ENGINEERING AND R&D SERVICES

21ST CENTURY TECHNOLOGIES

Digital Thread Enabled Through Semantic Approach

Presented by:

Louis J Pascarella

Chief Technology Officer, GeometricPLM

HCL Technologies

HCL

Louis Pascarella
Chief Technology Officer, HCL Geometric PLM

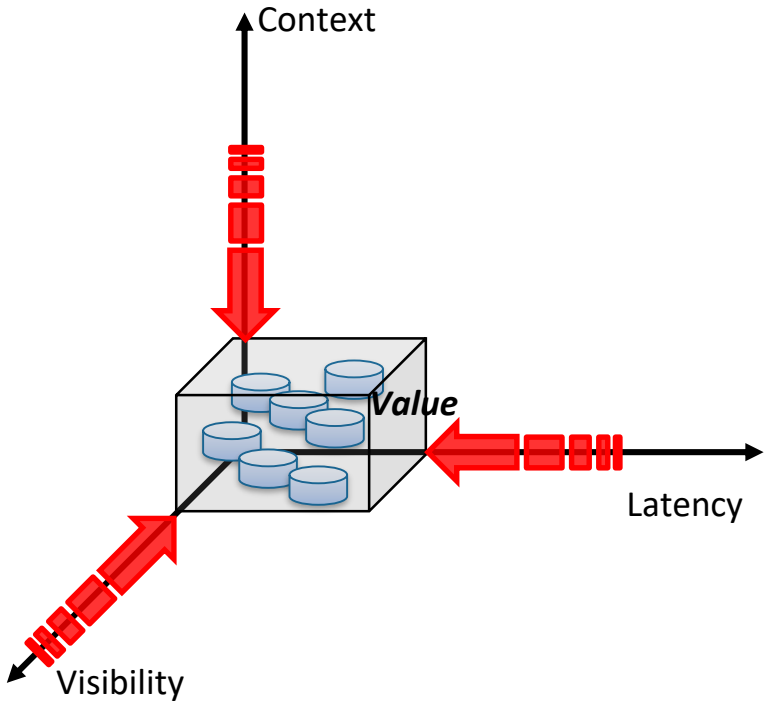
Louis Pascarella is CTO of HCL's Geometric PLM organization focused on Product Creation Methodologies, Product Lifecycle Management and Digitalization of Enterprise Ecosystems, including Digital Thread/Twin enablement.

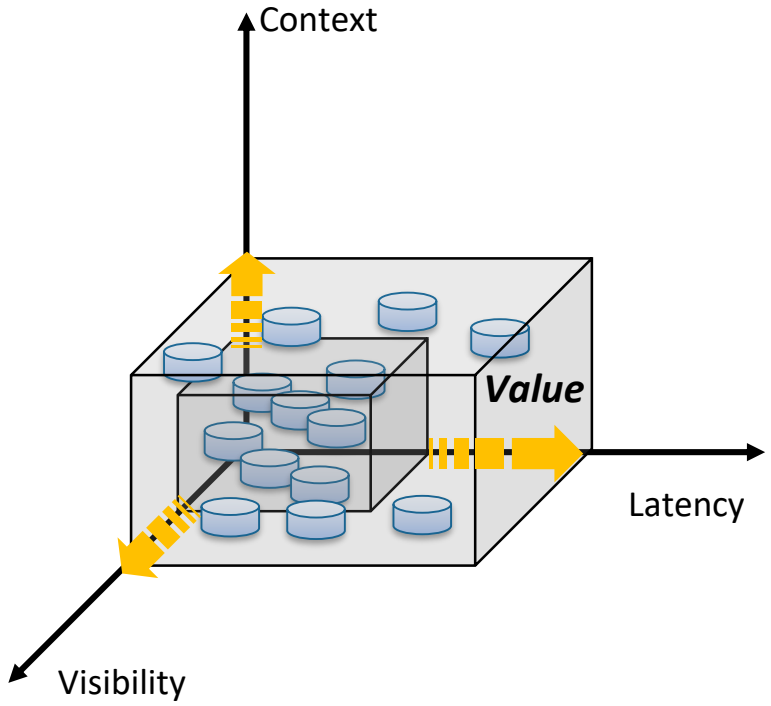
He has been working with global Automotive, Aerospace and Software Vendors for over 35 years in the areas of Visualizat
Software Lifecycle Management with a focus on strategy, planning, consulting, systems engineering, and knowledge capture & ma

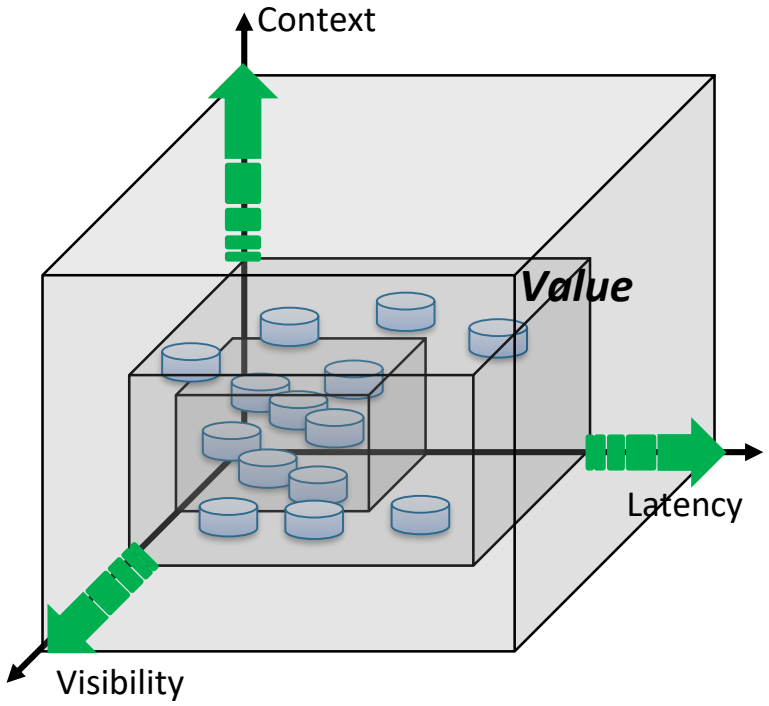
Mr. Pascarella has a leadership background (CTO, VP R&D) in PLM & Manufacturing technology development and implemen
Windchill, & ENOVIA), solution architecture, enterprise middleware technologies (EAI, SOA), and Industrial Internet of Things (IIOT

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

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

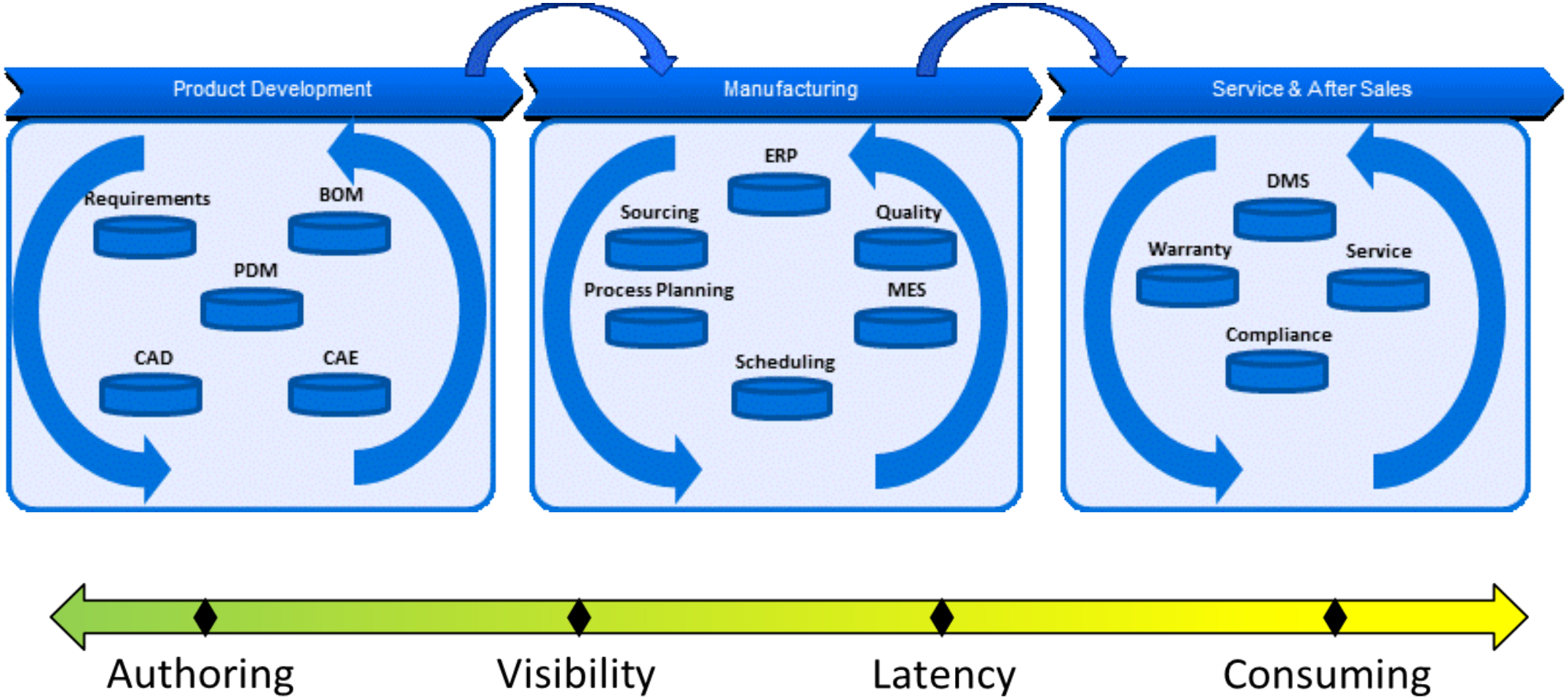
Enable Data Consumption

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

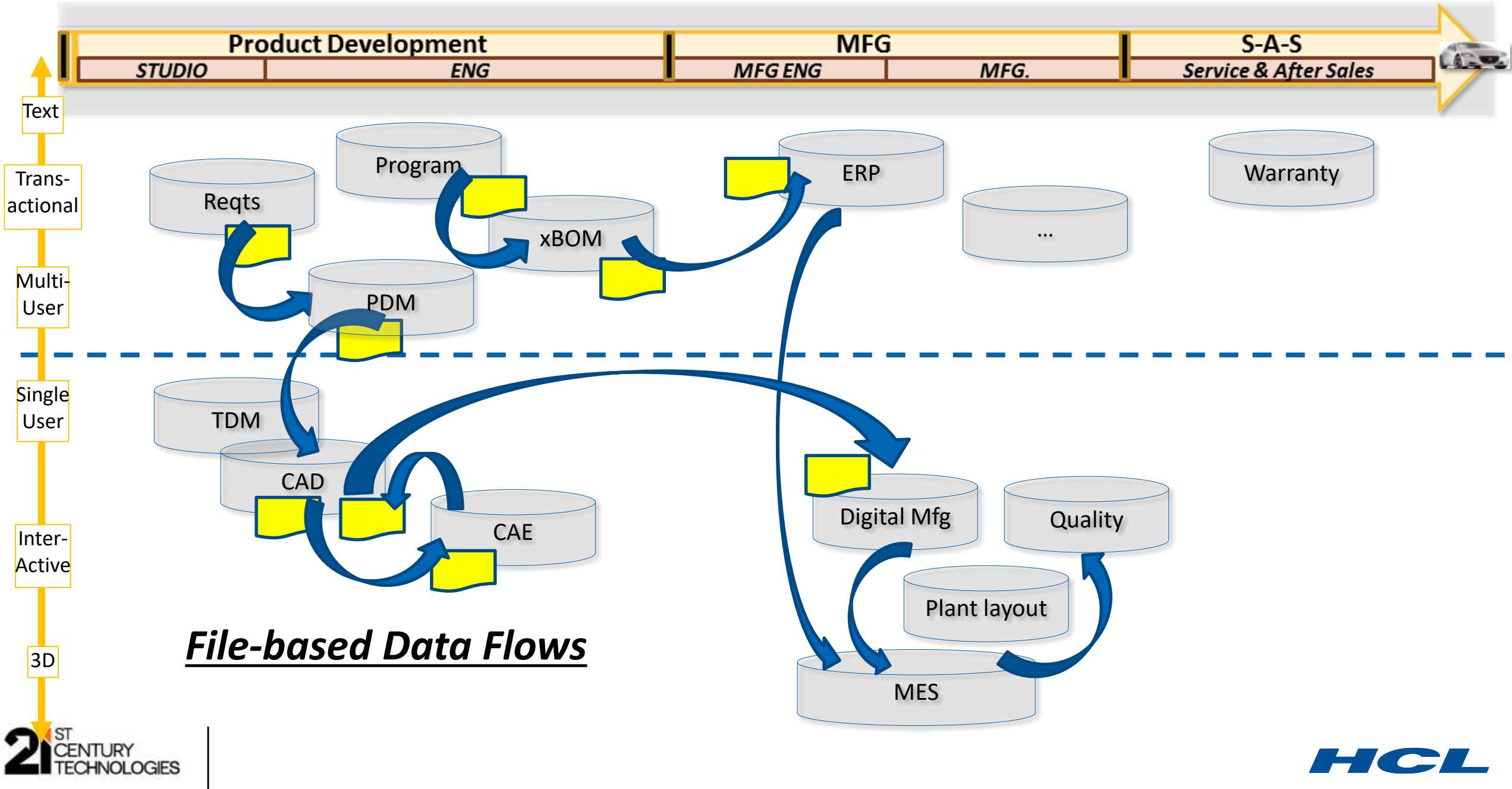
Data → Information → Knowledge

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

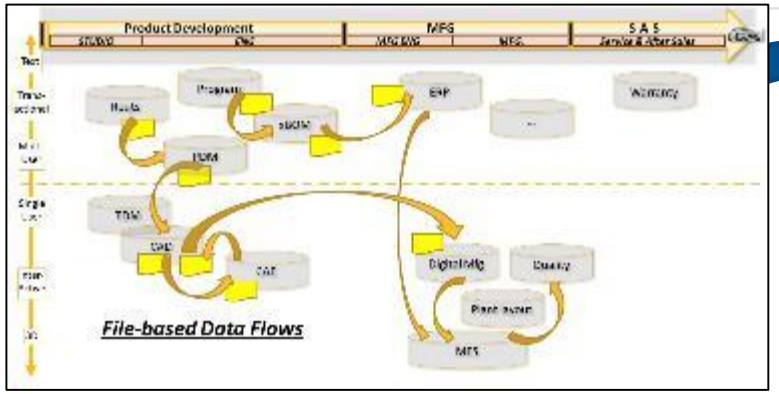
What We Built ➔ An Application Footprint Focused on Authoring…

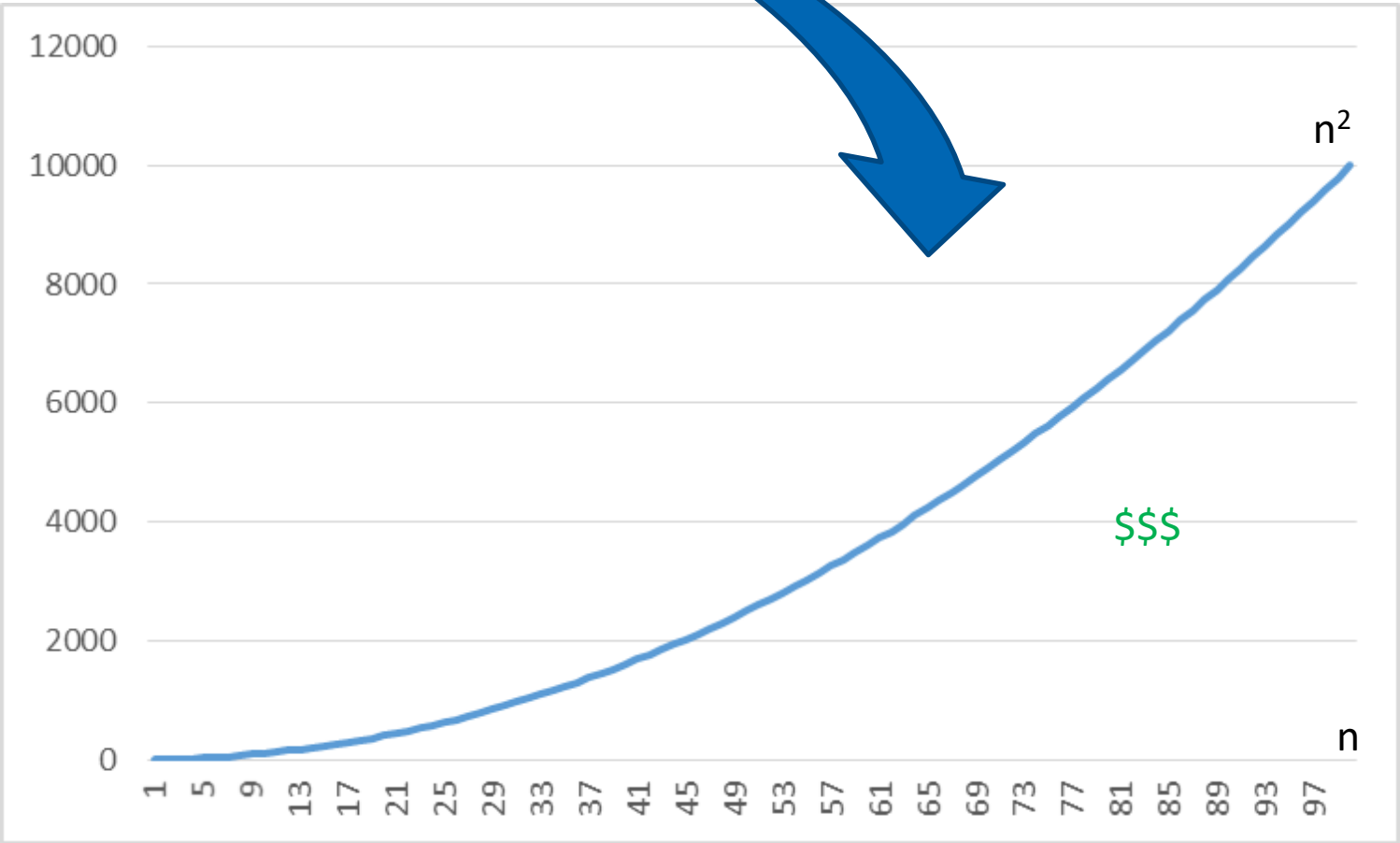


But We Tried to "Consume"… and Built Semantic based Point-Point Integratiions

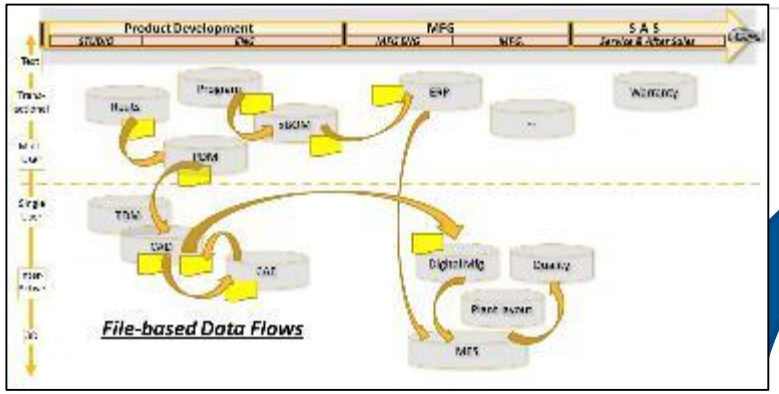


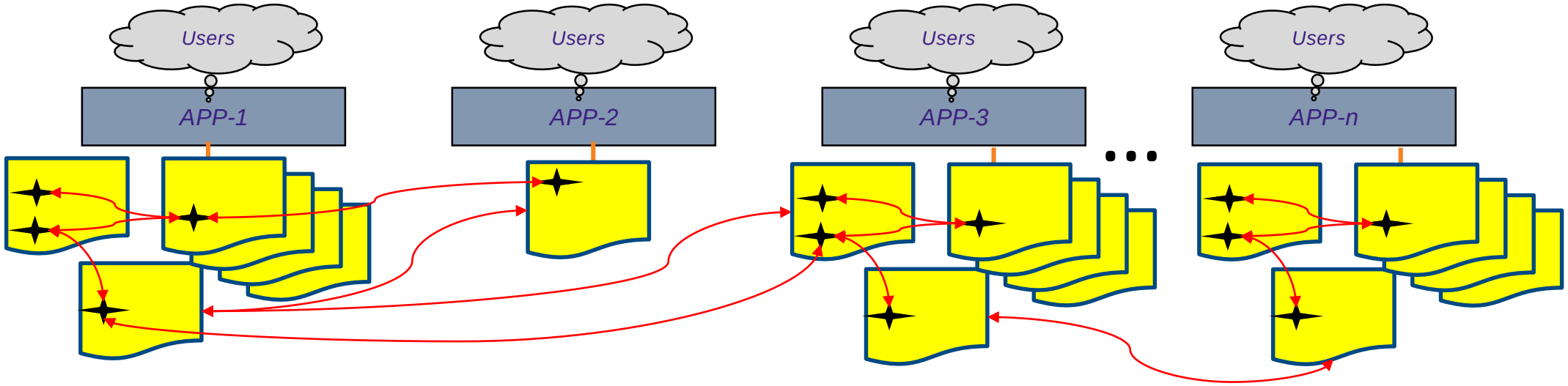
And Hit a Wall…. File-Based Links Scalability Barrier





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



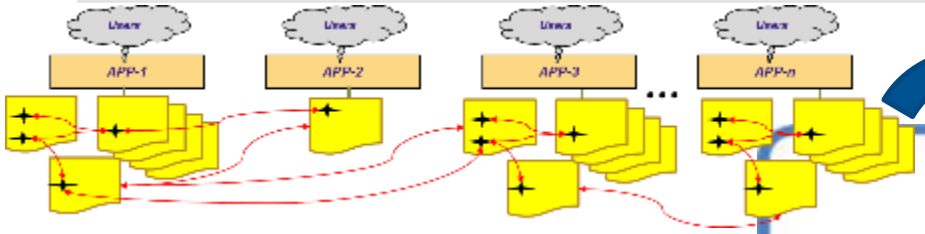


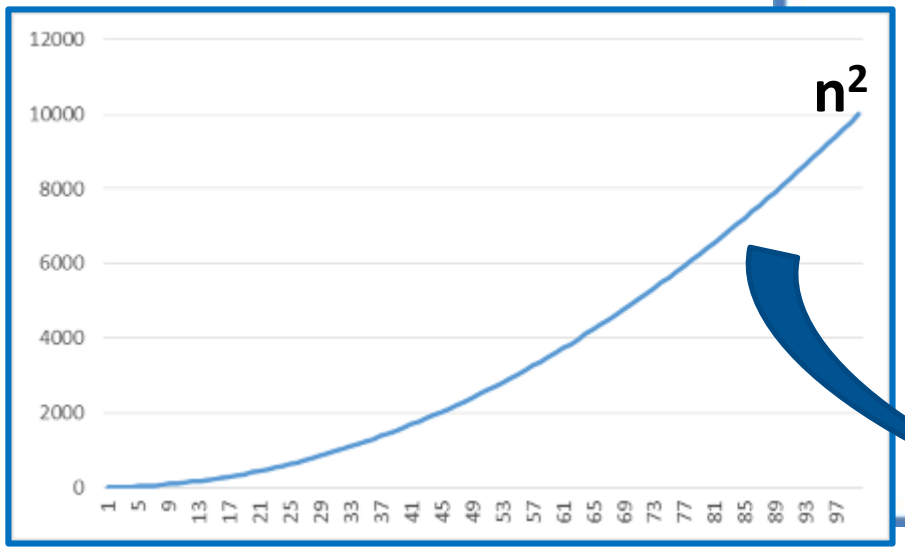
Links

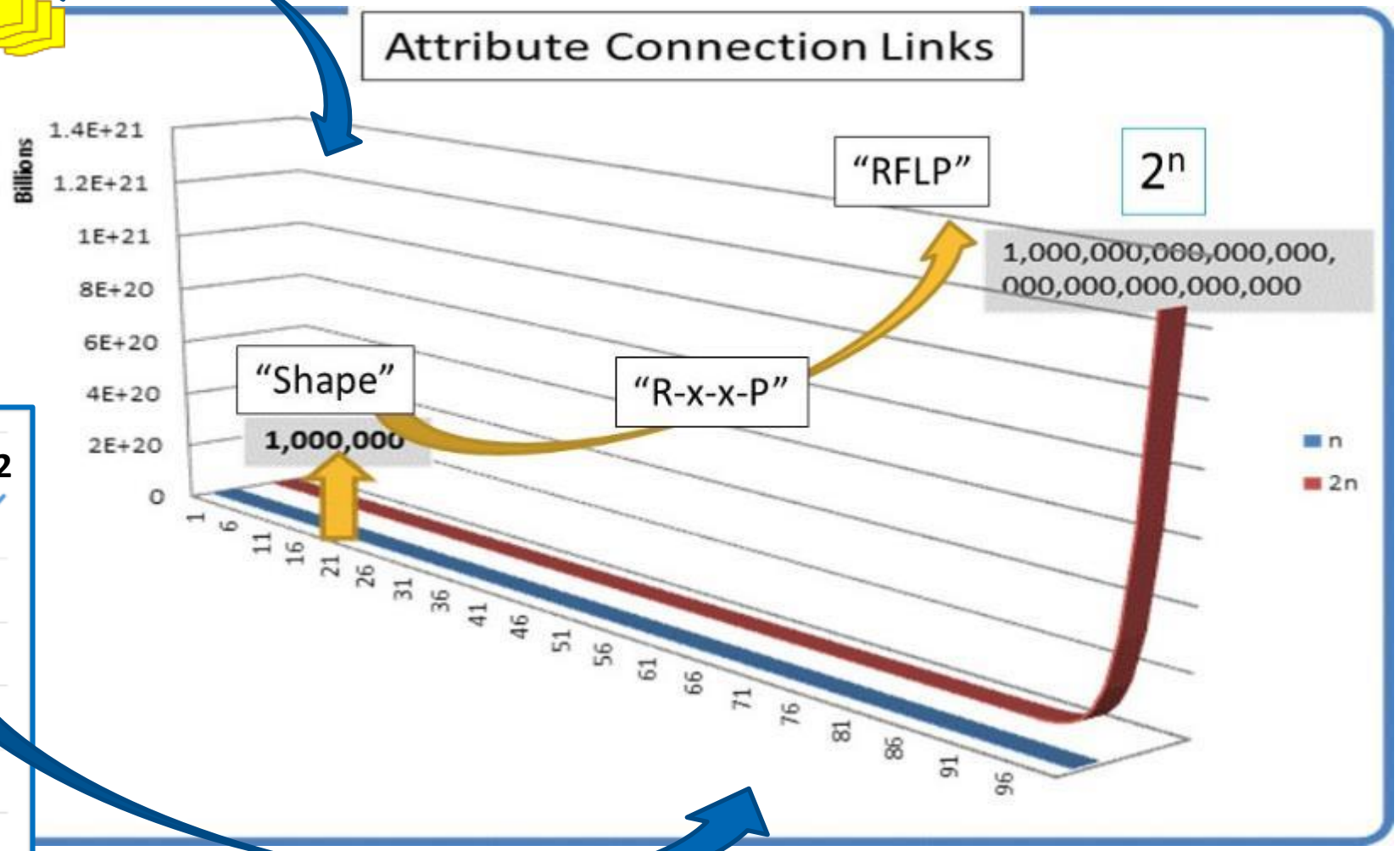
21ST CENTURY TECHNOLOGIES

HCL

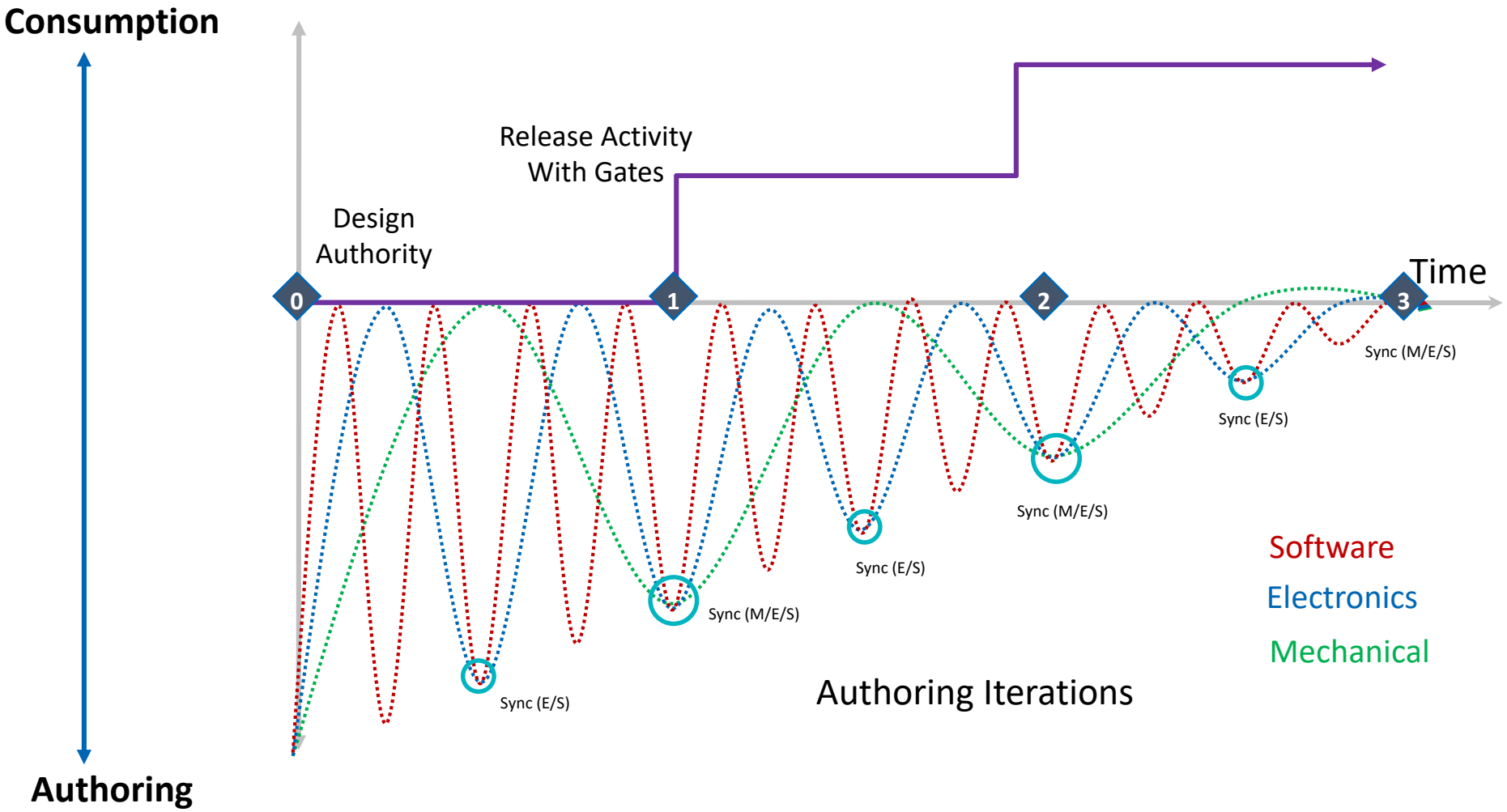
And Now the Wall is Higher!!!! *Attribute Linkage & Traceability Scalability Barriers*







Product Complexity - Authoring & Consumption



Consumption

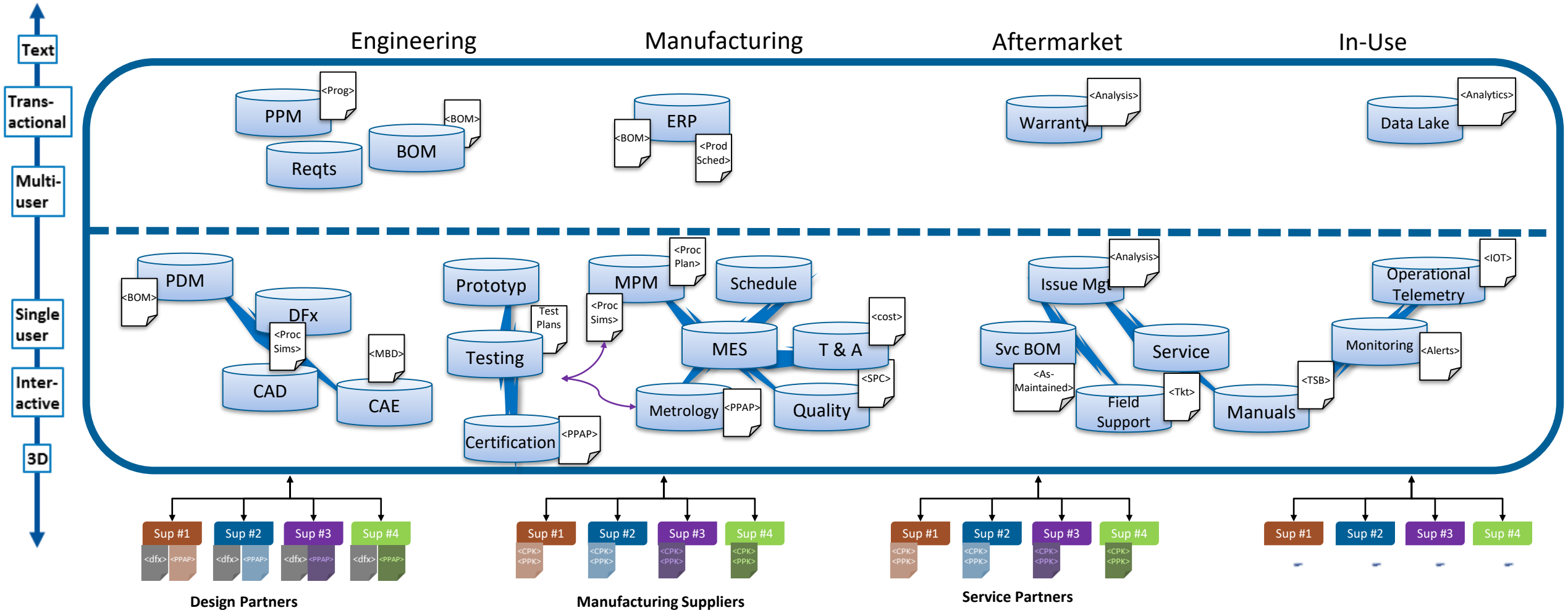
- Bills of Material (BOMs)
- Configuration Management
- Release Management
- Change Management
- Project Management
- Product & Portfolio Mgmt
- Cost, Compliance & Quality

Authoring

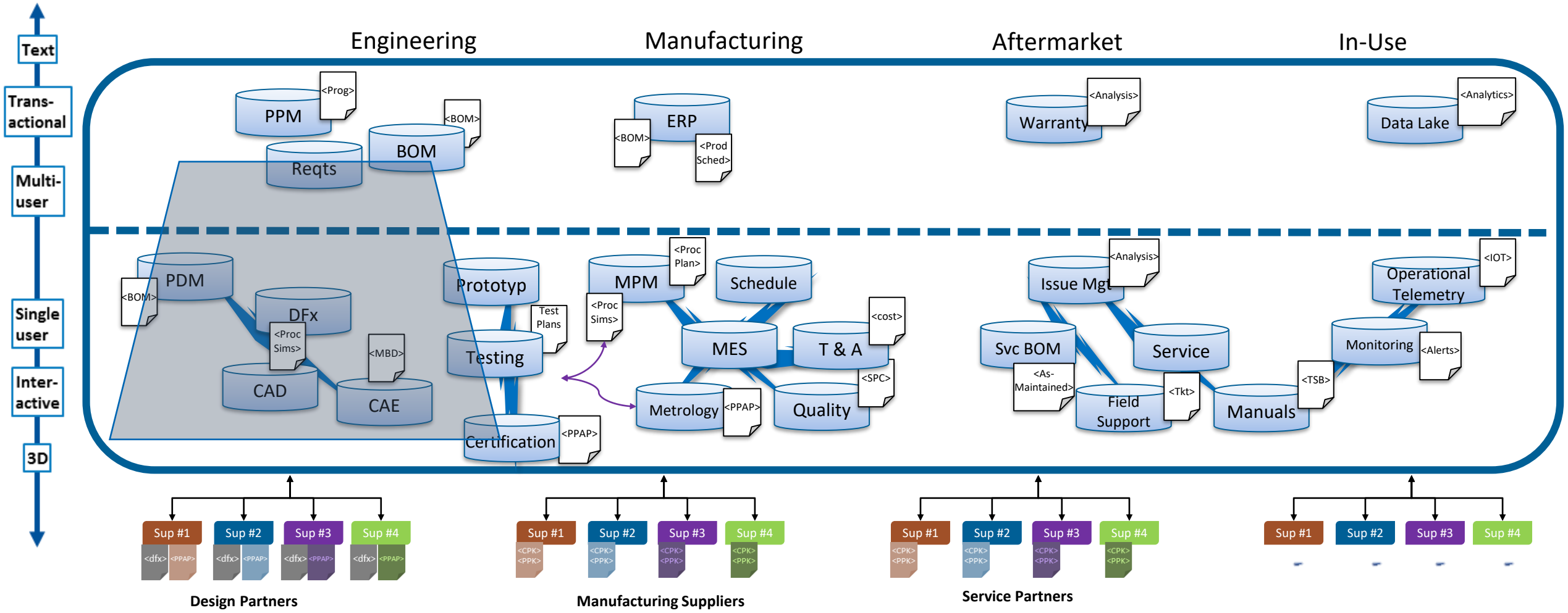
- User Workspaces
- Team Collaboration
- Integration
- Simulation
- Verification & Validation
- Supplier Collaboration

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.

Corporate Ecosystem Application Footprint → Macro Semantic view



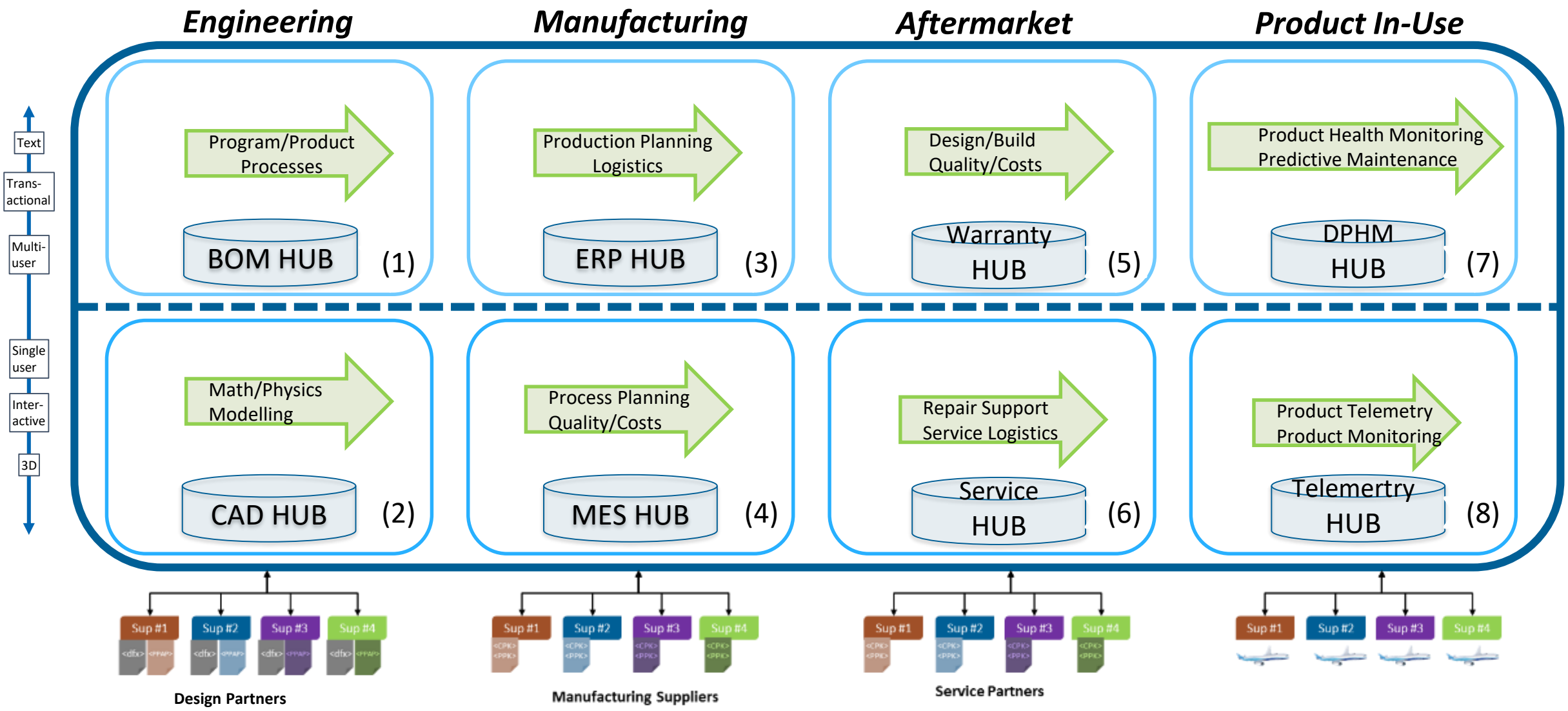
Corporate Ecosystem Application Footprint → Macro Semantic view



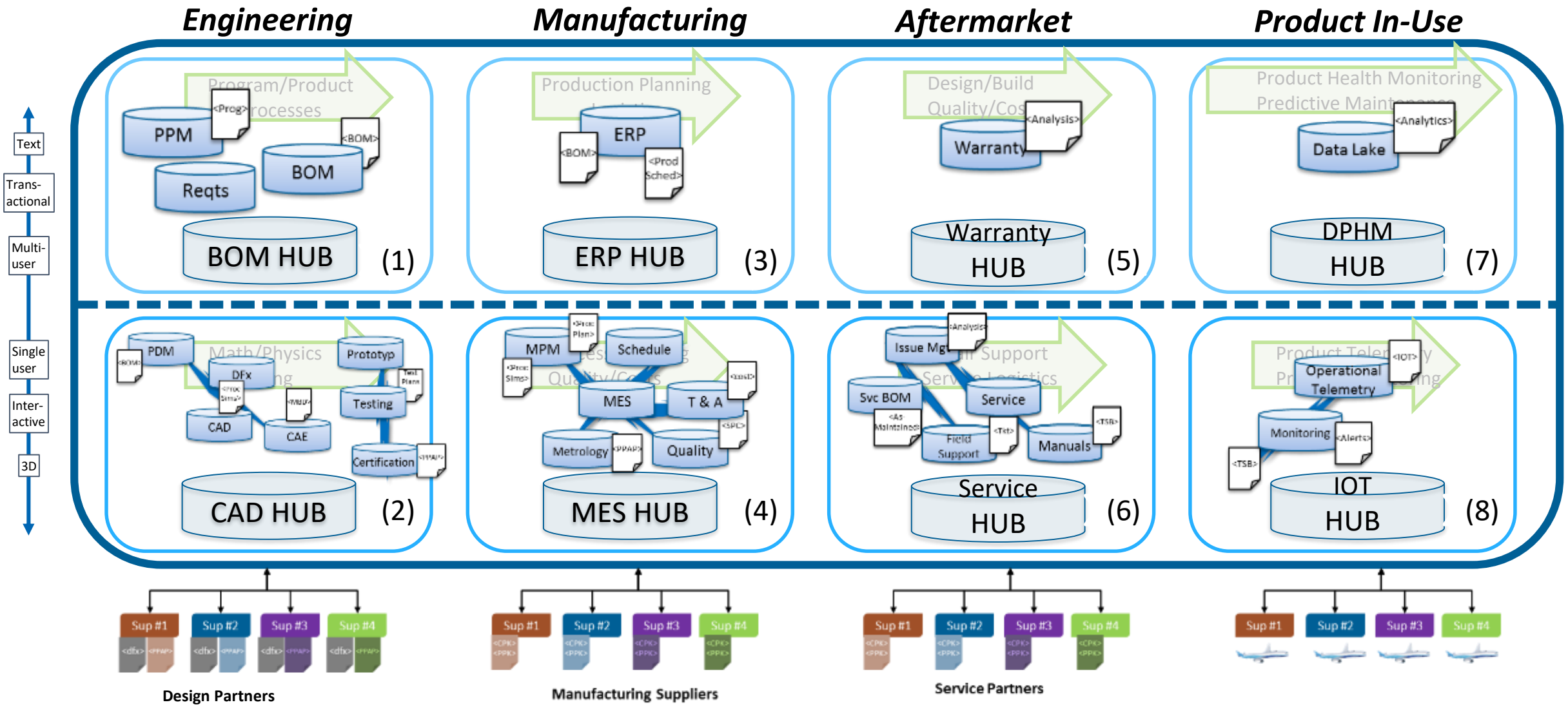
21ST CENTURY TECHNOLOGIES

HCL

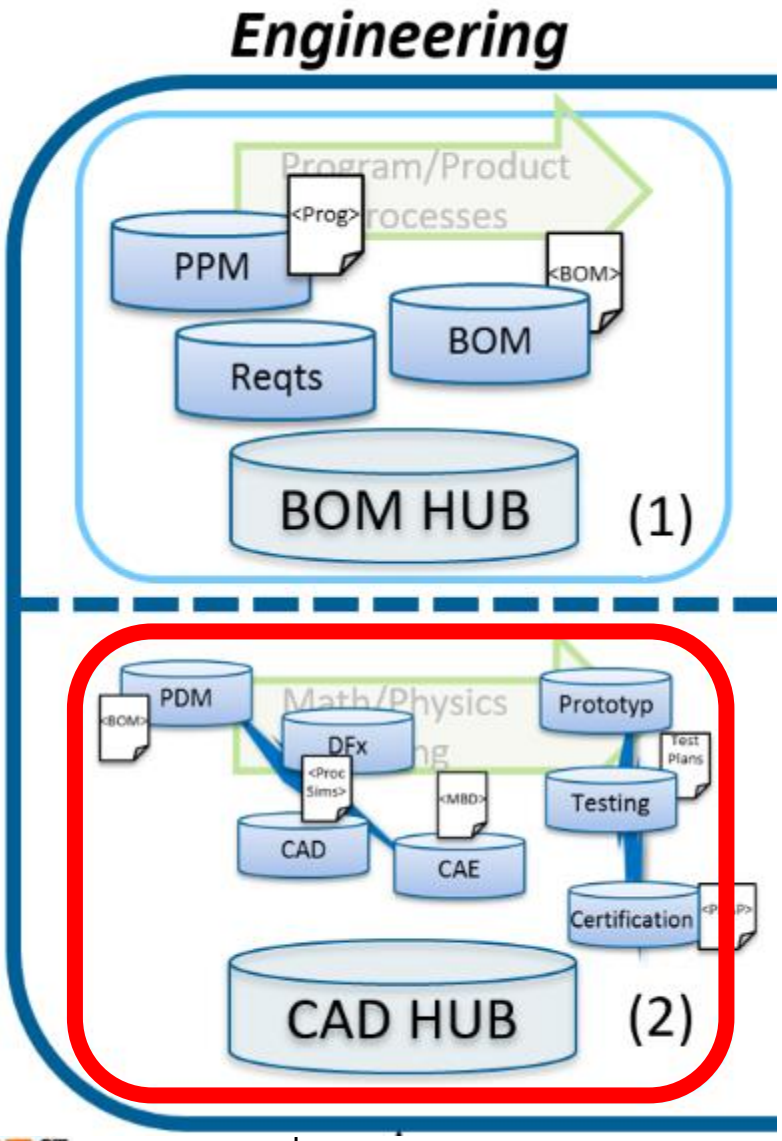
Corporate Ecosystem application footprint → Micro Semantic view



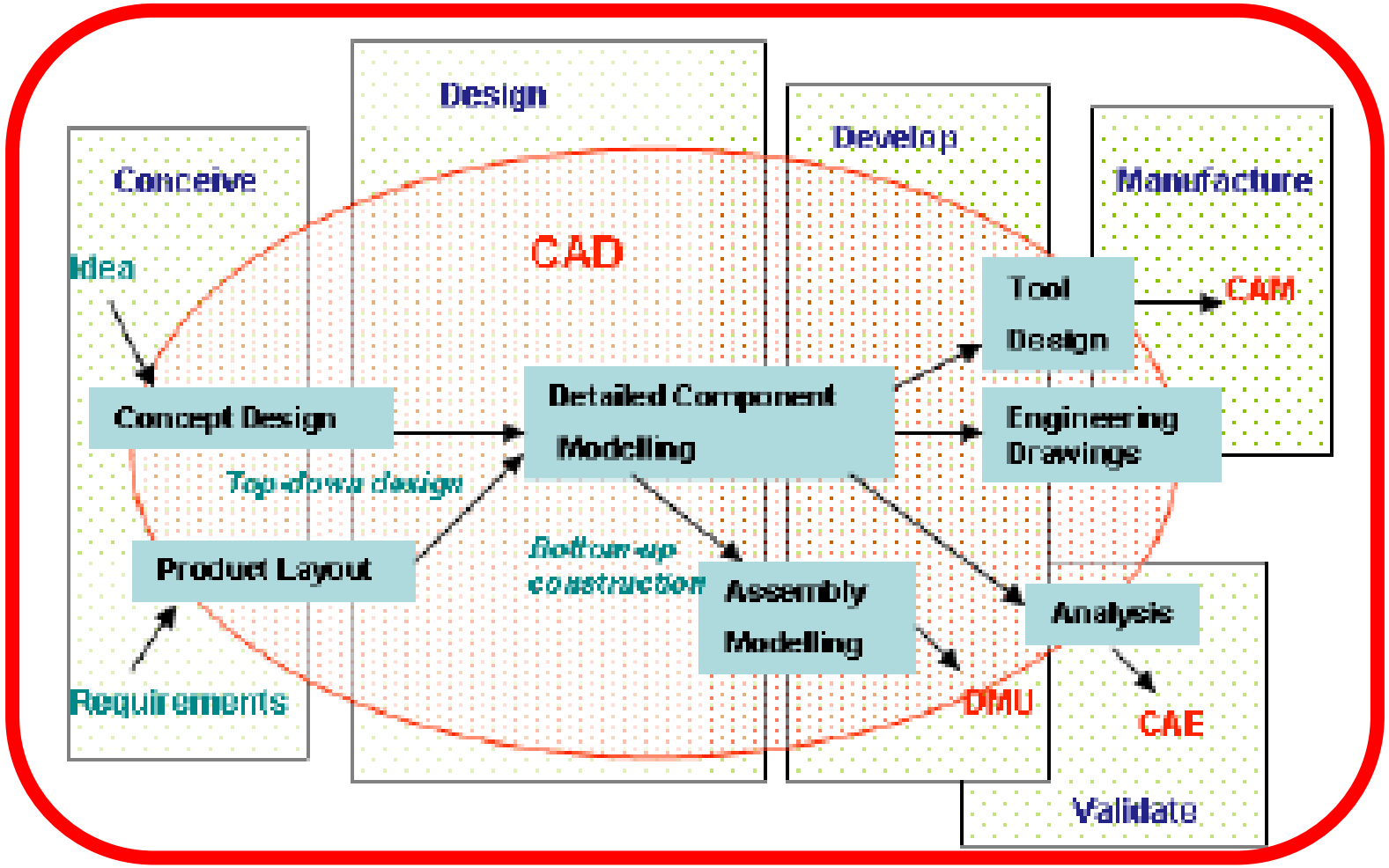
Corporate Ecosystem application footprint → Micro Semantic view



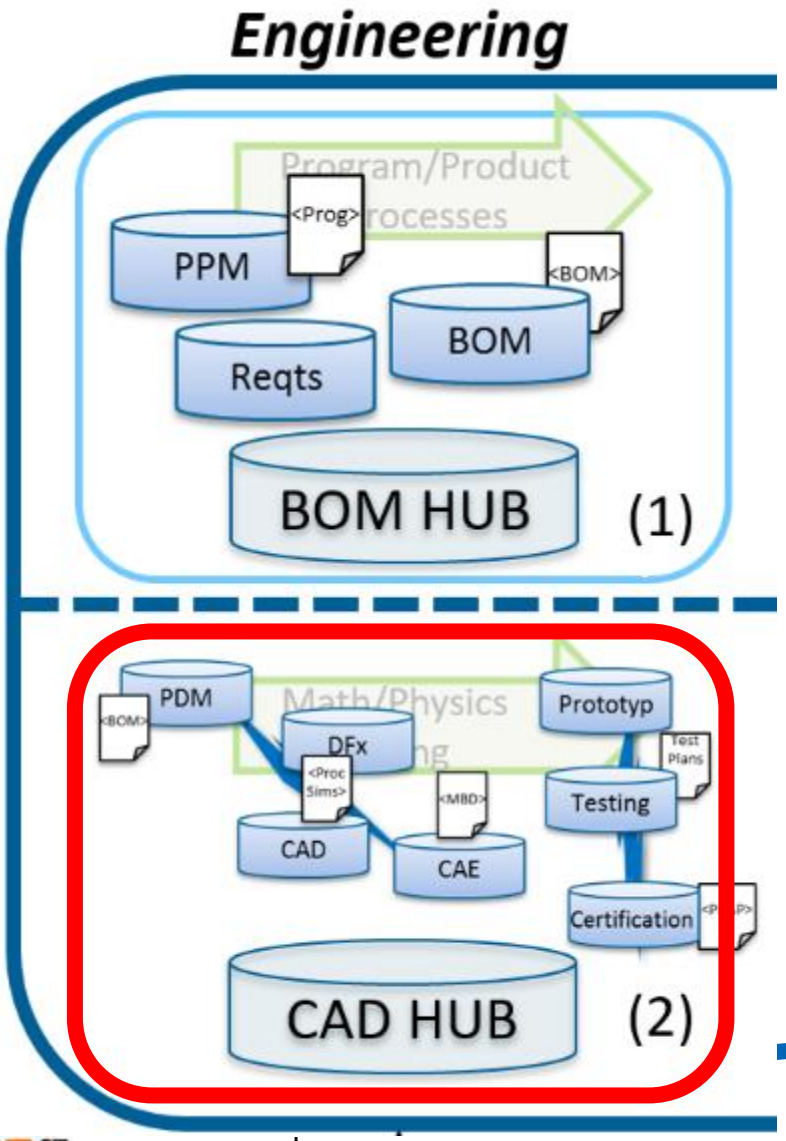
What is Inside the CAD Hub…..



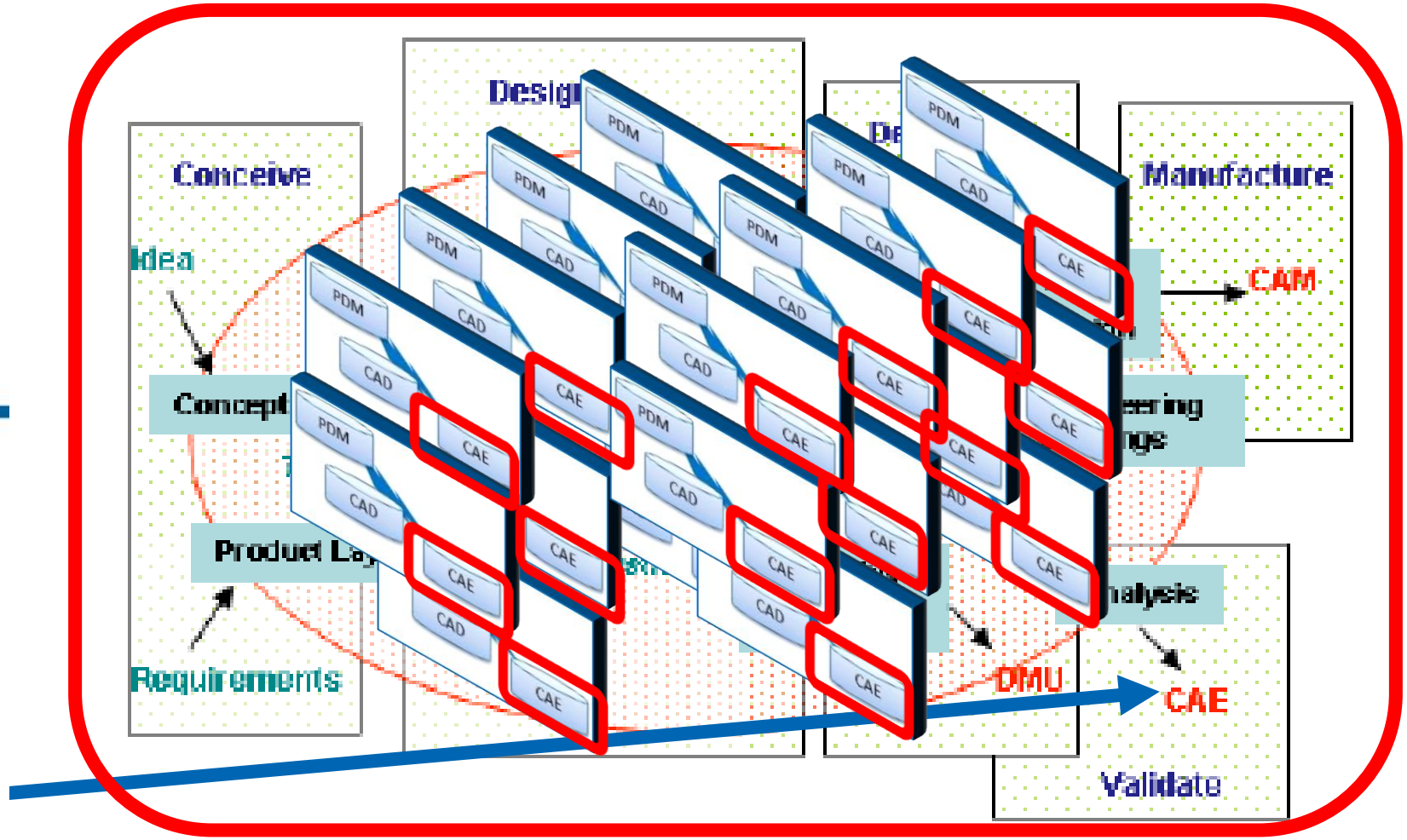
Formalized Process….



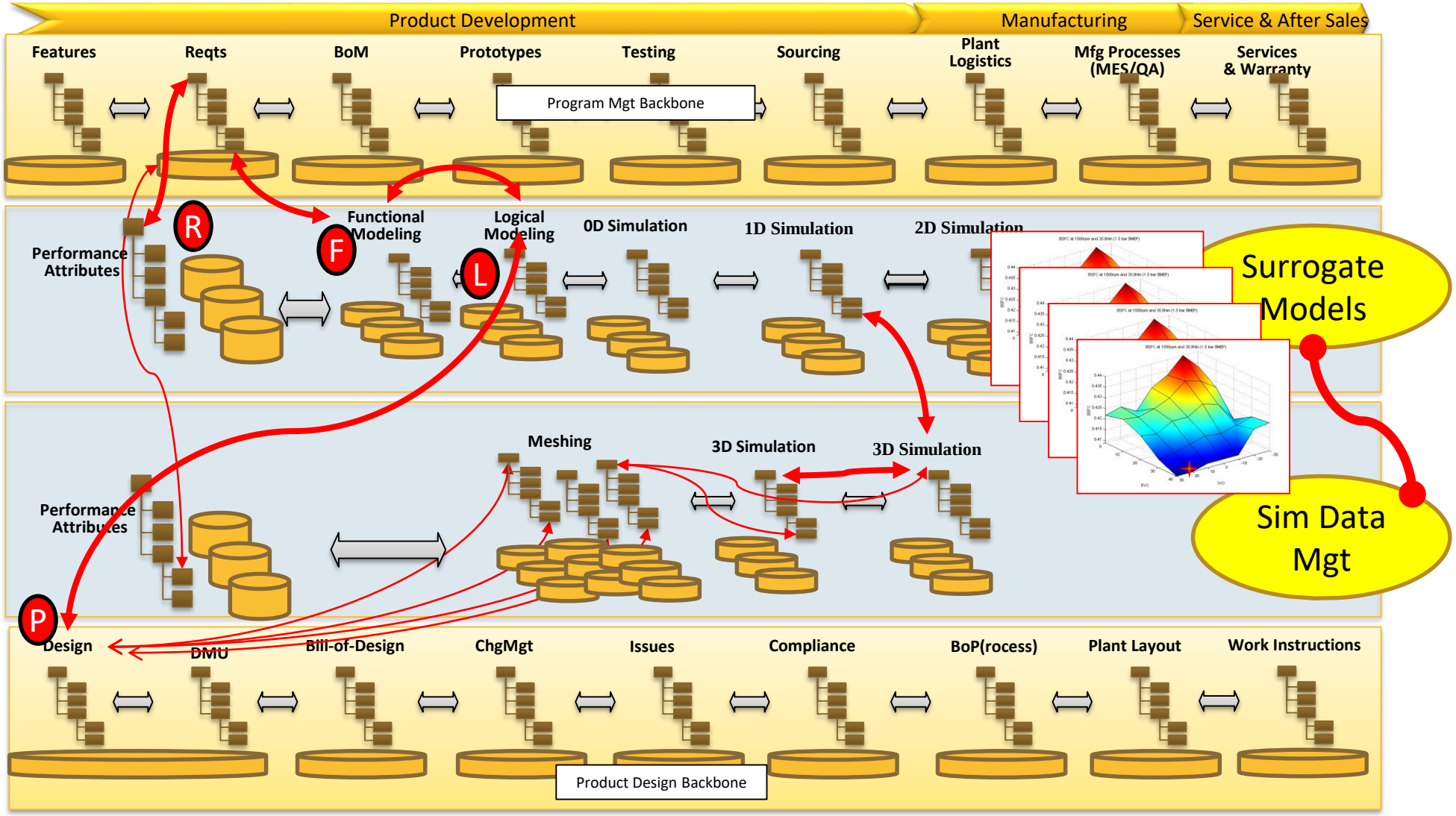
What is “REALLY” Inside the CAD Hub…..



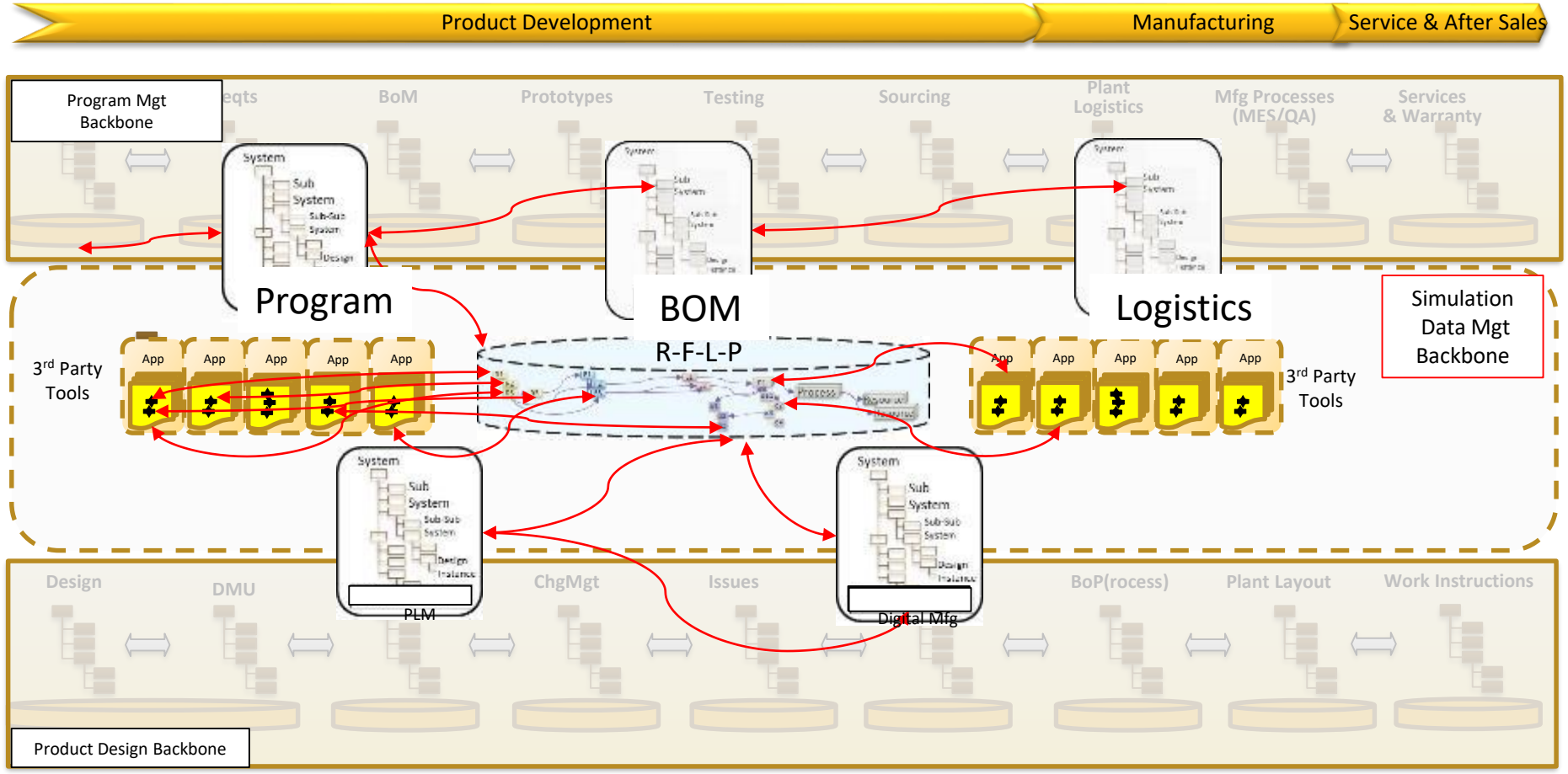
Ad Hoc Process….



The need to mange a Formalized Simulation Backbone….



And…. must manage massive heterogeneity



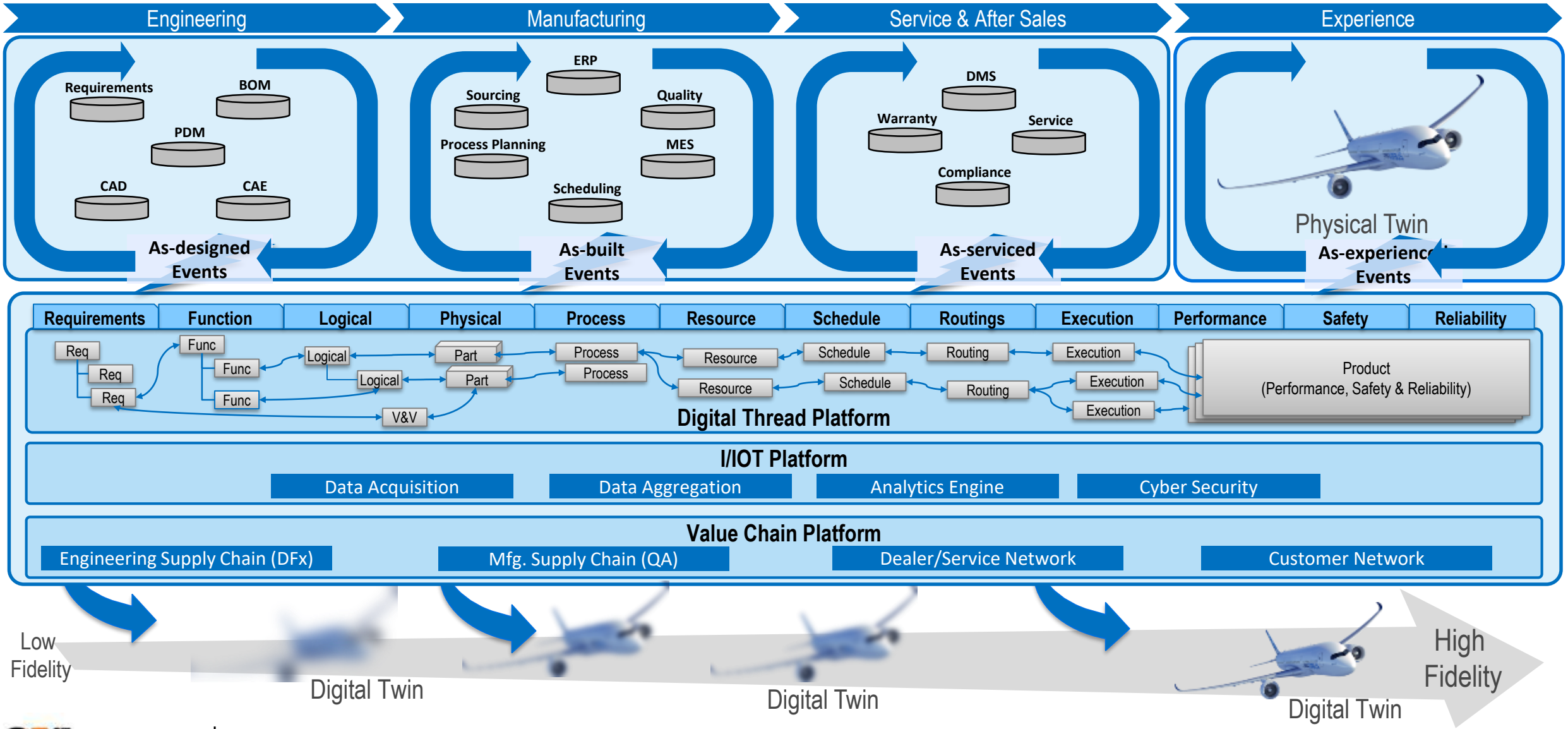
Fueled by Linked Data & Semantics

A PATH FORWARD…..

21ST CENTURY TECHNOLOGIES

HCL

Enabling the Model Based Enterprise



21ST CENTURY TECHNOLOGIES

HCL

Digital Thread Consumption……..

Predictive Models

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

Big Data

Context

RCA

Trends/Patterns

Rules/Stds

Big Data

Operations

Engineering | Manufacturing | Service & After Sales | Experience

Requirements, BOM, PDM, CAD, CAE, As designed Events

ERP, Sourcing, Process Planning, Quality, MRS, Scheduling, As-built Events

DMS, Warranty, Service, Compliance, As-serviced Events

Physical Twin, As-experienced Events

Requirements | Function | Logical | Physical | Process | Resource | Schedule | Routings | Execution | Performance | Safety | Reliability

Product (Performance, Safety & Reliability)

Digital Thread Platform

IIOT Platform

Data Acquisition | Data Aggregation | Analytics Engine | Cyber Security

Value Chain Platform

Engineering Supply Chain (DFx) | Mfg. Supply Chain (QA) | Dealer/Service Network | Customer Network

Low Fidelity — Digital Twin — Digital Twin — Digital Twin — High Fidelity

Eng Hrs: 1000, 5000, 7500, 10000, 15000

Flt#: 63, 132, 218, 2443, 236

Tail#, Tail#, Tail#

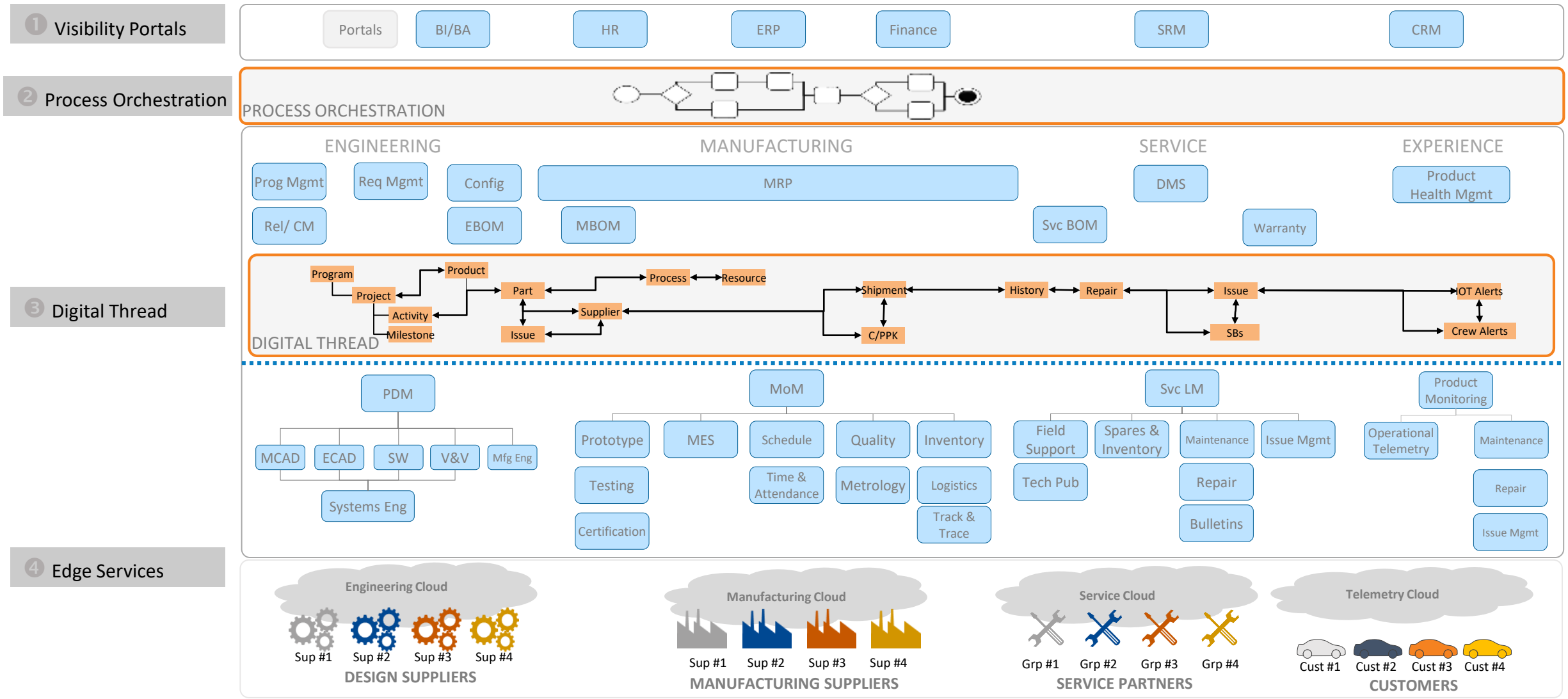
Explanatory Models

- Enabling prescriptive analysis

21ST CENTURY TECHNOLOGIES

HCL

Digital Enterprise : Solution Topology

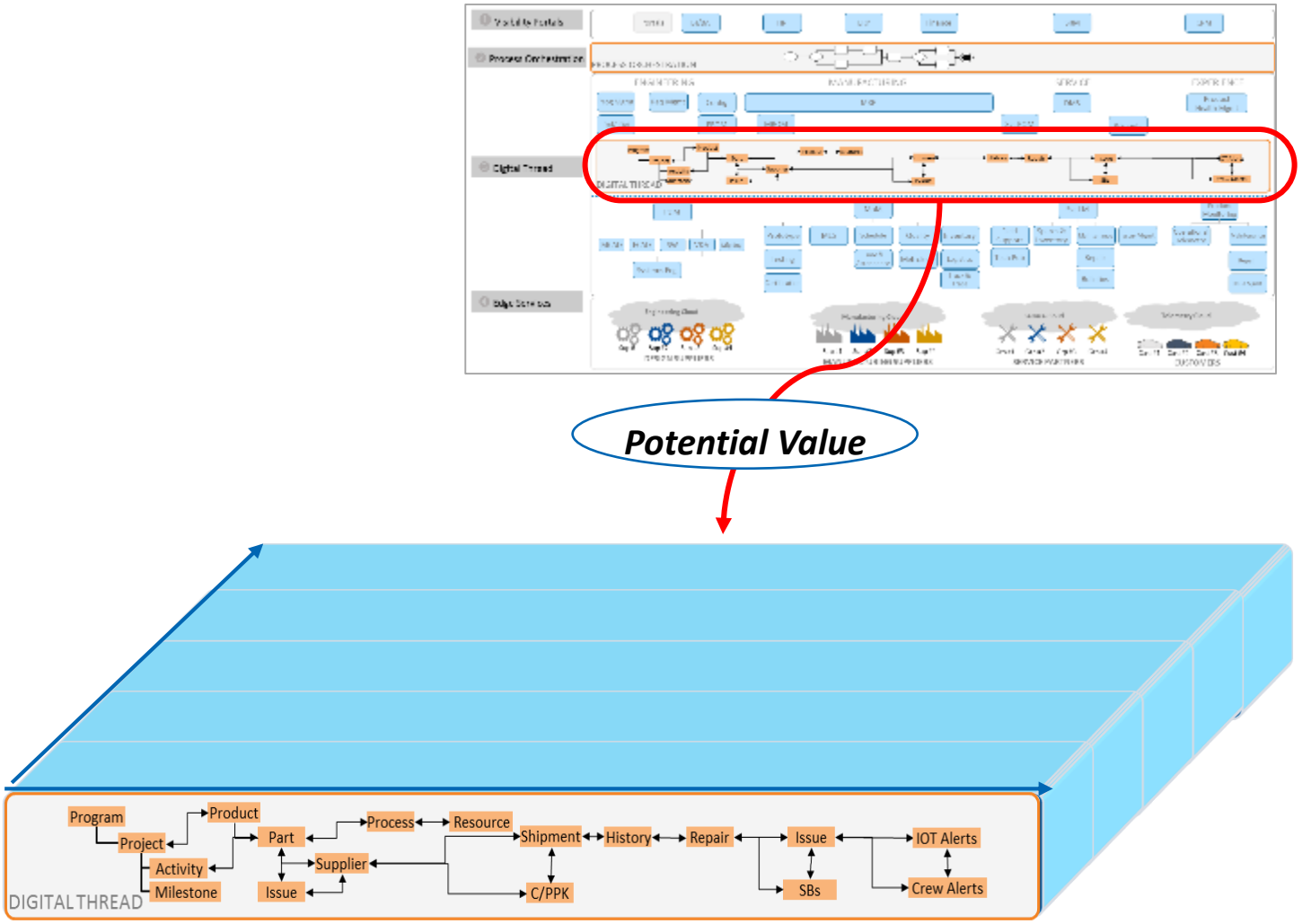


21ST CENTURY TECHNOLOGIES

HCL

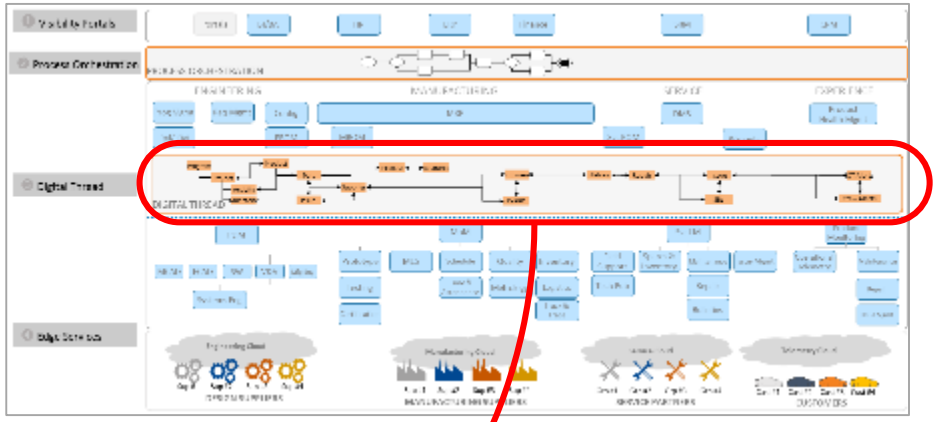
Digital Thread : Potential Value

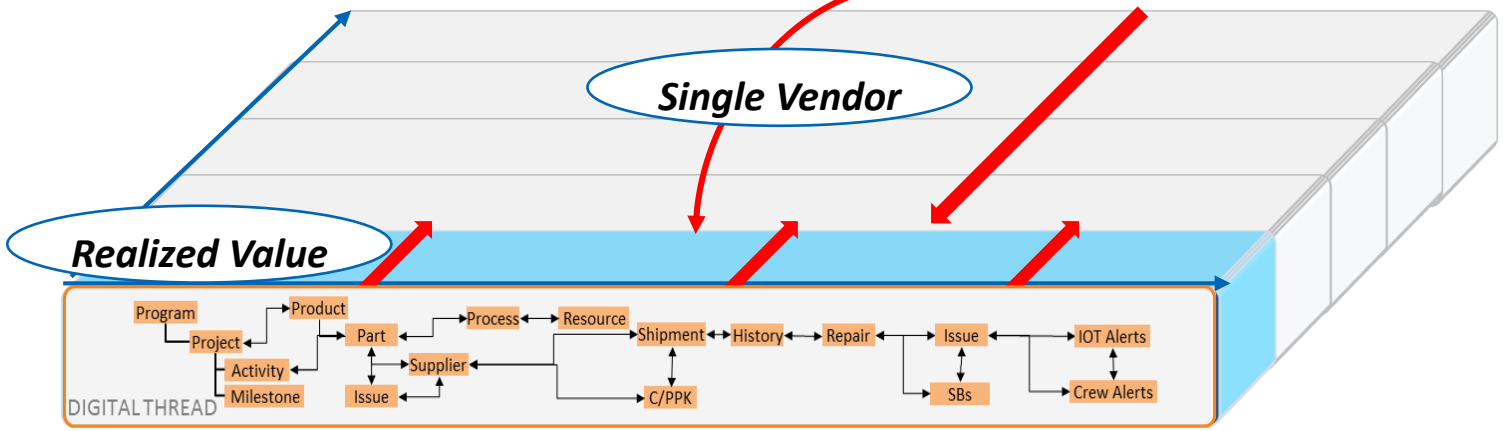
- Digital Thread Value Prop
  - Provide bi-directional traceability to improve the context and impact analysis across the domains (horizontal/breadth) and in a domain (vertical/depth)
  - Make key information available to all stake holder thus improving visibility
  - Provide information in near real-time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



Digital Thread : Single Vendor Value

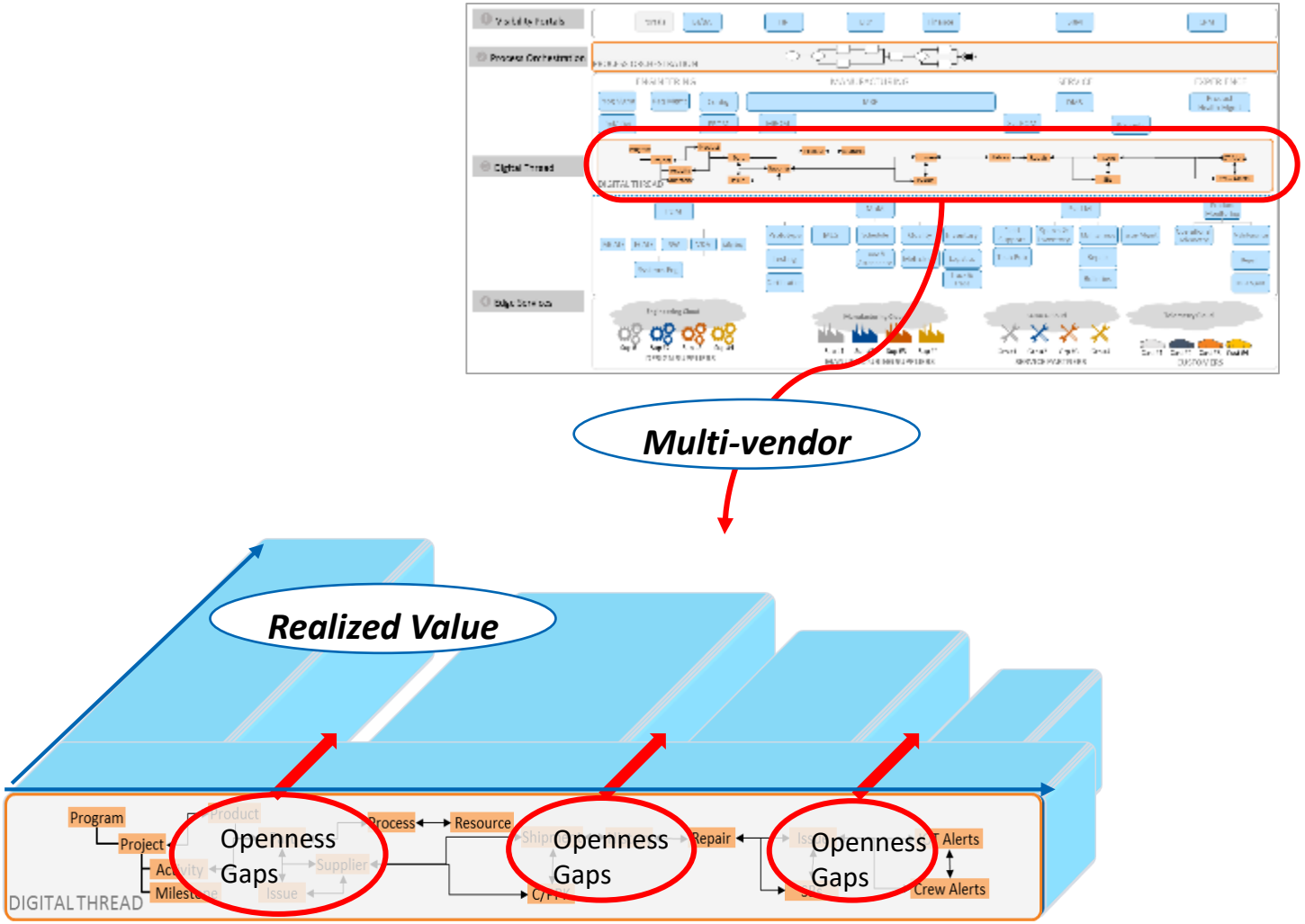
- In a single vendor system the value of a Digital Thread is constrained by
  - Functional nature of the systems
  - Domain specific interpretation of data and elements
  - The value is reduced to a common minimum subset





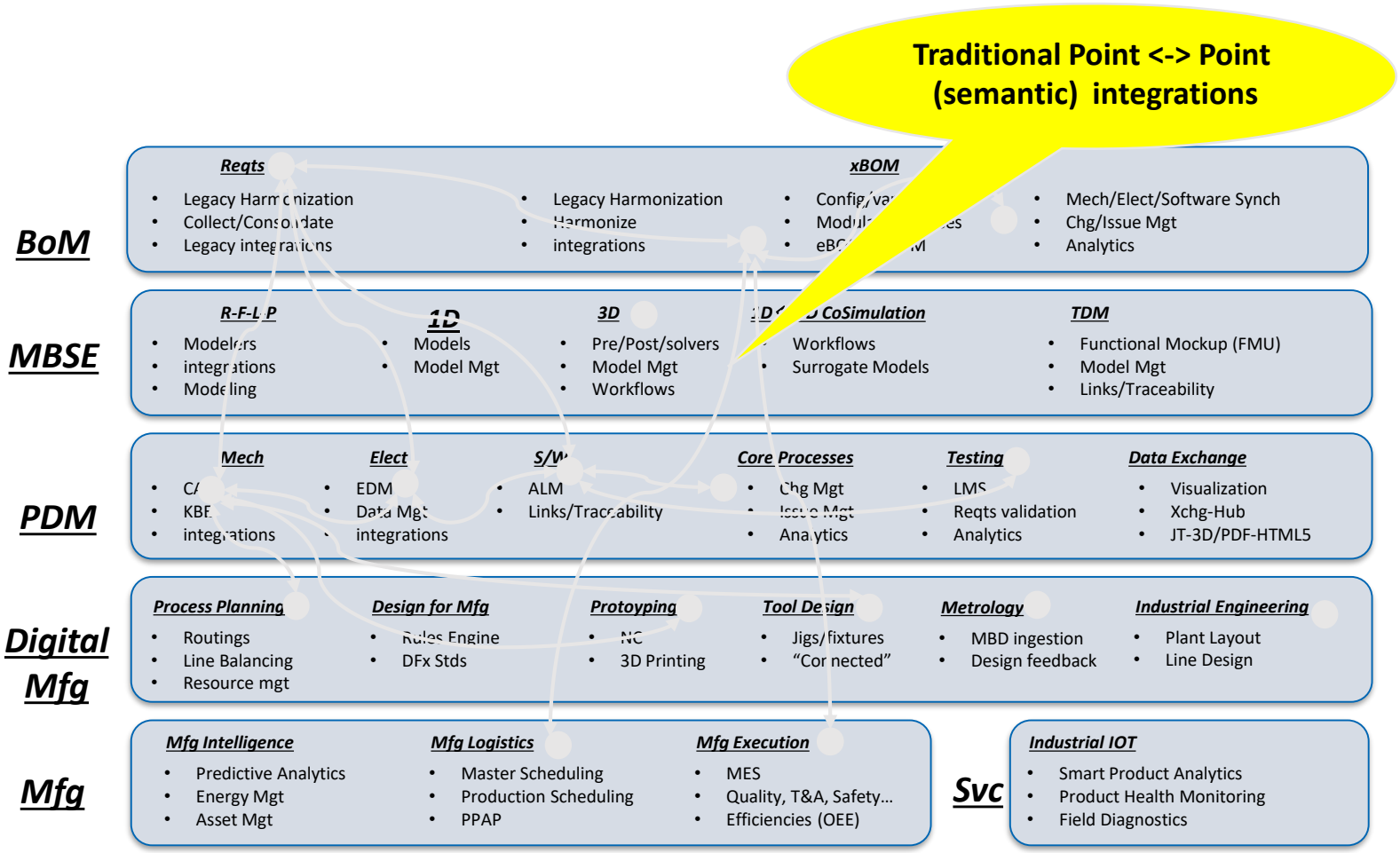
Digital Thread : Multi-vendor with “openness” constraints

- 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



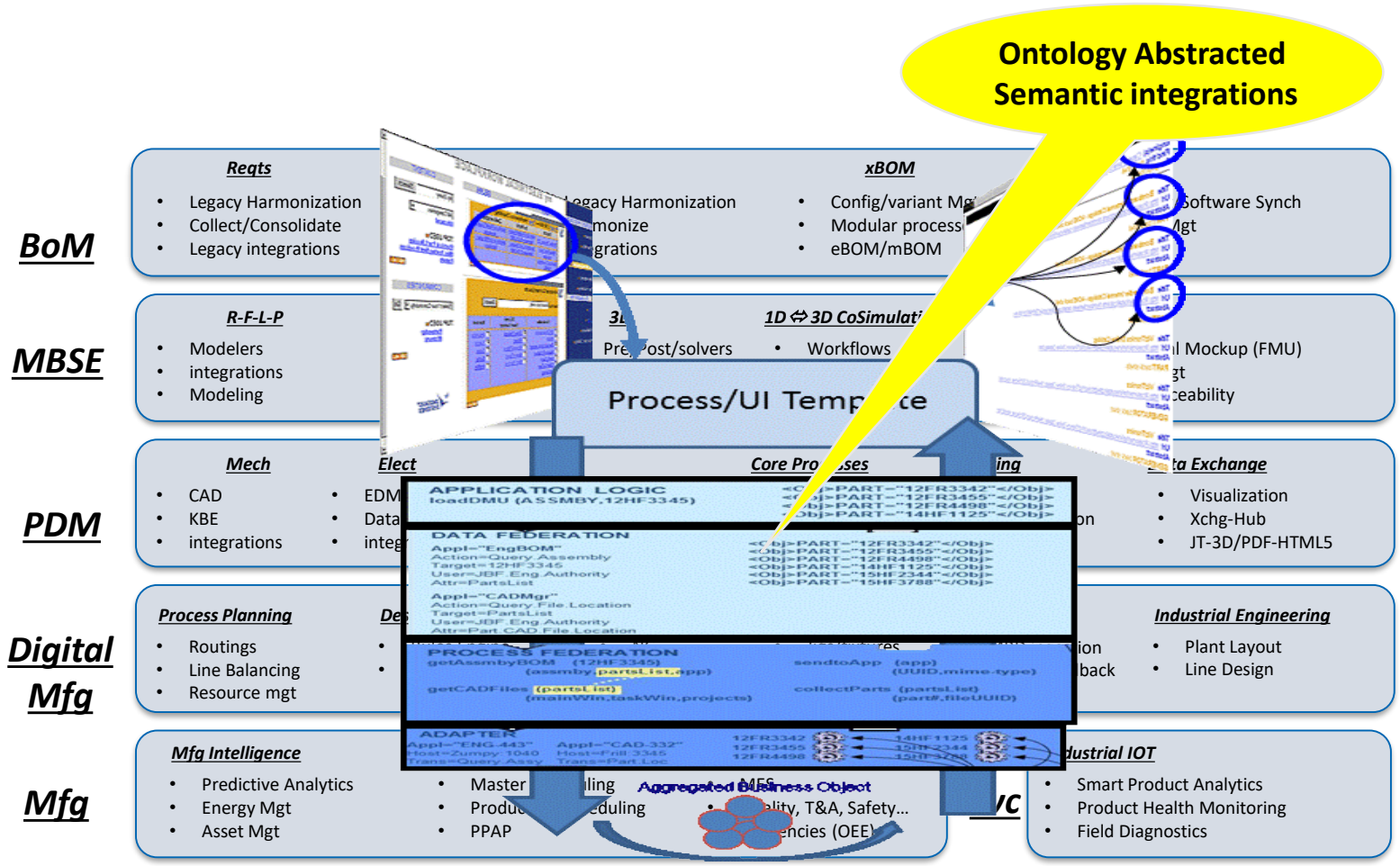
Enterprise Application Footprint with Traditional Integrations (Fixed Mappings)

- 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



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



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

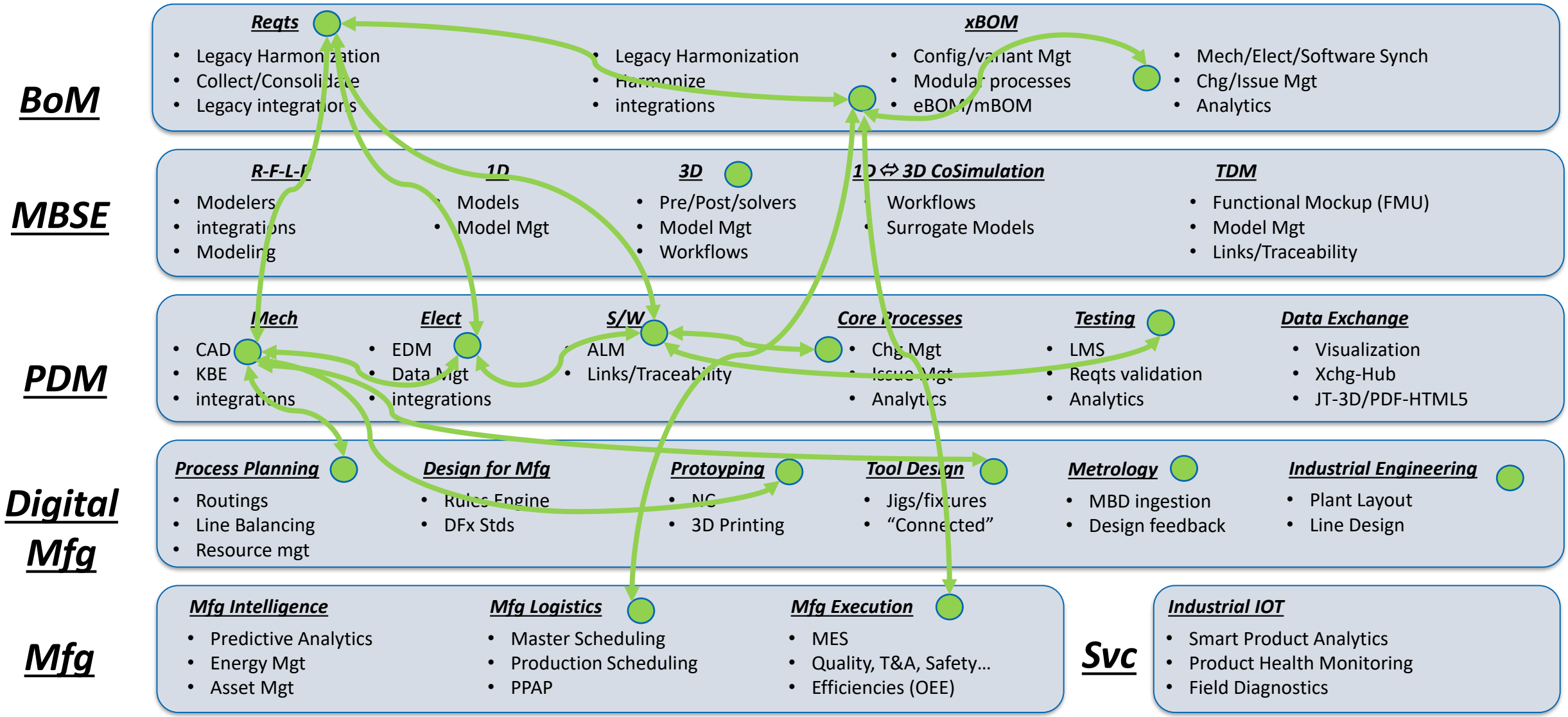
Mfg Logistics
- Master Scheduling
- Production Scheduling
- PPAP

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

Svc

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

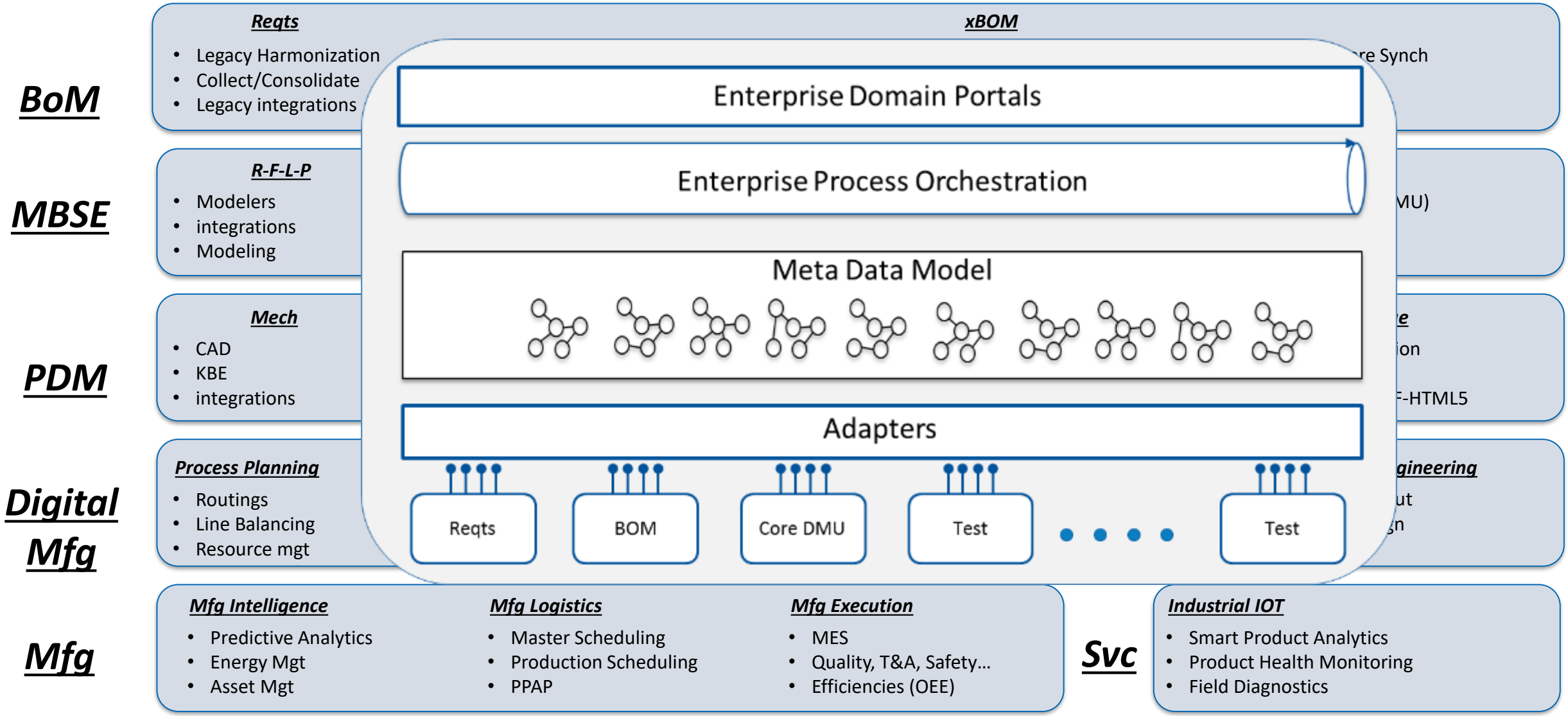
Semantic Integrations (Mappings → with Associativity → Vertically & Horizontally)



21ST CENTURY TECHNOLOGIES

HCL

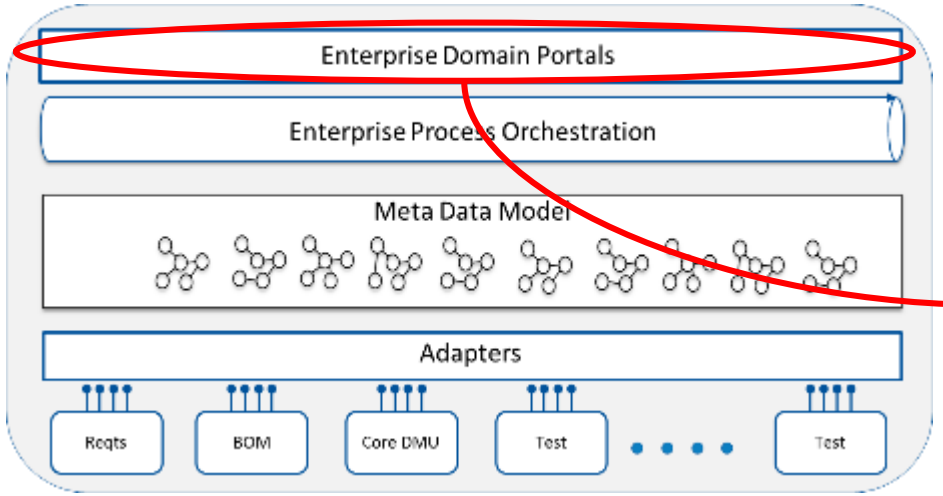
N-Dimensional Mappings (FUNCTIONAL) → with Associativity → Vertically & Horizontally

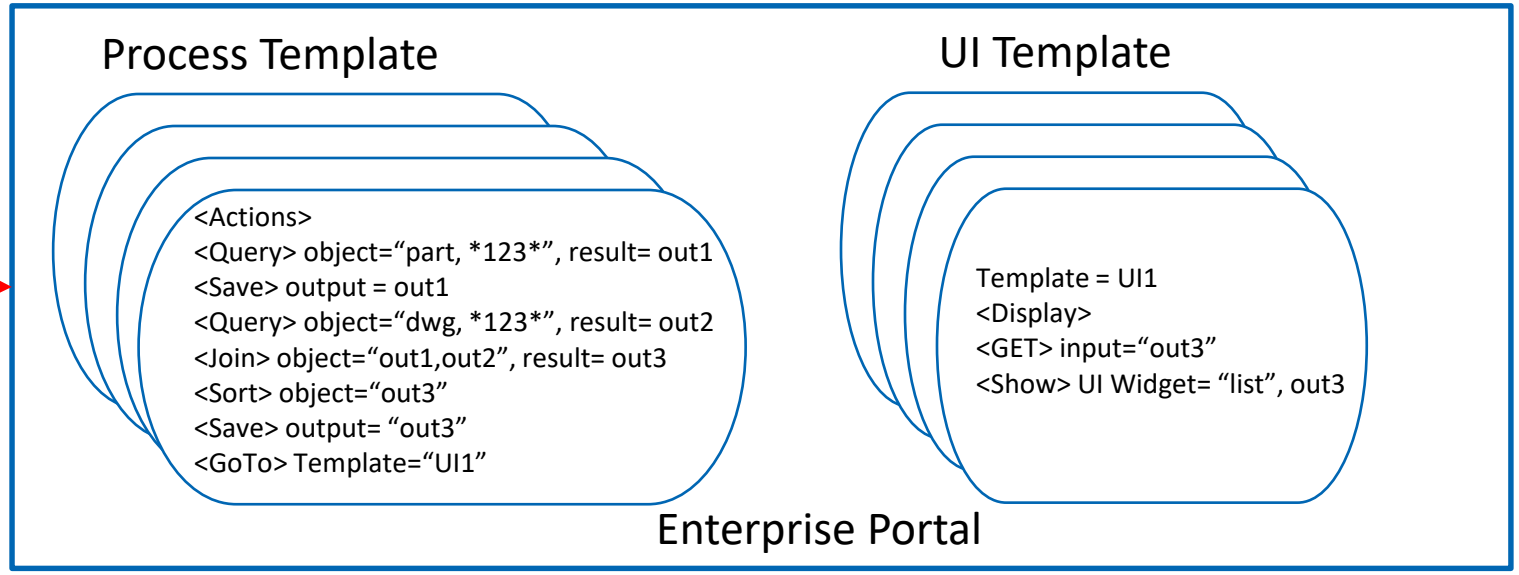


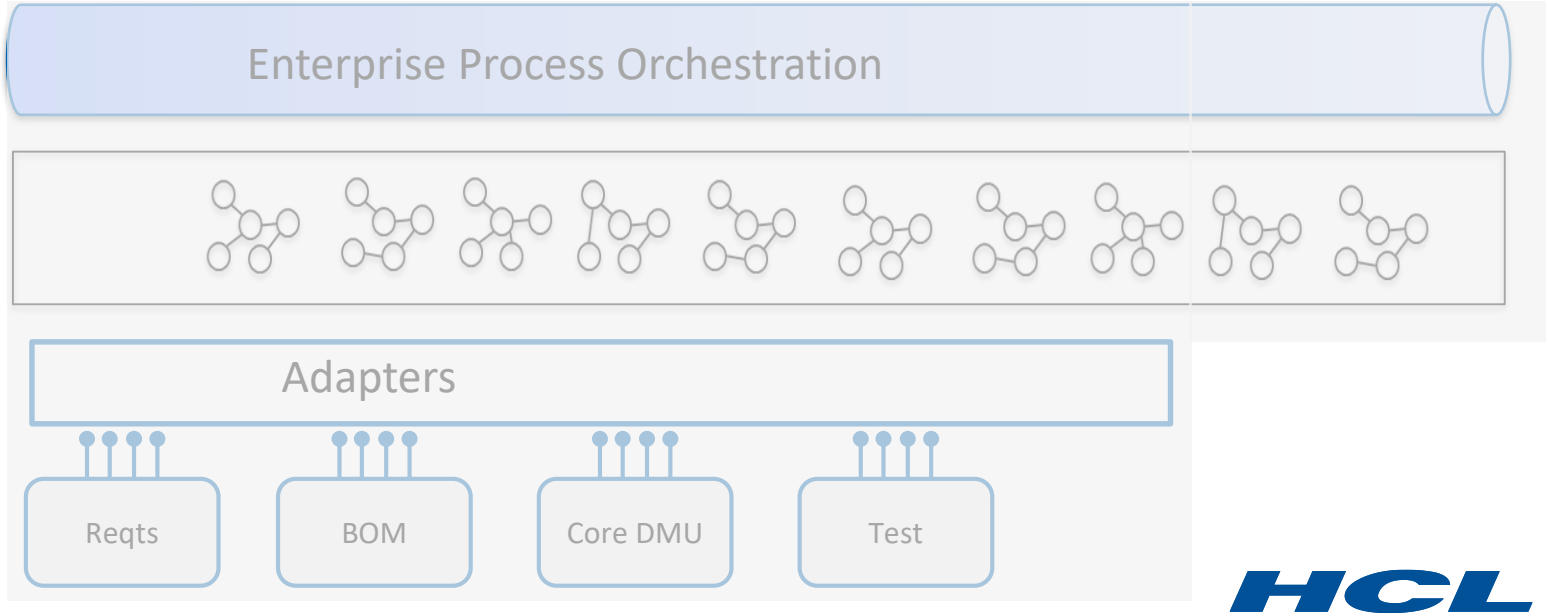
21ST CENTURY TECHNOLOGIES

HCL

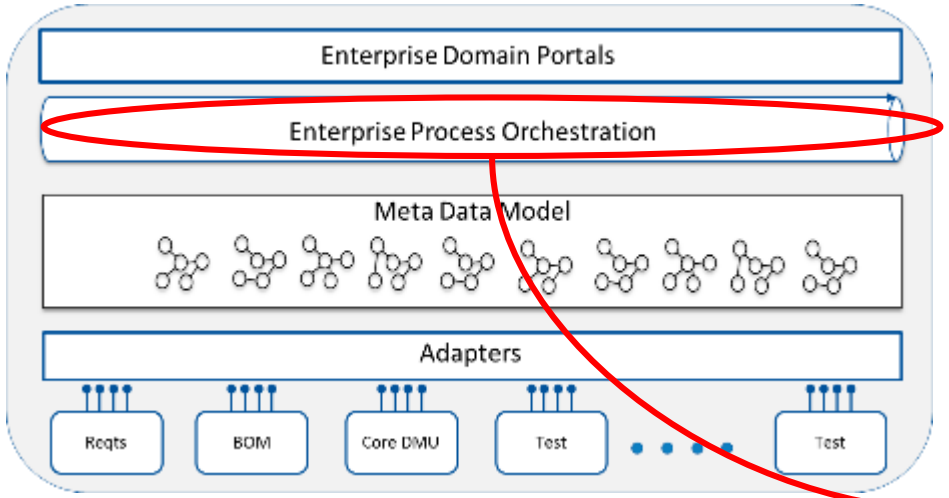
Digital Thread: Template UI & Process (Define)

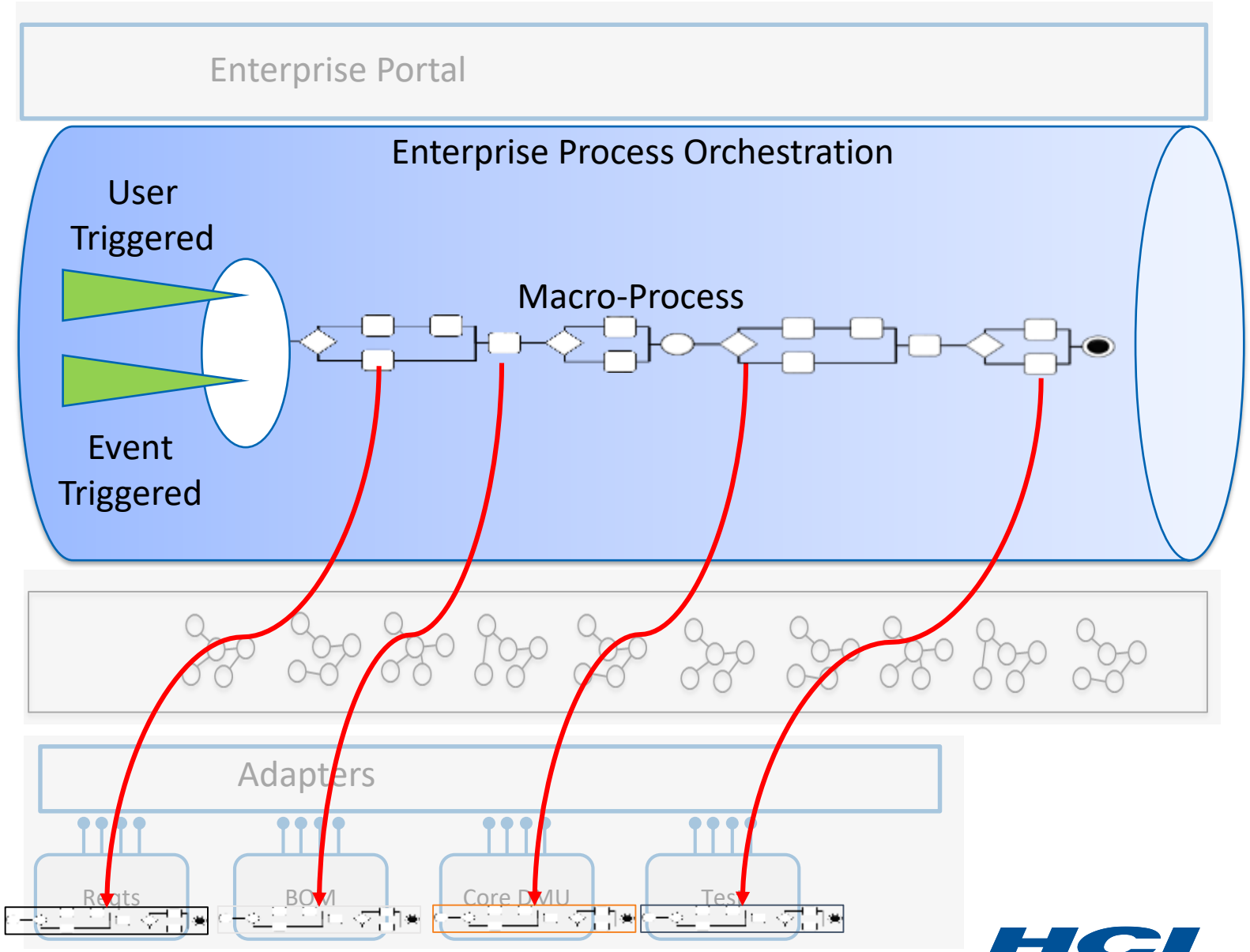




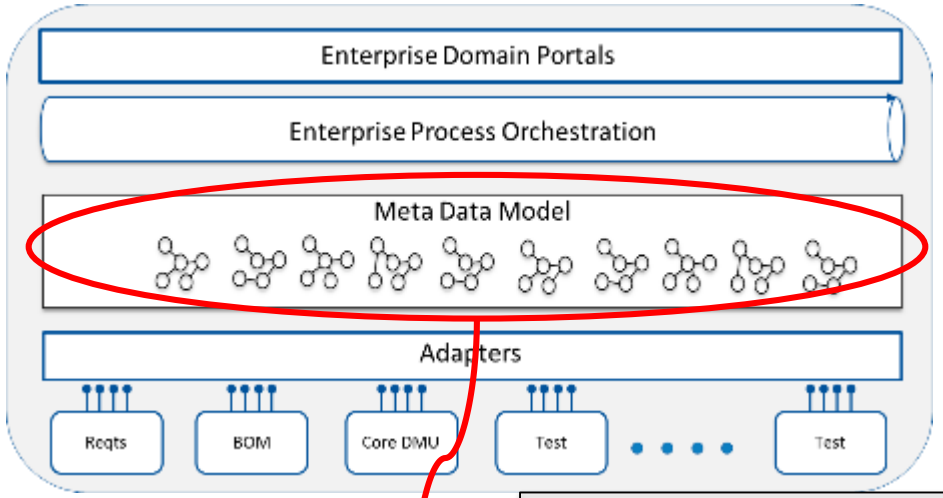


Digital Thread: Process Orchestration (Define)

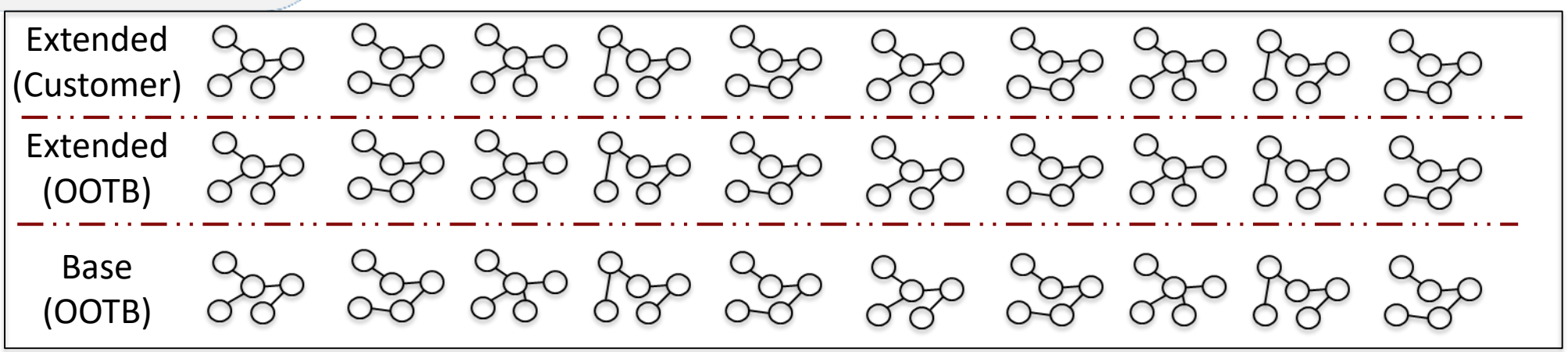


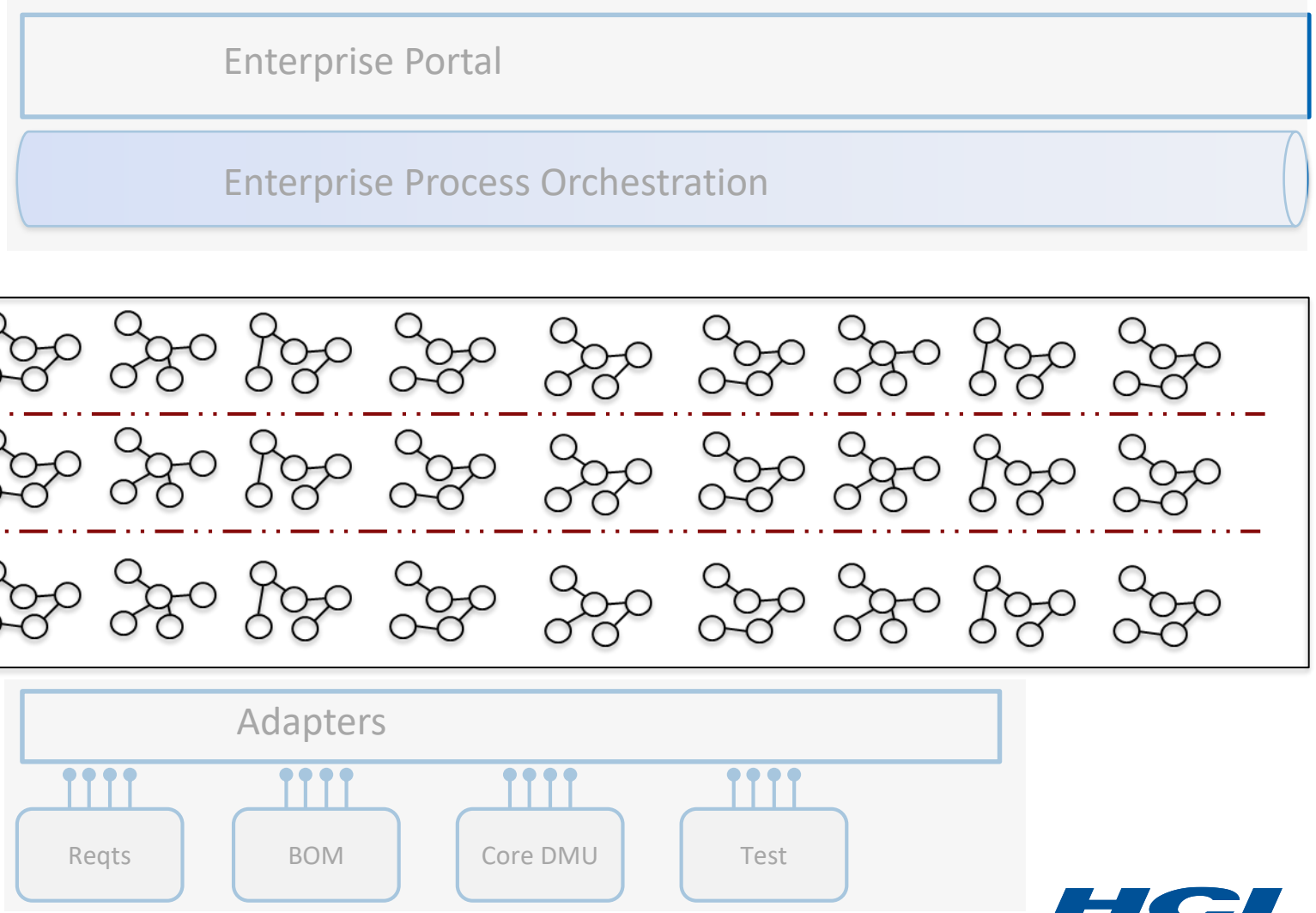


Digital Thread: Meta Data Model (Define)

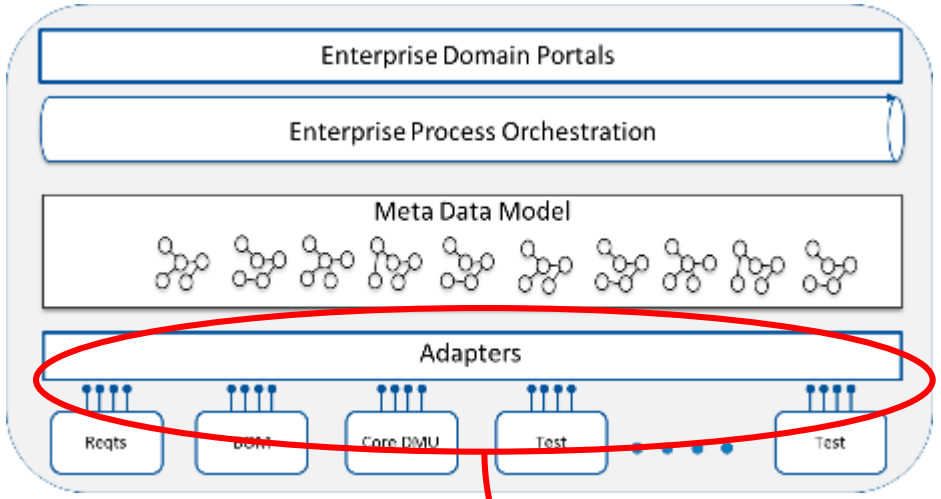


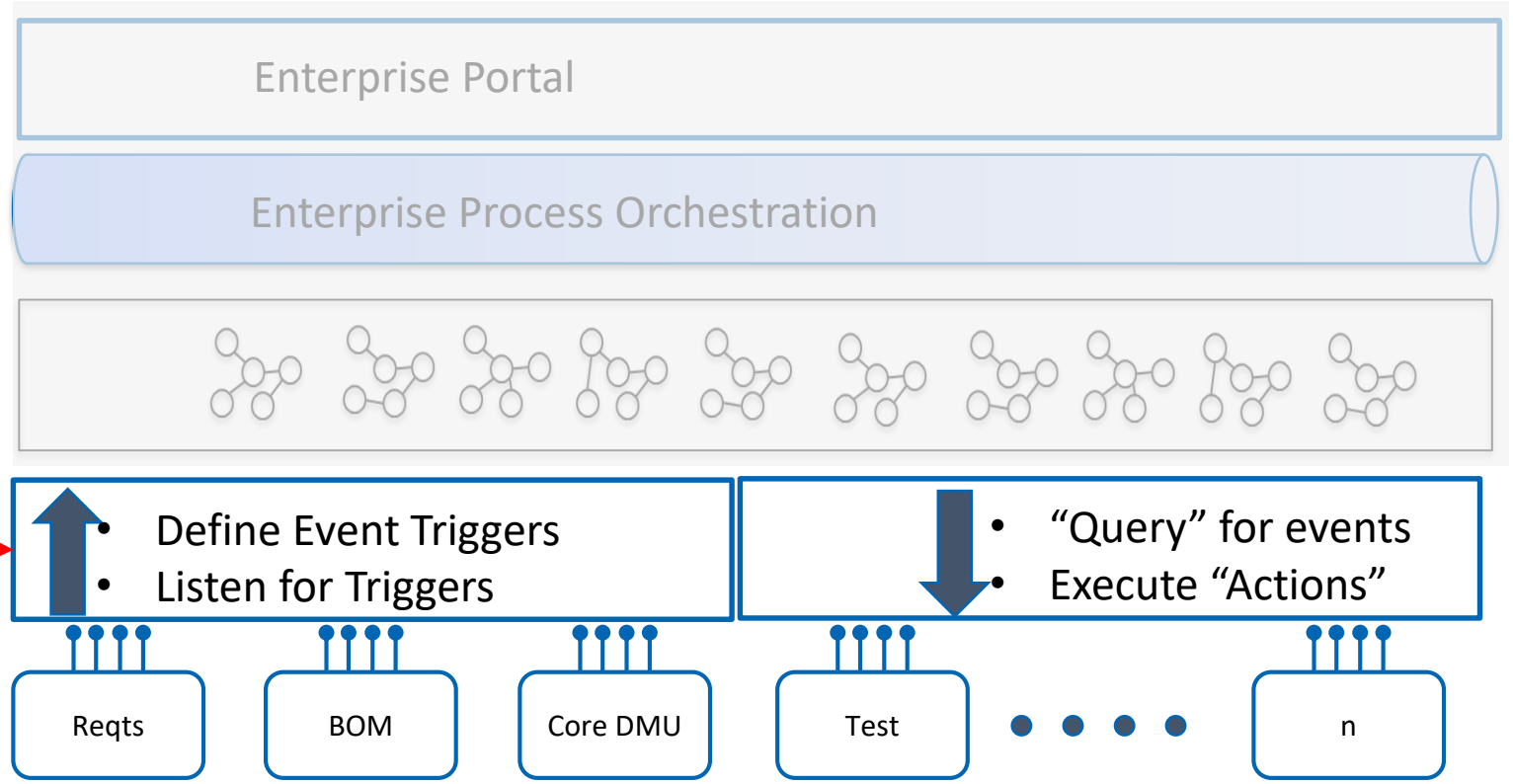
Meta Data Model



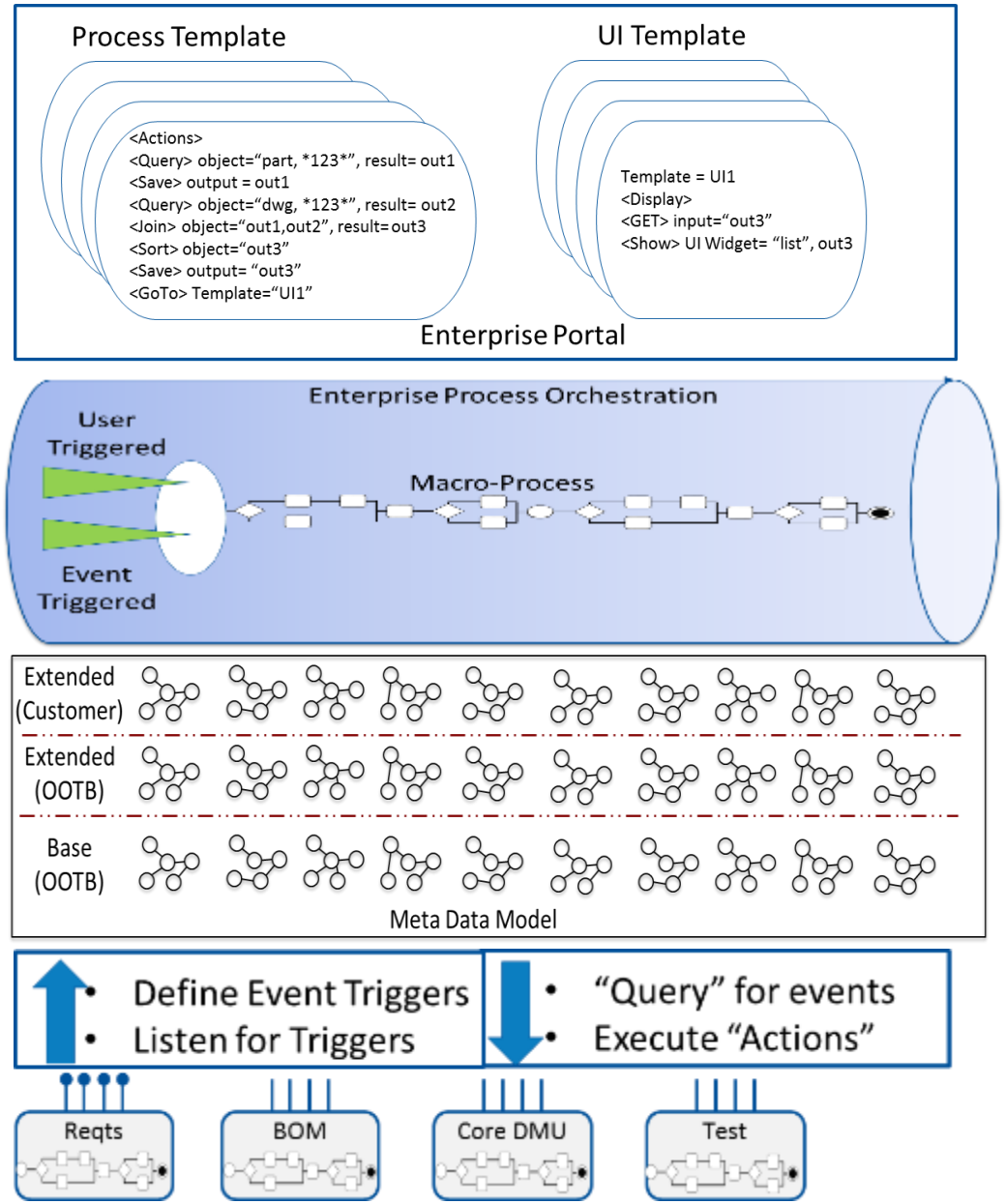


Digital Thread: Application Adapters (Define)





Digital Thread: Level 2 Spec



The transformation to Maximize Value – Minimize Disruption

Digital Transformation

Step#1

Maturity Baselining
- Systems
- Processes
- Interoperability

Supply chain collaboration
- Visibility
- Traceability

Design for manufacturing

Step#2

Model based enterprise
- MBD
- TDP
- MPM

Systems Engineering
- RFLP Modeling

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

Step#3

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

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

IIOT
- Manufacturing operations intelligence

Step#4

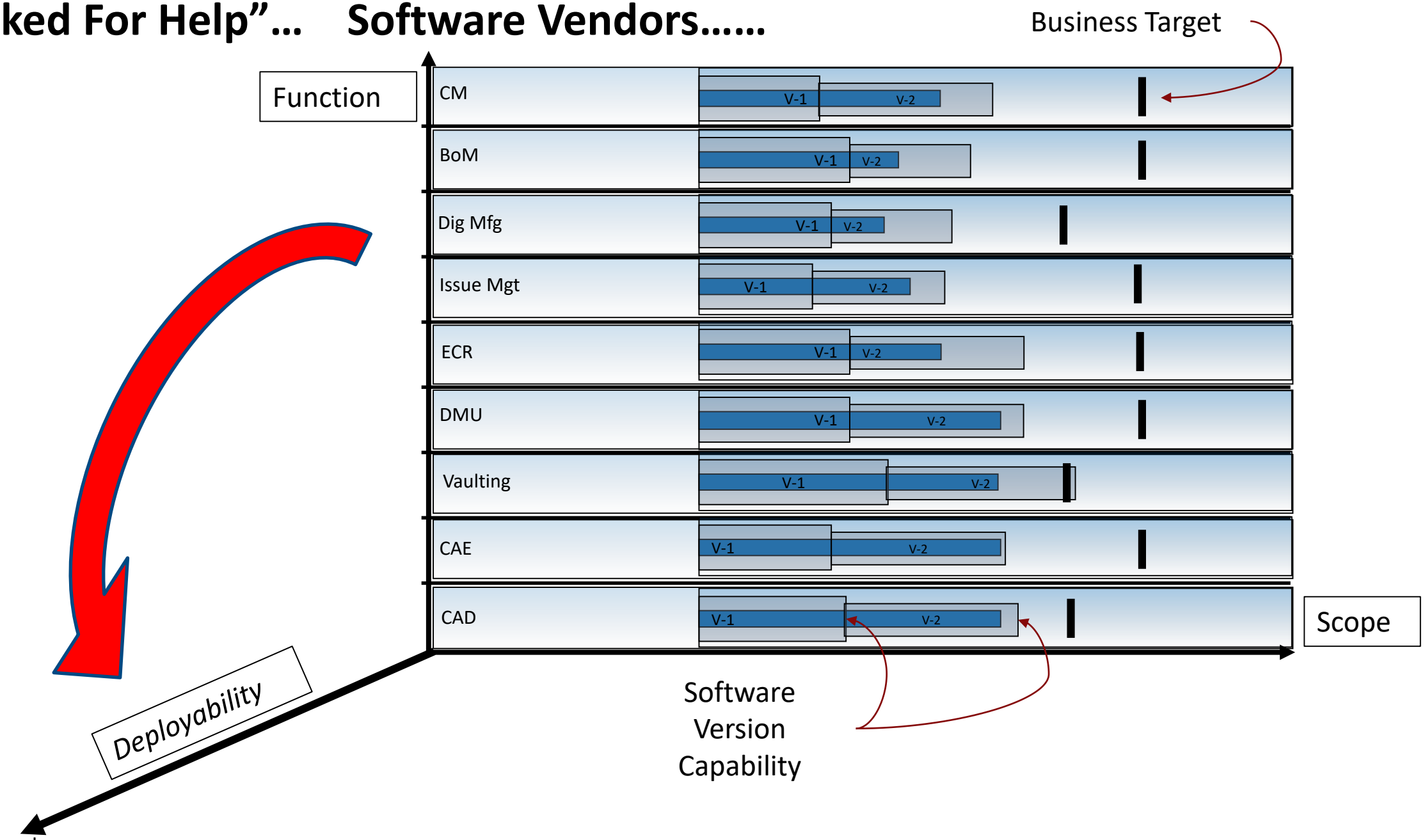
Systems Engineering
- Rqts driven bidirectional traceability – files

IOT
- Prescriptive product health
- Knowledge Mining

Step#5

Systems Engineering
- Rqts driven bidirectional traceability - features

“We Asked For Help”… Software Vendors……



21ST CENTURY TECHNOLOGIES

HCL

End of presentation.

THANK YOU

21ST CENTURY TECHNOLOGIES

HCL