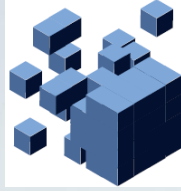


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für Bildung  
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Collaborative Embedded Systems



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# Co-Simulation scenarios in industrial production plants

Two use cases from the manufacturing domain and the process industry

Andrés Botero, Tim Schenk, Jan C. Wehrstedt

# Some challenges for modular production plants during the lifecycle **SIEMENS**

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## Manufacturing plants

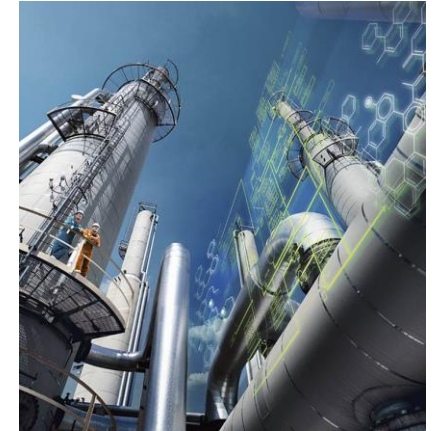
- **Task**  
Arrange and parameterize plant out of available components to
  - avoid bottlenecks
  - maximize total load capability
  - assure quality
- **Challenge**  
Setup of comprehensive plant simulations by considering impact of all hierarchical levels:
  - Material flow
  - 3D kinematic in each cell
  - First principle simulation of components



Source: Siemens

## Process Plants

- **Task**  
Verify the engineered plant automation virtually before the plant is commissioned in reality
- **Challenge**  
Conventional approach is not applicable as
  - inner module behavior (automation & process) is unknown to plant commissioner and
  - modules probably have different automation systems and thus require multi-vendor SW environment.

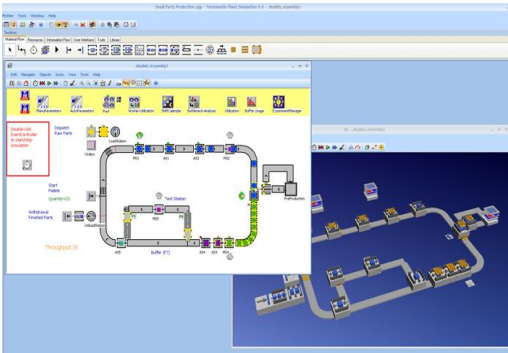


Source: Siemens

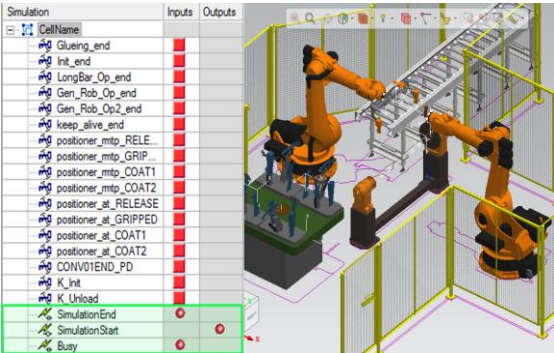
- **Engineering of Manufacturing plants**
- Virtual commissioning of process plants

# Comprehensive simulation of modular manufacturing plants has to be executed by using different tools

	Plant Simulation	Process Simulate
Type	Material flow	3D kinematic
Timing	Event-based	Time discrete
Scope	Logistics, material flow, dimensioning,...	Interaction between machines, humans and product
Purpose	Calculation of plant KPIs	Evaluation of dynamic behavior
Modeling aspects	Cells are modelled as time-delay blocks	Physical behavior is simplified



Source: Siemens

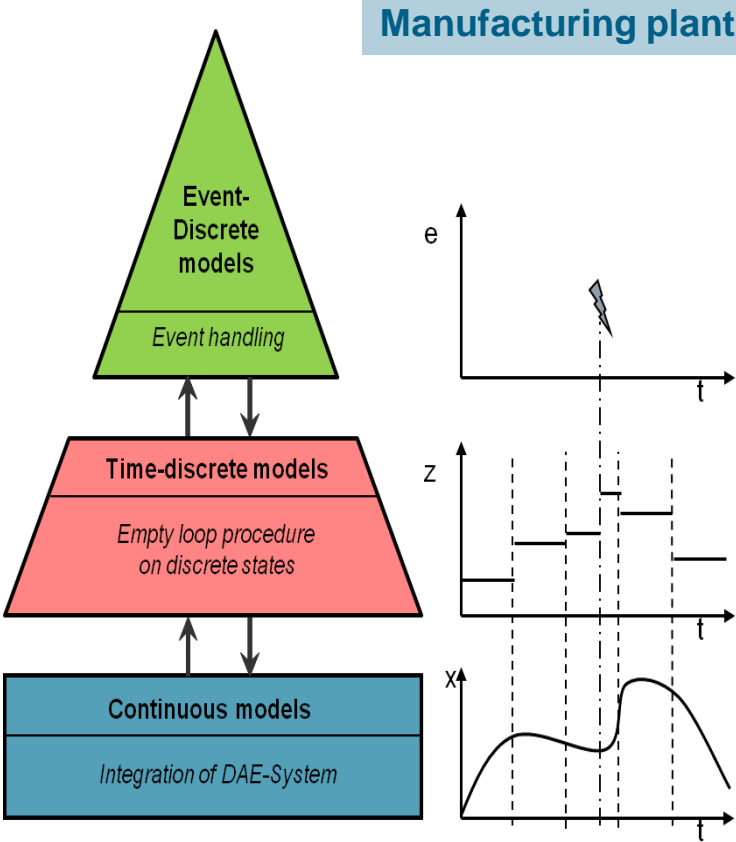


Source: Siemens

Material flow simulation

3D kinematic simulation

First principle simulation for component behavior



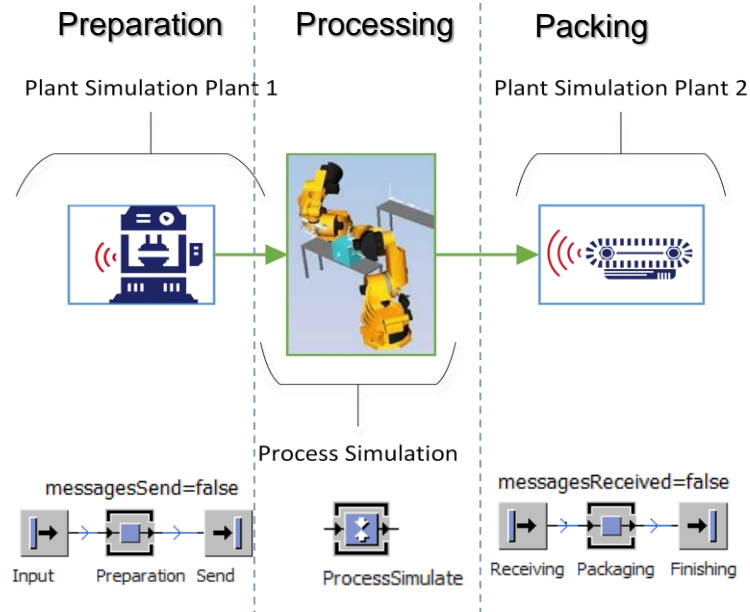


# A Co-Simulation approach accounting for different time evaluation strategies of the clients is required

## Use Cases for such a coupling

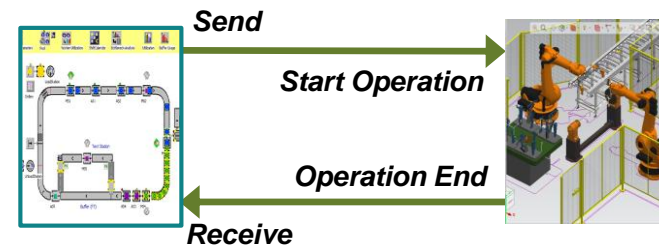
- Validation of detailed cell behavior in the whole plant context (different cell configs, different component vendors)
- Accurate plant simulation by detailed cell behavior

## Example Setup

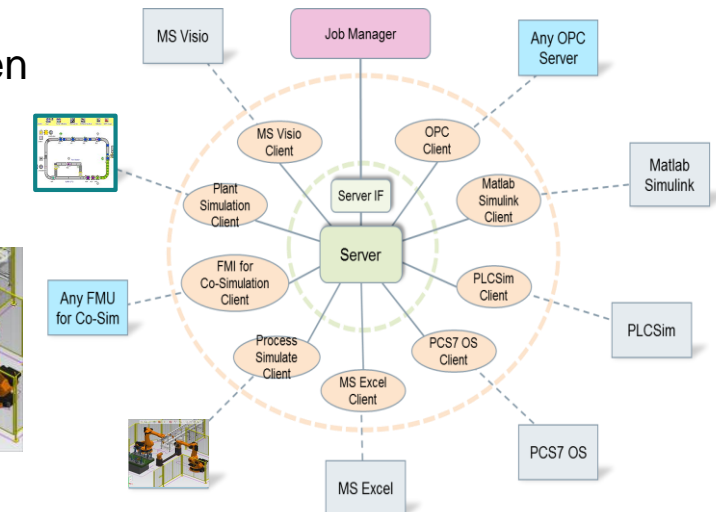


## Realization by a master-slave co-simulation environment

- Establish communication between *Plant Simulation* and *Process Simulate*



- Co-Sim Master coordinates event-based, time-discrete and continuous simulators



# Demo of interplay between Plant Simulation and Process Simulate



© Siemens CT RDA SDT MST

- Engineering of Manufacturing plants
- Virtual commissioning of process plants

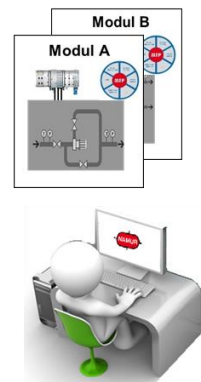
# Modular process plants are a new approach to reduce engineering effort, reduce downtimes and be much more flexible



## Process Plants

- **Process Equipment Assembly (PEA)**  
Module with integrated control (e.g. automation)
- **Module Type Package (MTP)**  
Description used for integration into higher level plant automation
  - Module services (utilized in state-based process control)
  - Communication variables
  - Communication technology
  - HMI description
  - Open to further aspects
- Connection of PEAs results in process
  1. Import of MTPs
  2. Orchestration of the services

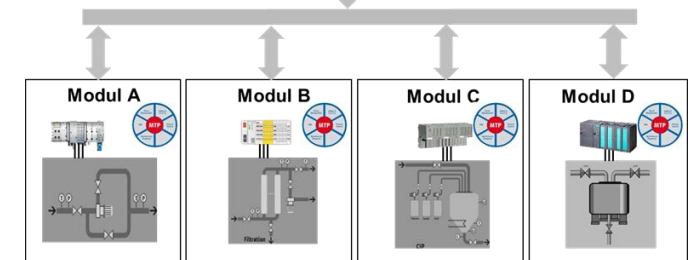
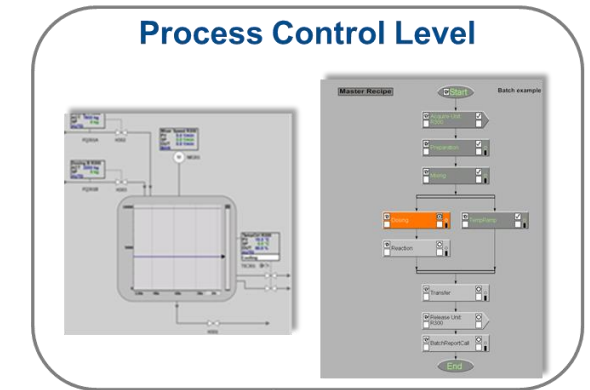
### Module Engineering



### Plant Engineering



### Process Control Level



Source: J. Bernshausen & A. Haller, Namur HS 2017

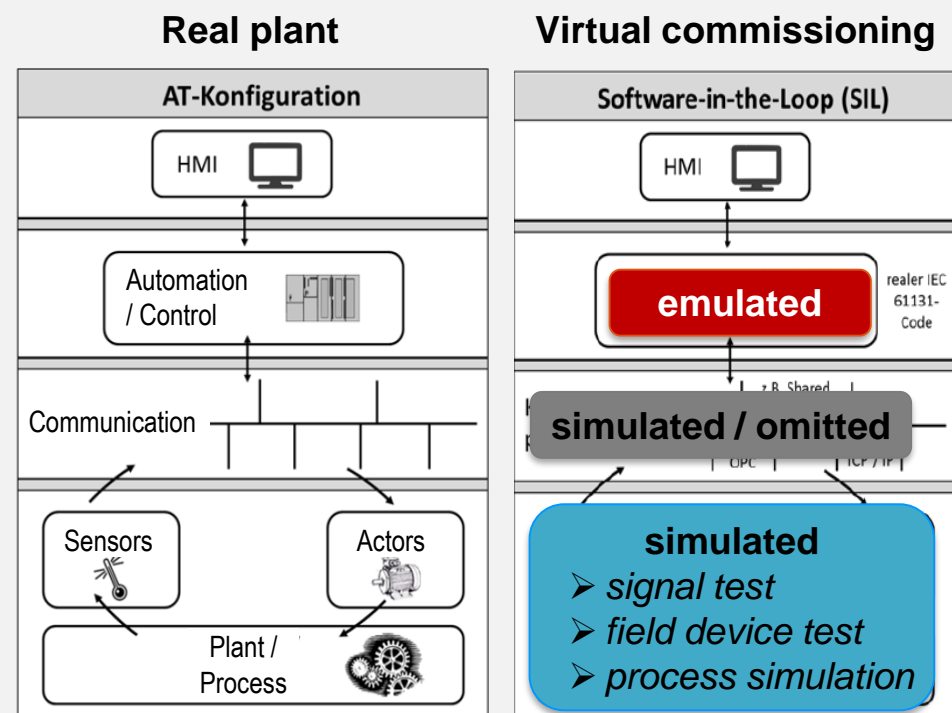
# Virtual commissioning of a process plant has to test the engineered automation against different virtual realizations of the plant

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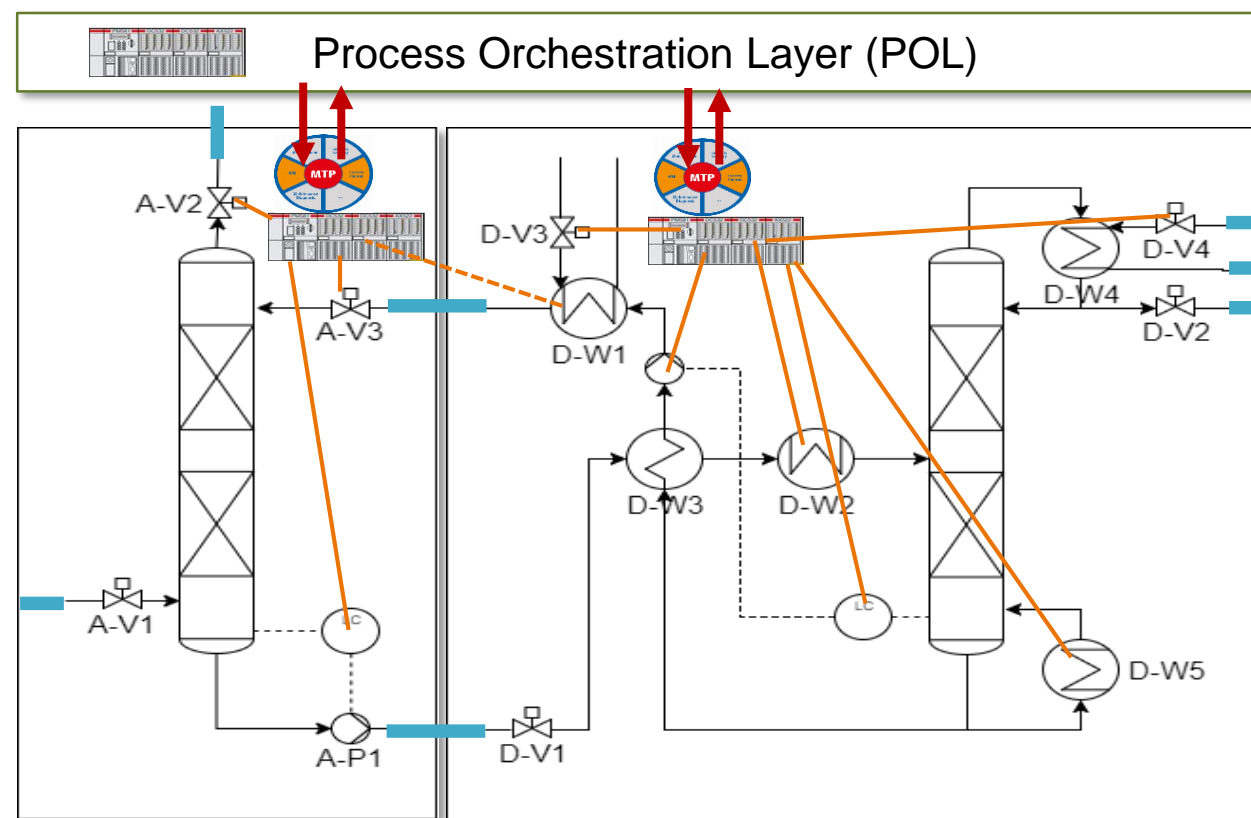
Process Plants

## Conventional Plant



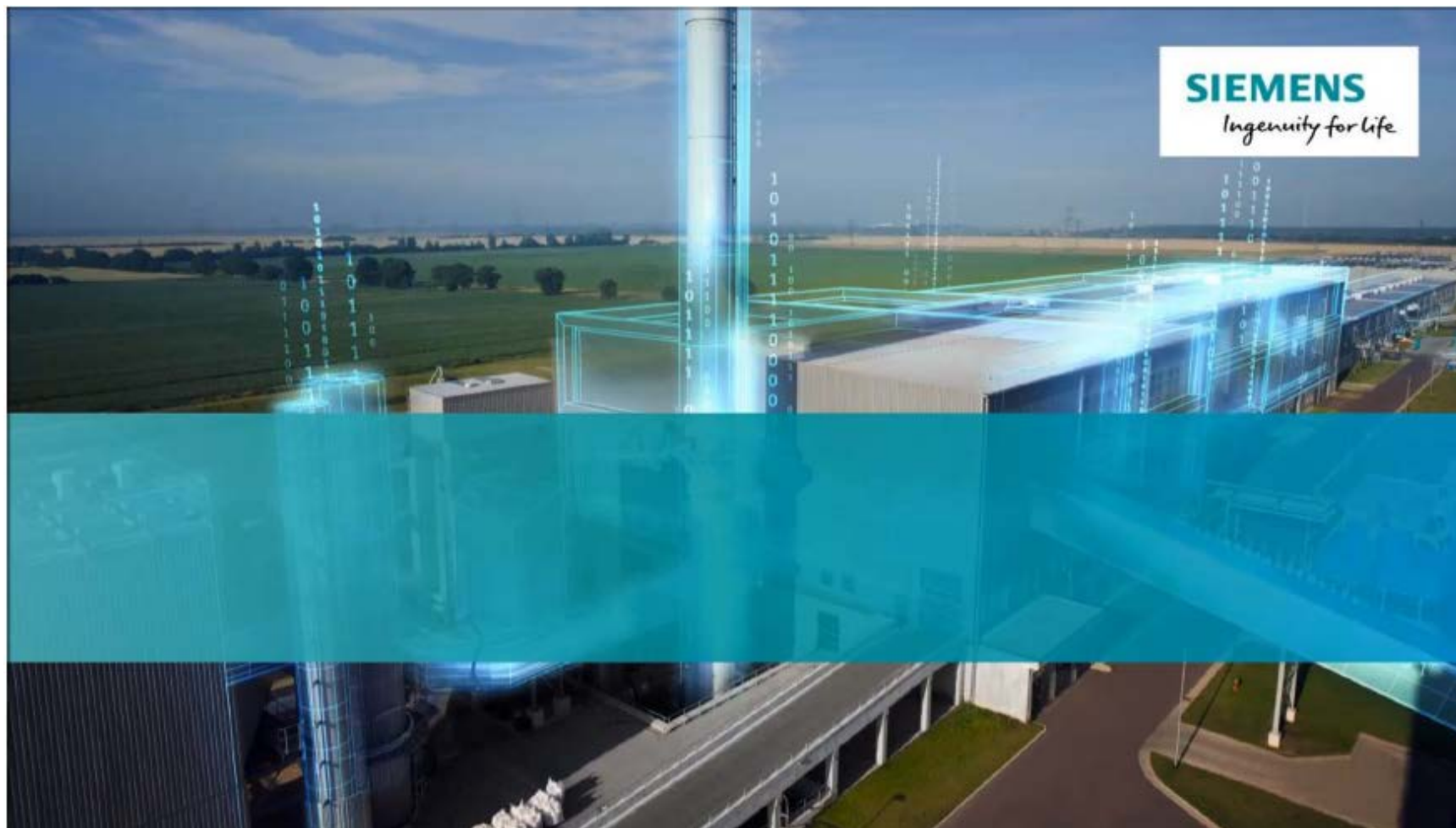
Source: VDI/VDE 3693

## Modular Plant





# Demo of proprietary modular VIBN with Siemens tool SIMIT



© Siemens PD TI AT

# Virtual PEAs (modules) can solve the problem of setting up a comprehensive simulation model of the whole plant

## “Model-Cuts”

- Single model containing automation & process
- Separate models for AT & process (+ coupling)

## Model wrappings

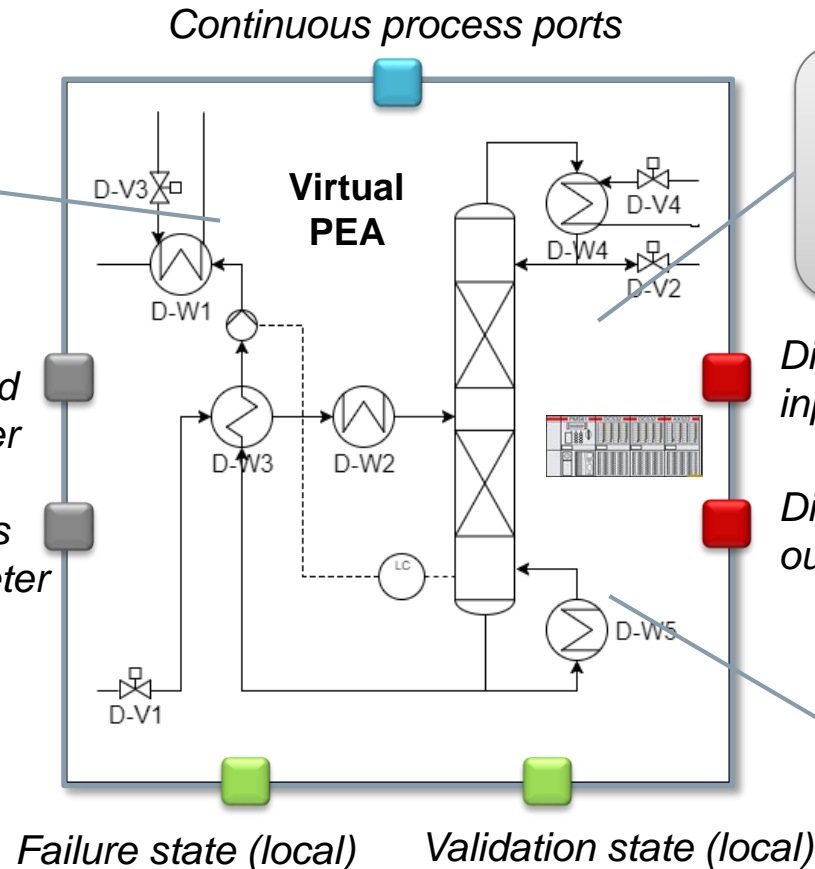
- Process: FMUs
- Automation: Vendor specific virtual controller (via OPC UA, VM or FMU)

## Operator-specific parameterization

- Material databases
- Behavior models (e.g. reaction kinetics)

Automation / field device parameter

Process parameter



Discrete input signal

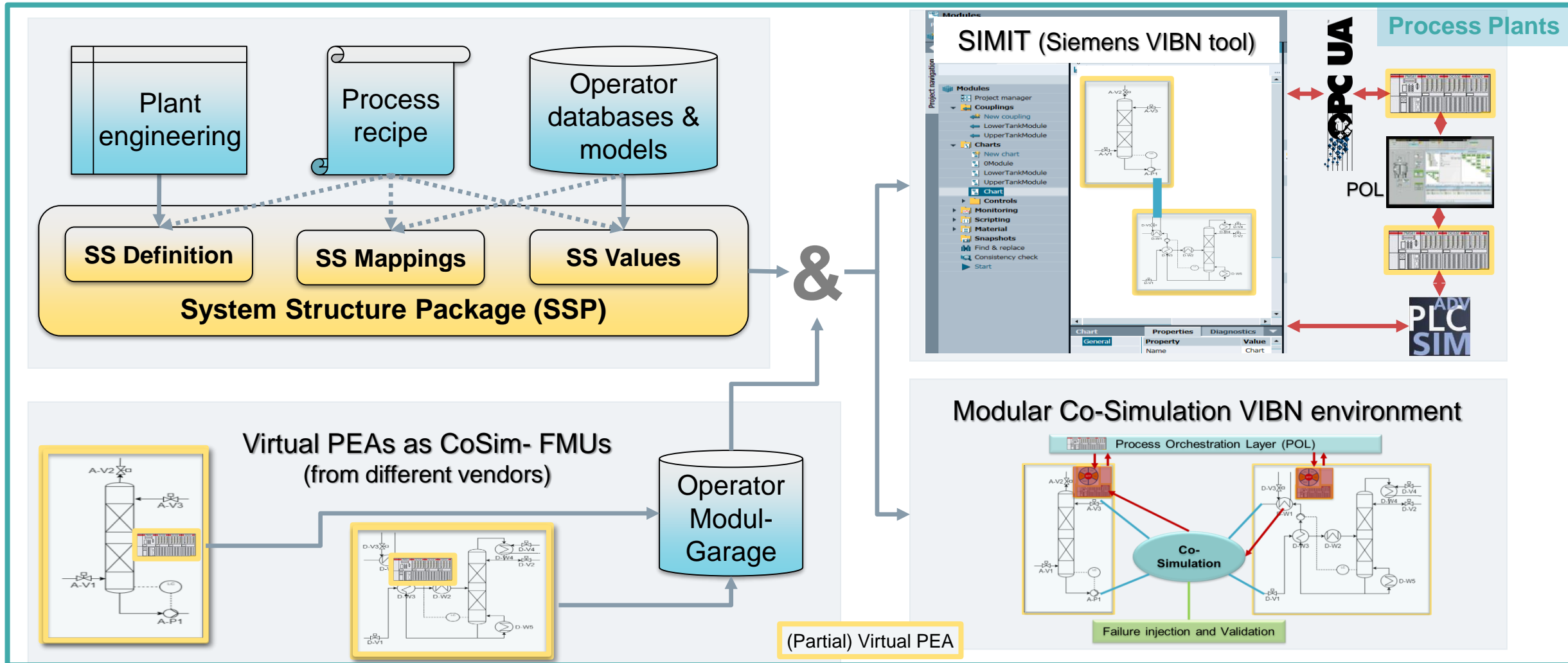
Discrete output signal

**Today no FMU export for VCs**

**Different levels of process models for specific VC tests**

**Specific virtual commissioning states**

# Co-Simulation realizations can be set up by either vendor specific tools or a generic co-simulation environment



# Co-Simulation together with utilization of standards like FMI and the new SSP speed up different use cases in the production industry



## Summary & Outlook

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- As production plants get more modular and thus **multi-vendor plants**, simulations cannot be set up with a single simulation environment anymore.
- The modularity enables a new flexibility of the plants, which allow **fast plant changes**. To not loose this advantage by conservative (long-lasting) verifications of the new setup, the (simulation-based) validations have to be as flexible.
- **Co-Simulation is actually the appropriate choice** of exchange as most of the commercial simulation tools in the production industry support only one specific solver type.
- The engineering of production plants results already in a **topology model**. Export into a standard like SSP enables an easy setup of system simulations independent of the specific simulation environment.
- **Virtual commissioning tools** should be able to **import Co-Simulation FMUs** (Siemens SIMIT plans to release this feature in next version). **Virtual controller** should be able to **export FMUs**.



## Contact information

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