German Research Center for Artificial Intelligence GmbH


# Open semantic meta-model as a cornerstone for the design, engineering and management of CPS-based Factories

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# MAYA – The Overview

36 months (10/2015 - 10/2018)

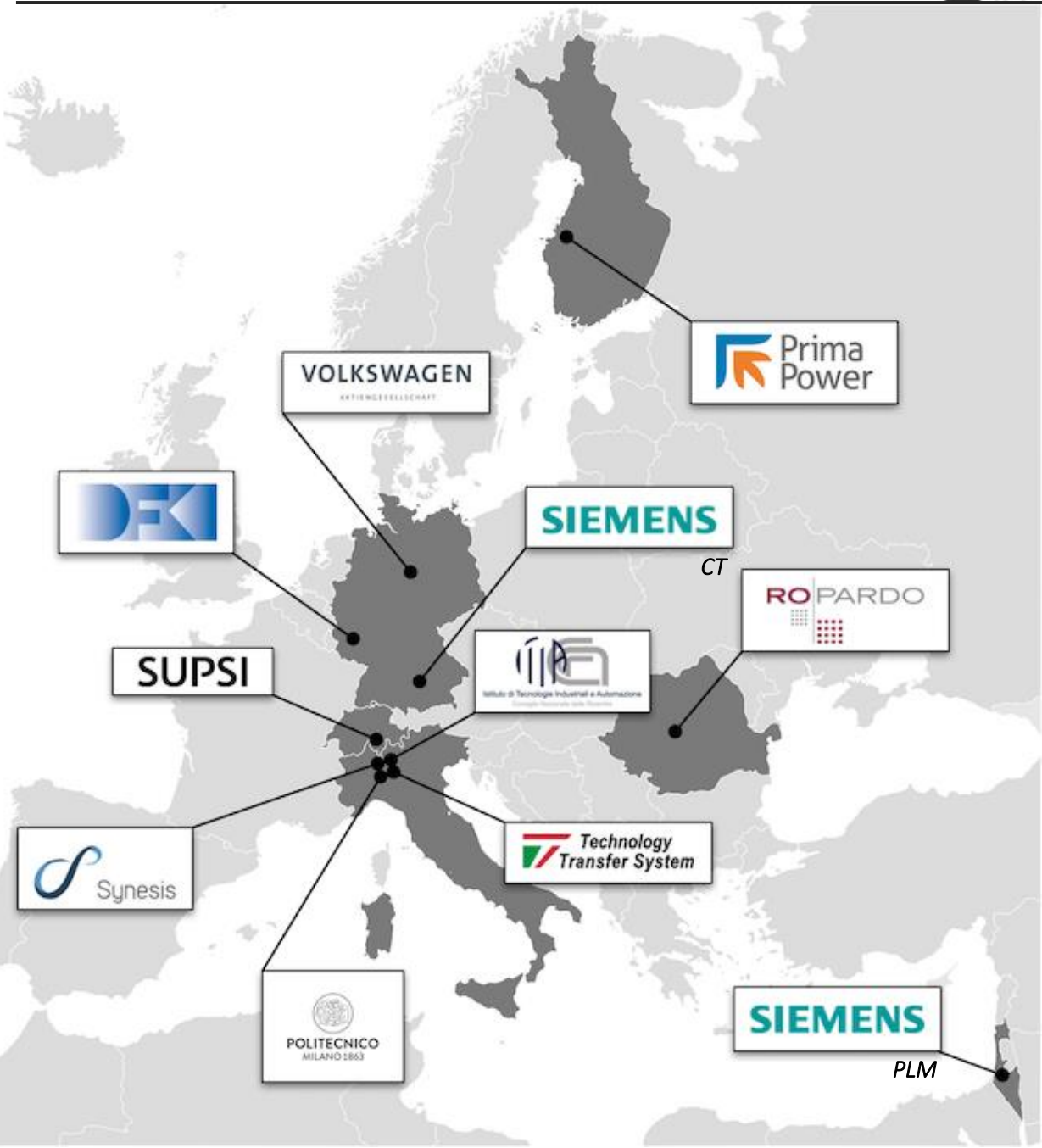
EC HORIZON 2020 | FoF 8

Grant agreement: 678556

The Goddess of Illusion

MAYA

Developing multi-disciplinary integrated simulation tools and methodologies for the design, engineering and management of **CPS-based (Cyber Physical Systems) Factories**



# MAYA in Context of „Industrie 4.0“

*MAJOR FACTS*

## Factory and Value Chain
- International competition
- Rapid shortening of innovation cycles

## Factory and Nature
- Increasing cost and competitive pressure
- Lowest resource consumption

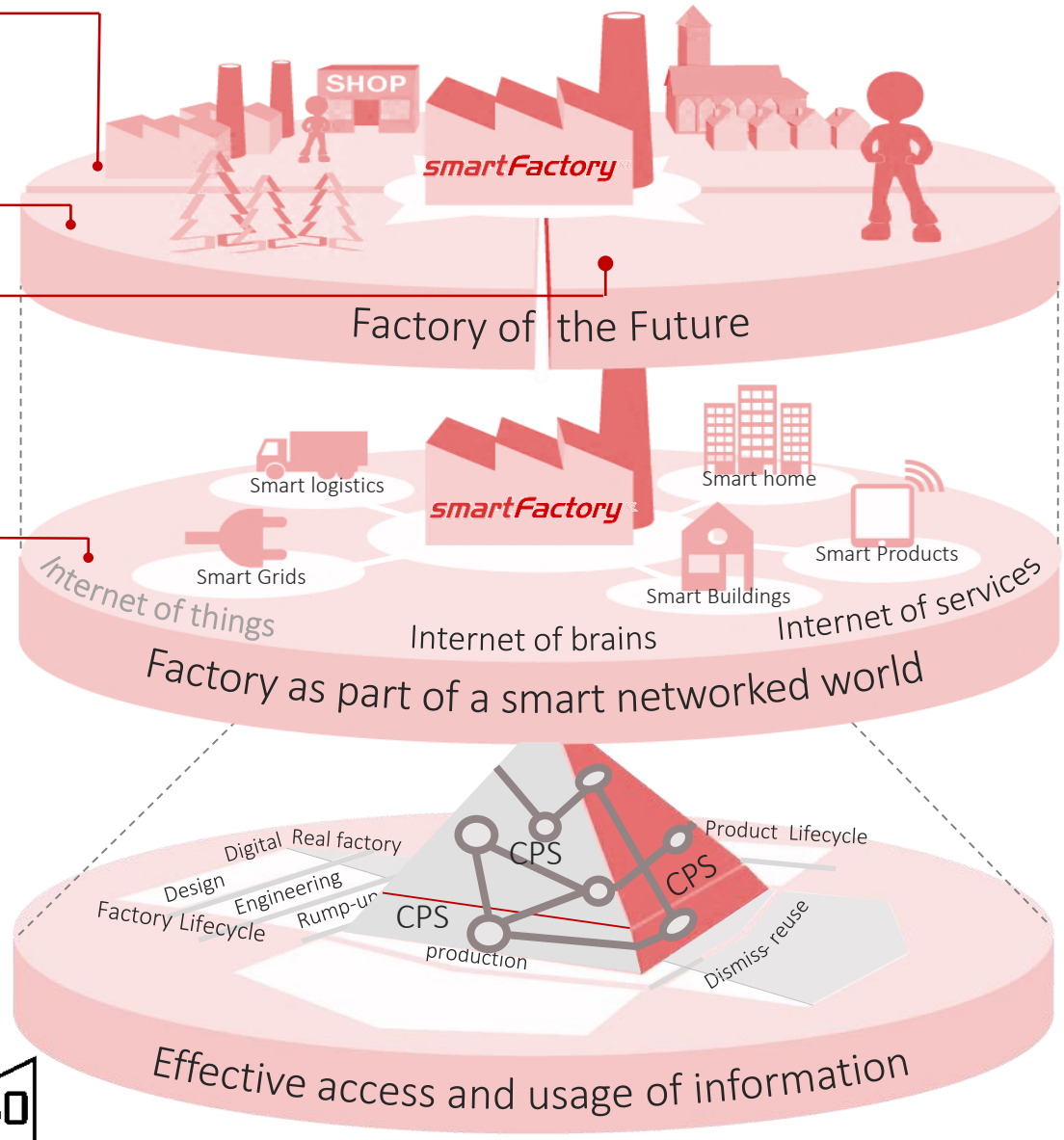
## Factory and Humans
- High customer requirements
- Human oriented interfaces for workers

*ENABLER*

## Prevalence of Internet technologies
- ICT revolutionize our daily life
- Factory as part of a smart networked world
- Merging of automation and ICT

*FORTHCOMING CHANGE*

## Future Factory Environment
- Mass customization with highly modular and flexible systems for quick changes (Network of multi-vendor production units)
- Prevalence of so-called “Cyber-Physical Production Systems”
- Smart Products and Advanced HMI
- …




Industrie 4.0

# Engineering “at any point of time”

## Changing demands of the market

Customization | Resource efficiency | Global Competition

*REAL WORLD*
***PLUG AND PLAY***

Re-Engineering at the point of interest

ICT

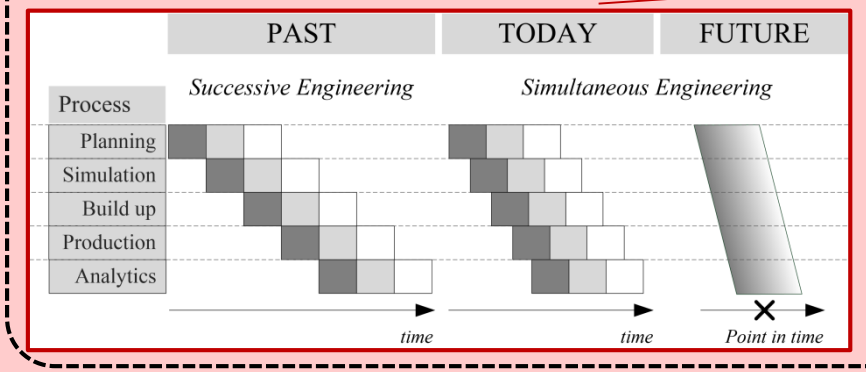
Scalable CPS environment
-> Interoperability, Modularity

Production **Planning** | Production **Design** | Production **Engineering** | Integration and **Ramp-Up** | **PRODUCTION** | Production **Recycling**

PLM Tools and Concepts

*DIGITAL WORLD*
***PLUG AND SIMULATE***

‘Synchronized’ Engineering



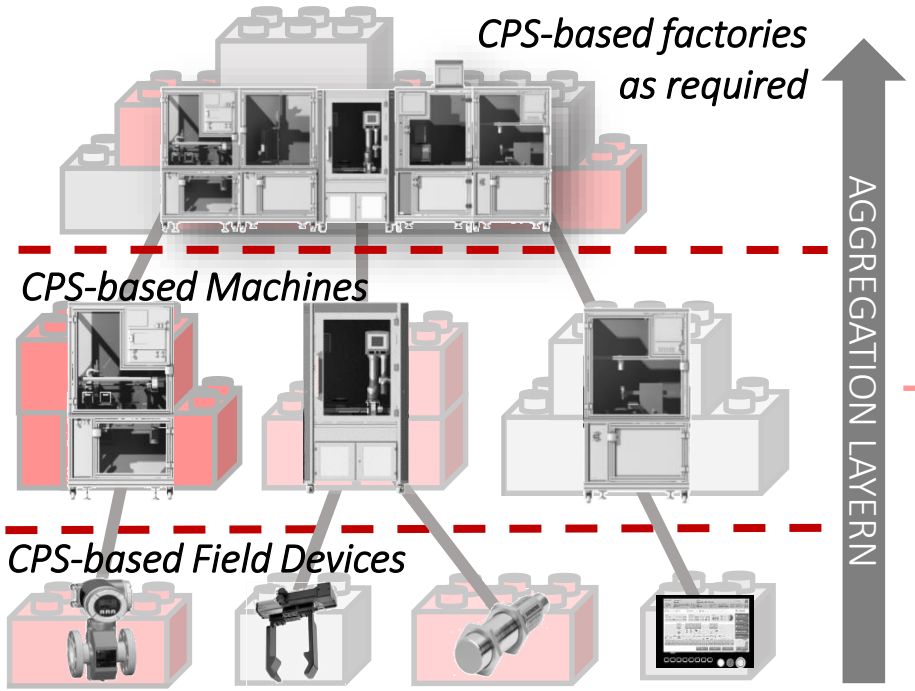

Various manufacturing + sim. tools

→ Should be possible to engineer, manage and simulate our scalabe CPS-based factories

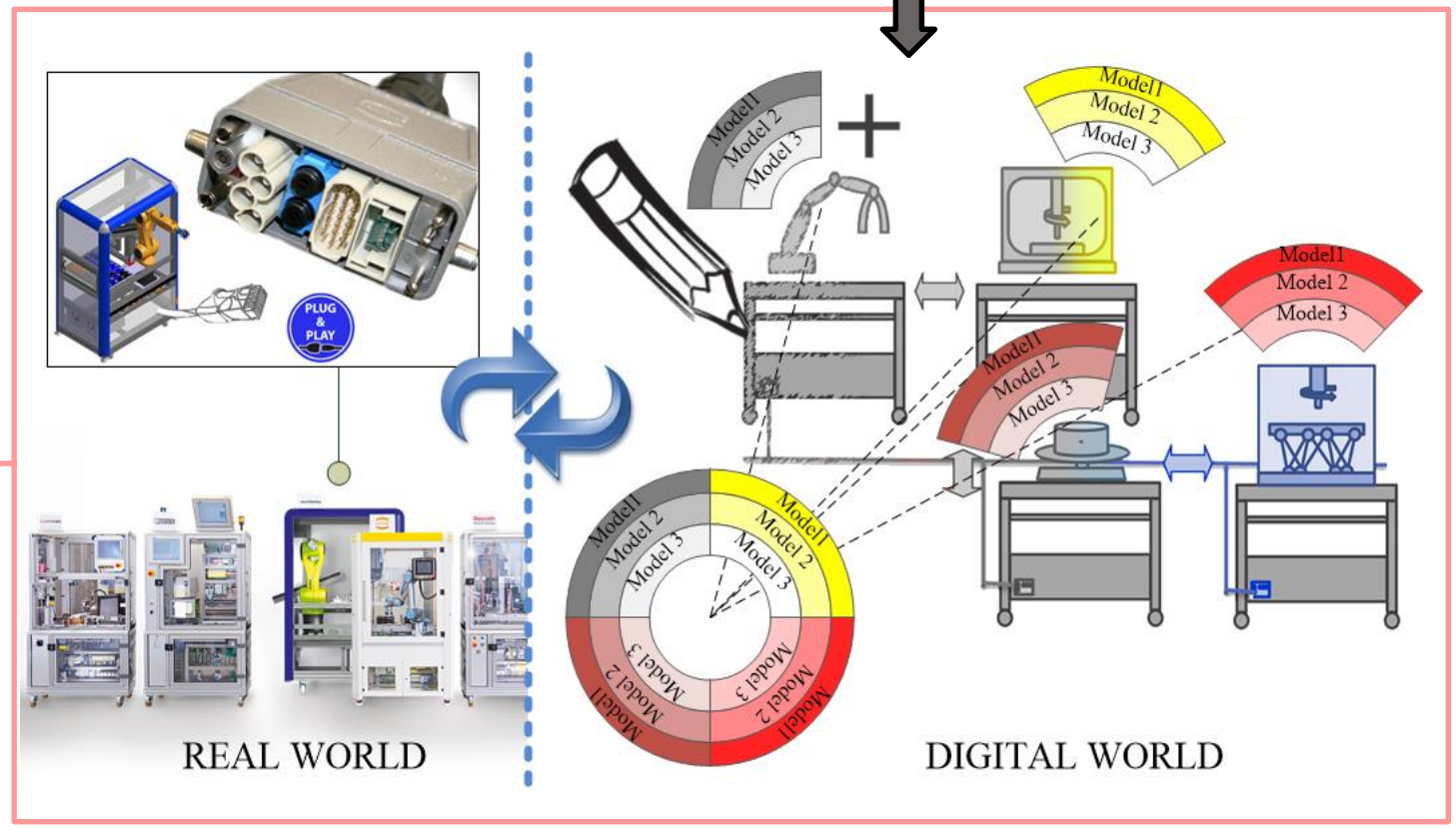
Digital Twin Concept

Seamless Integration of data

# From Plug'n Play to Plug 'n Simulate




PLM TOOLS



# 3 main objectives within MAYA

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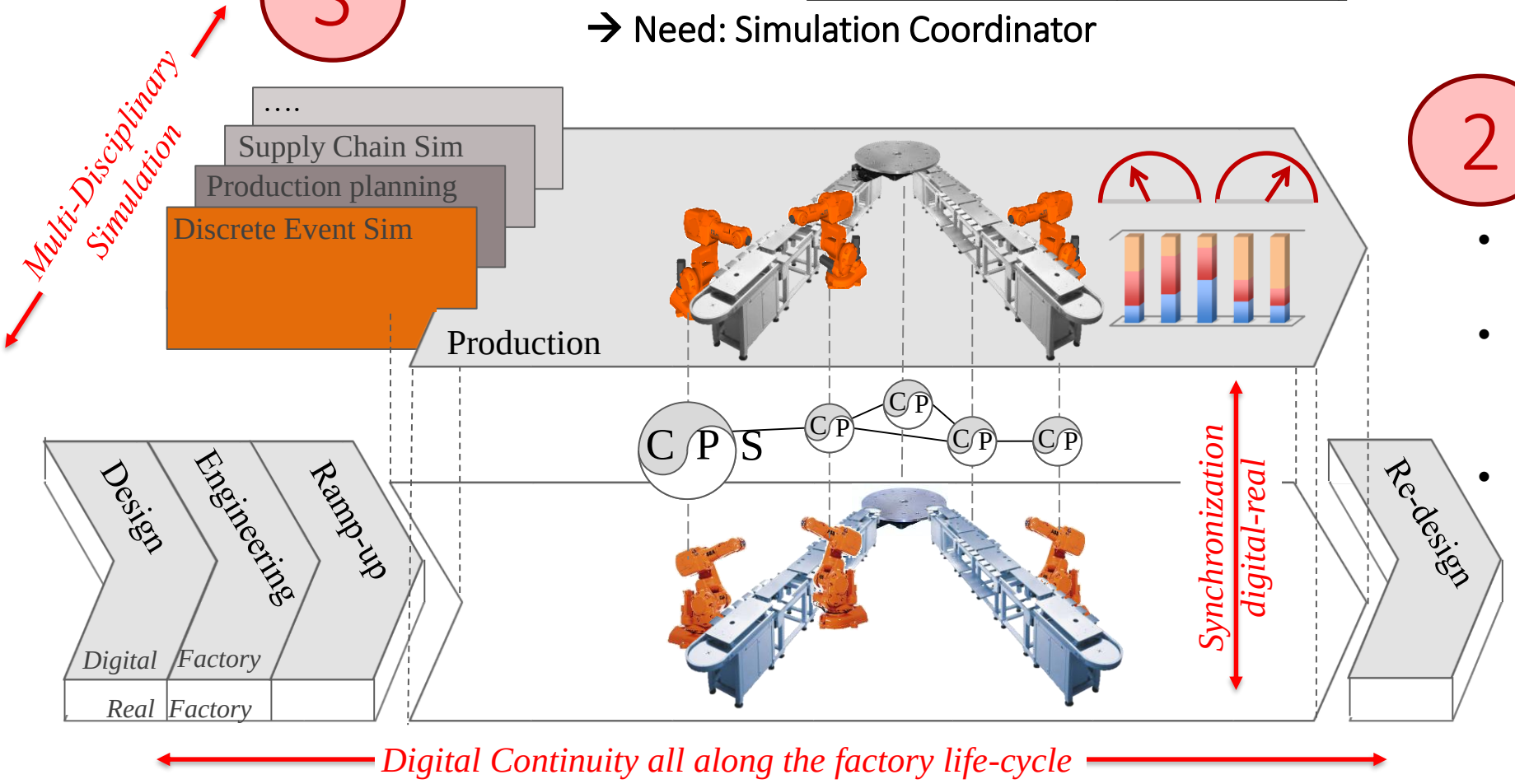
- interaction between multi-vendor tools (focus on SME) and running simulations

→ Need: Simulation Coordinator

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- identification, recognition as well as integration of instantiated CPS
- easily embeddable within multi-level simulation and monitoring tools
- Platform-independent access

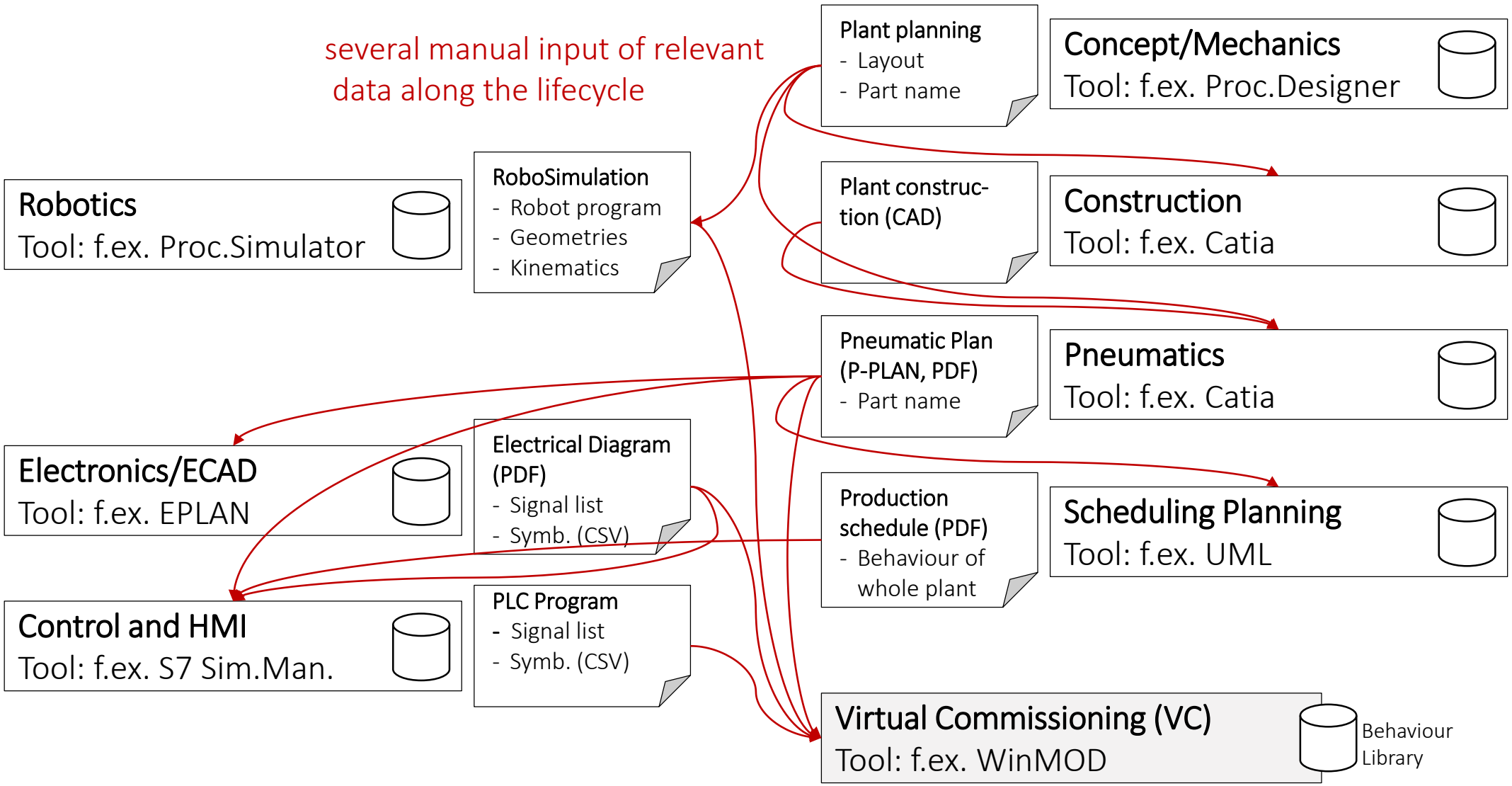
→ Need: central support infrastructure

1

- maintaining the relevant digital information across a varied set of tools
- allowing data to be enriched and used as needed for each phase

→ Need: common CPS description and container model (digital twin concept)

# EXAMPLE: Virtual Comissioning



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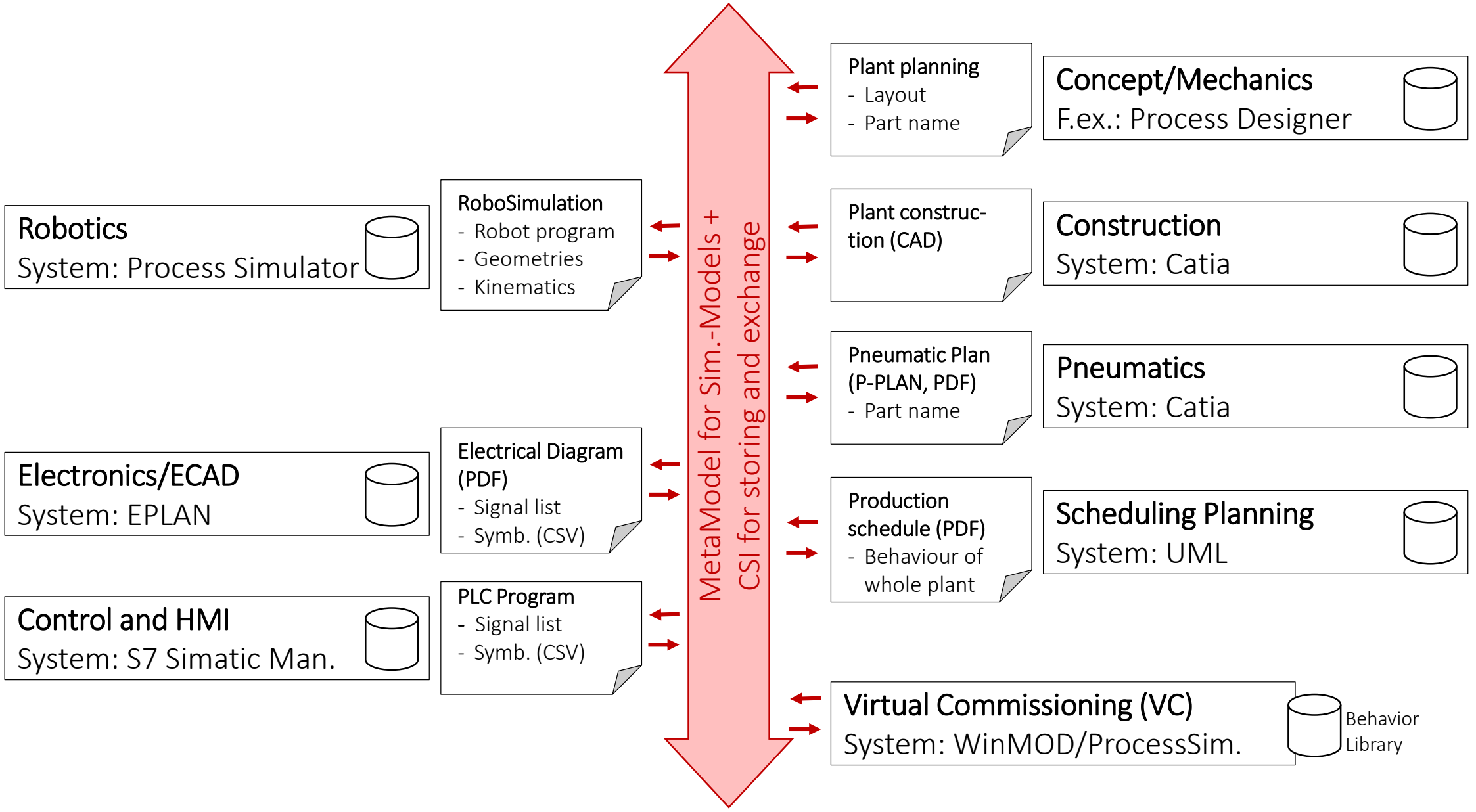
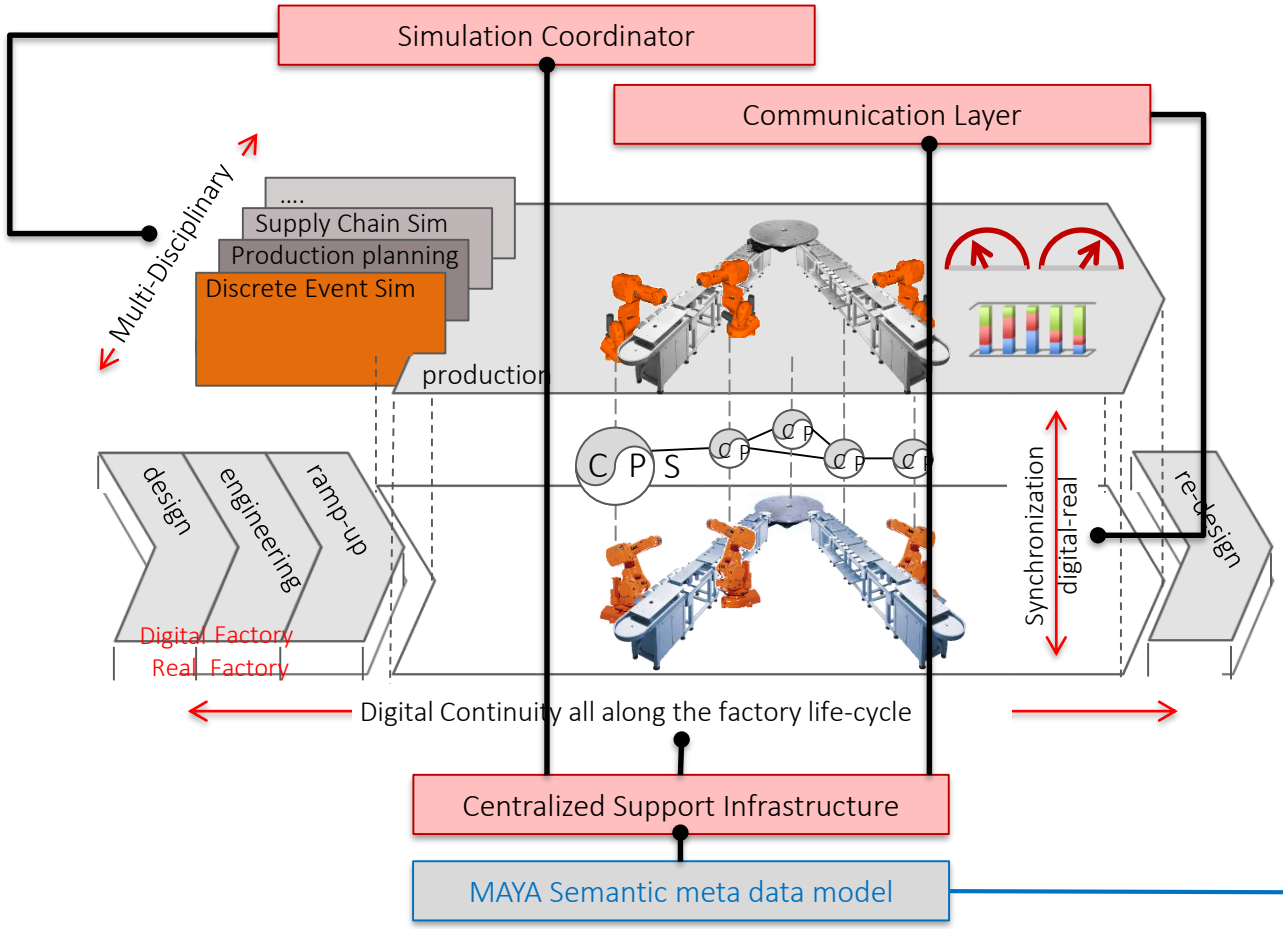
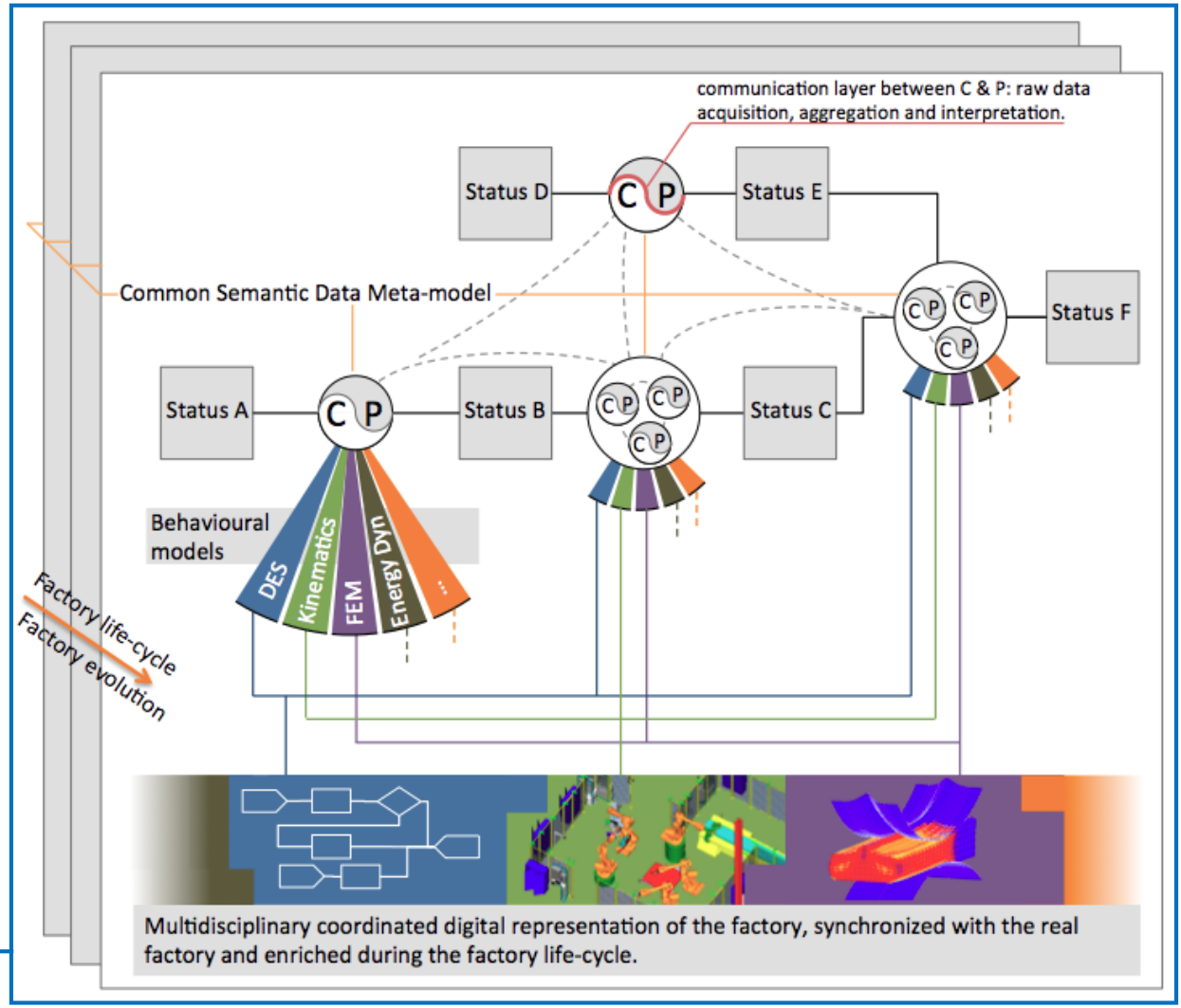
# EXAMPLE: VC

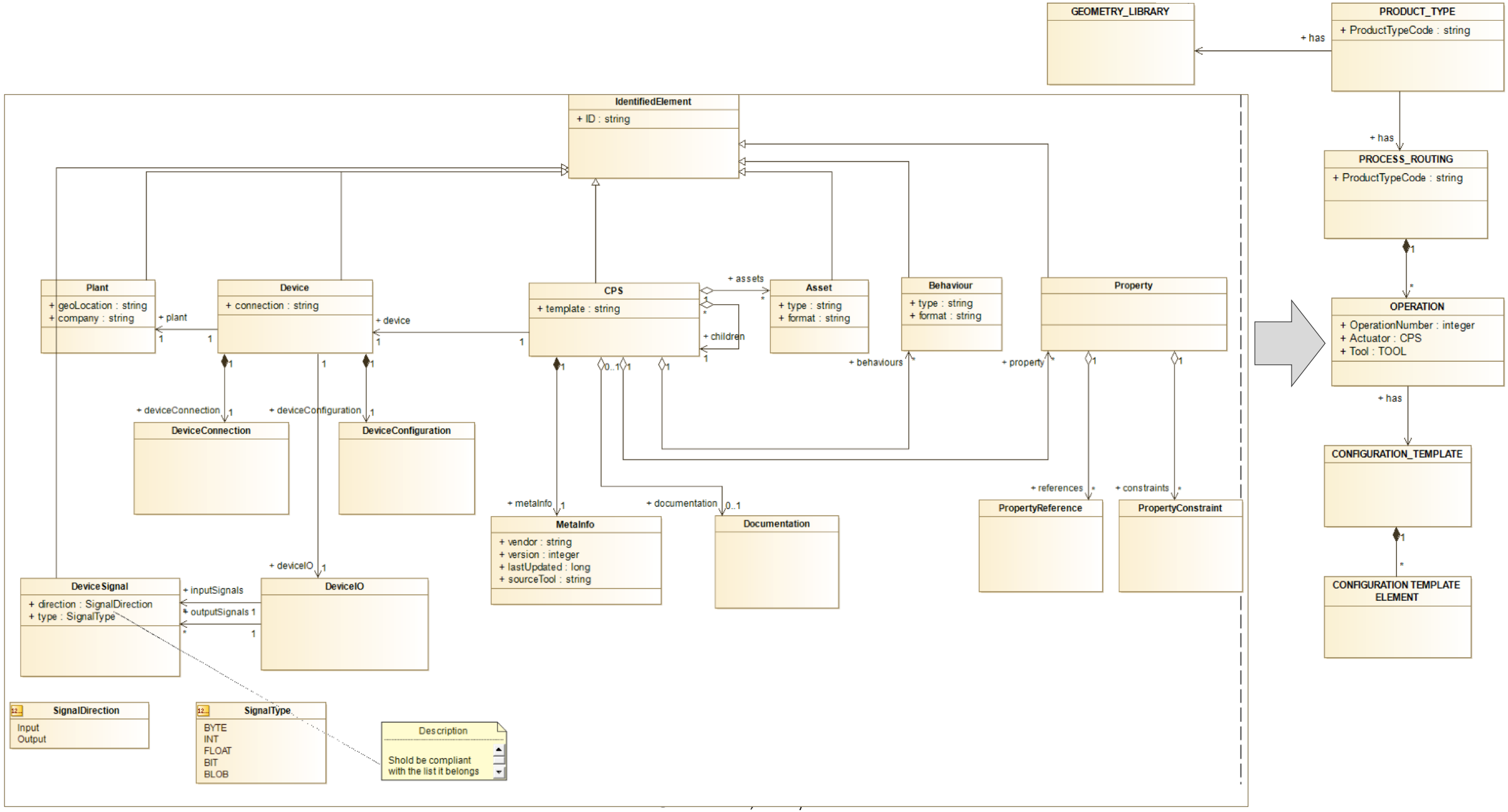


# Architecture Components



# The MetaModel (Draft)



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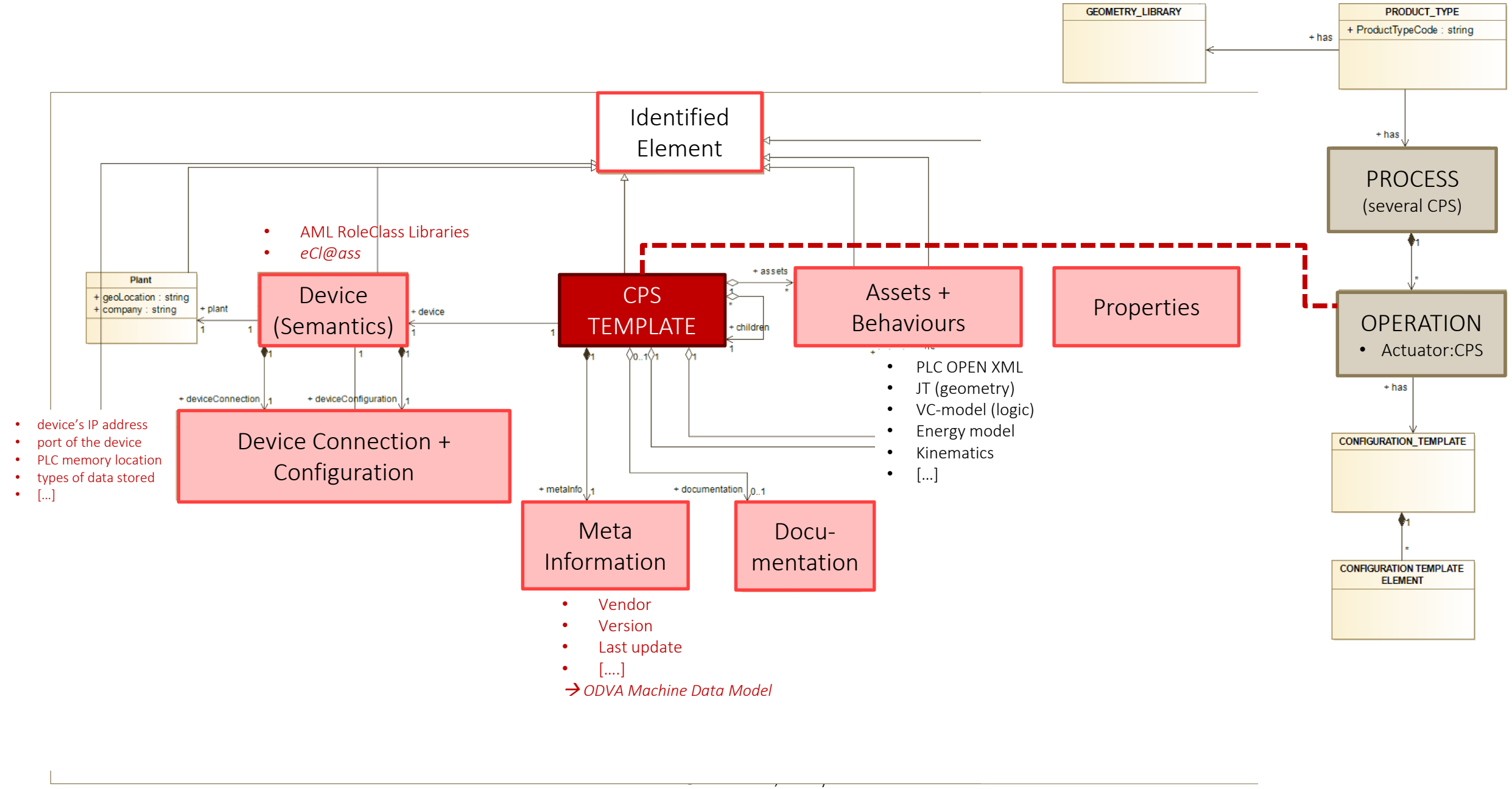

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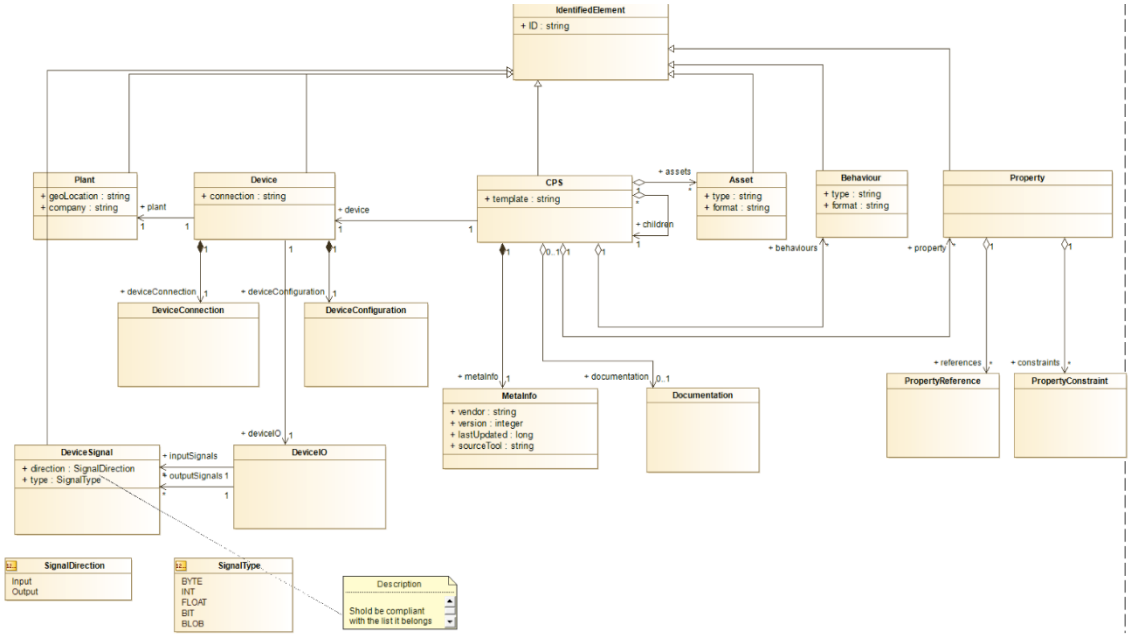



DESCRIPTION OF TEMPLATE (AML, CAEX)

| MAYA | AutomationML |
|---|---|
| CPS Template | SystemUnitClassLib |
| CPS Instance | InstanceHierarchy, InternalElement |
| Asset | ExternalDataConnector, COLLADAInterface |
| Behaviour | ExternalDataConnector, PLCopenXMLInterface, … |
| Property | Attributes |
| Device | Role classes: Resource, DiscManufacturingEquipment, … |
| Plant | Role classes: ResourceStructure, Site, … |

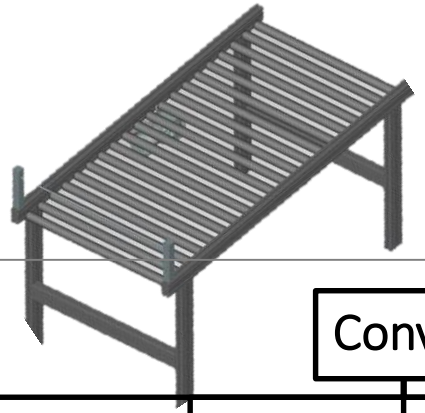
**In a nutshell:**

- Meta model for **describing a CPS template** (description of the container model)
- **Enrichment** of the template with relevant simulation data and models and **store** them
  - → Reuse of simulation models along the lifecycle
  - → Models stored in the „Central Support Infrastructure“
- **AML used for**
  - the description of the container model (CAEX)
  - No direct use for the data exchange (communication over MQTT, RestAPI, …)
  - some relevant simulation models (PLCopenXML, logic models for VC?…)

↓

TEST IMPLEMENTATION

# Logic models for VC (test implementation)



conveyor_mesh.dae

4| 3D world send light barrier status to PLC

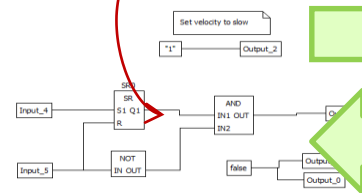
2 Logic model sends speed to graphic

<AutomationML/>

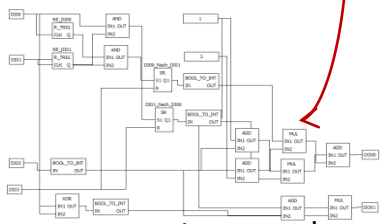
- Conveyor
  - PLC
    - PLC-Interfaces
    - PLCLogic Interface
    - Inputs & Outputs
  - Conveyor Interfaces
    - COLLADA
    - JT
    - MaterialFlow
  - Engine
    - EngineLogicInterface
    - Inputs & Outputs
  - Light BarrierStart
    - COLLADA
    - Outputs
  - Light BarrierEnd
    - COLLADA
    - Outputs

1 PLC controls Engine ✓

Engine sends status to PLC ✓

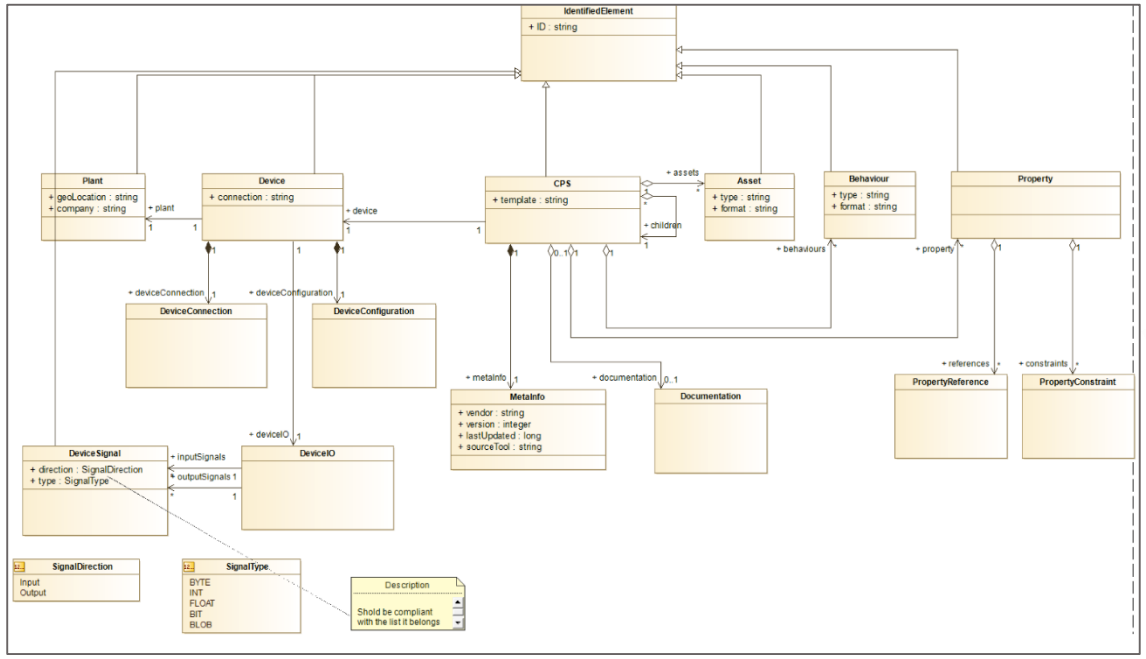


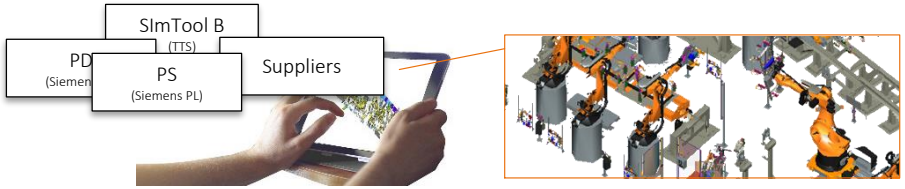
plc.xml



conveyor_engine.xml

# Instantiation of CPS Templates within CSI






M2M Interface | Web GUI

**CPS Model Manager**
Library for CPS templates

**Simulation Coordinator**
(HLA)

**Model Database**
Database
(MongoDB, NoSQL)

**CPS Registry**
Integrated CPS objects within real world

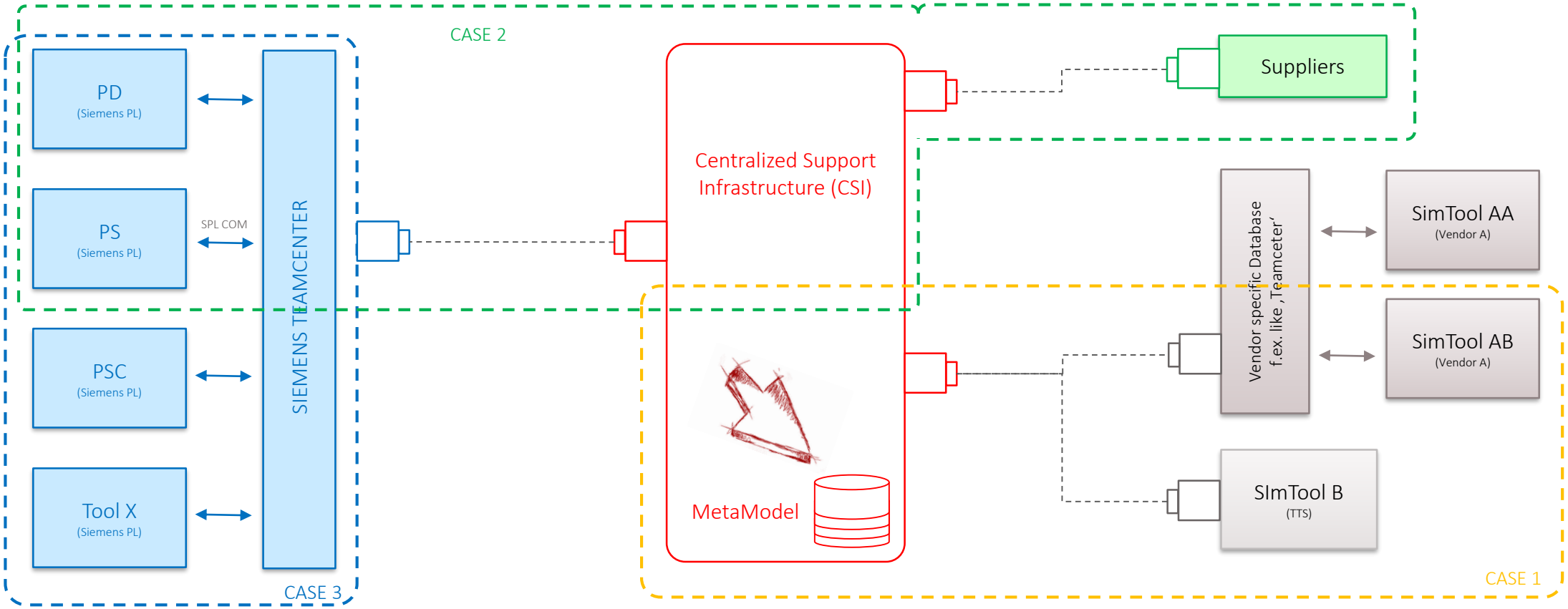
WebSocket


CPS-based production

## CSI in a nutshell:

- offers a library of existing CPS templates with links to database (various simulation models) → PLM platform for SMEs
- "Registry": Identification and recognition of instantiated CPS (real factory)
- "Simulation Coordinator" for the interaction of running simulations (time synchronization, …)

# CSI + MetaModell



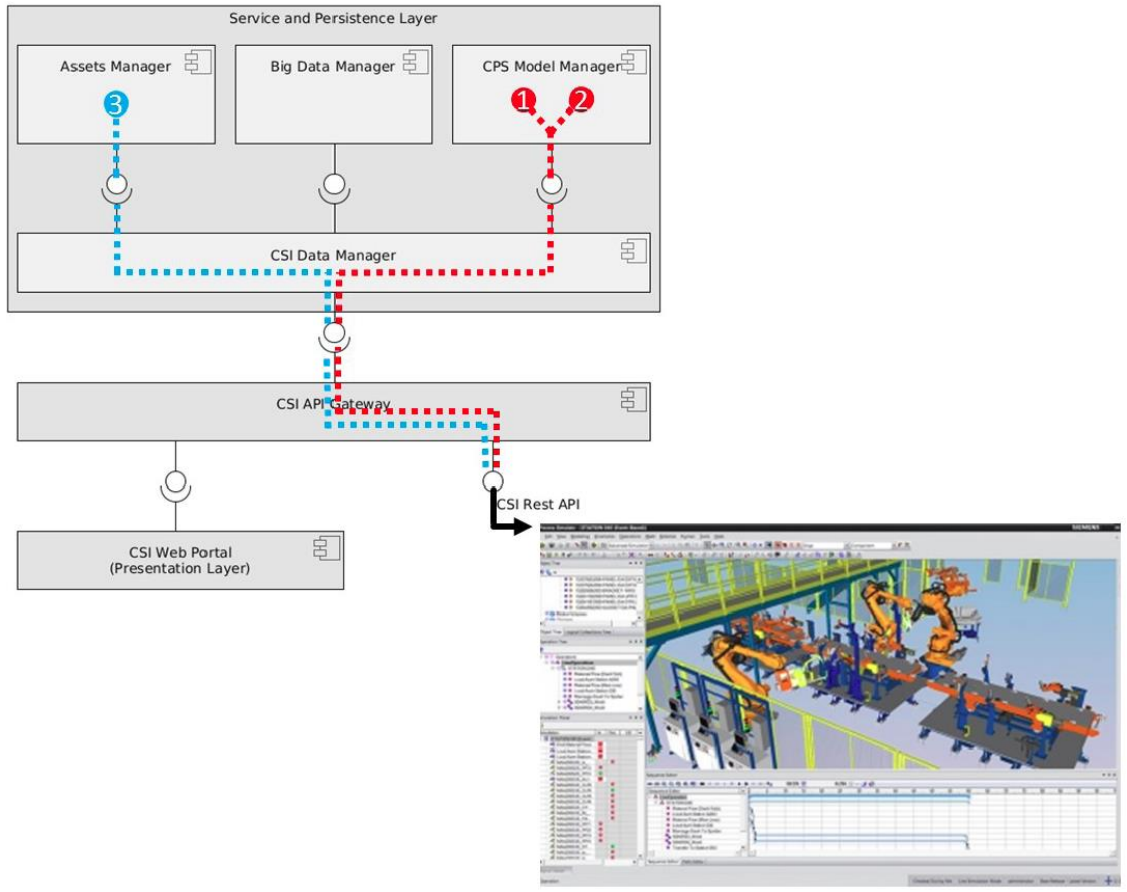

**CASE 1:** SME with multi-vendor tool environment are relying on CSI as a central data base (FINNPOWER, …)

**CASE 2:** Mix of siemens tools and external engineering tools and data f.ex. from suppliers (VW)

**CASE 3:** FullServiceProvider (f.ex. Siemens) which offer all relevant models/data and tools to costumer within teamcentre (not focus in MAYA)

# Example of Use (1)

## Simulation tool using CSI to download CPS models/data




## Procedure:

1. Tool (e.g. Process Simulate) uses REST API to retrieve the list of available CPS templates (i.e. devices library)
2. User choose a CPS Template
3. The information retrieved for that CPS contains the reference to the 3D geometry and additional data required for his simulation (e.g. smart component definition, input/output signals).
4. Once the device has been selected, the tool can use the REST API to download the 3D geometry file (using the reference contained in the template)
   - The API Gateway validates the requires (has the user the rights to access the resource)
   - the Data Manager dispatch the request to the Asset Manager and the resource is sent to the tool
5. The new device is added to the hierarchy of CPS instances

# Example of Use (2)

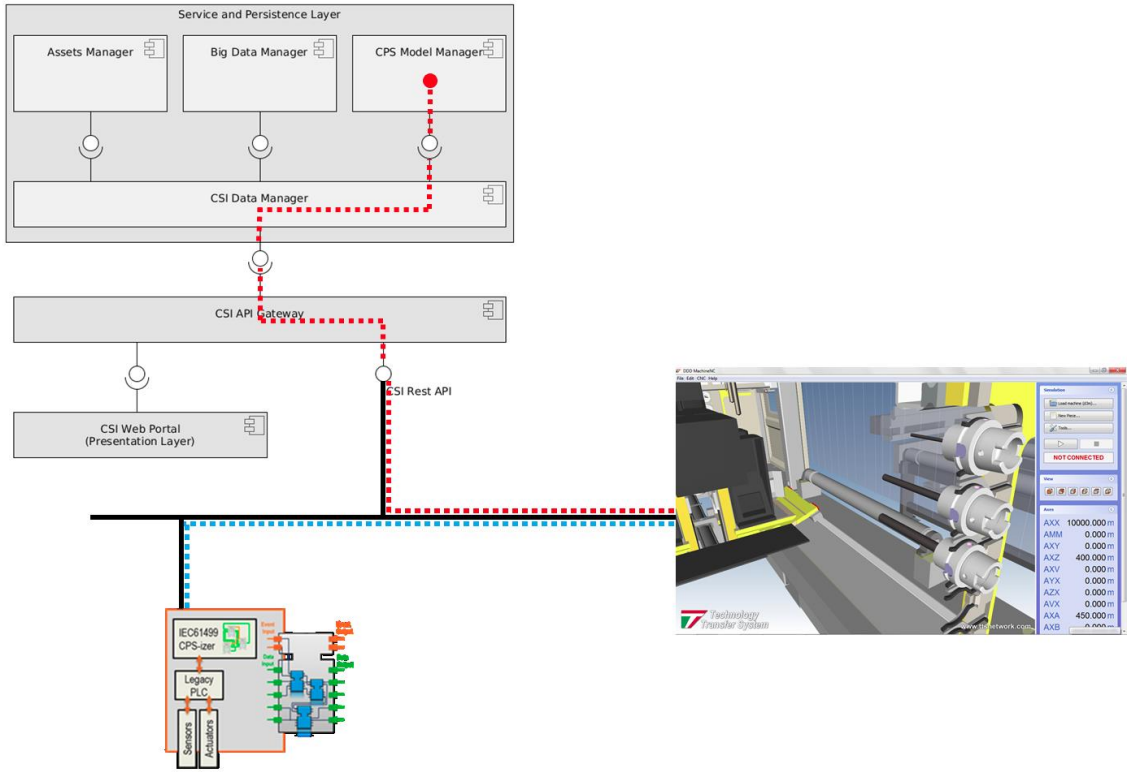
## Simulation tool connecting to real device

1. Direct connection between a device and a tool requires two steps :

    1. Retrieve the connection information (e.g. IP address, protocol):

        → this is done by getting the CPS instance of the device from the Model Manager + Registry

    2. Using this connection information to actually open the communication channel directly with the device



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# Thanks for your attention : )

Design, engineering and management of **CPS-based (Cyber Physical Systems) Factories** enabled by a:

1. Common CPS description and container model
2. Centralized Support Infrastructure (CSI)
3. Coordinator for multi-disciplinary simulation


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