

Christian Doppler Laboratory

Software Engineering Integration For Flexible Automation Systems

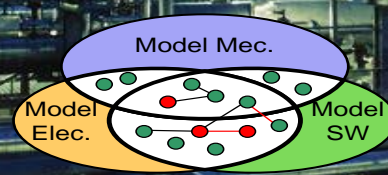
Engineering Model Exchange in Multi-Disciplinary Engineering with the AutomationML Hub

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Tool Mec.
Tool Elec.
Tool SW

Tech. Interop.

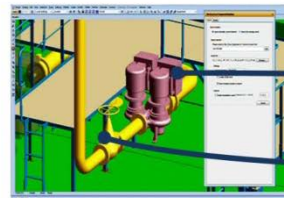
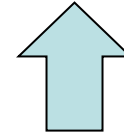
SCADA
Analysis
Workflow



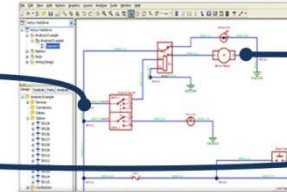
Context



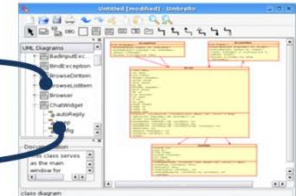
- Large-Scale Engineering Projects, e.g., hydro power plants, car manufacturing plants, steel mills.
- Cooperation of **different** engineering **disciplines**.
- Disciplines have **specific** engineering **tools**.
- Manual effort required for data exchange and synchronization.



Mechanical Eng.



Electrical Eng.



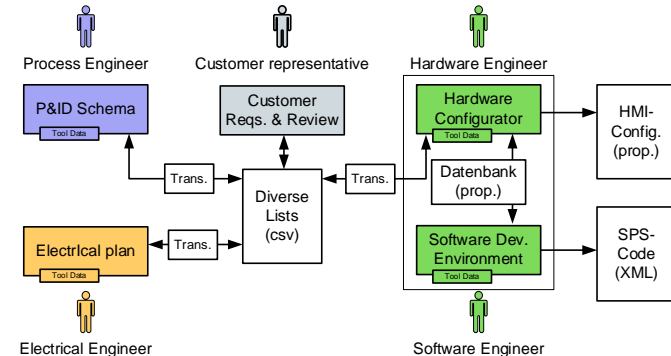
Software Eng.

Challenges in Multi-Disciplinary Engineering Environments



- Engineering process as **sequence of exchanges**
 - work results between roles / domains
 - Export and import of engineering know-how from/to tools
- AutomationML (AML) allows engineering data exchange, modelling and AutomationML-based engineering
- Most engineering **models in tool networks** are **not AutomationML** models

What is a good foundation for a **step-by-step migration** to AML-based engineering projects?

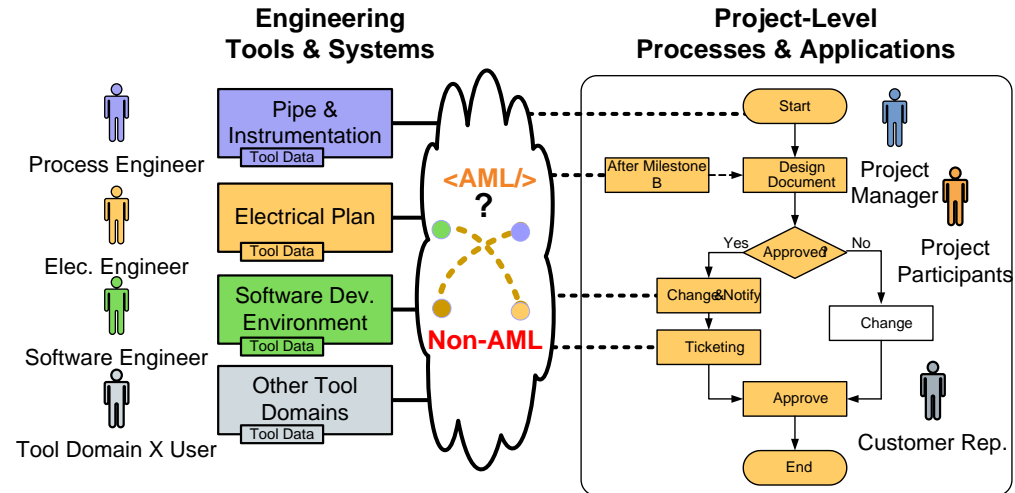


Requirements for Engineering Tool Networks with AutomationML and Non-AutomationML Models



- Domain experts continue **using** their **familiar tools**
- **Tailorable** to organization and engineering process
- **Versioned storage** of tool data
- Change **analysis** capabilities

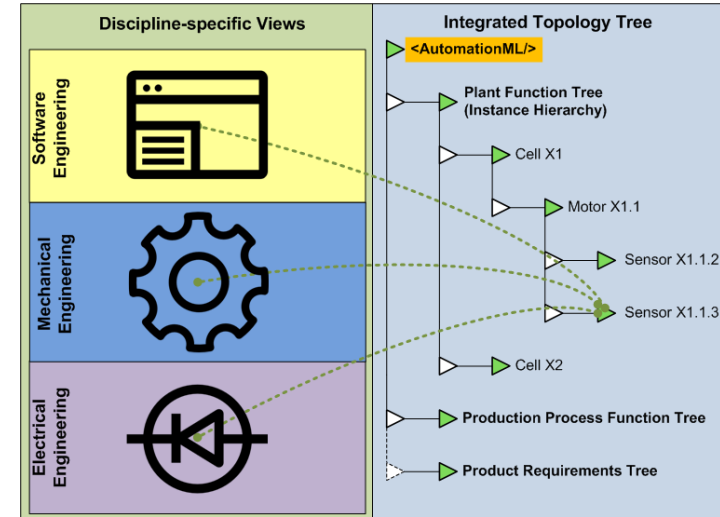
- Further requirements
 - Representation of responsibilities and work states in the engineering team
 - Continuous visibility of progress and risk to project management
 - Notification of relevant roles on changes to data and risk items



AML-based Integrated Plant Model



- Overarching Plant Representation
 - captures discipline-independent view on the engineering plant
 - combines engineering views into one AutomationML-based plant model
- Provides means to
 - derive discipline-specific topology tree
 - maintain tool-specific view on the automated system
- Facilitates consistent, easy, and efficient quality assurance

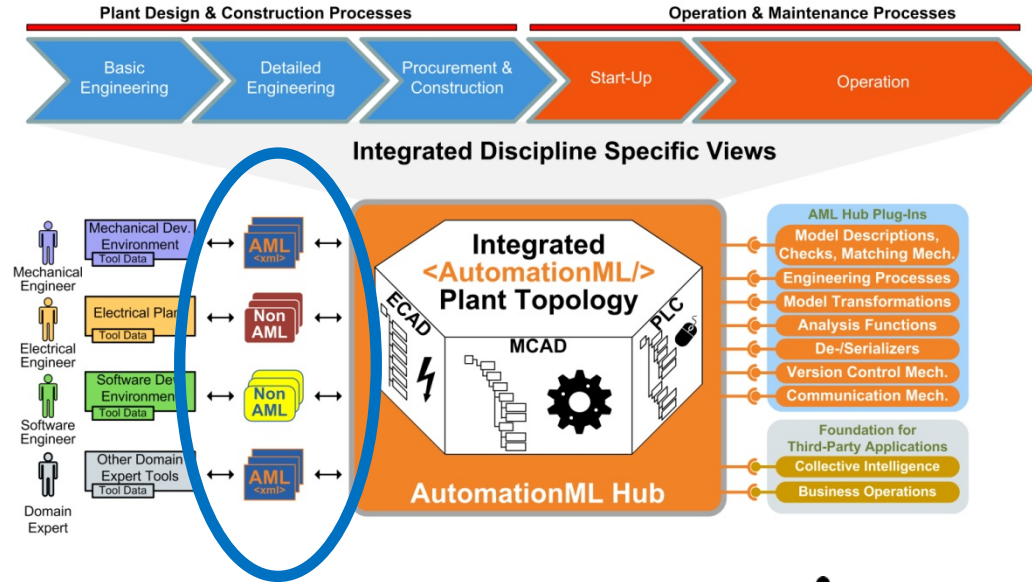


At the **core** every engineering **project is compatible to AML** structure
– a common starting point for migration

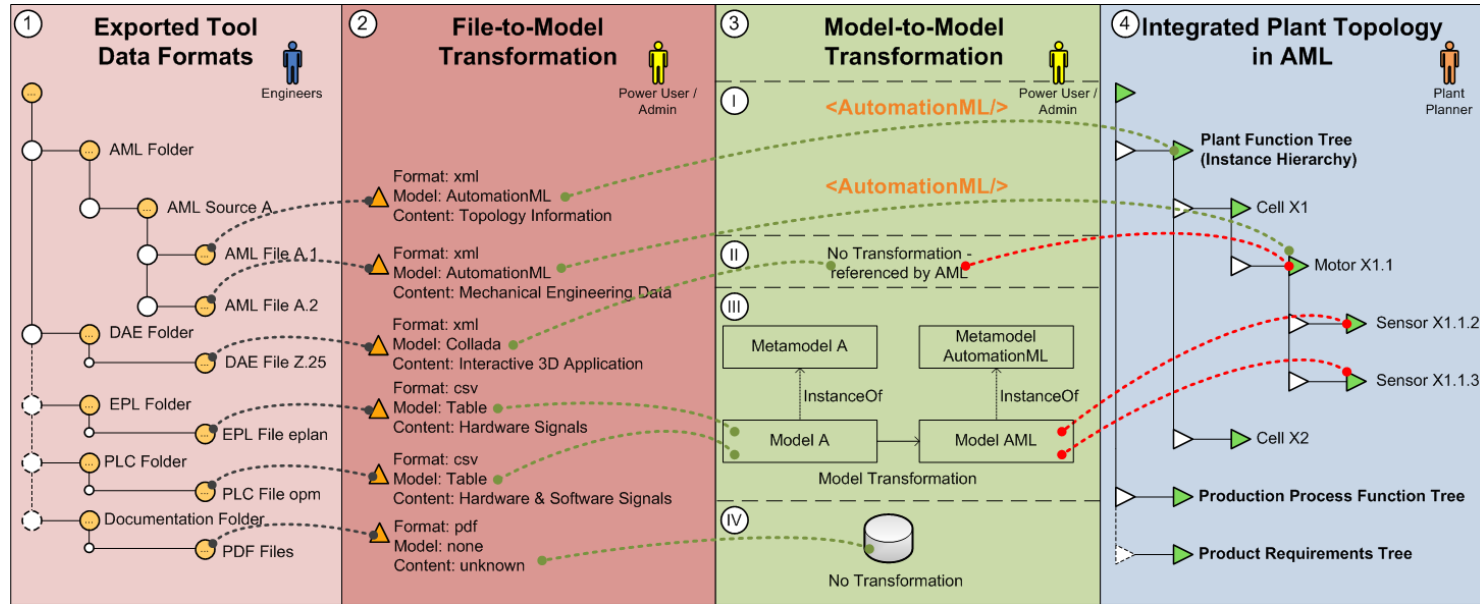
AML Hub Data Management



- Open **integration and communication** platform
- **Versioned** AutomationML model repository for **plant topology** and class libraries
- **File-based version management** system.
- Allows **managing and reporting changes and consistency** of AML-models and -libraries and connections to incorporated models.



Model Management in AML.hub



1. File Format Analysis

2. File-to-Model Transformation

- Requires model description

3. Model-to-AML Transformation

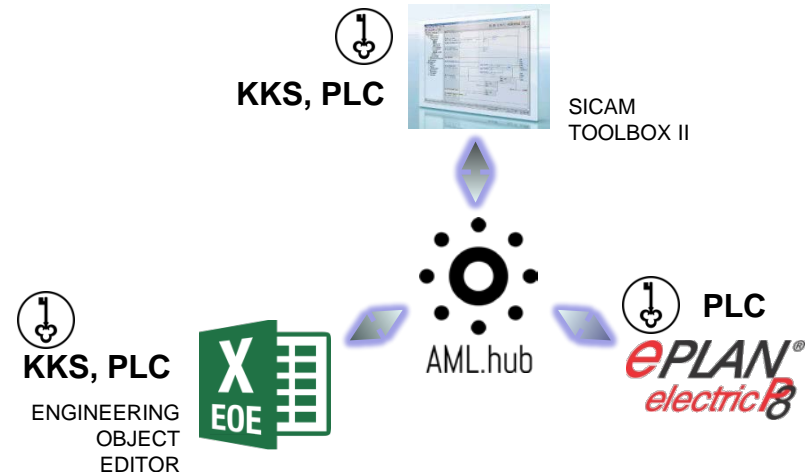
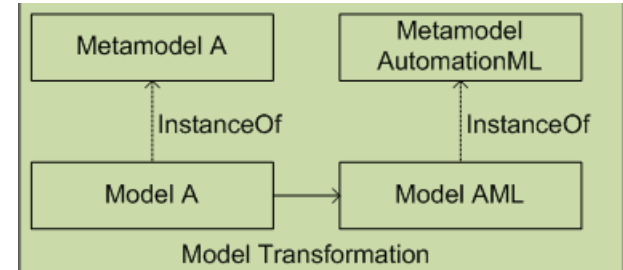
- Models with cross-discipline information

4. Merge with Integrated Plant Topology

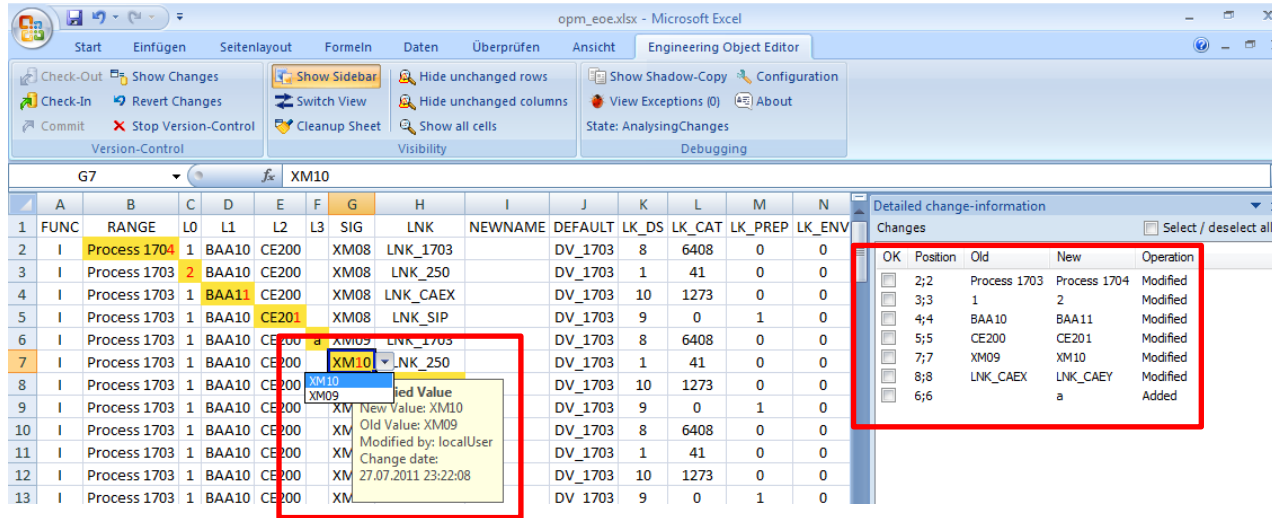
Industrial Use Case

Findings from Engineering Hydro Power Plants

- Engineering Data
 - Working with the **data format as exported** by tools
 - KKS and PLC key system
- Challenges
 - Hardware and software signals
 - Multiple pin assignments
 - **local key system matching** instead of AML-UUID matching
- Engineering Process
 - Enforcement of **Collaboration Policies**



Cooperation with external Project Partners based on non-AML models



OK	Position	Old	New	Operation
<input type="checkbox"/>	2;2	Process 1703	Process 1704	Modified
<input type="checkbox"/>	3;3	1	2	Modified
<input type="checkbox"/>	4;4	BAA10	BAA11	Modified
<input type="checkbox"/>	5;5	CE200	CE201	Modified
<input type="checkbox"/>	7;7	XM09	XM10	Modified
<input type="checkbox"/>	8;8	LNK_CAEX	LNK_CAEX	Modified
<input type="checkbox"/>	6;6		a	Added



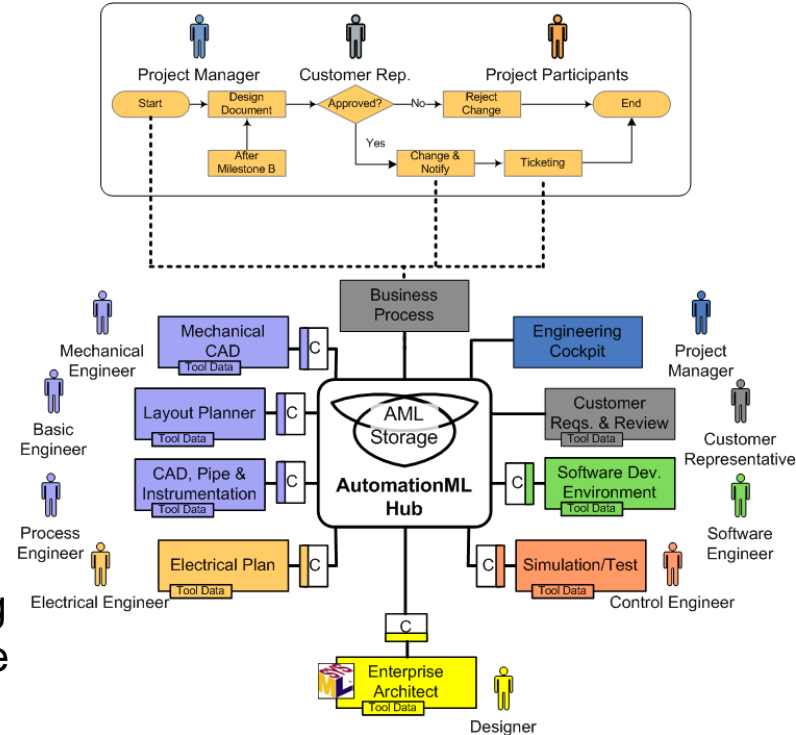
- Engineering Object Editor (EOE) acts as a bridge
- EOE functions as Quality Gate
- EOE provides a user-specific view on data coming from different engineering tools
- EOE is an intelligent add-on for Excel to version engineering data

Summary AML.hub

- Most exchanged engineering **models** in tool **networks** are not **AutomationML** models.
- With the AML.hub, engineering projects **become AML-ready** even if the tools do not export AML.
- Integrated plant model captures a **discipline-independent view** on the engineering plant while the AML.hub maintains **tool-specific views**.
- A **migration strategy** from traditional engineering tool networks to AML-based tool networks may be defined.



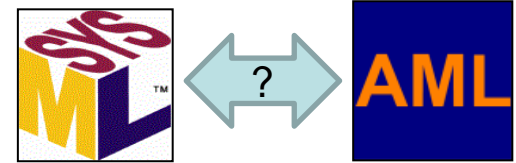
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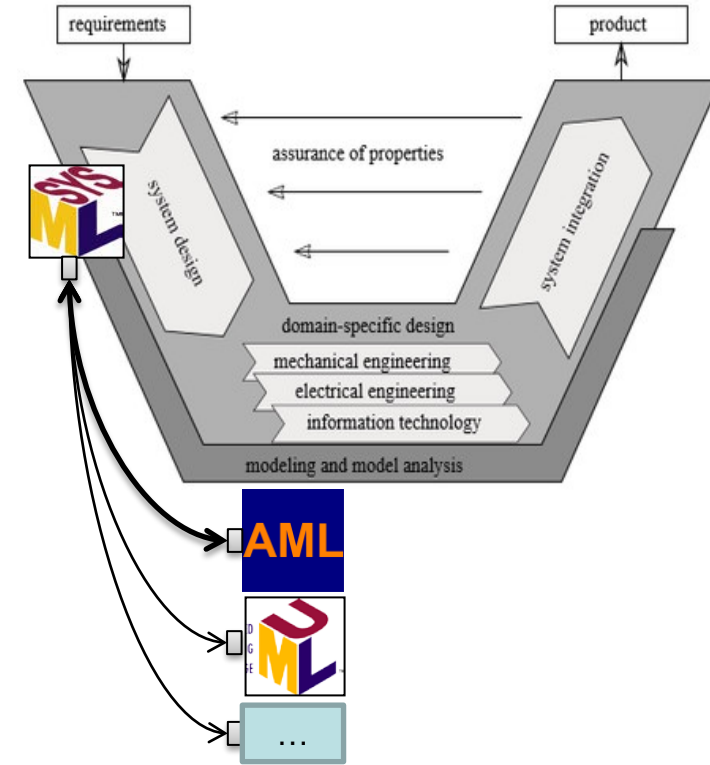
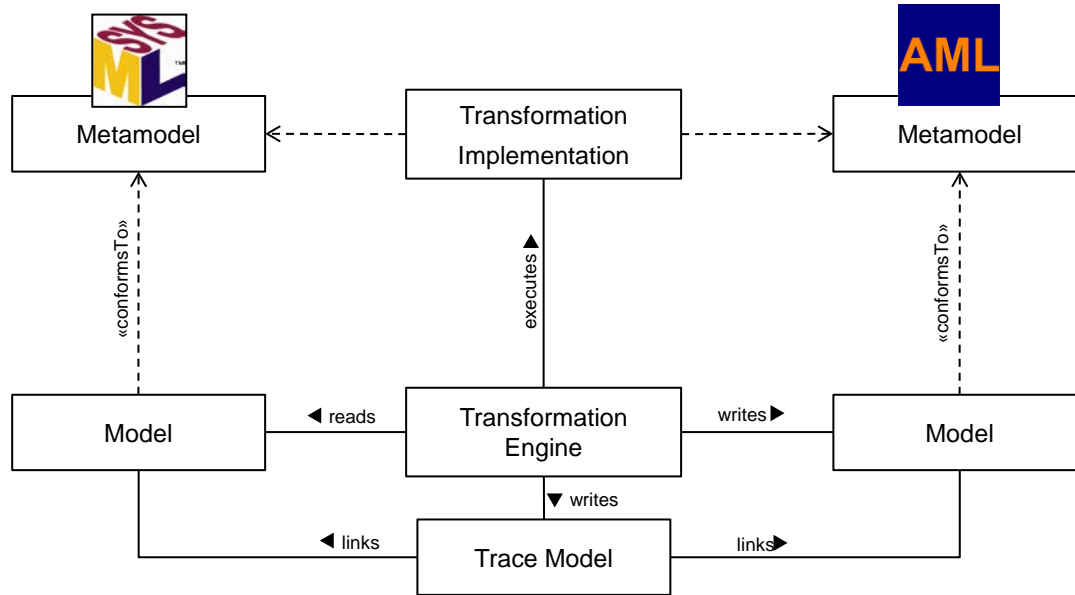
Engineering with AML and SysML Data Models



- **SysML** is a graphical modeling language standardized by OMG for the development of large-scale, complex, and **multi-disciplinary systems in a model-based approach**.
- It provides modeling concepts for representing the **requirements, structure, and behavior** of a systems.
- Captures the overall design of a system on a high level of abstraction and traces this design to the discipline-specific models
- How can we connect SysML models with AML models?
- Can we use AML for exchanging SysML models?



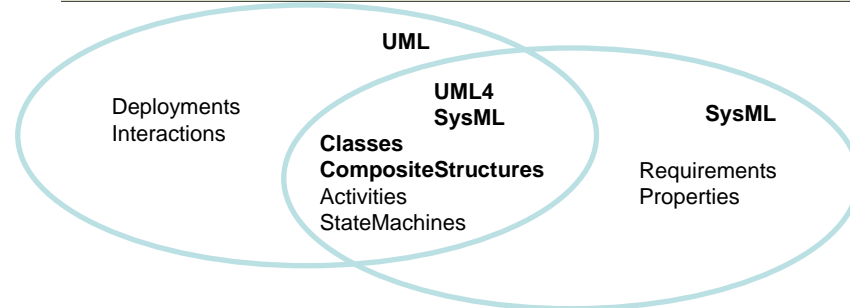
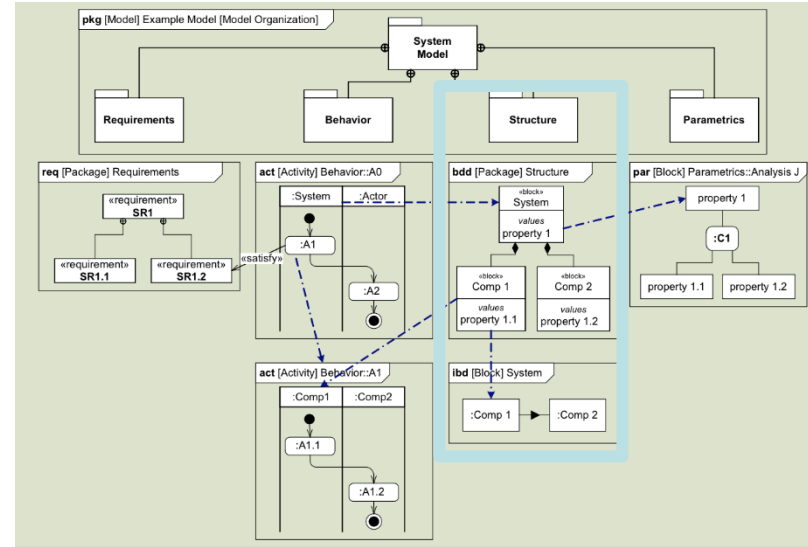
Use Case I: Exporting SysML to AML with Traceability



SysML in a Nutshell



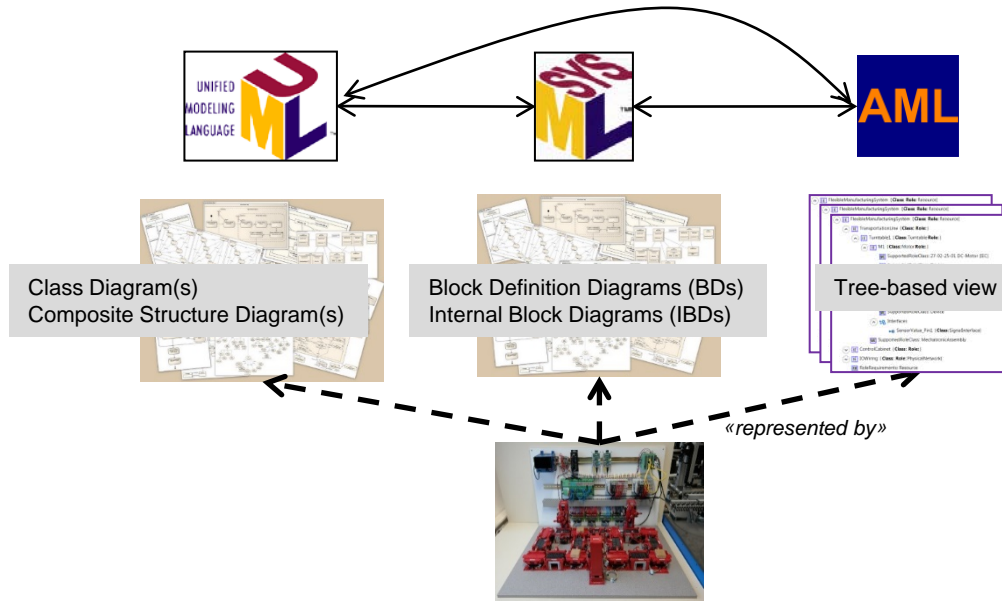
- **Additions to UML** for Requirement and Property Modeling
- **Customization of UML** for structural modeling through Classes and Composite Structures
- **Block** derives from CompositeStructures::Class
- For instance, **Enterprise Architect** provides SysML modeling support



From UML/SysML to AutomationML and Back Again

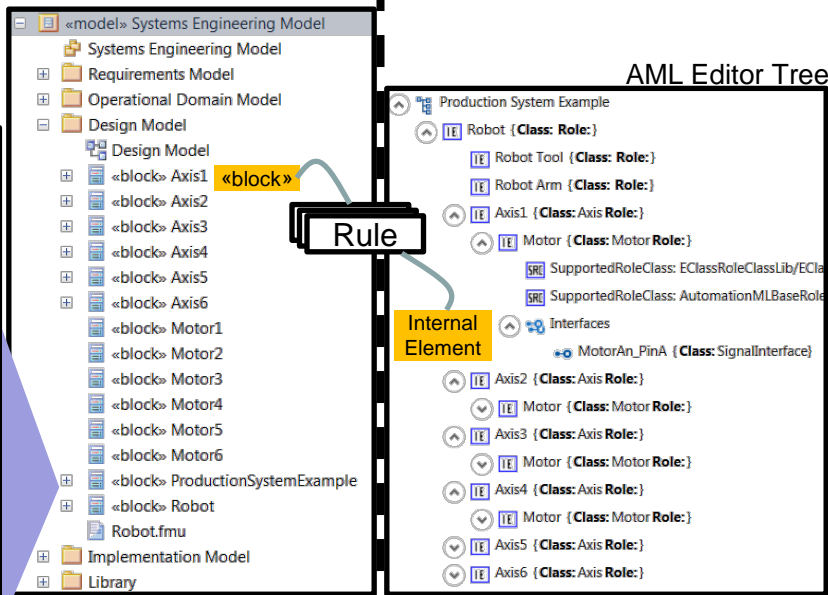
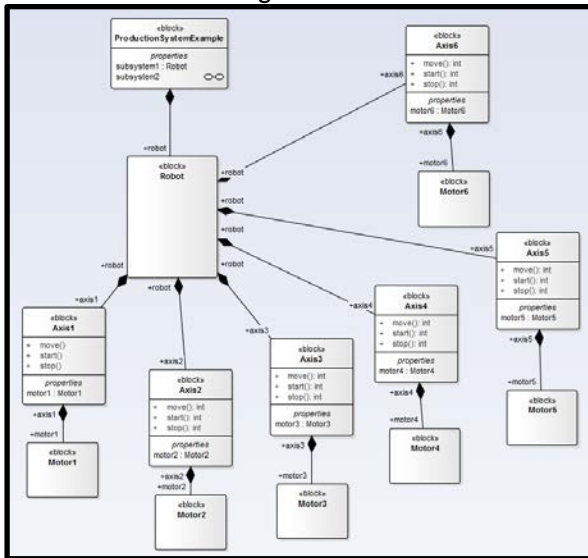


- 1) **Studied commonalities and differences** between the structural modeling sublanguages of AML (CAEX) and SysML (Block Diagrams)
- 2) **Specified AML metamodel and profiles** for UML and SysML
- 3) **Implemented Transformations** between AML and SysML (UML/SysML already available)



Use Case I: Exporting SysML to AML with Traceability

- Plugin for Enterprise Architect allows to **export SysML diagrams as AML files + trace model**
- For instance, **block maps to internal element**
- Transformation is customizable

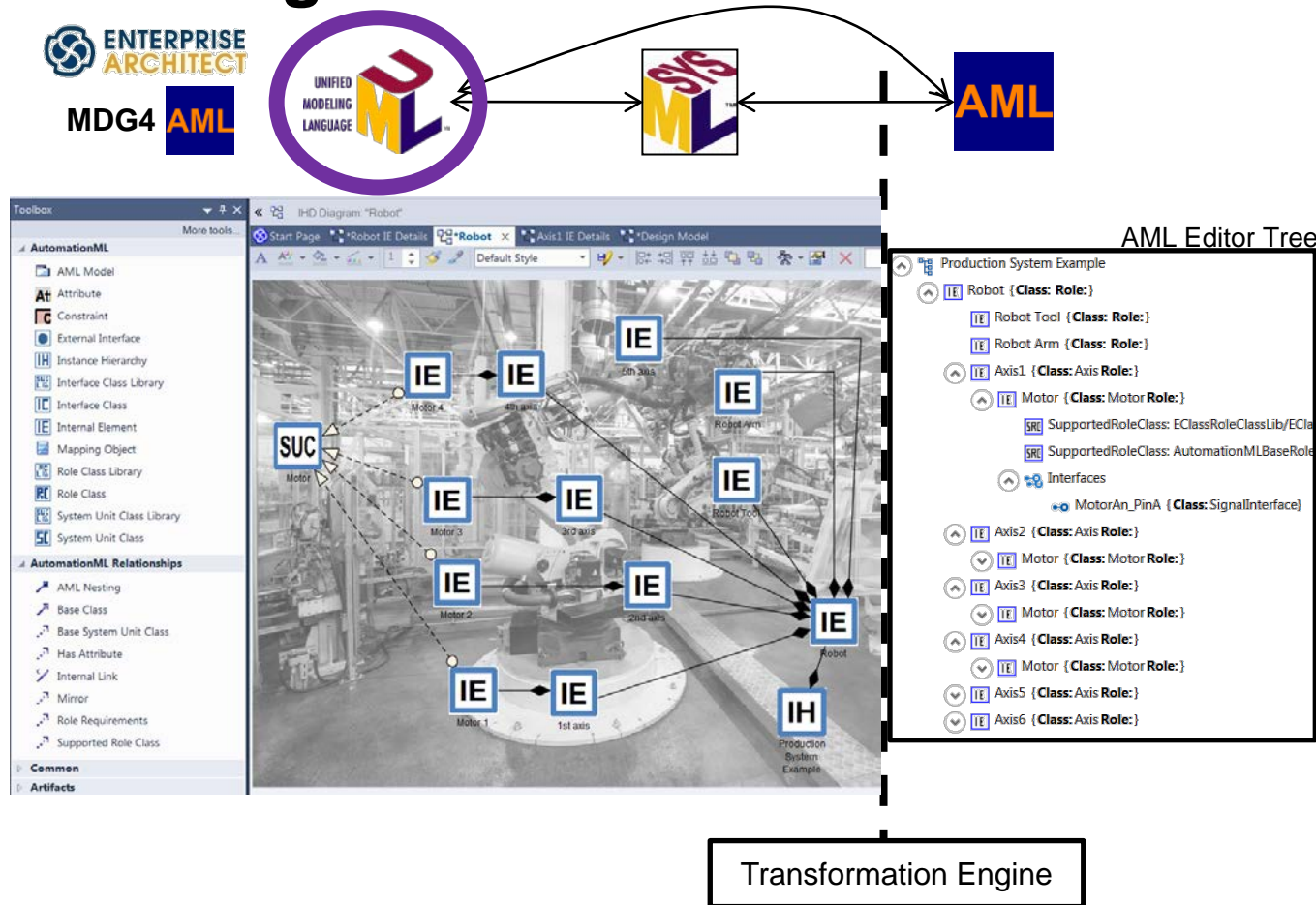


Transformation Engine

▶ **Trace1: [block:Axis1]--[IE:Axis1]**

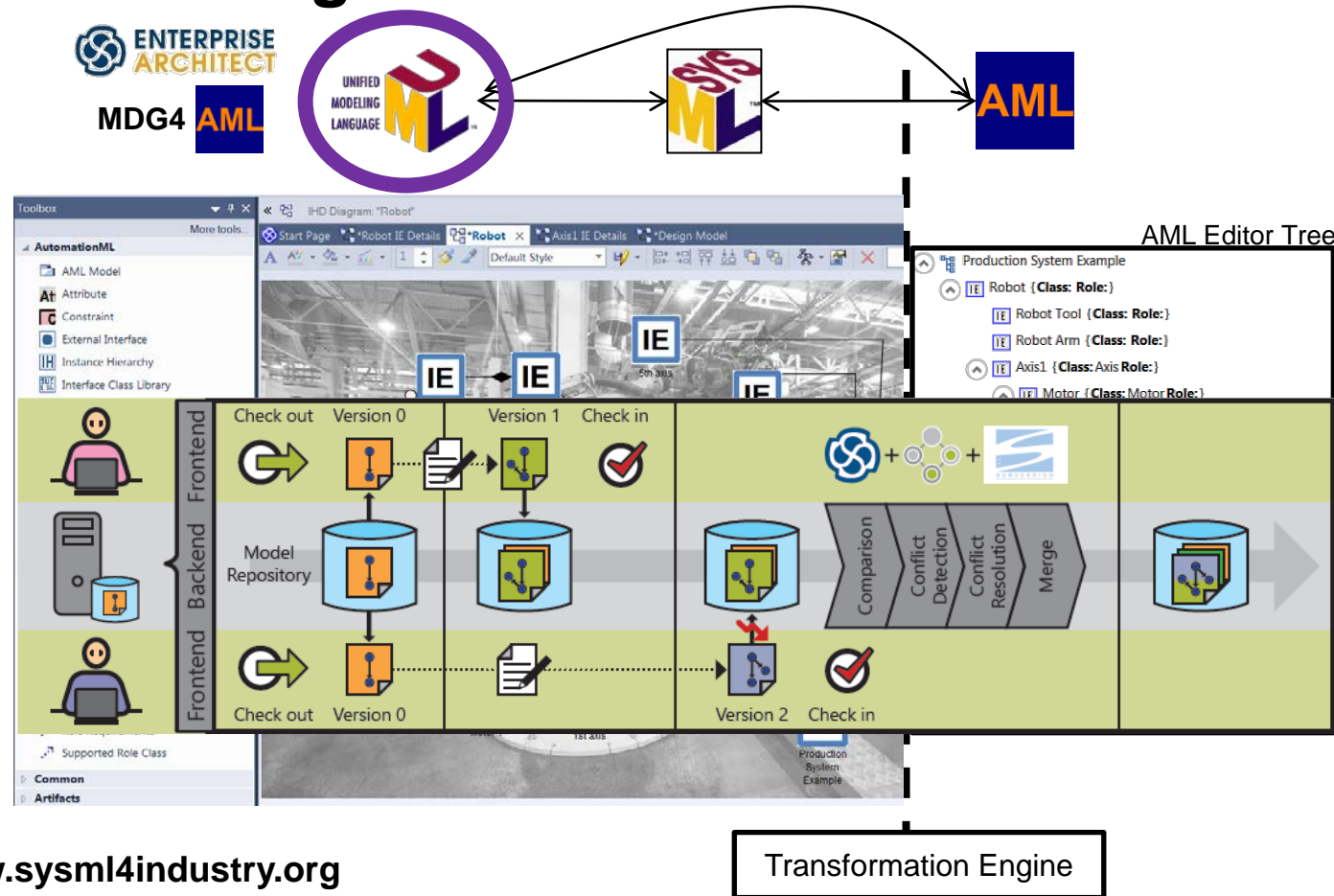
Use Case II: Visualizing AML Data

- Plugin for Enterprise Architect allows to import AML data as AML diagrams
- Different visualization algorithms are available
- Different views can be defined on one AML file
- Data management operations such as diffing, merging, and versioning available



Use Case II: Visualizing AML Data

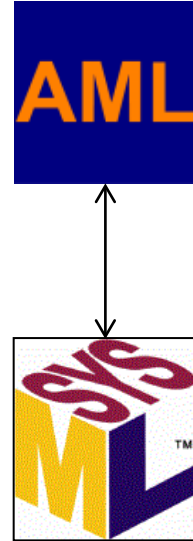
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Summary

Engineering with AML and SysML

- Interoperability between different modeling languages is needed
- Model transformations are a powerful tool to exchange data from heterogeneous sources to AML
- Standard techniques which already available are reused as much as possible



Conclusion

- **Coexistence of engineering tools** exporting and importing AutomationML models and of tools that do not yet facilitate AML is supported.
- The **Integrated Plant Model ensures** at the core of an engineering project the **compatibility with the AutomationML** structure.
- **Exchange with other modeling standards** originally coming from the software engineering domain is **possible with AML**
- **Graphical multi view-based modeling/visualization** facilitates to explore large **graph-based AML** files

