Inspiration in Engineering in The Future
ALM-PLM Interoperability

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The Challenges……

1. The Model Based Development Approach
2. MBSE a new Design Methodology (the mecpro² Project)
3. The Interdisciplinary Digital Model and Twin (the InnoServPro Project)
4. The Future IT Infrastructure
   \(\Rightarrow\) federated semantical network based on linked data
5. ALM PLM integration as a first step to MBSE SysLM
Why do we need a System Model

Management of complex technical systems Today...
- Increase in software components
- Different engineering disciplines required
- Specialized and distributed systems
- Entire organizations involved

Interconnection and communication among sub-systems
- No more “stand alone” systems
- Parts of a larger whole (system)
- Communicating Systems

[Source: Systems Engineering Handbook (INCOSE)]

[Source: execpastor.com]
System Model Must be Administered by SysLM

The Model Based Development Process is based on a Product and Process Management Level \( \text{ SysLM } \)

Source: Discussions with Chris Paredis, Georgia Tech
A methodical, interdisciplinary approach for the design, realization, technical management, operations, and retirement of a system.

Formalized application of digital modeling to support system requirements, design, analysis, verification and validation, process planning and service activities beginning in the conceptual design phase and continuing throughout planning, concept, development, test and simulation, production planning and after sales.
Motivation: Time, Budget and Cost Saving

Cost Ratio and ROI for Median Program

Motivation: The early phase is responsible for 80% of the Product Cost and Defects

Defect Detection versus Cost to Repair (Embedded Systems)

Source: Capers Jones
The Automotive Research Approach

What are Prerequisites for MBSE Processes and IT Tools for products and Services
The Basis for MBSE Method (mecPro²)

Method steps from VDI 2221
Design Methodology for Mechanics

SPES (ISO/IEC 15288 and ISO/IEC 12207)
SPES= SW Platform for Embedded Systems

Integration Frame Based on VDI 2206
The mecpro² MBSE Methodology

mecPro² MBSE Process

mecPro² MBSE Profil

mecPro² SysLM Model

Source: VPE Research Project mecPro² (T. Gilz)
The MBSE Process

Textual Requirements

System Lifecycle Management Backbone

- System Model
- Requirement Engineering
- Simulation Model
- Modeling and Specification
- CASE Model
- M-CAD Model
- E-CAD Model
- Requirement Engineering and Specification (Requirements, Functions and Behavior)
- Logical System Design and multiphysical Simulation
- Digital Process Planning
- Service
- Validation
- Discipline Specific Design
- Discipline Specific Detailing
- Modeling and Analysis
- Physical Tests
- Hybrid Tests (e.g. HIL)

B: Behavior
R: Requirements
F: Functions
L: Logical Solution Elements
P: Physical Elements
Detailed MBSE Method

1. Detailed System Requirements
   - Functional System Requirements
   - System Context

2. Provide documentation & structure
   - System Functions
   - Input/Output Parameters

3. Logical System Elements
   - Logical System Elements

4. System Simulation
   - Modelica, Matlab

5. Discipline-specific Design
   - e.g. M-CAD, E-CAD, upper/lower CASE tools

Source: VPE Research Project mecPro² (T. Gilz)

SRD: System Requirement Diagram
SDD: System Definition Diagram
FPD: Functional Product Diagram
SFN: System Function Network
SAD: System Architecture Diagram
The System Architecture on Three Levels

The interdisciplinary Architecture Model  RFLB (SysML)

Textual Requirements

Interdisciplinary Requirements \{R1,R2,R3,\ldots,Rn\}

SW Component Architecture (UML) HW/ES Component Architecture RFLB (SysML,\ldots)

Mechanic

Physical Component Architecture
Anwendungsszenario: Intelligent Autonomes Parken

Benutzerinteraktion (UML)

Logische Systemstruktur (SysML)

“Parkplatznummer: 1453”

„Zufahrtsbeschränkung“

„Kennzeichen“

„Uhrzeit, Geschwindigkeit“

Parkplatzanfrage

Verfügbarkeitsprüfung

Parkplatzzuweisung (Modelica)

Vernetzung von Parkhaus, Smartphone, Fahrzeug (SysML)

Autonomes Einparken (Modelica)

“Benutzerdaten: KundenID, Position“

Kundenkonto?

 BMW

ParkhausApp

Benutzerdaten

IPhoneApp

"Standort ermitteln"

"KundenID übermitteln"

"KundenID übertragen"

"Anmeldung am Parkhaus"

Dauerparker Standardparkplatz

"Zufahrtsbeschränkung"
We are able to integrate BPMN and SysML in a common Backbone Concept.
From BOM Centric to Model Based

Hierarchical Structures
Mechanic is dominant

Hierarchical, linear und network oriented Structures
Electronic and especially Software becomes dominant

Document and BOM centric

Interdisciplinary Digital Model

Source: VPE C. Muggle, M. Pfenning
Different Processes for Architecture, HW and SW

- **Software Configurations Management (SCM)**
  - Optimized for the Management of Source Code (Text) + additional documents
  - Branching, Tagging (Baseline), Merging

- **Product Data Management (PDM)**
  - Optimized for the Management of BOMs (hierarchical Objects) + additional documents
  - Managed Items are belonging to Hardware and have Life Cycles
  - Change Management for Items and BOMs based on rules

- **Architecture Management (and Process Plan and BPMN)**
  - Combination of Hierarchy and Network
  - Intelligent Information: Ports, with Flow of Energy, Material, Information,.....
Digital Models Along the Product Lifecycle

Integration on TDM/PLM Level

Integration on Authoring System Level

Engineering Processes (ERM, ECM, CM, Data Exchange,...)

Digital Models

Authoring Systems

TDM and PLM/SysLM

Plan
Concept
Design
Validate
Production
Support
Digital Model versus Digital Twin

Virtual World
- Baureihe A
- Baureihe B
- Digitales Modell
- Serviceinformationssystem (SIS) (gepflegt durch Service)
- Digitaler Zwilling
- Physische Prototypen
- Feedback in Development with impact on the digital Model

Real World
- Reales Produkt
- Instanzen von Produkten

Feedback in Development with impact on the digital Model
Alternatives for Publishing MBSE models

Managing MBSE artifacts:

- Alternative A: Managing SE-project modules (files)
- Alternative B: Managing model elements with structure
- Alternative C: Managing model elements with structure, ports and topology

A: publishing MBSE File
B: publishing hierarchical MBSE structure with RFL-link
C: publishing
  C1: MBSE Ports
  C2: MBSE Ports+int. relations

Slider depending of customer requirements and intelligence of SysML Tool

VPE: Gilz, VPE 2014
Types of MBSE PLM Integrations

- **Direct Integration**
  - ERP
  - PLM
    - ECM
    - VM
    - RM
    - R&R
  - TDM
    - SysML
  - Authoring System

- **3 Layer, Simple TDM**
  - ERP
  - PLM
    - ECM
    - RM
    - CM
  - TDM
    - VM
    - R&R
  - Authoring System
    - SysML

- **3 Layer, ext. TDM**
  - ERP
  - PLM
    - ECM
    - RM
    - CM
  - TDM
    - VM
    - R&R
  - Authoring System
    - SysML

**Icons:**
- Datenbank
- Synchronisation
- Kopplung

**Abbreviations:**
- RM: Release Management
- ECM: Engineering Change Management
- R&R: Rights- and Roles Management
- VM: Version Management
- CM: Configuration Management
Verknüpfte Modelle des Produktlebenszyklus

SYNC

Systemmodell
The MBSE Integration into an PLM/SysLM
Authoring system – PLM Connector

PLM Connector in an MBSE authoring system

Source: VPE Research Project mecPro² (T. Gilz)
PLM Backbone ARAS with Embedded MBSE

PLM Backbone manages relevant model elements
- Defined by the mecPro² PLM/SysLM Productmodel

relations to discipline-specific Development

Systems Engineering elements (for System Architects)

Source: VPE Research Project mecPro² (T. Gilz)
Visualization with a Browser in PLM/SysLM

Source: VPE Research Project mecPro² (T. Gilz)
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SysLM Backbone Federated Backbone based on Data Linkage

- Enterprise Service Platform
- MRP/ERP
- Product/Process Backbone
- Team Data Management
- Authoring Tools

Requirements | System Architecture | Software | Mechanical | E/E | Sim | DiFa | ... |
---|---|---|---|---|---|---|---|

System Lifecycle Management

- TDM and authoring tool tightly connected
- Need for OSLC
- TDM and authoring tool freely integrated
SysLM Backbone Federated Backbone based on Data Linkage

**Enterprise Service Platform**

- Requirements
- System Architecture
- Software
- Mechanical
- E/E
- Sim
- DiFa
- ...

**MRP/ERP**

**Product/Process Backbone**

**Team Data Management**

**Authoring Tools**

- System Lifecycle Management
- MRP/ERP
- MES
- TDM and authoring tool tightly connected
- Need for OSLC
- TDM
- Authoring tool
- freely integrated
SysML the Future ➔ Semantical Network for ECM

Model Based Semantical Network/ Repository in SysLM

Research Project with SharePoint, Aras and ILC (Step 1 WEBservices Step 2 REST)

REST = representational state transfer
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Standards and their Organizations

- **OASIS**
  - OSLC

- **OMG**
  - SysML
  - UML
  - ReqIF

- **ISO**
  - STEP AP233
  - STEP AP242
  - JT

- **Modelica Association**
  - MODELICA
  - FMI

**Standards**

- 10303-233:2012
- 10303-242:2014
- 14306:2012
New ProSTEP iViP Workflow Forum:

- OSLC-based integrations of ALM and PLM as a future requirement for successful development processes
- Covering challenges of complexity for the development of interdisciplinary products

Objectives:

- Sharing technological knowledge in the field of OSLC within the user group
- Defining harmonized use-cases
- Giving feedback to OSLC Technical Committees and their specifications
- Collect requirements for software vendors
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Potentielle OSLC Application on OSLC WF Level

System Lifecycle Management based on semantical network/repository + OSLC

TDM and authoring tool tightly connected
Need for OSLC

TDM
Authoring tool
freely integratable
Thank You!

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