

The Digital Enterprise Journey

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GLOBAL PRODUCT DATA INTEROPERABILITY **SUMMIT** 2016



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 **BOEING**

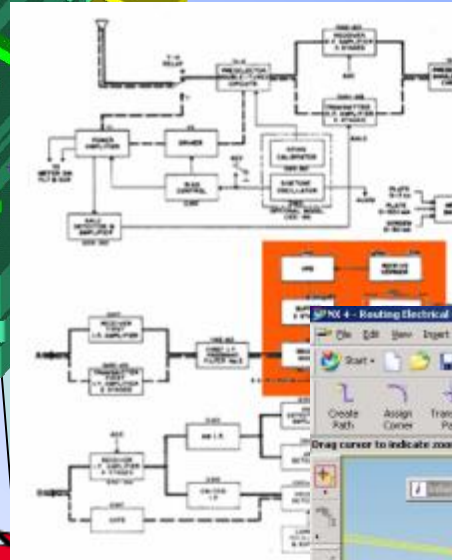
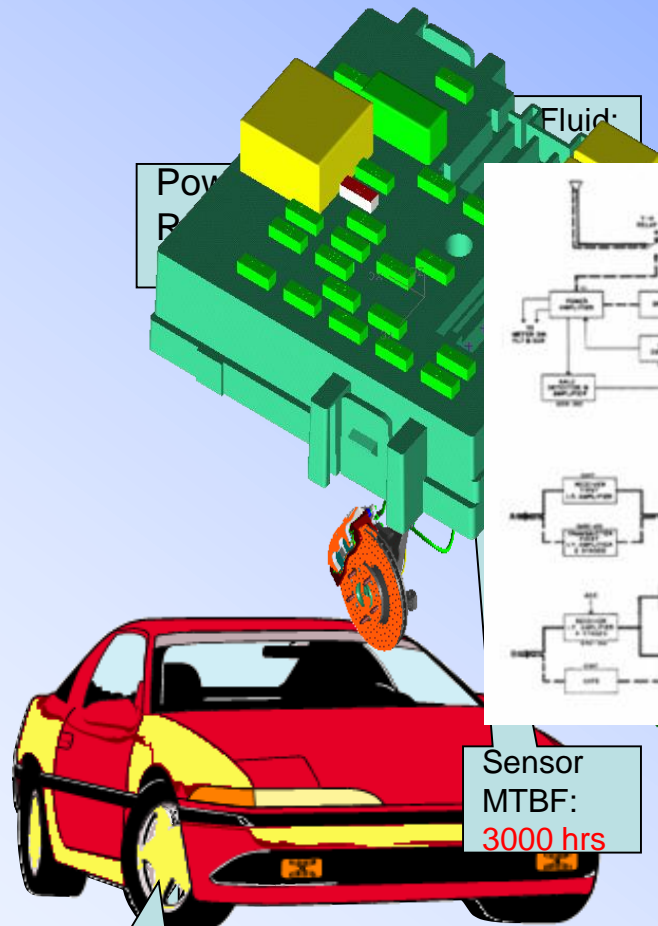
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Integrated Systems Engineering Vision



FAILURE MODE AND EFFECTS ANALYSIS DESIGN FMEA														
1	Part #	0103 Body	Rev.	A										
2	System/Subsystem/Component	SubSystem	Design Responsibility	Reliability Engineering										
3	Model Year(s)/Vehicle(s)	2005	Rev. Date	00000										
4	Team	T. Fender, Car Prod. Dev. Children, Max J. Ford, Assembly Ops												
5	Item	Individual	Failure Mode	Effect	Cause	Severity	Occurrence	Detectability	Recommendation	Residual Risk	Priority	Open	Close	Remarks
6	First Done	17	Control interior level door panels	Unintentional appearance due to rust	None	Other Edge of protection not specified insufficient rust thickness specified	2	Vehicle general durability test F-118 F-120 F-121	None	None	None	None	None	None
7	18													
8	19													
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85	96													
86	97													
87	98													
88	99													
89	100													



Minimum Turn Radius: 24 ft.
Dry Pavement Braking Distance at 60 MPH: 110 ft. 90 ft

Current Integrated Systems Engineering

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- Current systems engineering tools leverage computing and information technologies to some degree, and make heavy use of office applications for documenting system designs. The tools have limited integration with other engineering tools



A WORLD IN MOTION

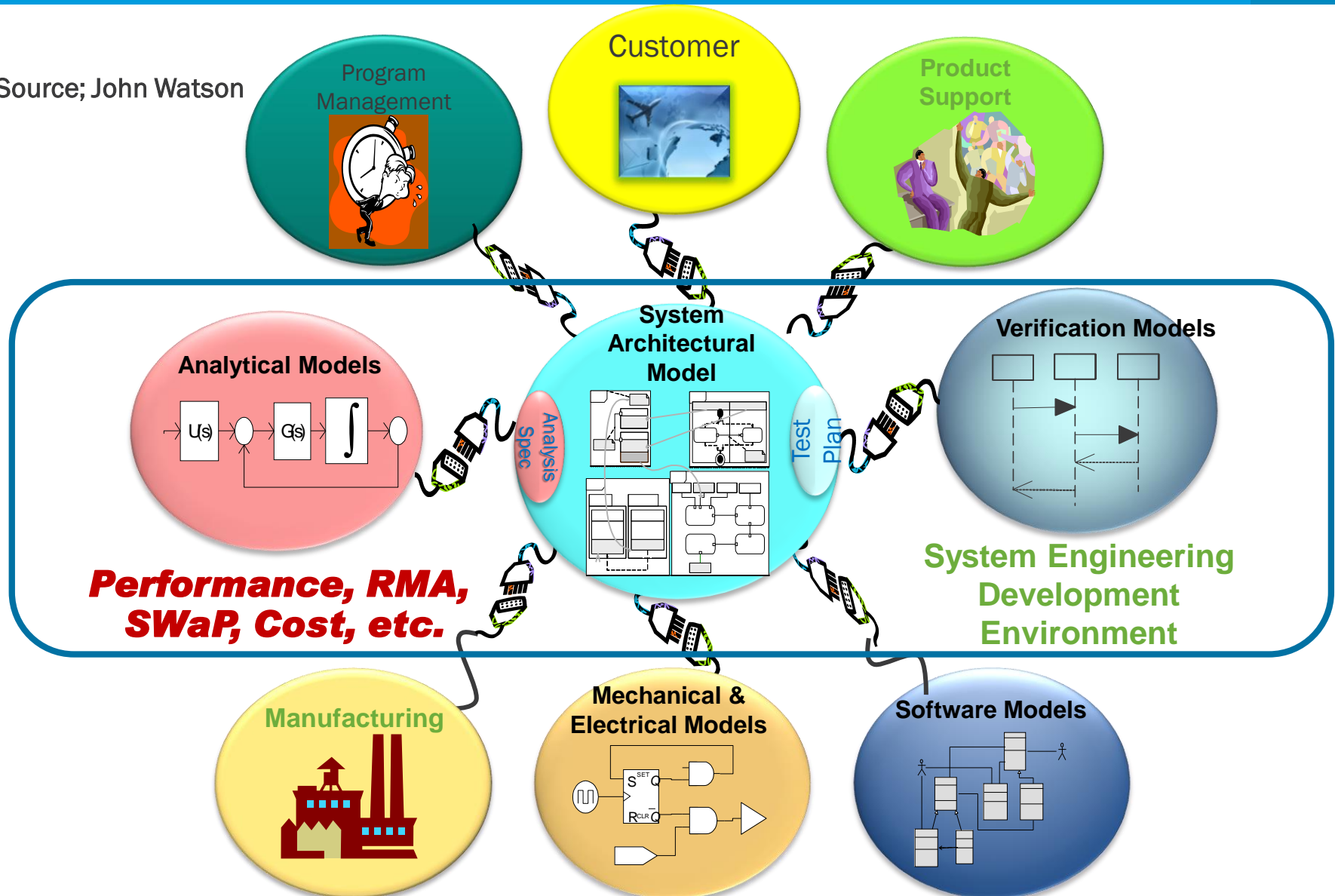
INCOSE Systems Engineering Vision • 2025

Integrated Systems Engineering Vision 2025

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- The systems engineering tools of 2025 will facilitate systems engineering practices as part of a fully integrated engineering environment.
- **Systems engineering tools will integrate with CAD/CAE/PLM environments, project management and workflow tools as part of a broader computer-aided engineering and enterprise management environment.**
- Systems engineering tools will support high fidelity simulation, immersive technologies to support data visualization, semantic web technologies to support data integration, search, and reasoning, and communication technologies to support collaboration.
- Systems engineering tools will benefit from internet-based connectivity and knowledge representation to readily exchange information with related fields.
- The systems engineer of the future will be highly skilled in the use of IT-enabled engineering tools.

Source; John Watson



To measure MBSE effectiveness we need to understand the context of how it is used

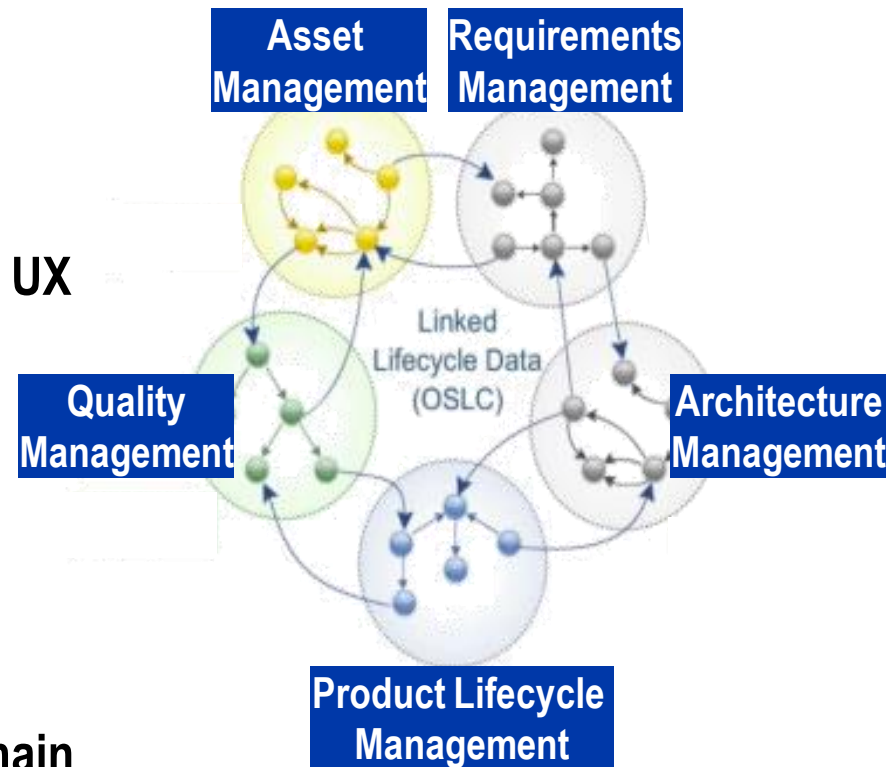
Open Services for Lifecycle Collaboration

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OSLC is being used as a foundational layer to satisfy key customer use cases – extended as needed to deliver more robust interoperability.

- **Standards-based**
 - Extends the value of ALM investments
 - RESTful Web Services architecture
- **Designed for maintainability**
 - Source application owns both data and UX
 - No data transformations, replication or synchronization
- **Open / extensible**
 - Enables use cases for cross-vendor interoperability
 - Supports N:N relationships – ideal for selective data sharing across supply chain

“Link, not synch”



OSLC Groups

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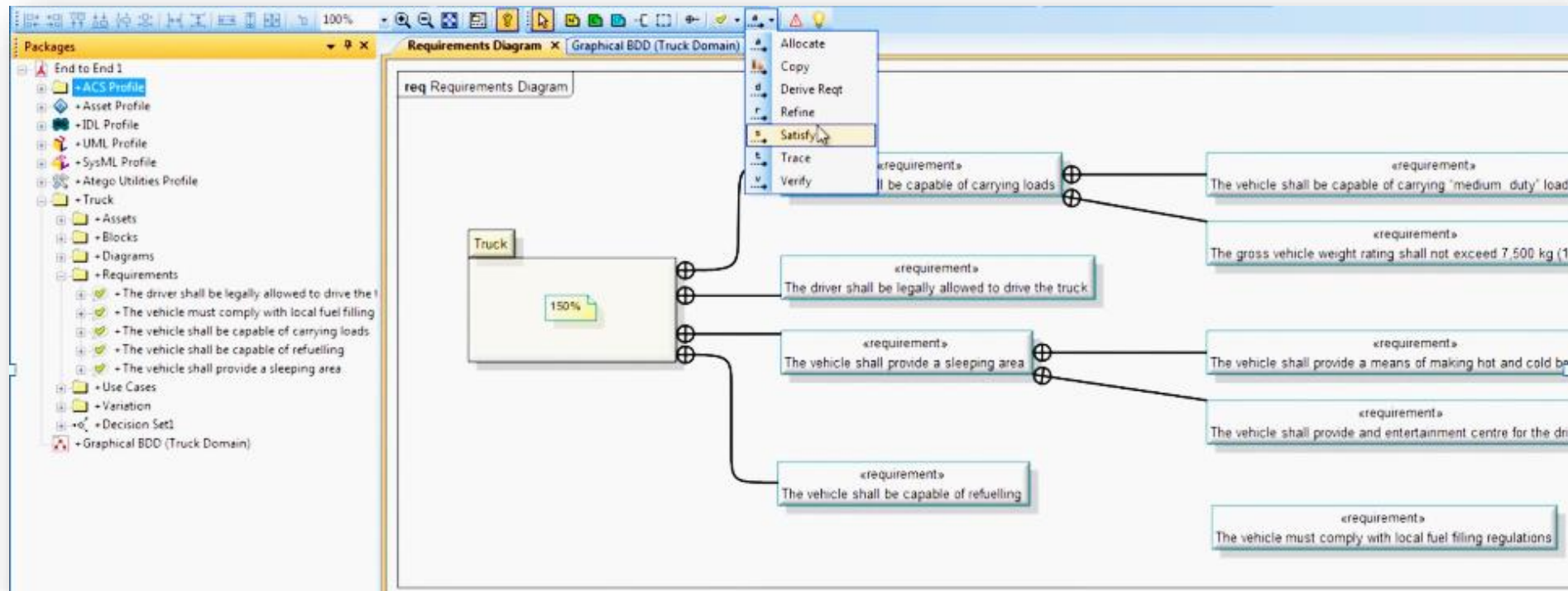
- ALM-PLM Interoperability (2nd edition)
 - Define Industrial relevant scenarios for interoperability of ALM and PLM engineering.
- Lifecycle Integration Patterns
 - A user group focused on finding and sharing of solutions to common lifecycle integration problems.
- Linked Data Platform
 - Writing a W3C specification for HTTP-based (RESTful) application integration patterns using read/write Linked Data.
- RDF Data Shapes
 - Writing a W3C Recommendation for describing structural constraints and validate RDF instance data against those
- Automation
 - Reducing manual interactions in all phases of software development and operations
- Change and Configuration Management
 - Tasks, defects, assets, and configurations at OASIS
- PROMCODE TC
 - Exchanging project management information across organizational boundaries
- Core
 - Common problems with finding, creating, and updating resources
- Architecture Management
 - Modeling, diagrams, and use cases for software development
- Automation
 - Plans, requests, and results for builds and deployments
- Change Management
 - Defects, enhancements, changes, and tasks
- Performance Monitoring
 - Watching availability, performance, and capacity
- Quality Management
 - Plans, cases, and results for ongoing testing
- Requirements Management
 - Define stakeholder needs and how to meet them
- Embedded Systems
 - Integrating dedicated components
- Mobile
 - Mobile-specific needs
- Asset Management
 - Reusable components, documentation, and representations
- Configuration Management
 - Snapshots, baselines, and versions
- Estimation and Measurement
 - Size, quality, time, and effort for making software

Application Lifecycle Management

Requirements Modeling

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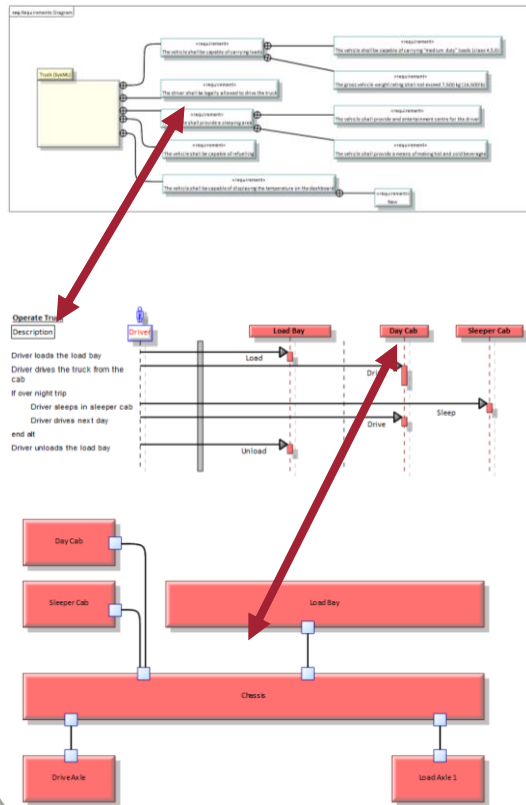
- Model Requirements in SysML or
- Import from a Requirements Management tool



MBSE and Requirements Integration

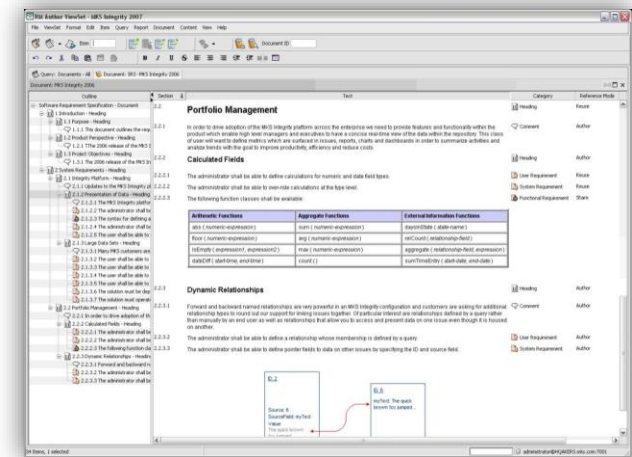
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MBSE Tool



MBSE/Requirements Synchronizer

Requirements Management Tool



Requirements

Additional
Model Elements

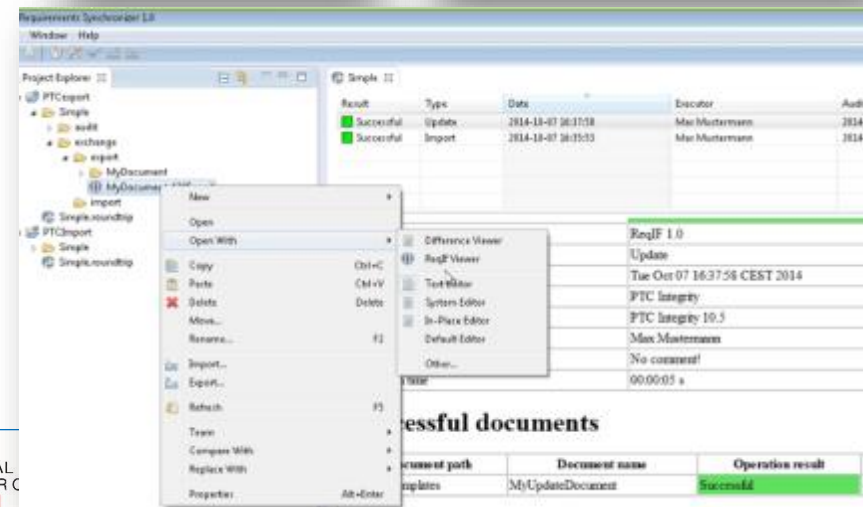
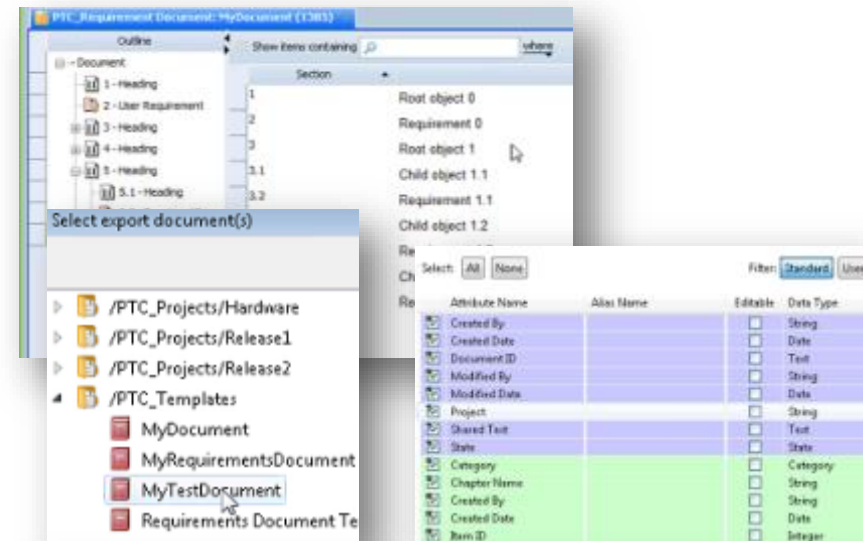
Model Trace
Links

OMG ReqIF Requirements Interchange

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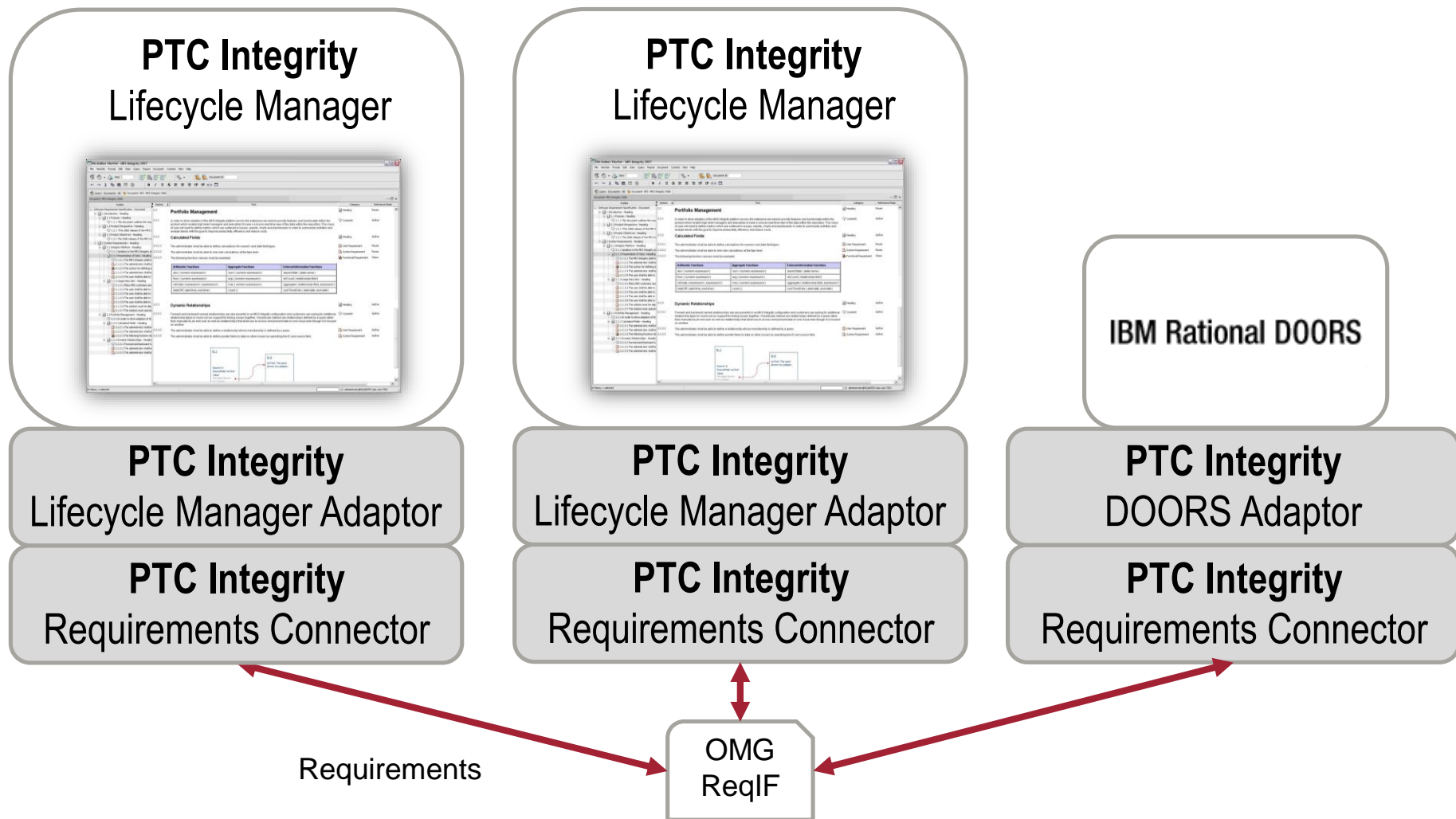
Challenge: Difficulty in exchanging requirements across various boundaries

- **Description of Problem**
 - Customers increasingly need to exchange requirements and specifications between or within companies using the same or different requirement management applications
- **Use Case(s)**
 - Synchronize requirements for supported applications
 - IBM DOORs
 - PTC Integrity Lifecycle Manager
 - Imports and exports standard ReqIF (requirement interchange format) files
 - Support rich text, images, OLE, and relationship information
 - Independent viewer for standard ReqIF files
 - Flexible configuration and mapping of exchange information
- **Customer Value**
 - Enables organizations to interchange large amounts of requirements information on an on-going and managed basis over the lifetime of any particular project or product.



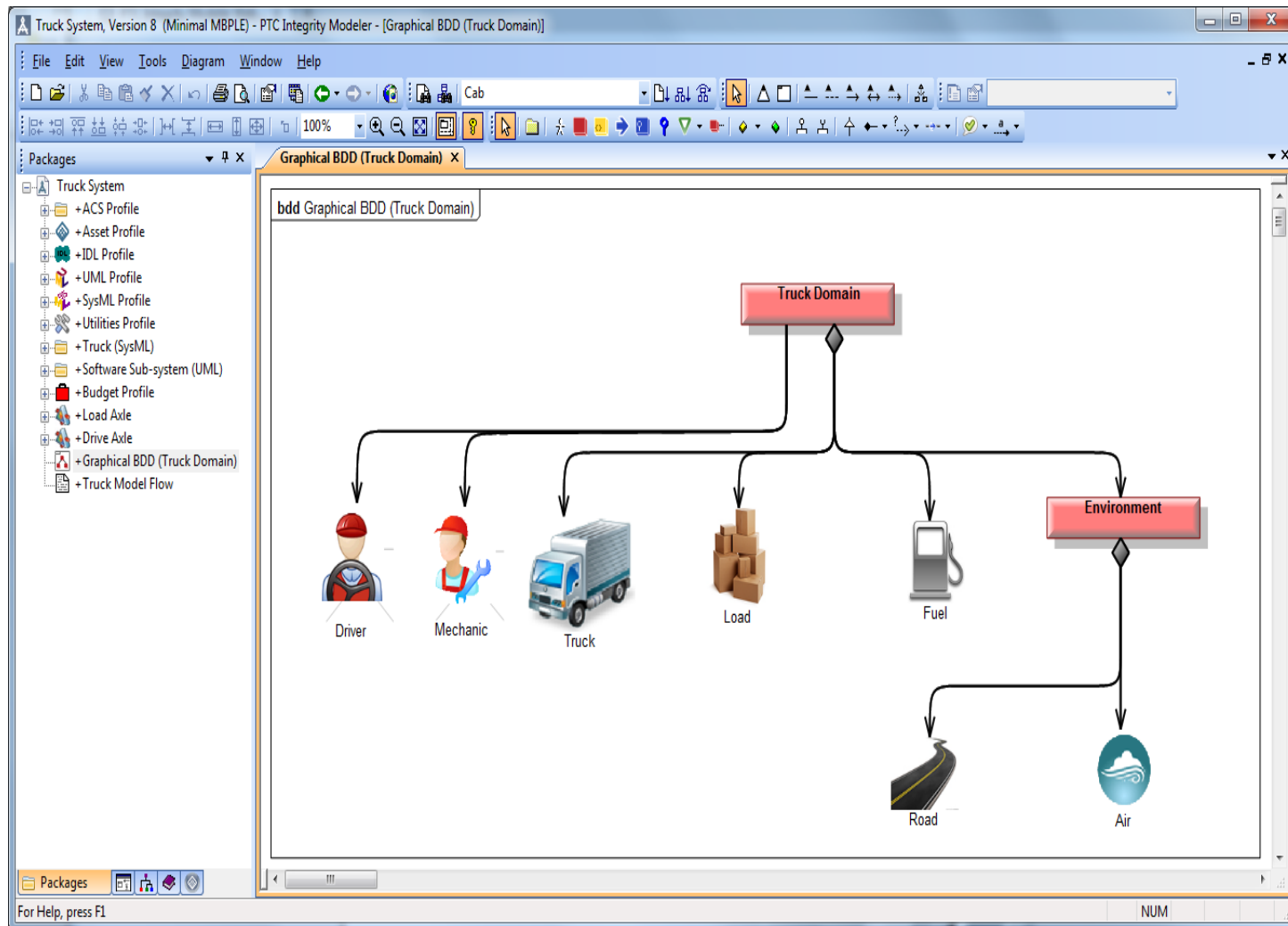
Requirements Interchange and Connection

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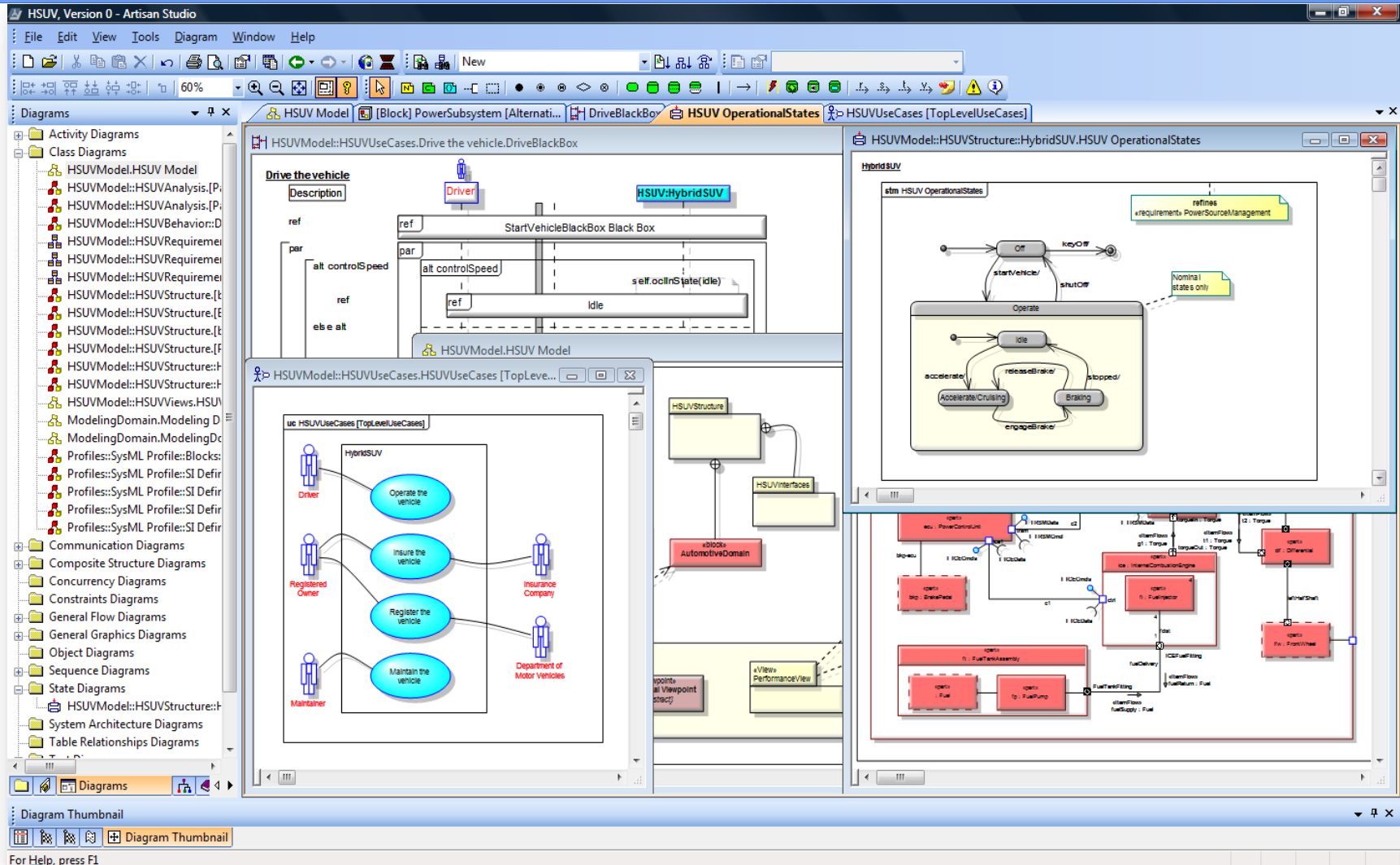
System Context Modeling

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Structural and Behavioral Modeling

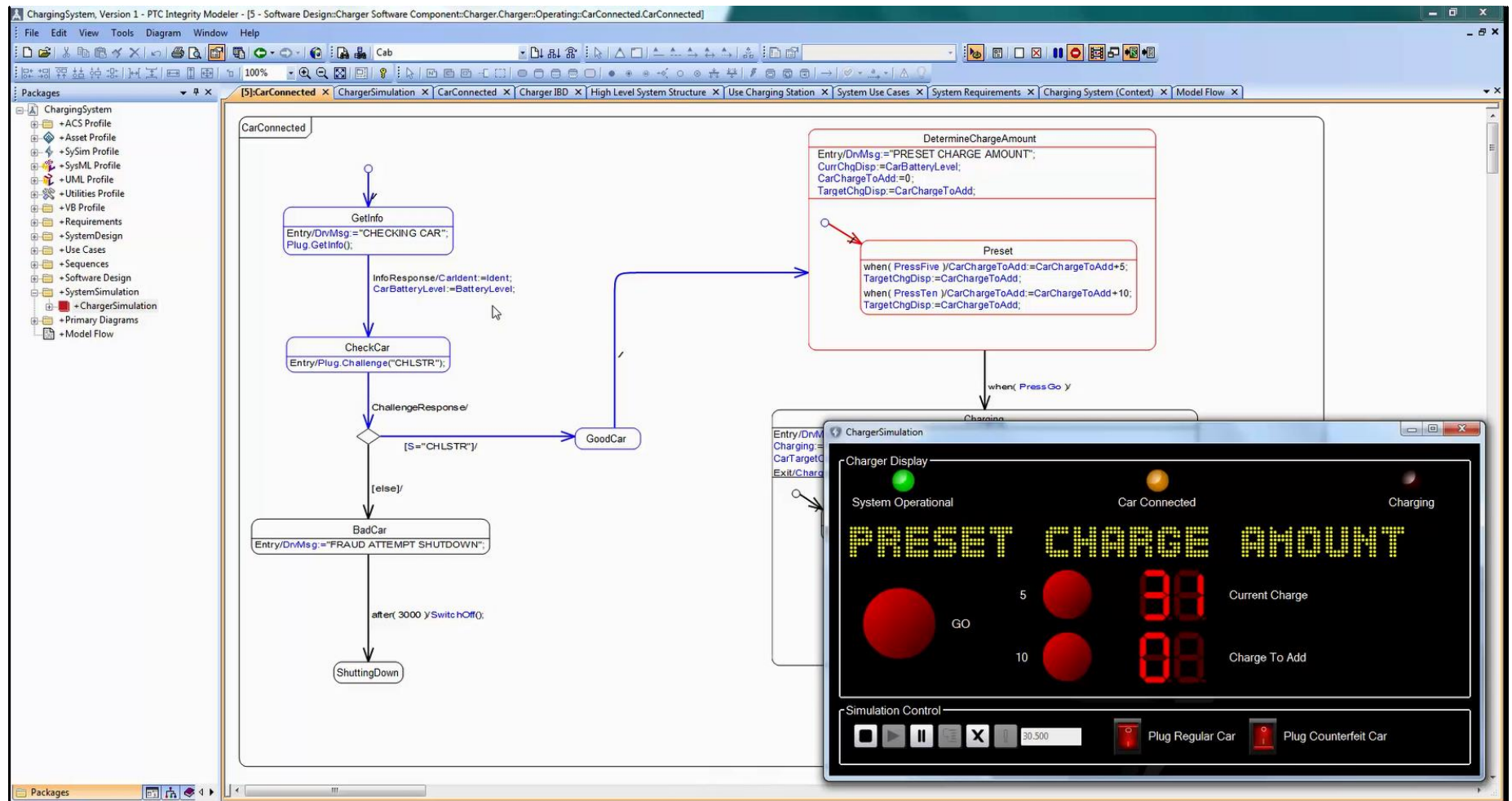
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For Help, press F1

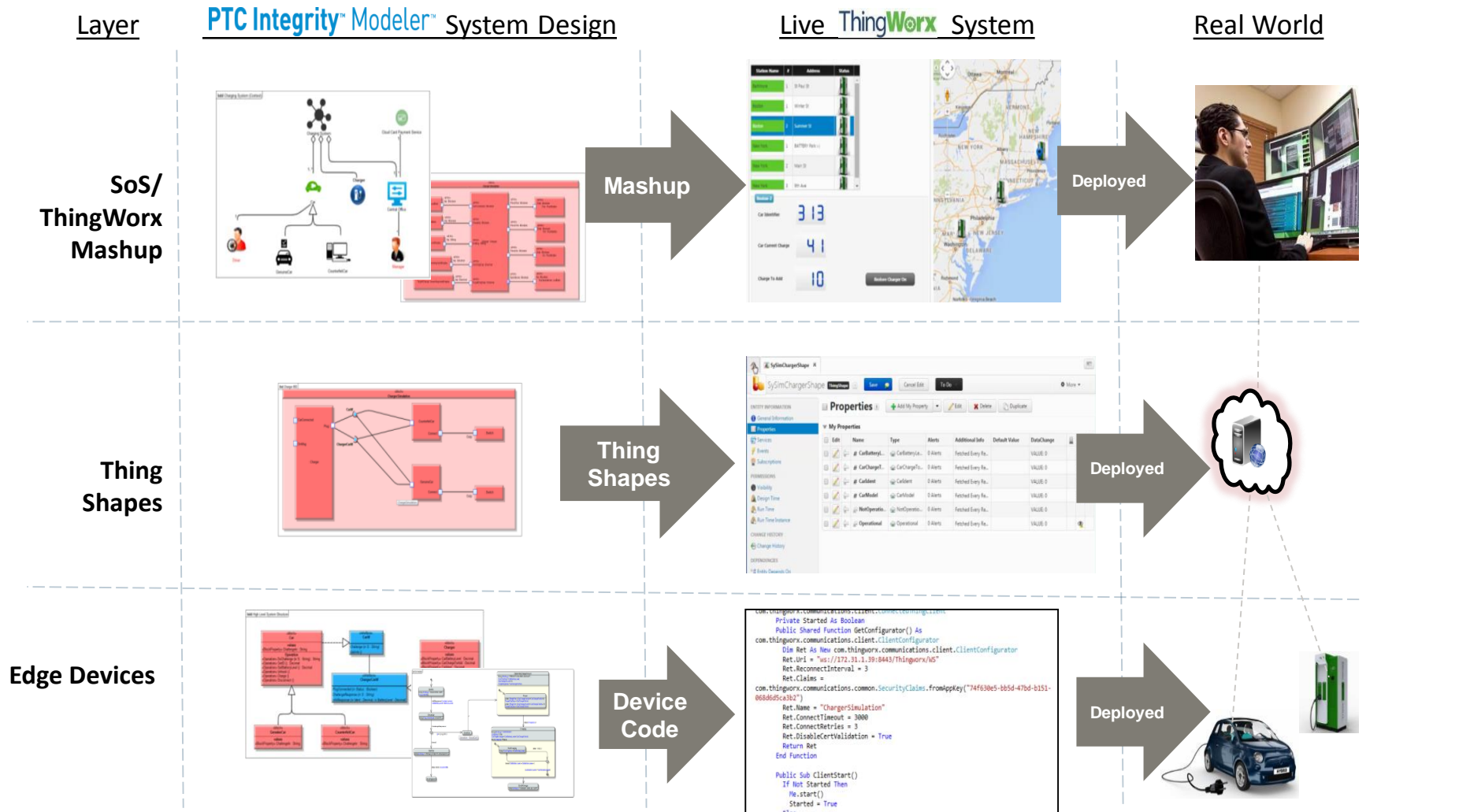
System Model Simulation

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Systems Engineering and the Internet of Things

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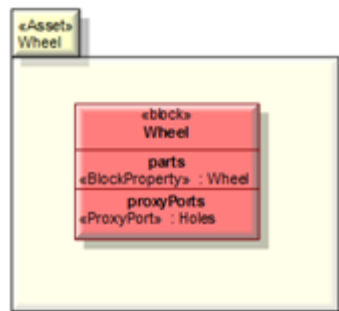


Product Line Engineering

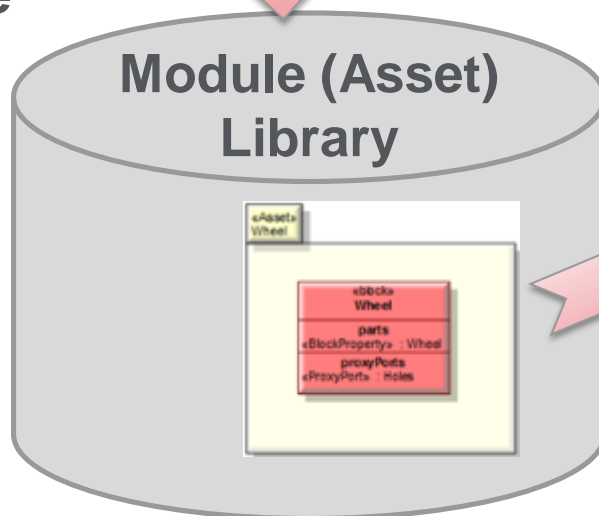
OMG Reusable Asset Specification (RAS)

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- Modular Design is an approach which segments the design of whole systems into linked, manageable and reusable sub-system designs

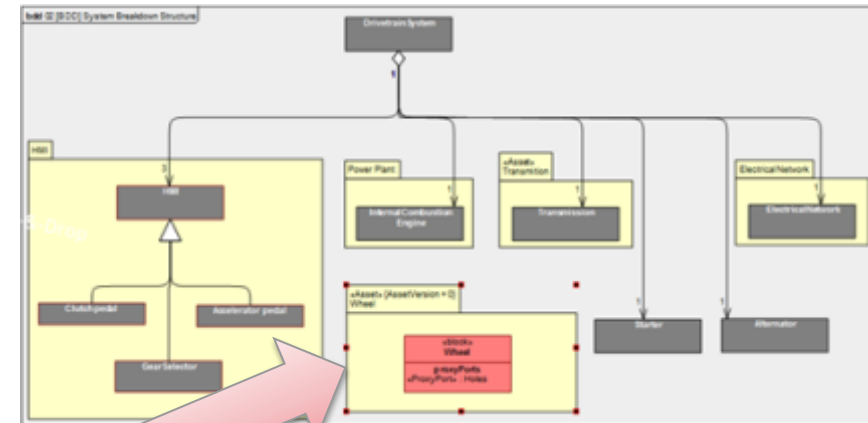


Module



Module (Asset)
Library

System Model

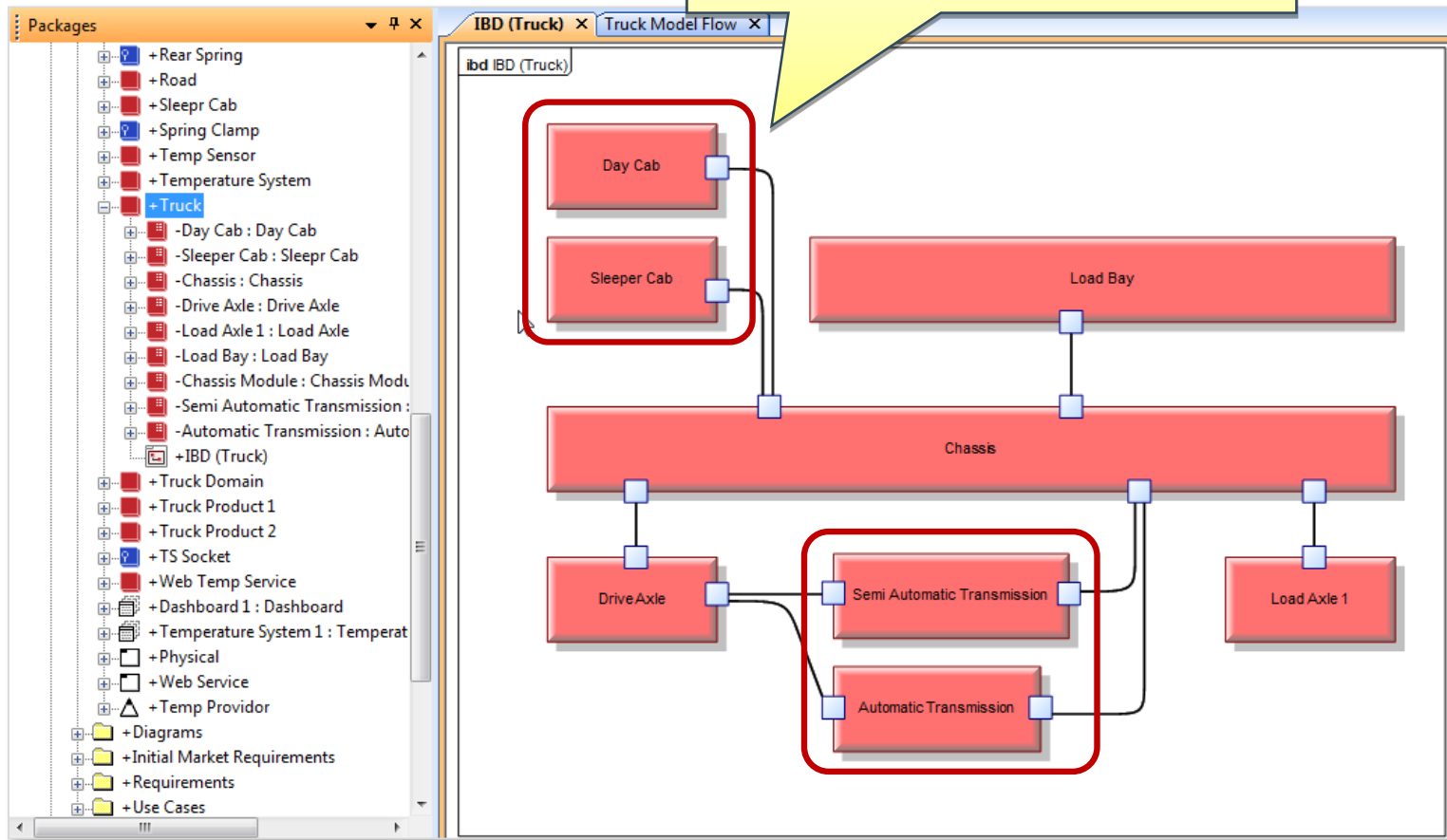


Expand product offering while
reducing costs

The Overloaded System Model

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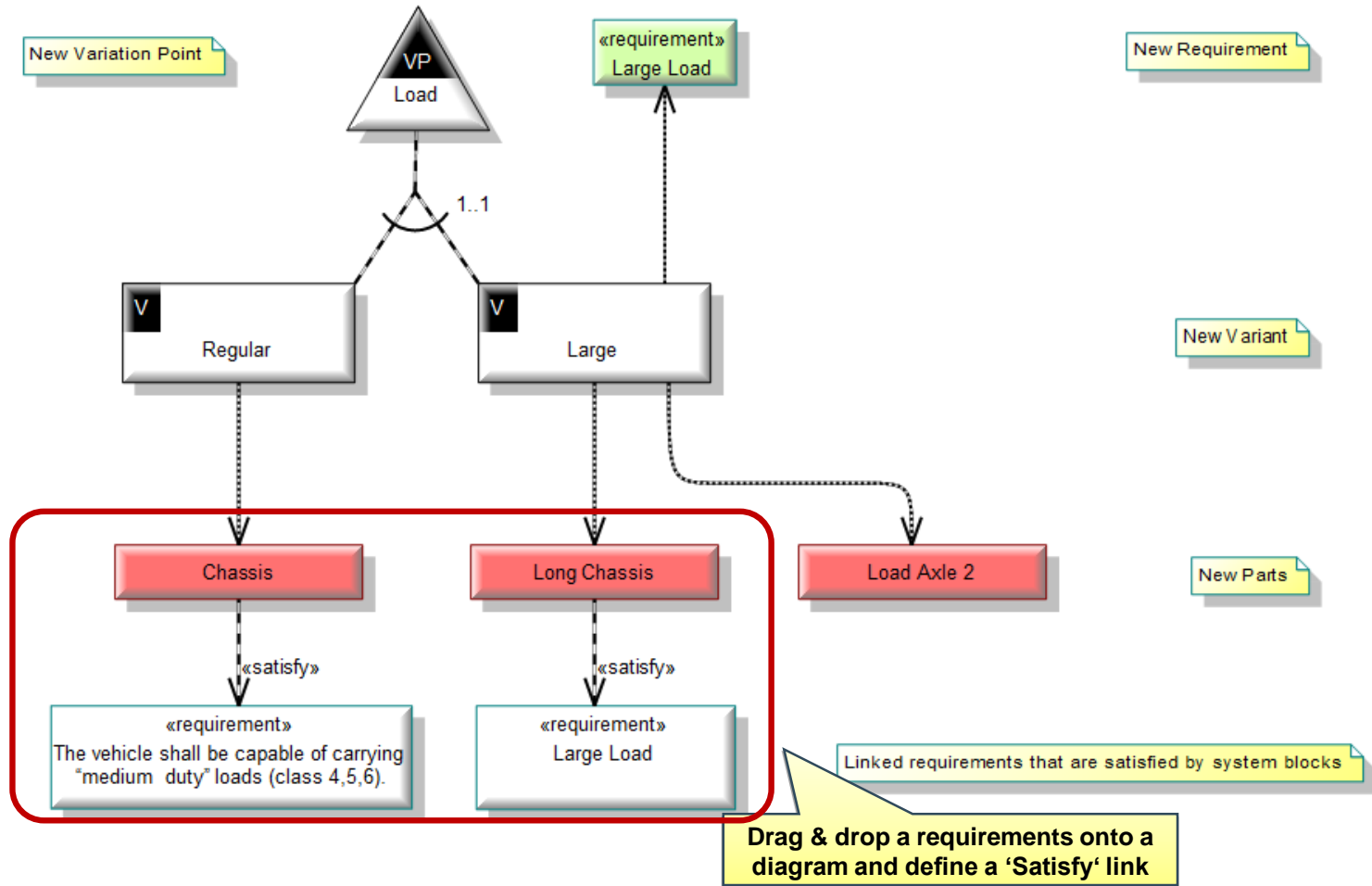
The resulting 'Overloaded' System Model created by using previously created System Blocks, or reused Library Assets



Model Based Product Line Engineering ISO 26550

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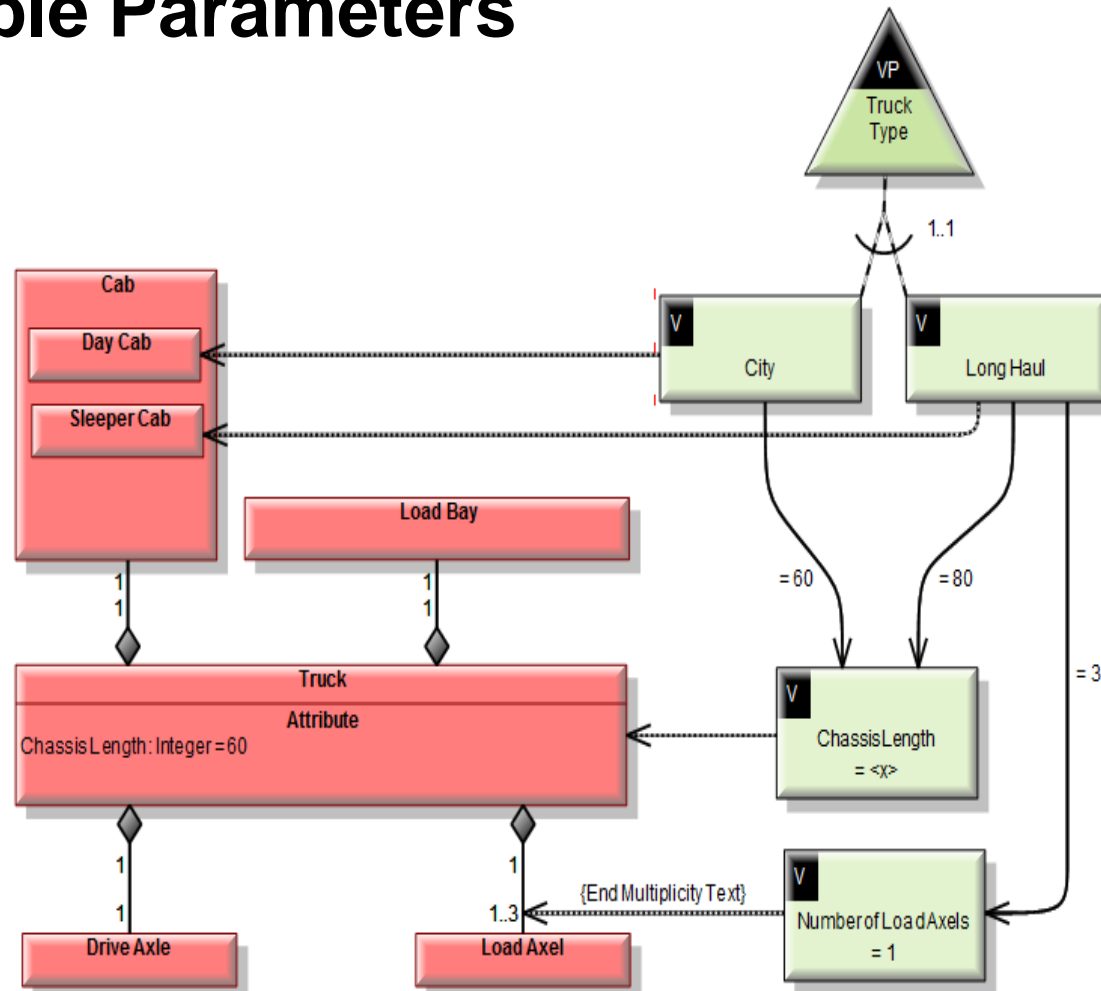
Orthogonal Variability Modeling (OVM)



Model-based Product Line Engineering

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Variable Parameters



Generate the Product Model

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Use the Variant Selector to create a Product Model

The screenshot shows a software interface titled 'Truck Decision Set1'. On the left is a vertical list of product attributes, each with a green checkmark: Accomodation (None), Fuel (Gas), D Tank Volume, Gas Tank Volume, Length (48), Load (Large), Temp Provider (Physical), and Transmission (Automatic). A red box highlights a 'Create Product Model' button in the top toolbar, with a yellow callout pointing to it. A large white speech bubble in the center contains the text 'Make your decision for each Variant:' and three buttons: a question mark, a green checkmark, and a red X. On the right, a 'D Tank Volume' panel shows four options: 'D 32 Gallons', 'G 34 Gallons', 'G 48 Gallons', and 'D 52 Gallons'. Each option has three buttons: a question mark, a checkmark, and an X. A progress bar below this panel shows '(6/8)'. At the bottom, a confirmation dialog box asks 'Are you sure you want to Create Product Model?' with 'Yes' and 'No' buttons. A mouse cursor is clicking the 'Yes' button.

Truck Decision Set1

Create Product Model

Accomodation
✓ None

Fuel
✓ Gas

D Tank Volume

Gas Tank Volume
✓

Length
✓ 48

Load
✓ Large

Temp Provider
✓ Physical

Transmission
✓ Automatic

Make your decision for each Variant:

?

✓

✗

D Tank Volume

✗

?

✓

✗

D 32 Gallons

?

✓

✗

G 34 Gallons

?

✓

✗

G 48 Gallons

?

✓

✗

D 52 Gallons

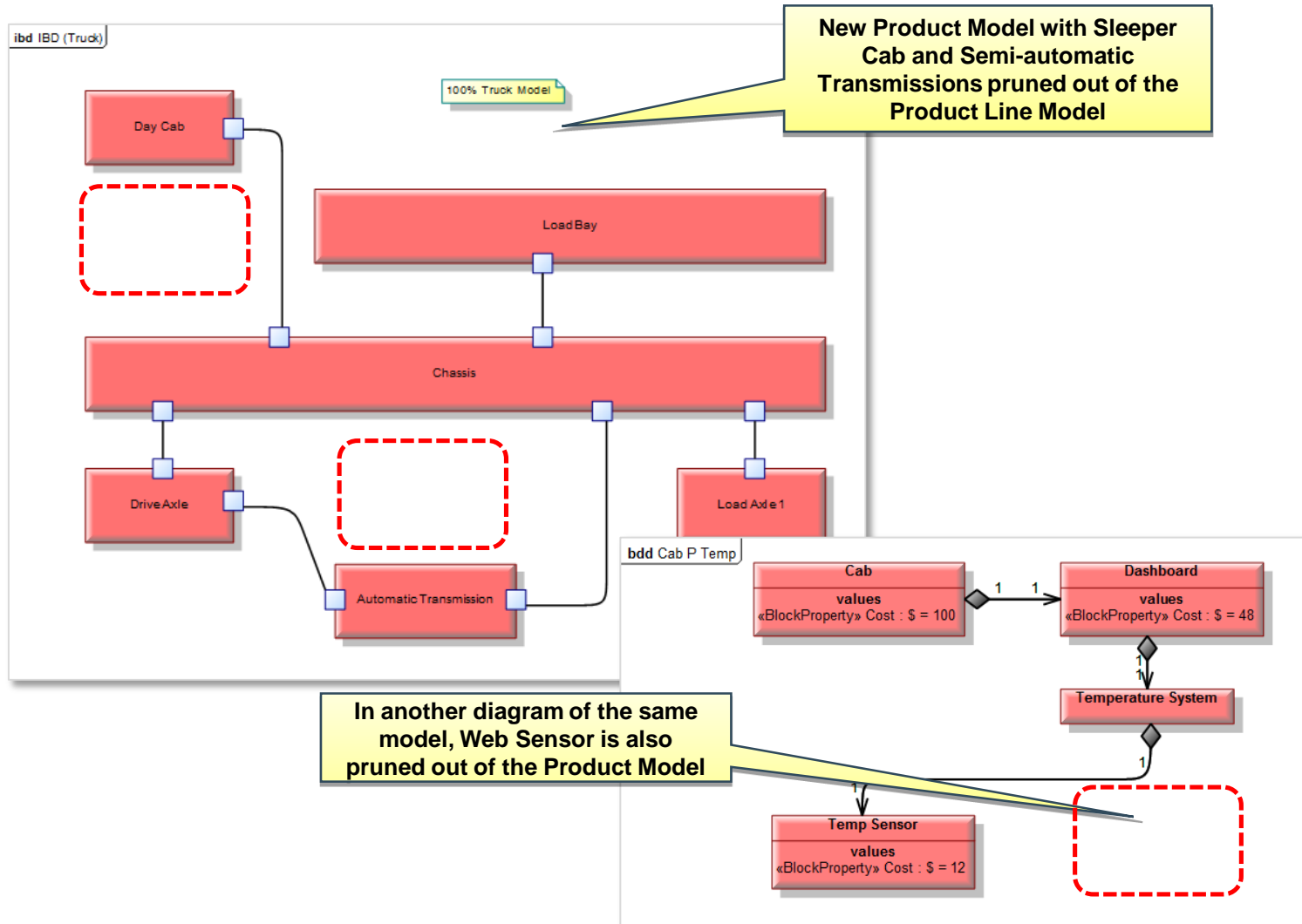
(6/8)

Are you sure you want to Create Product Model?

Yes No

The Generated Product Model

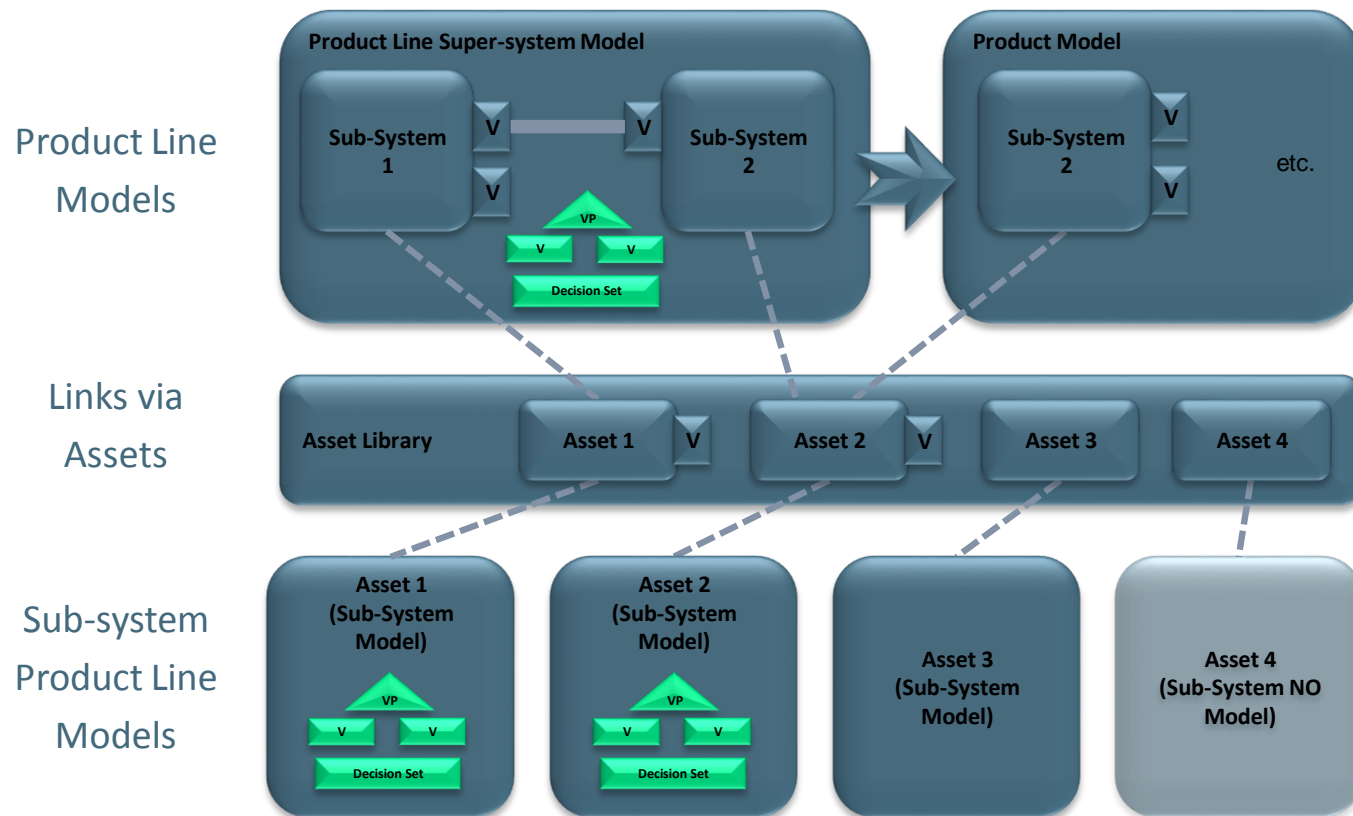
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Model- Based Product Line Engineering

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- Integrated MBSE, Modular Design & Variability Modeling = Model-based Product Line Engineering



Product Lifecycle Management

Product Lifecycle Management (PLM)

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- Product lifecycle management (PLM) is the process of managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products. PLM integrates people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise.
- Within PLM there are five primary areas;
 - Systems engineering (SE)
 - Product and portfolio m² (PPM)
 - Product design (CAx)
 - Manufacturing process management (MPM)
 - Product data management (PDM)

Current SysML / MBSE limitations

- SysML tools lack integration with other engineering tools and requirements management systems
 - Lack of standardized interfaces
 - Immaturity of model exchange
 - Problems handling large sets of structured requirement
- Lack of representation of artefacts from important disciplines:
 - Mechanical CAD, Geometry
 - Electrics, Electronics (ECAD)
- Insufficient support for the re-use for system models
- No encapsulation of SysML models
 - To support model assemblies like in 3D CAD
 - To build model libraries
 - To exchange model patterns
- Lack of variant-, configuration, and change management
- Lack of information traceability throughout the whole lifecycle, including maintenance, disposal

Facets of PLM-MBSE integration

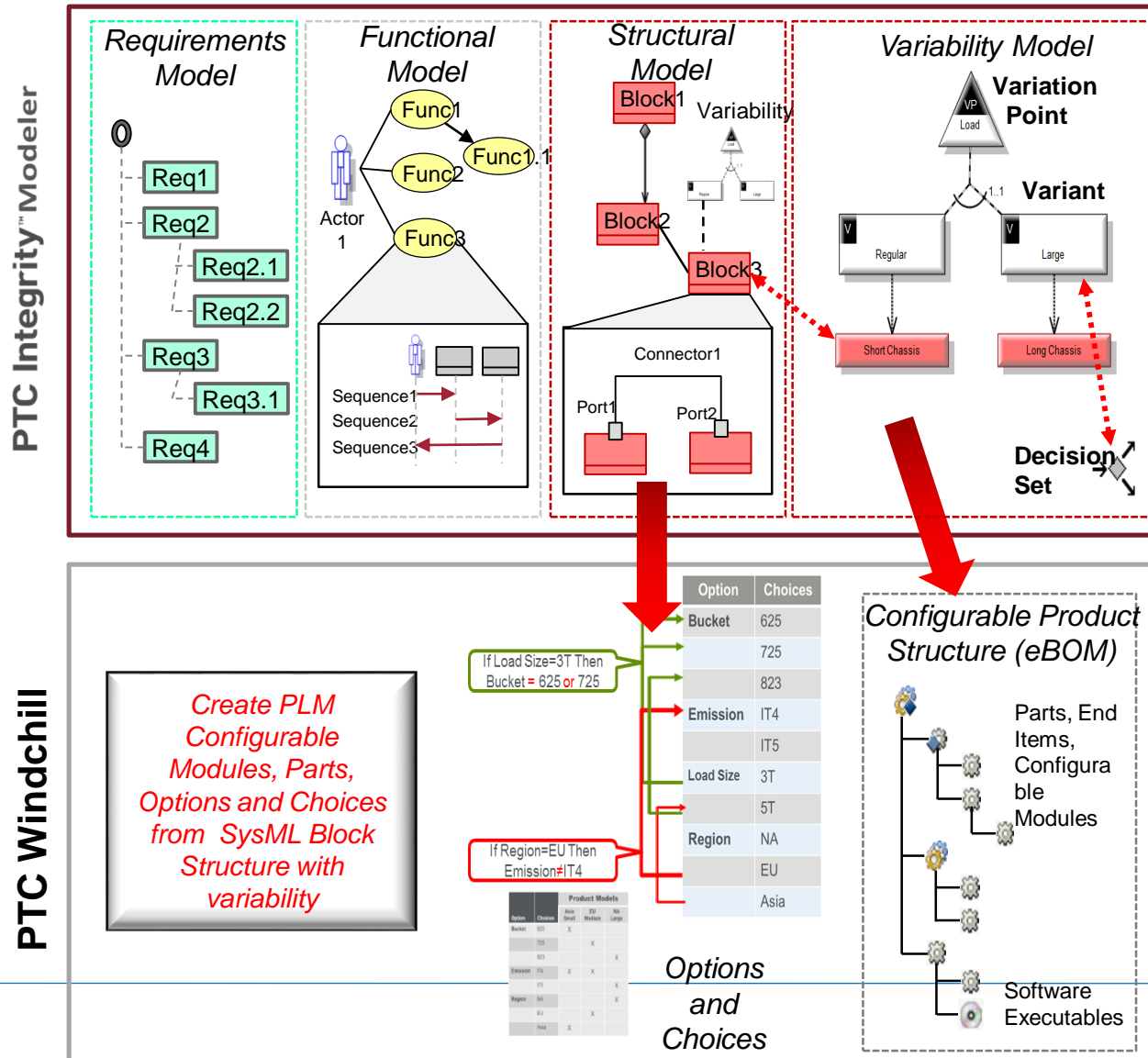
Or: fundamental issues in product development that need to be solved

- Need for a holistic integrated system model
 - Multidisciplinary development needs common language
- Traceability
- Complexity management
 - Large sets of requirements
 - Many dependencies between system components
 - Collaboration between many development teams
- Co-Simulation
- Increase comprehensibility of a product/system
- Integration of enterprise and business aspects
 - Enterprise architecture
 - Business objectives
- Support for collaboration in MBSE
- Support management of MBSE artefacts

- ? Product line engineering = ALM

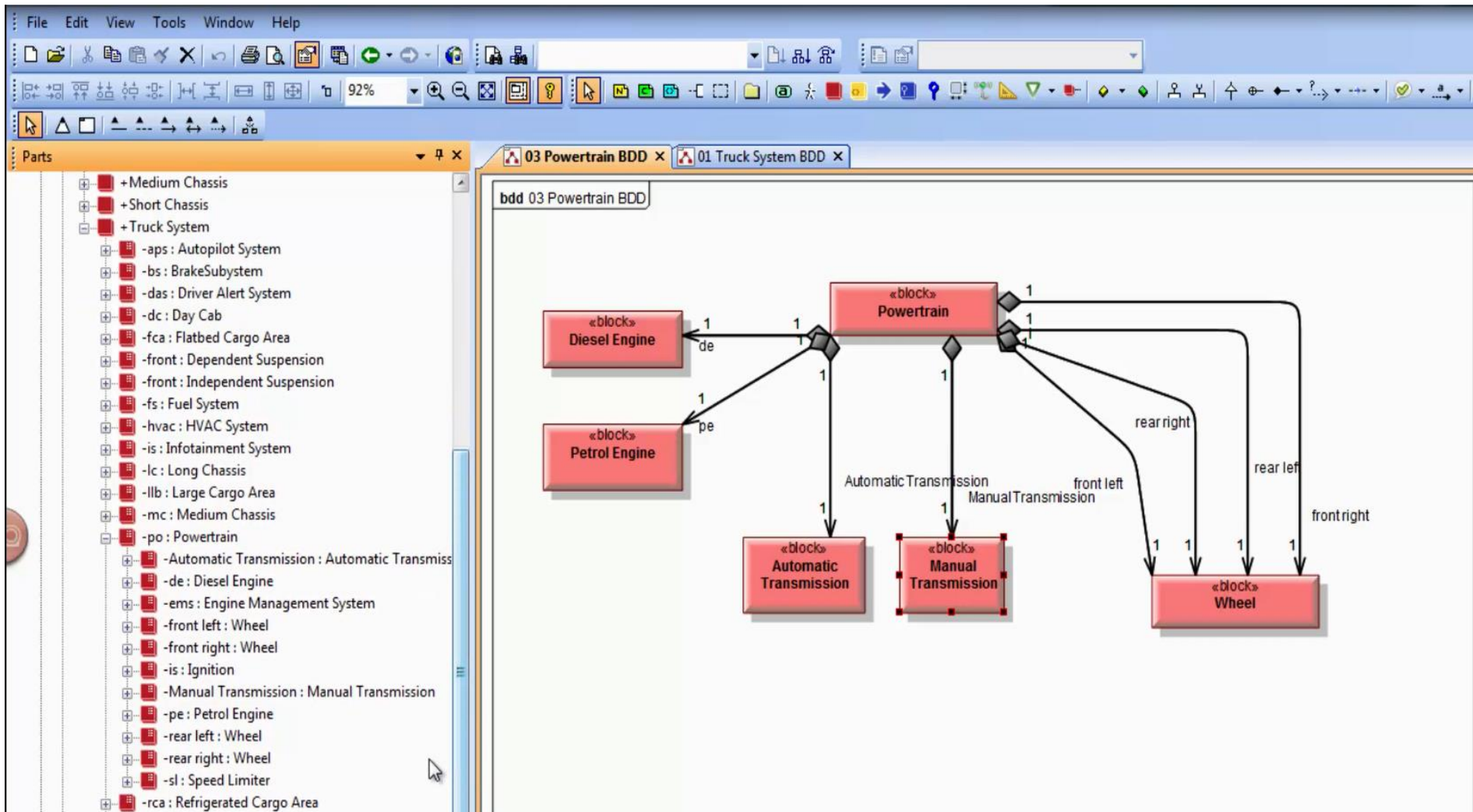
MBSE to PLM Productivity – High Level SCENARIO

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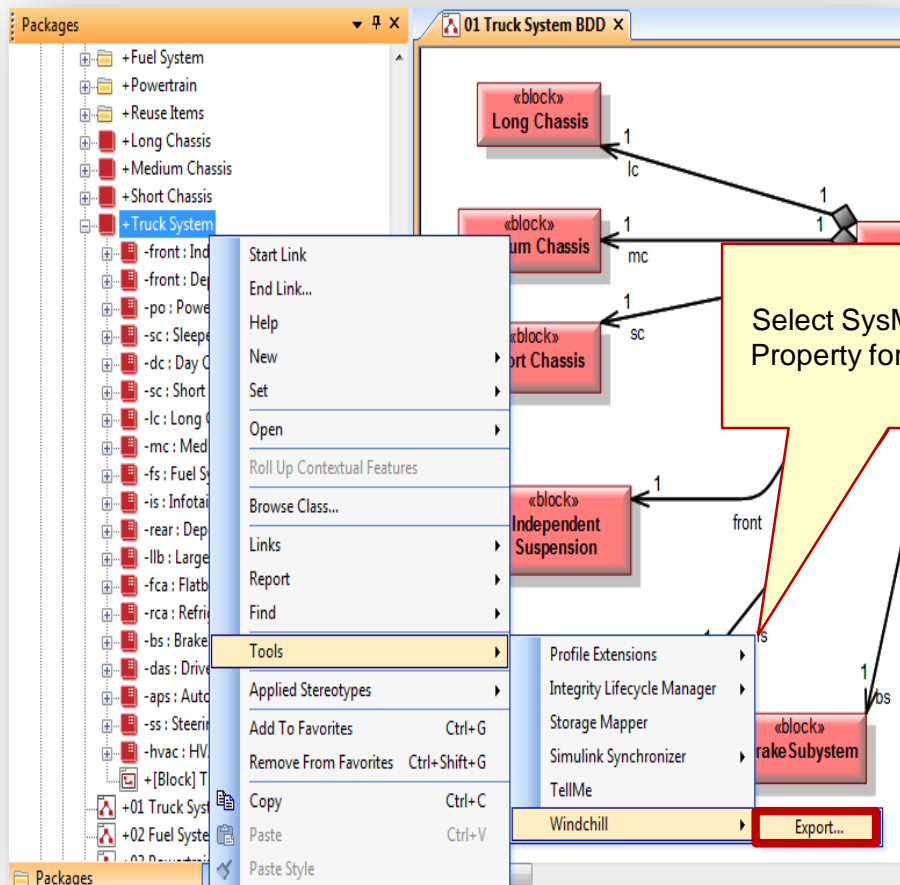
Model and Part Structure in SysML

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Export of MBSE Parts List to PLM

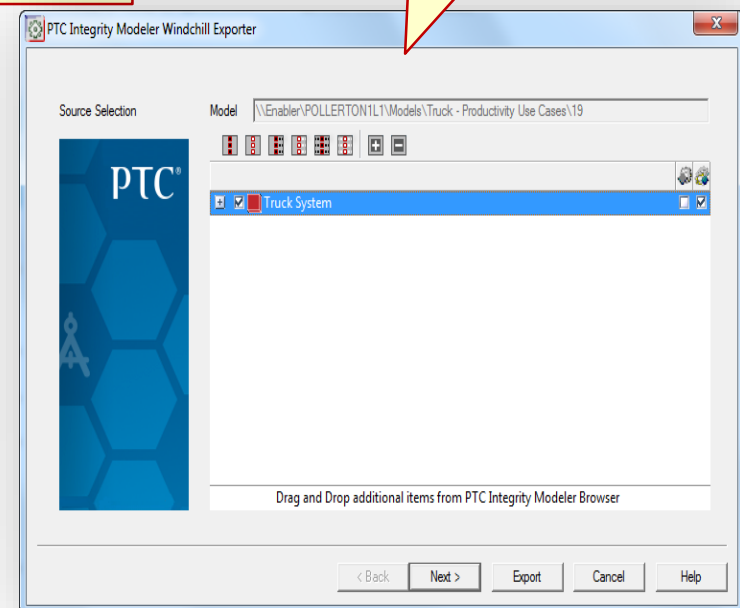
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Select SysML Block/Block Property for export to PLM

Export tool will launch
with the selected item
and it's Block Properties

Can also be a Variation Point



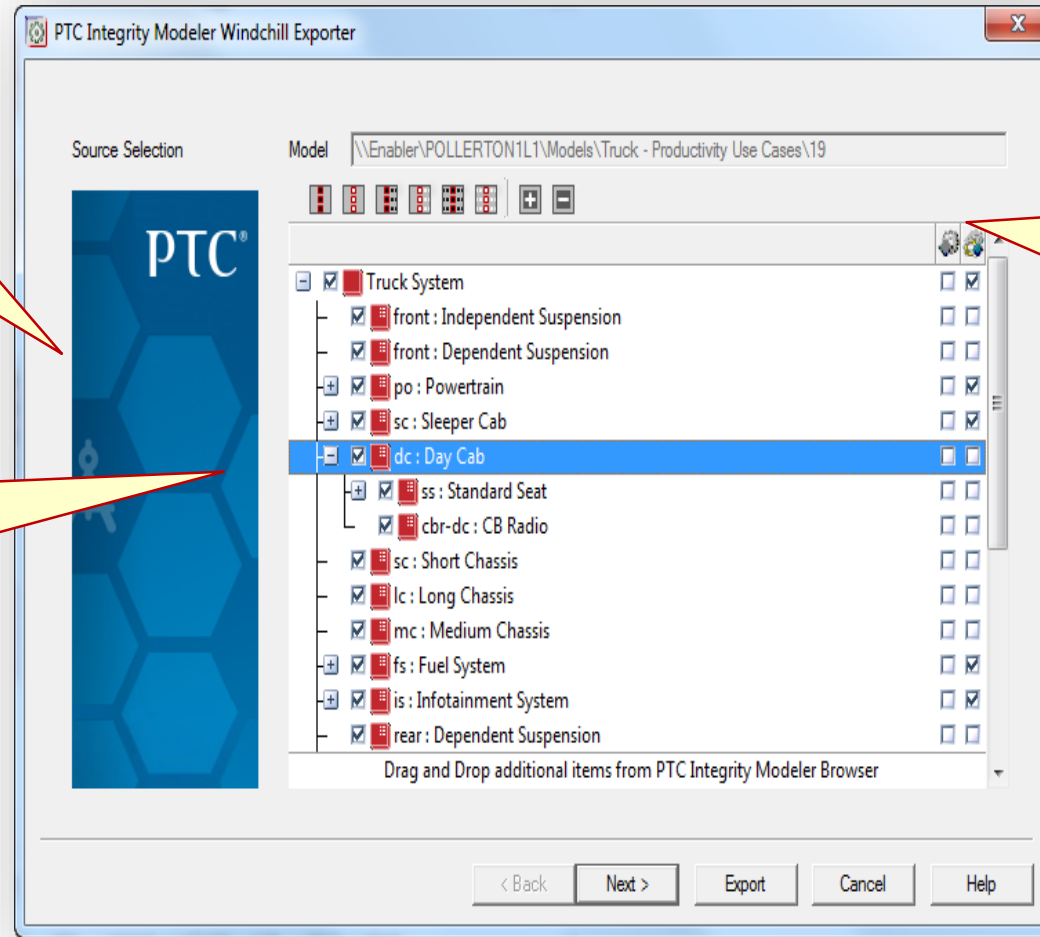
MBSE to PLM Selection of Parts

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Review and confirm the items selected for export
Drag and drop additional items from standard Modeler Browsers

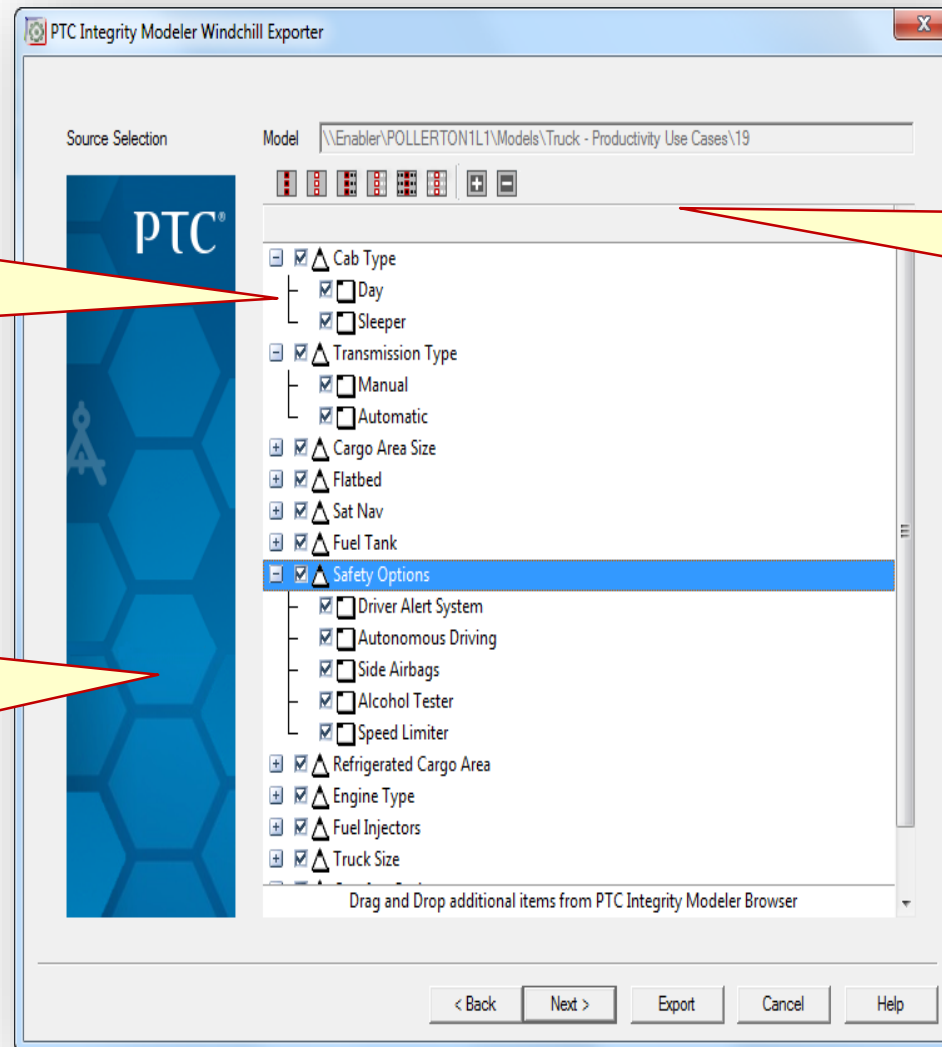
Structure can be expanded/collapsed
Items can be marked as included/excluded for export

Items can be defined as Windchill PDMLink End Items or Configurable Modules



Export of MBSE Variability to PLM

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If the included Blocks/Block Properties have related variability items, they are automatically included in step 2 of the Exporter

Review and confirm the variability items selected for export

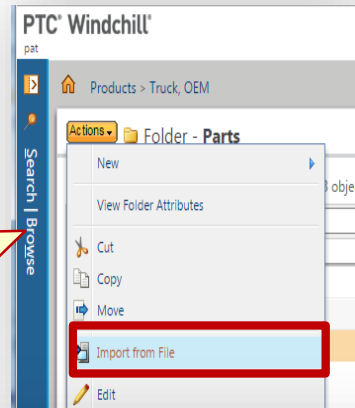
Structure can be expanded/collapsed

Items can be marked as included/excluded for export

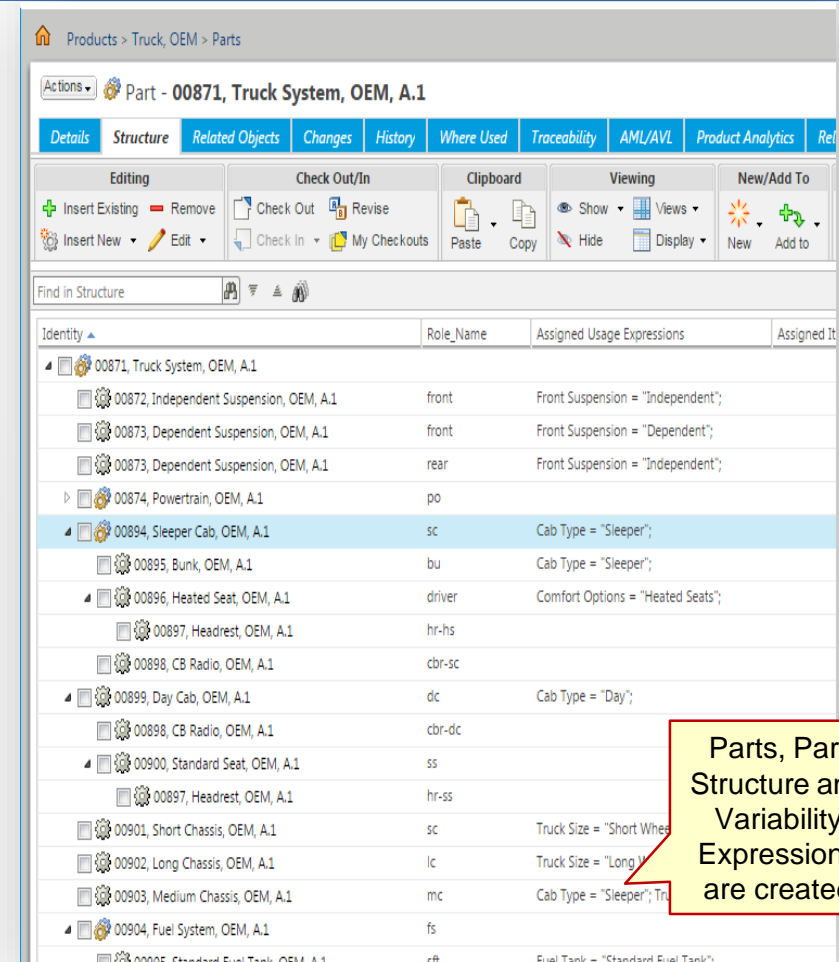
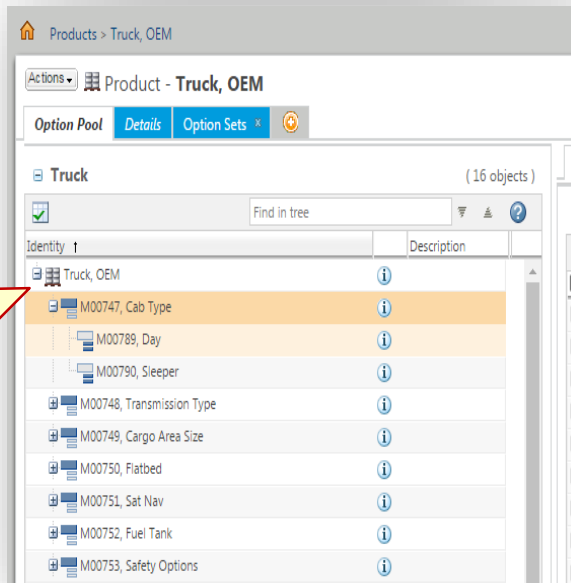
MBSE and PLM Traceability

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MBSE SysML
Structure is
Imported into
PLM



Options,
Choices and
Option Set
are created



Parts, Part
Structure and
Variability
Expressions
are created

MBSE and PLM Bi-Directional Traceability

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PTC® Navigate™ Manage Traces

Trace Implement Apply Import

Bookmark: HSUVStructure Add Delete

Name	Type	Description
HSUVStructure	Package	
HSUVFlowSpecs	Package	
HSUVDataTypes	Package	
HSUVInterfaces	Package	
PowerControlUnit	Block	
ChassisSubsystem	Block	
FuelRegulator	Block	
BatteryPack	Block	
LightingSubsystem	Block	
Road	Block	
ExternalObject	Block	
Weather	Block	
PowerSubsystem	Block	
Differential	Block	
BrakePedal	Block	
AutomotiveDomain	Block	
FuelRail	Block	

Number	Name	Version
00022	PowerSubsystem	A.1
00024	BatteryPack	A.1
00035	ElectricMotorGenerator	A.1
00029	Differential	A.1
00027	PowerControlUnit	A.1
00036	CAN_Bus	A.1
00028	ElectricalPowerController	A.1
00023	accelerator	A.1
00031	InternalCombustionEngin	A.1
00025	FuelTankAssembly	A.1
00030	Transmission	A.1

Details Traces View

Block

Field	
Description	
Id	MProvhhttp://uk-che-devm-123.atego.test:57851/ModelerServ
FullScopedName	HSUVModel:HSUVStructure:FuelRegulator
Name	FuelRegulator
IsAbstract	FALSE

Details Traces

Number 00035

Name ElectricMotorGenerator

Version A.1

State In Work

Close

Browse
Modeler data
and select
items

Select items
on both sides
and click
Apply to
create new
trace links

View details
and existing
traces for
selected item

MBSE and PLM Bi-Directional Traceability

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Trace Links can be viewed in PLM Traces tables

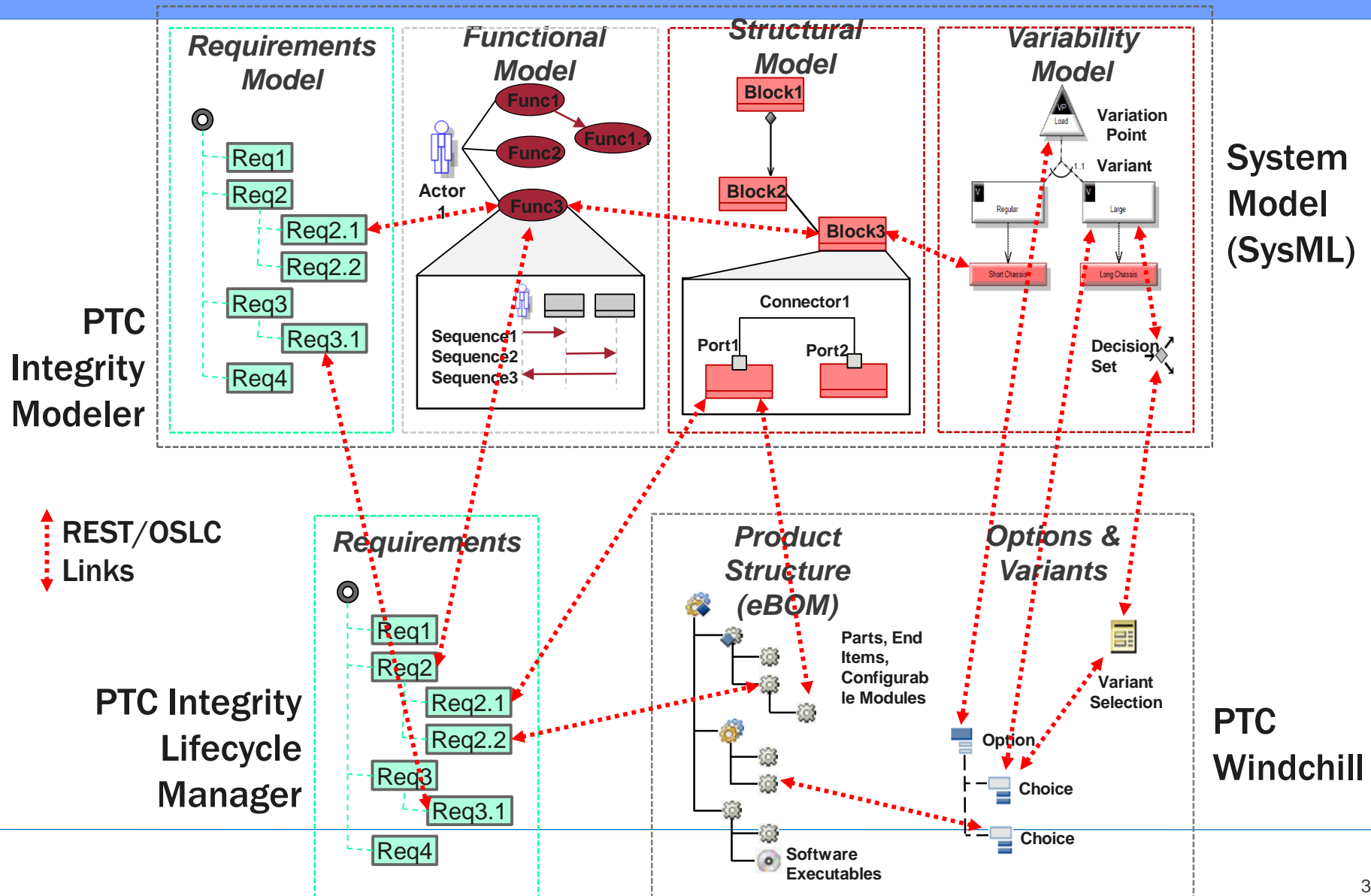
The screenshot displays a PLM software interface for a part named '00022, PowerSubsystem, A.1'. The 'Traces' tab is selected, showing a table of trace links. A red box highlights the 'Traces' tab in the top navigation bar. A yellow callout box points to the 'Traces' tab with the text 'Trace Links can be viewed in PLM Traces tables'.

Identity	Role Name	Assigned Item	Assign
00022, PowerSubsystem, A.1			
00023, accelerator, A.1	acl		
00024, BatteryPack, A.1	bp		
00025, FuelTankAssembly, A.1	ft		
00027, PowerControlUnit, A.1	ecu		
00028, ElectricalPowerController, A.1	epc		
00029, Differential, A.1	dif		
00030, Transmission, A.1	trsm		
00031, InternalCombustionEngine, A.1	ice		
00035, ElectricMotorGenerator, A.1	emg		
00036, CAN_Bus, A.1	can		

Attributes	Uses	Occurrences	Supersedes	Traces
Traces All				
Identifier	Trace	Type	Version	
d83246cd-3126-40c6-a4fe-b44edb7480...	Implement	Architecture Resource		
(0 objects selected)				

PLE integration across ALM, Modeling and PLM

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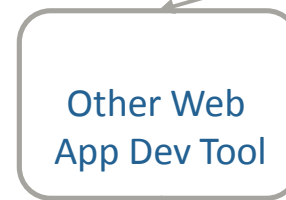
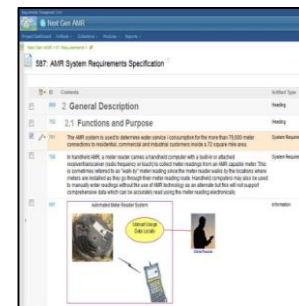
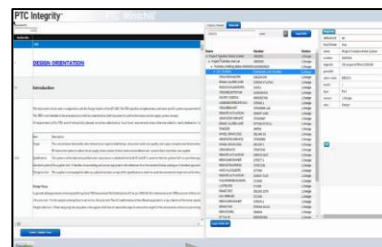
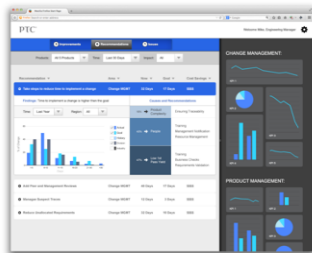
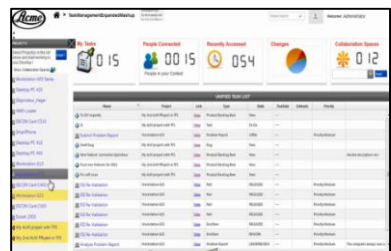


Integrated MBSE – PLM - ALM

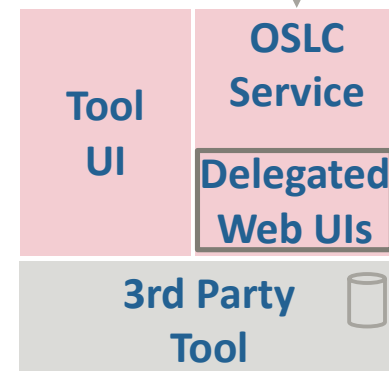
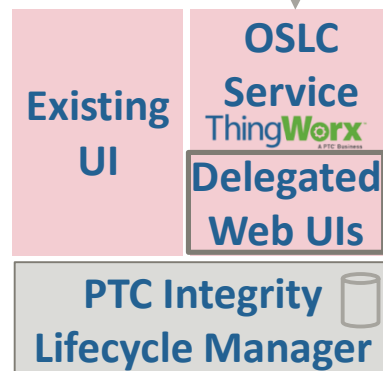
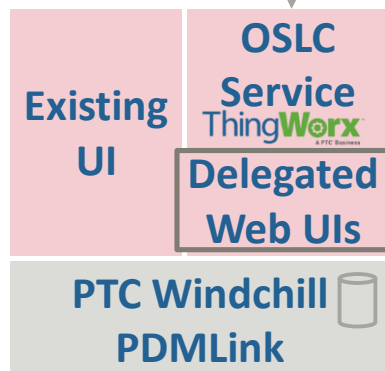
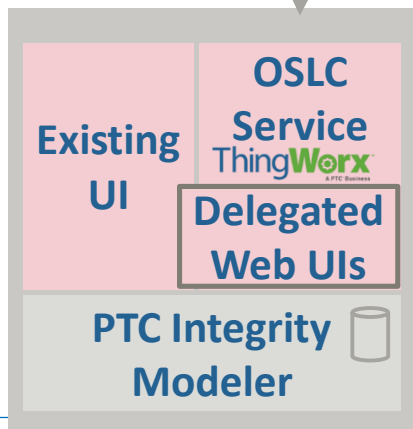
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OSLC

Task Based Web Apps (single or multiple data sources)



REST Architecture

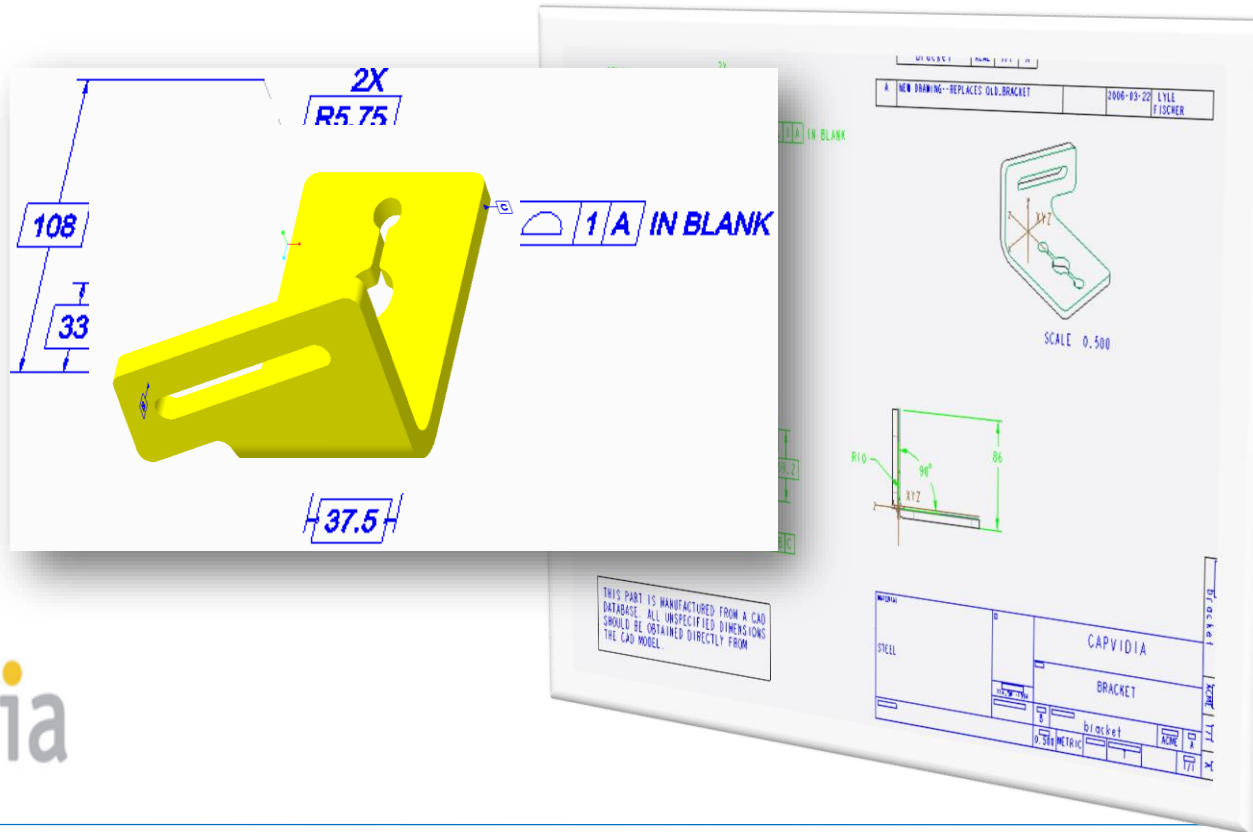


MBDVidia for PTC Creo

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2D/3D Annotation Synchronization

- Adds missing annotations from drawing to 3D model
- Corrects incomplete/incorrect annotations
- Creates combined states on 3D model from each drawing view
- Creates 3D cross sections from 2D cross sections
- Checks consistency between 2D & 3D annotations



capvidia

LINKING DIGITAL ASSETS TO THE REAL WORLD

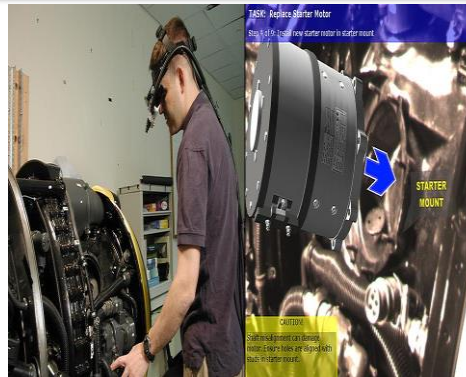
According to a study last year by Boeing and the University of Iowa, Augmented Reality can...

- Increase first-time fix rate by 90%
- Speed procedures by 30%



Visualize

Enhance the user's view of the physical world with the overlay of **actual** or **hypothetical digital** information



Instruct

Train or guide users on how to perform a task through the overlay of **graphical instructions** or **real-time expert guidance**

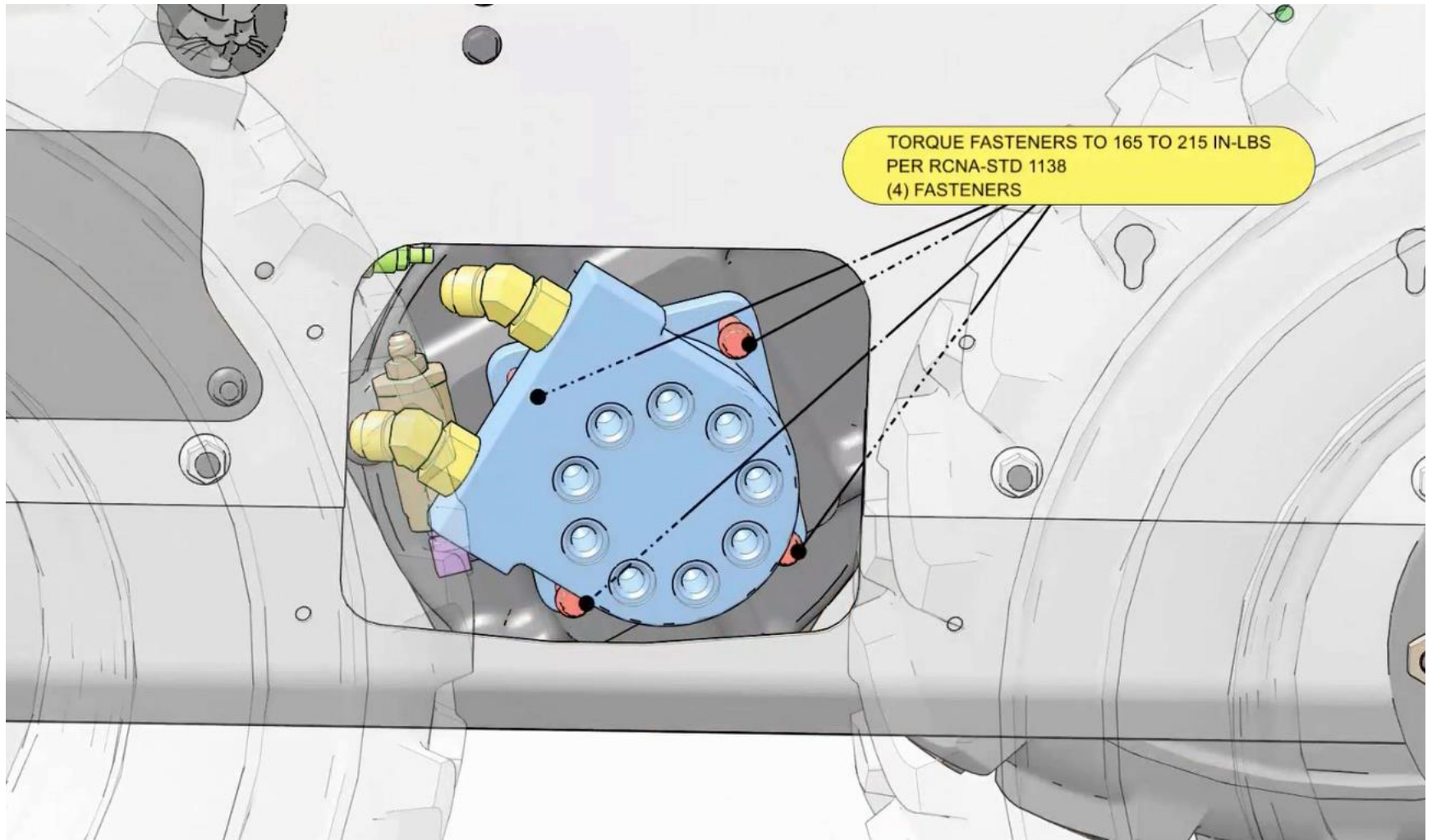


Interact

Manipulate digital information with natural user interfaces or **control** a product through an **augmented digital user interface**

Virtual Reality

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Augmented Reality

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- **Stop by the PTC booth for a demonstration.**



Service Lifecycle Management Portfolio

Connecting Products & Services

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Service Information

Create, Manage, Deliver, and Advise



Service &
Parts
Information



Service Knowledge
and Diagnostics

Service Event

Management & Execution



 **servicemax**
Field Service Management

Service Parts

Optimization



Service Parts
Management



Service
Parts
Pricing



Service
Network
Management

Smart, Connected Service for Smart, Connected Products

ThingWorx
A PTC® Business



Machine Learning



ThingWorx



ThingX (Augmented Reality)

Connected Service Applications



 **servicemax**
Connected Field
Service



Remote
Service



Connected
SPM



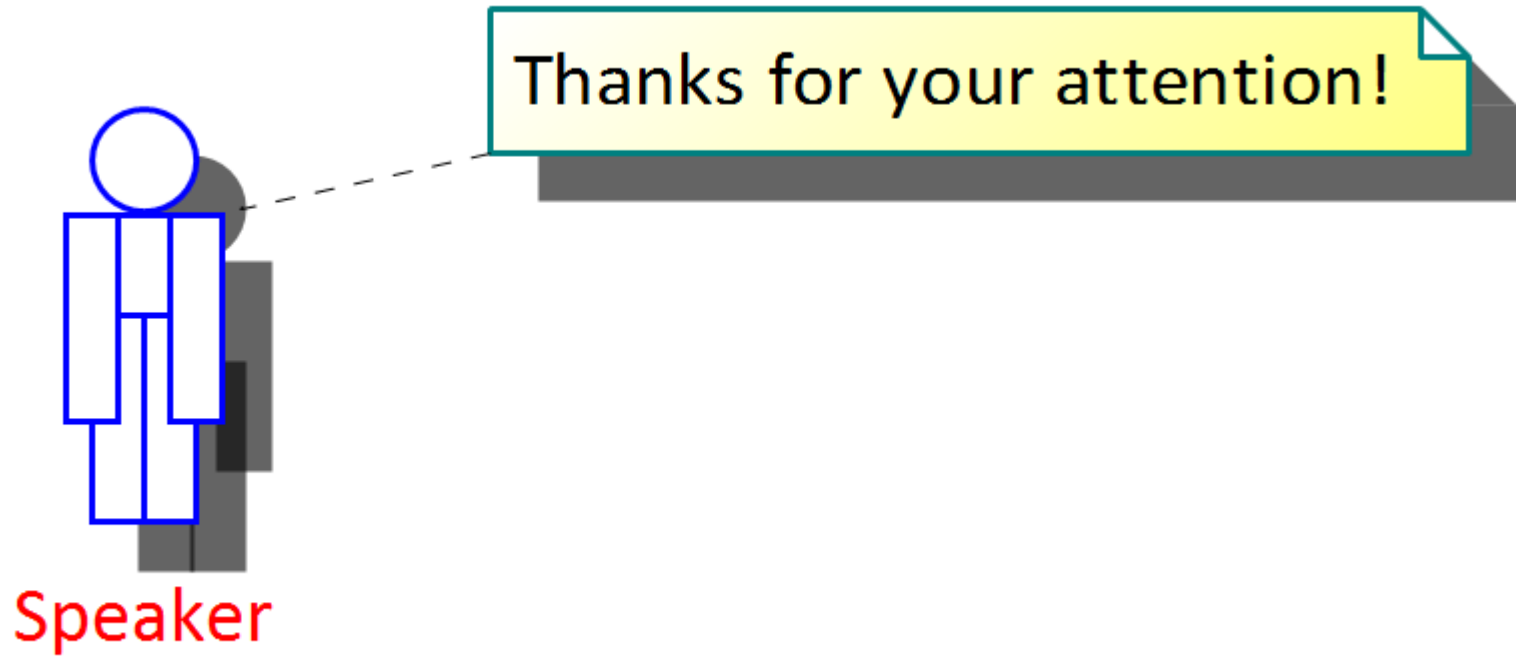
Equipment
Service



Predictive
Service

Questions and Answers

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