

# Perspective on the Product and System Lifecycle

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# Industrie 4.0 versus Industrial Internet

Industrial Internet is the next generation of the Internet. It is a global system based from networked computers, sensors, actuators, machinery and equipment. Merging the physical world with the virtual world of the Internet and the software allows to develop and apply Internet-based business models and new services..



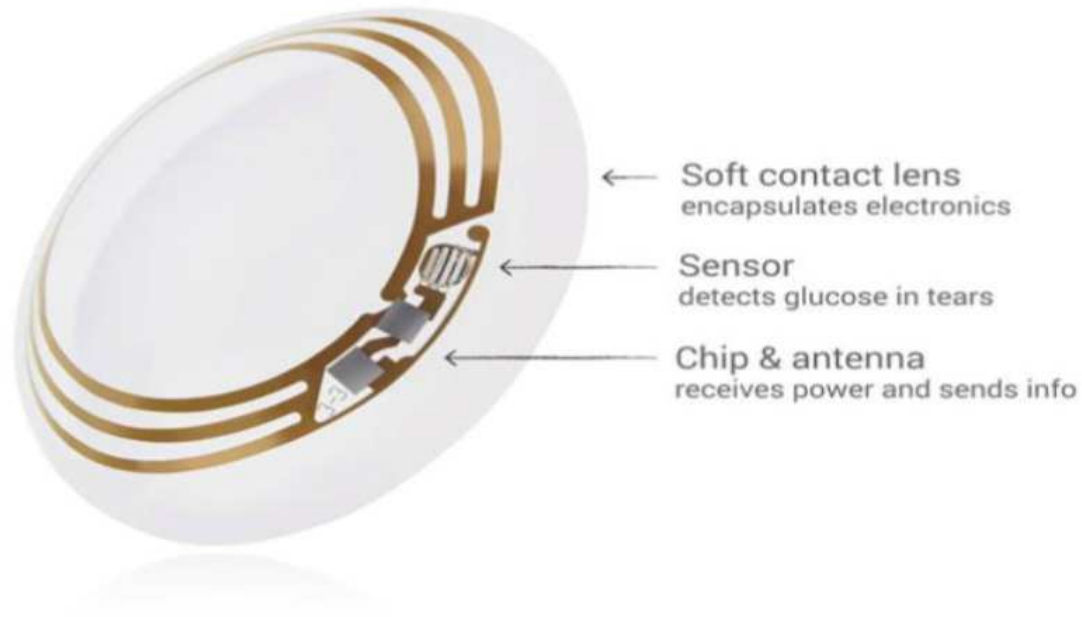
WLAN communication car system

[Image Source: Motorauthority.com]

The term industry 4.0 was defined in Germany and is initially very strong production oriented. In English-speaking countries, the term **Industrial Internet** is common. It supplements the terms Internet of Things (IoT) and Internet of Services (IoS) to big data analytics and in this respect the comprehensive concept ..

Radboudumc

**„Insideables“**



\* Industrial Internet Consortium (IIC), <http://www.iiconsortium.org/>.

Radboudumc

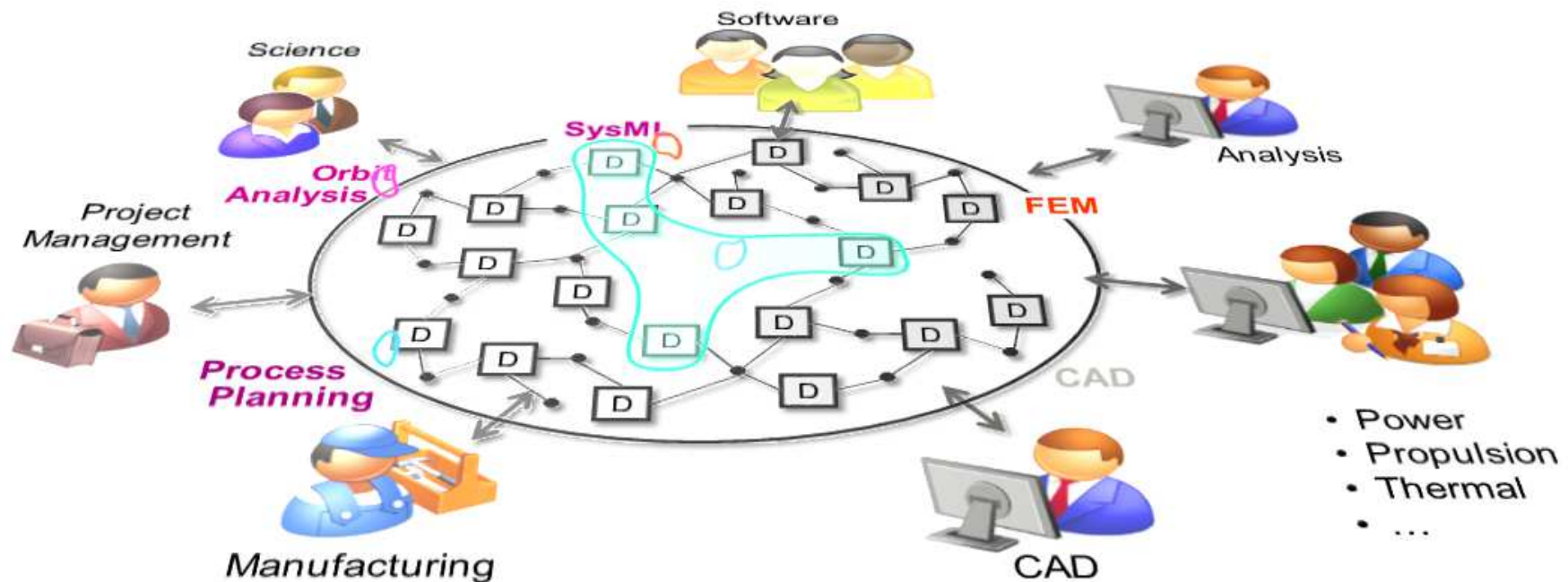
„Insideables“

Industrial Internet will change Engineering Processes more rapidly and dramatically than Mechatronic!  
Collaboration, Integration and Interdisciplinarity is job#1  
We need a new interdisciplinary Design Methodology, Processes and IT-Tools  
System Lifecycle Management (SysLM) has to administrated these processes

\* Industrial Internet Consortium (IIC), <http://www.iiconsortium.org/>.

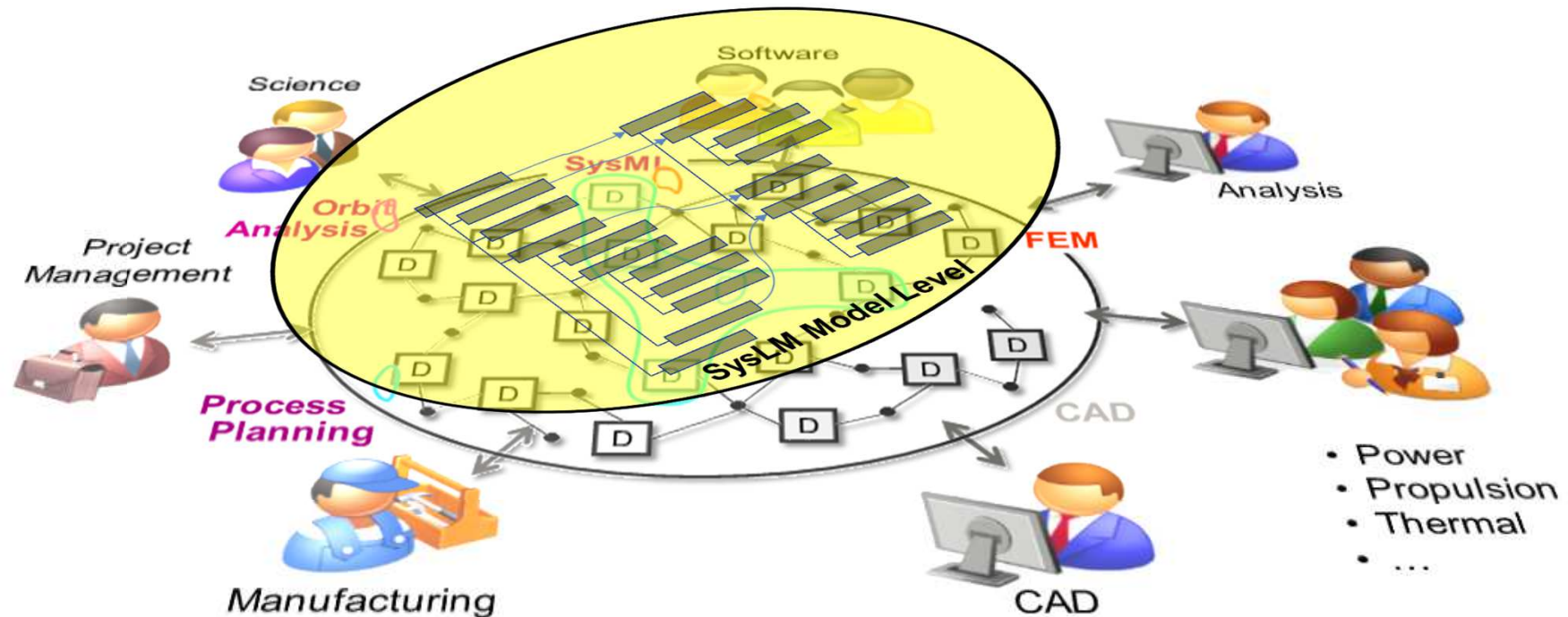
# System Lifecycle Management (based on extended PLM, ALM, ERP,...) and Model Based Systems Engineering

Industrial Internet requires an Model Based Development Process. (Model Based Systems Engineering = MBSE)



Source: Discussions with Chris Paredis, Georgia Tech

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Planning

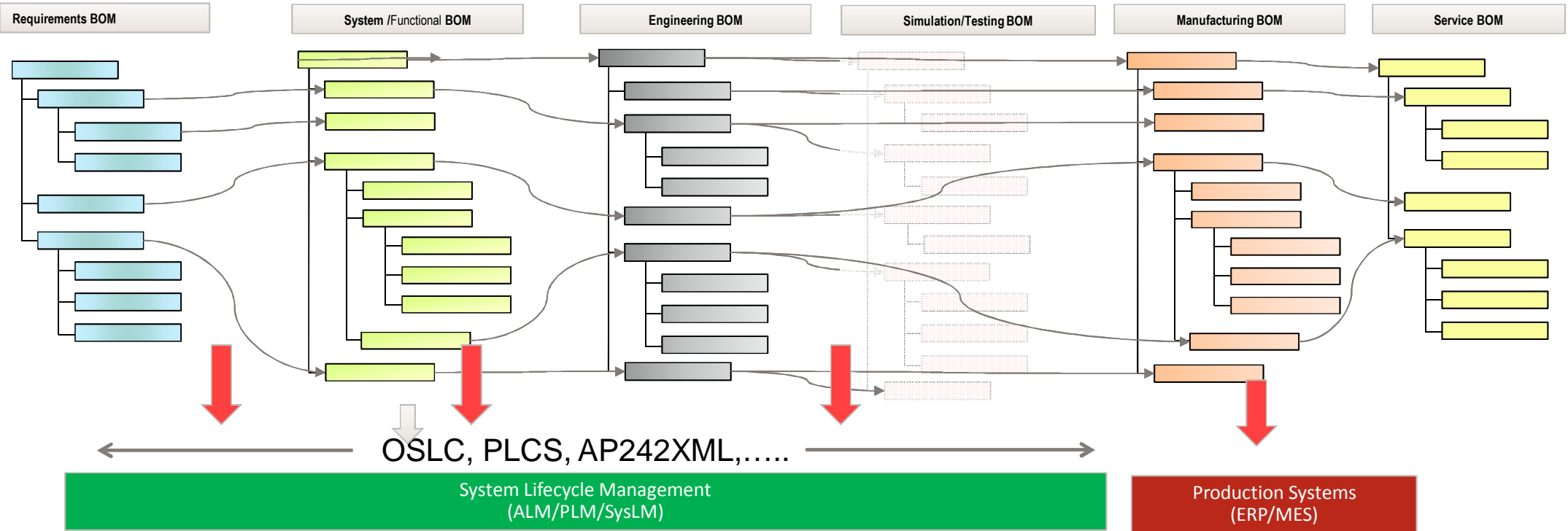
Concept

Design

Test

Production

Service



Planning

Concept

Design

Test

Production

Service

Requirements BOM      System /Functional BOM      Engineering BOM      Simulation/Testing BOM      Manufacturing BOM      Service BOM

**MBSE**

RM e.g. Doors



**Integrated and interdisciplinary ECM and CM for Traceability**



OSLC, PLCS, AP242XML,.....

System Lifecycle Management  
(ALM/PLM/SysLM)

Production Systems  
(ERP/MES)

# The Role of PLM and ALM

Planning

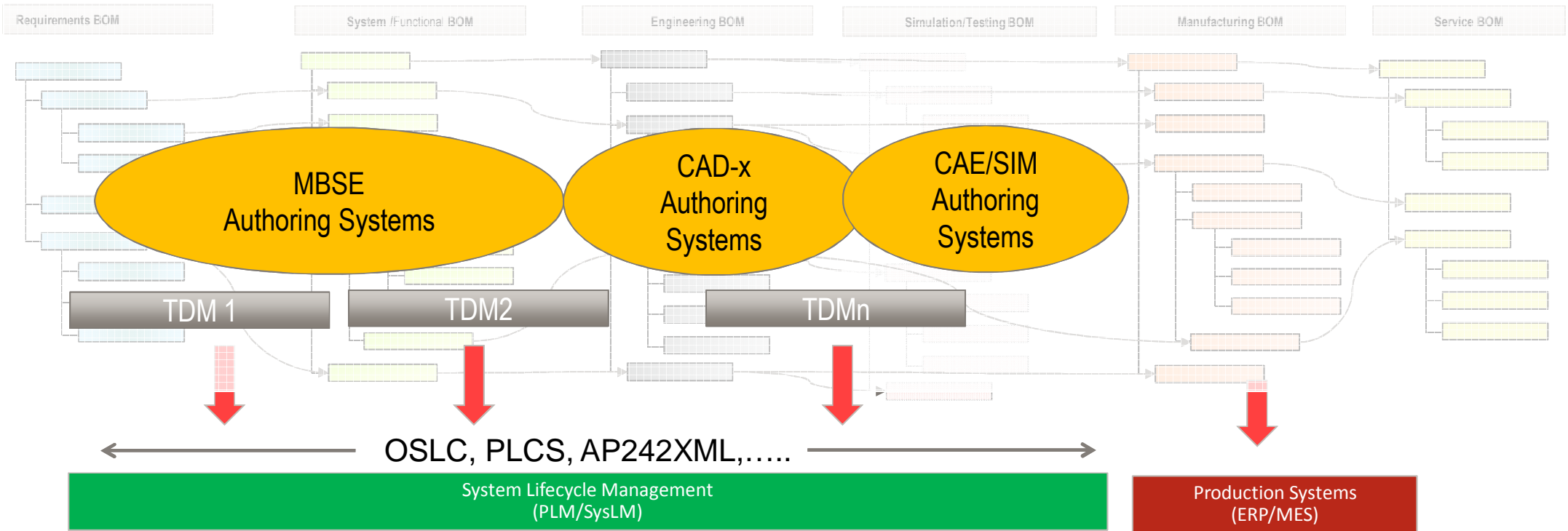
Concept

Design

Test

Production

Service



### What is the role of PLM?

*Solution 2: PLM and ALM are co-existent (my favorite solution)*



Gate (slider depending when admin is necessary)

Planning

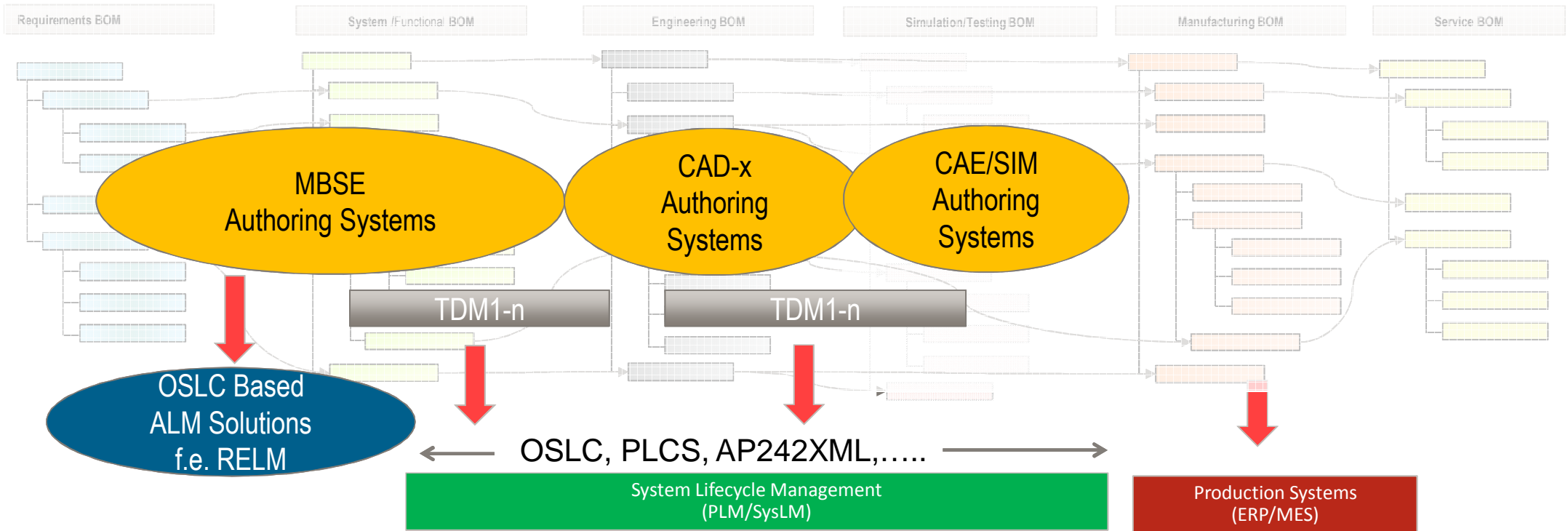
Concept

Design

Test

Production

Service



Planning

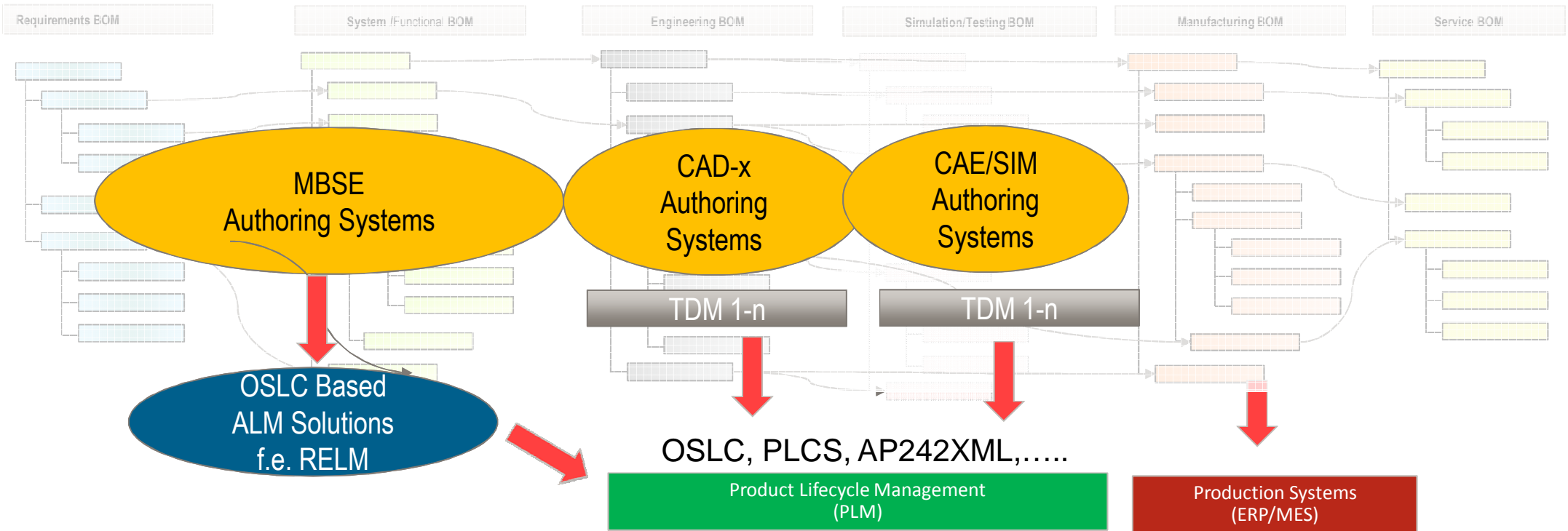
Concept

Design

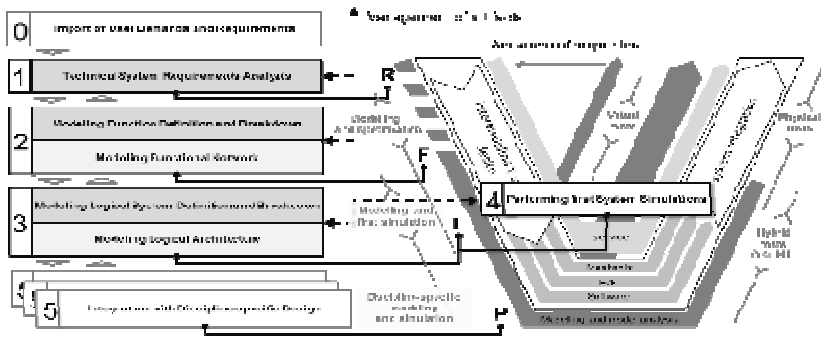
Test

Production

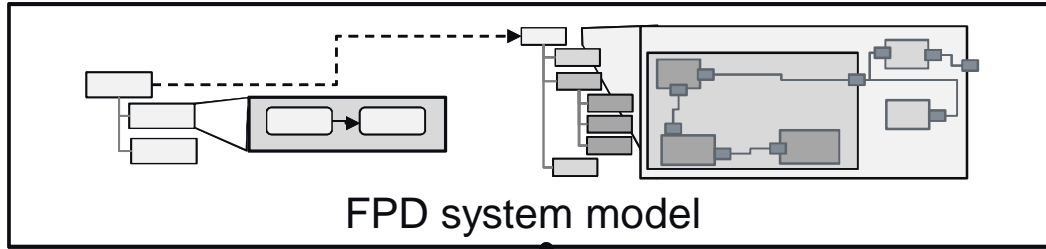
Service



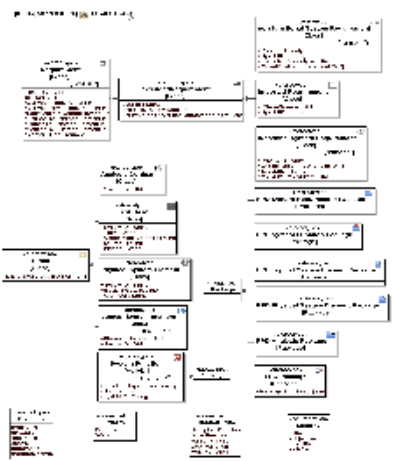
# What are the Prerequisites for a Standardization



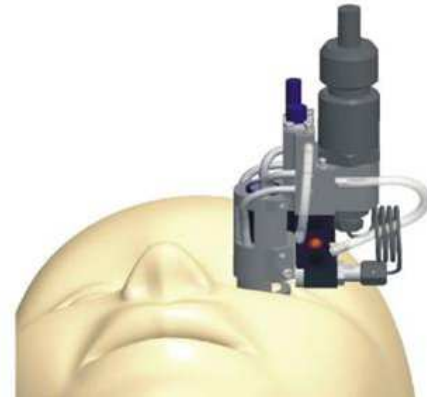
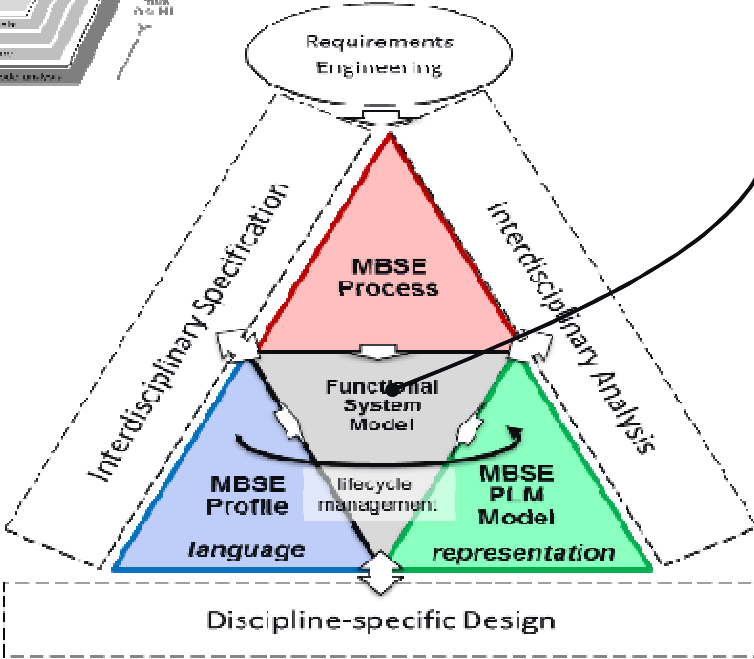
SE-Process



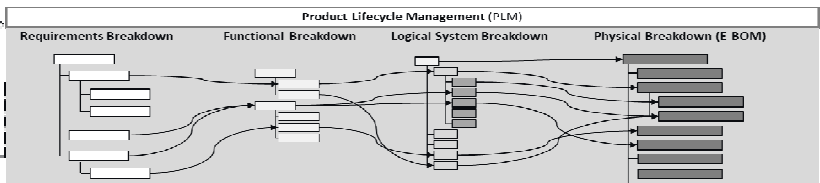
FPD system model



SE - Profile



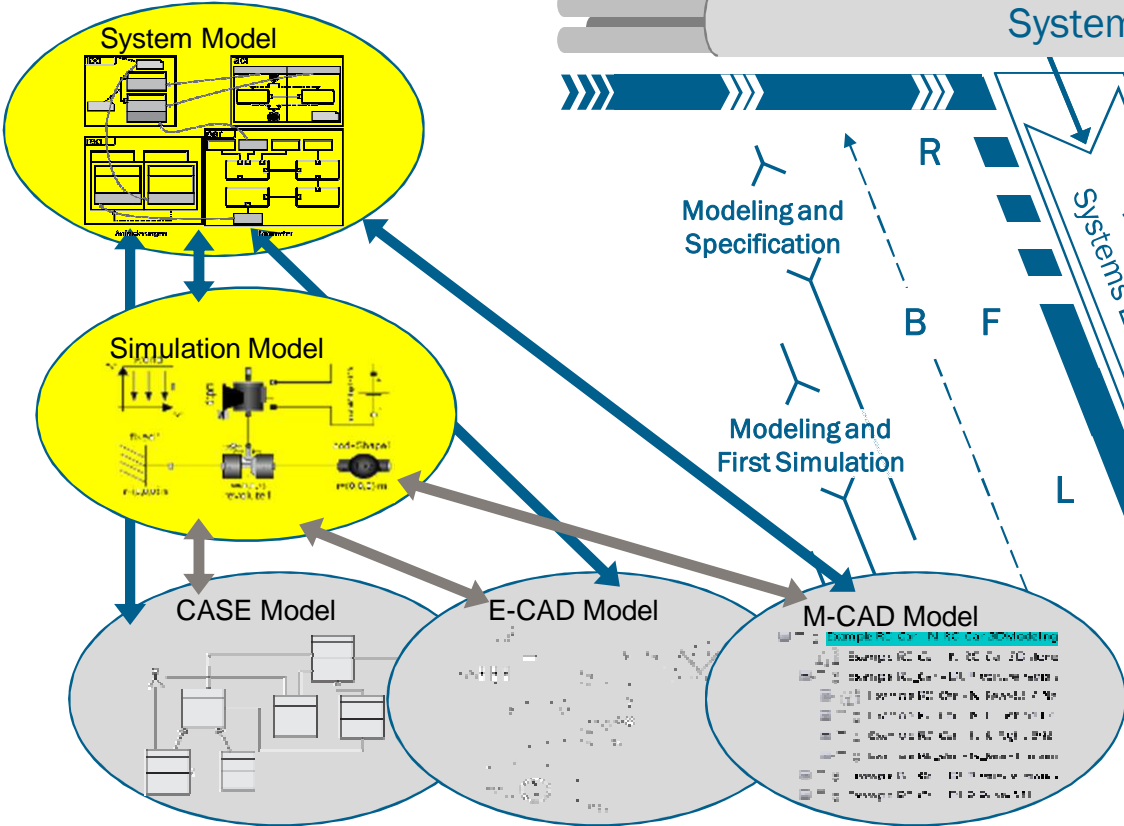
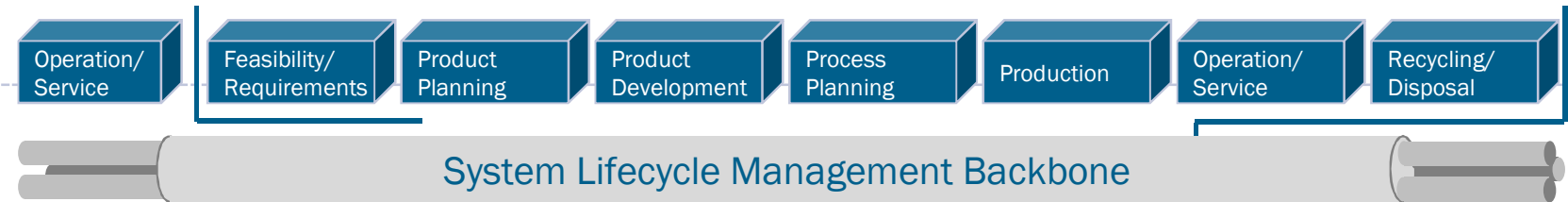
[image source: Loof, C.: Entwicklung eines Hydrokratoms für die LASIK-Chirurgie, KIMA, Kaiserslautern/Germany, PhD Thesis, 2008.]



SE-Data Model



# The MBSE Process



System Lifecycle Management Backbone

Modeling and Specification  
Modeling and First Simulation

R  
B  
F  
L  
P

Interdisciplinary  
Systems Engineering

Property Validation

Virtual Tests

System Integration

Physical Tests

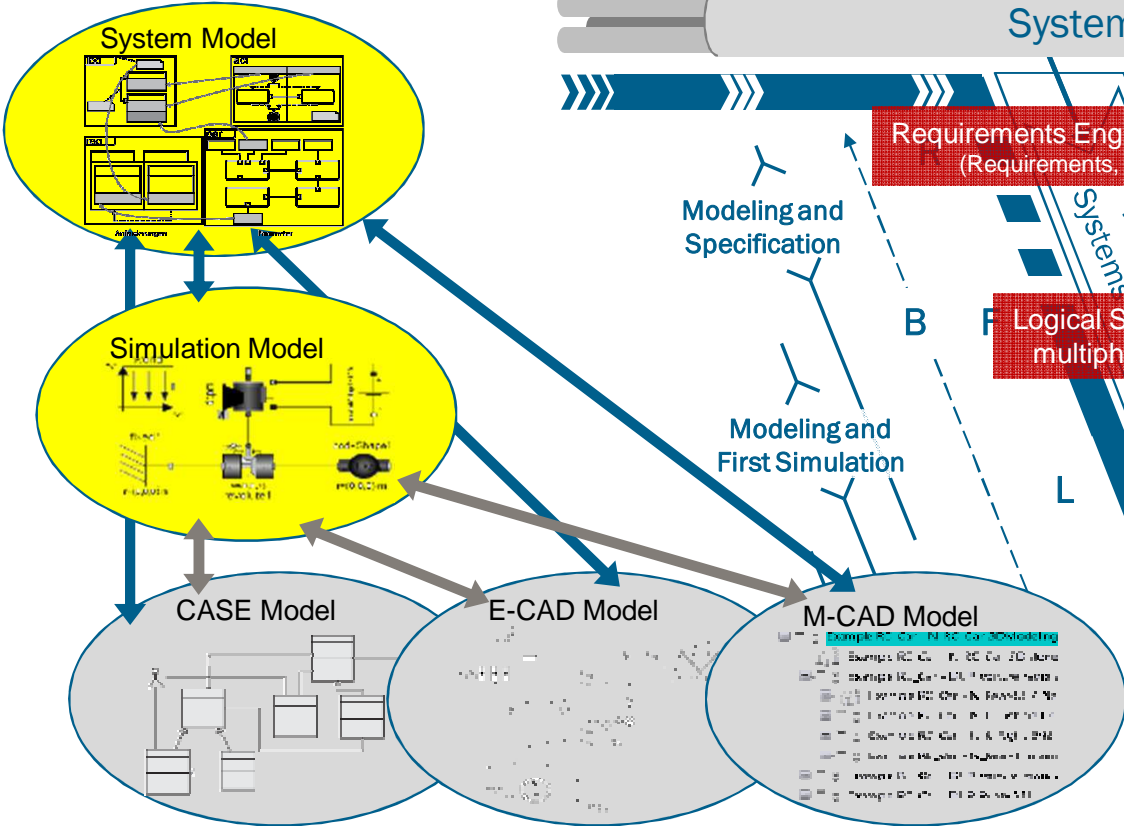
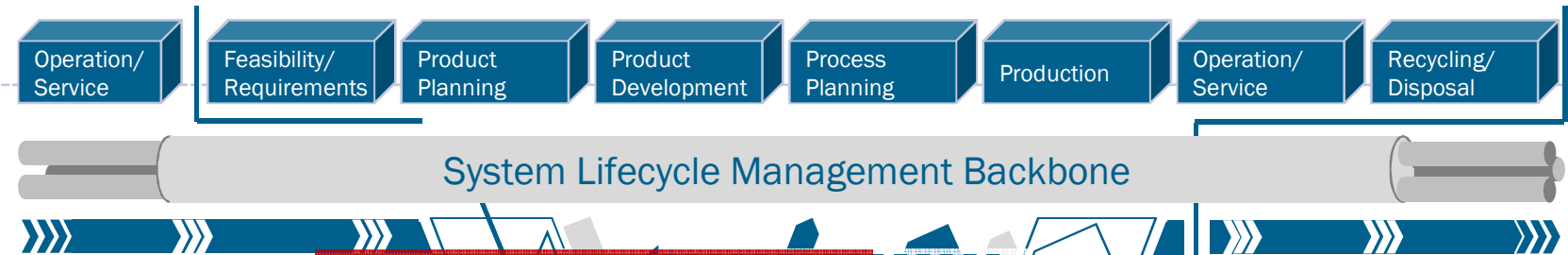
Hybrid Tests (e.g. HiL)

Service  
Mechanics  
Electrics/Electronics  
Software

Modeling and Analysis

- B: Behavior
- R: Requirements
- F: Functions
- L: Logical Solution Elements
- P: Physical Elements

# The MBSE Process



Requirements Engineering and Specification  
(Requirements, Functions and Behavior)

Modeling and Specification

Modeling and First Simulation

Logical System Design and multiphysical Simulation

Simulation Testing

Discipline Specific Design Service

Mechanics

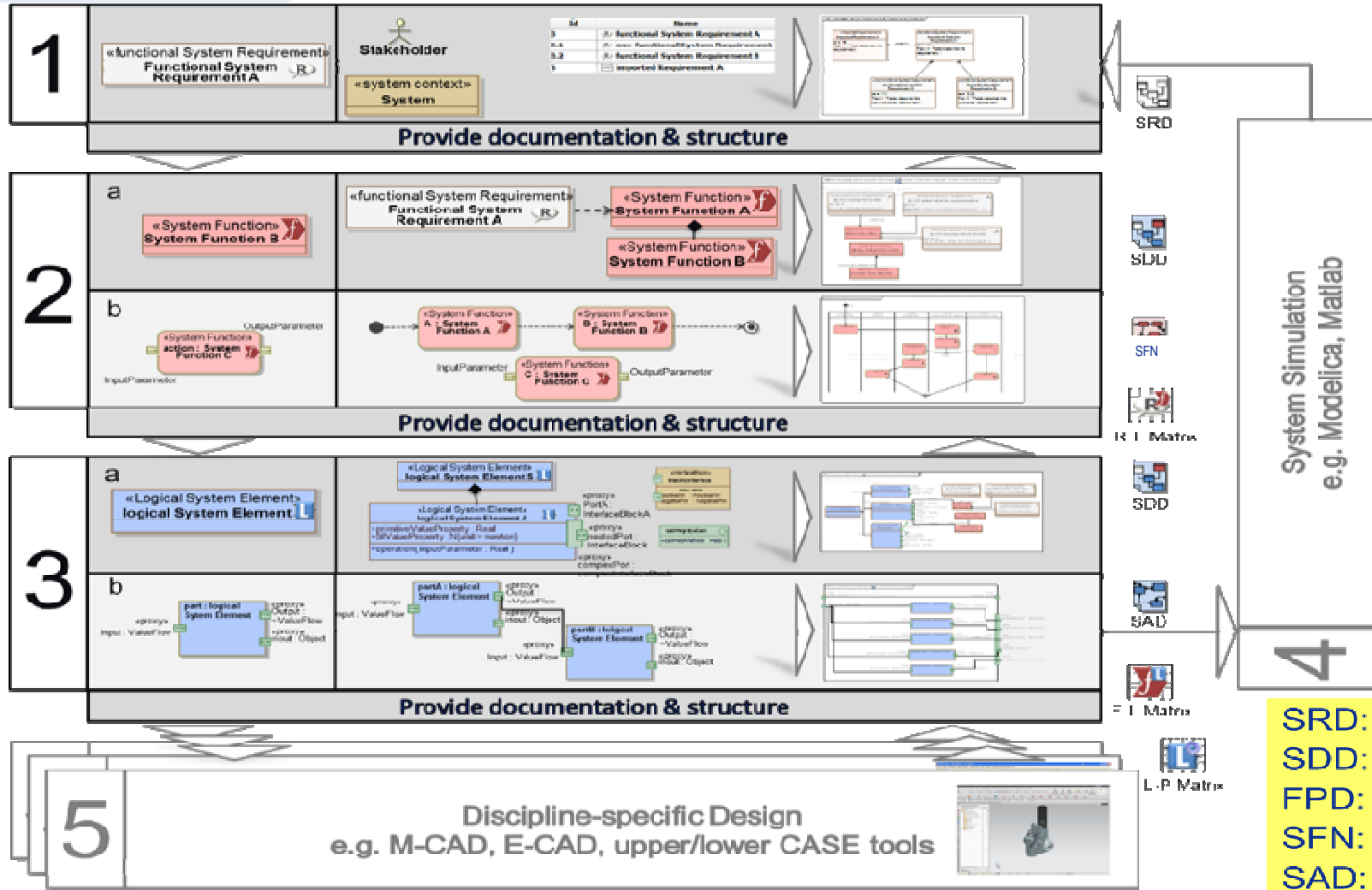
Discipline Specific Detailing

Modeling and Analysis

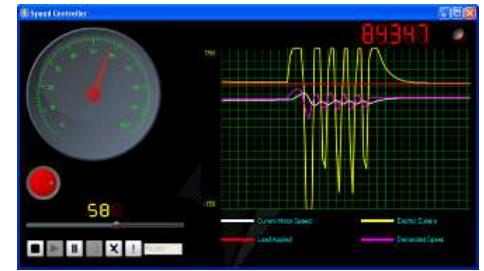
Physical Tests

Hybrid Tests (e.g. HiL)

- B: Behavior
- R: Requirements
- F: Functions
- L: Logical Solution Elements
- P: Physical Elements



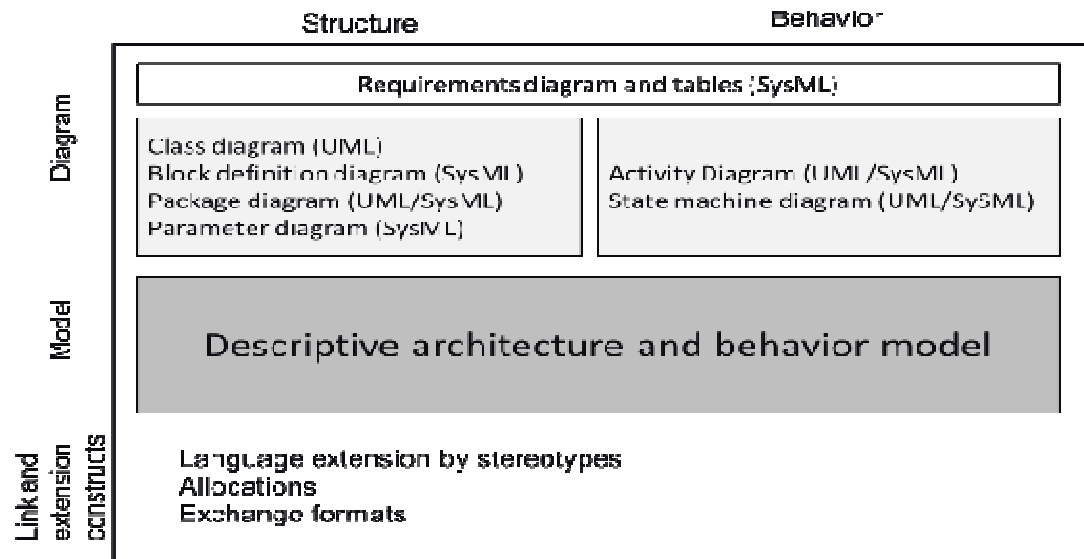
SRD: System Requirement Diagram  
 SDD: System Definition Diagram  
 FPD: Functional Product Diagram  
 SFN: System Function Network  
 SAD: System Architecture Diagram



# The MBSE Profile for SysML (Example)

## Absolute Prerequisite for the Standardization of SysML

### System Modeling Language (SysML)



**Customizes diagrams**

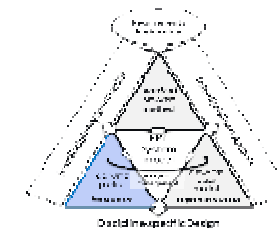
- System Requirement Diagram (SRD)
- System Definition Diagram (SDD)
- Function Network Diagram (FND)
- Behavior Network Diagram (BND)
- System Architecture Diagram (SAD)

**Defines validation rules**

**Stereotypes for specific modeling concepts**

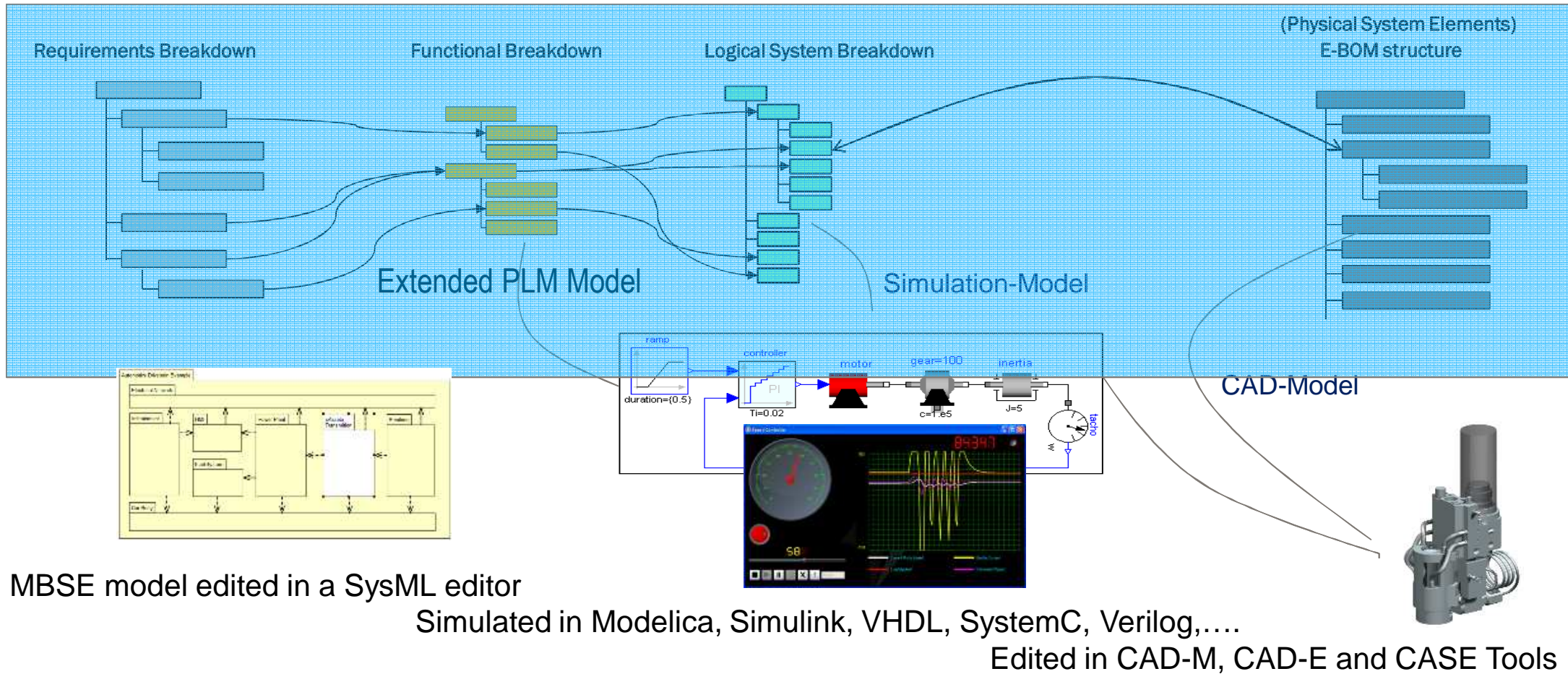
- System Requirements
- System Functions
- Logical System Elements
- Behavior Elements
- Allocations (R-F, R-B, F-L, F-B, R-L, L-P)

**MBSE Profile**



[Weikens, Tim: Systems engineering with SysML/UML, Modeling, analysis, design. Morgan Kaufmann, Burlington, MA/USA, 2008.]

- Map R, F, B, L to discipline specific parts and assemblies



MBSE model edited in a SysML editor

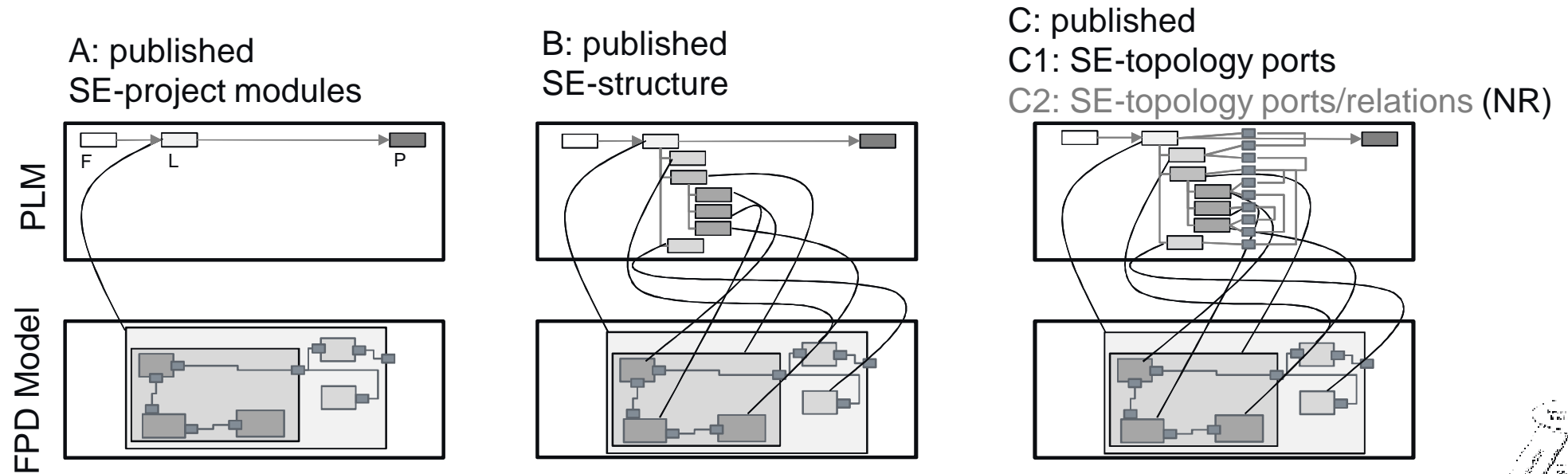
Simulated in Modelica, Simulink, VHDL, SystemC, Verilog,....

Edited in CAD-M, CAD-E and CASE Tools

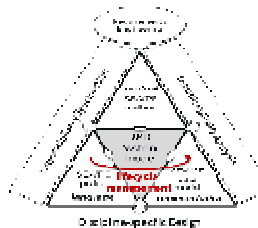
# Different Levels of Integration

## SysML to ALM/PLM

- Managing SE 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



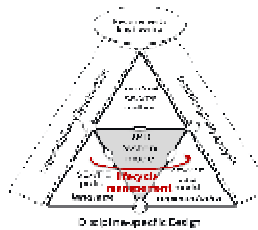
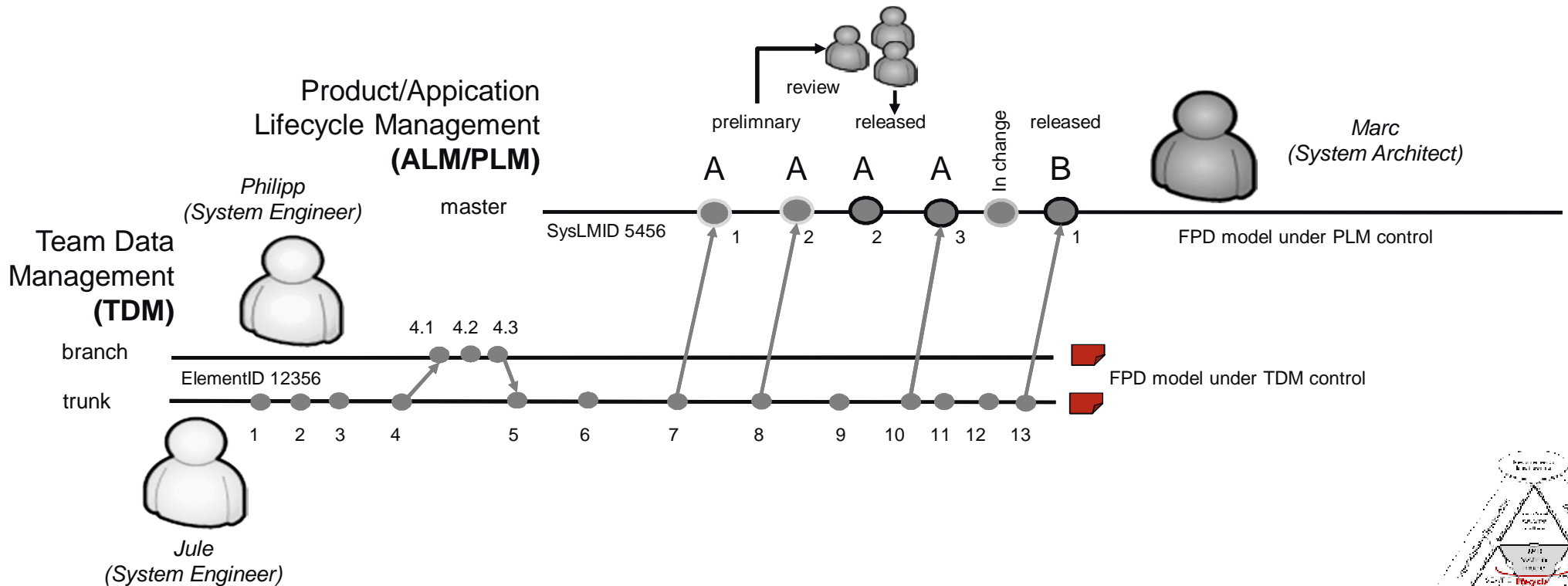
**B and C1 are my favorite solutions**



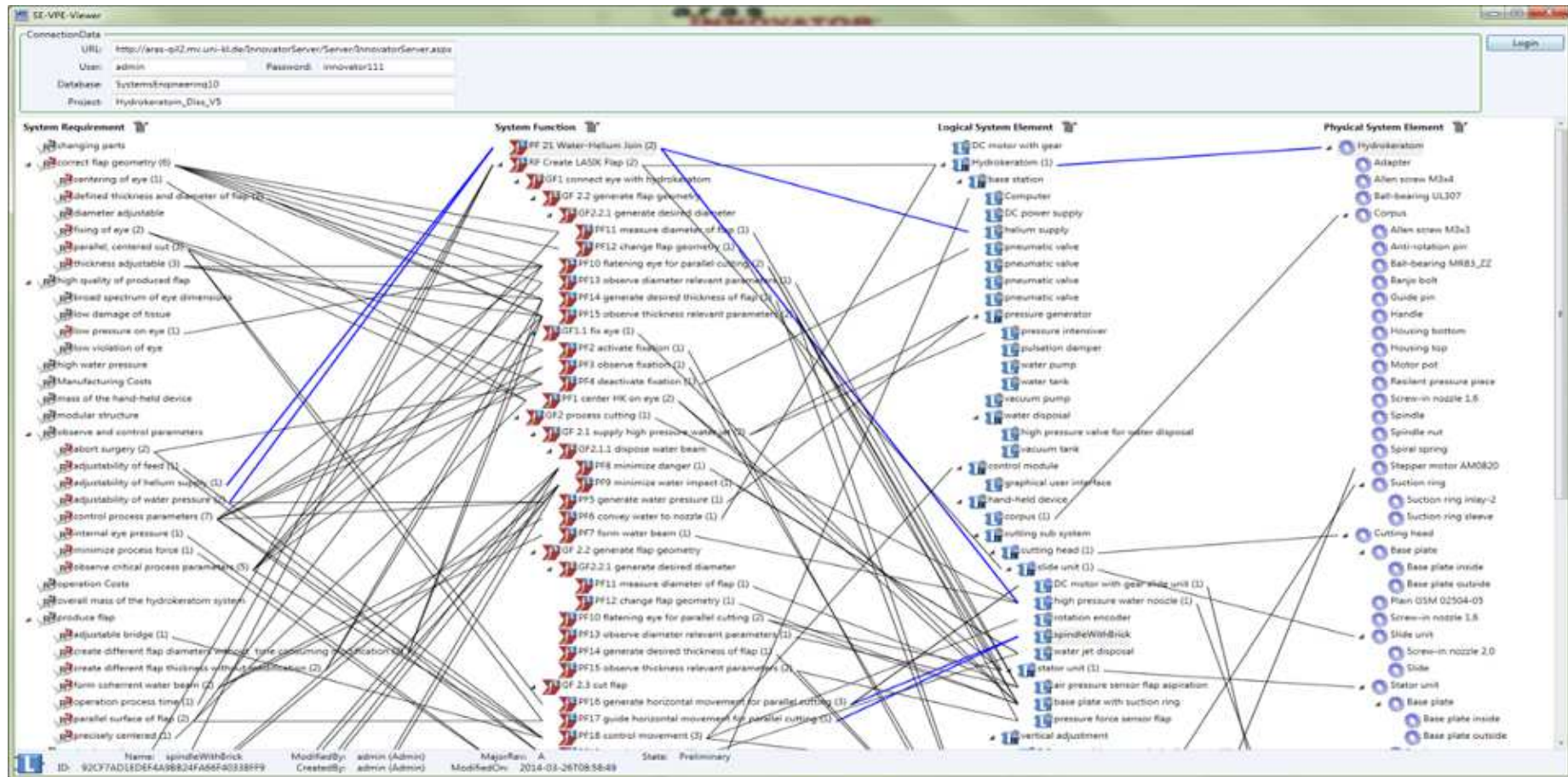
An ECM/CM process must be  
established for the SysML artifacts  
in ALM/PLM



- FPD model is partial model inside a SysML model in a CASE tool and managed in Team Data Management (TDM) tool
- PLM backbone controls FPD model items after commit



**An easy Visualization must be established  
for the affected Items in an ECM Process**

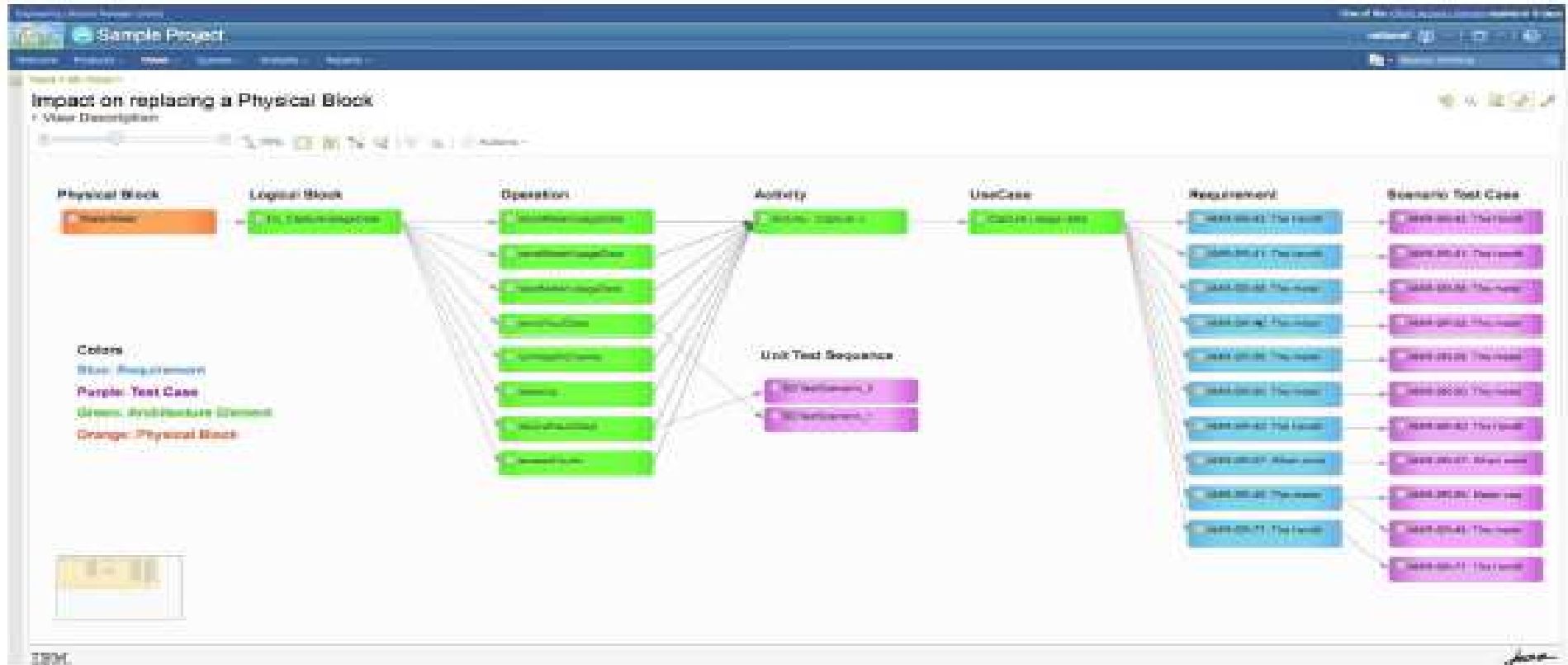


System Requirements

Functions

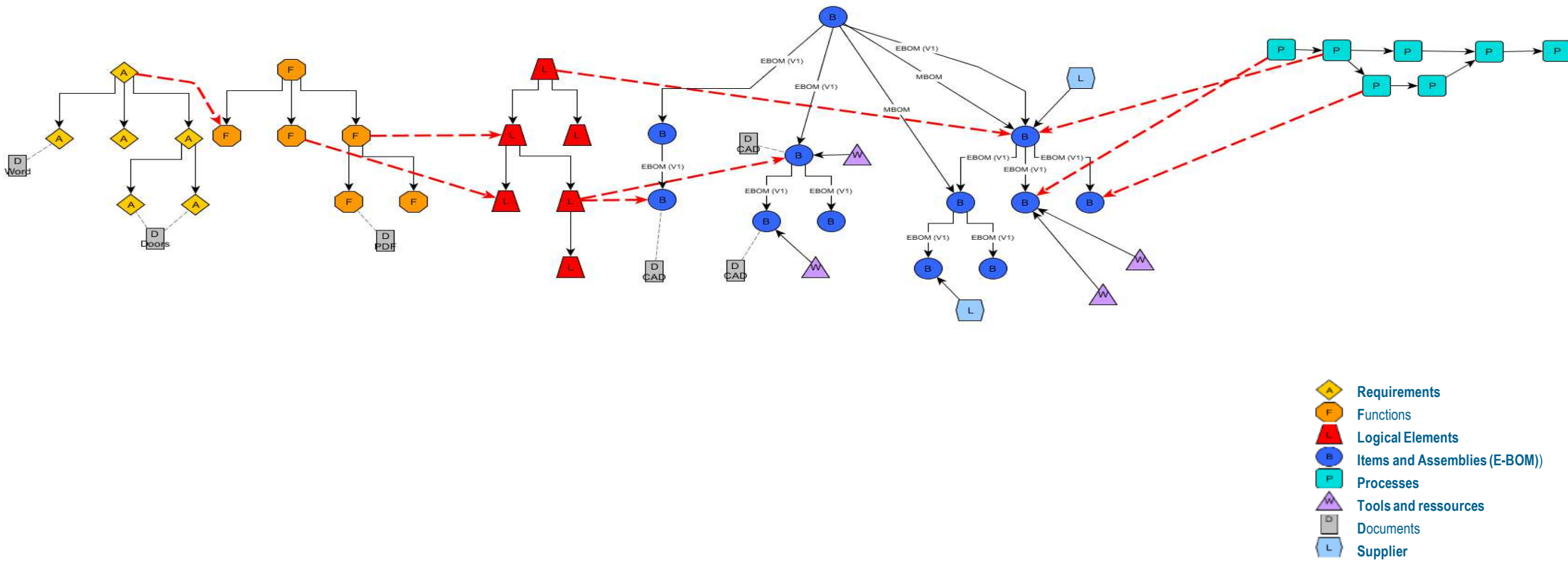
Logic

E-BOM



Quelle: Gray Bachelor, PDT Europe 2013

- Graph representation of affected item based on MBSE Datamodel stored in PLM and MRP (SAP)



- Persistent Administration in an extended PLM and/or ALM System for the following MBSE artefacts:
  - Requirements, Functions, Behavior and Logical Elements two levels hierarchy and network
- Version/revision control, ECM and Configuration Management needed for traceability (product reliability, ISO 9001, ISO 262606,.....)
- Seamless Integration into existent Enterprise ALM/PLM solution
  - ↳ One single source of truth
- Integration of MBSE in the enterprise ECM (Engineering Change Management) and CM (Configuration Mgmt)
  - ↳ Version and Revision Management as basis for CM
- Integration of the MBSE Authoring Systems via TDM into PLM and ALM
  - ↳ 4 Level VDA concept
- Security, Safety and common access rights
- Visualization of the MBSE artifacts
- Data Exchange in the early phase based on Standards (OSLC is not designed as a data exchange standard)
- Eventual co-existence between OSLC (integration) and PLCS (data exchange)

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## Thank You and Questions?

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