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Automatic Generation of a Simulation-based Digital Twin From a 3D Plant Model

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Digital twins



Digital Twin

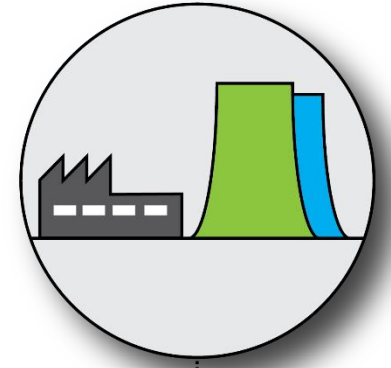
A digital replica of a plant, which contains information of the:

- Structure
- Dynamics of how the devices or processes operate

Physical Plant



Digital Twin



Digital Twin: Structure information

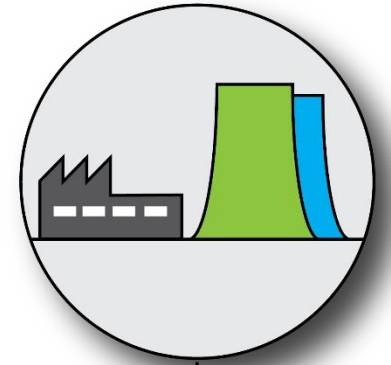
A digital replica of a plant, which contains information of the:

- Structure, which can be obtained from plant design material

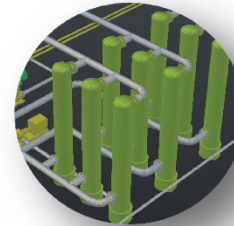
Physical Plant



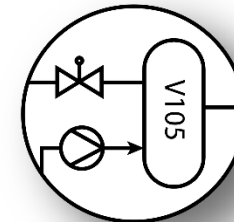
Digital Twin



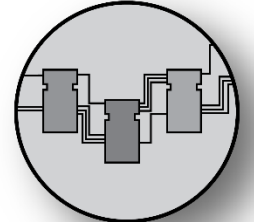
3D Plant Models



Piping & Instrumentation Diagrams



Control Application Programs



Simulation-based Digital twin



Digital Twin: Dynamics of the plant

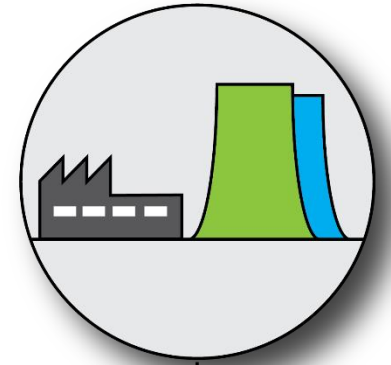
A digital replica of a plant, which contains information of the:

- Dynamics, which can be simulated using first-principles simulation models of the plant

Physical Plant



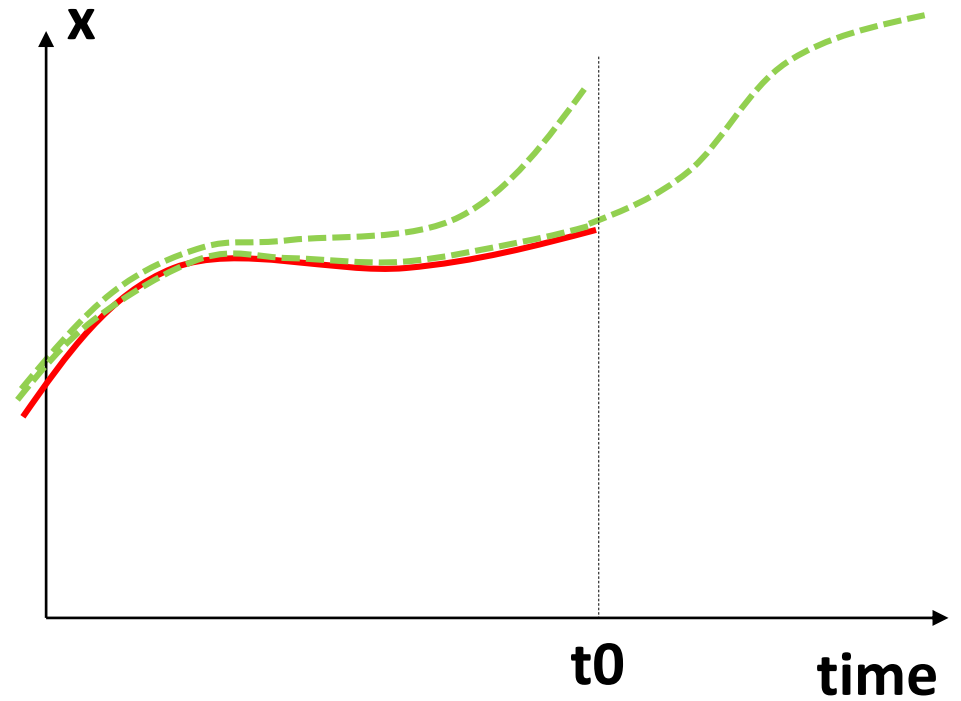
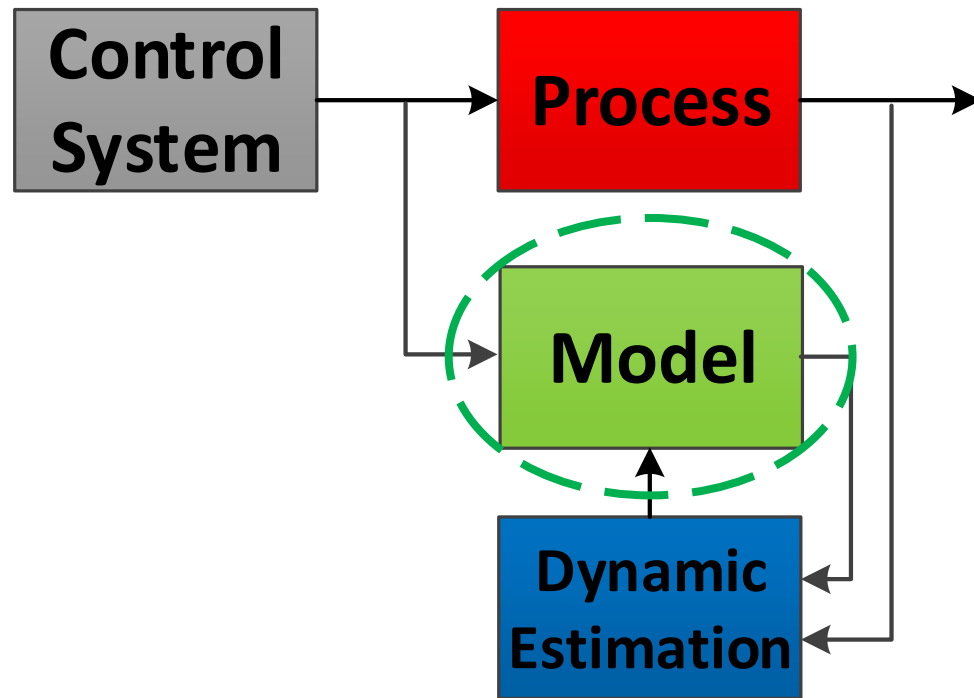
Digital Twin



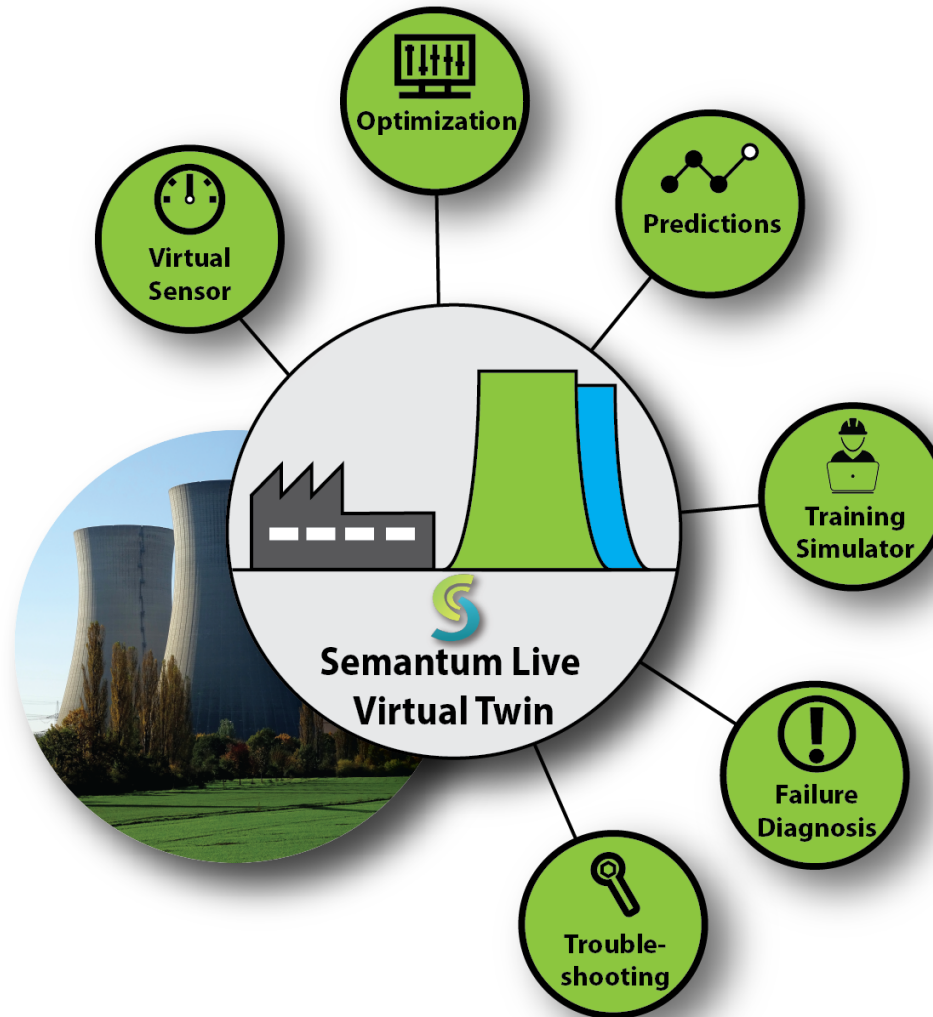
**Simulation Model
of the Plant**



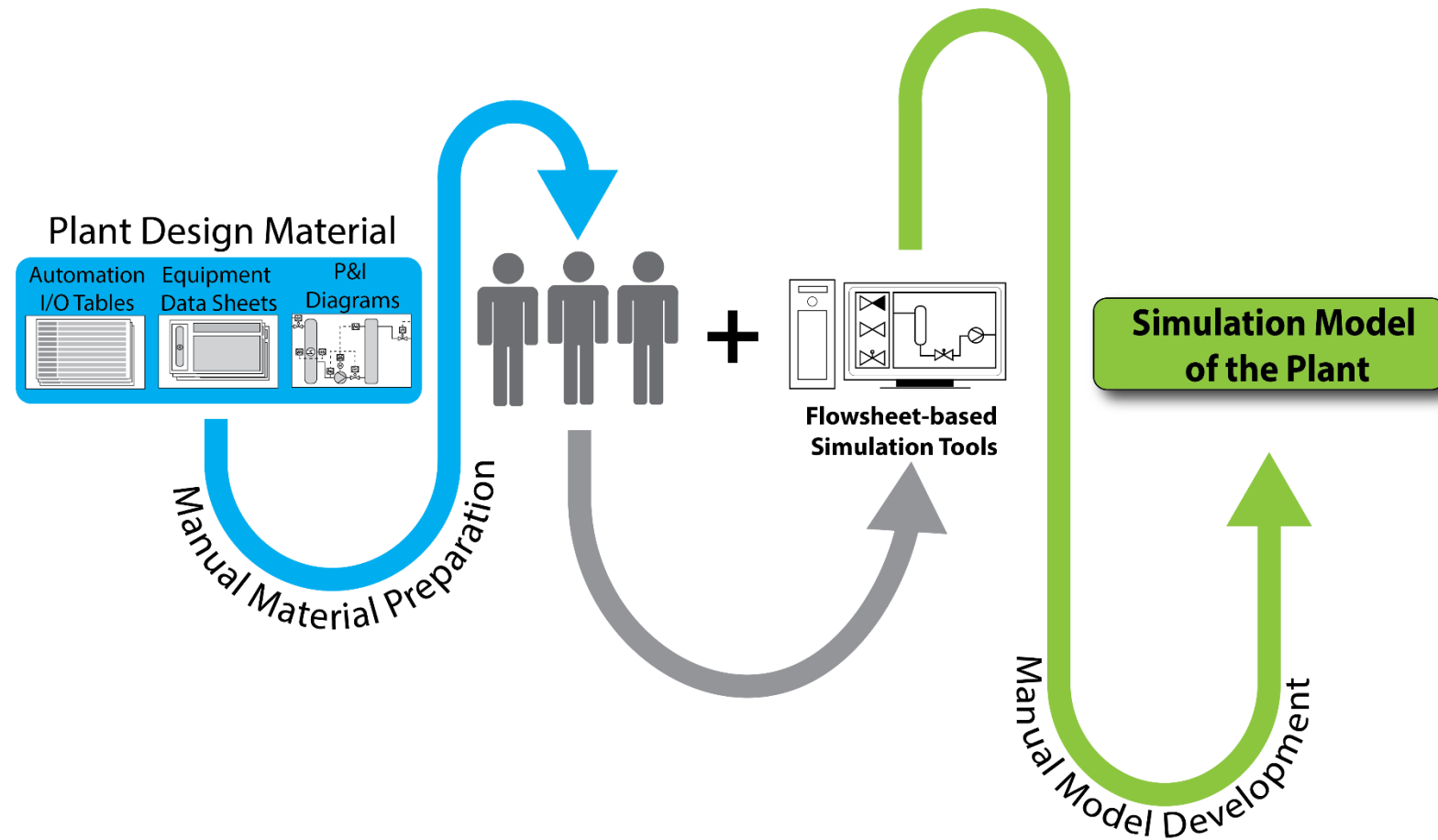
Tracking simulator



Simulation-based Digital Twin: Applications



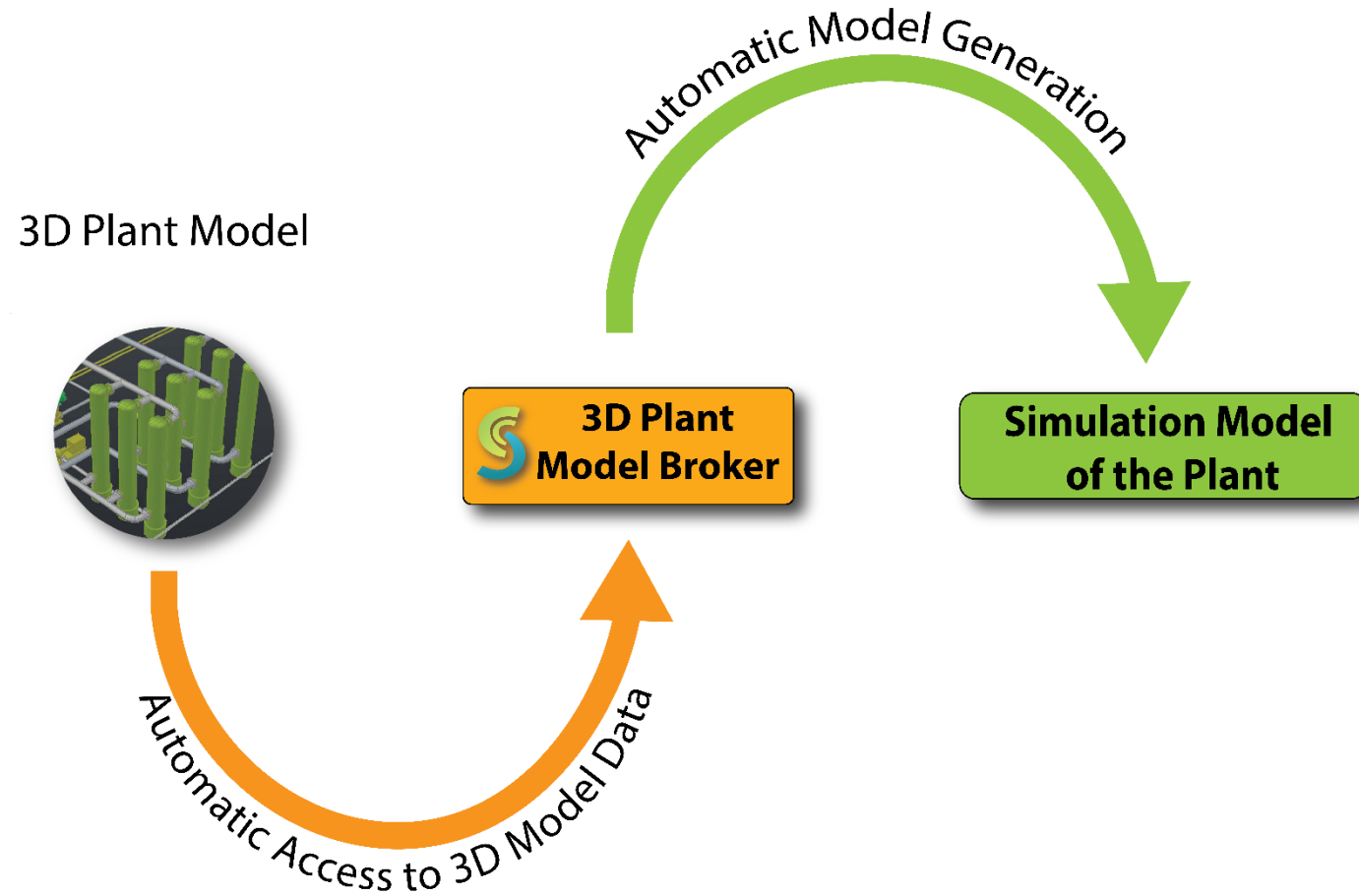
Model development in process industry



Automatic Simulation Model Generation from 3D Plant Model



Automatic Simulation Model Generation from 3D Plant Model



Enabling Technologies

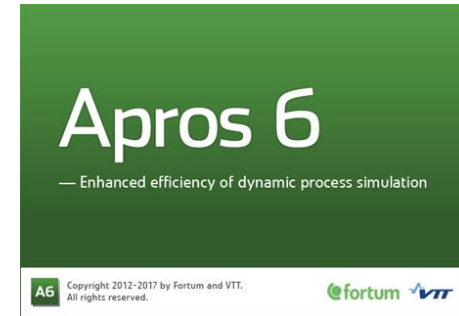


3D to Simulation: Enabling Technologies



AutoCAD Plant 3D™

An industry-specific toolset for plant design and engineering to create P&IDs and integrate them into a 3D plant design model.



Apros 6™

A modelling tool for high-fidelity dynamic process simulation.

Apros® is a registered trademark of Fortum and VTT
<http://www.apros.fi>

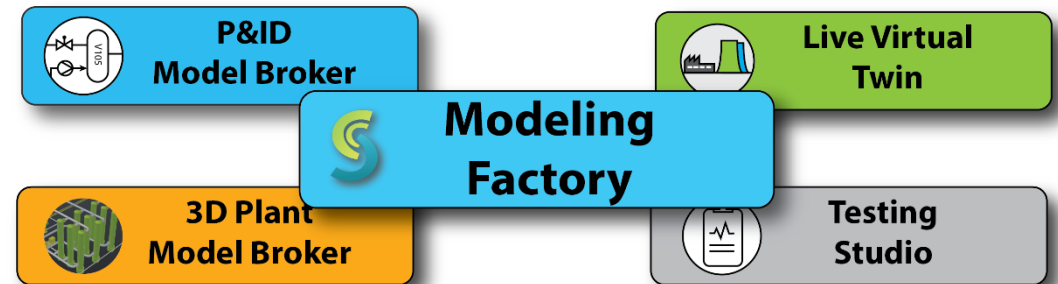
Modeling Factory™

Engineering Automation Services

Modeling Factory is a cloud-based service for managing creation and use of engineering assets throughout the plant lifecycle.

Different **Modeling Factory Workrooms** can be used e.g. to:

- **Automatically generate simulation models** from engineering data sources.
- Configure and use Digital Twins.
- Manage and automate collaborative multi-simulation for testing.
- More!

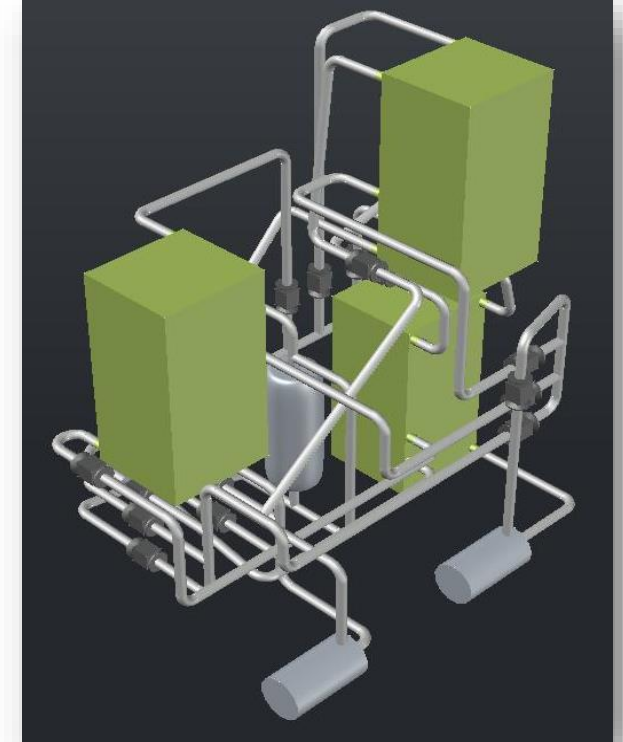
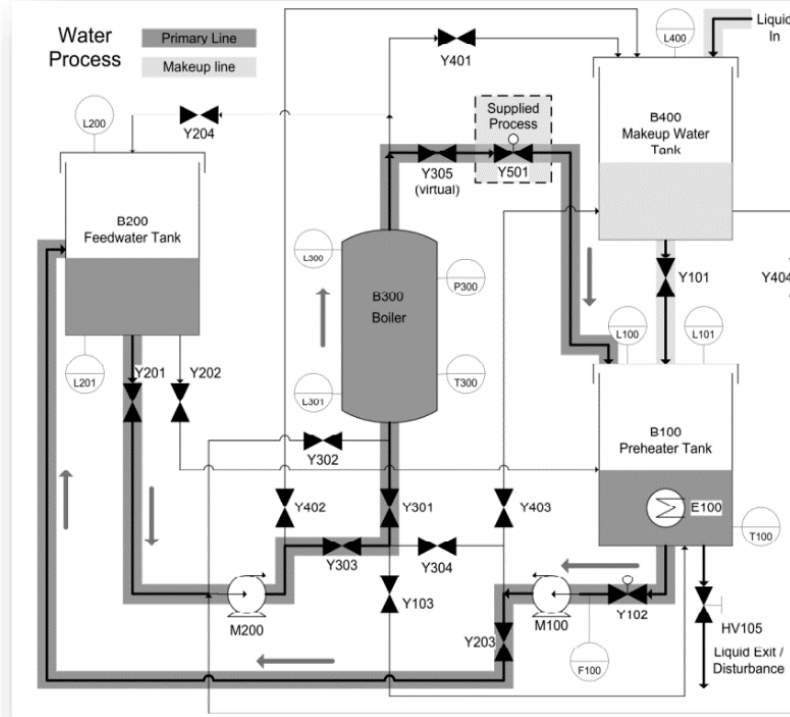


Implementation Example: Simulation-based Digital Twin of a Laboratory- scale Water Heating Process

* This work has been carried out at Aalto University as part of the Engineering Rulez Project.



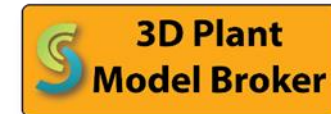
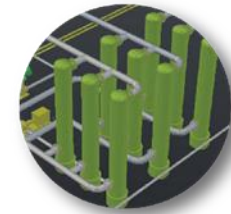
Laboratory Water Heating Process



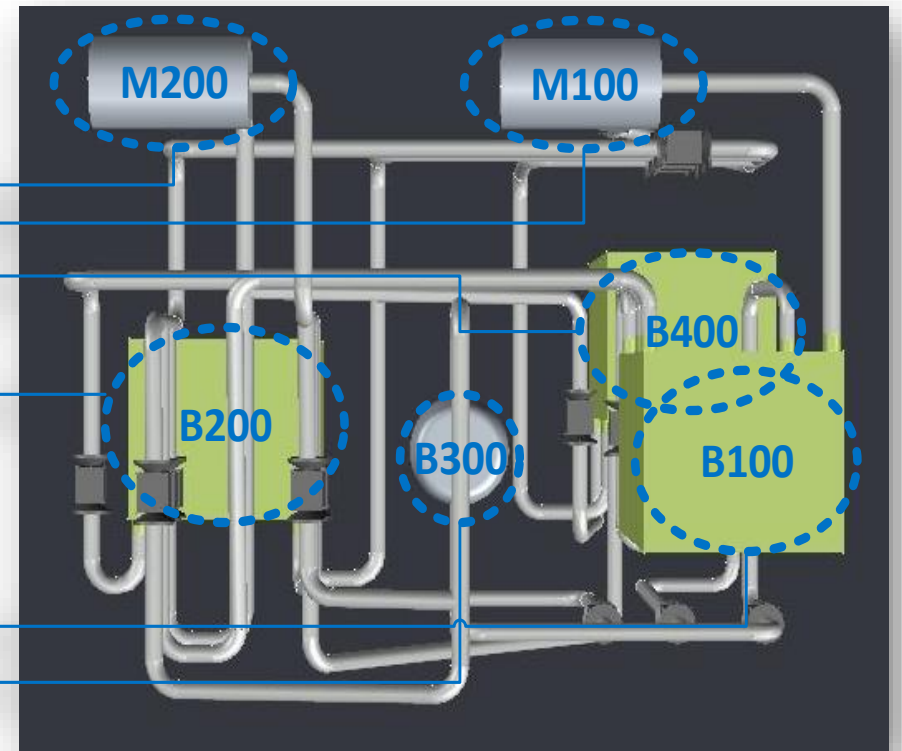
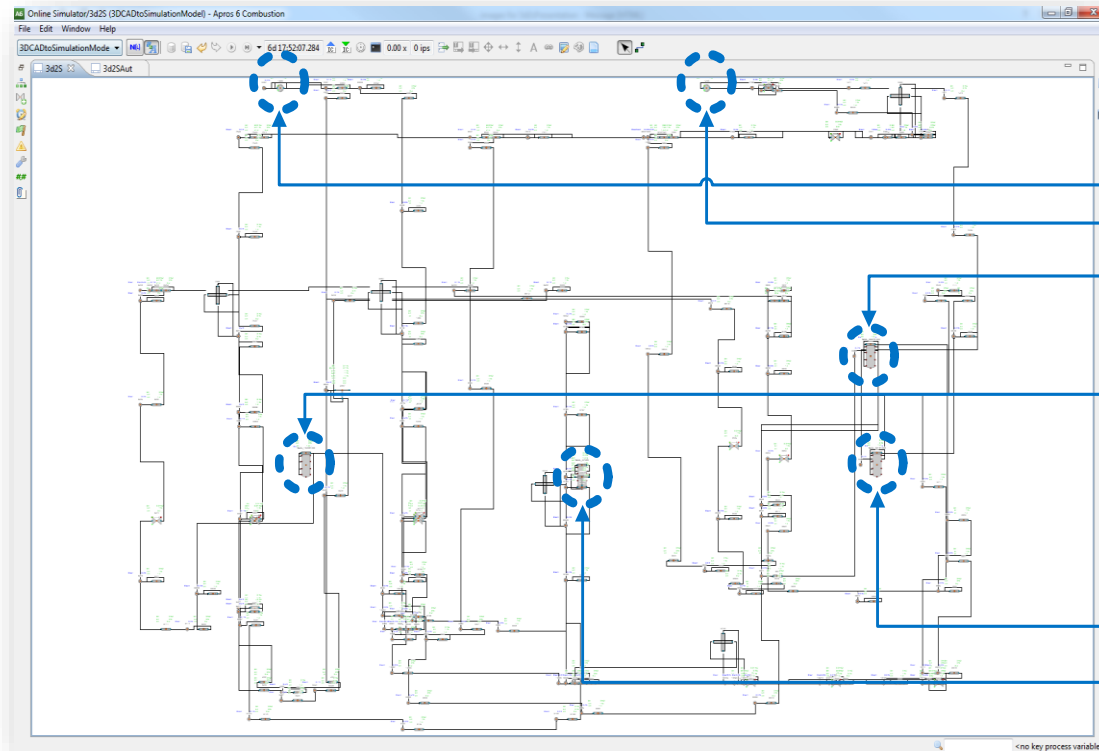
Automatic Model Generation

- Automatic model generation in 3D Plant Model Broker is based on Semantics Constraint Language.
- AutoCAD Plant 3D model is used to retrieve geometrical data of:
 - Equipment
 - Piping
 - Pipes, elbows and tees.
 - Points
 - Connections

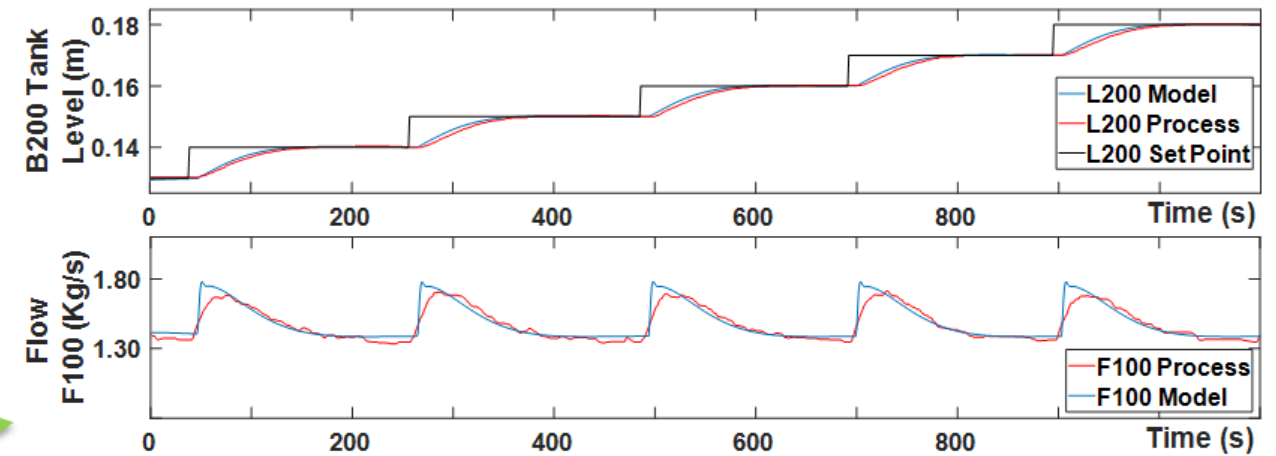
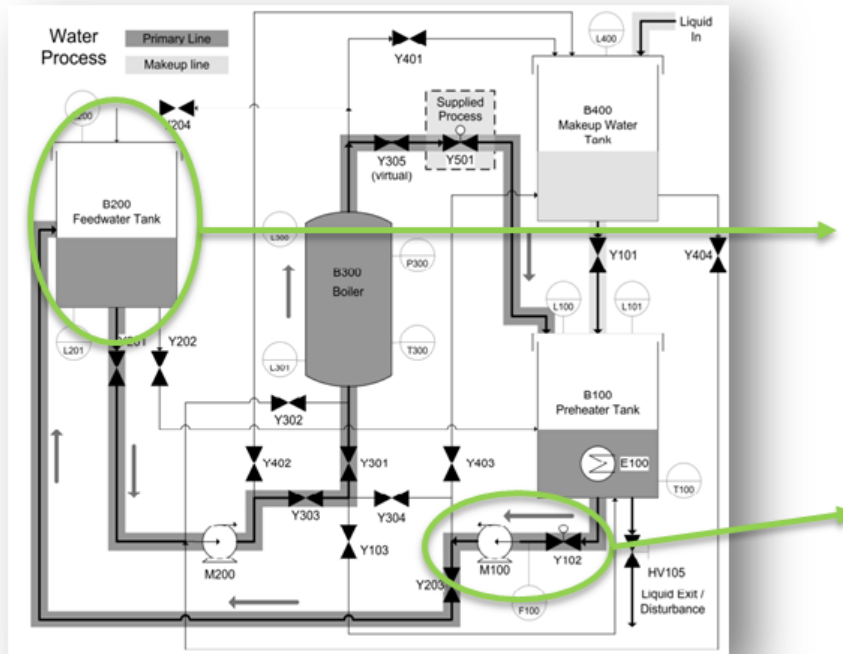
3D Plant Model



Simulation Model Results

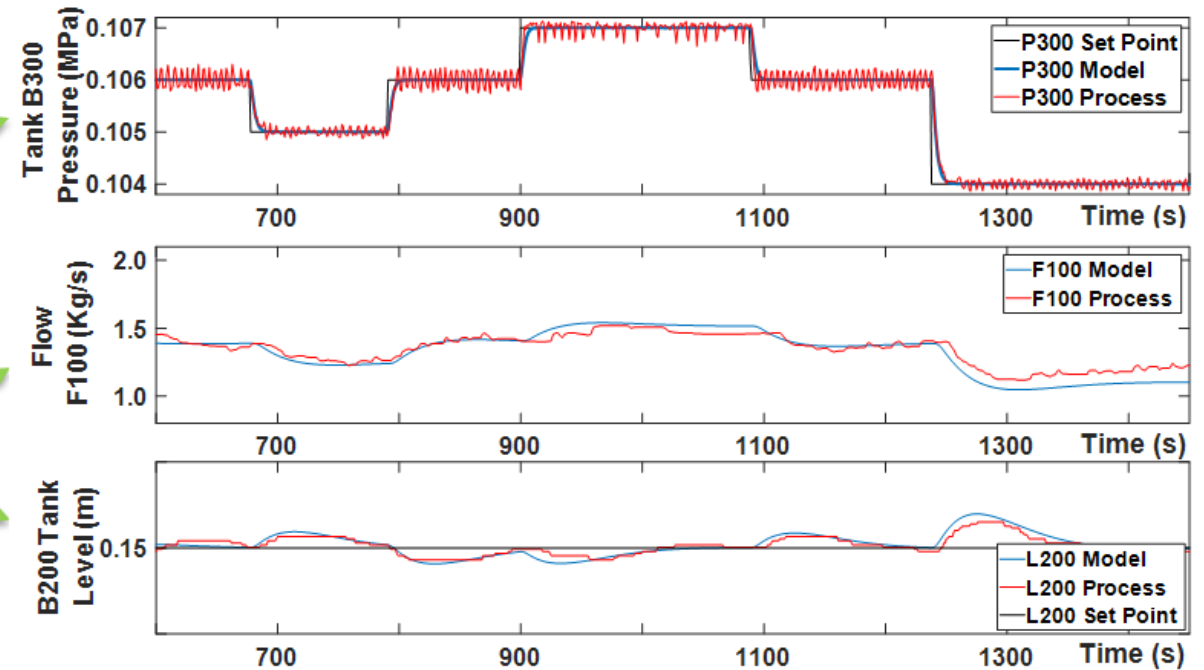
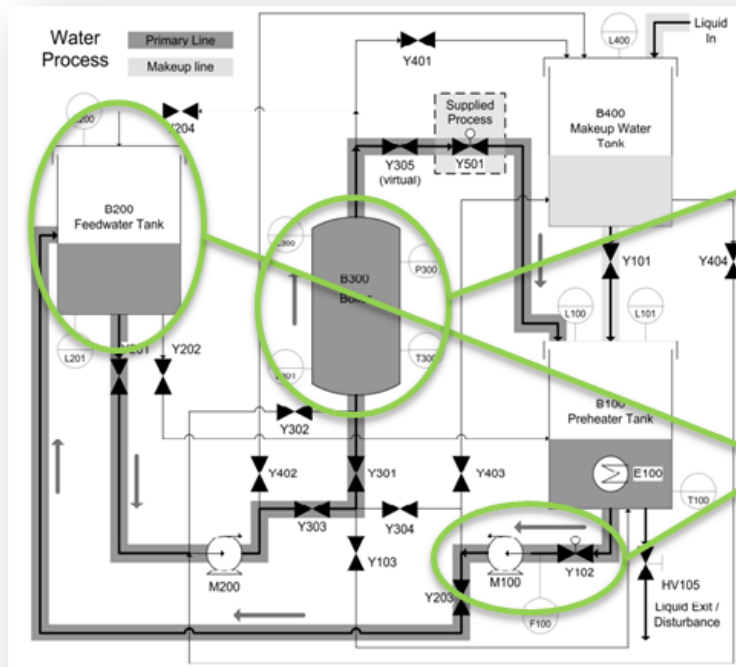


Simulation Model Results



G. Santillán Martínez, S. Sierla, T. Karhela, J. Lappalainen, and V. Vyatkin, "Automatic Generation of a High-Fidelity Dynamic Thermal-hydraulic Process Simulation Model from a 3D Plant Model," *IEEE Access (Under Review)*, 2018.

Simulation Model Results

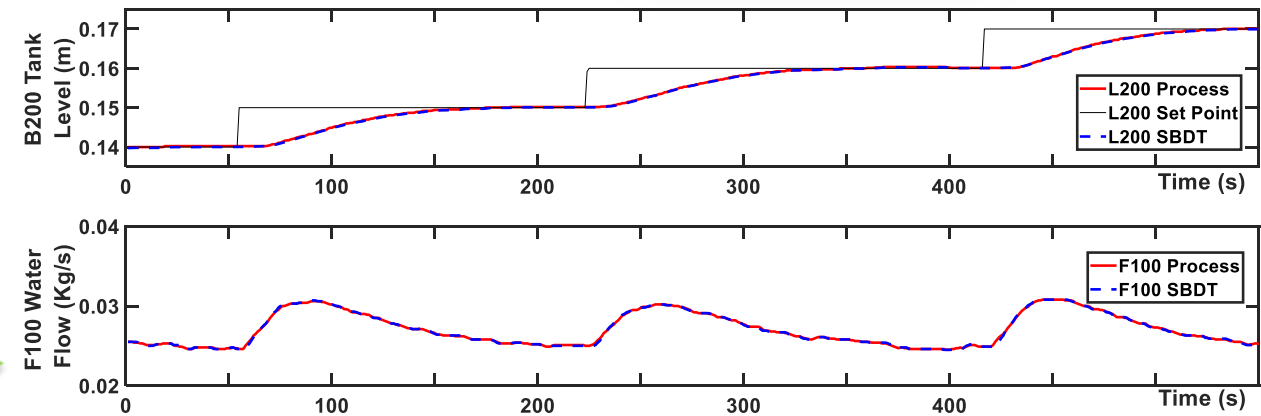
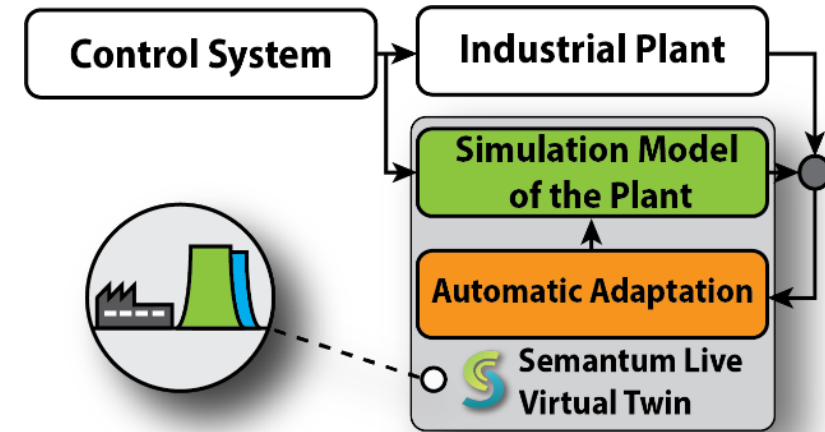
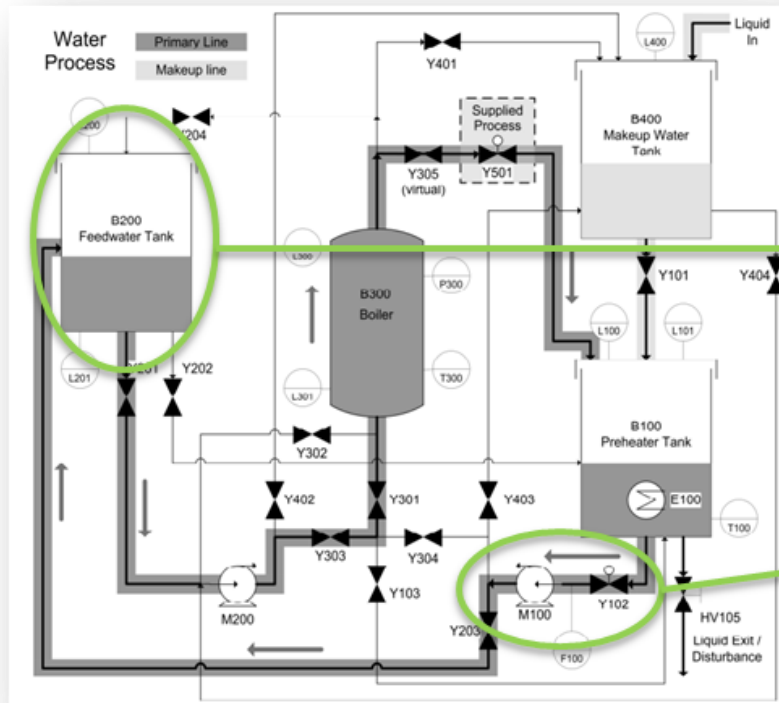


G. Santillán Martínez, S. Sierla, T. Karhela, J. Lappalainen, and V. Vyatkin, "Automatic Generation of a High-Fidelity Dynamic Thermal-hydraulic Process Simulation Model from a 3D Plant Model," *IEEE Access (Under Review)*, 2018.

Simulation model synchronization with the process



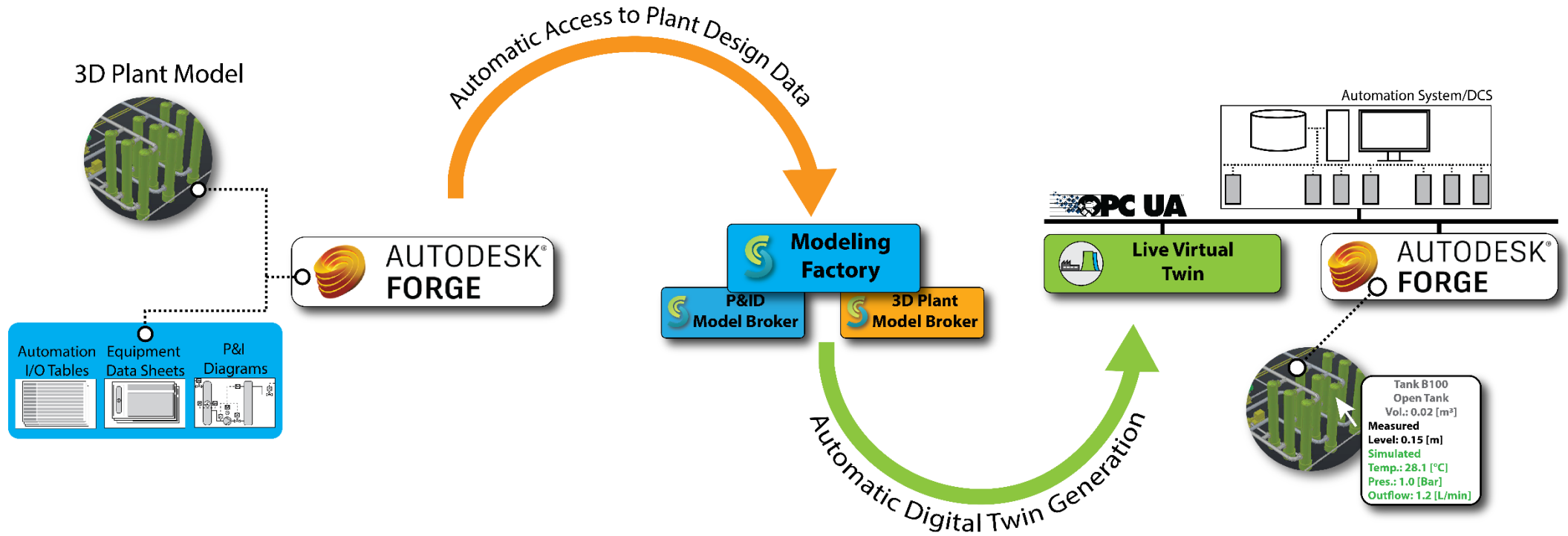
Tracking simulation results



Semantum Live Virtual Twin visualization



Live Virtual Twin 3D Visualization through Autodesk Forge™

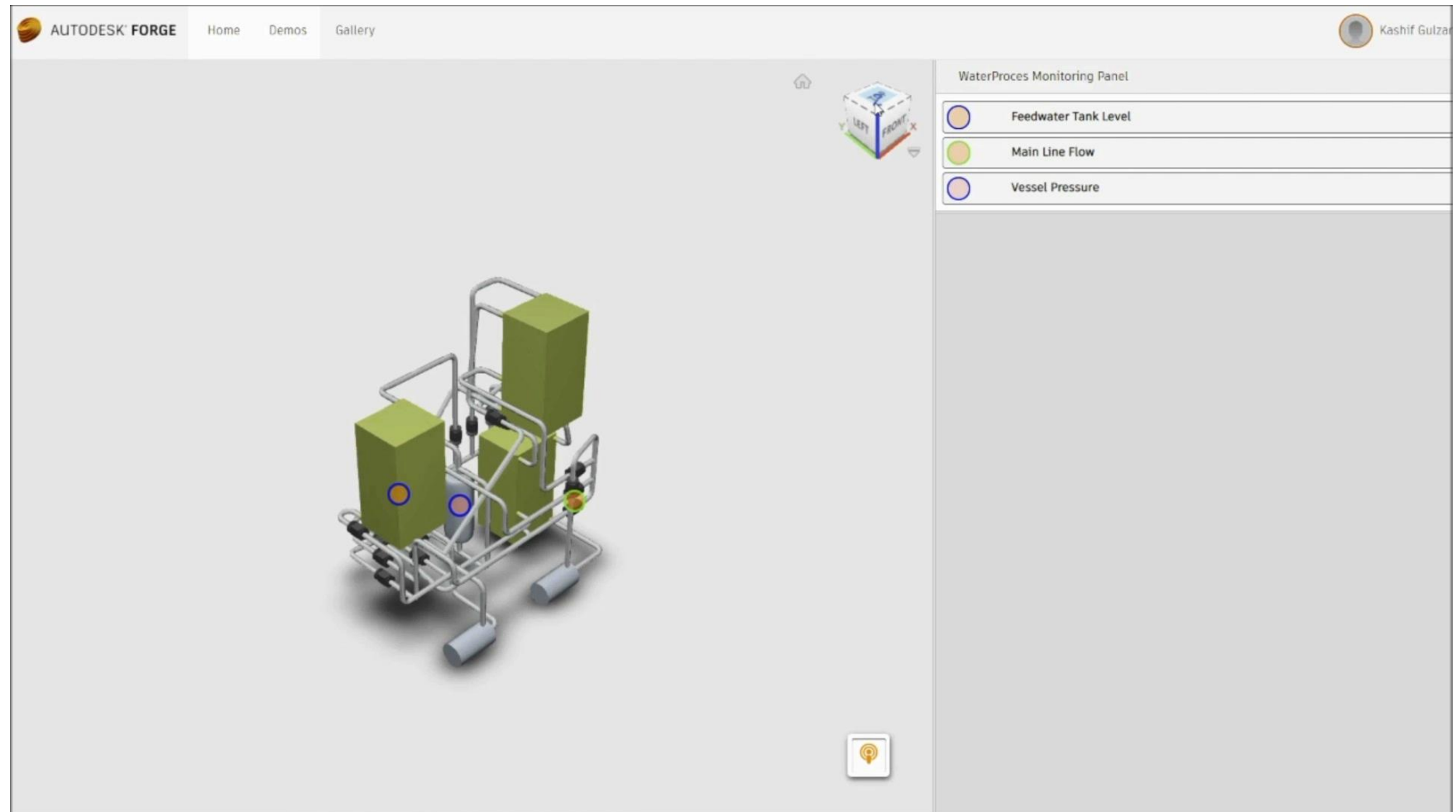


Simulation-based Virtual Twin of a Lab-scale Heat Production Plant

Enabled by Autodesk Forge & Semantum Modeling Factory



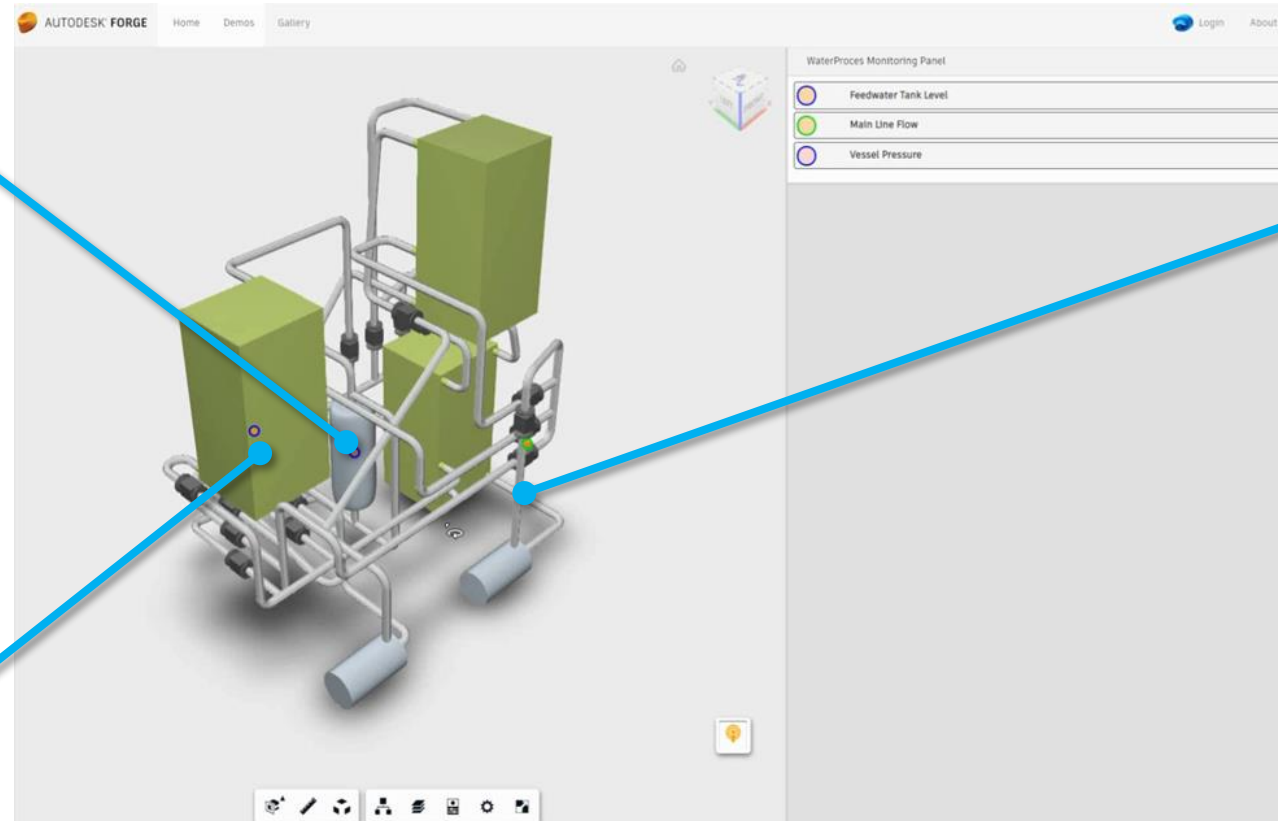
Interface overview



Hotpots description

**Vessel
Pressure**

**Feedwater
Tank Level**



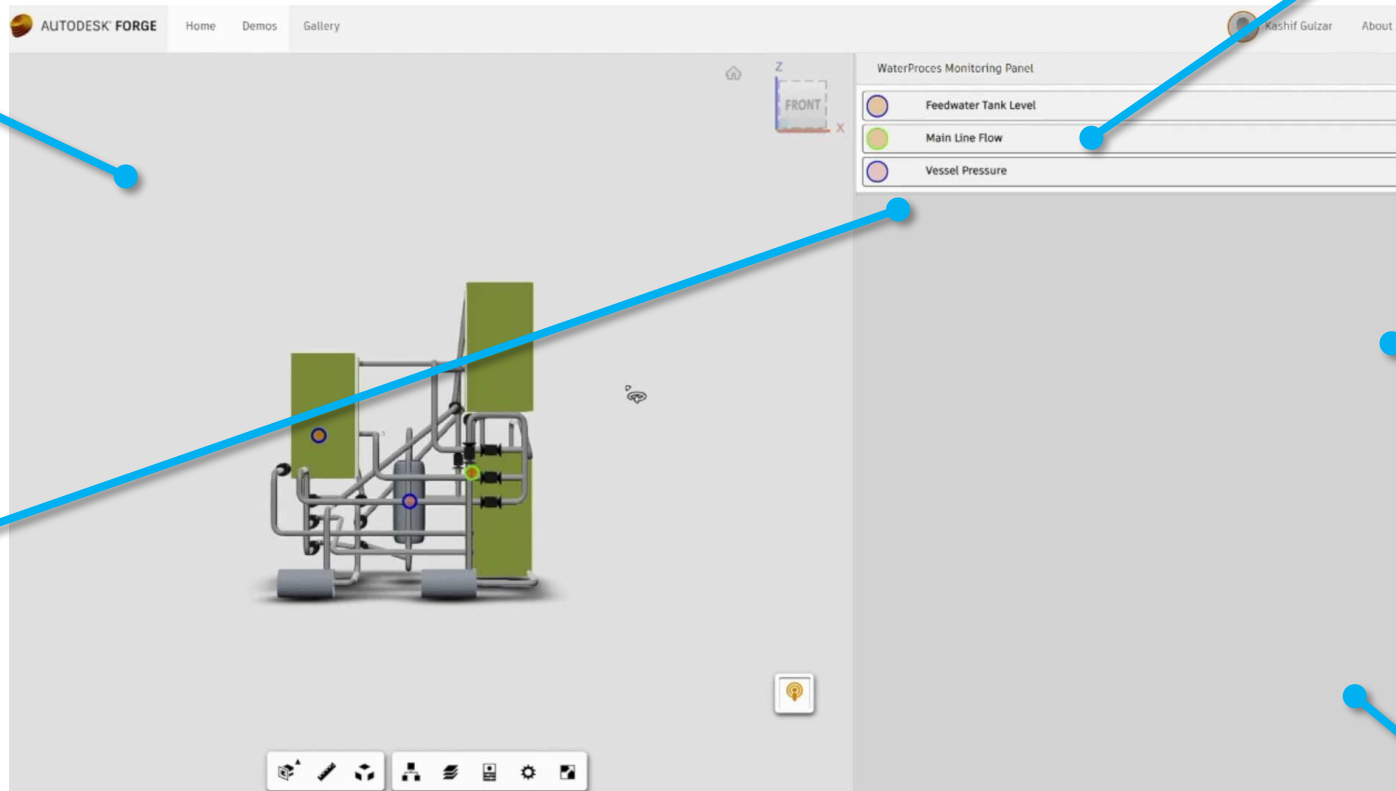
**Main Line
Flow**



Hotpots navigation

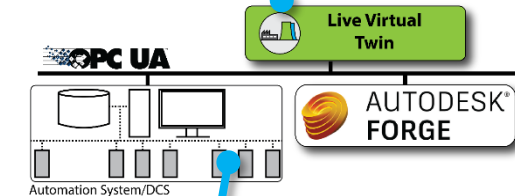
3D model
navigation
interface

Simulation
control buttons



Hotspot
description

Digital Twin
Results



Process
Measurements

Application case: Predictive Transient Simulation



Transient prediction

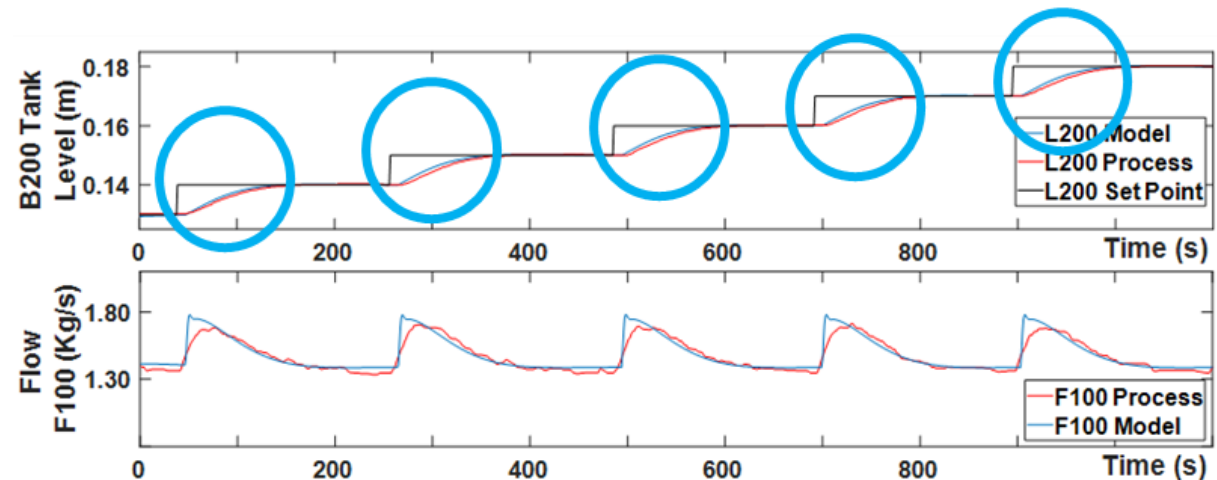
Production transients are caused by changes on the plant states due to:

- External disturbances
- System malfunctions
- **Production set point changes**

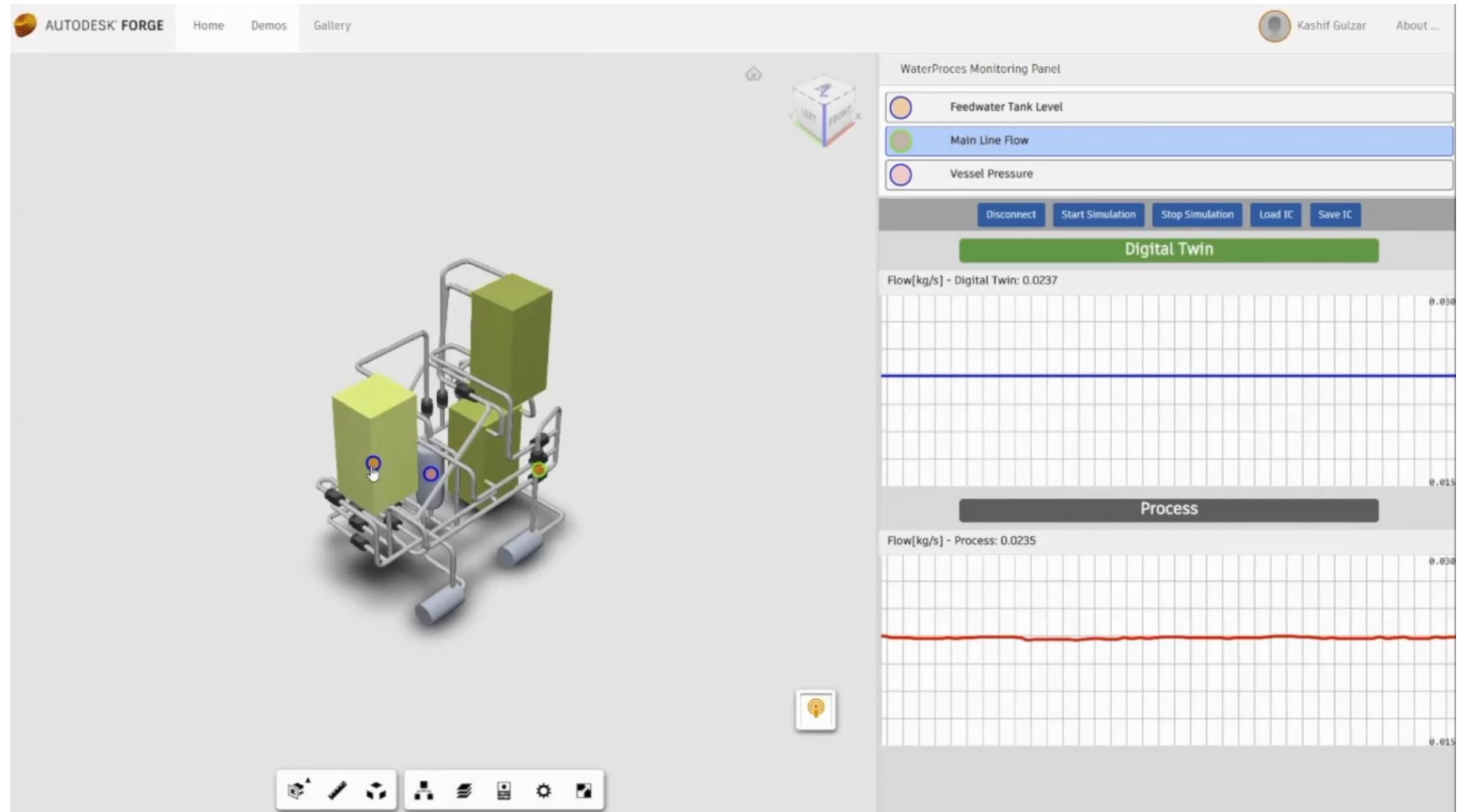
Predicting the plant's transient response is critical for ensuring that:

- **the changes are safe (e.g. system stability)**
- **the production remains efficient**

Reliable transient prediction can only be achieved through dynamic simulation!!



Transient prediction with Digital Twin

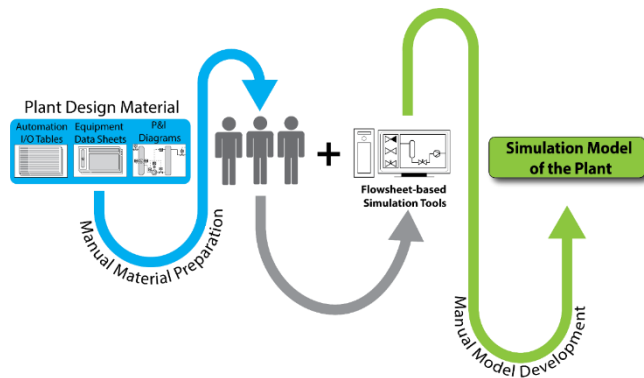


Benefits

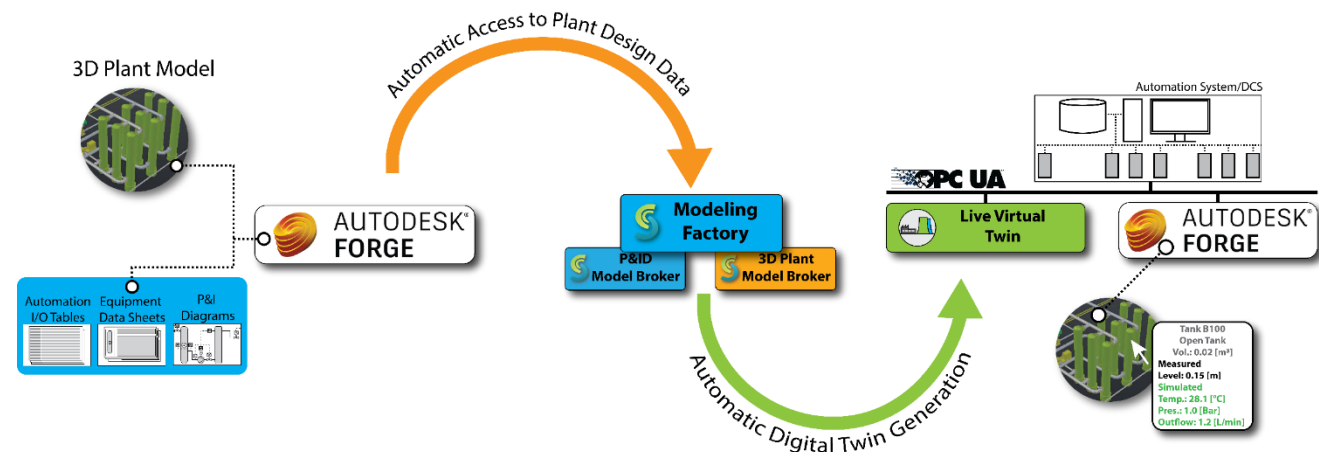
Reduction of Simulation-based Digital Twins development time and cost

- Automatic model generation dramatically reduces model development and maintenance time and costs.
- OPC UA reduces system integration effort
- Utilizing the 3D plant model for DT visualization reduces development time and costs

Current Model Development Workflow

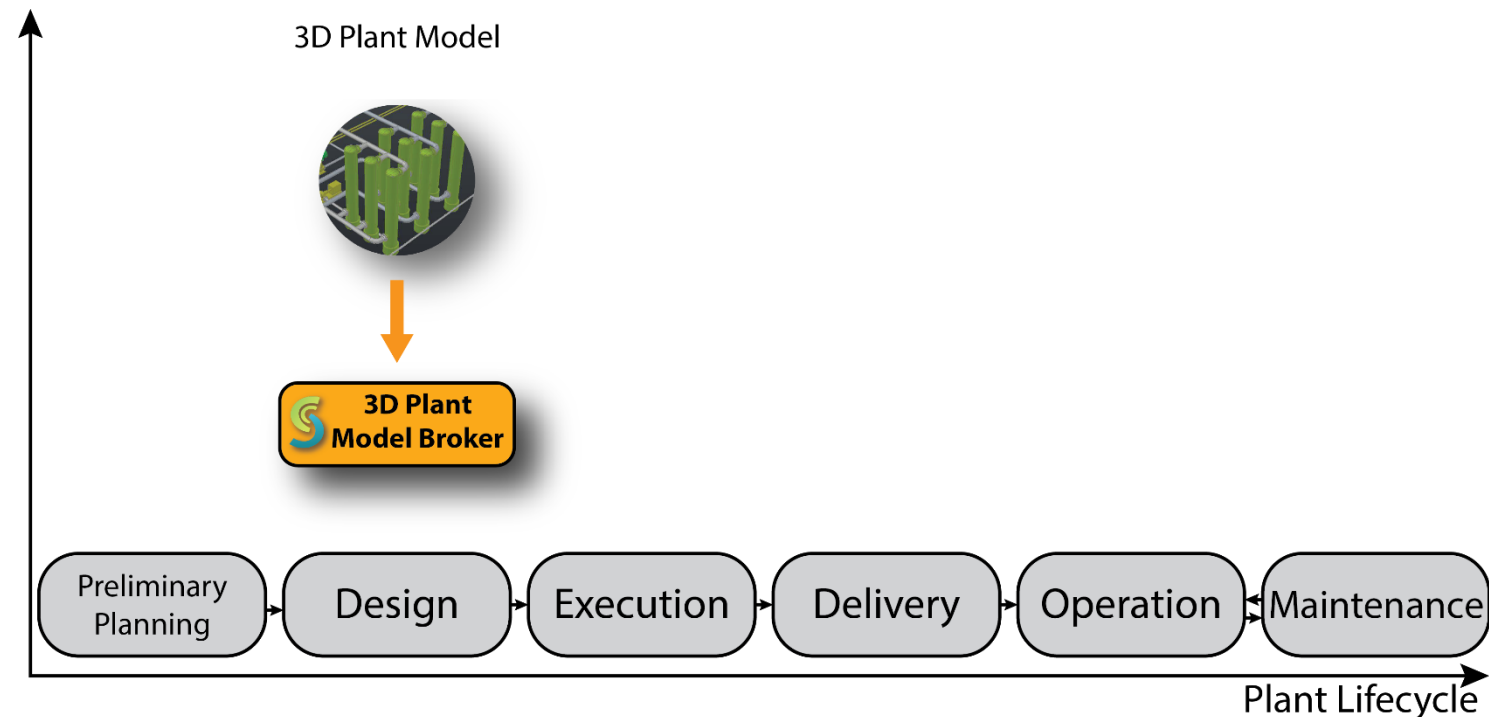


Our Solution: Engineering Automation



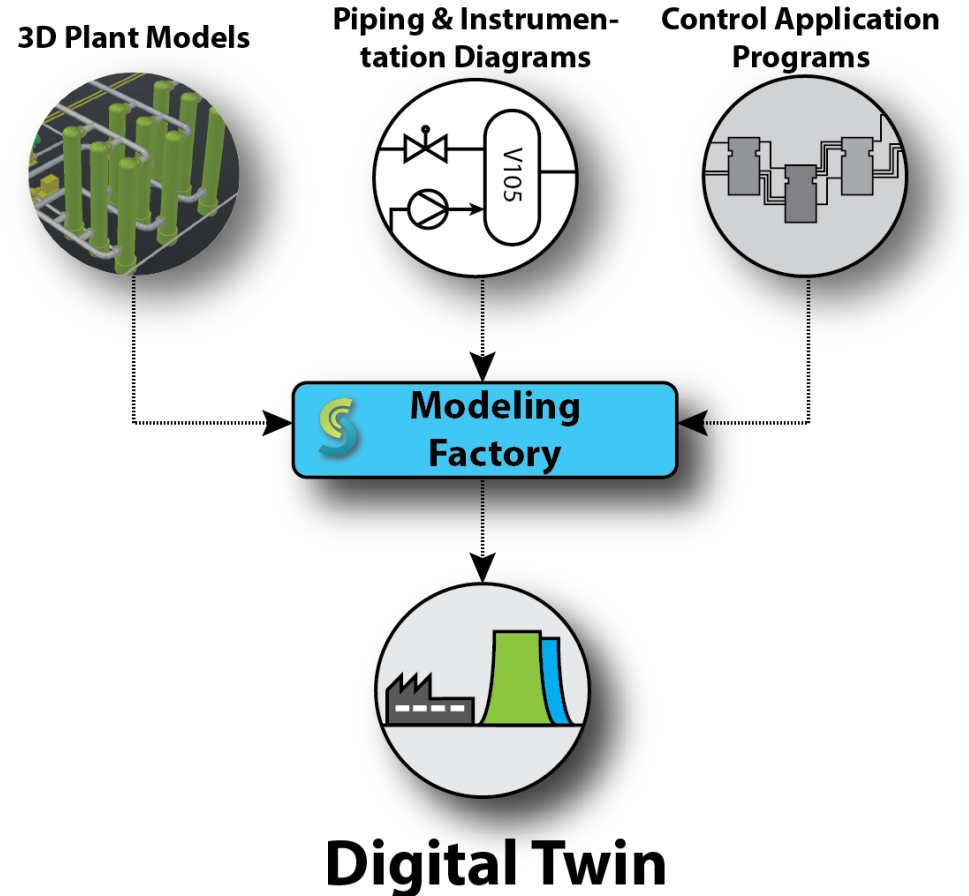
Automatic model generation available during early process design

- 3D Plant Model Broker can be utilized already during early process design phases when the 3D plant models are available.

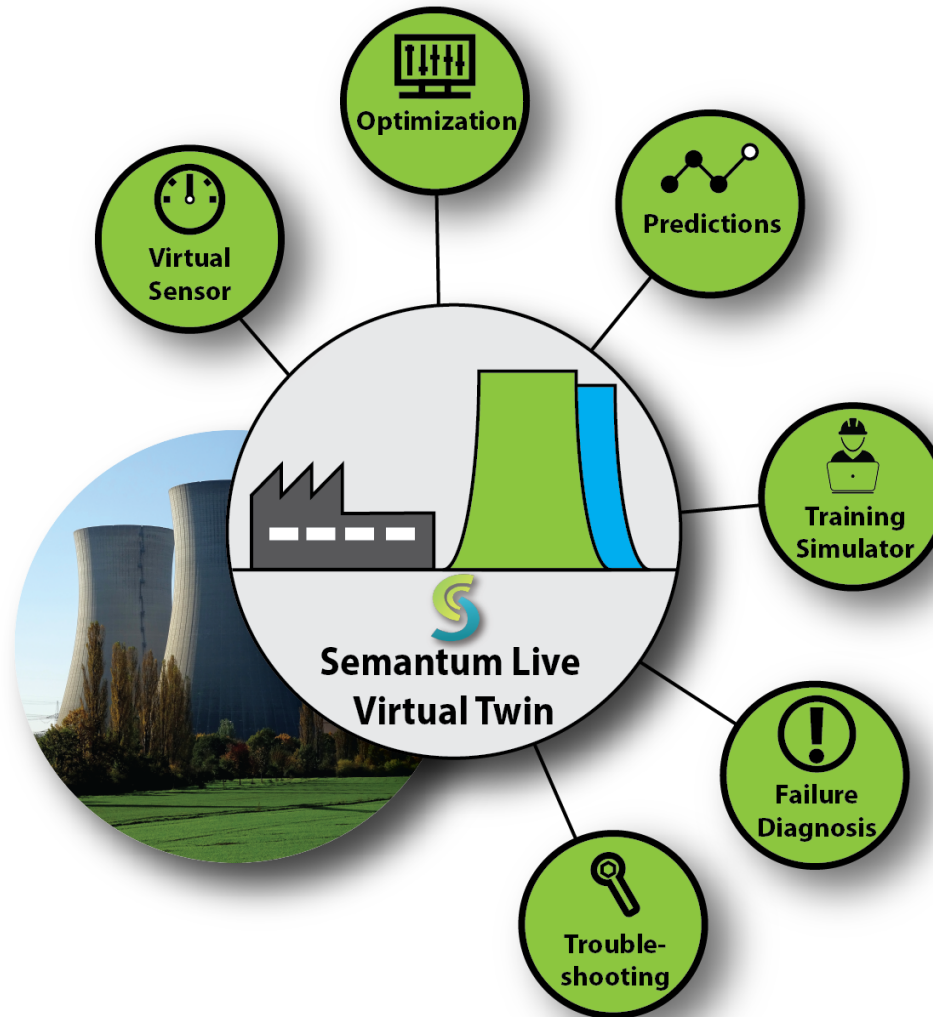


Available also for P&ID

- Results of simulation models automatically generated improve when other engineering data sources are combined.



Simulation-based Digital Twin: Applications



Thank you!

