Integrating System Modeling with PLM Platform to Enable Enterprise MBSE Capabilities…

… to Develop the Right System Right, on Time and on Budget

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NDIA

21st Annual Systems Engineering Conference

Tampe, FL

22-25 October 2018

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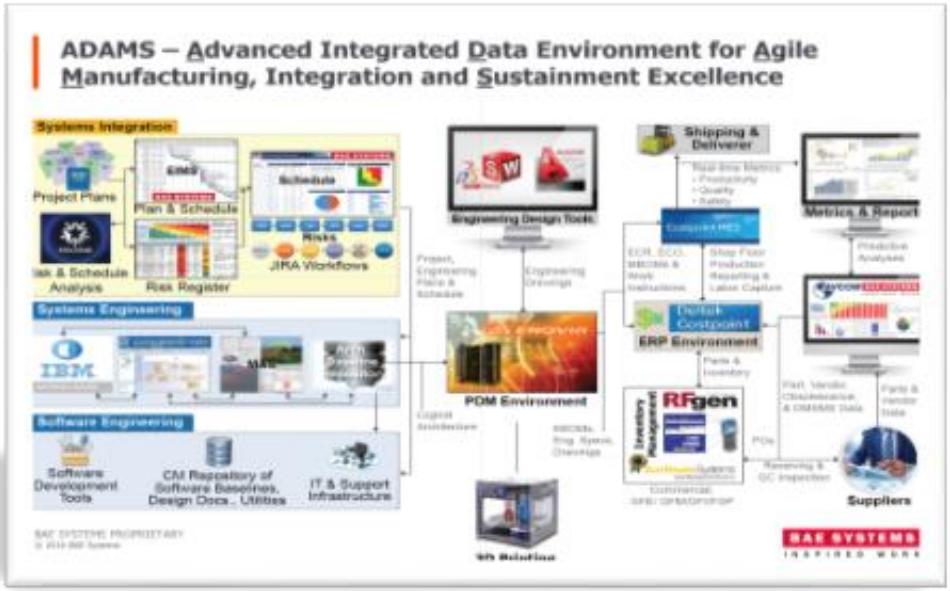
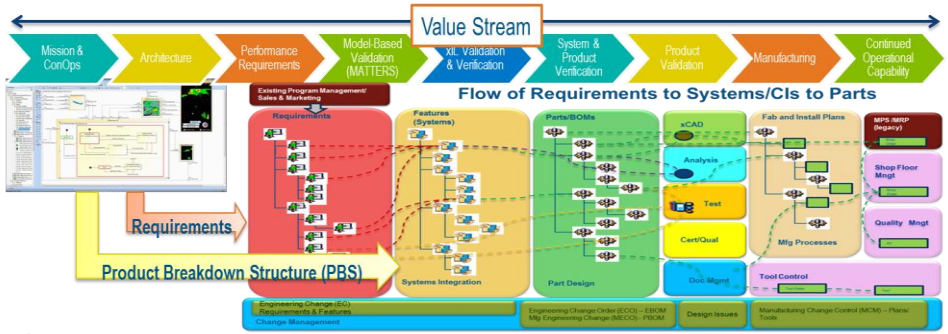
Outline

- BAE Systems MBSE Initiative
- An MBSE/MBE Integrated Data Environment (IDE)
- A Use Case: Visual Factory Development
- Selected Capabilities Demonstration:
  - RFLP Traceability: System Model (SysML) to eBOM (PLM) and Source Code
  - Automated Model Based Testing
- Conclusion & Future Work

MBSE Initiative at BAE Systems Intelligence & Security – Strategy to Drive Business Growth





(Credit: Dassault Systemes)

MBSE Strategy

- Digital enterprise for engineering services
  - Paperless environment
  - Digital thread with integrated and interconnected models to provide a "single, authoritative source of truth"
- Backbone for systems engineering & integration, system modernization
  - Owning the technical baseline and managing changes
  - Earlier system understanding, improve product quality, reduce cost and time-to-market, and improve productivity and competitiveness

Targeted Capabilities:

- Integrated *Data Traceability*:
  - Reqt → Functional → Logical → Physical (eBOM) → Manufacturing (mBOM) → Procurement (supply chain)
- Integrated *Toolsuite*:
  - DOORS → Magic Draw → SolidWork 3D → ENOVIA → MES/VF → CostPoint
- System Modeling
  - Technical baseline & change management
- Multi-function *Collaboration*:
  - PM – Eng – Ops – Proc
  - External/customer collaborations

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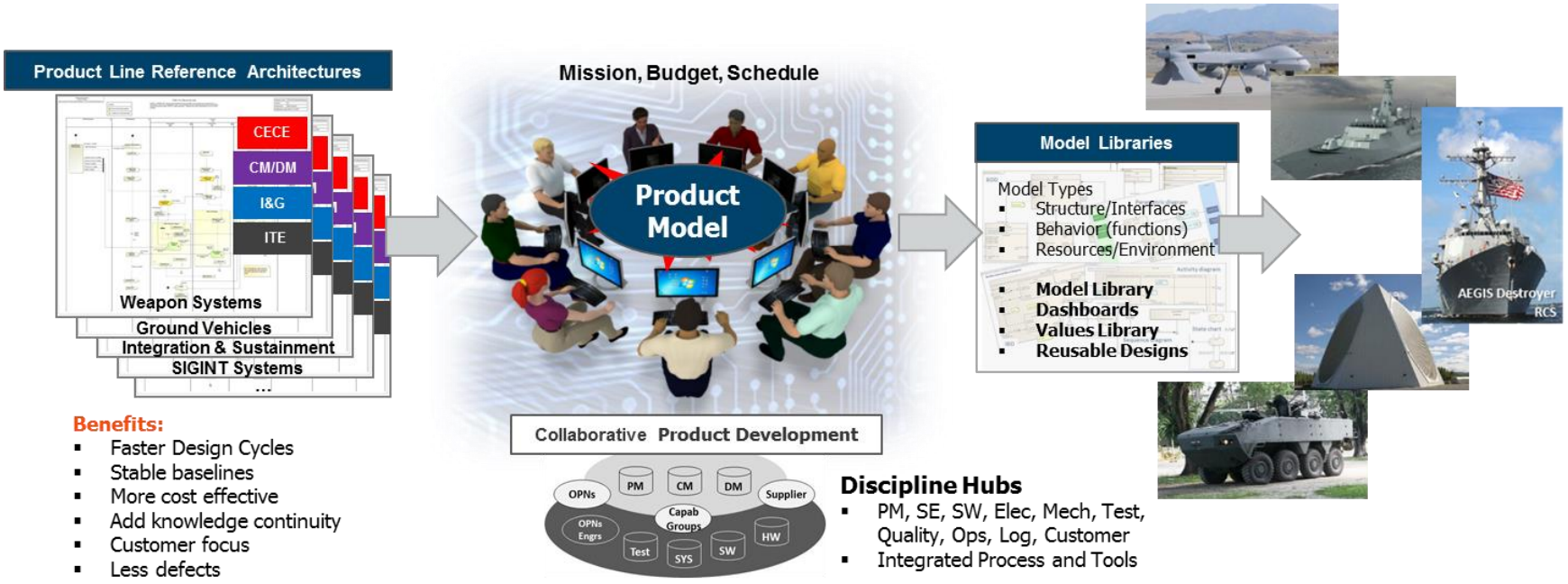
MBSE "To-Be" State: Collaborative Product Development Based on Shared Reference Architecture and Model Libraries



Benefits:

- Faster Design Cycles
- Stable baselines
- More cost effective
- Add knowledge continuity
- Customer focus
- Less defects

Discipline Hubs

- PM, SE, SW, Elec, Mech, Test, Quality, Ops, Log, Customer
- Integrated Process and Tools

Cross-business Sharing of Vision, Process, Model Library, and Best Practices

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Terminology Referenced

- SysML – General-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities, one of the most popular in the world
  - Developed by OMG and INCOSE
  - Adopted by OMG in May 2006 – OMG standard
  - ISO/IEC 19514:2017, OMG XML Metadata Interchange (XMI®) / ISO 10303-233
- RFLP – The acronym for Requirements, Functional, Logical and Physical architecture views – adopted since the 80s a known description of the core elements of Systems Engineering
  - Supported by MIL-STD 499B, "Military Standard – Systems Engineering" (first version 1974, draft revision 1994)
  - Then replaced by IEEE/1220 (first version: 1994, revised in 1999 and 2005), "Standard for Application and Management of the Systems Engineering Process"
- Dassault RFLP – a combination of framework, language, and method
- Platform – Dassault Systemes 3DExperiance (3DS)
- MagicDraw® / Cameo Systems Modeler® – UML/ SysML models authoring and management tools.
- MagicGrid® – SysML based model based systems engineering method and framework
- Model execution – Cameo Simulation Toolkit provides the first in the industry extendable model execution framework based on OMG fUML and W3C SCXML standards
  - Extends modeling to validate system behavior by executing, animating, and debugging in the context of system architecture and design
  - Conformed to standards: Activity execution (OMG™ fUML standard), State machine execution (W3C SCXML standard), SysML parametric execution (OMG SysML standard), Multiple action languages support (JSR223 standard), Pluggable engines and evaluators

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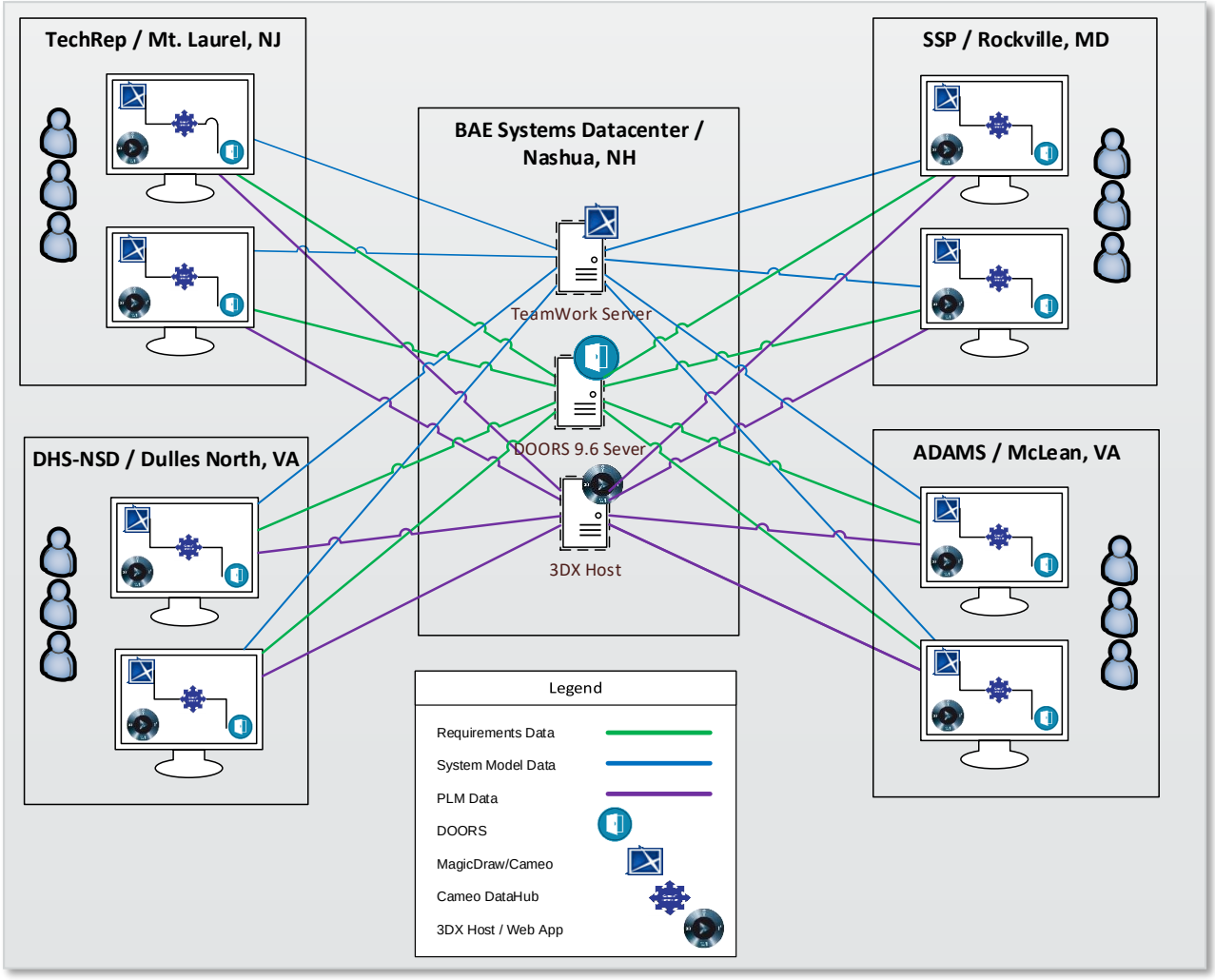
MBSE/MBE Integrated Data Environment (IDE) Deployment



- Multi-site, collaborative teams
- Collaborative development
- Central database & CM/admin
- Services hosted in corporate cloud / datacenter
  - Servers & databases
  - 3DExperience Sandbox

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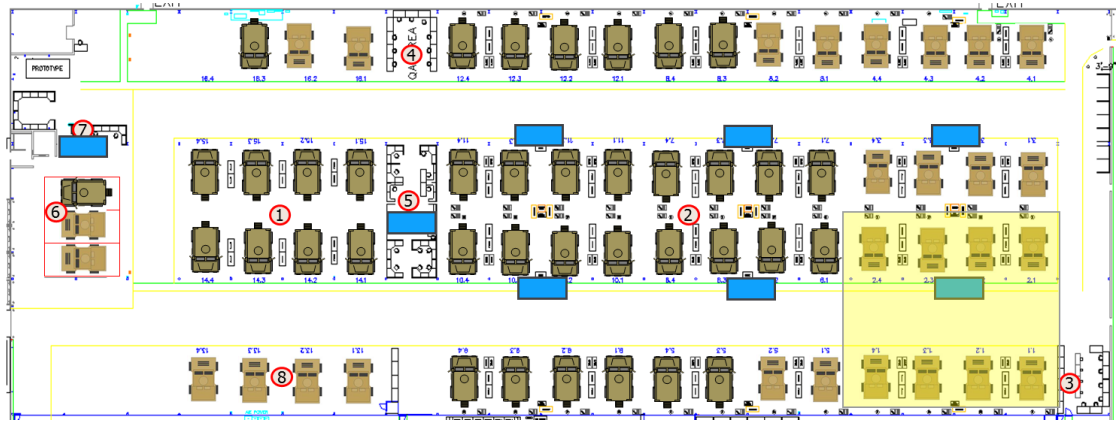
An MBSE Use Case: Visual Factory Development

- Visual Factory: a lean, scaled version of Production Execution System (MES)
  - *Office*: desktops
  - *Factory floor*: data kios, large screen displays
  - Digital shop floor
- Real-time, collaborative production execution management
  - Planning, scheduling & configuration
  - Real-time data entry, data collection, & production status
  - Multi-team, shop-floor management



Production Teams:

1. Overhead Work
2. Vehicle Integration
3. Quality Control
4. Quality Assurance
5. Bullpen Area
6. Heat Shrink Wrapping
7. Transportation Coordination
8. APO QA Area

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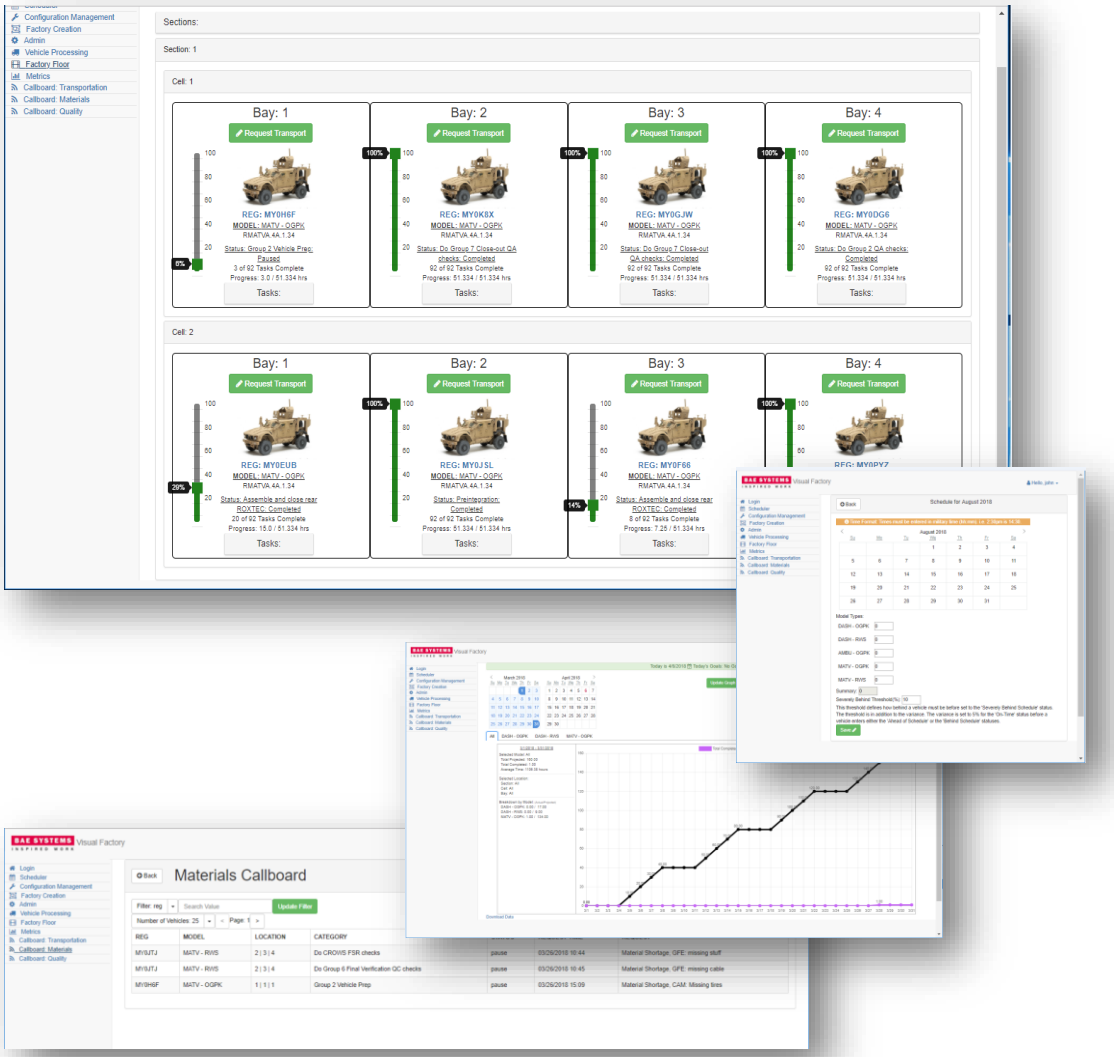
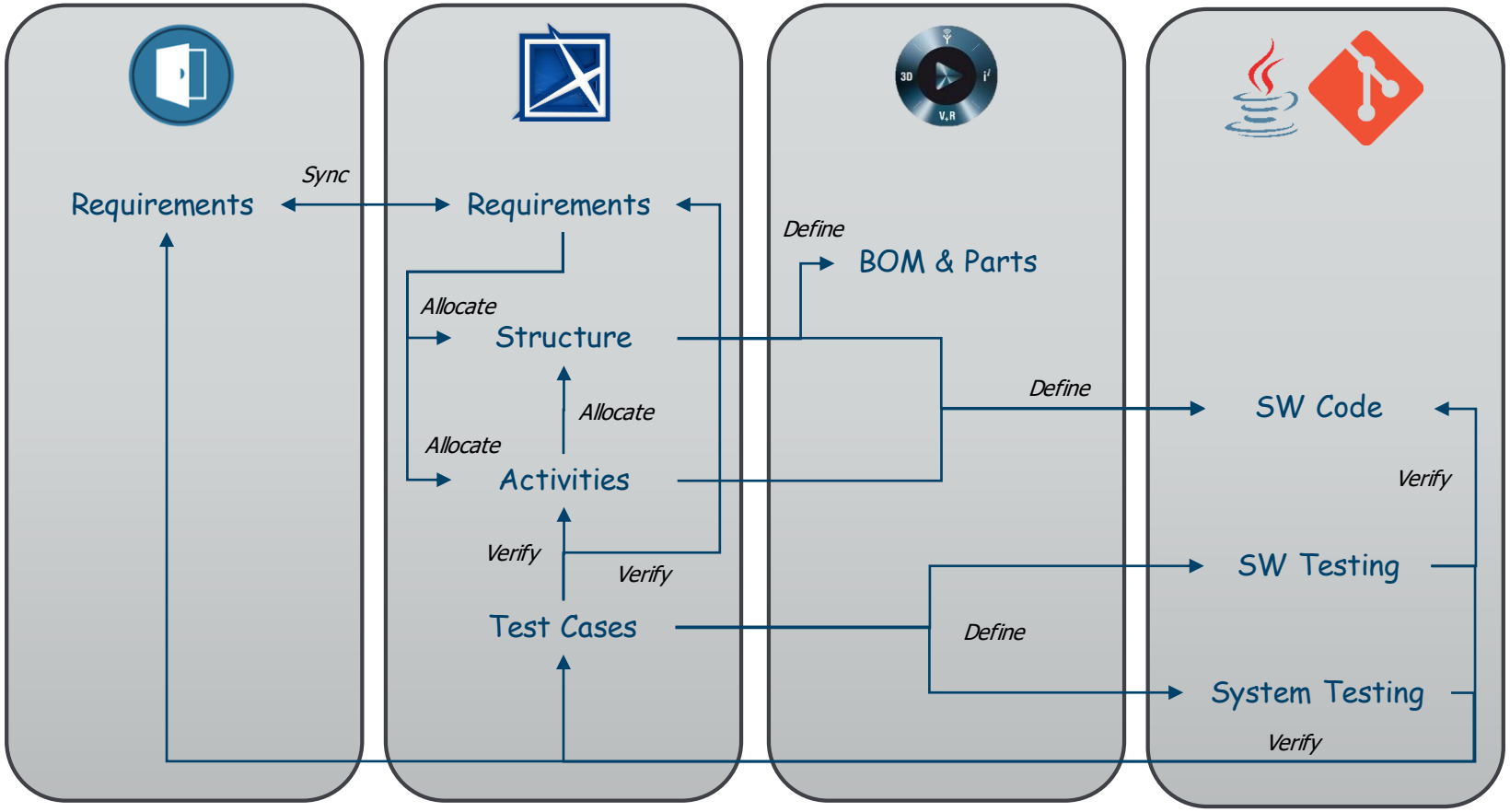
Visual Factory System & Application

- Hardware:
  - Server
  - Thin & thick clients
  - TV displays
  - Network
- Application Software:
  - A web application
  - Factory layout
  - Production scheduling
  - Vehicle/system configuration
  - Work initiation, work-in-progress tracking
  - Production floor status
  - Call-boarding and issue resolution (material, transport, quality, etc.)
  - User, team management
  - Data collection and analysis



Visual Factory System Architecture Developed in the MBSE IDE to Establish End-to-End (RFLP-T) Architecture Traceability



Integrated System Modeling & PLM/ALM Environment Ensures RFLP-T Traceability in Design

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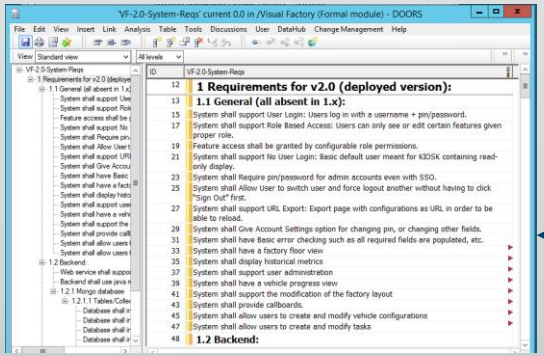
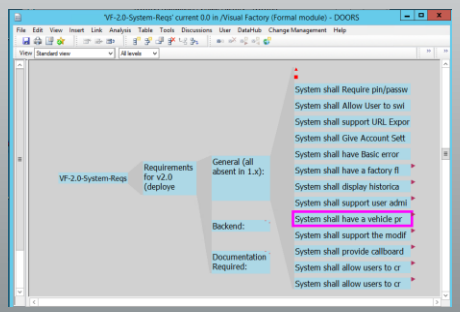
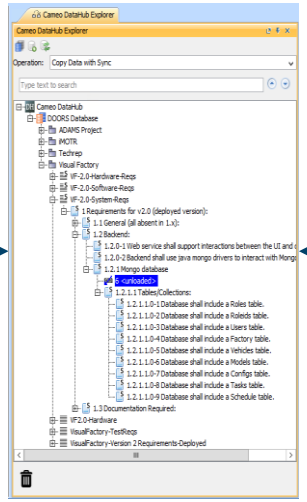
System & Subsystem Requirements – Sync'ed Between DOORS and MagicDraw

DOORS

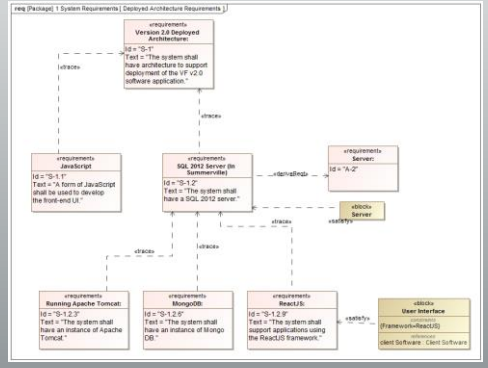






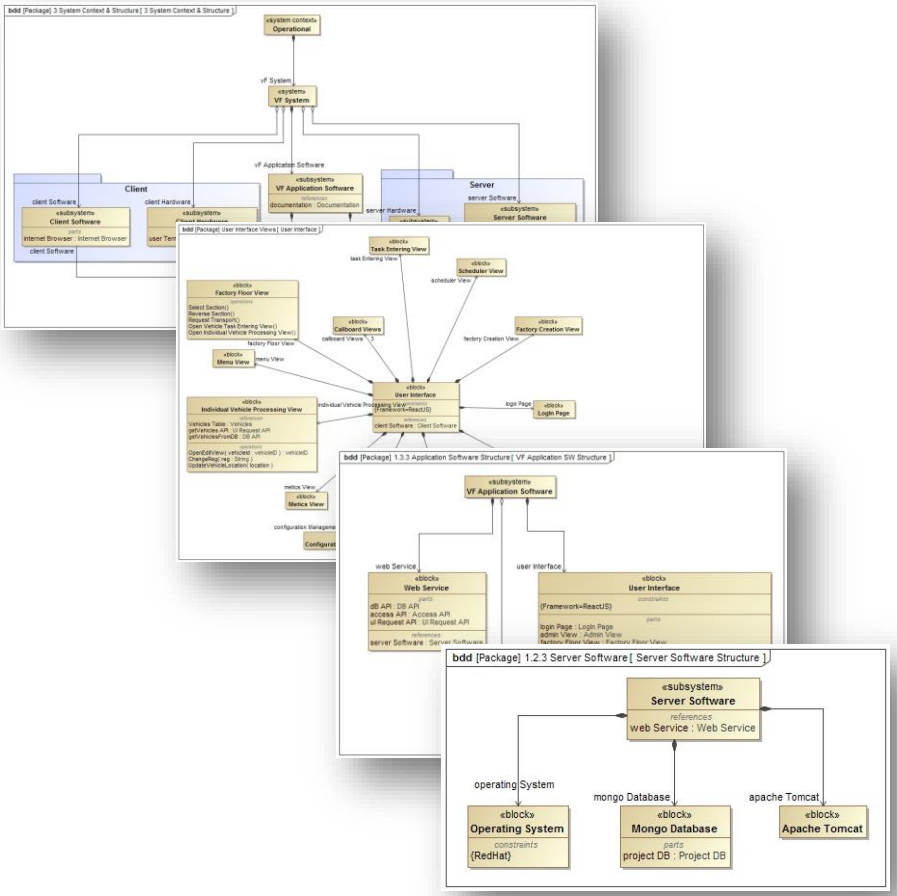
Cameo DataHub

MagicDraw

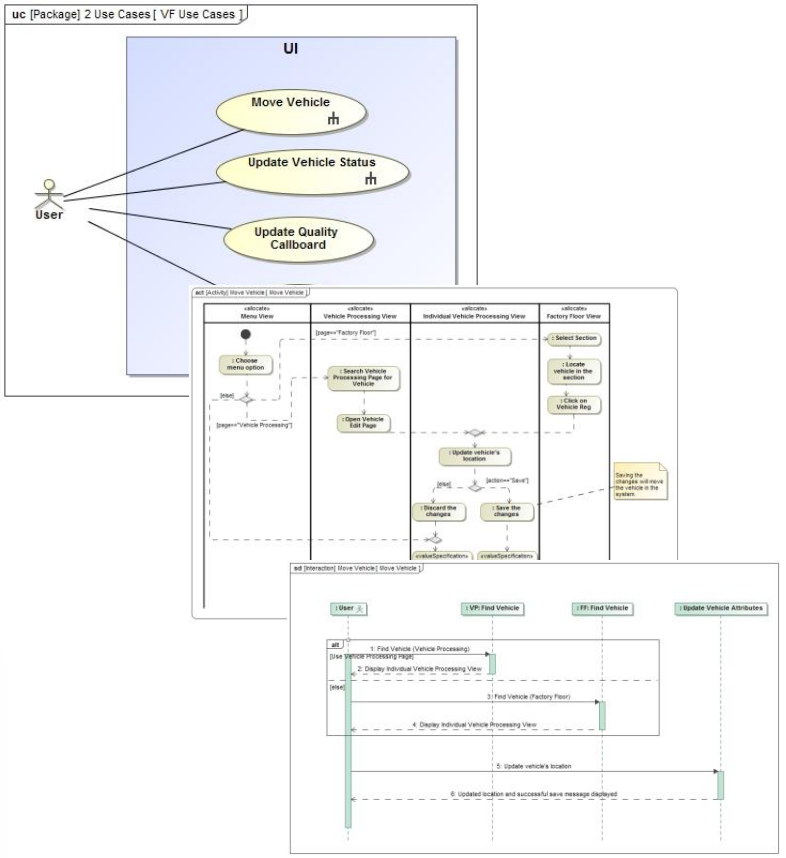


System Modeling: Structure, Use Cases, Activities in SysML

System, HW & SW Components:

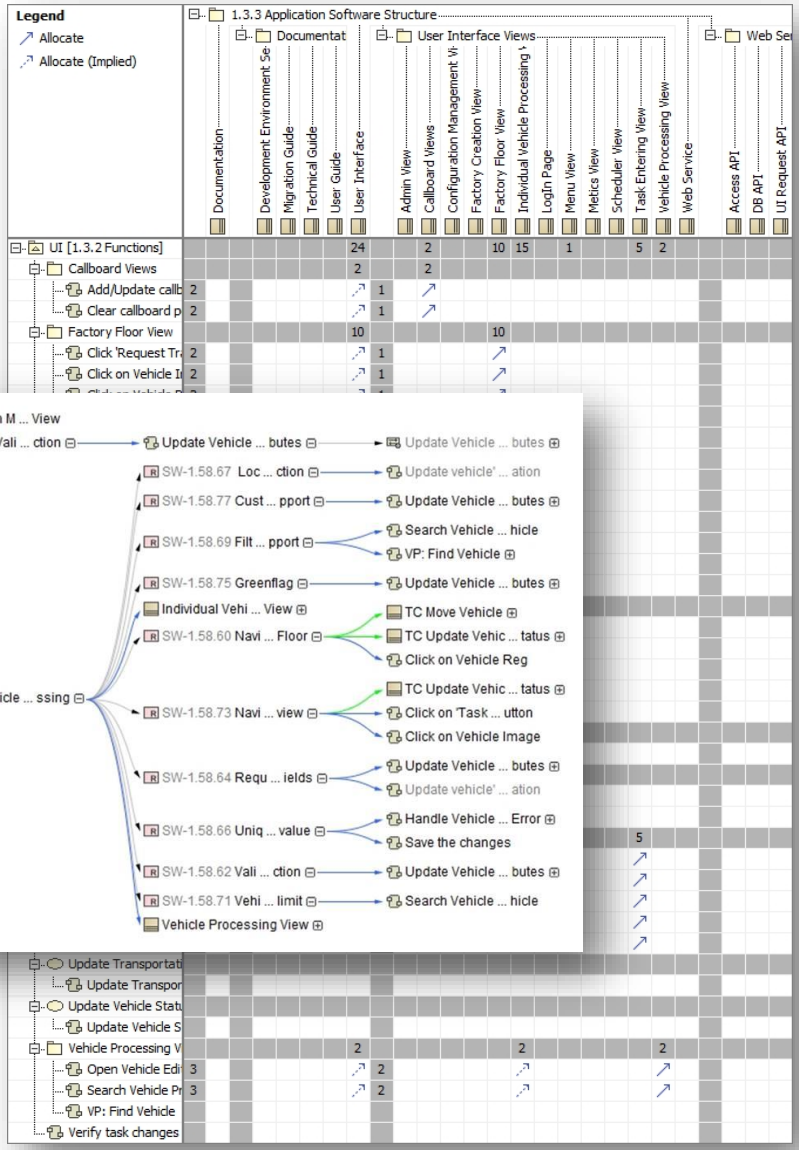


Functions, Workflows:

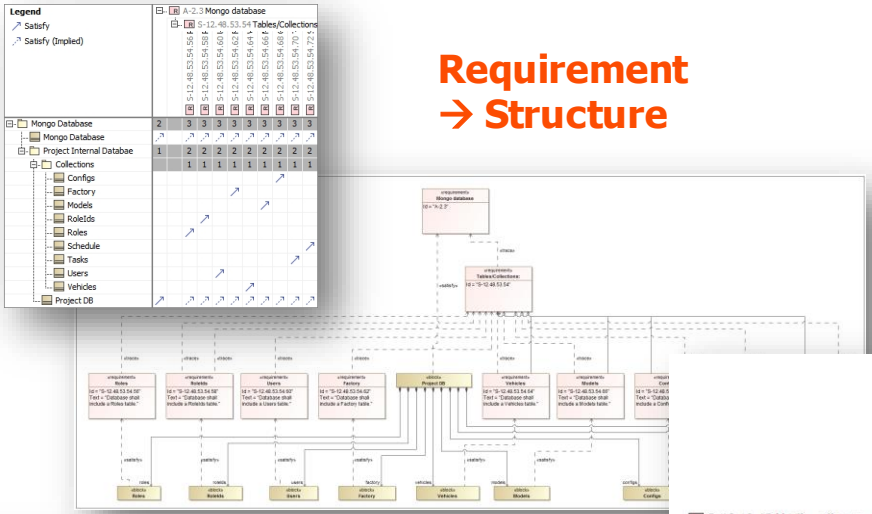


Architecture (RFL) Traceability in SysML

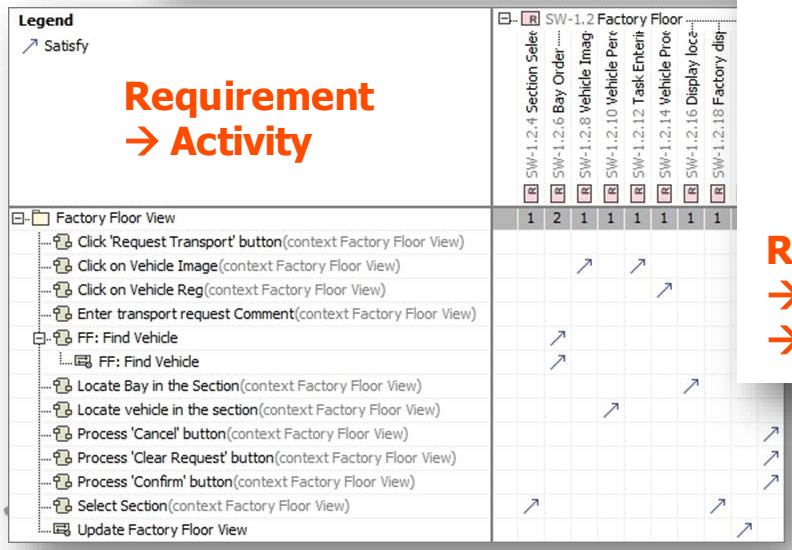
Activity → Structure



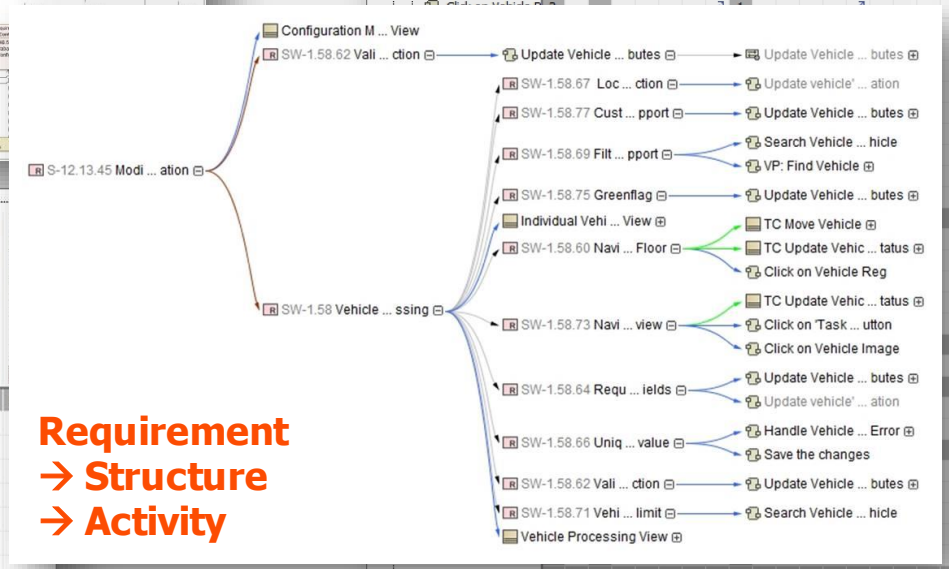
Requirement → Structure



Requirement → Activity

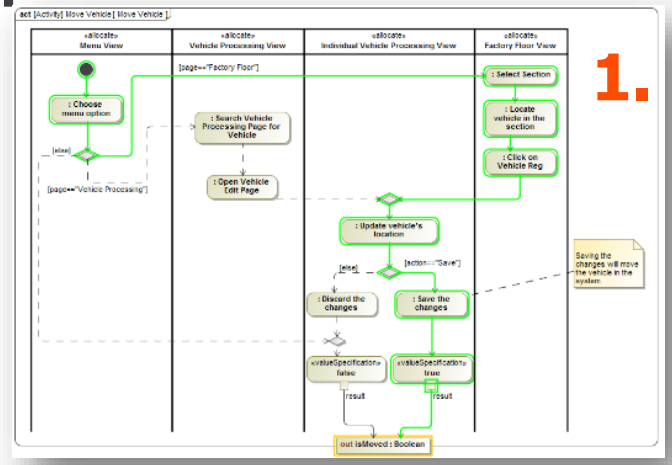


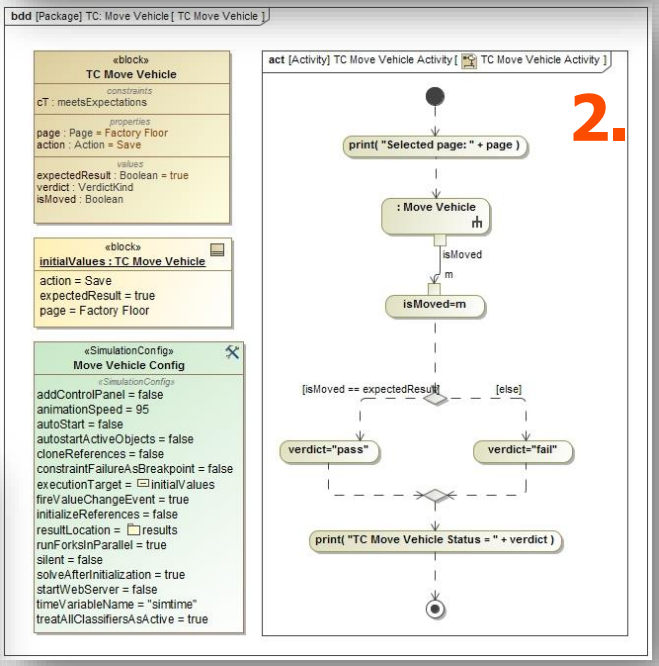
Requirement → Structure → Activity

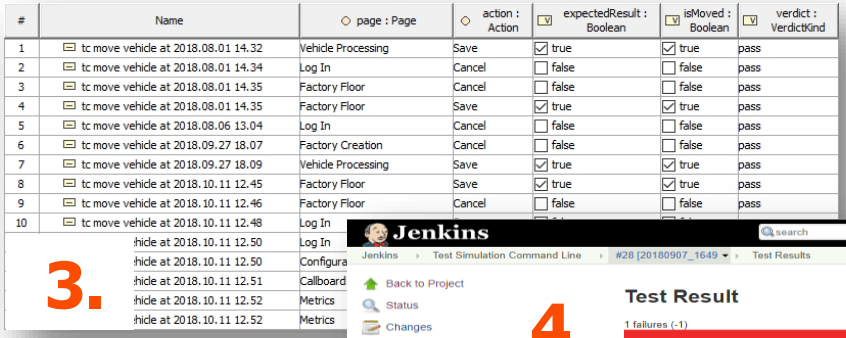


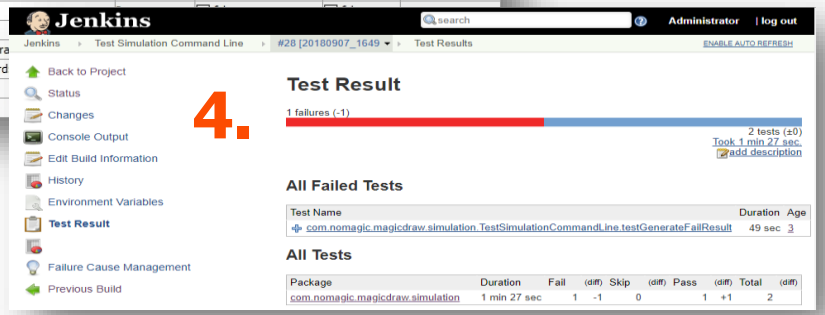
Model-Based Testing for Early Verification

- Goal
  - Automatic architecture and design model verification
- Process:
  - Step 1: Specify operational scenarios and system functions
  - Step 2: Specify or record tests cases
  - Step 3: Execute testing
  - Step 4: Setup automated regression / continuous testing









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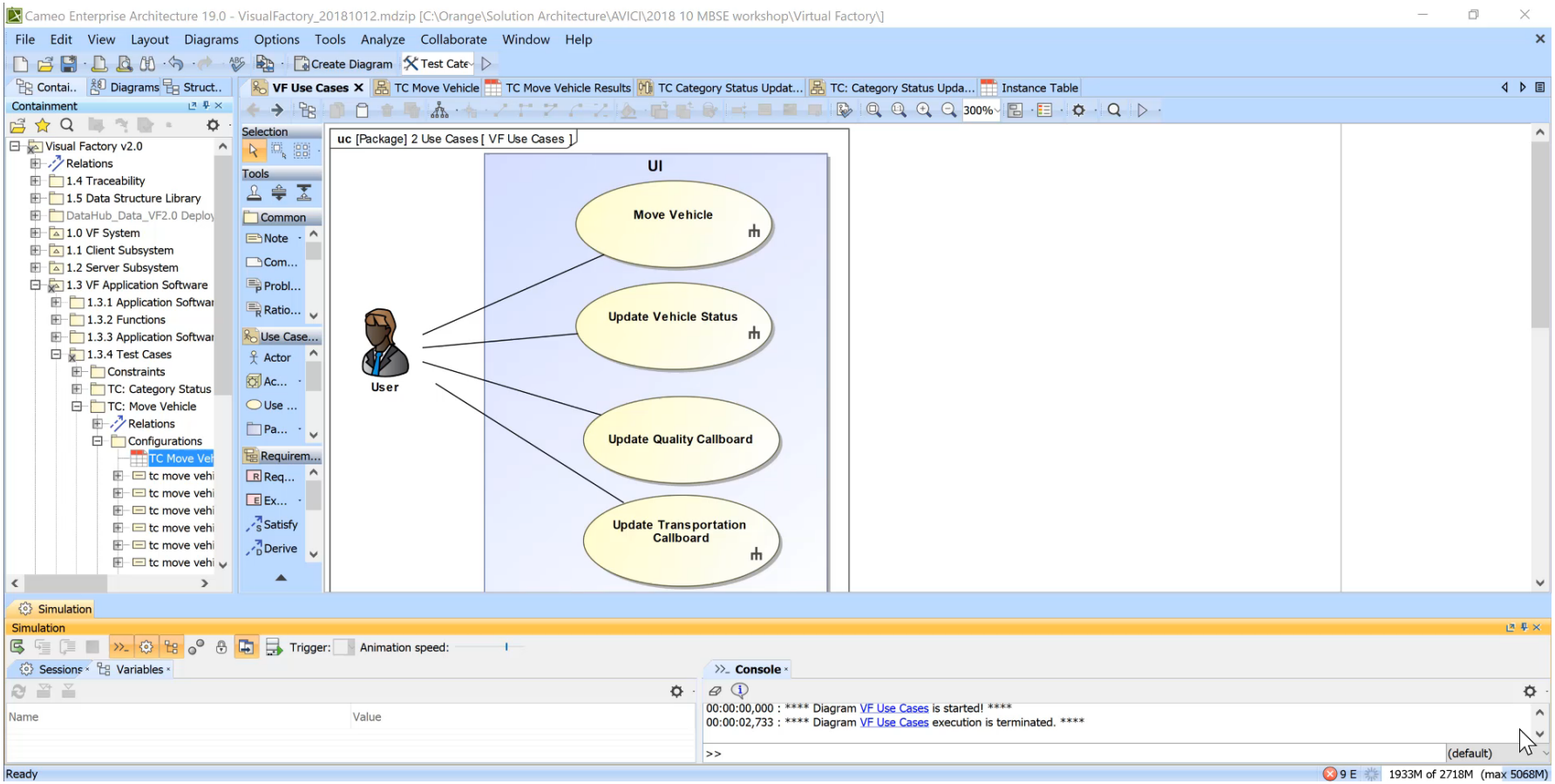
Conducting Model-Based Testing (Video)



Connecting System Model (MagicDraw) to Physical Product Definition (3DS) – Extending the RFLP Traceability

- Goal
  - Establish RFLP traceability across platforms and perform change impact in a multi-domain, integrated ecosystem
- Process:
  - Step 1: Publish SysML model to 3DS using MagicDraw-3DS Connector
    - Publishing maintains all SysML connections in 3DS
  - Step 2: Create additional connections between relevant system model elements and eBOM elements in 3DS using *3DS System Synthesis*
    - To complete the RFLP traceability
  - Step 3: Repeat publishing from MagicDraw to 3DS to sync the changes only
    - 3DS Platform tracks the changes
    - Established traceability is maintained
- *Note: Capabilities shown are not yet published and for demonstration purpose Only*

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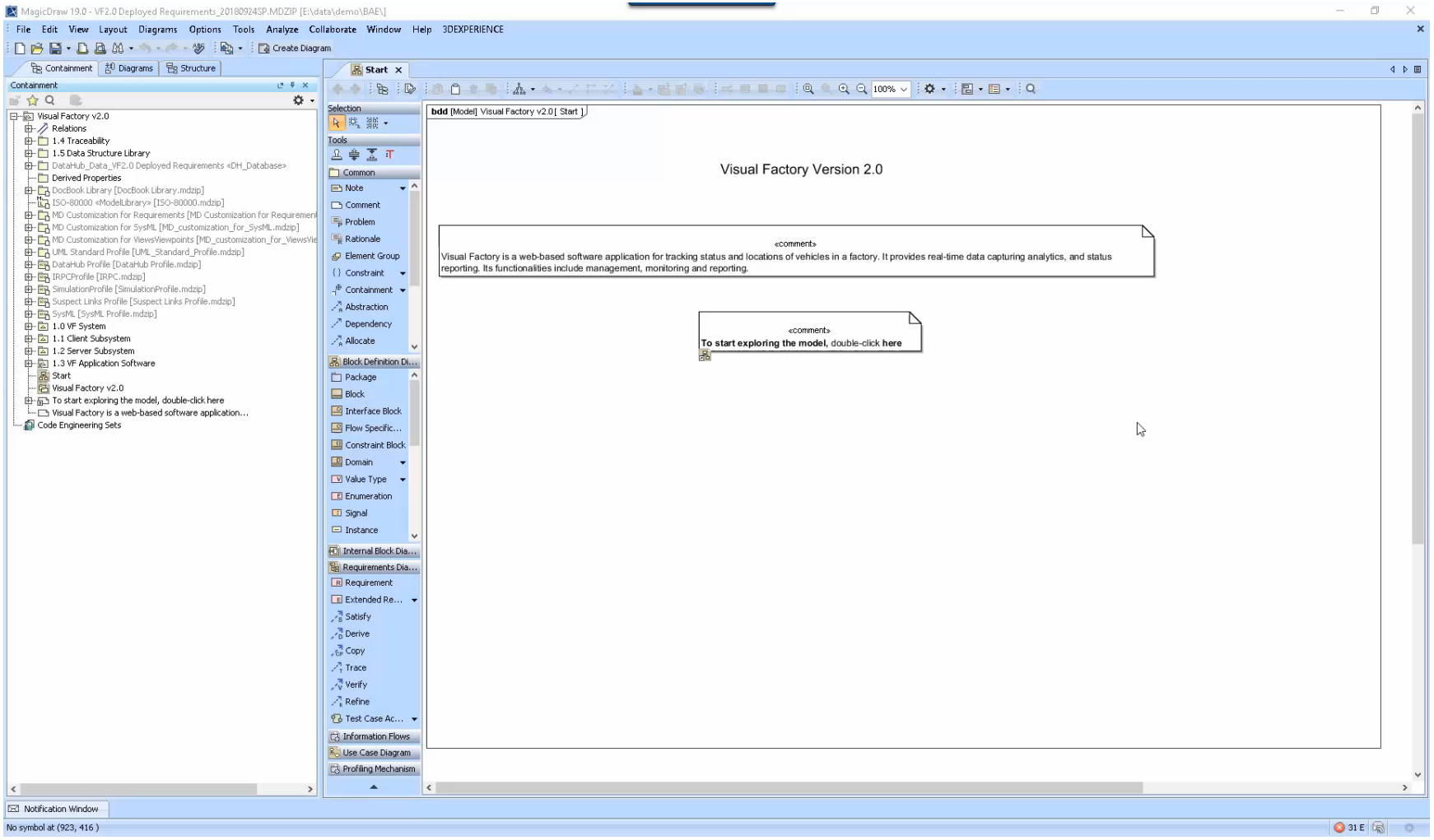
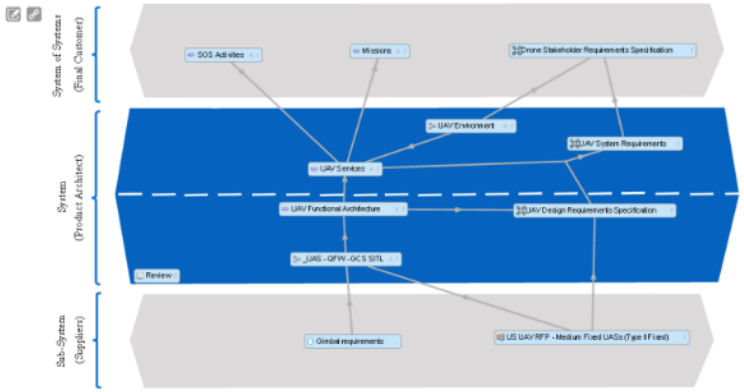
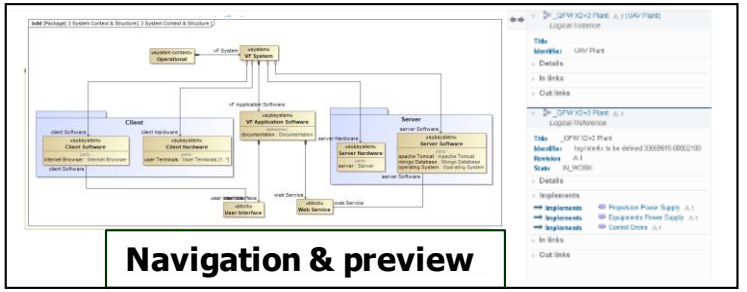
SysML to RFLP Traceability with 3DS System Synthesis – Enabling Change Impact Analysis (Video)



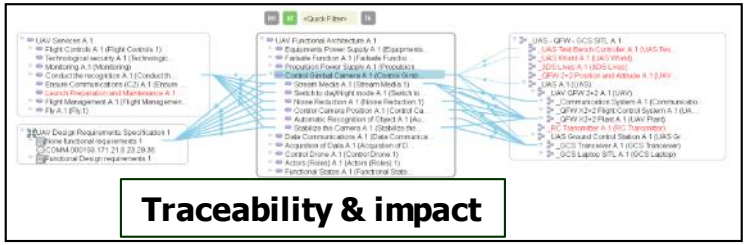
3DS System Synthesis: 3DS App for SysML/PLM Connectivity

Scope

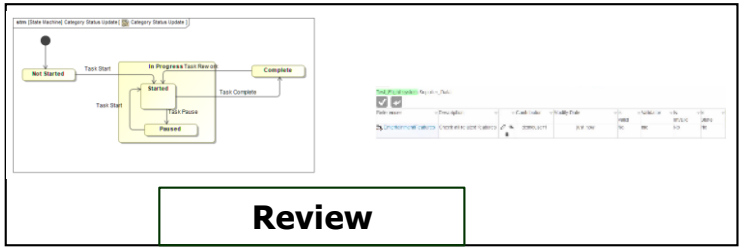




Navigation & preview

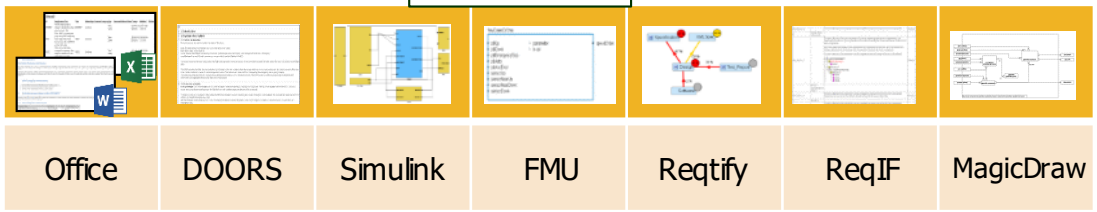


Traceability & impact



Review

Connectors



Software Development Kit (SDK) available for specific connector

Conclusion

- RFLP architecture traceability through model integration is becoming a reality
  - System Models – BOM – Source Code – Testing
  - 3DS System Synthesis – unique integration framework which delivers connection between UML / SysML models and other data sources on 3DS platform
- Automated model-based testing using formally interpreted standard model – SysML is the critical linchpin which verifies system architecture through model execution
  - Speeds up testing process
  - Enables test automation (with model execution & Monte Carlo Simulation)
  - Improved test rigor – minimizes errors, reduces defects – that improves quality

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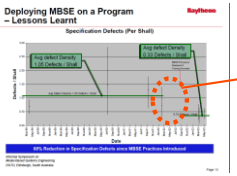
Key Business Benefits: Digital Transformation for Better Systems and Empowered Engineering Teams

Cost Reduction / Take-out

- *Reduced defect rates & cost of poor quality av*

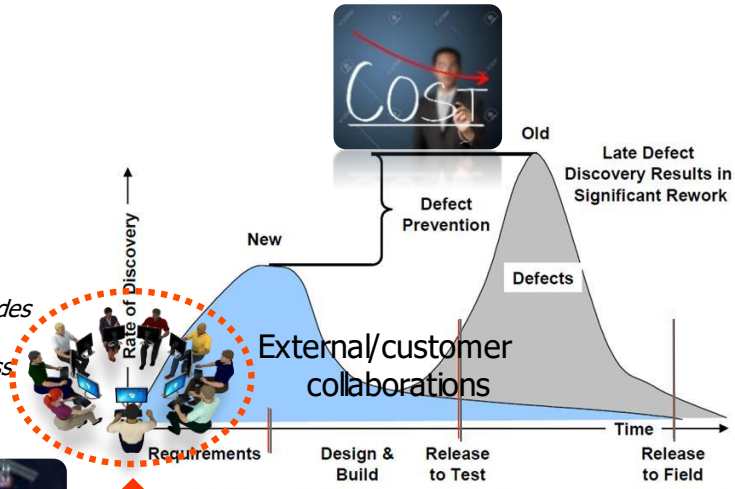


Specification Defects Reduced 68%

- *Systematic design reuse and architecture trades*
- *Reduction of transactional costs*
- *Lean engineering, productivity & effectiveness*

Cycle Time Reduction

- *Systematic design reuse*
- *Competitive engineering solutions enabling Business Winning*
- *Rapid engineering change responses*
- *Early architecture decisions*

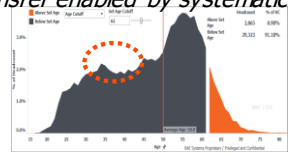


MBE: *Left-Shifting Engineering*
- Earlier Design Decision Reduce Lifecycle Costs
- Earlier Defect Detection & Reduce Rework

New Business Winning

- *Competitive technical solutions & discriminators*
- *Rapid engineering change responses*
- *Early architecture decisions, time to market*
- *Expertise and authority*

Knowledge Transfer



- *Expedited knowledge transfer enabled by systematic knowledge management*
- *From "grey beard" to codification of corporate knowledge*
- *Institutionalization of IP, trade secret & product know-how*

Employee Morale and Retention

- *Engineering workforce empowered by advanced engineering tools*
- *Changed work style from transactional to transformational*
- *Inspired Millennial generation by state-of-the-art technology and capabilities*

Inspired Work – Competitiveness - Improved Bottom Line

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Progress & Future Work

- Current progress:
  - SysML model visualization & interaction (including diagrams) through 3DS Platform web app interface
- Future work:
  - Future development will allow publish SysML elements to native 3DS metamodel (RFLP) elements
  - Traceability to cross-platform data sources, including DOORS requirements, Simulink model, BOM, Code; Collaborate, documentation, track change impact, etc.

Thank You

Dr. Gan Wang, BAE Systems

Dr. Saulius Pavalkis, 3DS (No Magic, Inc.)

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