MODEL-BASED SYSTEMS ENGINEERING IN REAL LIFE

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GOAL AND AGENDA

• Collaborative MBSE; involving multiple stakeholders and engineering disciplines
  – BMW

• Architected, modular MBSE for designing connected systems & MBSE supply chains
  – German Tier-1/2

• Model-based system product line engineering
  – Alstom

• System & software design for the Internet of Things
  – Schneider Electric

• Product functionality simulation and improvement
  – DB Netz AG
1. Systems Engineering connects the different disciplines coherently
2. Collaboration through System Architectures
3. A common language is needed and available
4. Systems Engineering is not only for experts
5. Real products are always developed in Product Lines
6. Connectivity needs the System View
7. Modeling is always useful, often necessary, but never an end in itself

OUR RED LINE THROUGH MBSE: THE 7 PILLARS TO UNDERSTAND AND USE MBSE
1. Model-based Systems Engineering is the glue between the different engineering domains (and other stakeholder perspectives)
   - Pragmatic: formal as needed, not as possible
   - Automotive Example: ISO 26262 requires use of „semiformal methods“
   - See INCOSE 2020

• Requirements to a Modeling Tool Chain:
  - Collaborative: Not „my model“ (and many of them), but „our model“
  - Open Interfaces to other development artifacts
  - Emphasize on the Information you need (Role-based views)
LOOK INTO MODELER

• UI
• Multi-User
• User Roles
2. System Architecture models define the level of re-usability
   – Just doing functional decomposition only allows a low-level library concept
   – The basic concept should be object-oriented (a network of connected elements)
     • OO -> UML -> SysML
   – Tree Structures should be just filters or perspectives

• Requirements to a Modeling Tool Chain:
  – Keep Type Definition and Type Usage separate
  – Support Compositions and Abstraction
  – Model-in-Model Concept
• SysML ABS Example
3. SysML is a common Modeling Language on System Level
   - Adaptable through light-weight extensions
     • To ease the use of the agreed methodology
     • To include domain-specific Information
   - Can be used in parallel with other UML-based profiles

• Requirements to a Modeling Tool Chain:
  – Extensions without visible overloading of UML Elements
    • Why is Java set als default implementation language for a SysML Block of Requirement?
  – Ergonomic Profiles: Tool behaves differently due to the profiles in use
  – Profiles affect the Mapping to external Information
• 4 SMARDT Levels
  – According, but simplifying ISO26262

• Using SysML
  – plus an SysML-based SMARDT Profile

• PTC Integrity Modeler chosen due to
  – Adaptability
  – Multi-User Support
  – Interfaces
ABSTRACTION AND MODEL PERSPECTIVES
• Translations
• Requirements Subtypes
Model-based Systems Engineering is a team effort and not only for a few experts
- The System Model is the "man in the middle" for all project artifacts
- Models aren't just modeled, but transformed, read, reviewed, released, annotated, changed, reused etc.

Requirements to a Modeling Tool Chain:
- Model-compatible Config Management
- Access Rights Management
- Different access to Model information:
  - Verification and Reviews
  - Web-Access
  - User Roles to filter out unnecessary Information
  - Programmatic Access
  - Link and Sync: Ein Beispiel-IBD
DEUTSCHE BAHN EXAMPLE
DIGITAL PRODUCT TRACEABILITY

• 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
5. Explicit Product Line Engineering included in the System Model (MB-PLE) is needed to completely show and use the Project Reality with Variants, Configurations and word Concept Templates
   - Re-Use of existing solutions cannot efficiently be based on „Clone and Own“
   - Separated variant or feature models have to be kept in sync with all referenced development artifacts, which will not be easy.

• Requirements to a Modeling Tool Chain:
  - Support a Variability Modeling Standard
    • OVM, as used in ISO26550:2015
  - Direct link from variants to model artifacts
  - Online checks on variability decisions
  - Automatic transformation from product family to product models

A Example Variant Diagram
ALSTOM TRANSPORT CHOOSES PTC INTEGRITY MODELER AS THE PLATFORM FOR ITS GLOBAL SYSTEMS ENGINEERING STRATEGY

With revenue of €5.5 billion, Alstom Transport is present in over 60 countries

“PTC modeling technology significantly improved quality and consistency, and reduced effort throughout the design lifecycle.”

Marco Ferrogalini
Chief System Engineering,
Alstom Transport, Rolling Stock & Components Product Lines
MB-PLE

• Audio-Example
6. Connectivity in the product and in the development artifacts have both to be expressed
   - „System“ and „System-of-Systems“ exist on many levels
   - Abstraction and implementation exist in both the products and in the development and usage concepts
   - Abstract System Levels allows to validate new business models

• Requirements to a Modeling Tool Chain:
  - Use the same connectivity approaches and techniques for the connected systems and the connected development Artifacts
  - Keep this open and use standards
    • OSLC
CONNECT

INTER-DISCIPLINARY MBSE

- Connected to Windchill PLM
- Connected to Integrity Lifecycle Manager Requirements

And more...

PTC MBSE
7. Modelling and Models are not an end in themselves nor by-products
   - The transformation from document-based to model-based Systems Engineering is a general trend, as INCOSE 2020 indicates
   - Model-based Specifications can be used in addition to Model-based Systems Design
     • More formal Requirements Perspective
   - Models are the common knowledge base on all system aspects
     • Continuous Engineering on the model as agile work principle

• Requirements to a Modeling Tool Chain:
  - Model Exchange in different Development Phases
    • Respecting intellectual property concerns
    • E.g. using Standards like OMG RAS
  - Versions of models define the project status
  - Bridges to ALM, RM and PLM
  - Enable incrementally the transformation from textual Systems Engineering to the use of connected System Models