AGILE SYSTEMS ENGINEERING: DESIGN AND SIMULATION OF COMPLEX IOT SYSTEMS

Hedley Apperly, VP Solutions Management

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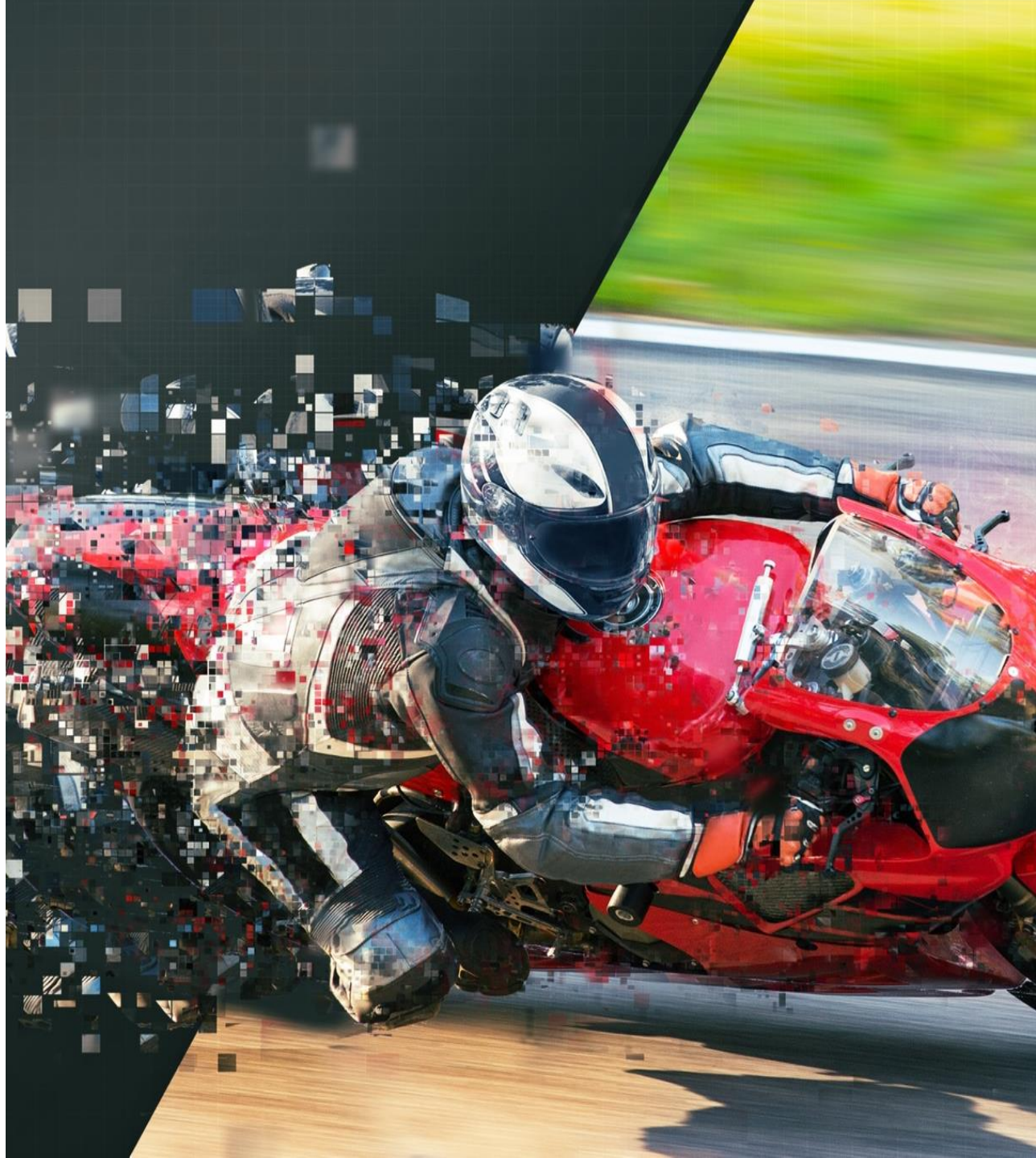


Note: This presentation includes forward looking information that is subject to risks

IOT'S IMPACT ON PRODUCT DEVELOPMENT

IoT is changing the way we do business and creating new business opportunities.

Product design has increasingly become much more complex and requires an agile, multi-disciplined approach.

Today's systems demand an integrated, collaborative approach within engineering, as well as with our customers, suppliers, and users.

Julie DeMeester, Engineering Fellow Raytheon Integrated Defense Systems

AGILE AT SCALE

"When looking at **Agile at scale**, it is important to understand that this refers to the ability for multifaceted agile execution in the **delivery and management of large scale systems**"

(European multinational communication technology provider)

"Unified **Agile toolsets** and **Agile processes** will help Agile teams to collaborate better."

(European embedded technology)

Investing time in **planning** and providing relevant and appropriate **documentation** still has a crucial role in Agile delivery, since products and projects can require a **long term vision**.

(European embedded technology)

Modularity at the systems level is important to ensure that development and delivery can happen in **parallel**. Focusing on modularising and segmenting the wider **systems architecture** into complete **sub-systems** with minimum dependencies is therefore an essential foundation to achieving **Agile at scale** within a large and complex systems based organisation.

(European multinational communication technology provider)

Having an approach to **planning and architecture is crucial** even if it doesn't fully conform to the Agile manifesto.

(European Automotive Manufacturer)

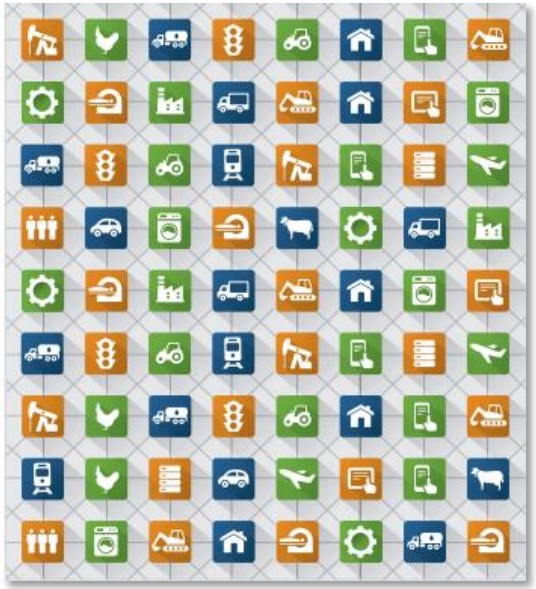
From research by Creative Intellect Consulting CIC 2014-2015

THE TIME IS NOW

- **Systems Engineering Accelerators**

  “Smart, connected products require a fundamental rethinking of design. At the most basic level, product development shifts from largely mechanical engineering to true **interdisciplinary systems engineering. “**

  “A **focus on systems**, not discrete products”



- **Systems of Systems**

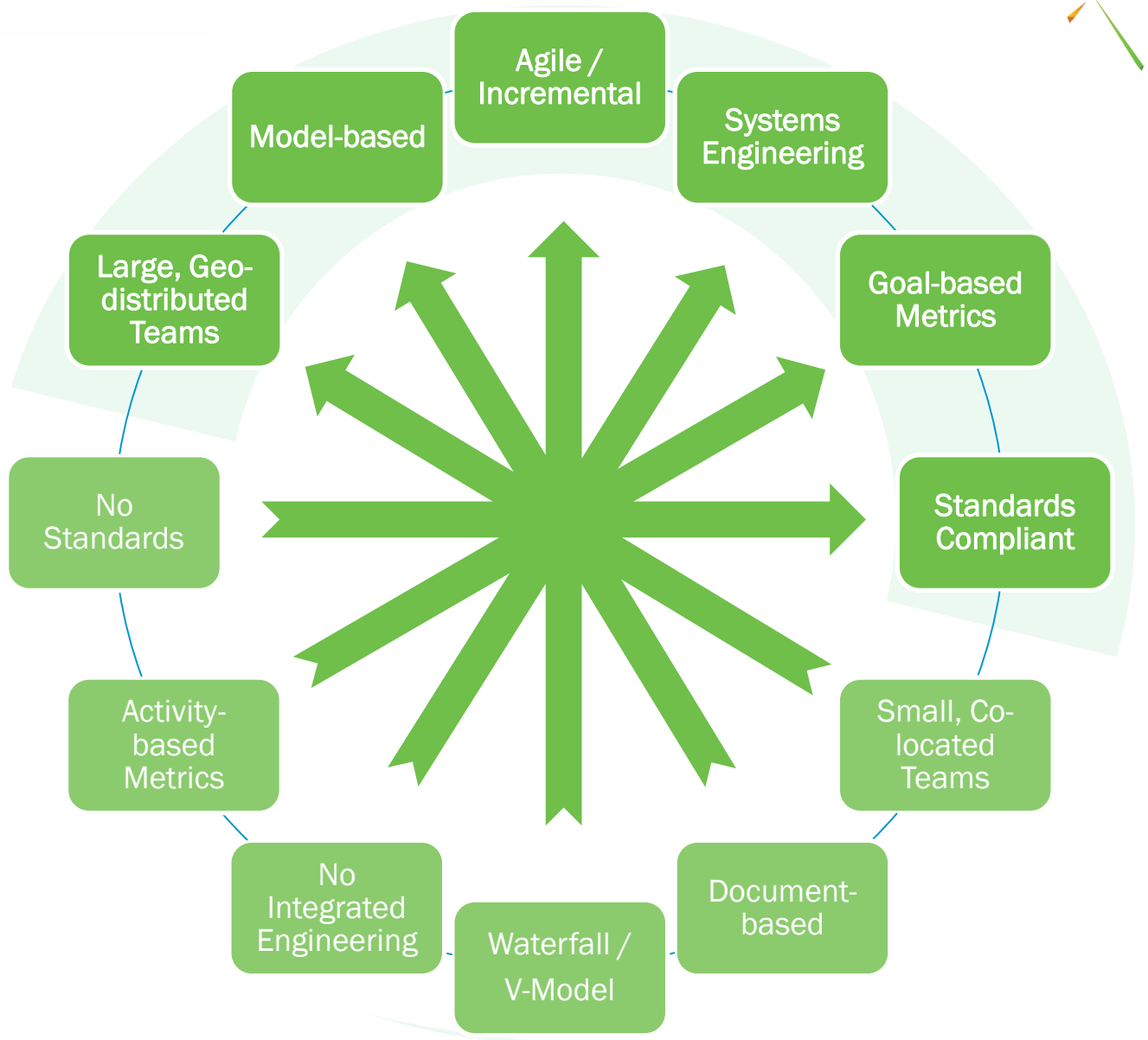
  “As products become components of broader systems, the opportunities for **design optimization** multiply”

Michael Porter, Jim Heppelmann, Harvard Business Review, November 2014 & October 2015

TRENDS IN SYSTEMS ENGINEERING

- Rapidly changing requirements & shorter iterations of delivery
- Models as the core communication platform between all stakeholders and Agile engineers
- Incremental functional analysis with Use Cases refining User Stories
- Executable Requirement / Story modeling with SysML
- Architecture – to enable parallel teams
- Asset-based modular design for sub-systems & interfaces
- System variability & product lines for rapid response to market & customer needs – Engineering Agile Systems

Model-based Systems Engineering is now recognized as the Agile SE



AGILE SYSTEMS ENGINEERING

"A solid, **'visual' planning phase** not only helps to alleviate friction between different functions, it can provide the necessary **higher level insights** that can often be lost in agile project with numerous moving parts and short delivery time scales."

(Saab Electronic Defence Systems)

Finding a way to **bring software and hardware development together** was crucial to gaining support for Agile within the organisation.

(European Electronics Company)

Coordination and management of Agile is actually harder than Waterfall. There are many small moving parts within very short timeframes that need to be managed.

(US Medical Device Company)

Technologies that provide mock **interfaces**, mimicking service calls and **simulated functionality**, allow teams with different workflow dynamics and execution speeds – as in the case of software and hardware disciplined teams - to **maintain Agile velocity**.

(European Embedded Technology Provider)

Enabling multiple Agile engineered products to work seamlessly together **requires an investment in solution planning and architecture.**

(European Automotive Manufacturer)

From research by Creative Intellect Consulting CIC 2014-2015

AGILE MBSE

- IoT market opportunities lead to increased product complexity
  - Smart connected products combining mechanics, electronics, software & more
- Interdisciplinary systems engineering is necessary for complex product manufacture
  - Collaborative planning & architecture definition, involving customers, suppliers, end users & engineers from multiple domains
- Today's leading systems suppliers and integrators also apply Agile practices
  - Just enough architecture planning, using system models
  - Collaborative, incremental & iterative Agile systems modeling
  - Modularity at the systems level to scale Agile
  - Visual mockups and simulation
- Modeling is the enabler for Agile Systems Engineering for IoT

Breakthrough Product Engineering

UNIFY
the cross-discipline team

ORGANIZE
for product variants

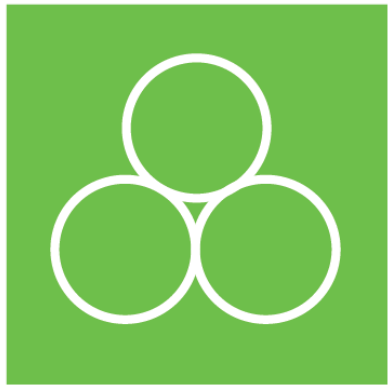
SAFEGUARD
quality and safety

CONNECT
to real-world insight

EMPOWERING YOUR AGILE ORGANIZATION

- AgileWorx Solution
  - What, where, when, who…
  - Scrum product, story and task management
- MBSE Solution
  - How, with what…
  - Optional tools for;
    - » visual collaboration
    - » modular system architecture
    - » interface management
    - » system product lines
    - » simulation
    - » IoT design & development

ENABLING AGILE SYSTEMS ENGINEERING



unify

PTC Model-Based Systems Engineering

- MBSE typifies Multi-discipline Engineering
- Common modeling Language
- System Model as the Hub
- Stakeholder In-the-Loop simulation

safeguard

PTC Model-Based Systems Engineering

- Track Stories to Architecture & Modules
- Module Reuse
- Automated Architecture Design Review
- Module & Interface Consistency

organize

PTC Model-Based Systems Engineering

- Incremental & iterative modeling
- Designed Modular Architecture
- Manage Module Interfaces
- Design PLE platforms & variants

connect

PTC Model-Based Software Engineering

- Connected to IoT with automated ThingWorx code generation
- Simulation with ThingWorx in-the-loop for Product Feedback
- Connection to PLM

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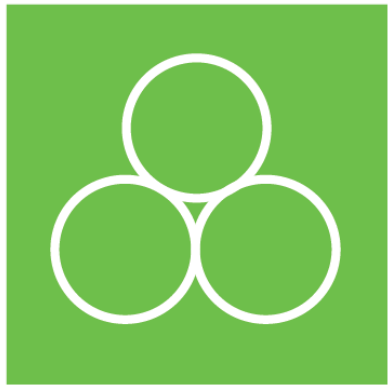

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UNIFY

MULTI-DOMAIN ENGINEERING

- Common systems level language
- Whole team transparency
- Access to systems of record
- Stakeholders in-the-loop

PTC MBSE

Customer

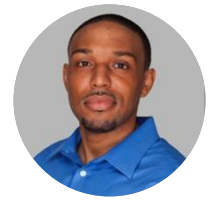
Product Owner

Project Manager

Software Developer

Systems Engineer

Electrical Engineer



Quality Manager

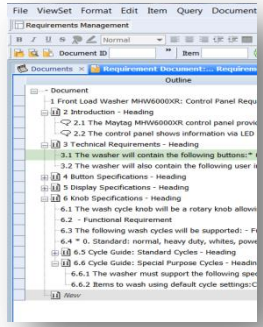
Mechanical Engineer

Standard Language | Functional Modeling | Structural System Modeling

Use Case Modeling | ptc mbse | Modular Design

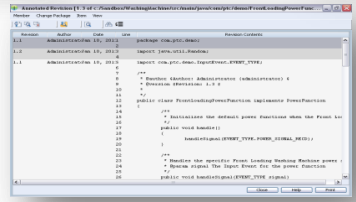
Incremental Modeling | Simulation | Trade Study Analysis

Requirements & Stories

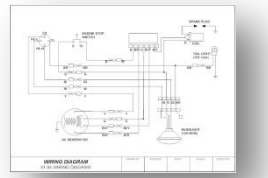


Hydraulic

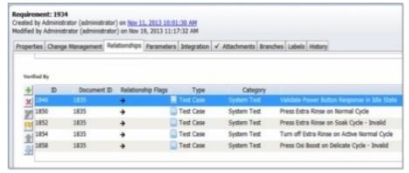
Software



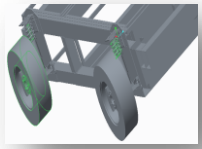
Electrical



Test Cases & Results



Mechanical

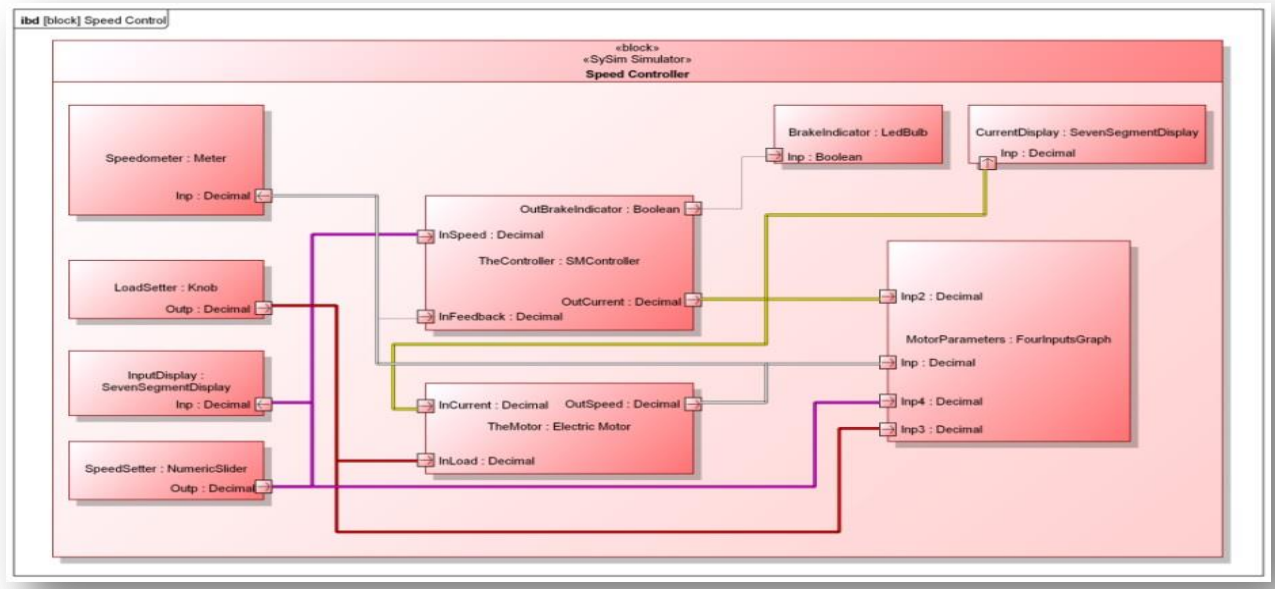


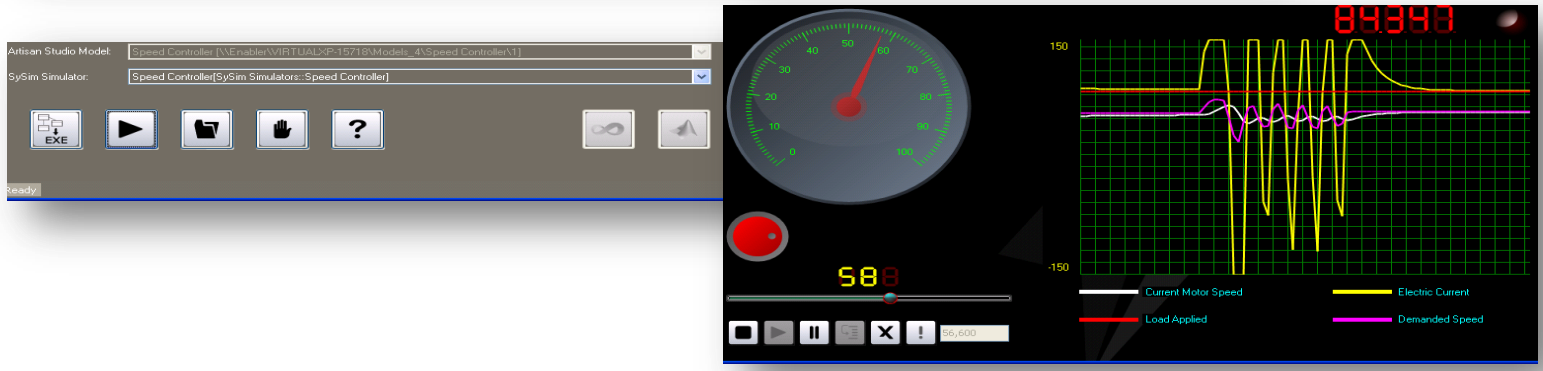
UNIFY

VALIDATE COMPLEX BEHAVIOR EARLY

- Stakeholder in-the-loop
- Visually simulate systems model functionality
- Record simulation results for analysis
- Co-simulate with 3rd-party simulators (e.g. MATLAB Simulink™)

Functional System Simulation





ENABLING AGILE SYSTEMS ENGINEERING

unify

PTC Model-Based Systems Engineering

- MBSE typifies Multi-discipline Engineering
- Common modeling Language
- System Model as the Hub
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safeguard

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- Track Stories to Architecture & Modules
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organize

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- Manage Module Interfaces
- Design PLE platforms & variants

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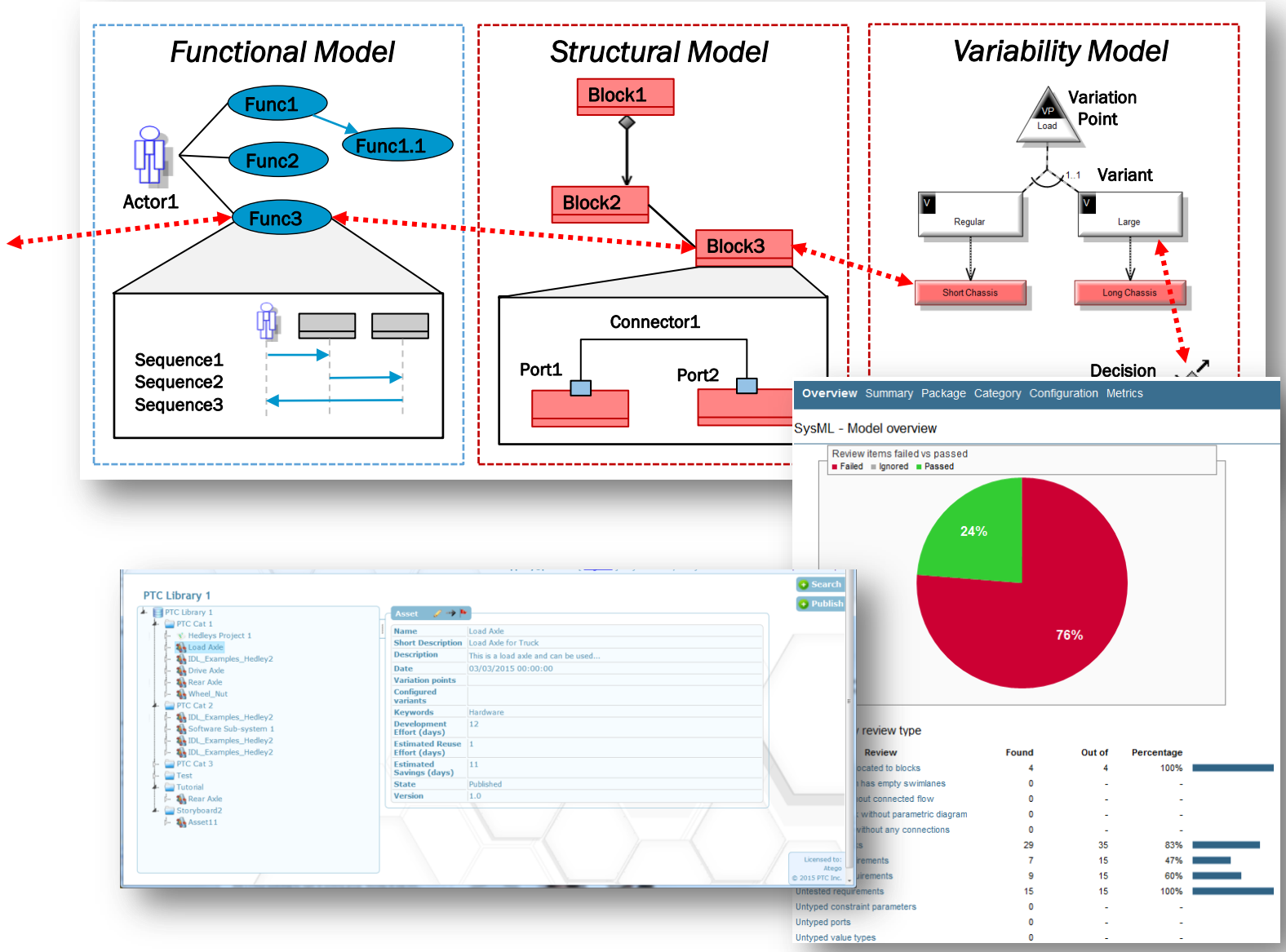
SAFEGUARD

DESIGNED IN QUALITY

- Standard language compliance
- Traceability for impact analysis
- Earlier Problem Identification
- Reuse tested assets



PTC MBSE

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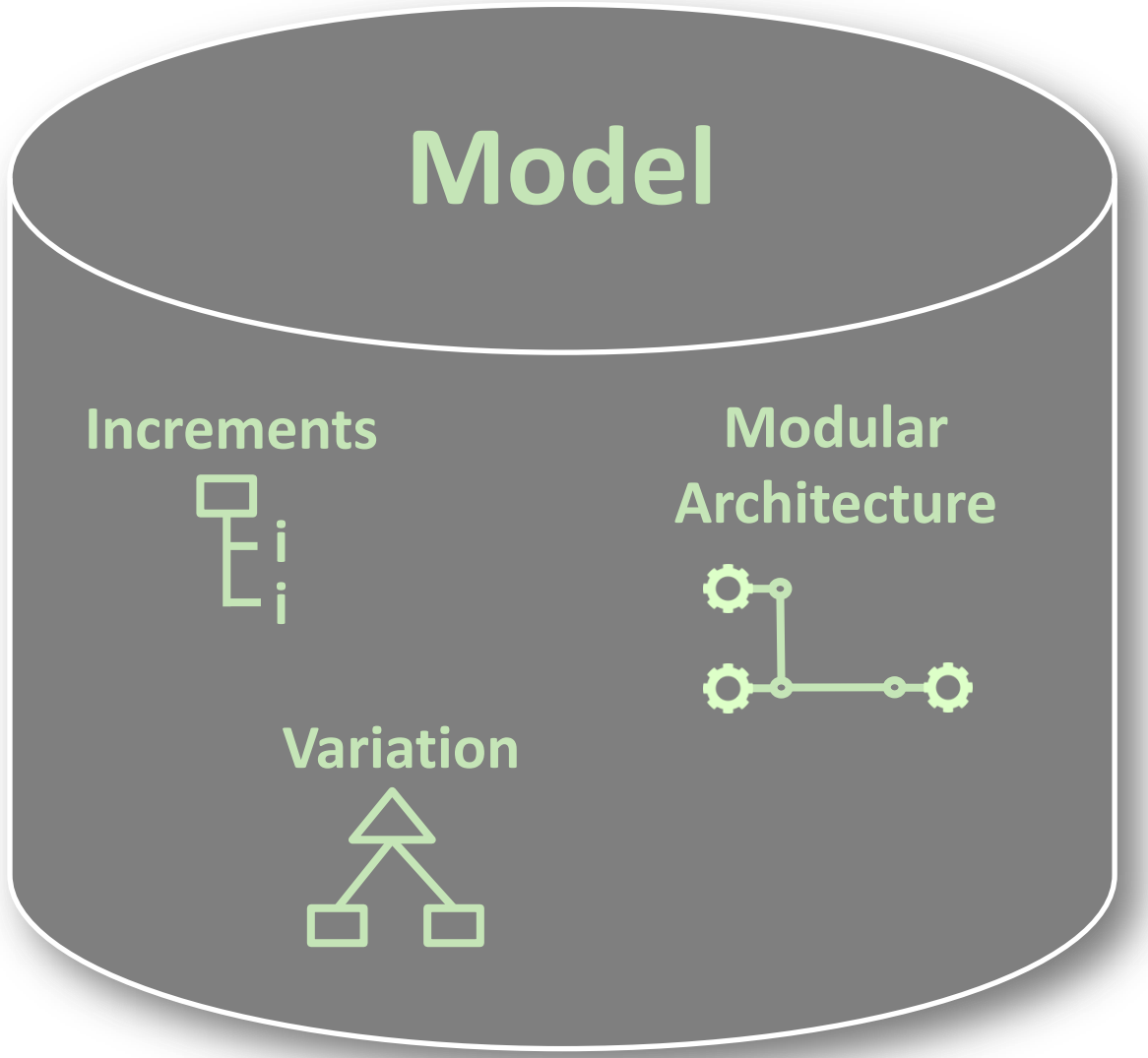
ORGANIZE

ARCHITECTED FOR AGILITY

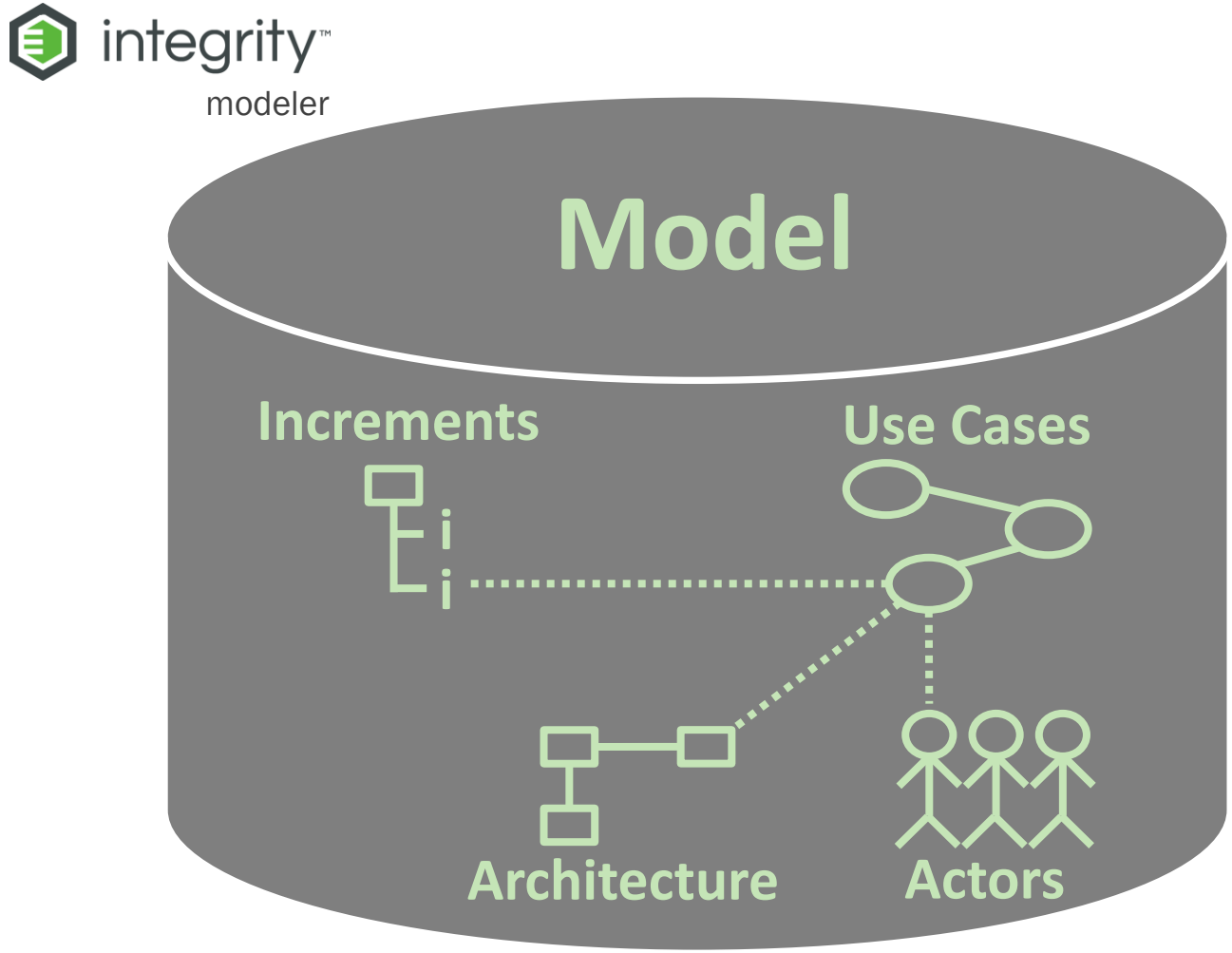
- Incremental & iterative modeling
- Designed modular architecture
- Module interface management
- Product platforms & variants



ORGANIZE

INCREMENTAL MODELING

- Agile model increments
- Iterative, additive & evolutionary modeling
- Just enough modeling to deliver products

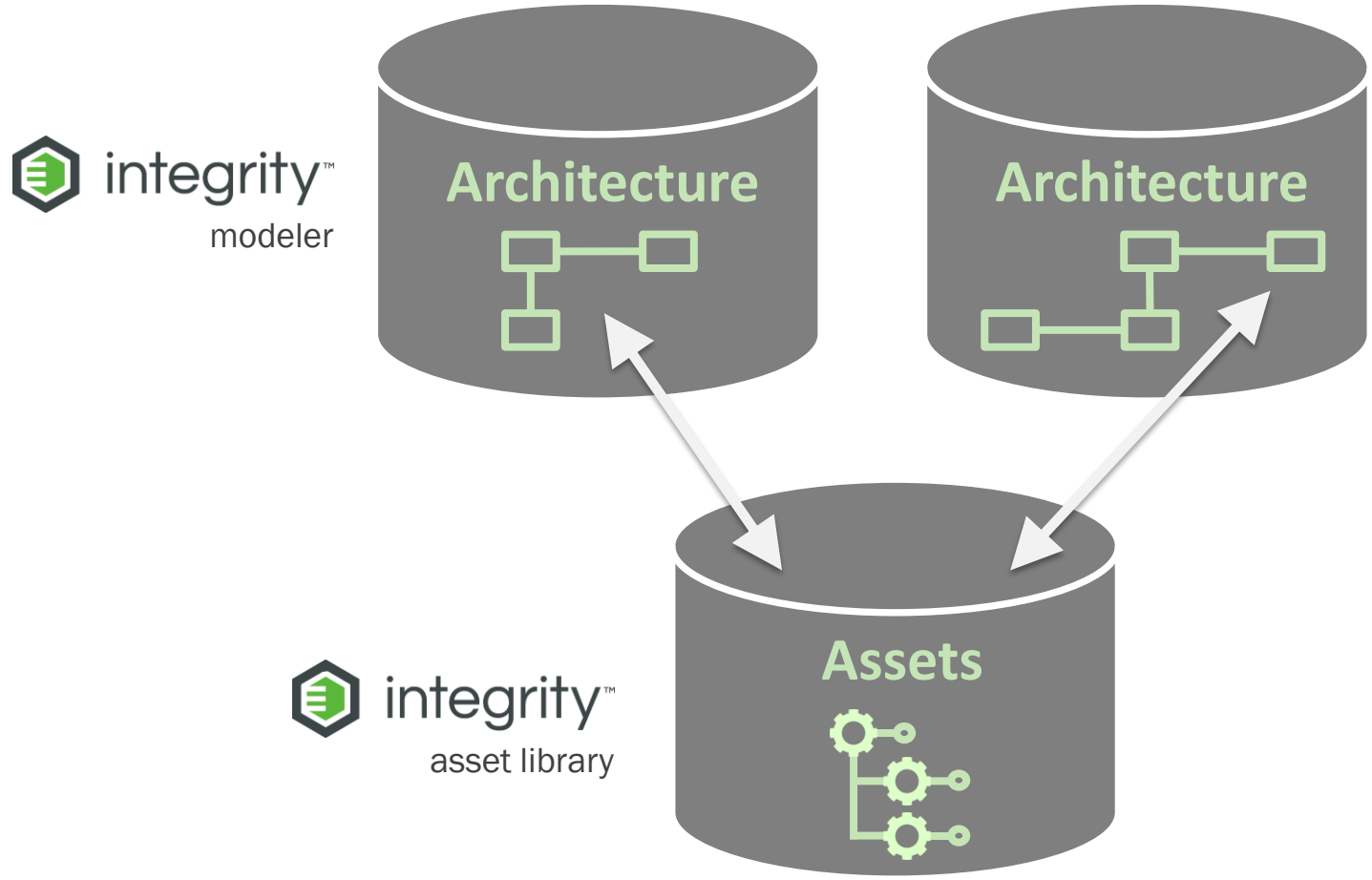


ORGANIZE

MODULAR ARCHITECTURE

- Architecting for agility
- Asset-based modular architecture
- Component interface management
- Parallel working & supply chains

PTC MBSE



ORGANIZE

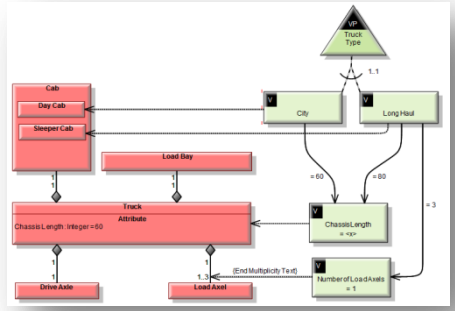
PRODUCT PLATFORMS AND VARIANTS

- Agile system product lines
- Drives module inclusion, parameters & numbers of parts
- Define product line configuration logic and rules

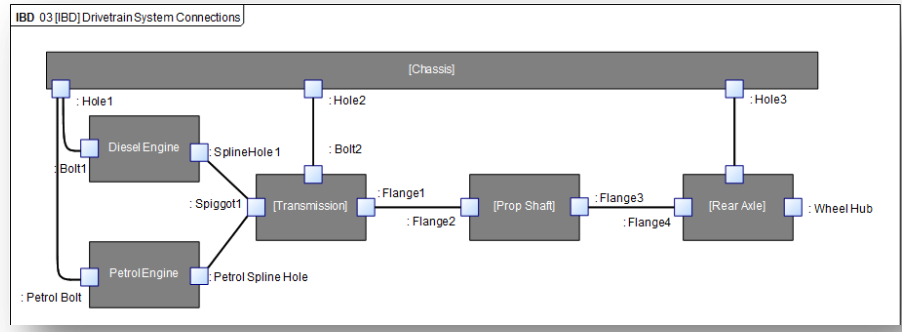
PTC MBSE

Make better trade-off decisions

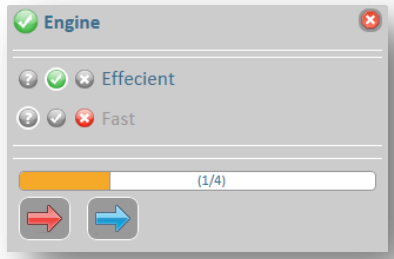
Variability Model



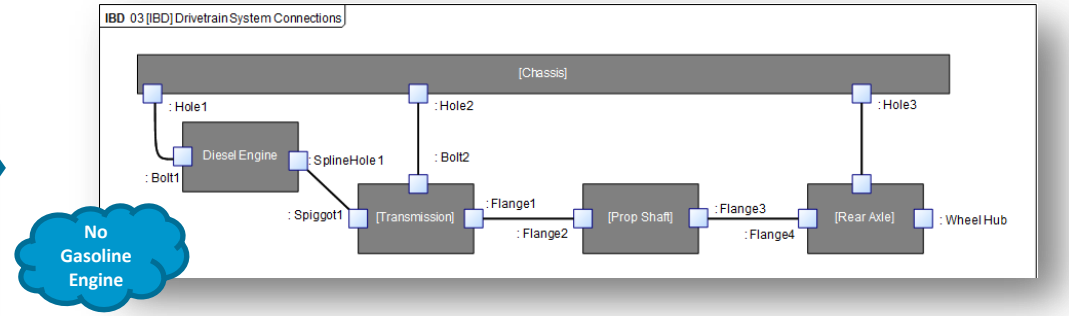
150% Model



Variant Selection



Product Model



Improve system portfolio agility

Improve management of configurations

Improve reuse productivity

TODAY'S LAUNCH: ENABLING ORGANIZATIONAL AGILITY

unify

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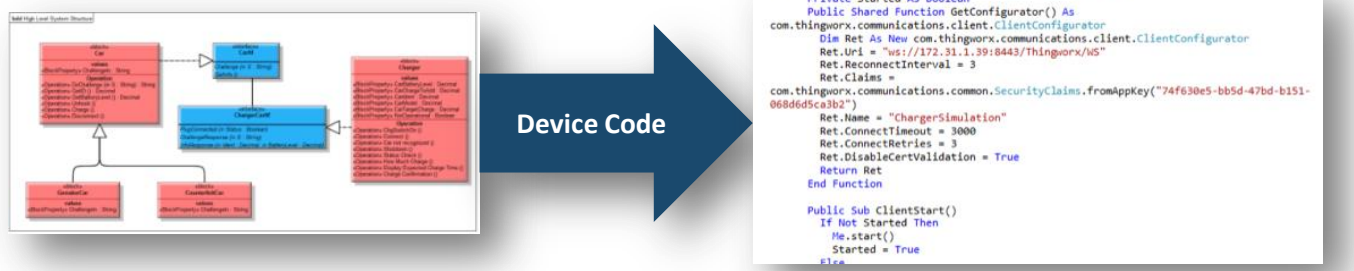
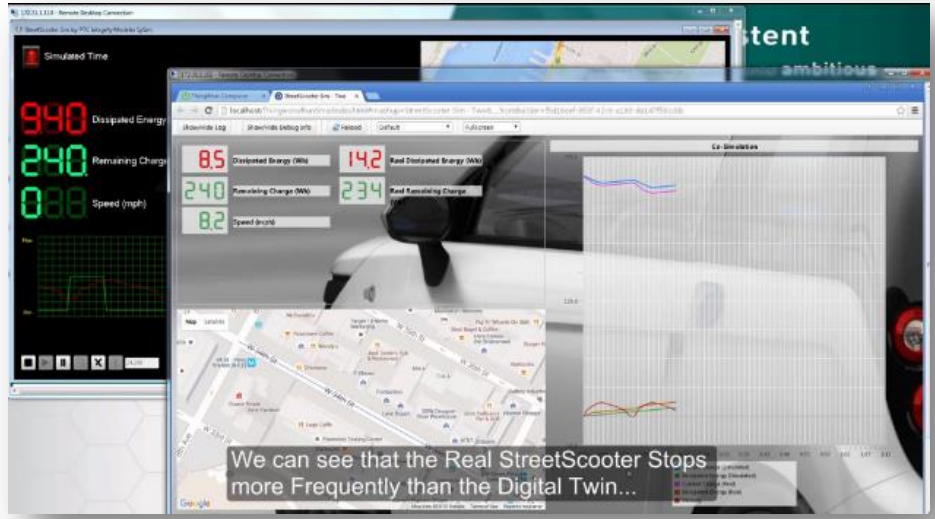
CONNECT

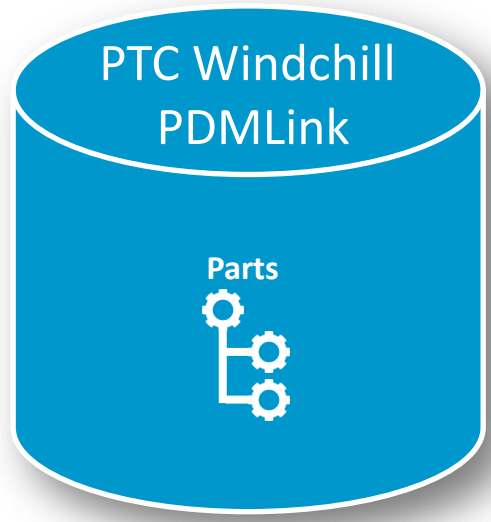
SYSTEMS THINKING

- Models as the design platform shared between all stakeholders
- Connected to IoT with automated ThingWorx code generation
- Simulation with ThingWorx in-the-loop for Product Feedback
- Connection to Windchill PLM

PTC MBSE







CONNECT

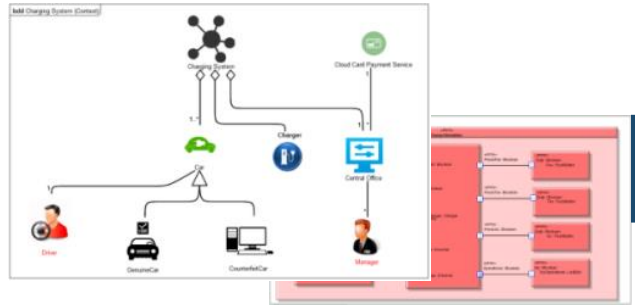
MODEL-DRIVEN IOT

- IoT system architecture design for complex systems
- Systems flow-down to IoT software modeling
- Automated IoT code generation for ThingWorx
- Edge-device to Cloud and Edge-device to Edge-device

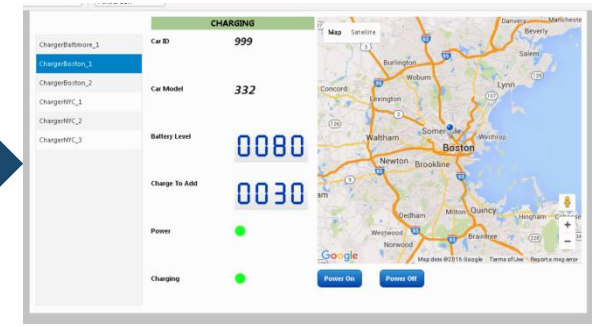
PTC MBSE

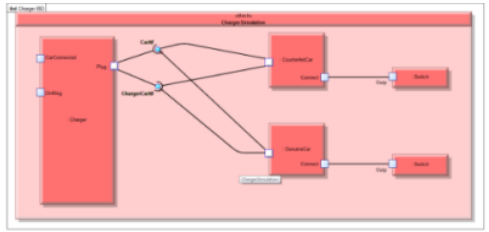
PTC Integrity™ Modeler™

ThingWorx

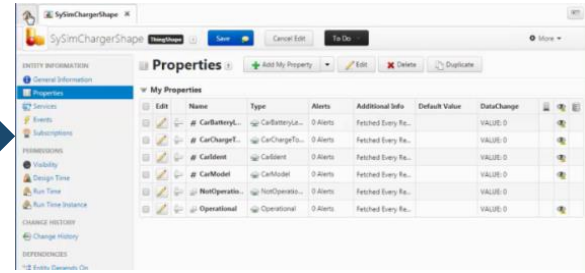


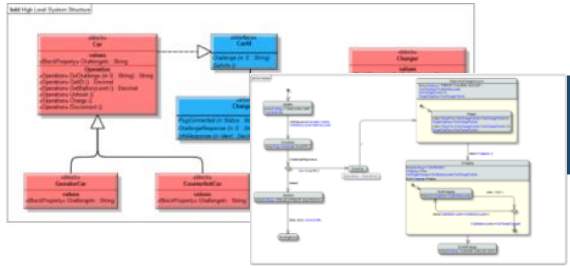
Mashup Things





Data Links





Device Code

CONNECT

SYSTEM SIMULATION WITH IOT DATA IN-THE-LOOP

- System simulation with ThingWorx in-the-loop
- IoT data refining simulation & improving designs
- Closed-loop system level IoT modeling

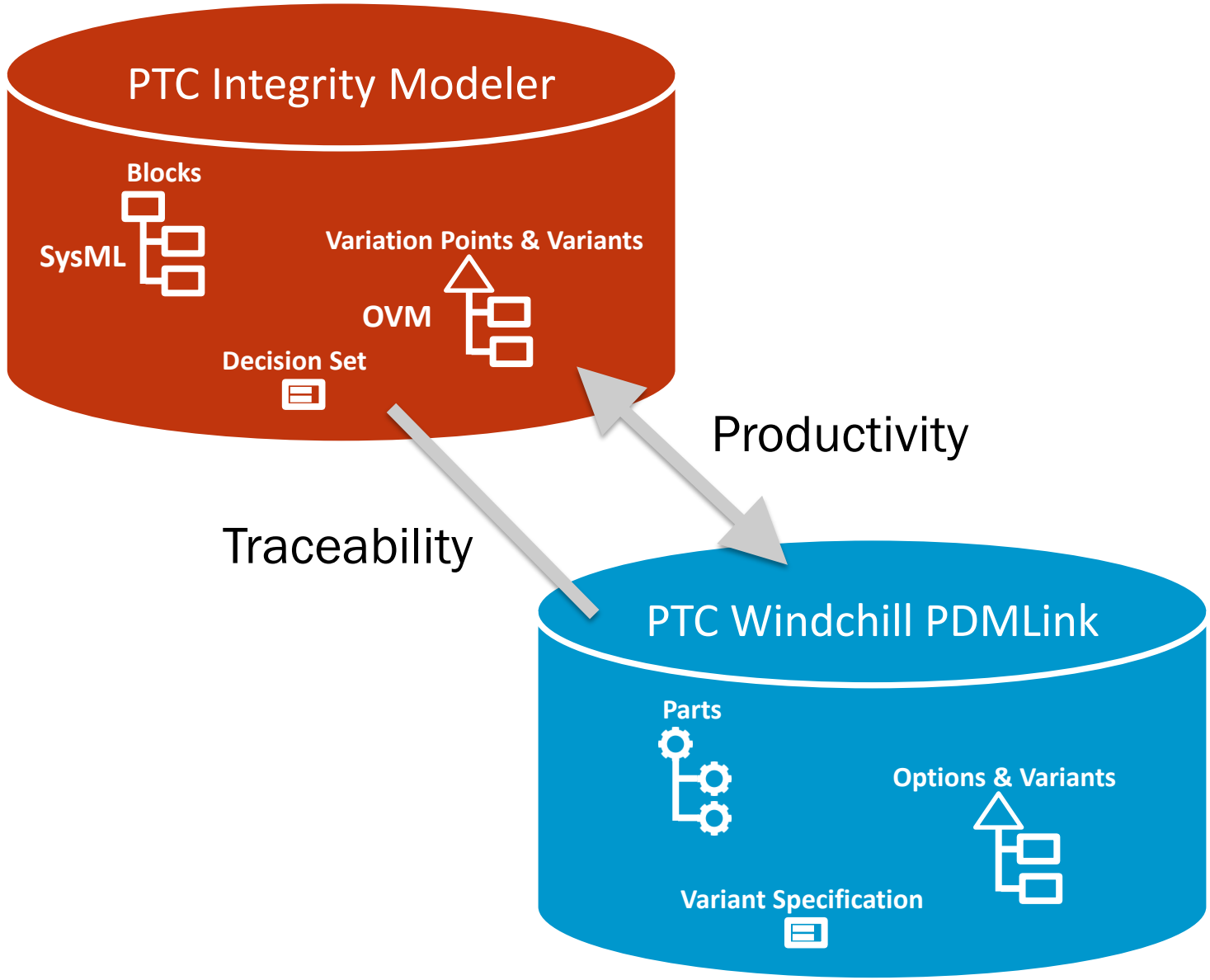
Product data driven simulation

CONNECT

INTER-DISCIPLINARY MBSE

- Connected to Windchill PLM
- Connected to Integrity Lifecycle Manager Requirements
- Connecting to AgileWorx Stories

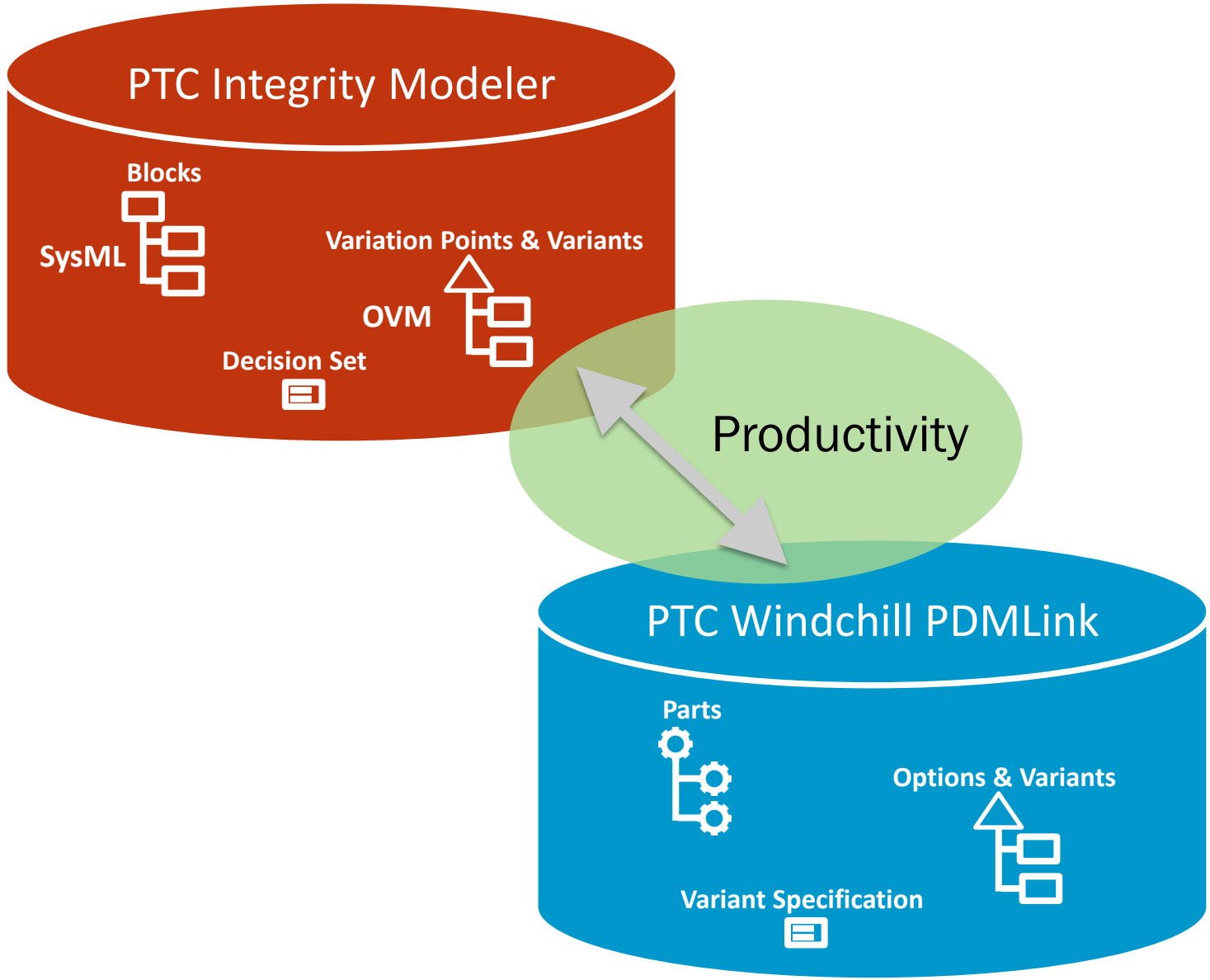
And more…



CONNECT

INTER-DISCIPLINARY MBSE

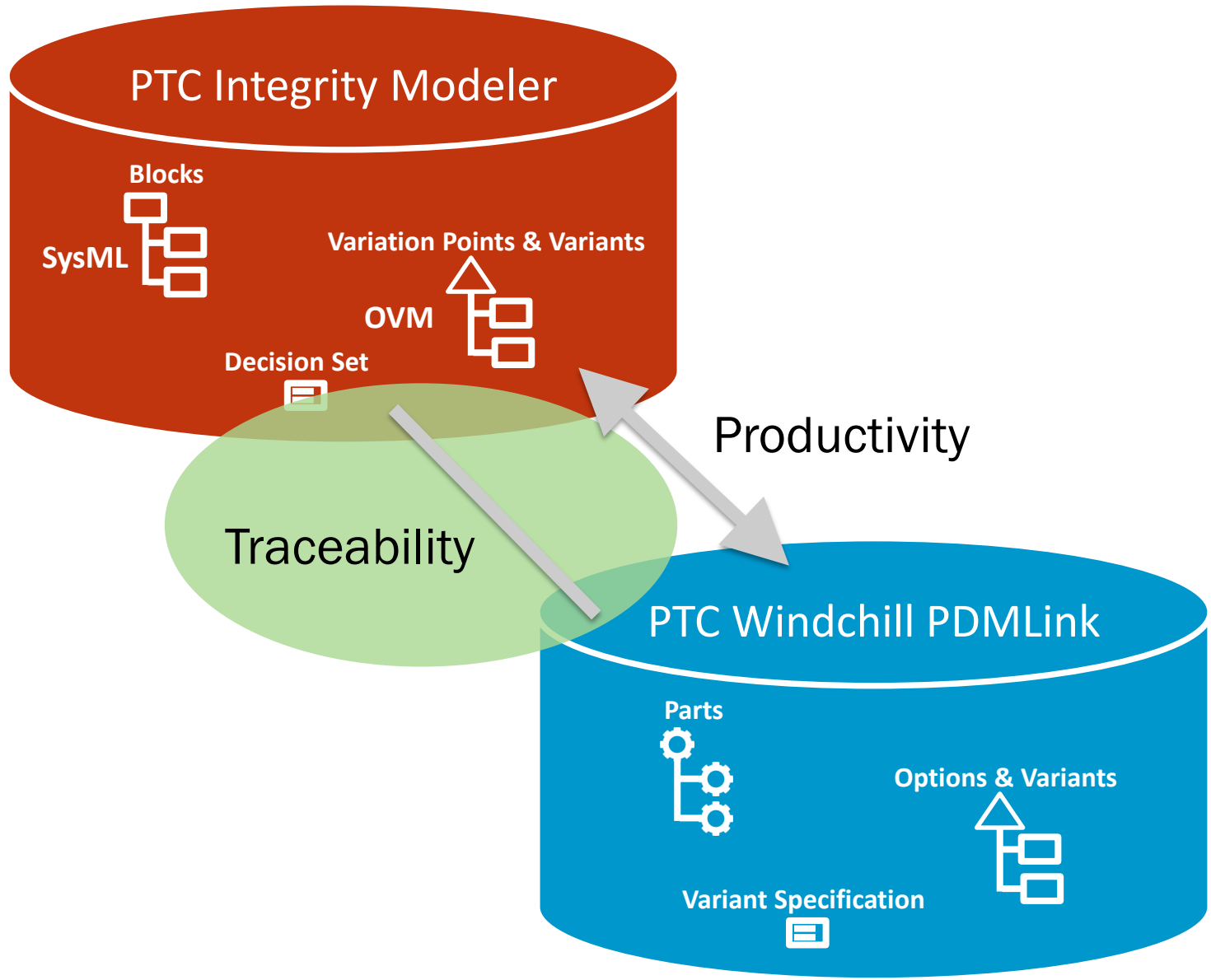
- Improved lifecycle productivity
- Improved quality, with information flow-down
- Improve Agility, with connected teams



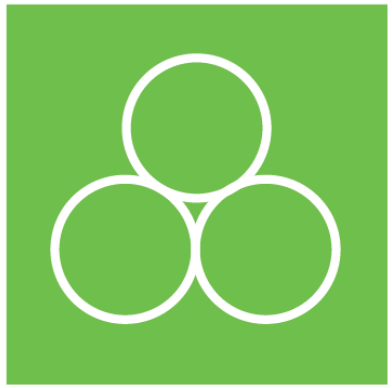
CONNECT

INTER-DISCIPLINARY MBSE

- Improved proof for certification
- Improved products, satisfying system level designs
- Improved Agility, with timely impact analysis & changes



ENABLING AGILE SYSTEMS ENGINEERING



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SUMMARY

- Interdisciplinary model-based systems engineering is a must for complex product manufacture
  - Collaborative planning & architecture definition, involving customers, suppliers, end users & engineers from multiple domains
- PTC's Agile MBSE for IoT
  - Just enough modeling
  - Collaborative, incremental & iterative
  - Modular & variable for IoT SoS & product lines
  - Visual mockups and simulation
  - Continues to support traditional approaches, including the V-Model
- Modeling is the enabler for Engineering Agile Systems and Agile Systems Engineering


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