System Lifecycle Management as a Federated Bimodal IT Approach

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1968 - 1971 Toolmaker
1971 - 1976 University of Karlsruhe (TH)
Studies in Mechanical Engineering and Economy
1977 - 1980 University of Karlsruhe (TH)
PhD Institute of Computer Applications in Design
1980 - 1985 Robert Bosch GmbH
Head of Department Technical IT and Organisation
Solution Provider for PLM Solutions
Until 2001 chief executive office
Until 2003: chairman of the board and CTO
since 2003 EIGNER Engineering Consult
since 2004 University of Kaiserslautern
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since 1992 University of Karlsruhe (TH)
Visiting professor
since 1999 TU Sofia, Bulgaria
Visiting professor

2009 Awarded with UNICUM Germany’s Professor of the Year 2009
2014 Award „Lehre Plus“ of the University of Kaiserslautern for „Industry 4.0“ und „Information technology“
ARE WE USING PLM, OR IT’S STILL PDM
The Vision: Traceability of Engineering Data all along the Product Lifecycle

SysLM = PLM + ALM + SLM

- Authoring Systems integrated via TDM
  - OSLC / REST Technology
- Authoring Systems directly integrated
- TDM Systems

Integrated via TDM

SysLM = PLM + ALM + SLM

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Typical Challenges in Automotive Industry

- **Service**
- **MCAD**
- **TDM**
- **Digital Factory**
- **Simulation / Test**
- **Electrics / Electronics**
- **Mechanic**
- **Software**
- **System Architecture**
- **Requirements**

**System Lifecycle Management (SysLM)**

- **Authoring Systems**
  - RM
  - SysML, …
  - CASE
- **Team Data Management**
  - SIM1
  - CASE
- **Engineering Backbone**
  - SIM2
  - ECAD 1
  - ECAD 2
  - Sim
  - PDM
- **Enterprise Service Platform**
  - MRP/ERP
  - MES
  - DiFa
  - TDM Systems
  - ECAD 1
  - ECAD 2

**Focus**

- **Authoring Systems integrated via TDM**
  - OSLC / REST Technology
- **Authoring Systems directly integrated**
- **TDM Systems**
  - API- / Web-Service- based Integration via Data Link or Exchange
Typical Challenges in Automotive Industry

- **System Architecture**
  - Requirements
  - Software
  - Mechanic
  - Electrics / Electronics
  - Simulation / Test
  - Digital Factory
  - Service

- **Enterprise Platform**
- **MRP/ERP**
- **Engineering Backbone**
- **Team Data Management**
- **Authoring Systems**

> 100 fragmented TDM / PDM and Authoring Systems + Excel and other hidden DBs ("Shadow IT")
Typical Challenges in Automotive Industry

- System Architecture
- Software
- Mechanic
- Electrics / Electronics
- Simulation / Test
- Digital Factory
- Service

Enterprise Service Platform

MRP/ERP

Engineering Backbone

Team Data Management

Authoring Systems

System Lifecycle Management (SysLM)

Harmonization Strategy only partially successful

Authoring Systems integrated via TDM

OSLC / REST Technology

Authoring Systems directly integrated

API– / Web-Service–based Integration via Data Link or Exchange

TDM Systems
Typical Challenges in Automotive Industry

A fully integrated Engineering Backbone does not exist
(Exception: DAIMLER Smaragd comes close)
Typical Challenges in Automotive Industry

 enterprise service platform

 MRP/ERP

 Engineering backbone

 Team data management

 Authoring systems

 High redundancy between all connected systems

 - Requirements
 - System Architecture
 - Software
 - Mechanic
 - Electrics / Electronics
 - Simulation / Test
 - Digital Factory
 - Service

 System Lifecycle Management (SysLM)

 - Enterprise Service Platform
 - MRP/ERP
 - Engineering Backbone
 - Team Data Management
 - Authoring Systems

 - MRP/ERP
 - MES

 - MRP/ERP
 - DI Fa

 - High redundancy between all connected systems

 - Authoring Systems integrated via TDM
 - Authoring Systems directly integrated
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 - OSLC / REST Technology
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Typical Challenges in Automotive Industry

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<th>Enterprise Service Platform</th>
<th>MRP/ERP</th>
<th>Engineering Backbone</th>
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Highly customized TDM / PDM / PLM Systems demand re-customizing with each new release of the basic system.

Authoring Systems: integrated via TDM

OSLC / REST Technology

API- / Web-Service-based Integration via Data Link or Exchange

Highly customized TDM / PDM / PLM Systems demand re-customizing with each new release of the basic system.
PLM QUO VADIS?
Gartner Research’s **bimodal IT framework** recognizes that traditional development practices are no longer sufficient for organizations with growing enterprise application demand. Instead, the bimodal IT strategy calls for two parallel tracks that support rapid application development for digital innovation priorities, alongside existing application maintenance and operational stabilization projects.
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The CIMdata Platform Approach

“Product Innovation Platforms: Definition, Their Role in the Enterprise, and Their Long-Term Viability”
CIMdata, Position Paper
What does this mean for PLM?

- From document-based to model-based (System Architecture becomes the driving Structure)
- Support of the full Product Lifecycle incl. the Digital Twin
- From hierarchical (traditional BOMs) to networks (SysML) and linear structures (software).
- Support for Engineering Change Management (ECM) and Configuration Management (CM) for mechanic, electric / electronic and software design
What does this mean for PLM?

- From monolithic to federated and light weighted systems based on Model Based Repository and linked data technology (REST / RDF / OSLC / WEB services)

- Split of application data and meta data based on an Model based Repository means:
  - agile implementation based on dramatically decrease of customization effort
  - automatically upgrade even of customized applications

- Offering at different cloud levels (IaaS, PaaS und SaaS)

- Different levels of TDM / PLM and Authoring Systems integration (the challenge for Shadow IT)

- New flexible business models based on subscriptions instead of licenses
MBSE
SYSTEM ARCHITECTURE AND THE DIGITAL MODEL = THE FOUNDATION FOR DIGITALIZATION AND DIGITALIZATION
Complexity of Mechatronic and Cybertronic Systems:

**Problem**: Vertical integration is defined but no horizontal integration.
With horizontal integration the customer benefit will be 20+30% higher!!!

Source: C. Huwig, J. Rambo: prostep ivip Sysmposium 2017
Complexity of Mechatronic and Cybertronic Systems:

**Problem:** Vertical integration is defined but no horizontal integration. With horizontal integration the customer benefit will be 20+30% higher!!!

Source: C. Huwig, J. Rambo: prostep ivip Sysmposium 2017
New Business and Cooperation Models based on MBSE

- Standardized Data Exchange of Mechatronic System Architecture in the Early Phase of Systems Engineering

Communication along the Supply Chain via System Architecture Model (RLFB)

Based on: Julia Seeßle, Engineering-IT Standardisierung im Systems Engineering der frühen Phase, PhD Thesis, VPE 2017
New Business and Cooperation Models based on MBSE

The interdisciplinary Architecture Model RFLB (SysML)

- Requirement Engineering
  - Interdisciplinary Requirements \{R1,R2,R3,...,Rn\}
- SW Requirements \{RS1,RS2,RS3,...,RSn\}
- HW Requirements \{RH1,RH2,RH3,...,RHn\}

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

Mechanic

Based on SIEMENS

Physical Component Architecture
New Business and Cooperation Models based on MBSE

The interdisciplinary Architecture Model RFLB (SysML)

Upper Level of System Architecture (OEM)

Transfer along the Supply Chain for Electronic, Software and Embedded Systems

Based on SIEMENS
MBSE: Digital Models along the Product Lifecycle

Digital Model

TDM and PLM / SysLM

Anforderungen
Funktion und Logik
Physikalisches Design
Simulation/Test
Fabrik / Werk
Service

Integration on TDM/PLM Level

Integration on Authoring System Level

Plan
Concept
Design
Validate
Production
Support
MBSE: Digital Models along the Product Lifecycle

The Digital Thread

Integration on TDM/PLM Level

Integration on Authoring System Level

Digital Model

TDM and PLM / SysLM

Authoring Systems

Digital Model Engineering Processes (ERM, ECM, CM, Data Exchange, …)

Integration on TDM/PLM Level

Functioning / Behaving / Line

CAD Structure, Network and linear Structures (CASE)

Process Plan / Ressourcen
IOT AND IOS
SERVICE ORIENTED BUSINESS MODELS AND DIGITAL TWIN
Scenario: Autonomous Construction Area 4.0

System context

Requirements diagram

Use Case

Scenario: Autonomous Construction Area 4.0

Autonomous Truck Loading
(Communicating Systems)

Internal block diagram

Digital Model and Digital Twin

- **PR**: Product Release
- **PT**: Prototype
- **N**: Number (Prototype/Serial)

Feedback in Development with impact on the Digital Model
Digital Model & Digital Twin (DT)

Not all of the complex PLM data is required (depends on when/where the Digital Twin should be used)

**Virtual World**
- Digital Model: Virtual representation of an existing physical product (evolves over time)
- Digital Twin:
  - Derived from one version of the Digital Model (less or equal 100%)
  - Matches the state of the corresponding physical product

**Physical World**
- Physical instances of the product
  - (Digital twin tracks real-time sensor/field data, maintenance data, replaced parts, …)

**PLM**
- Pred.
- Succ.
- Digital Model
- Production Twin (as-built)
- Service Twin (as-maintained)
Digital Model & Digital Twin (DT)

Questions:
- Application Area? Use Case?
- Which System (PLM or ERP) generates the DT?
- Where is the Digital Twin located / saved?
- Who is the Owner of the Dig. Twin?
- Who is Stakeholder / User of the Digital Twin
- How is the Dig. Twin being reduced?
- Temporary snapshot (disconnected PLM)?
- Context information needed:
  - Position indicator
  - Supplier
  - …
- Flat or structured?
- DMU needed?
- …

Digital Model
Virtual representation of an existing physical product (evolves over time)

Digital Twin
- Derived from one version of the Digital Model (less than 100%)
- Matches the state of the corresponding physical product

Physical World
Physical instances of the product (Digital twin tracks real-time sensor/field data, maintenance data, replaced parts, …)
What is the impact of IoT/IOS on PLM?

- More Mechatronic (product and processes)
  - MBSE as prerequisite of Dig***
  - Systemarchitecture (RFLB) is the driving structure for Concept design
- Service as part of Engineering (4th Discipline)
  - Digital TWIN
- Full traceability
- Lightweight federated Backbone
LIGHT WEIGHT BACKBONE

SP²IDER BASED ON REST / RDF

SP2IDER = Semantic Product/Process Information & Digitized Engineering Repository
SP²IDER Level 1 (based on Model Based Repository and WEB Services)

SP²IDER = Semantic Product/Process Information & Digitized Engineering Repository

Graphical GUI with embedded WEB Services

Graph Based Visualization

Link Repository (WEB Services OSLC)

ALM
- Requirements
- Functions
- Logic BD

PLM
- EBOM
- CAD
- Other Documents
- MBOM

ERP
- Ressources
- Process

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Visualisation 2 and Search of ECM Processes
Graph-based Presentation of Affected Items for ECM

- Requirements
- Functions
- Logical Elements
- Items and Assemblies (BOM)
- Processes
- Tools and resources
- Documents
- Supplier
The Engineering Cockpit integrates Processes, Data & Systems

Schaeffler Business Processes

Role Based Views

Engineering Cockpit Functions

- Maintain a cross-discipline engineering data model
- Configure products & systems with multiple baselines at any time
- Initiate & monitor changes end-to-end across systems
- Query & search and generate views and reports
- Process & monitor engineering service request and delivery

Engineering Cockpit APPs

Configuration Management
Change Management
Service Request
Management Reporting
Search and Browse

TDM/PDM-Tools

- Plans/ware
- MS Project
- Integrity Lifecycle Mger
- Doors + RQM + Change
- ReqMan
- PDM Author.
- Integrity Modeler
- Rhapsody
- Integrity Lifecycle Mger
- Synergy & Change Suite
- SVN
- Hypertest
- BRS
- WTI / Tanass
- Album
- Mentor
- EPLAN
- VLT
- Creo
- SAP
- Enovia
- SAP
- TIB / Others
- MatLab, Bearinx, Famos, Abaqus

Authoring-Tools

- Project Management
- Req. & Test Engineering
- Systems Engineering
- Software Engineering
- Vrt. & Phys. Validation
- E/E Engineering
- Mechanical Engineering
- Industrial Engineering
- Sales/Service

Domains

Project Management
Req. & Test Engineering
Systems Engineering
Software Engineering
Vrt. & Phys. Validation
E/E Engineering
Mechanical Engineering
Industrial Engineering
Sales/Service

No strategic tool
SP²IDER = Semantic Product/Process Information & Digitized Engineering Repository

- **REST** Representational State Transfer:
  - Access resources using stateless operations
  - is encoded in the messages (as with URLs / "clicking a link")

- **RDF** The Resource Description Framework (RDF)
  - is a semantical framework for expressing information about resource graphs, i.e. nodes and edges …
  - … are stored as triples, transferred as RDF/XML, JSON-LD

![Diagram of SP²IDER Level 2](attachment:image.png)
SP²IDER and Semantics

- Dynamic extraction of semantics from source systems based on user-defined metrics and heuristics
- We do not believe in a global standard for a Engineering Lifecycle Schema for enterprise internal integration (OSLC?)
- Therefore we trust in using the extract of the semantic of the underlying legacy Systems

„Vertical Mapping“ (different units, locale settings, …) source systems and SP²IDER Core is managed by the Source System-specific Services

Horizontal Mapping (correlating objects across source systems) is created manually using a rule-based approach (see Biztalk, Conweaver, …)
Realization of a RDF- and Repository-based Backbone

Why RDF?
- Trend to RDF for Enterprise Data Modeling
- Easy to generate Graph DB
- Prerequisite for REST access

Aras Relationship

PLM Repository

RDF

Graph-based Visual Representation

RESTful Web Service Architecture
From PLM Items to RDF Triples / Graph Nodes and Vice Versa

Aras Relationship

\[
\text{Item type="Part" id="1AB34..."}\\ \text{<Relationships>}\\ \text{ Item type="Part BOM" action="get"}\\ \text{ Item type="Part"}\\ \text{ related_id }\\ \text{Item id="9876..."}\\ \text{Item}\\ \text{/related_id}\\ \text{/Item}\\ \text{/Relationships}\\ \text{Item}
\]

Aras AML representation

\[
\text{<rdf:RDF}\\ \text{ rdf:Description rdf:about="aras://1AB34..."}\\ \text{ aras-mockup:PartBOM rdf:resource="aras://9876..."}\\ \text{.rdf:Description}\\ \text{rdf:RDF}
\]

RDF/XML representation

\[
\text{<1AB34...} \text{<Part BOM} \text{<9876...>}
\]

//triple elements contain links to respective data

Triple representation

Graph-based Visual Representation
- MBSE + PLM = SYSLM
- MBSE THE FOUNDATION FOR DIG***
- SYSTEM ARCHITECTUR IS LEADING
- THE DIGITAL TWIN IS A CHALLENGE
- TRACEABILITY IS THE TARGET
- THE ENGINEERING BACKBONE IS A FEDERATED LIGHTWEIGHT BIMODAL PLATFORM
- THE IT TECHNOLOGY IS EXISTING SINCE 18 YEARS (REST, RDF,...)
THANK YOU FOR YOUR KIND ATTENTION

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