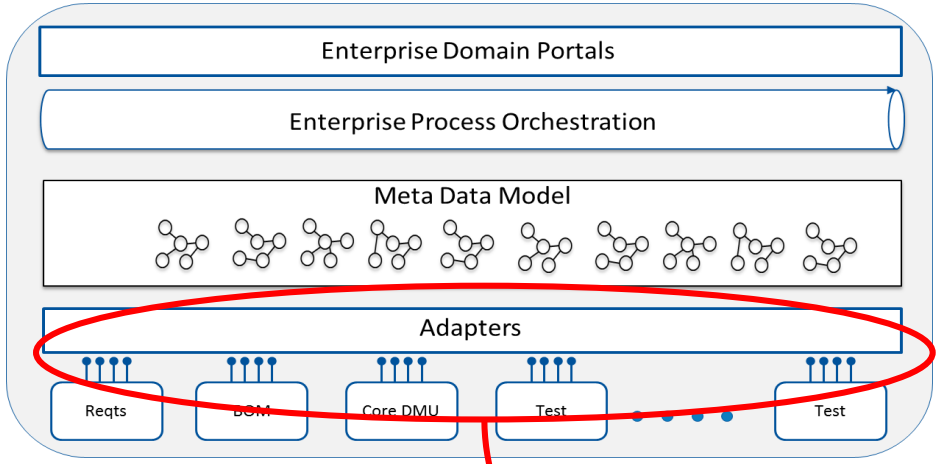
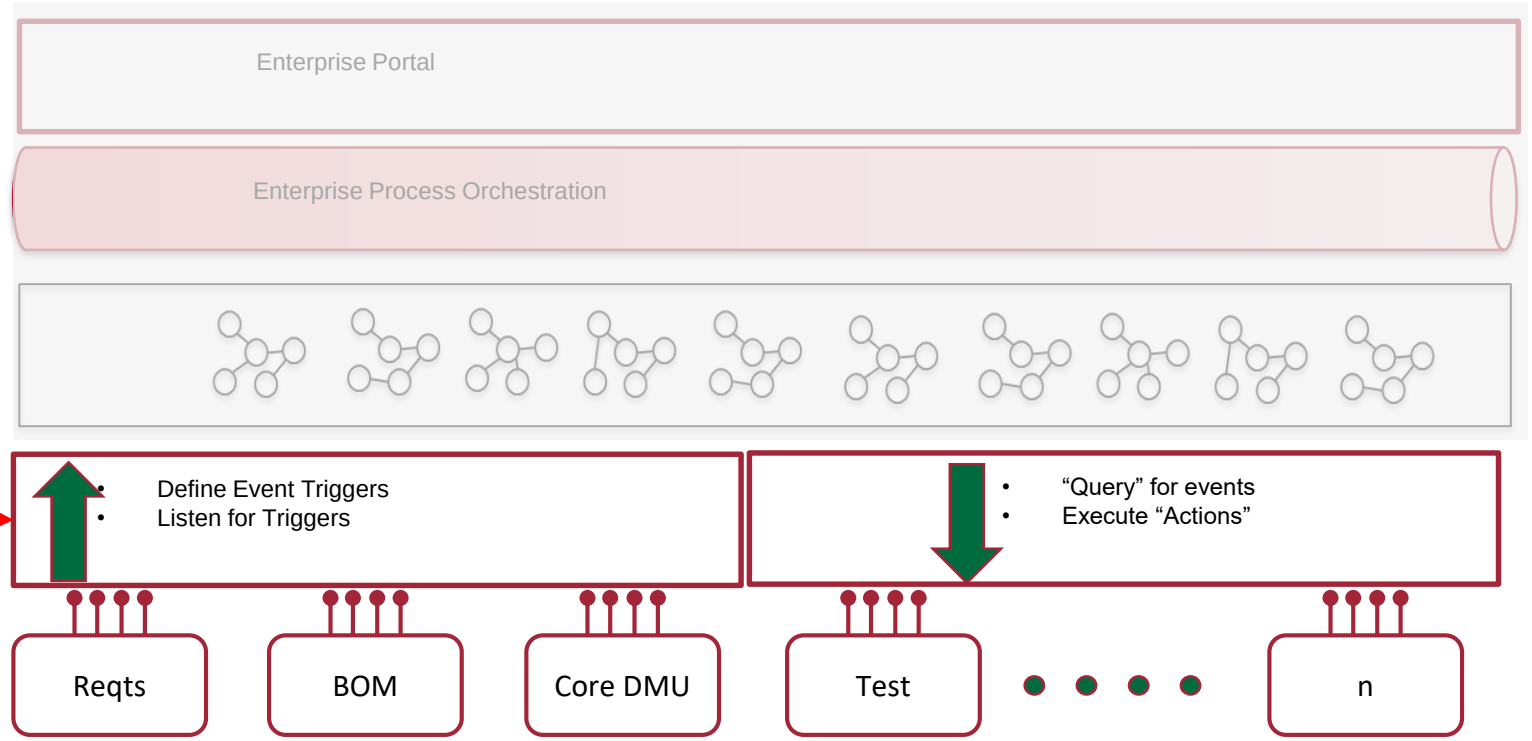
Digital Thread: Application Adapters (Define)





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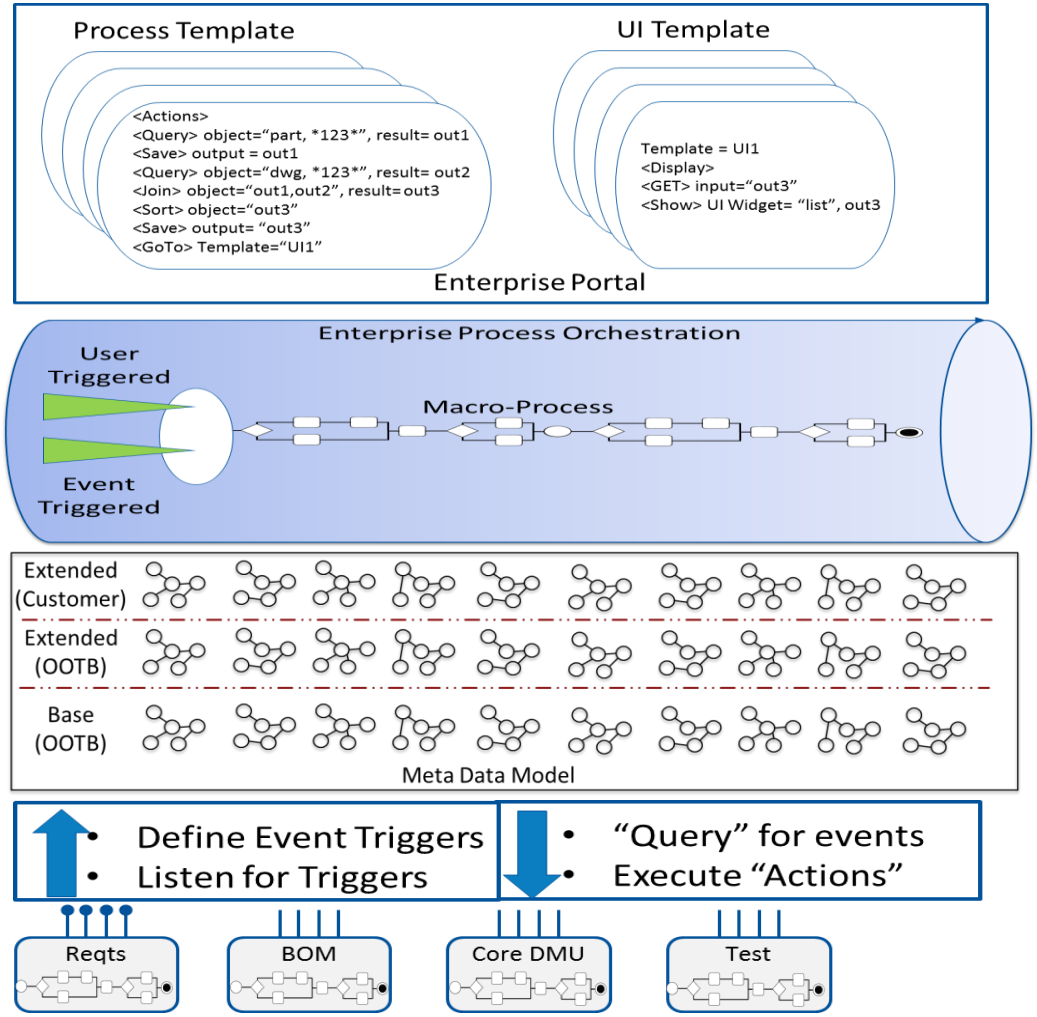
Digital Thread: Level 2 Spec



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The transformation to Maximize Value – Minimize Disruption

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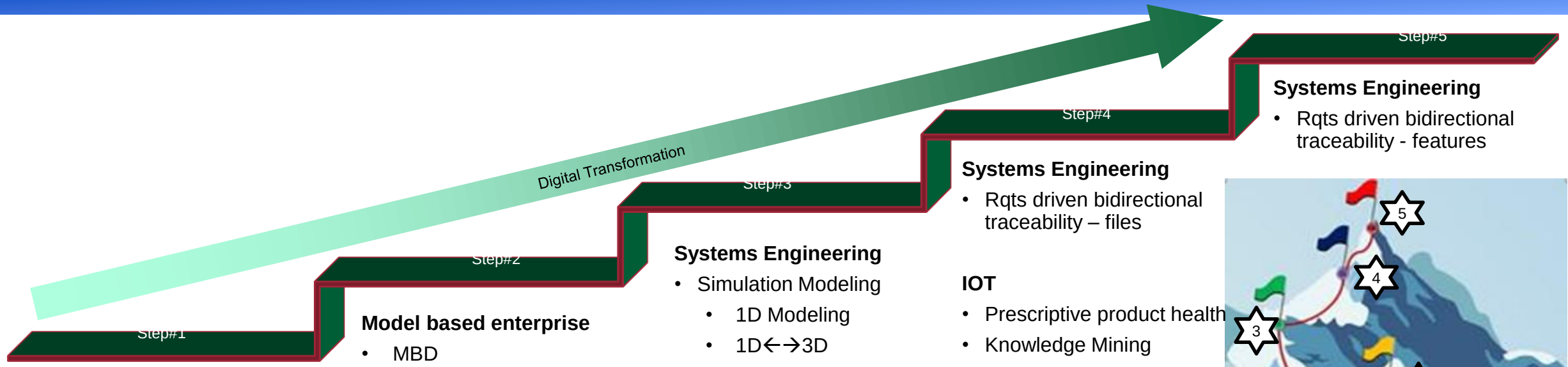

Maturity Baselining
- Systems
- Processes
- Interoperability

Supply chain collaboration
- Visibility
- Traceability

Design for manufacturing

Model based enterprise
- MBD
- TDP
- MPM

Systems Engineering
- RFLP Modeling

IIOT/IOT
- Product health monitoring
- Asset monitoring
- Energy & utility traceability

Systems Engineering
- Simulation Modeling
  - 1D Modeling
  - 1D←→3D
- Simulation Data Mgt.

IOT
- Predictive product health
- Decentralized command & control
- Data Mining

IIOT
- Manufacturing operations intelligence

Systems Engineering
- Rqts driven bidirectional traceability – files

IOT
- Prescriptive product health
- Knowledge Mining

Systems Engineering
- Rqts driven bidirectional traceability - features

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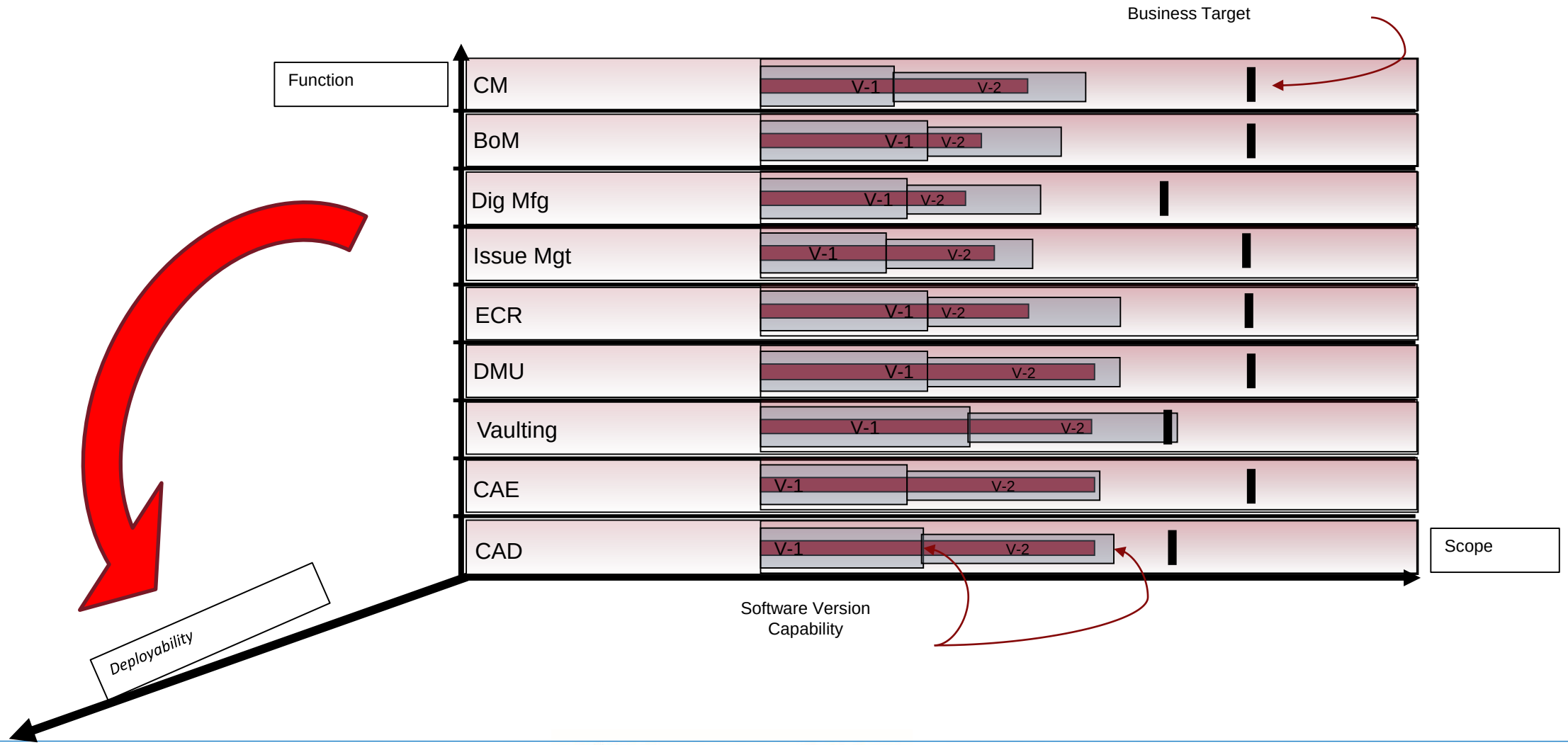
“We Asked For Help”… Software Vendors……



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Thank You

End Of Presentation

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