

Industry 4.0: Digital Twin

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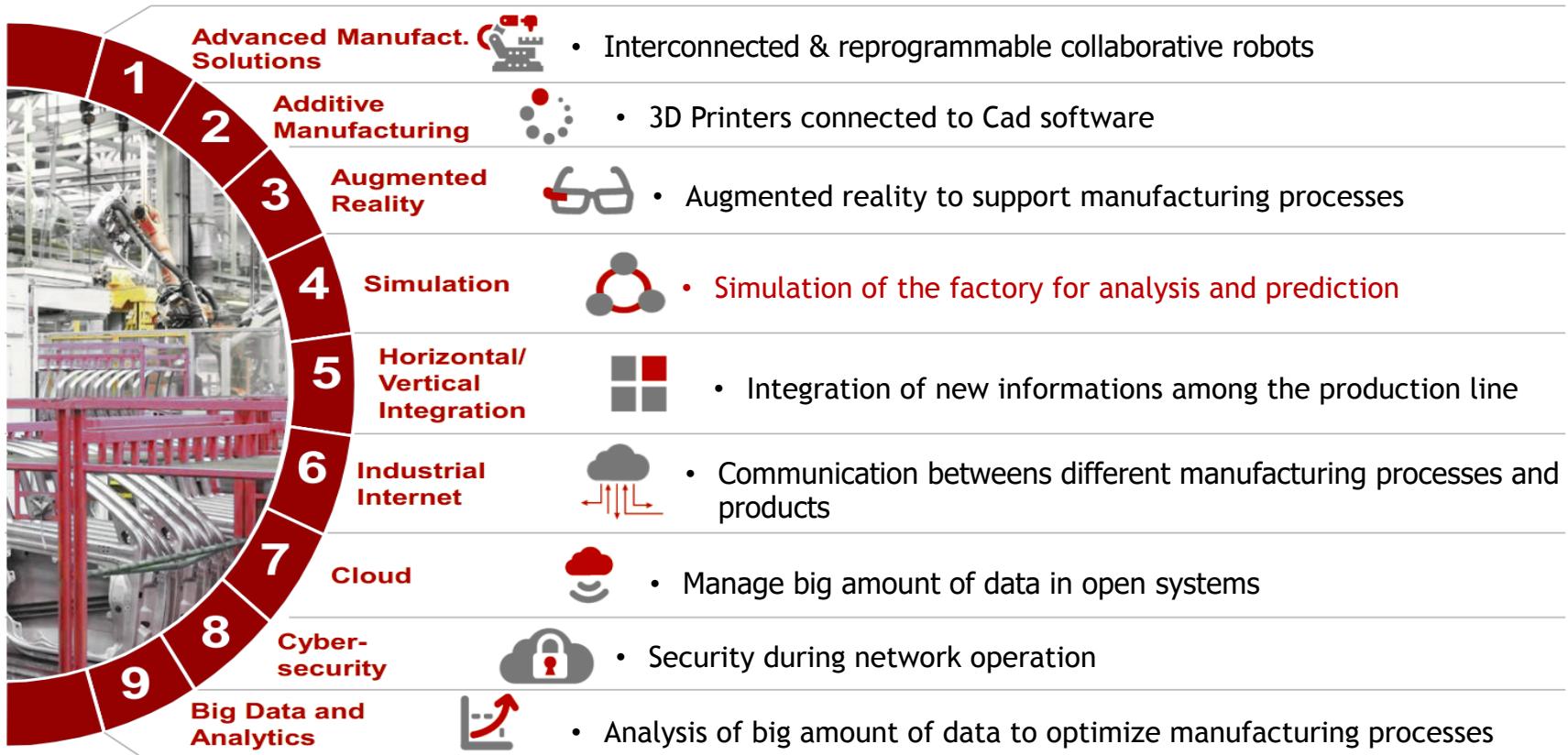


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di **INFORMATICA**

Agenda

- Simulation as an enabling technology
- Kinds of digital-twin
- Digital-twin how to build
- A concrete example

Key Enabling Technologies

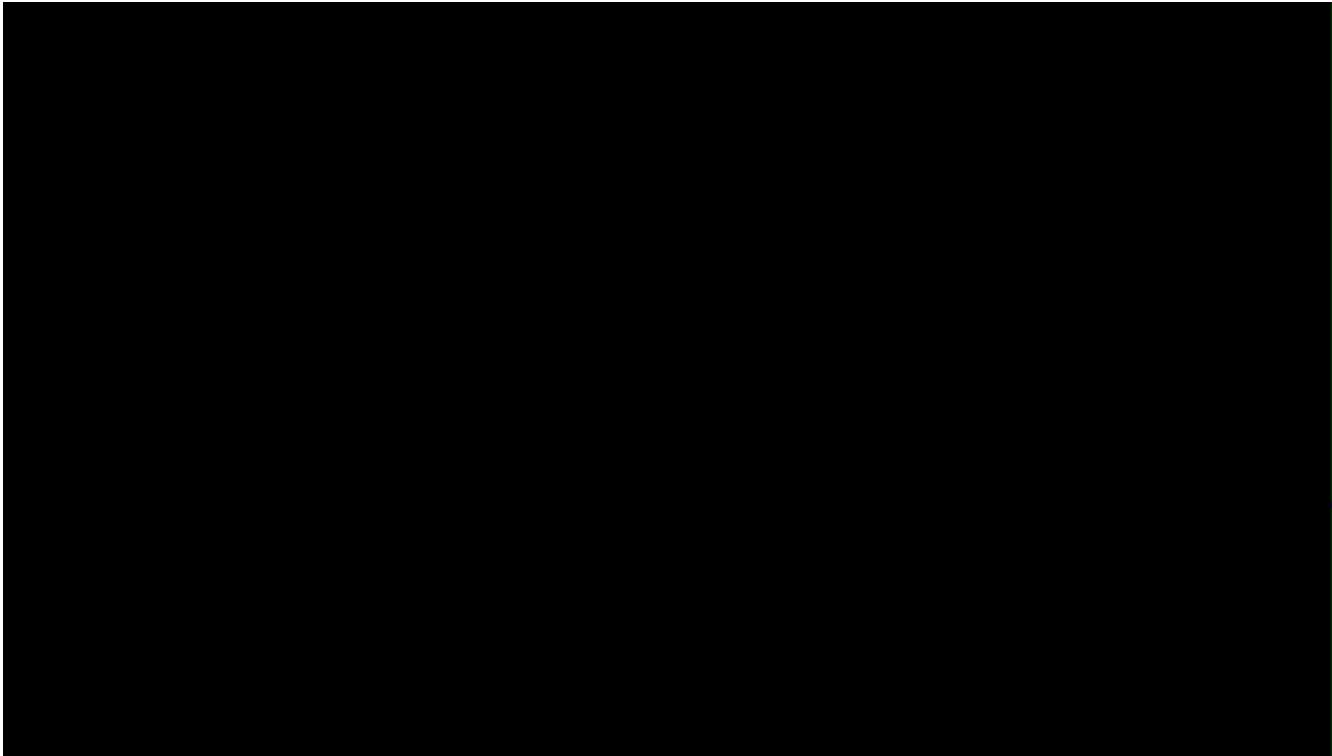


Digital Twin

- Digital Twin Is A Real Mapping Of All Components In The Product Life Cycle Using Physical Data, Virtual Data And Interaction Data Between Them"



Why Digital Twin will be backbone of Industry In The Future



Simulation

Virtual Factory

Simulation
of
Production Line



Analysis
&
Prediction



Optimization



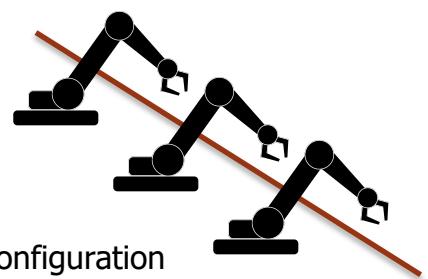
Network

Sensing

EISD

Controlling

Real Factory



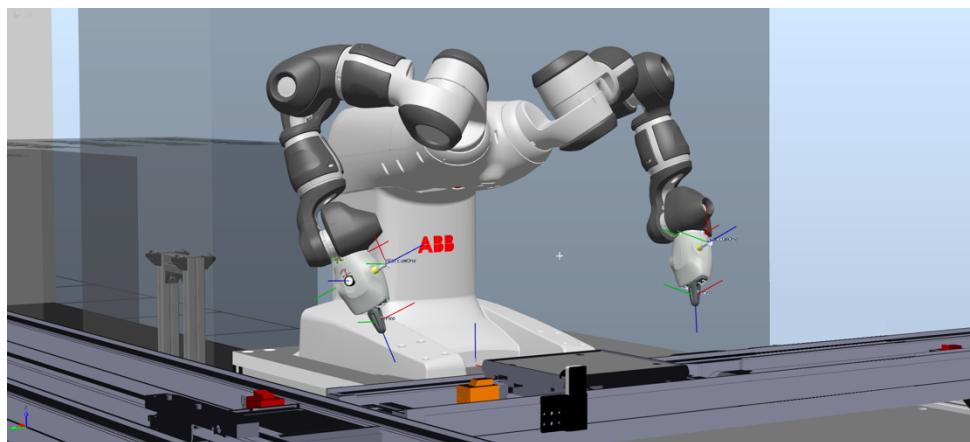
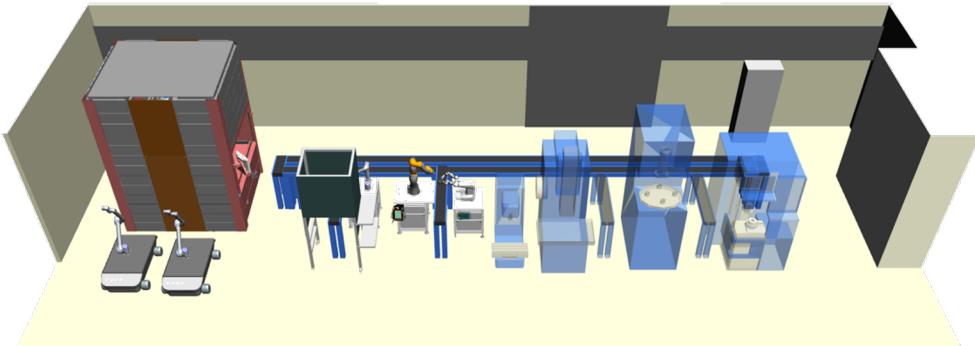
Reconfiguration

Simulation Software Survey

Survey on Discrete Events Simulators. OR/MS Today, October 2017

Tool	O.S.	Multiprocessor Support	Use External SW	Controlled by external SW
FlexSim	Windows	yes	Excel, databases, C++ applications	OLE, ActiveX
TecnoMatrix Plant Simulation	Windows	yes	Matlab, C dlls , MS Excel, SAP, Simatic IT, Teamcenter, Autocad, SimTalk	Parameterizing from MS Excel, Siemens PLCSIM Advanced, OPC, OPC UA, ODBC, MS Windows, Oracle
AnyLogic	Win, Mac, Linux	yes	Excel, Access, any database, any Java library	Models can be exported as standalone Java applications that can be run from/by any other application.
SIMIO	Windows	yes	Azure, OptQuest, .Net , Excel, Access, SQL Server, MySQL	Wonderware, OptQuest, .Net Programs
Simul8	Windows	yes	Microsoft Excel, Stat::Fit, OptQuest, SQL Databases	Microsoft Excel, Any COM enabled IDE

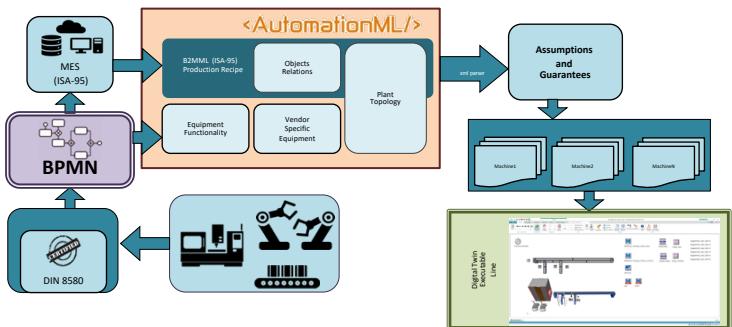
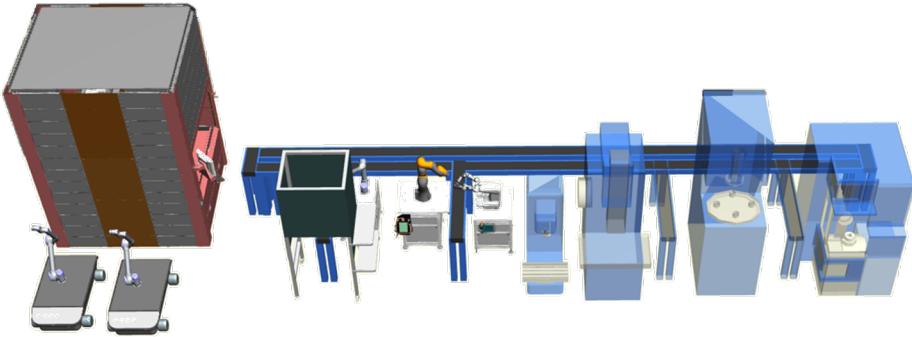
Digital twin



- A **digital twin** is a digital replica of a living or non-living physical entity
 - A digital replica can represent physical assets, processes, people, places, systems and devices
 - Can be used for various purposes
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- **Types of Digital Twin:**
 1. Autonomous
 2. Connected (digital shadow)
 3. Hybrid

1

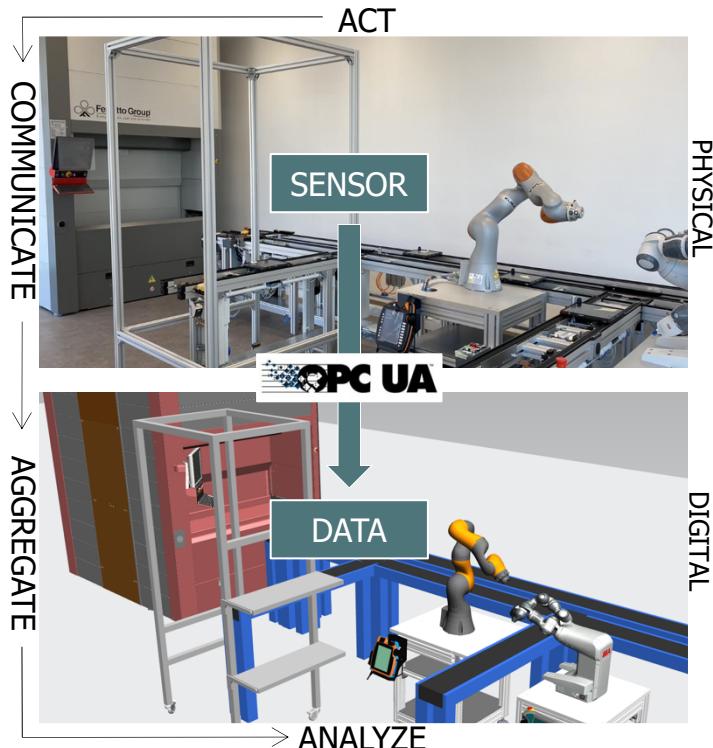
Autonomous



- Independence from the real line
- The line can be:
 - Already existing
 - A new model
- **ADVANTAGES:**
 - Errors or bottlenecks detection before production validation
 - Number reduction of physical prototypes with initial virtual validation
 - Cycle time optimization through simulation
- **SETTINGS:**
 - Speed
 - Time
 - Power

2

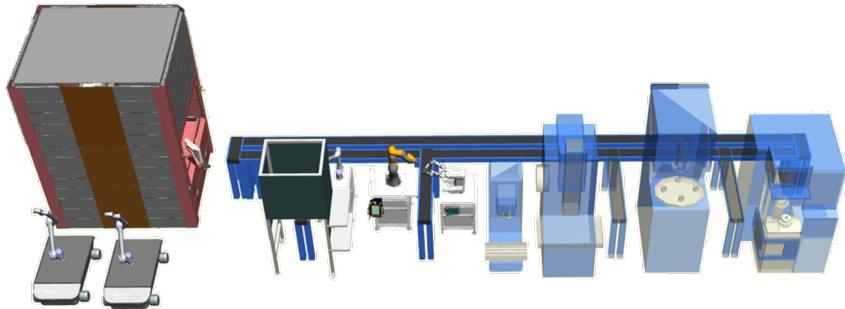
Connected (digital shadow)



- Digital twin communicates with the real plant with sensors
- The line must exist
- **ADVANTAGES:**
 - Production line monitoring even when far from the physical line
 - Failures or bottlenecks monitoring
 - Production process optimization thanks to the production data collection
 - Creation of statistics of intermediate and finished products produced by the line
- **SETTINGS:**
 - The digital twin utilizes the OPC-UA protocol for the communication with machines

3

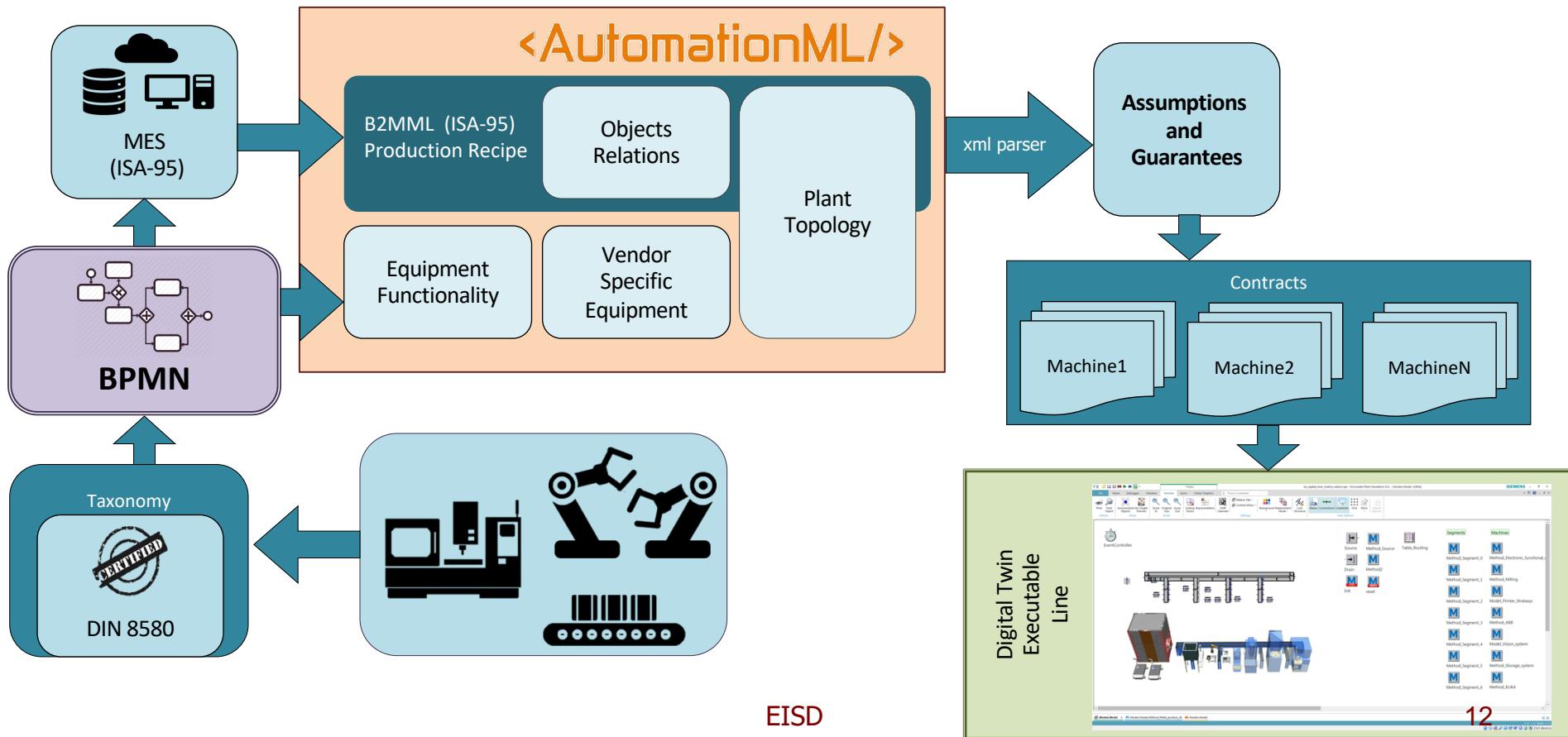
Hybrid



- Digital twin where some machines are real others are hypothetical
- The line exists in the middle
- **ADVANTAGES:**
 - Statistics of a hypothetical production
 - Optimization of production cycles
- **SETTINGS:**
 - The digital twin communicates with the existing machines with the OPC-UA protocol
 - Speed of hypothetical machines
 - Time of hypothetical machines
 - Power of hypothetical machines

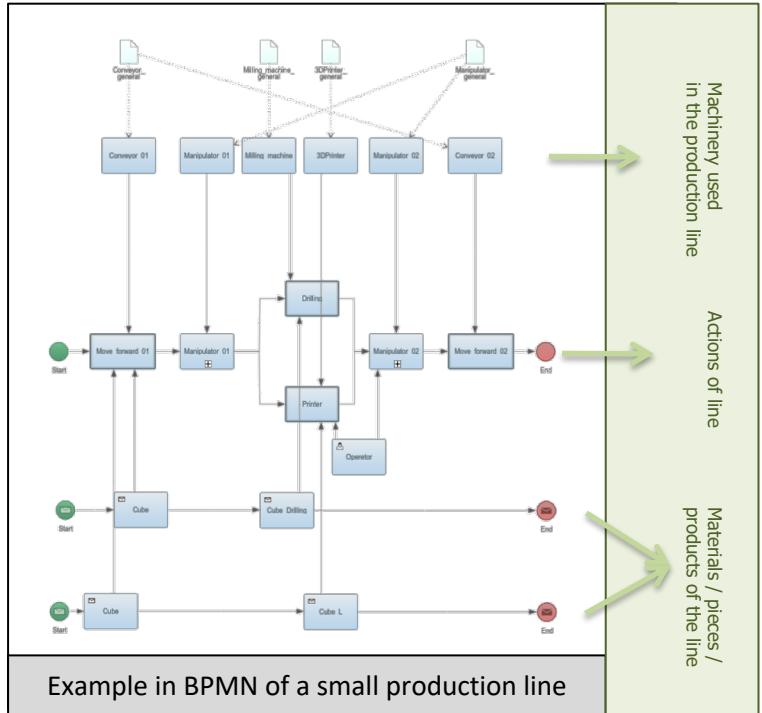
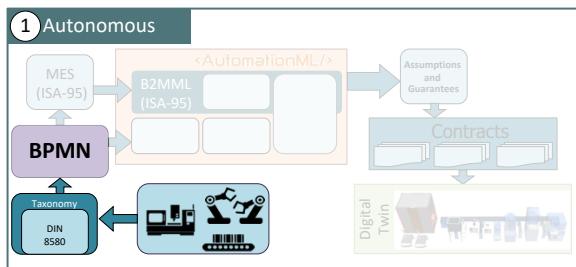
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Autonomous



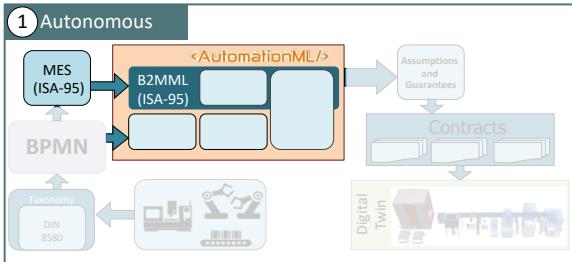
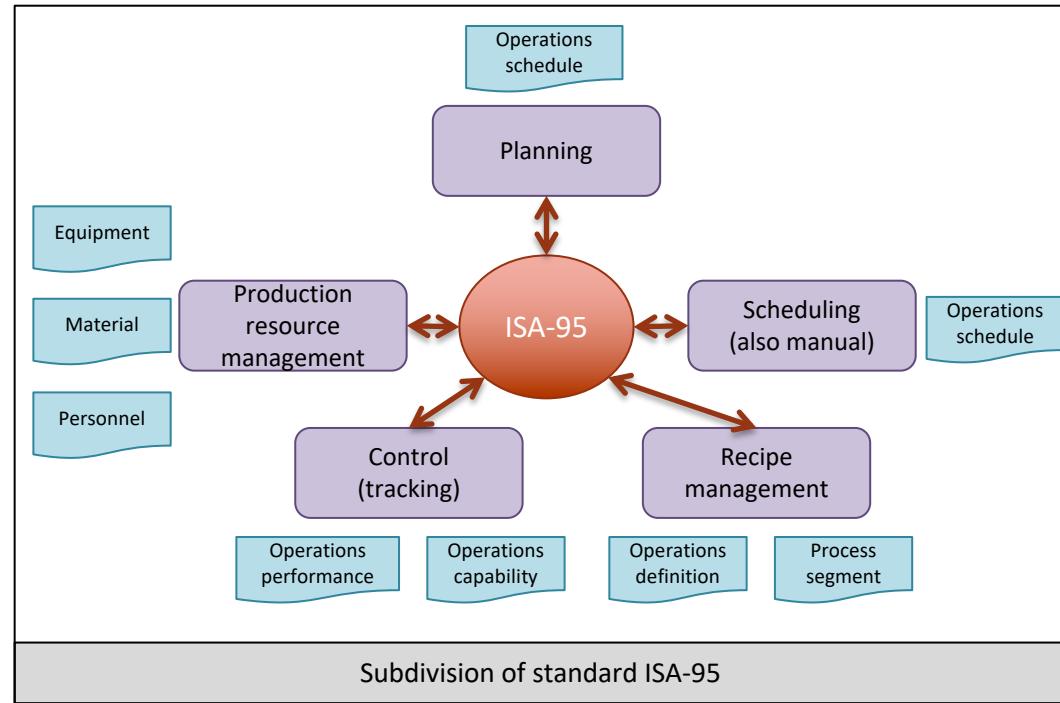
Taxonomy DIN – Business Process Model and Notation

- The **DIN 8580** standard categorizes the existing industrial processes in five macro sections.
- Each machine is represented by the actions it performs
- Business Process Model and Notation** (BPMN)
 - Graphical representation
 - Allows to specify business processes
- We use a **custom** BPMN as a front-end
- BPMN is **consistent** with the ISA-95 standard



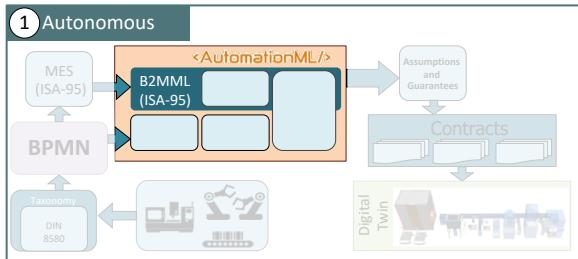
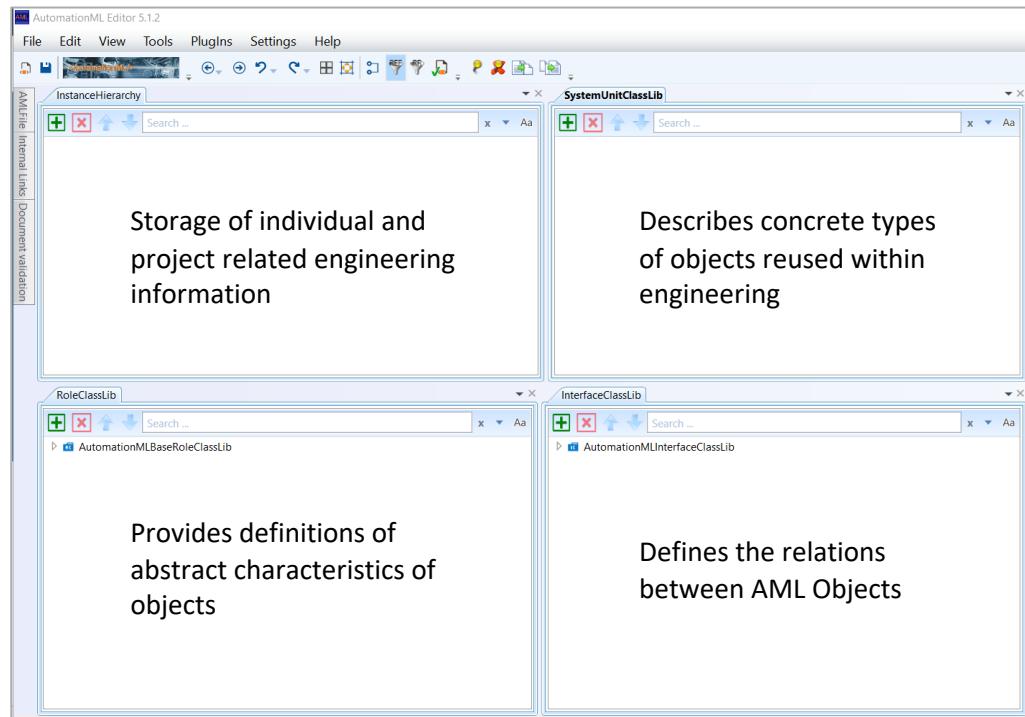
ISA-95

- ISA-95 is an international **standard**
- Used to develop an **automated interface** between enterprise and control systems
- Applied in:
 - all industries
 - batch, continuous and repetitive processes
- We create an AML model **consistent** with the ISA-95 standard
- AML is divided **according to the standard** subdivisions of ISA-95



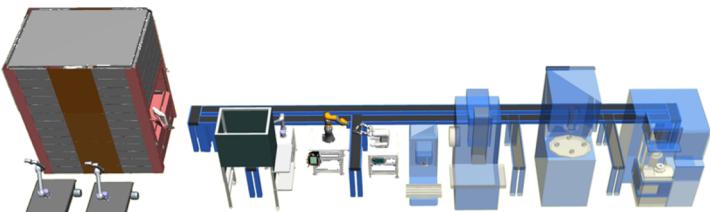
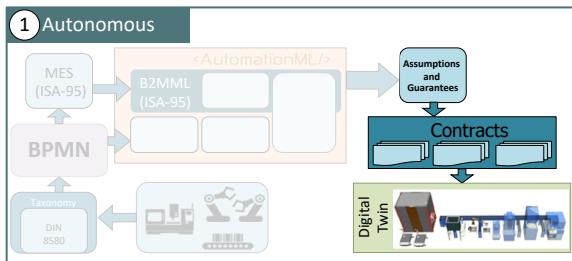
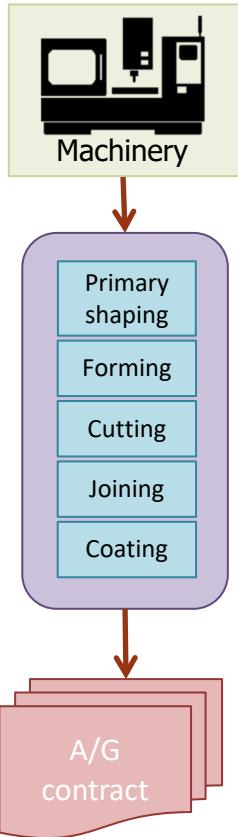
Automation Markup Language

- **Automation Markup Language (AML)** is an open standard
- Neutral data format based on XML for:
 - Storage
 - Exchange of plant engineering information
- Goal: **interconnect** the heterogeneous modern **engineering tools** in their different disciplines
- AML is divided into 4 parts:
 - Instance Hierarchy
 - System Unit Class Lib
 - Role Class Lib
 - Instance Class Lib



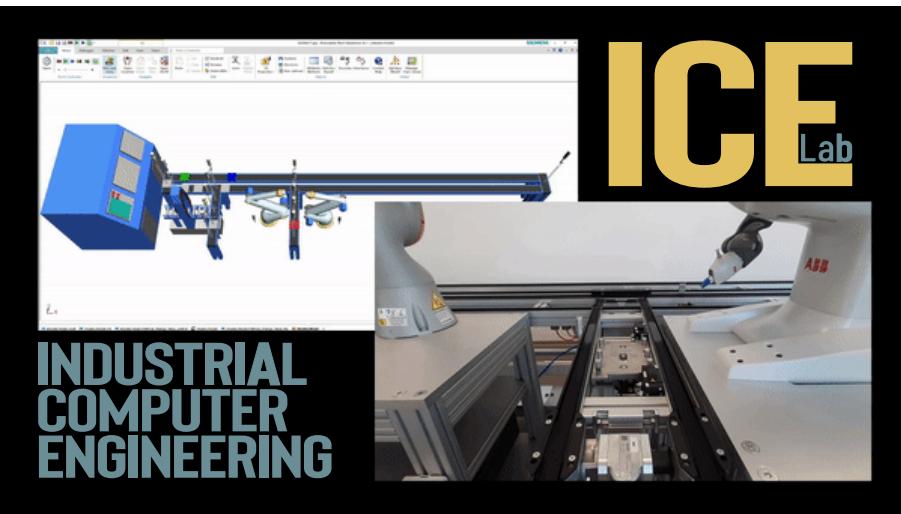
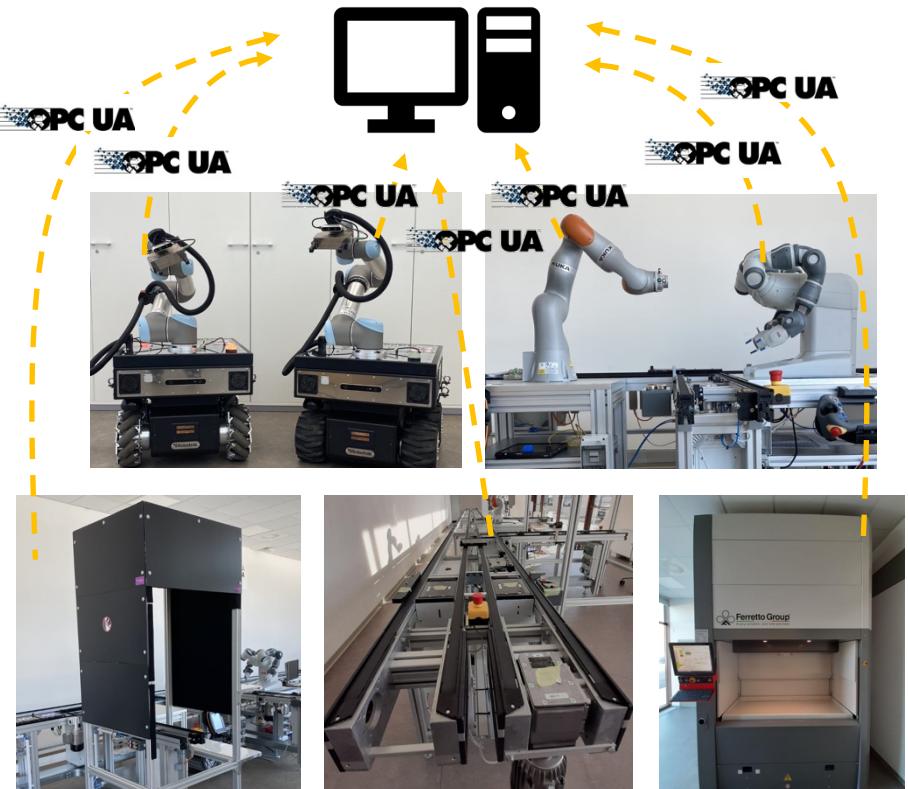
A/G Contracts – Autonomous Digital twin

- An **A/G contract** for a component is the set of:
 - the component **variables**
 - the contract's **assumptions**, i.e., the behavior of the environment of component assumed by the model
 - **guarantees**, i.e., the behaviors guaranteed by component whenever the assumptions hold
- We take every action of Taxonomy DIN 8580 and create a contract that describes it
- We characterize every action in Automation Markup Language
- **Autonomous Digital-Twin** is independent from the real line



2

Connected (digital shadow)



- **OPC Unified Architecture (OPC UA)** is a machine to machine communication protocol for industrial automation