Designing Systems & Software for Smart, Connected Systems

An MBSE Approach to IoT

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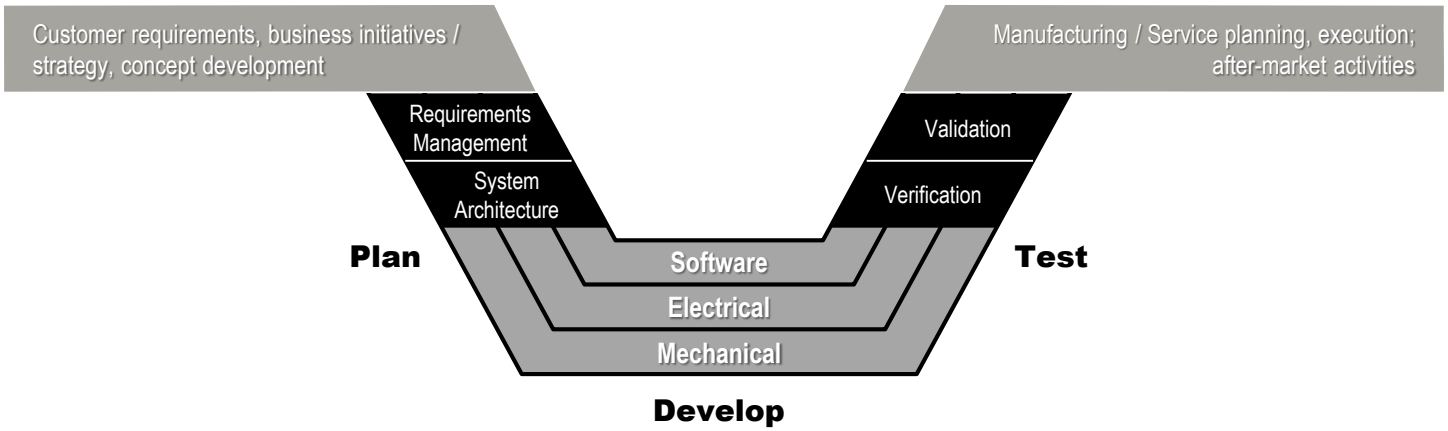
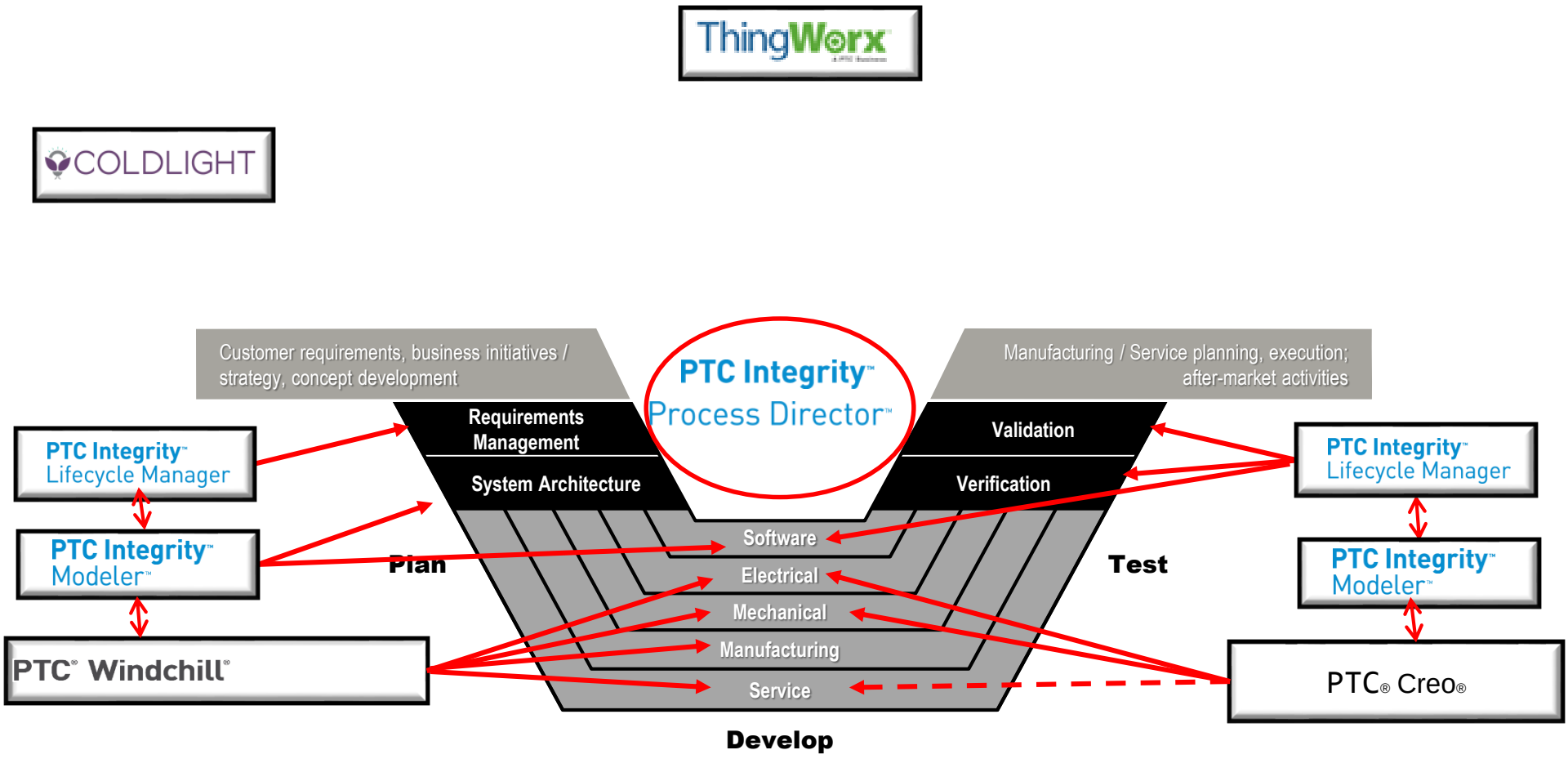
Agenda

- **PTC Vision of Smart Connected Systems**
- **Software/Systems Modeling (UML/SysML)**
- **Model transformation**
- **Product Line Engineering**
- **ThingWorx (IoT)**
- **Smart Connected System**
- **PTC ThingWorx Neuron**

Standard Systems Engineering “V”



Extended Systems Engineering “V”



PTC Integrity Modeler

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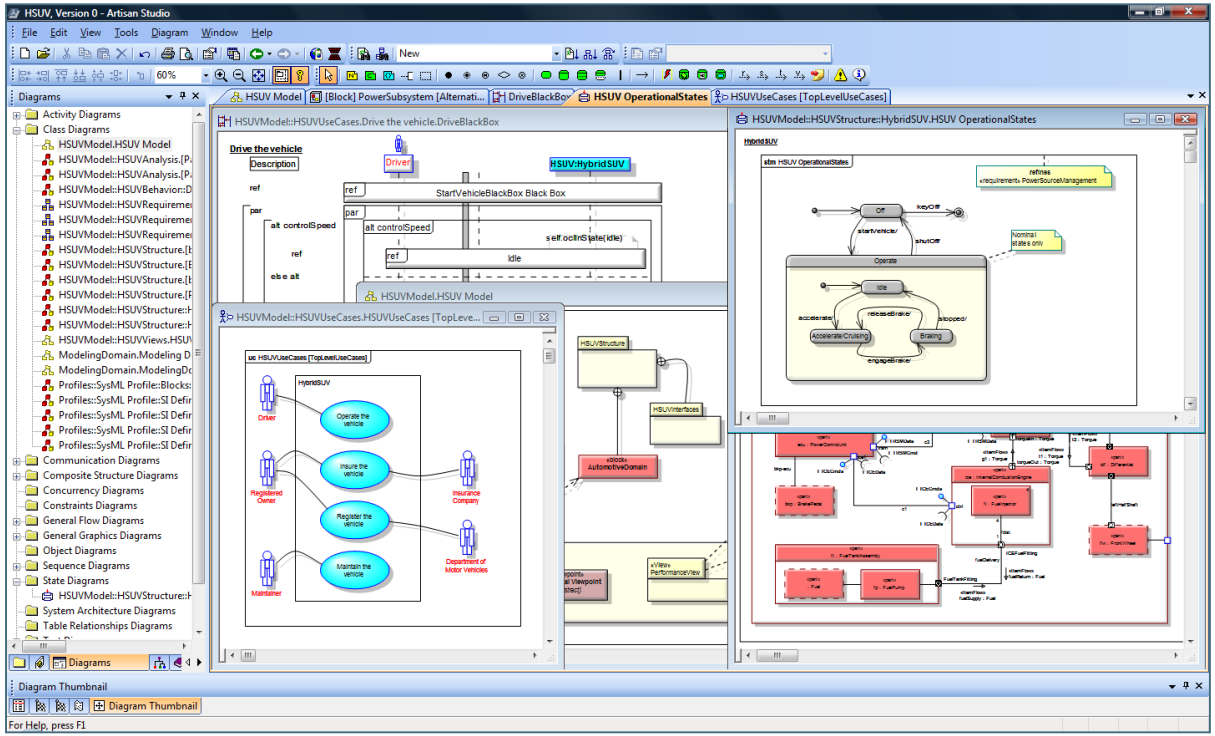
CAPABILITIES

- Scalable UML, SysML, UPDM
- Repository Collaboration
- Built-In Traceability
- Document Generation
- Automated Design Review
- System



BENEFITS

- Improved Quality through Early Design Review and Consistency
- Bring Systems to Market Faster with Parallel Design Effort
- Cost Reductions from Design and Development Automation

ELYSIUM Parker NORTHROP GRUMMAN BOEING GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2015

PTC Integrity Modeler - Lifecycle Manager Integration

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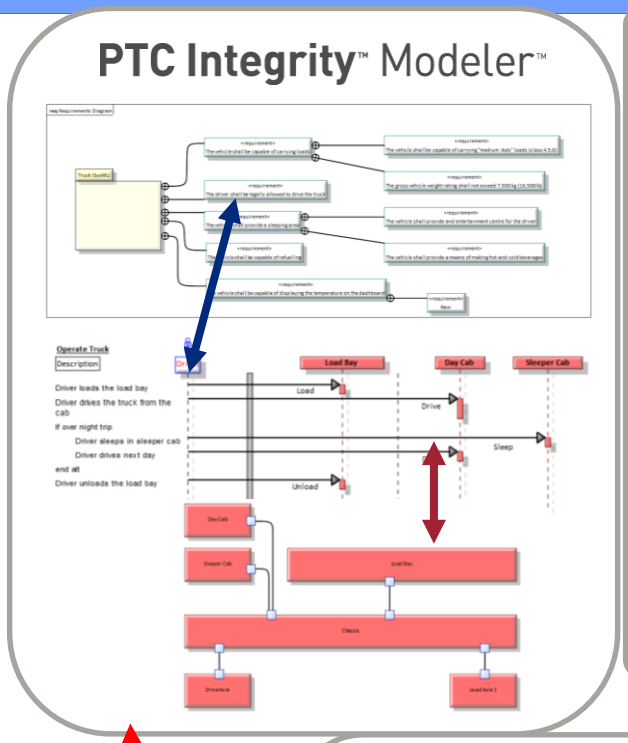
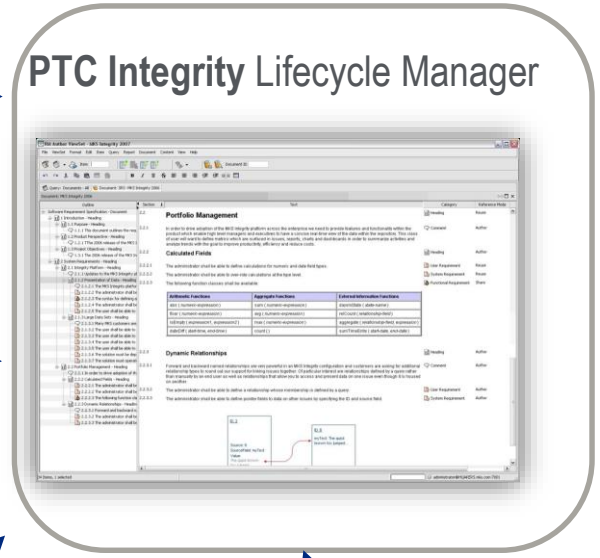


PTC Integrity Lifecycle Manager Synchronizer

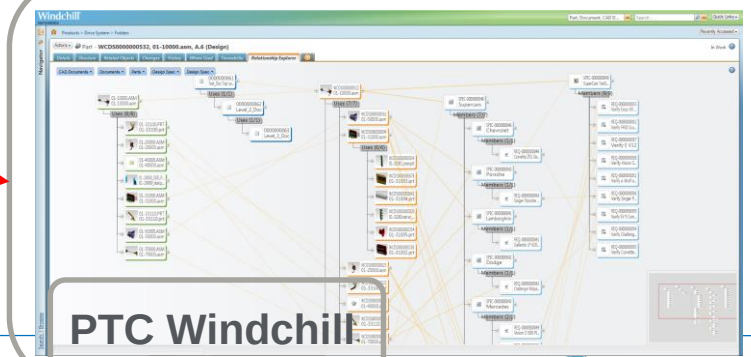
Requirements

Additional Model Elements

Model Trace Links



Requirements Software baselines



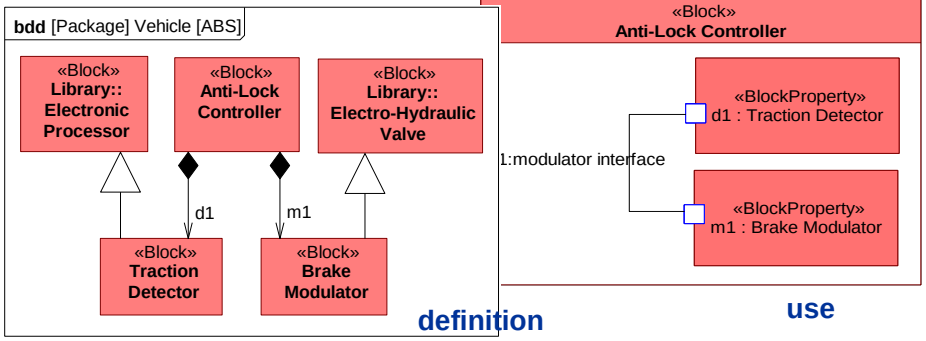
IBM Rational DOORS

PTC Integrity DOORS Adaptor

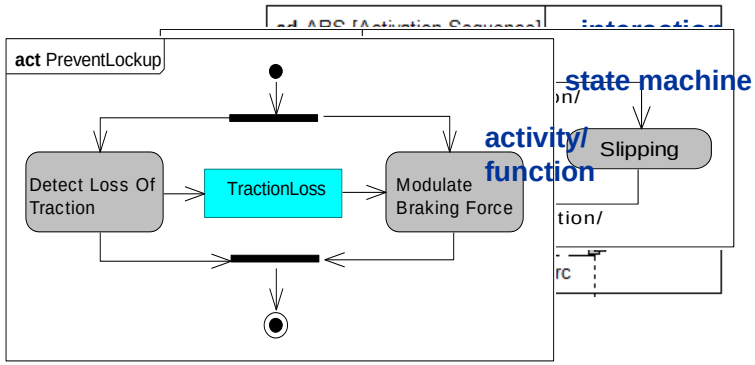
PTC Integrity Requirements Connector

The Four Pillars of Systems Modeling (SysML)

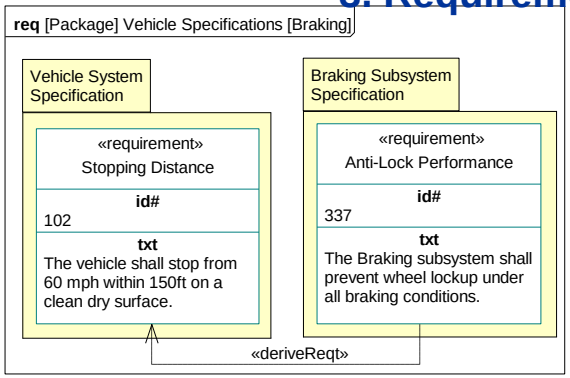
1. Structure



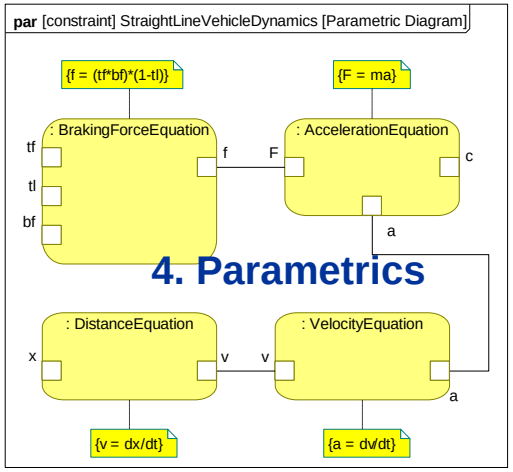
2. Behavior



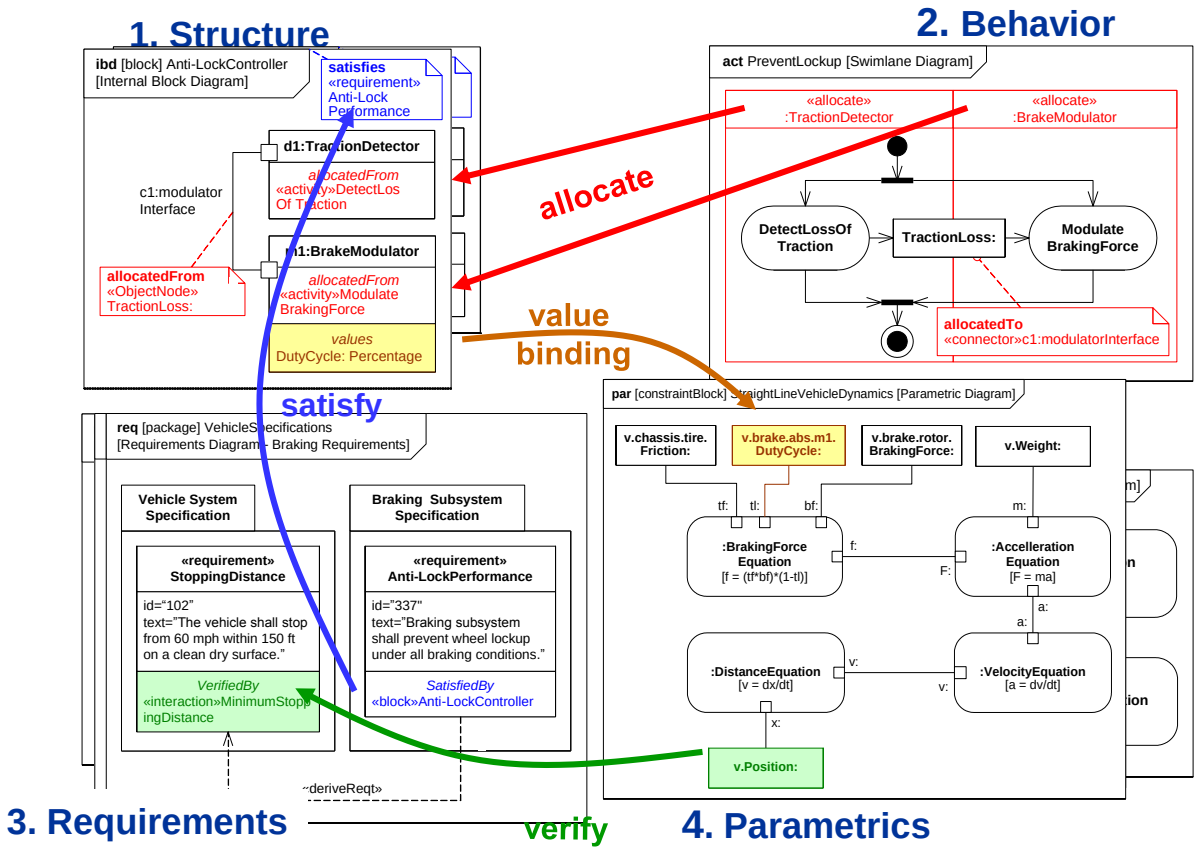
3. Requirements



4. Parametrics



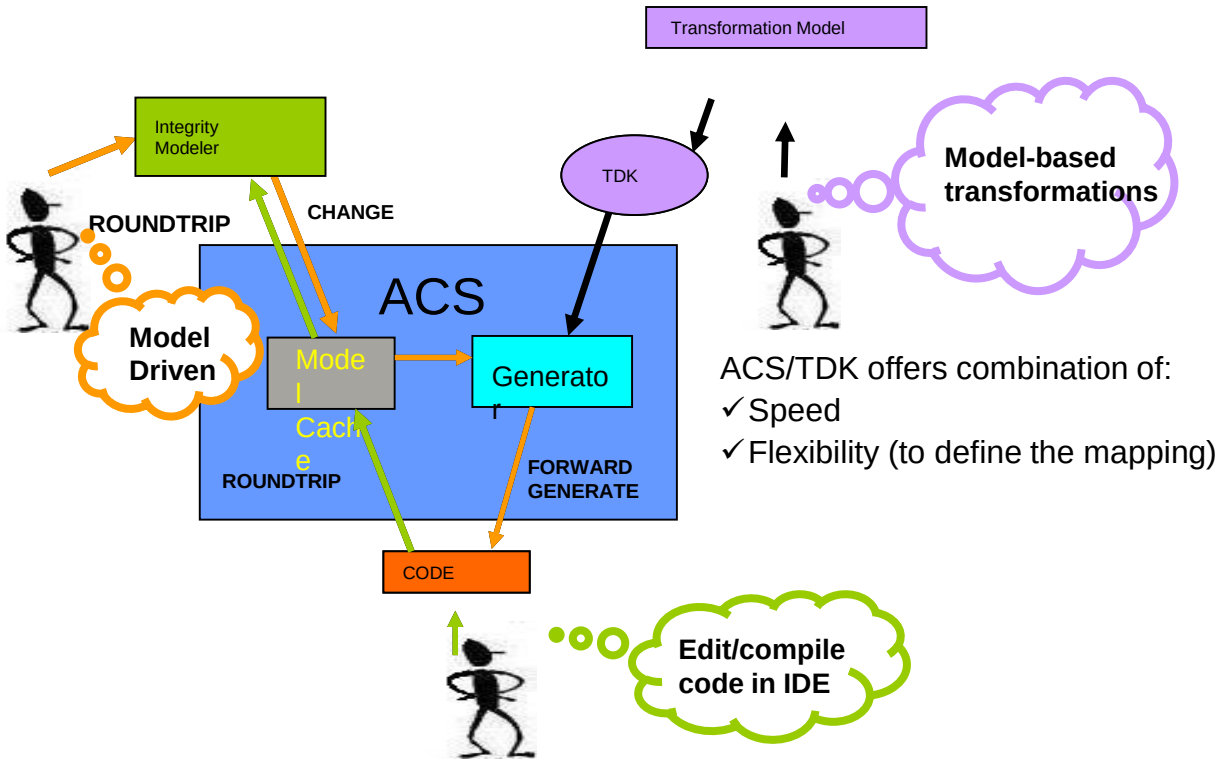
Cross Connecting Model Elements



Why use modeling tools?

Support the automatic generation of "things" from the model

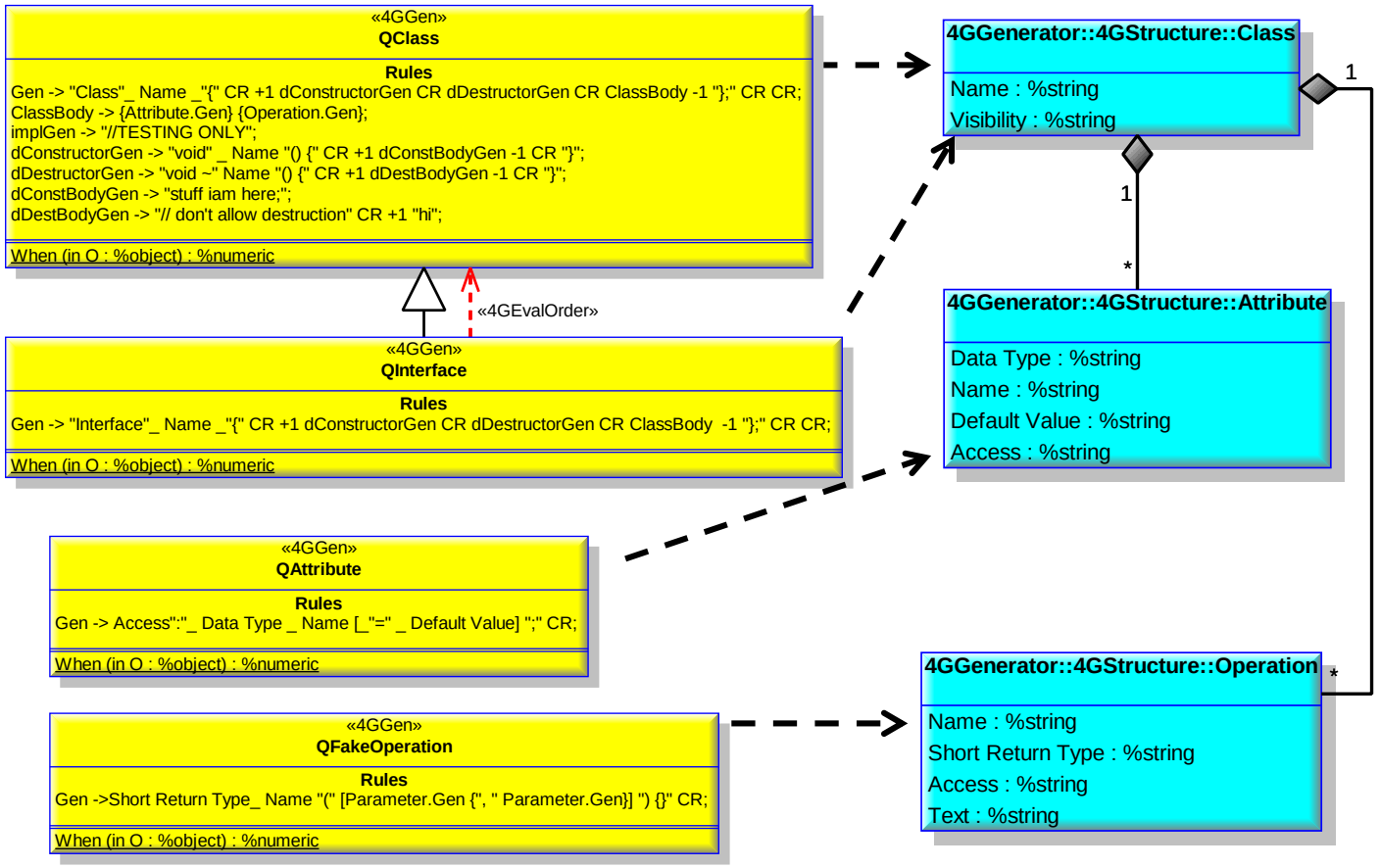
- Ada
- Java
- C/C++
- C#
- Visual Basic
- IDL/ IDL3+



ACS/TDK offers combination of:

- ✓Speed
- ✓Flexibility (to define the mapping)

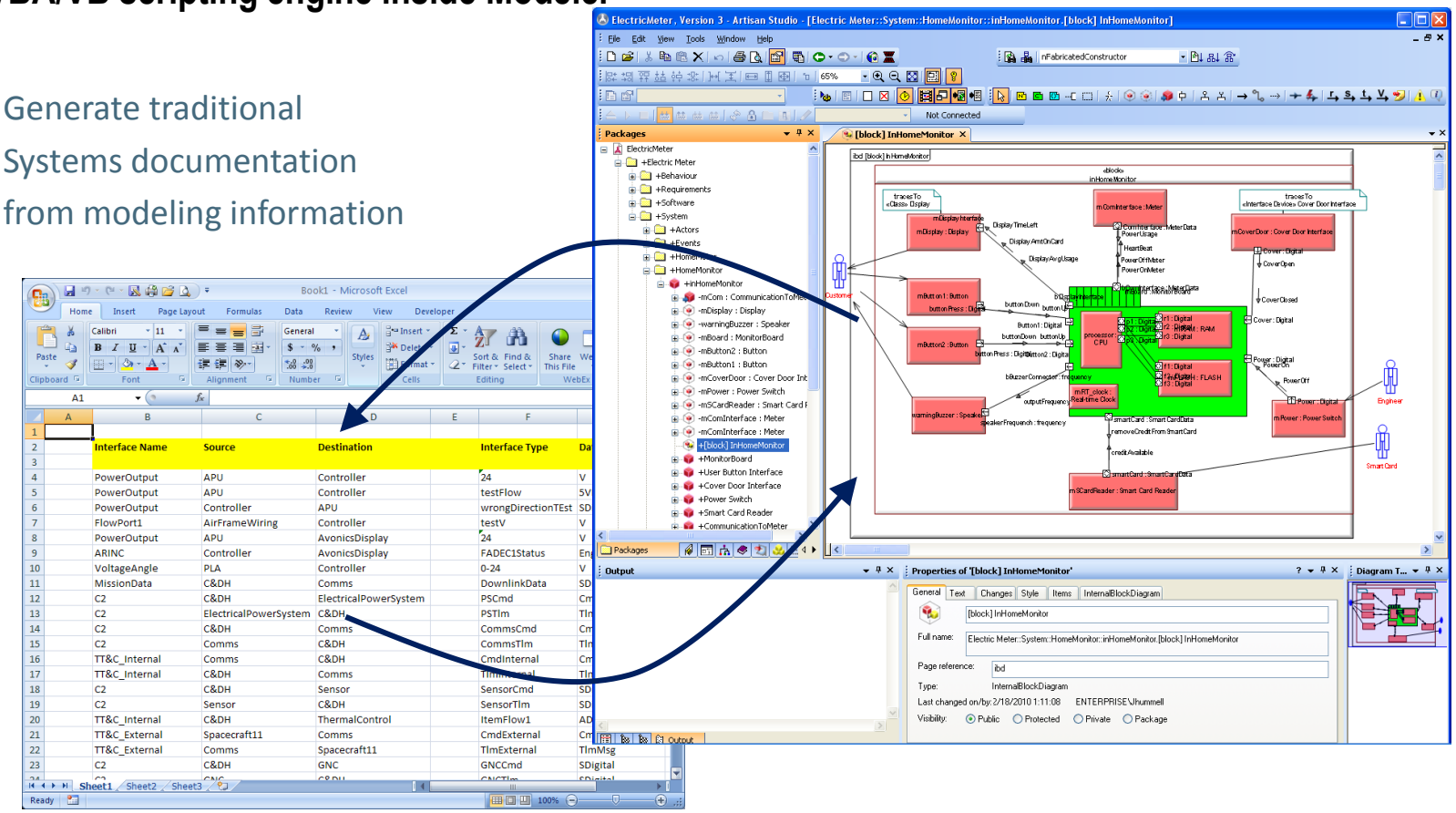
Code Generation Customization (Transformation Model)



Data Mining/Data Analysis (ICD Generator)

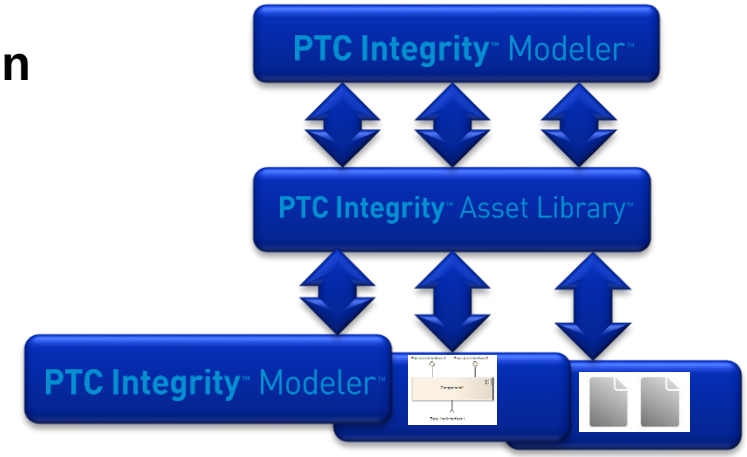
VBA/VB scripting engine inside Modeler

- Generate traditional Systems documentation from modeling information



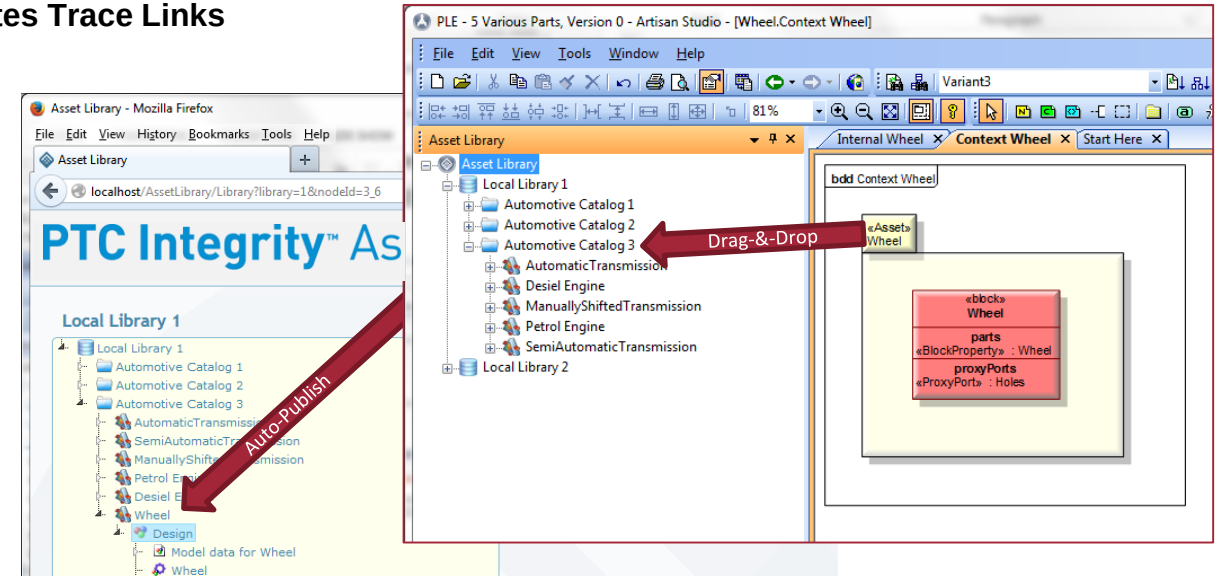
Asset-Based Modular Design

- **Design the same way you Build**
  - **Construct Systems of Sub-Systems (SoS)**
  - **Use Services to build your Application (SOA)**
  - **Plug Components together (CBD)**
- **Modular Design**
  - **Top-Down, Architected**
    - **Specification (& Requirements) Driven**
    - **Parallel Working**
    - **Separation of Concerns**
  - **Bottom-Up, Asset Mining**
    - **Un-modeled Assets**
    - **Other Modeling Tools**
    - **Legacy Integration**
    - **Published Interfaces (e.g. IDL)**



Asset-Based Modular Design

- **Publish from Sub-system model into PTC Integrity Asset Library**
  - **Auto-creates Trace Links**



System Product Line Engineering (PLE) Challenges

Product line explosion

- **Increasing number of product families**
- **Increasing number of products in families**
- **Understanding product similarity**
- **Maximizing reuse**
- **Understanding product variations**
- **Deciding between options**
- **Development cycle time**
- **Commercial product needs**
  - Customize existing capabilities to suit client requirements
  - Redeploy common systems & software to the Market
  - Time from requirements to cash

The Solution … Model-Based Product Line Engineering

Designing a single system platform rather than as creating a multitude of products

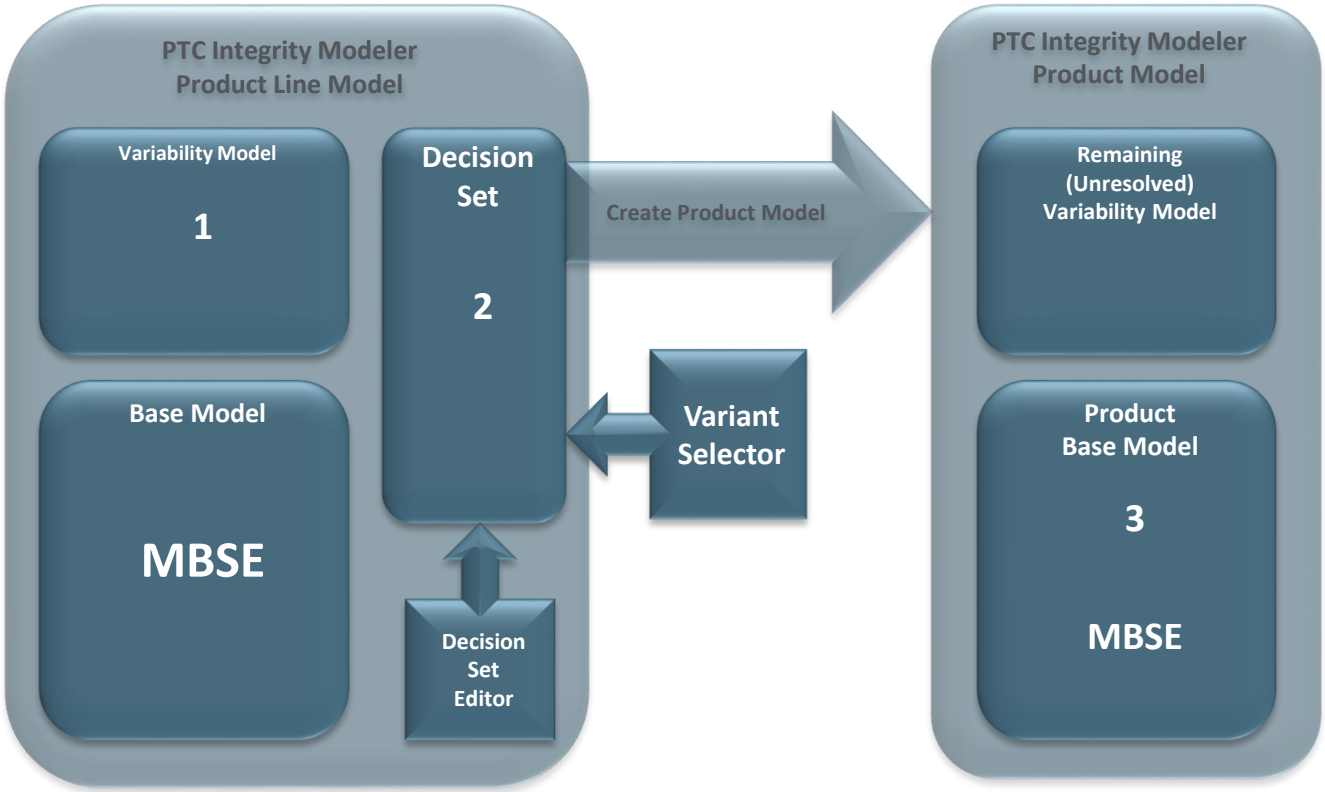
- **MBSE + Modular Design + Variation**
  - Common language improves
    - Communication
    - Collaboration
    - Stakeholder buy in
  - Architected modular design & reuse
  - System product lines designed up front
- **Maximum commonality & minimal variation**
  - Less duplicated effort with optimized reuse
  - Parallel working through 'design by contract'
  - More commonality between designs and implementations
  - Managed product line complexity
- **OVM Standards Based**
  - ISO 26550:2013 Software & Systems Engineering – Reference Model for Product Line Management & Engineering
  - PALUNO, The Ruhr Institute of Software Technology
  - Software Product Line Engineering (Pohl et al - Springer 2005)

OMG SYSTEMS MODELING LANGUAGE SysML™

+

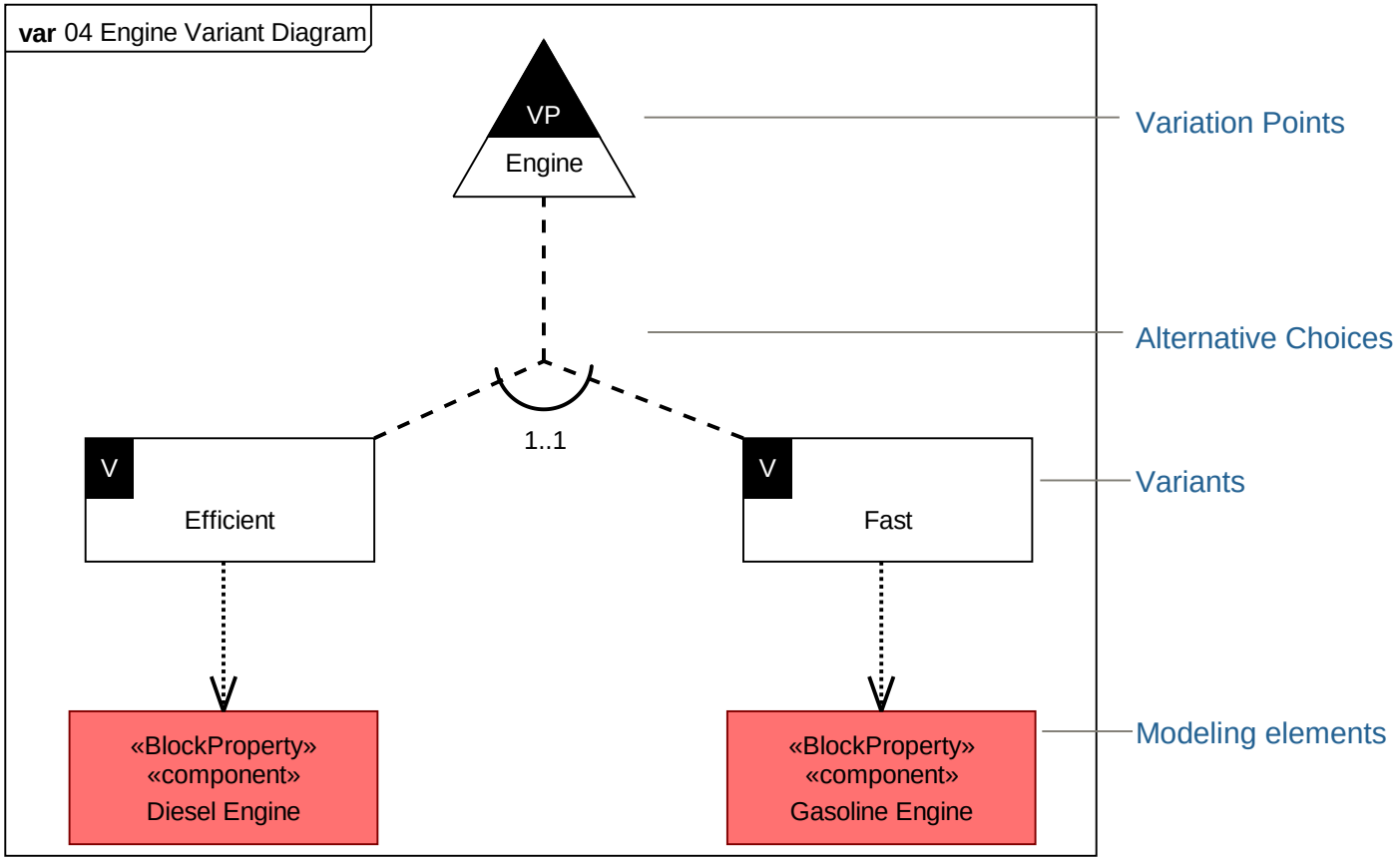
Orthogonal
Variability
Modeling ISO

Modeling Product Lines

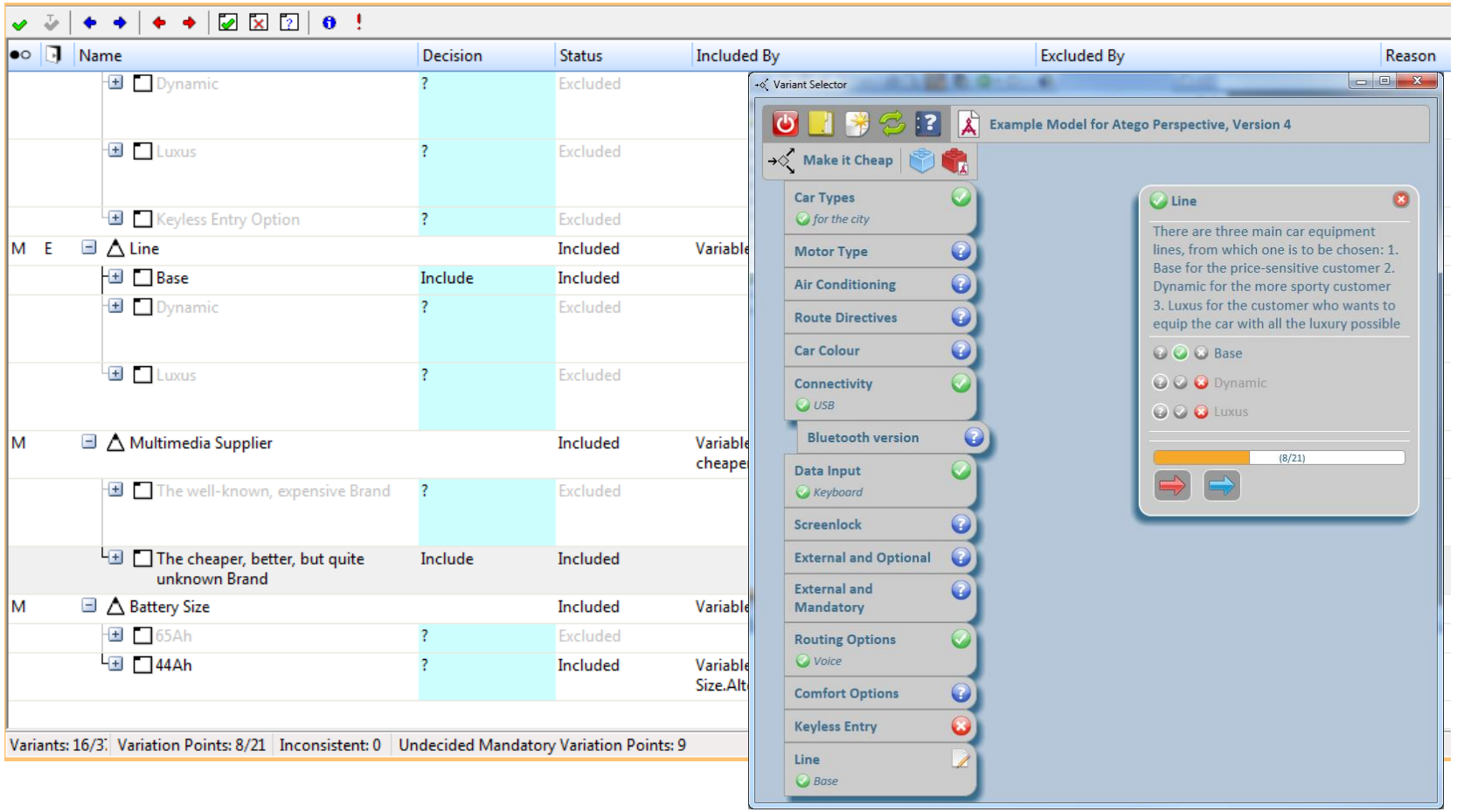


Modeling Variability

- **Engine variability along with model dependencies**



Decision Set Editor Variant Selector Examples



PTC Integrity Modeler SySim

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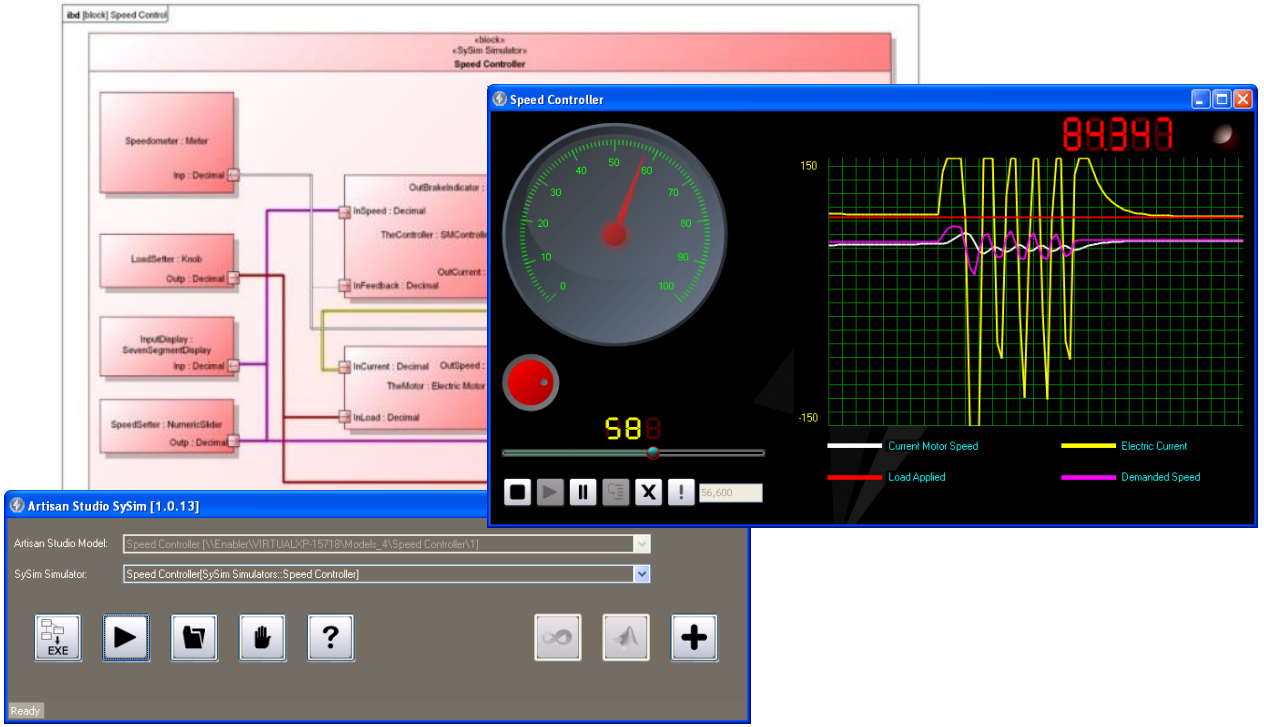
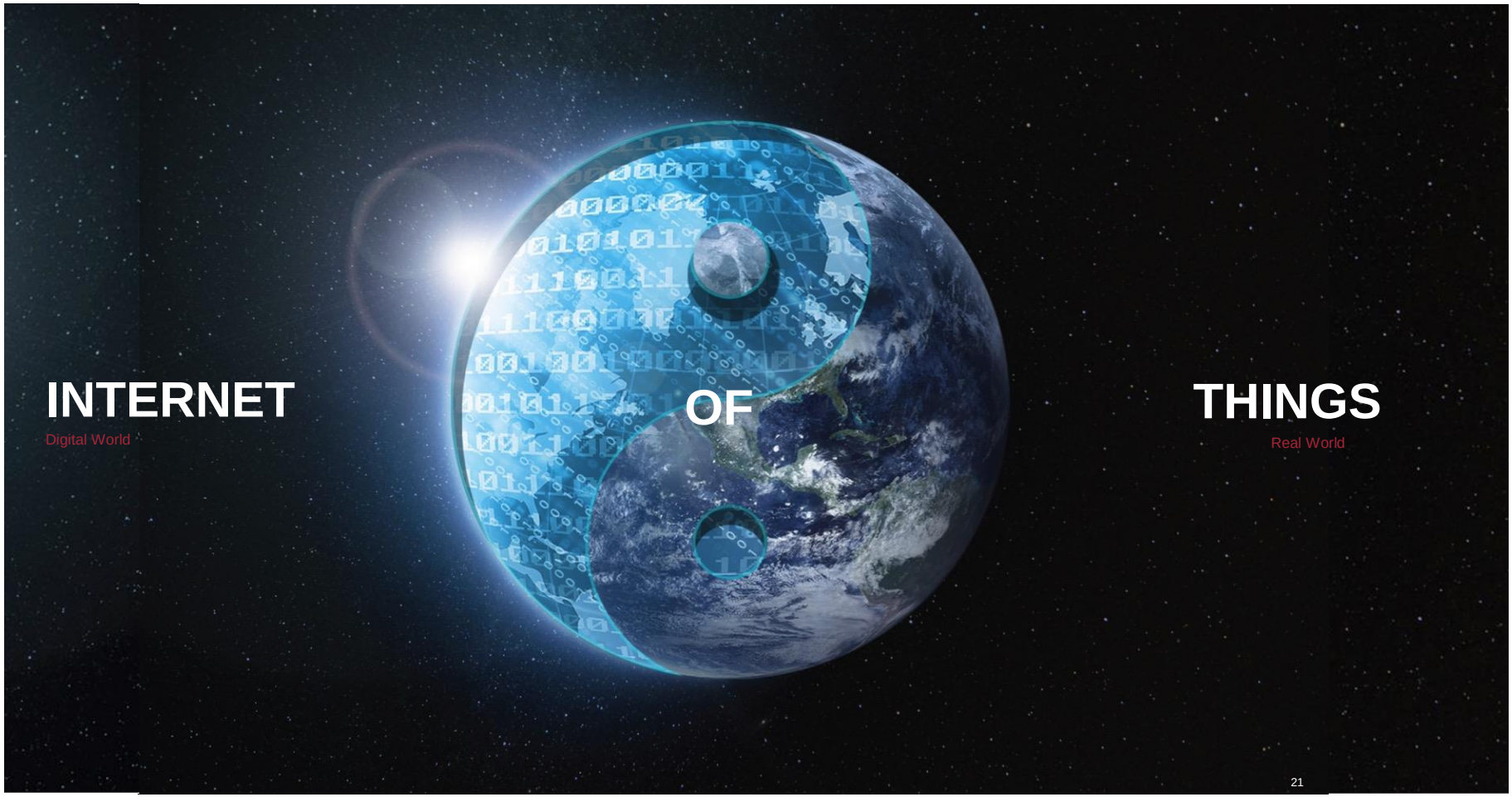
CAPABILITIES

- Early Complex Behavior Validation
- Block Level Reuse
- Drop-&-Play Simulation
- Connect to External Simulators
  - MATLAB Simulink™, etc.



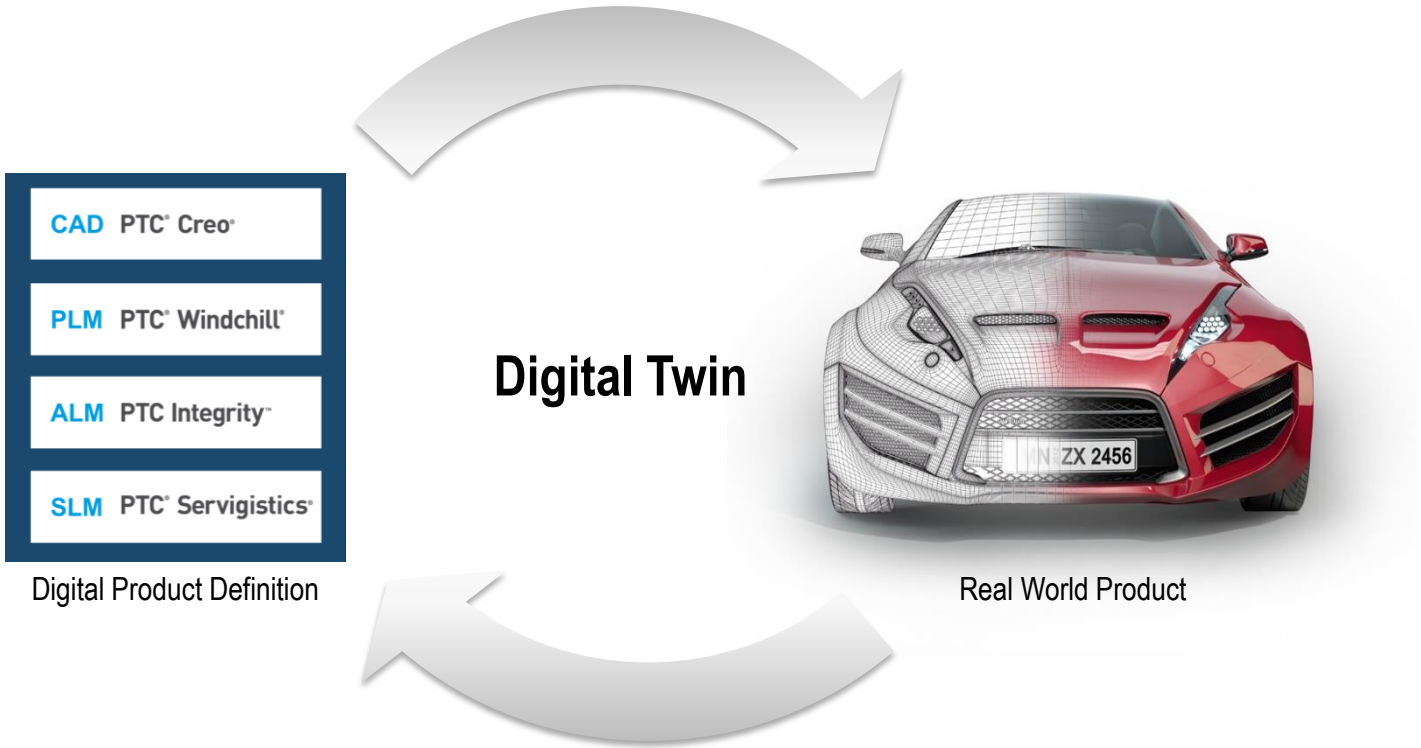
BENEFITS			
	Typical 20% reduction in model 'Design Walkthrough' effort	Up to 30% reduction in design errors	Significant reduction in overall project costs

New Reality: Distinct but Inseparable



PTC's Enterprise IoT Vision

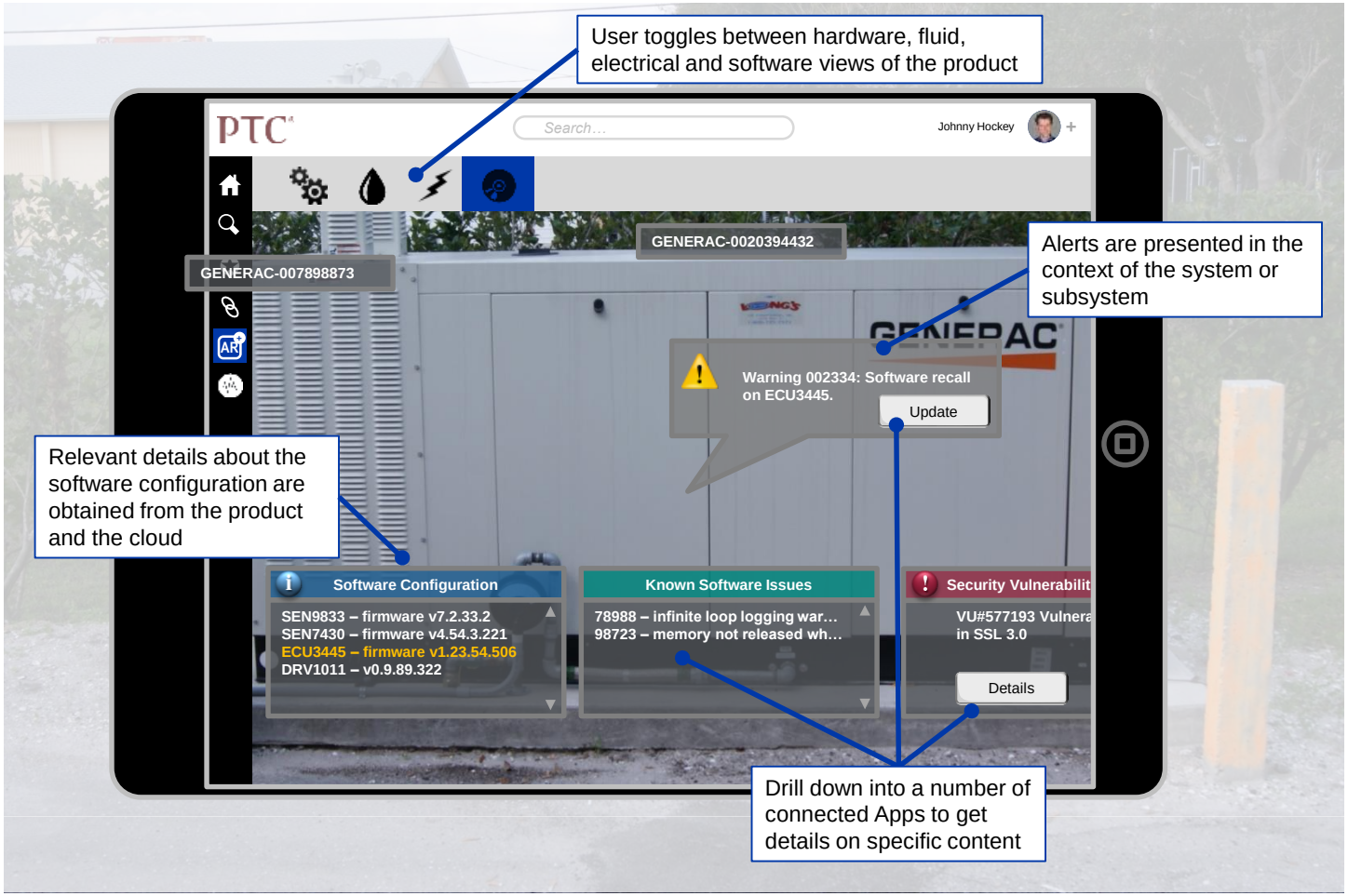
Produce and manage Smart, Connected Products

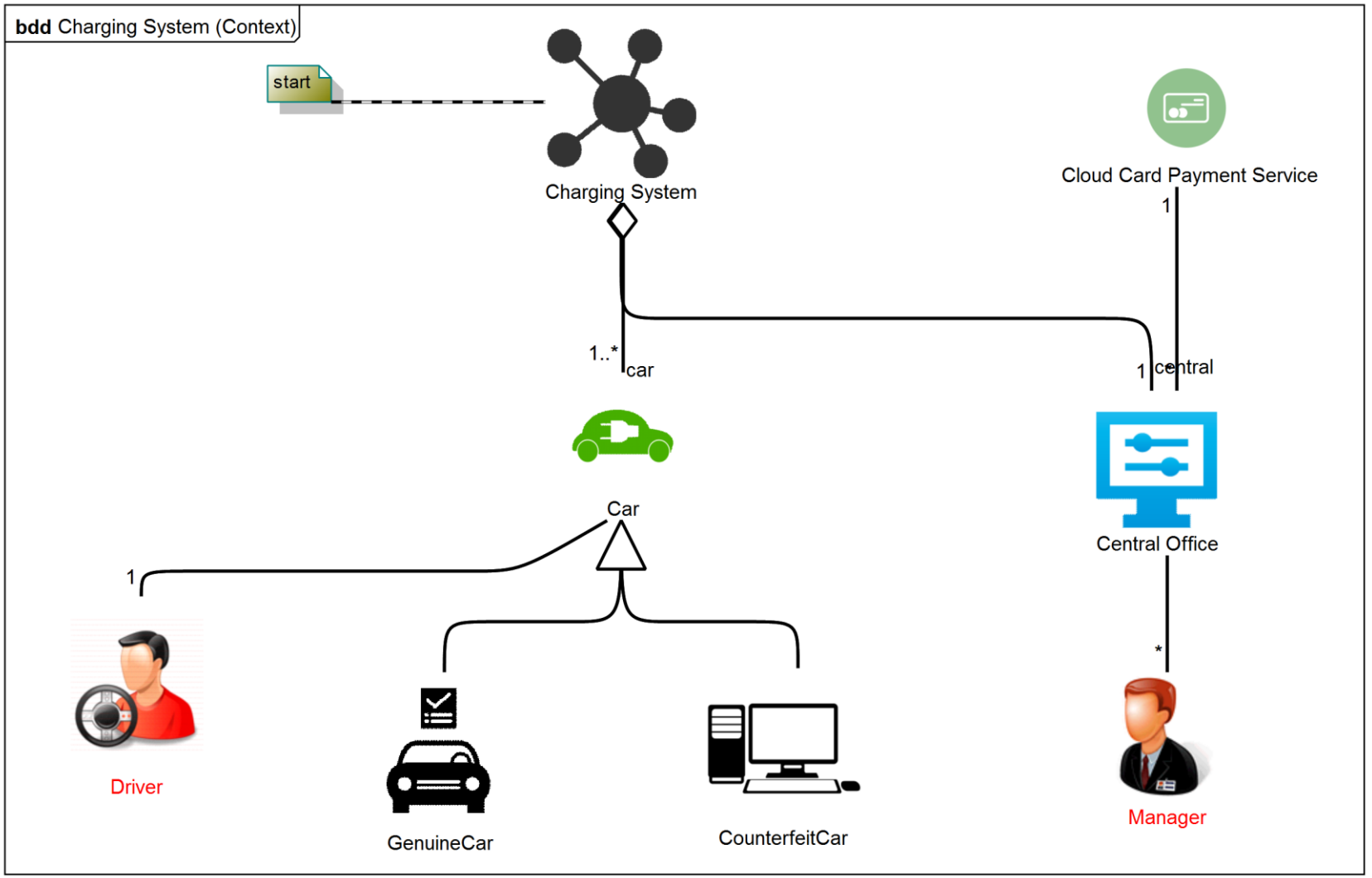


Leverage Smart, Connected Product data to improve products

With Augmented Reality (Software Configuration)

With Augmented Reality (Software Configuration)





Model Data Mining (ICD)

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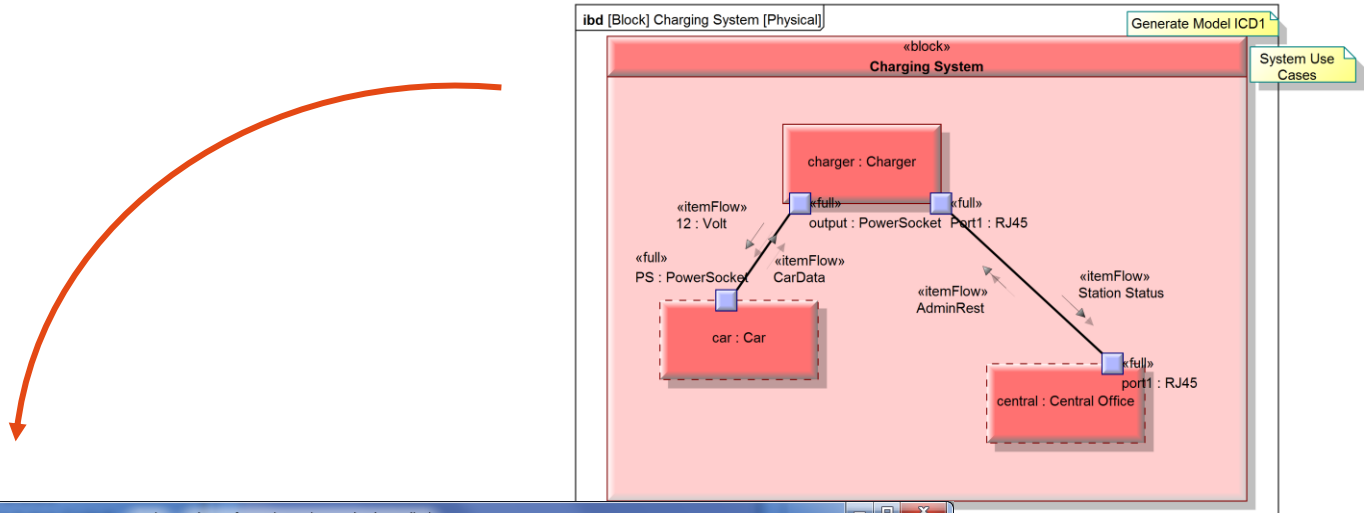
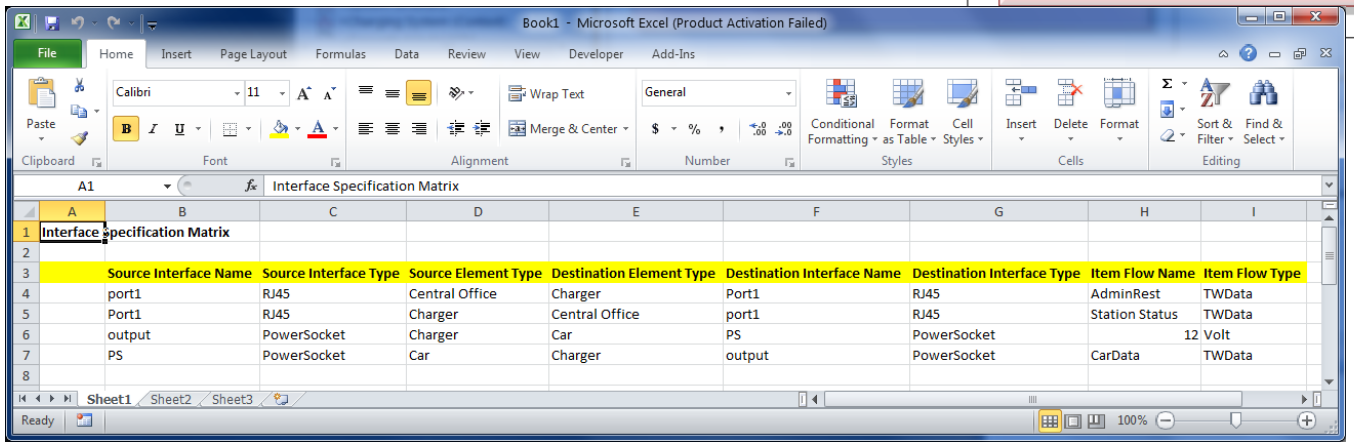


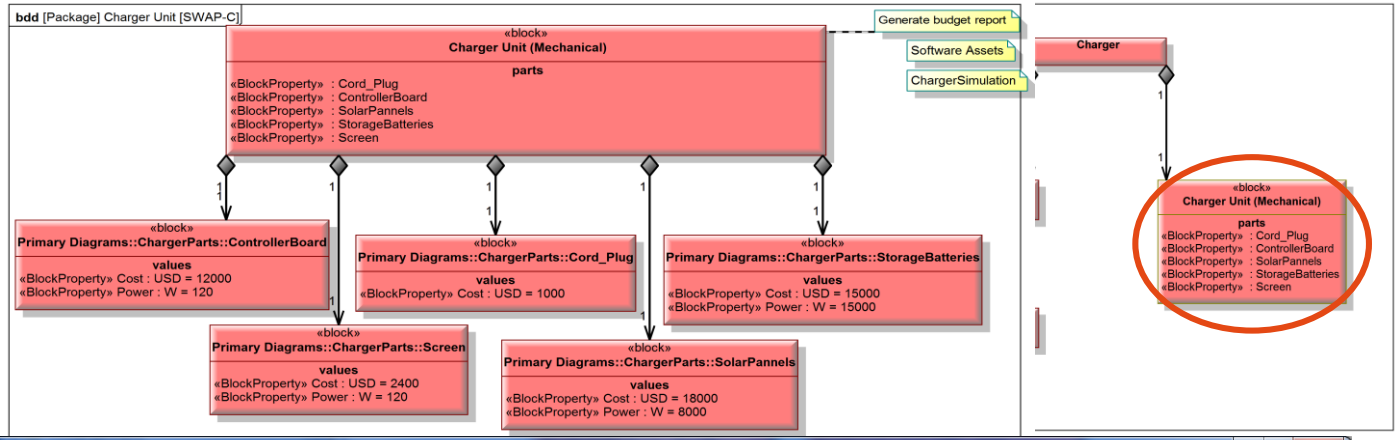


Book1 - Microsoft Excel (Product Activation Failed)

Interface Specification Matrix

	Source Interface Name	Source Interface Type	Source Element Type	Destination Element Type	Destination Interface Name	Destination Interface Type	Item Flow Name	Item Flow Type
4	port1	RJ45	Central Office	Charger	Port1	RJ45	AdminRest	TWData
5	Port1	RJ45	Charger	Central Office	port1	RJ45	Station Status	TWData
6	output	PowerSocket	Charger	Car	PS	PowerSocket	12	Volt
7	PS	PowerSocket	Car	Charger	output	PowerSocket	CarData	TWData

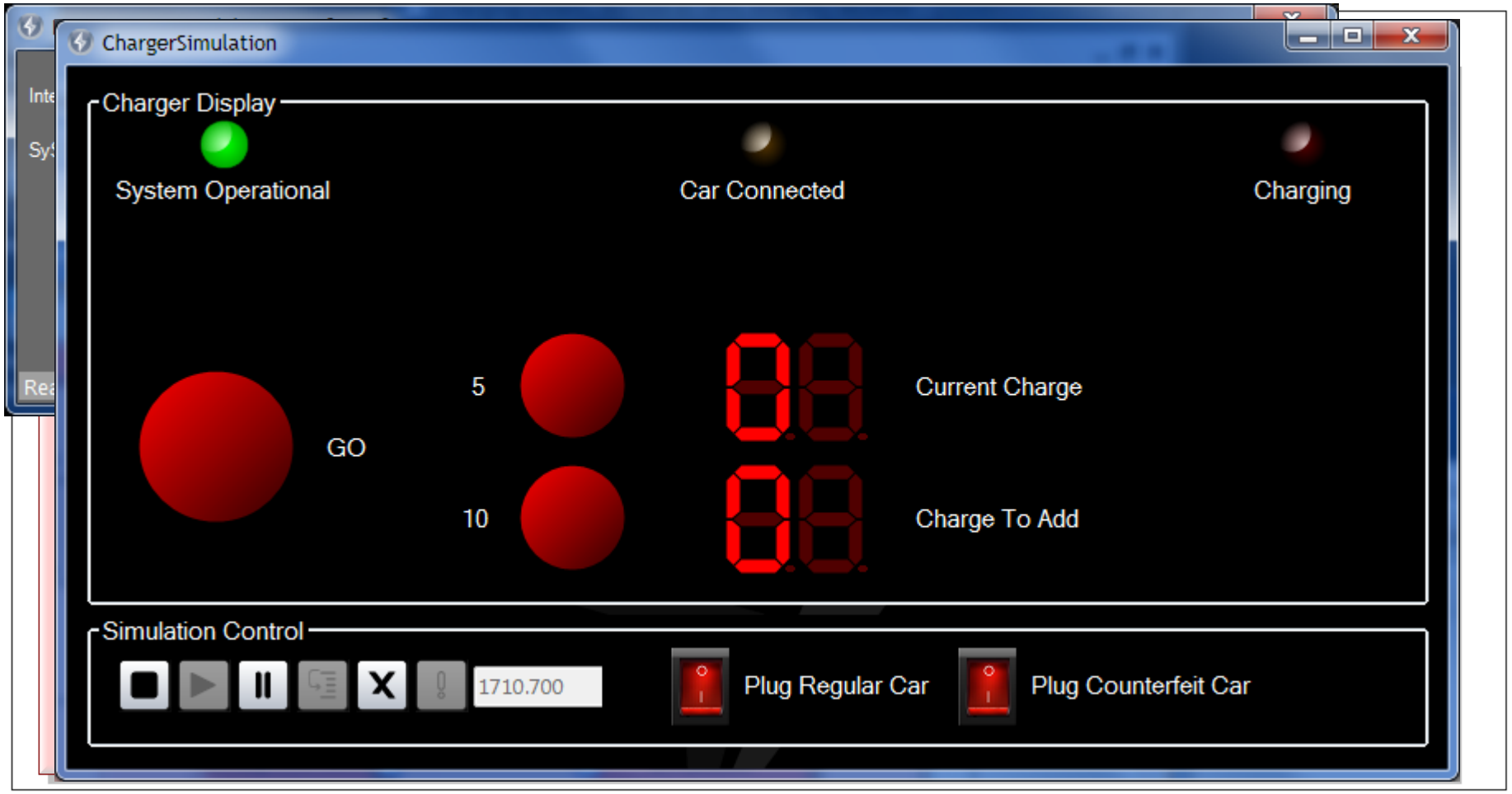
Model Analysis (SWAP-C)



Book2 - Microsoft Excel (Product Activation Failed)

Name	Quantity	Cost (in USD)					Power (in W)							
		Estimate	No Margin	Margin (%)	With Margin	Budget	Quantity On	Estimate	No Margin	Margin (%)	With Margin	Duty Cycle (%)	Average Power	Budget
Charger Unit (Mechanical) (Primary Diagrams)	n/a	0	43500	13.33%	49300	48400	0	0	1138000	5.48%	1200360	0.00%	0	23240
Cord_Plug (Primary Diagrams::ChargerParts)	1	1000	1000	5.00%	1050	1000	0	0	0	0.00%	0	0.00%	0	0
ControllerBoard (Primary Diagrams::ChargerParts)	1	10000	10000	20.00%	12000	12000	100	120	12000	2.00%	12240	10.00%	1224	120
SolarPannels (Primary Diagrams::ChargerParts)	1	20000	20000	5.00%	21000	18000	100	10000	1000000	5.00%	1050000	20.00%	210000	8000
StorageBatteries (Primary Diagrams::ChargerParts)	1	10000	10000	25.00%	12500	15000	10	12000	120000	10.00%	132000	50.00%	66000	15000
Screen (Primary Diagrams::ChargerParts)	1	2500	2500	10.00%	2750	2400	50	120	6000	2.00%	6120	40.00%	2448	120

Simulation Analysis (SySim)



IoT Visualization (ThingWorx)

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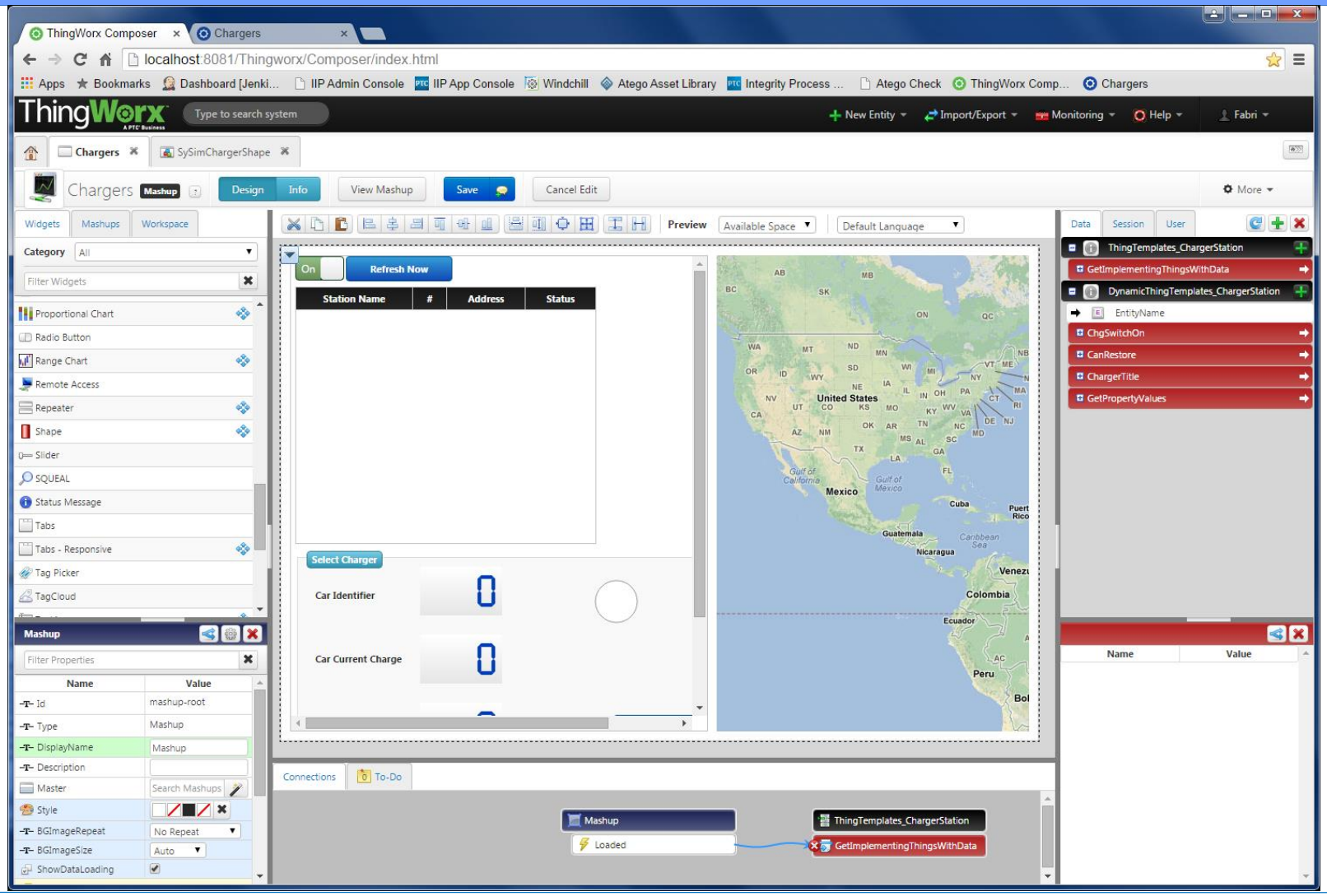

Simulate and Publish Data for IoT Subscribe

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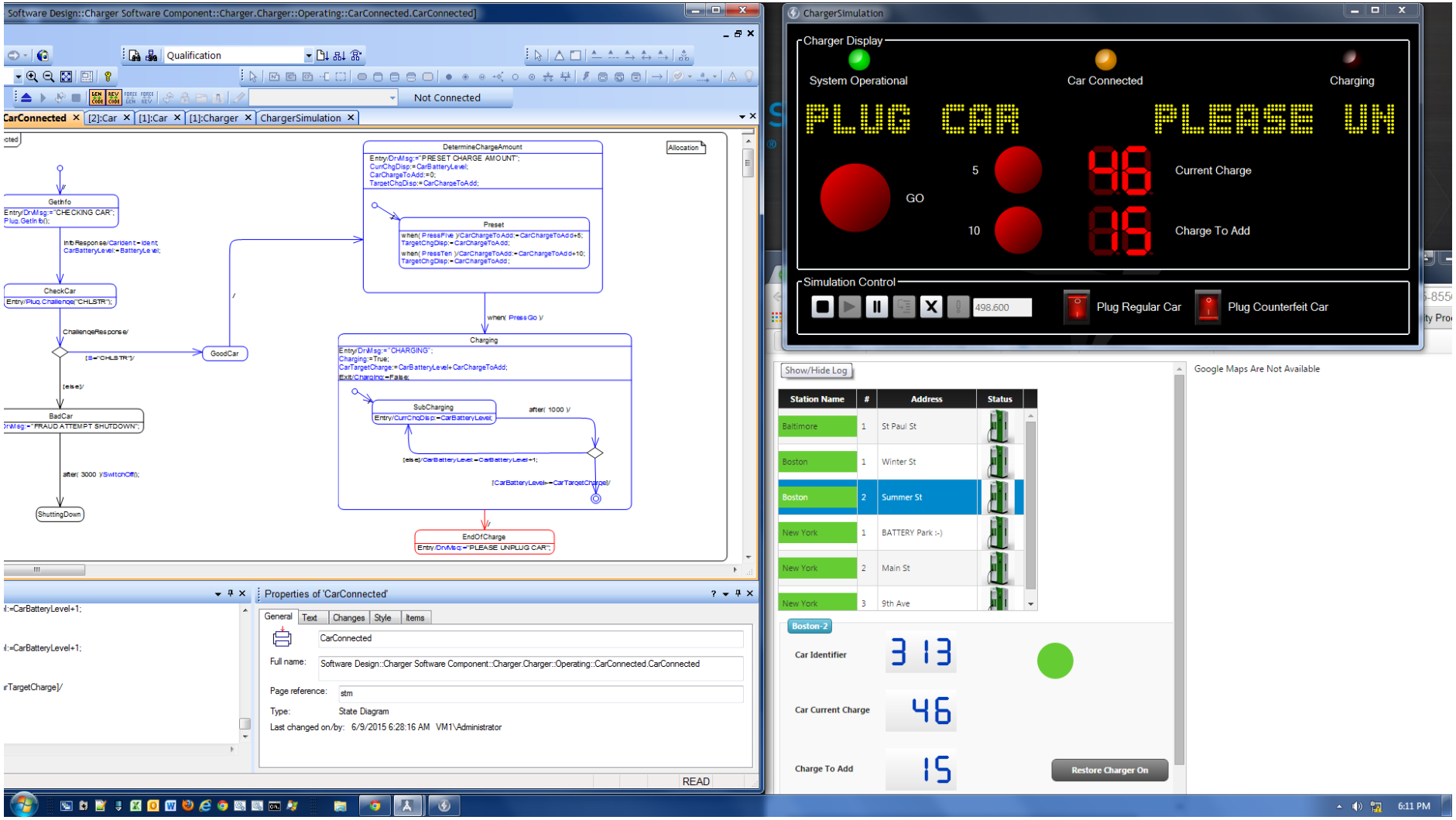
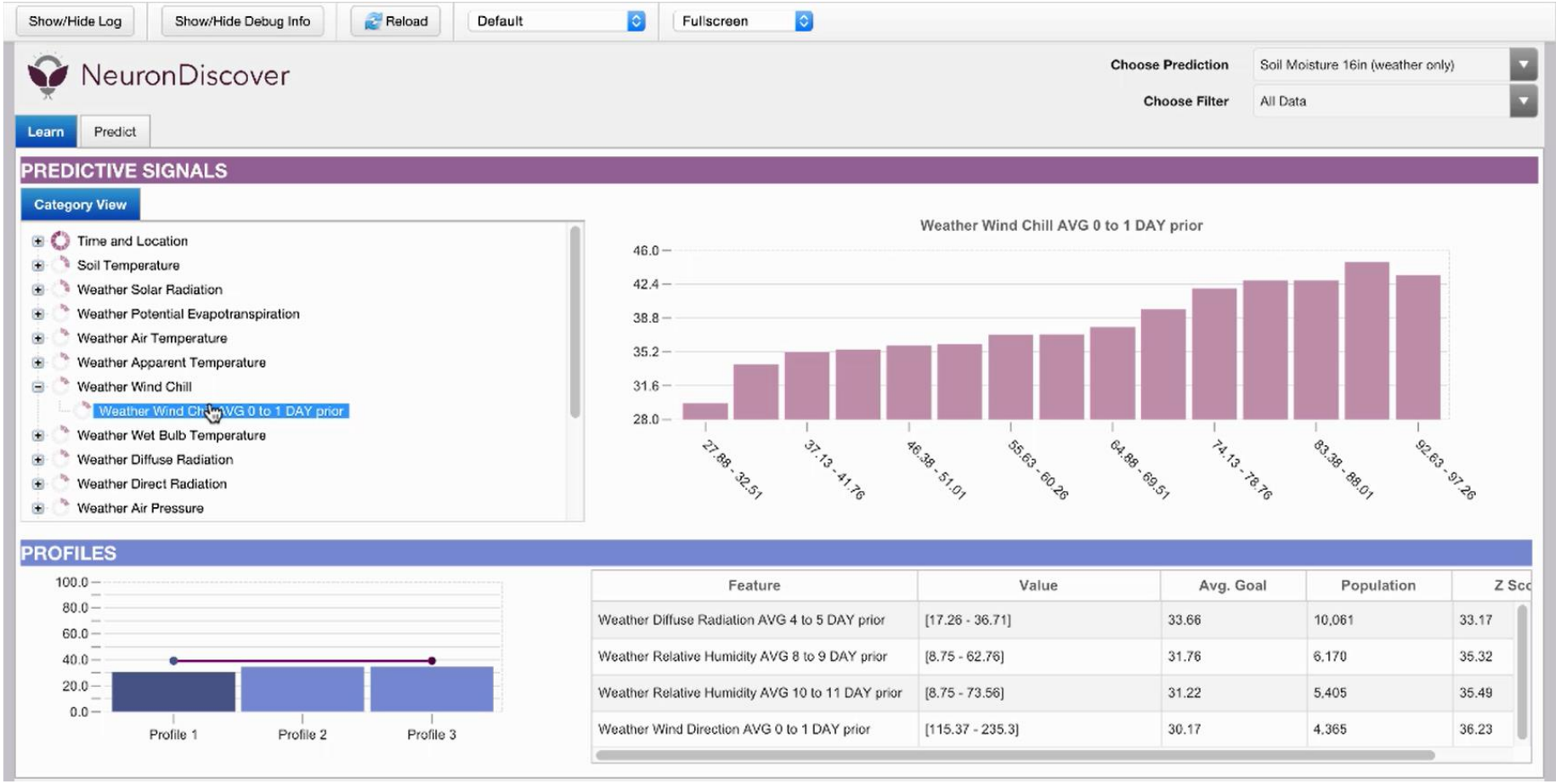


Predictive Signals



Predictive Analyzer

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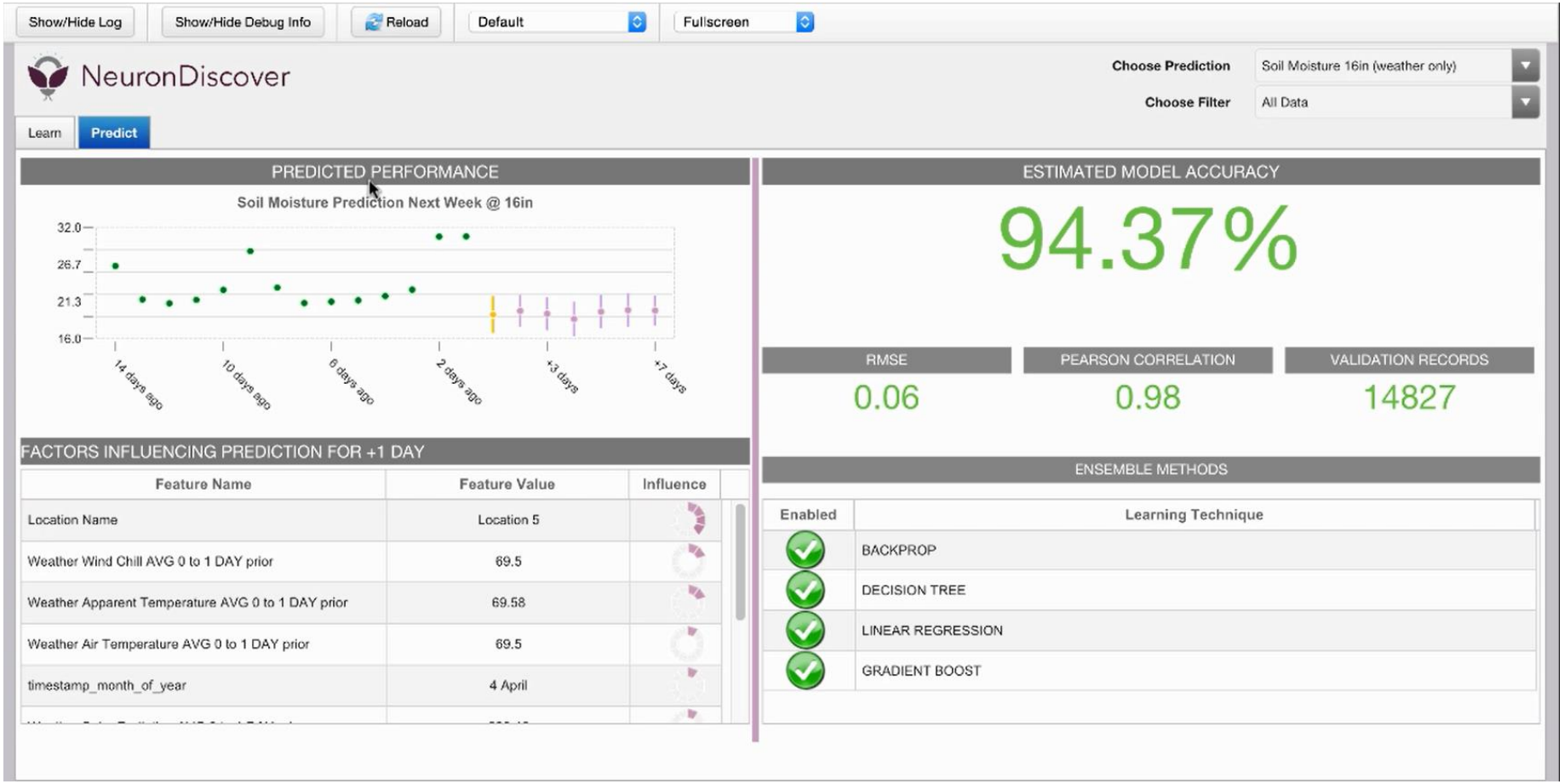

Questions and Answers