OST
Ostschweizer
Fachhochschule

Smart Factory Lecture

Rapperswil HS23

Dr. Shuangqing Liao

1st. December 2023

Industrial Engineering (OST-RJ)

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Education

2007 – 2011	Ph.D. in Industrial Engineering, Ecole Centrale Paris (FR)
2001 – 2007	Automatic Control(MSc), South-west Jiaotong University (CN)
	Engineer degree, Ecole Centrale Paris (FR)

Professional Career

2022 – now	Senior Supply Chain Analyst, Novelis AG, Küsnacht
2019 – now	Lecturer WING, OST, Rapperswil
2015 – 2022	Scientific Collaborator, IPEK, OST, Rapperswil
2011 – 2015	Postdoc-Researcher, EPFL, Lausanne

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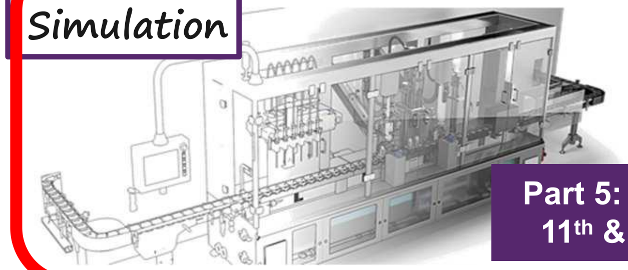
Overview

Simulation



Part 5: Simulation
11th & 12th week

Cloud & Software

Machine Learning

Part 3: Machine Learning
5th – 9th week

Connectivity & Integration

Part 2: Smart Factory Platform
2nd, 3rd & 4th week

Digitalization Technologies
Optimization of real plants by means of robotics, digital twin, data analytics, augmented/virtual reality, cloud and security concept

Production Plant

Part 4: Smart Factory Production Machine, 10th week

Automation Technologies
Control, sensors, drive systems, camera systems, data matrix code, RFID

IT Technologies
Industrial Ethernet, communication networks, security concepts, data standard

Production Management
Forecasting, Lot Sizing, Inventory Management, Materials Mgmt., Scheduling, Capacity Management

Production Technology
Injection molding, additive manufacturing
Robotics, metallic processes

Enterprise Software
CAD, PLM, ERP, MES, CRM – integrated Data flow

Strategy Part 1:
1st & 13th week

Objective/Use Case – Idea to earn money → **Learning from Data as the Key Topic in the Smart Factory** → **Changes in Organization, Processes, Products, Services & Business Model**

Course at-a-Glance

	Week	Content	Date
Part I) a	1	Strategy Development for Smart Factory	22.09.2023
Part II)	2	Device & Data	29.09.2023
	3	Cloud & Data Modeling	06.10.2023
	4	Data Visualization	13.10.2023
Part III)	5	Machine Learning: Machine Learning	20.10.2023
	6	Machine Learning: Neural Networks	27.10.2023
	7	Machine Learning: Training of a Multi-Layer Neural Network	03.11.2023
	8	Machine Learning: Neural Network and Classification	10.11.2023
	9	Machine Learning: Deep Learning	17.11.2023
Part IV)	10	Smart Factory @ Techpark	24.11.2023
Part V)	11	Simulation: Application in Lot Size Optimization	01.12.2023
	12	Simulation: Application in Production Network Management	08.12.2023
Part I) b	13	Strategy Implementation	15.12.2023
	14	Summary	22.12.2023

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Outline

Basics

DES for process improvement

Simulation
Industrie 4.0
Smart Factory

Applications in Smart Factory

Traditional simulation applications

- Production planning:
  - Milkrun configuration
  - Lot sizing
- Production network management

Digital twin

- Overview
- Application in Smart Factory

Perspective

Simulation for the better: the future in Industrie 4.0

Today's Objectives

Concepts:

- You understand when to use simulation as a tool, what simulation can do
- You understand the difference between optimization and simulation
- You have a good view of simulation in the context of Industrie 4.0

Techniques:

- You understand the basic approach in using simulation to support smart factory decision-making
- You know how to import data from different data resources
- You can evaluate the performance of different solutions under various condition assumptions

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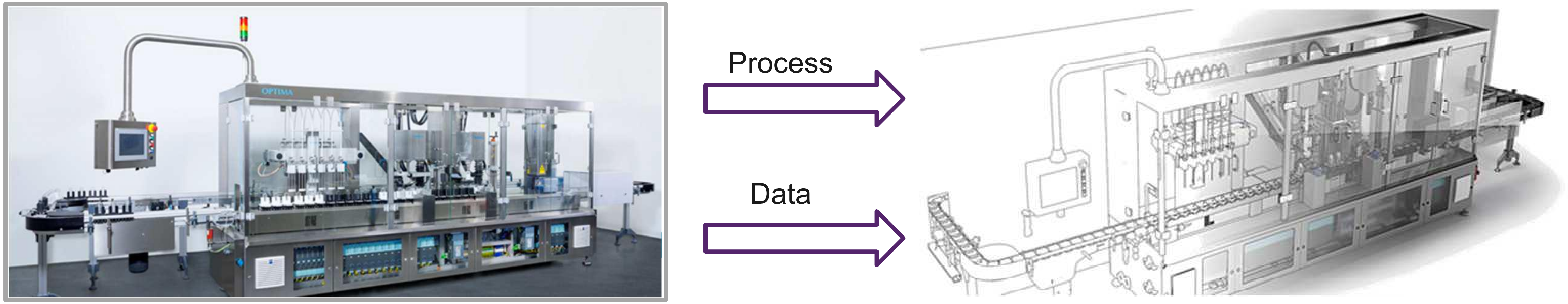
Simulation for the better: the future in Industrie 4.0

What is Simulation

Simulation comes from a Latin word, which means “I make like” or “I behave as if ”.

Simulation approximates imitation of the operation of a real-world process or system over time.



Simulation can be used to investigate a wide variety of “what if” questions, to **improve process**:
✓Simulate potential changes and predict their impact on the system
✓Find adequate parameter settings in the process before implementation

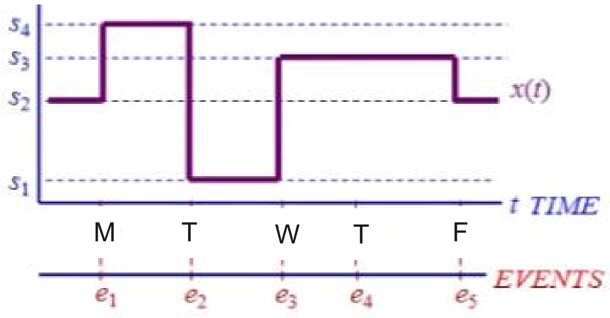
What is Discrete Event Simulation (DES)

Simulation: approximate imitation of the operation of a real-world process or system over time.

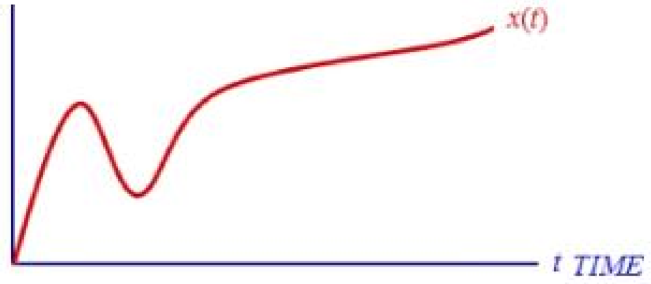
Discrete event simulation (**DES**) is the modeling of systems in which state variables change only at a discrete points in time.

Continuous simulation is modeling of systems in which states change continuously over time, based on a set of differential equations.

Inventory Level



Temperature



Example: Inventory changes in a warehouse
New oders in a company

Examples:Temperature in Zürich
Machine Signal, eg. Kolbendruck beim Spritzgiessen

DES is a good tool to support decisions in a factory:
scheduling, resource allocation, capacity planning are all discrete decisions

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Typical Processes

Supply Chain Logistics: Just-in-time, risk reduction, reorder points, production allocation, inventory positioning, routing evaluations, information flow and data modeling

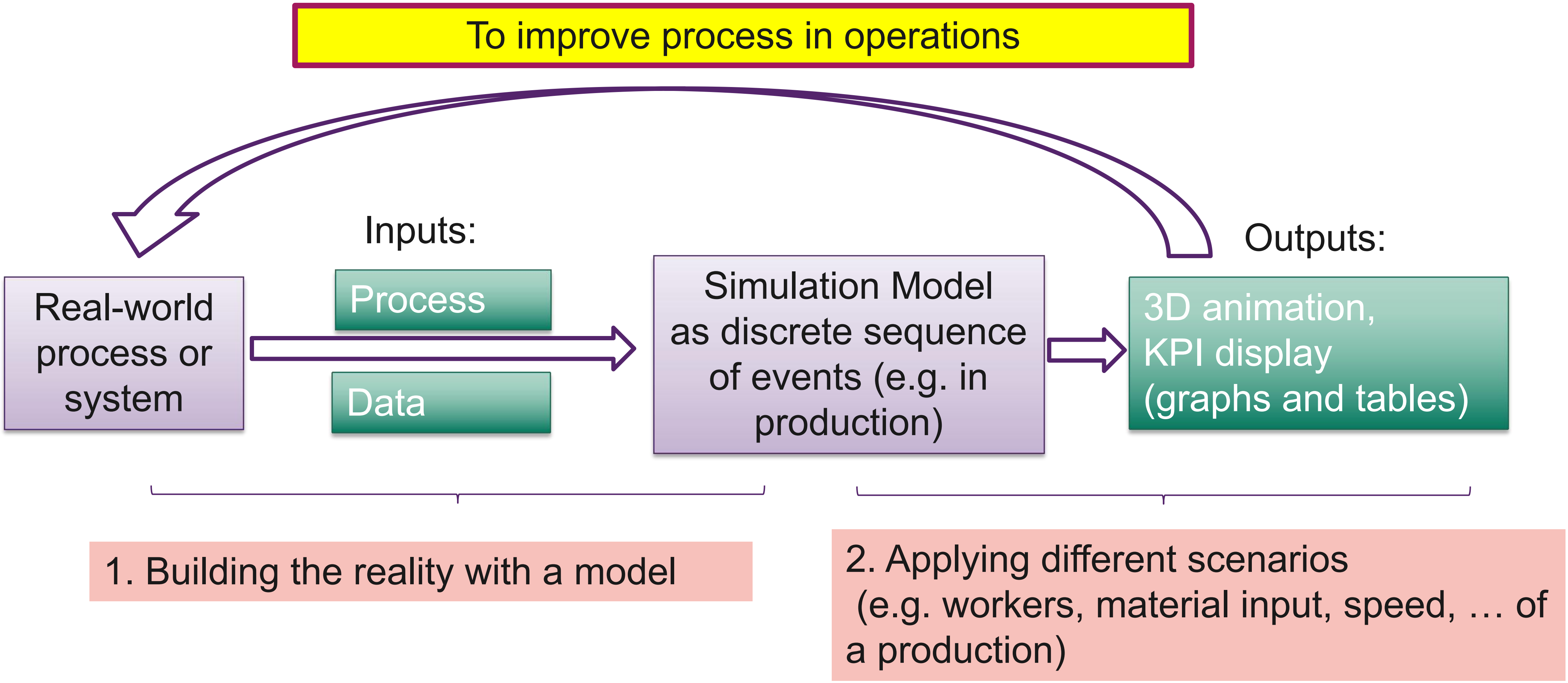
Transportation: Material transfer, labor transportation, vehicle dispatching, traffic management (trains, vessels, trucks, cranes, and lift trucks)

Staffing: Skill-level assessment, staffing levels and allocation, training plans, scheduling algorithms

Capital investments: Determining the right investments in the right things, at the right time; Investing for growth; Objective evaluation of return on investment

Productivity: Line optimization, product-mix changes, equipment allocation, labor reduction, capacity planning, predictive maintenance, variability analysis, decentralized decision-making.

DES Work Flow



Data

2. Fully implemented ERP today

ERP: Enterprise-Resource-Planning

Sensor Data

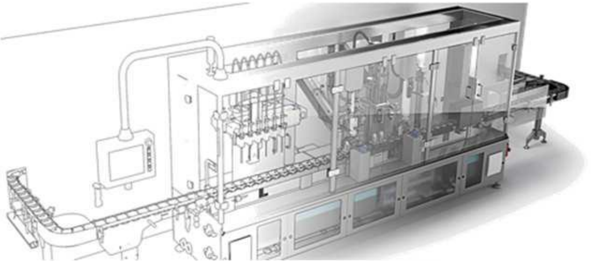
MES: Manufacturing Execution System e.g. MindSphere

More data & Better data

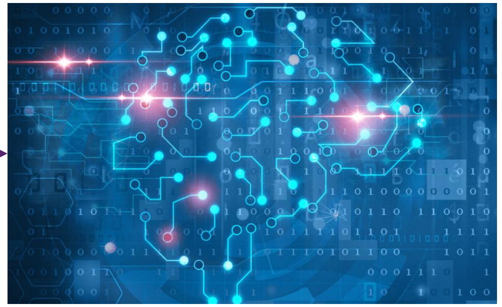
1. More high quality data

3. Data pool

Simulation



Machine Learning



E.g.

a. Machine time, cycle time, uploaded from machine to data pool, instead of rough estimation
b. Events (change materials, machine break down) in time series are recorded faster and easier by cloud, instead of manual entry by workers in an Excel sheet

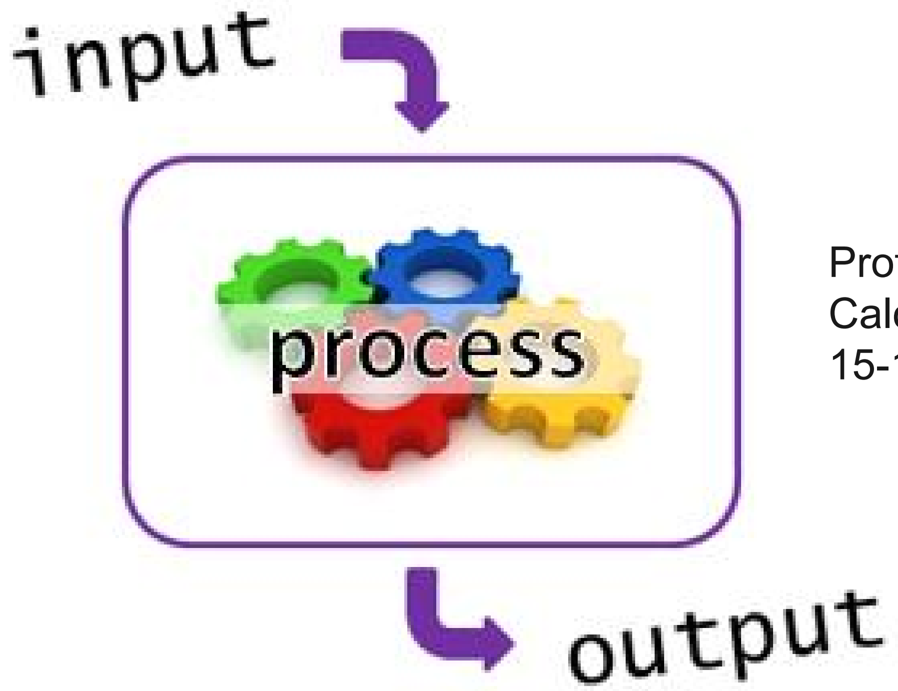
Quiz

When to use Simulation?

A. When process is known, but (some) inputs are unknown

B. When process is unknown, but inputs are known

e.g.
Cost: 10
Revenue: 15



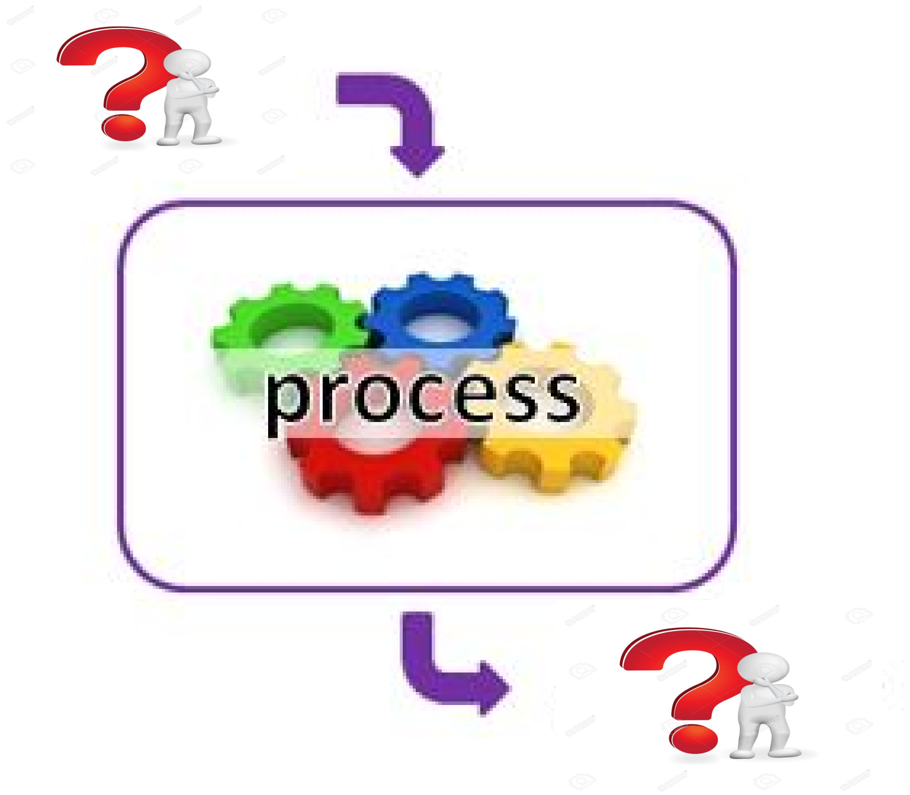
Profit Calculation: 15-10

Profit: 5

When to use Simulation?

When the process is known,
but inputs/outputs are unknown.

The goal is to find a range of outcomes by **randomly sampling** input values and calculating output repeatedly, **to improve process.**



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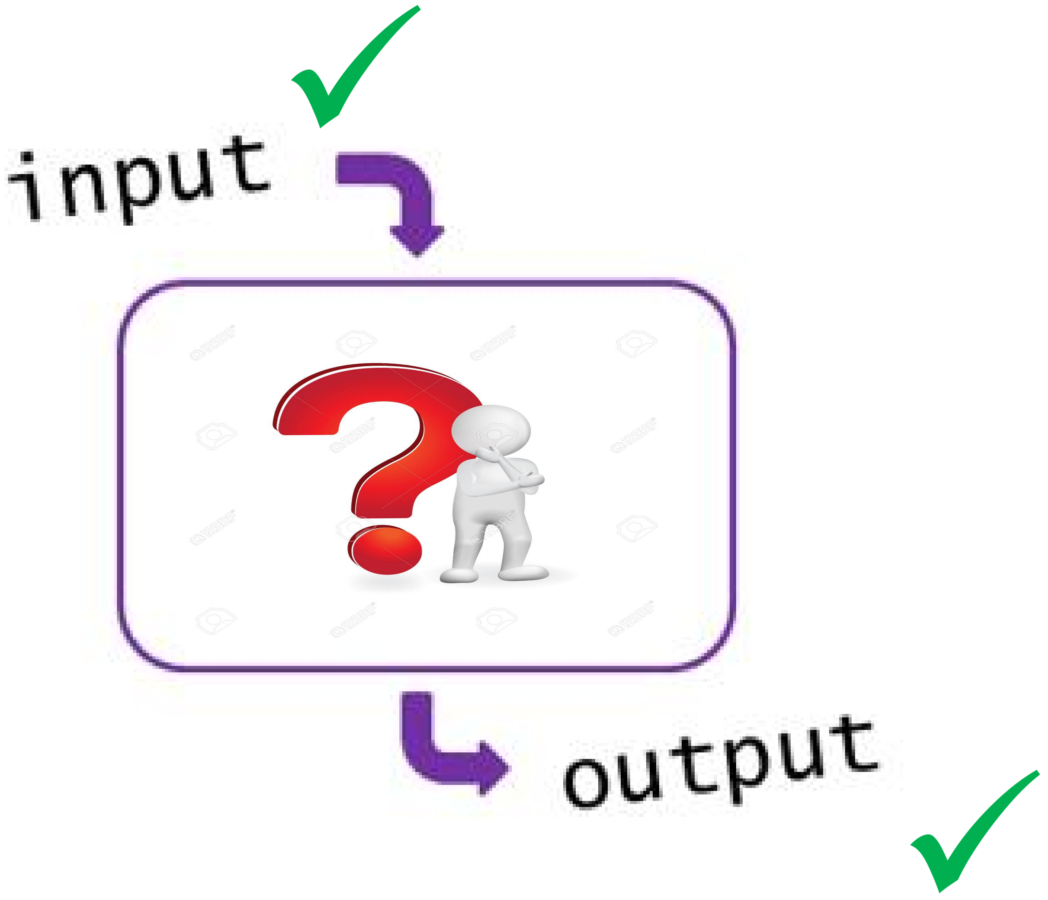
When to use Supervised Machine Learning?

When inputs and outputs are known,
but the process is unknown initially.

The goal is to refines the process model,
to **improve prediction** by iterations of learning.



Quiz: Simulation vs. Optimization

Does simulation generate the optimal strategy/process (optimal solution) for my problem?

A. Yes, sure, that is what I am waiting for.

B. No, simulation supports decision-making by evaluating predefined options. This method requires decision-makers to have comprehensive knowledge of the topic to ensure the correct selection of a single option from a potential field of thousands, in order to arrive at the best possible outcome.

Simulation vs. Optimization

Run | Solve

	Simulation	Optimization
Advantages	manages highly practical scenarios with **minimal assumptions**	produces **high quality analytical solutions**
	manages parameters of **uncertainty** and produces a **long- term** strategy	provides powerful tactical and strategic solutions for countless applications
Disadvantages	difficult process to obtain high- quality solutions	can **oversimplify** the problem during the modeling stage
	high costs associated with data sets and the modeling process	less effective as the degree of parameters of **uncertainty** increase

Outline

Basics	Applications in Smart Factory	Perspective
DES for process improvement	Traditional simulation applications ➢ Production planning: • Milkrun configuration • Lot sizing ➢ Production network management	Simulation for the better: the future in Industrie 4.0
Simulation Industrie 4.0 Smart Factory	Digital twin ➢ Overview ➢ Application in Smart Factory	

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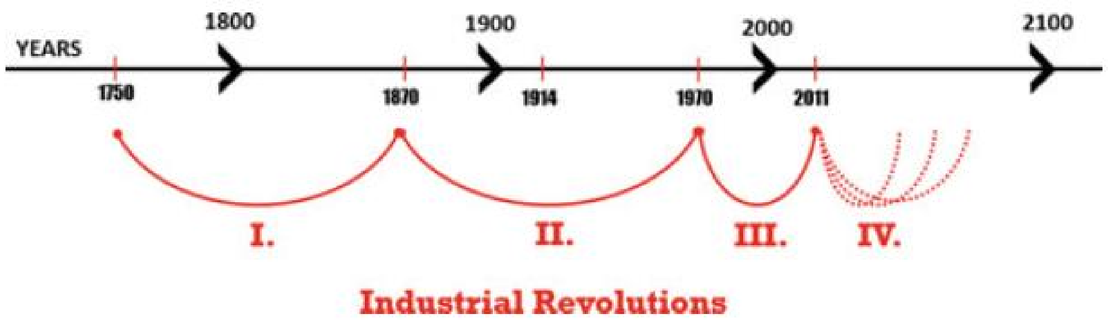
History of Simulation

- 1950s Computer Simulation, was started to be used by steel and aerospace corporations to solve complex problems with very complex models.
- 1970s First used in automotive and heavy industries.
- 1980s Simulation community was interested in Material Requirement Planning (MRP) and process planning in factories. Most simulations were run textually or numerically.
- 1990s Simulation by numbers turned to iconic animations, and then to 2 dimensional (2D) animations.
- 2000s Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) software became a part of product design and manufacturing, created a base for Industry 4.0. 3D visualization became a standard feature in DES software. The integration between simulation software and other utility software can also be seen in Enterprise Resource Planning (ERP) software.

Nine technologies which will drive the new industrial revolution



The main objective of Industry 4.0 is to create "smart factories" and "Cyber-Physical Systems (CPS)".

Simulation is at the heart of Industry 4.0.

Source: BCG

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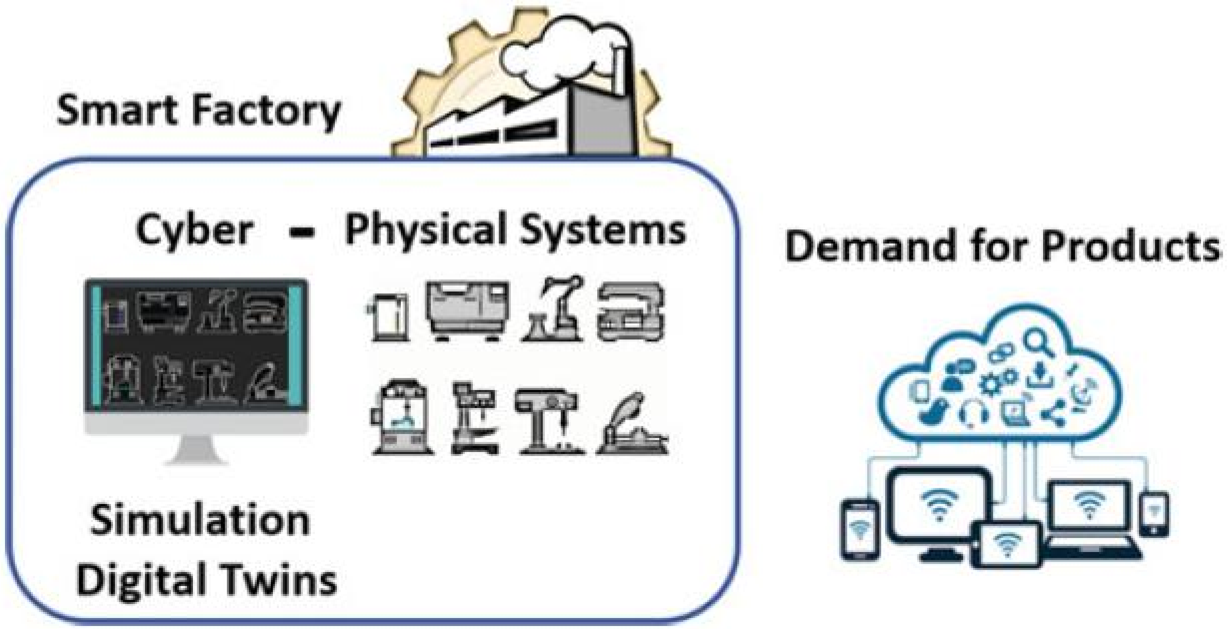
Cyber-Physical Systems (CPS) and Digital Twin



Cyber-Physical Systems and simulation

CPS: digitizing physical resources, mechanical and electronic parts of machines, with software and creating a replica, Digital Twin, in cyberspace.

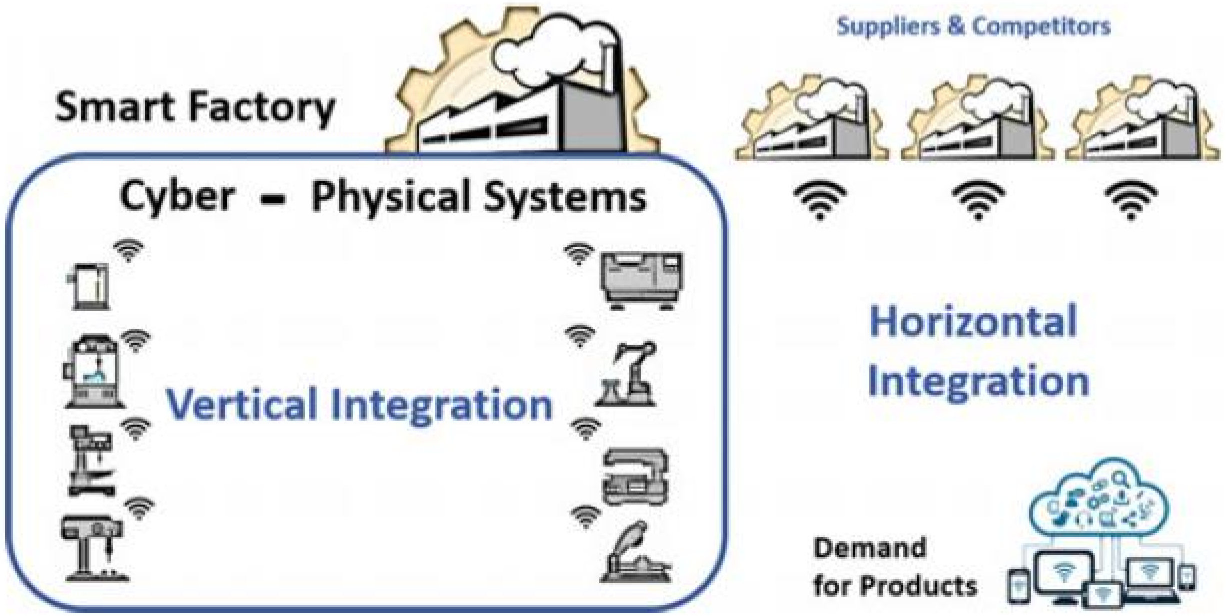
Digital Twin: the controlling software part of CPS, a simulation of the system that is replicated:

- Control devices and collect data from devices
- Act in real time and predict the effects of the action

Simulation for Industry 4.0, Gunal, Murat (Ed. 2019)

In CPS, Digital Twin simulates in the virtual world and predicts the possible outcomes of actions.

Vertical and Horizontal Systems Integration and Hybrid Modelling



Vertical and horizontal integration

Vertical integration:
linking machines and governing them centrally

Horizontal integration:
linking factories with suppliers and customers

Simulation:
designing, testing, and evaluating integration systems

Simulation for Industry 4.0, Gunal, Murat (Ed. 2019)

Simulation is used to make vertical and horizontal integration happen.

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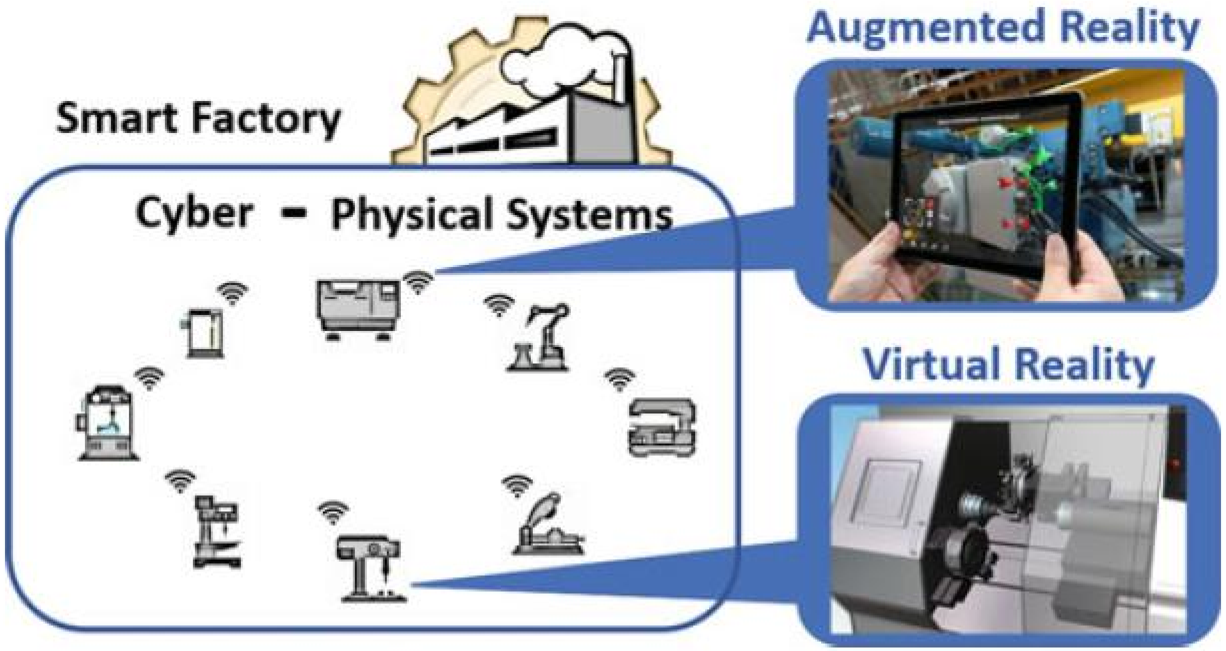
Augmented Reality/Virtual Reality (AR/VR) and Training People



Augmented Reality (AR) and Virtual Reality (VR)

Augmented Reality (AR) systems:
combine real and virtual objects, interact in real-time, use 3D computer generated objects.

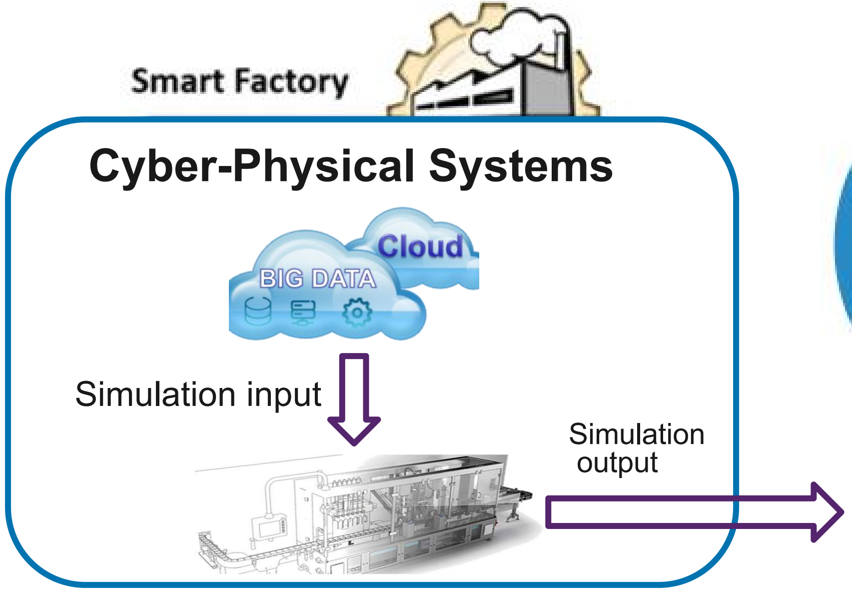
Virtual Reality (VR) systems:
the user is immersed in a virtual (simulated) world made of computer generated graphics.

Physically established simulation centers to train people who work in Industry 4.0 enabled factories.

Simulation for Industry 4.0, Gunal, Murat (Ed. 2019)

Simulation is used for training, collaboration, production planning

Cloud, Big Data Analytics and Simulation Input Modelling

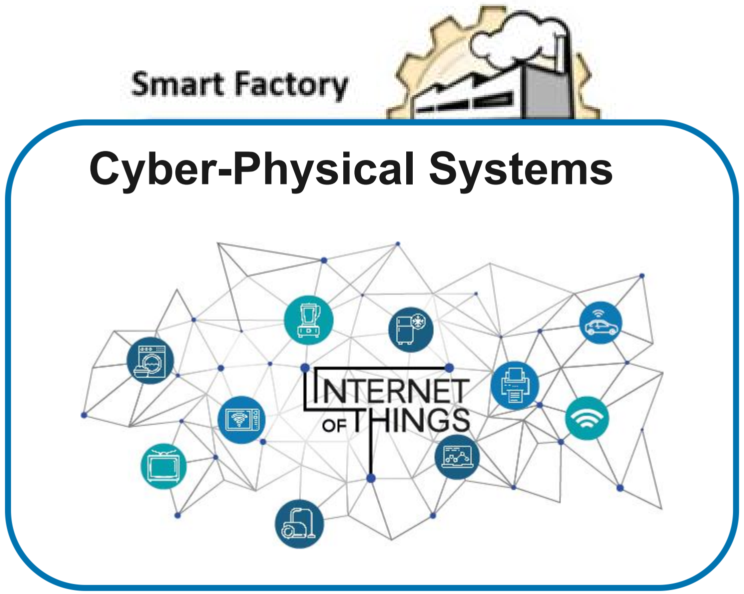


Cloud and Data Analytics

3D display	sensitivity analysis	what-if scenarios	Evaluate and compare alternatives

Simulation is used to analyse data for diagnostic, prediction, and prescriptive analytics.

Internet of Things (IoT) and Designing Connectivity



IoT helps things to be smarter.

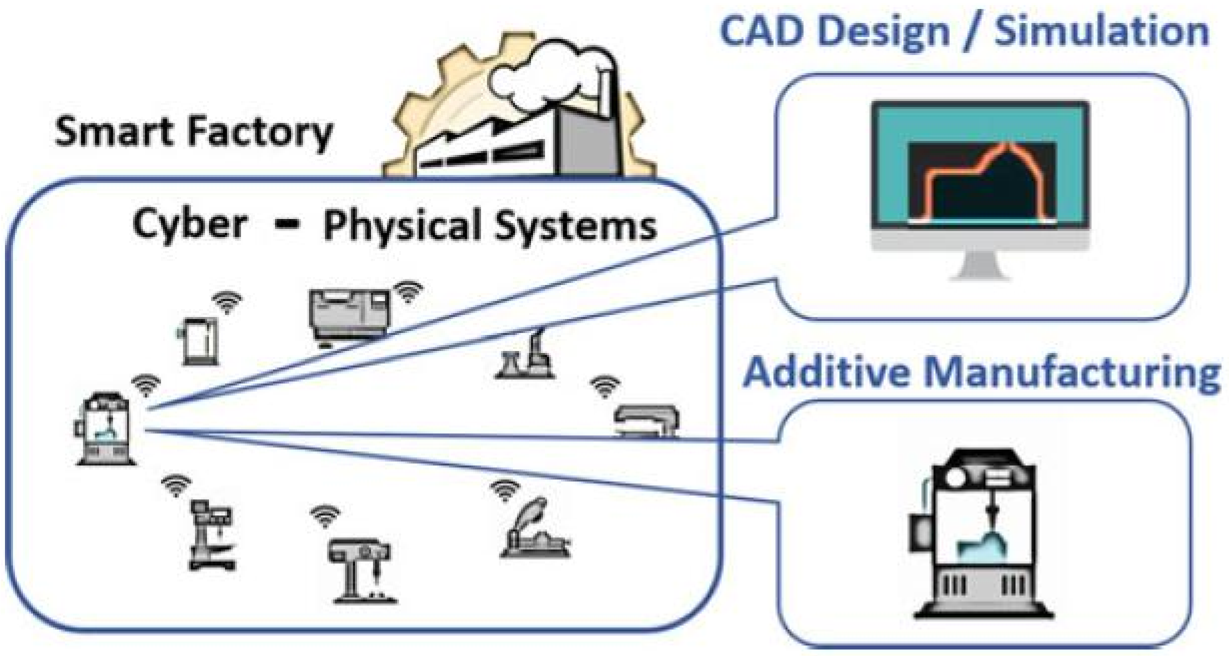
Expected benefits of using IoT in factories can be tested using simulation modelling. A simulation model of a factory with and without IoT can show differences between the two worlds, and help investment decisions.

e.g. what benefit can we gain if we track our finished products in our warehouse?

Simulation for Industry 4.0, Gunal, Murat (Ed. 2019)

Simulation can be used for designing and implementing IoT technology

Additive Manufacturing and Product Design



Additive manufacturing and simulation

Additive Manufacturing (AM) is a general term used for making 3D objects by adding forming material layer-upon-layer. It is a new way of manufacturing. It is mostly known with 3D printers.

Design of the object to be manufactured is done using CAD software. In the pre-manufacturing phase, 3D Printers software simulate the printing job, to avoid material loses and to test stability.

Simulation for Industry 4.0, Gunal, Murat (Ed. 2019)

Simulation in AM takes place in the design phase and pre-manufacturing phase.

Smart Factory: How it looks like?

What is new in Smart Factory?

What can be the contribution of simulation in Smart Factory?

What is new in Smart Factory

Discrete Event Simulation

Higher complexity
Generally larger, more sophisticated components;
More interaction between components.

→ It is difficult to **assess the impact of any specific advanced feature**. Simulation is possibly the only tool to allow you to objectively evaluate the interactions and contributions of each component, design a system that will work together, and then tune and improve that system.

More data
IT innovations such as Big Data and Cloud Operation make real time data much more available.

→ Use enhanced data to **identify areas of risk before implementation.**

Higher **automation and autonomy**:
operational flexibility.

→ An opportunity for a simulation to help assess those actions by **evaluating the performance of alternatives**.

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How DES contribute to Smart Factory

- predicting the resulting system performance
- discovering how the various parts of the system interact
- tracking statistics to measure and compare performance
- providing a knowledgebase of system configuration and its overall working
- serving as a valuable communication tool

Outline

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Smart Factory

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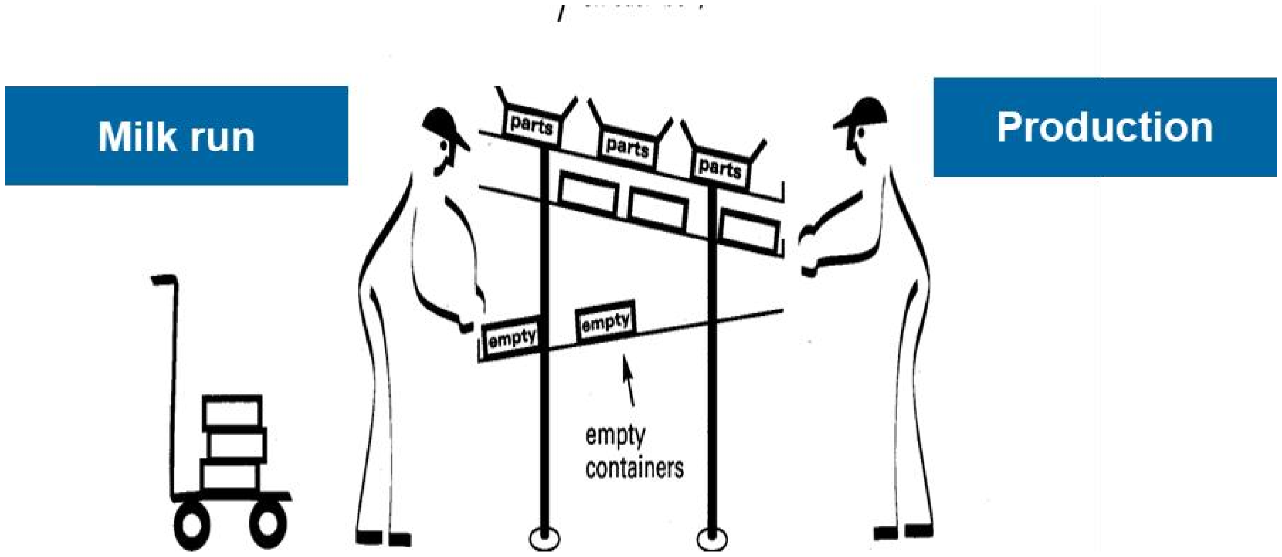
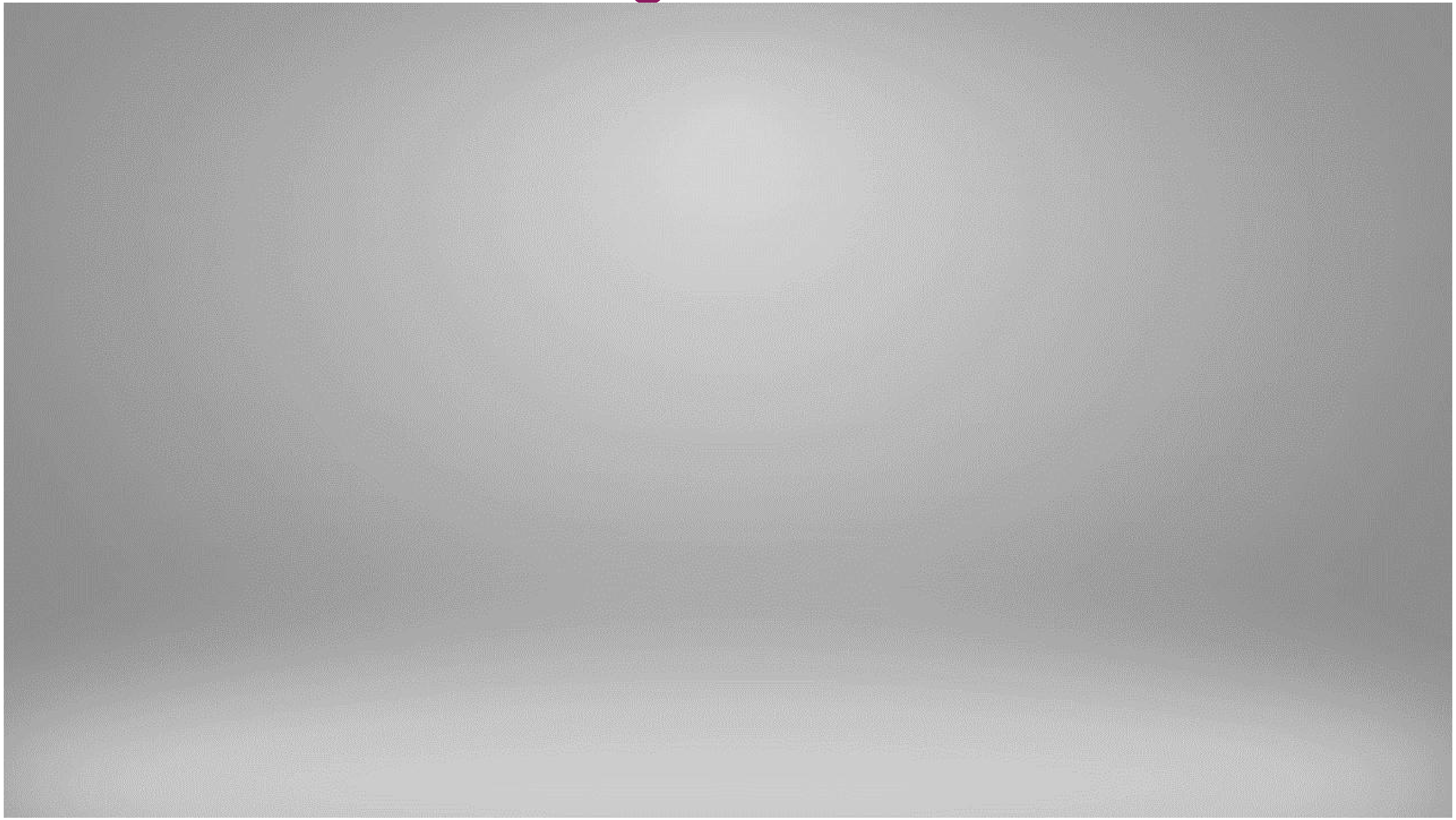
Simulation for the better: the future in Industrie 4.0

Simulation in Intralogistics Milk Run

The milk run is generally an “in-plant” transportation system where the materials are transported from a central area and delivered to different workstations within the facility.



Dynamic Milk Run Configuration



Targets and Decisions

Problem:
- Wrong material stock level in production stations: material missing (for some types), high stock (for other types).
- High labor cost.

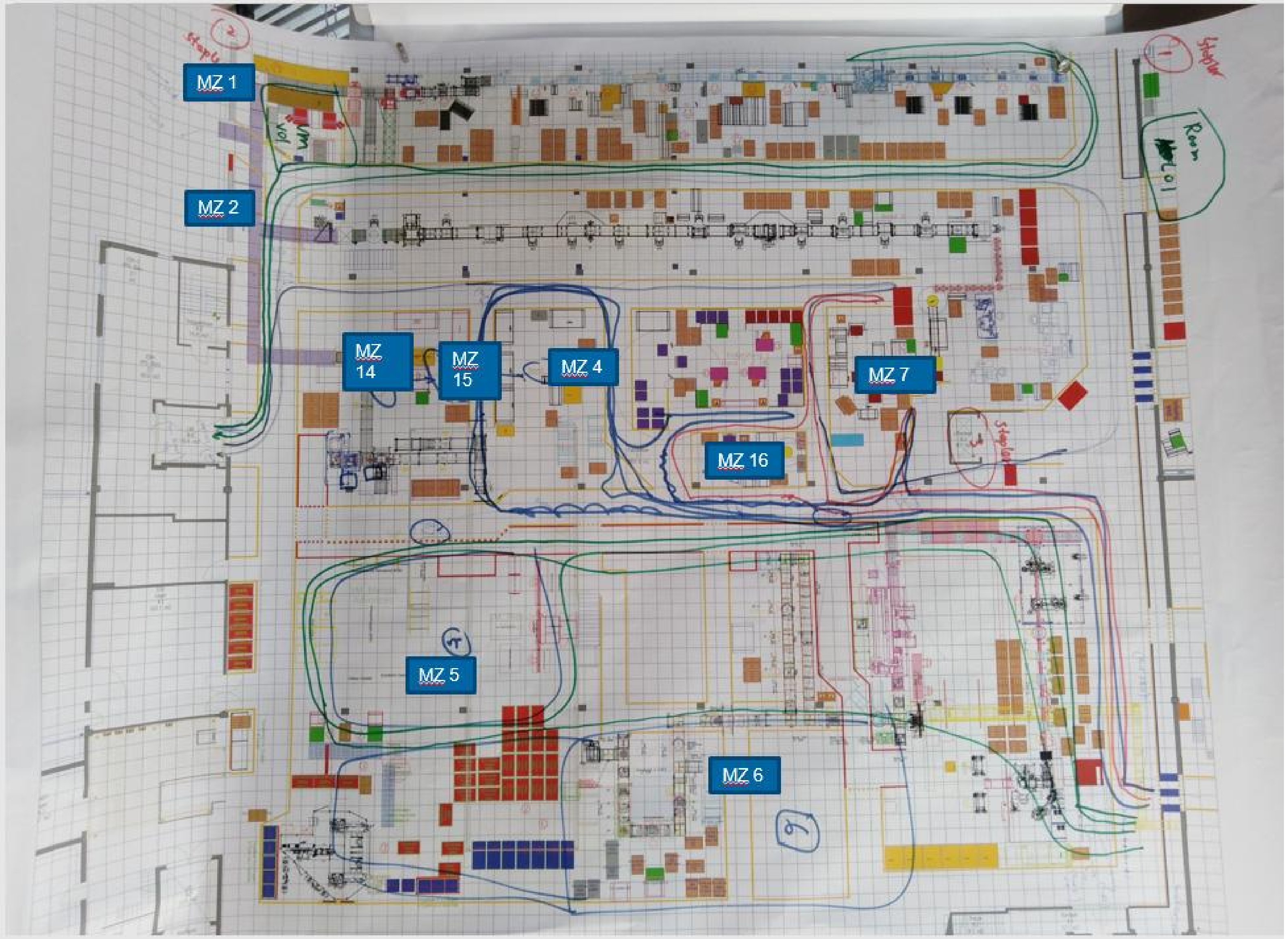
Targets:
A dishwasher manufacturer wants to better organize the milk run system of its production lines to **reduce the cost:**

1. **Inventory cost**
2. **Labor cost**

while keeping the **production running smoothly (no interruption of production)**.

Decisions:
1. Milk run interval
2. Configuration of boxes of the material: box size, number of boxes
3. Does digitalization of information to the employee help him in optimizing the work

Intralogistics Milk Run Input: Shop Floor Map



Intralogistics Milk Run Input: Raw Data

	autom.	Gebindeart	L	B	H	Stück pro Gebinde	Menge pro Palette	Menge pro Verpackung	Produktecode	durchschnittlicher Tagesverbrauch dTvH	Mehrfachverwendung Anz. AP	Quelllagerplatz	MZ	AP	WBZ-Code
2		221; B30307; Lagerfixkasten Gr. 221 rot	23	15	12.5	880	21000	3500	27	134.9	4	HF-L02-42.13.2	MZ-01	MO-L01-M01	Eingekauft
3		221; B30307; Lagerfixkasten Gr. 221 rot	23	15	12.5				27	5415	6	SFS	MZ-01	MO-L01-M01	Eingekauft
4		221; B30307; Lagerfixkasten Gr. 221 rot	23	15	12.5				27	2411	2		MZ-01	MO-L01-M01	Eingekauft
5		B-Boxe; B30008; Eurofix-Kasten EF 6179 rot	60	40	32	100	300	100	23	0.43	1		MZ-01	MO-L01-M01	Eingekauft
6		Palette	120	80	177	27	27	27	27	172.6	1	Bestellpunkt	MZ-01	MO-L01-M01	Eingekauft
7		Palette	120	80	194	27	27	27	27	118.9	1	Bestellpunkt	MZ-01	MO-L01-M01	Eingekauft
8		Palette	120	80	103	180	180	15	27	327.8	1		MZ-01	MO-L01-M01	Eingekauft
9		E-Boxe; B30009; Eurofix-Kasten EF 6180 rot	60	40	17	500	6000	2000	27	10.43	1	HF-L02-03.09.2	MZ-01	MO-L01-M01	Eingekauft
10		322; B30309; Lagerfixkasten Gr. 322 rot	35	21	20	130	5500	1100	27	290.8	1	HF-L02-02.09.1	MZ-01	MO-L01-M01	Eingekauft
11		322; B30309; Lagerfixkasten Gr. 322 rot	35	21	20	100	14400	400	27	325	1	HF-L02-04.07.1	MZ-01	MO-L01-M01	Eingekauft
12		322; B30309; Lagerfixkasten Gr. 322 rot	35	21	20	270	6000	1500	27	166.9	1	HF-L02-02.10.1	MZ-01	MO-L01-M01	Eingekauft
13		322; B30309; Lagerfixkasten Gr. 322 rot	35	21	20	170	3120	1560	27	325	1	HF-L02-02.10.2	MZ-01	MO-L01-M01	Eingekauft
14		322; B30309; Lagerfixkasten Gr. 322 rot	35	21	20	175	2000	1000	27	34.31	1	HF-L02-03.12.2	MZ-01	MO-L01-M01	Eingekauft
15		Original	60	40	39	54	1000	54	27	6.3	1	HF-L02-07.06.1	MZ-01	MO-L01-M01	Eingekauft

Input Elements to be considered

Topic	Elements
Stations	1. Shop floor layout 2. Materials to be consumed
Material	1. Article Number, 2. Working station, consuming rate at each working station 3. Price, inventory penalty
Labor /Forklift	1. Route plan, walking speed 2. Labor yearly salary
Digitalization	1. Material filling speed with/ without digital information

KPIs, Constraints and Decisions

Topic	KPI	Decisions	Constraints
Material	1.Inventory cost 2.Stock-out times	1. Kanban box amount 2. content in each Kanban box	No interruption of production
Labor / Forklift	1.Labor cost 2.Labor utilization	Milkrun interval	
Digitalization		Yes or no	

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How to Solve the Problem? By Excel

6 months history record (2520 rows): One type of material, in one workstation

	KanbanContent	Boxes	Av. Inventory Costs	Labor Costs
	550	3	CHF 7,106.02	99,000.00
	Average Demand per day	Replacement Time	Stock Out (timelength*amount)	**Total Costs**
	1245	1:00:00	0.00	**CHF 106,106.02**

Time	Demand per day	Average Demand per 30 min	Number of products at AP	Milkrun request	Milkrun	Inventory Costs	StockOut
8:00:00 AM	1245	62.3	1650	1	1	CHF 8,250	0
8:30:00 AM	1245	62.3	1588	0	0	CHF 7,939	0
9:00:00 AM	1245	62.3	1526	0	1	CHF 7,628	0
9:30:00 AM	1245	62.3	1463	0	0	CHF 7,316	0
10:00:00 AM	1245	62.3	1401	0	1	CHF 7,005	0
10:30:00 AM	1245	62.3	1339	0	0	CHF 6,694	0
11:00:00 AM	1245	62.3	1277	0	1	CHF 6,383	0
11:30:00 AM	1245	62.3	1214	0	0	CHF 6,071	0
12:00:00 PM	1245	62.3	1702	1	1	CHF 8,510	0
12:30:00 PM	1245	62.3	1640	0	0	CHF 8,199	0
1:00:00 PM	1245	62.3	1578	0	1	CHF 7,888	0
1:30:00 PM	1245	62.3	1515	0	0	CHF 7,576	0
2:00:00 PM	1245	62.3	1453	0	1	CHF 7,265	0
2:30:00 PM	1245	62.3	1391	0	0	CHF 6,954	0
3:00:00 PM	1245	62.3	1329	0	1	CHF 6,643	0
3:30:00 PM	1245	62.3	1266	0	0	CHF 6,331	0
4:00:00 PM	1245	62.3	1204	0	1	CHF 6,020	0
4:30:00 PM	1245	62.3	1142	1	0	CHF 5,709	0
5:00:00 PM	1245	62.3	1630	1	1	CHF 8,148	0
5:30:00 PM	1245	62.3	1567	0	0	CHF 7,836	0
6:00:00 PM	1245	62.3	1505	0	1	CHF 7,525	0
8:00:00 AM	1245	62.3	1443	0	1	CHF 7,214	0
8:30:00 AM	1245	62.3	1381	0	0	CHF 6,903	0
9:00:00 AM	1245	62.3	1318	0	1	CHF 6,591	0
9:30:00 AM	1245	62.3	1256	0	0	CHF 6,280	0
10:00:00 AM	1245	62.3	1194	0	1	CHF 5,969	0
10:30:00 AM	1245	62.3	1132	1	0	CHF 5,658	0
11:00:00 AM	1245	62.3	1619	1	1	CHF 8,096	0
11:30:00 AM	1245	62.3	1557	0	0	CHF 7,785	0

In reality the production plant has thousands of materials, 200 workstations and many production lines.

Simulation Approach

Display KPIs:

1. Cost: labor cost, inventory cost
2. Labor utilization
3. Inventory level (material value), material missing

Controls:

1. Milk run interval
2. Kanban configuration
3. Digital information
4. Demand distribution
5. Labor yearly salary

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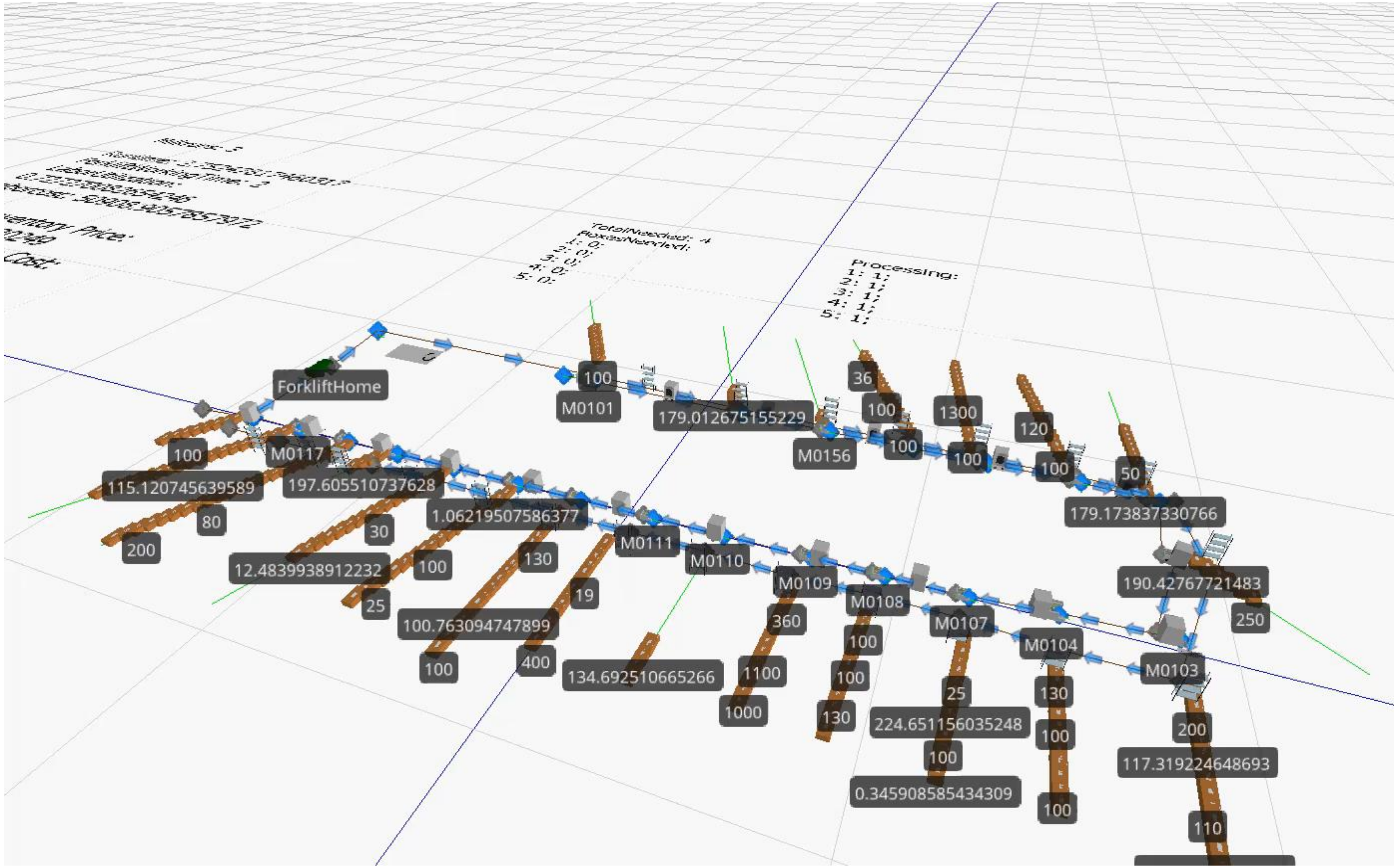
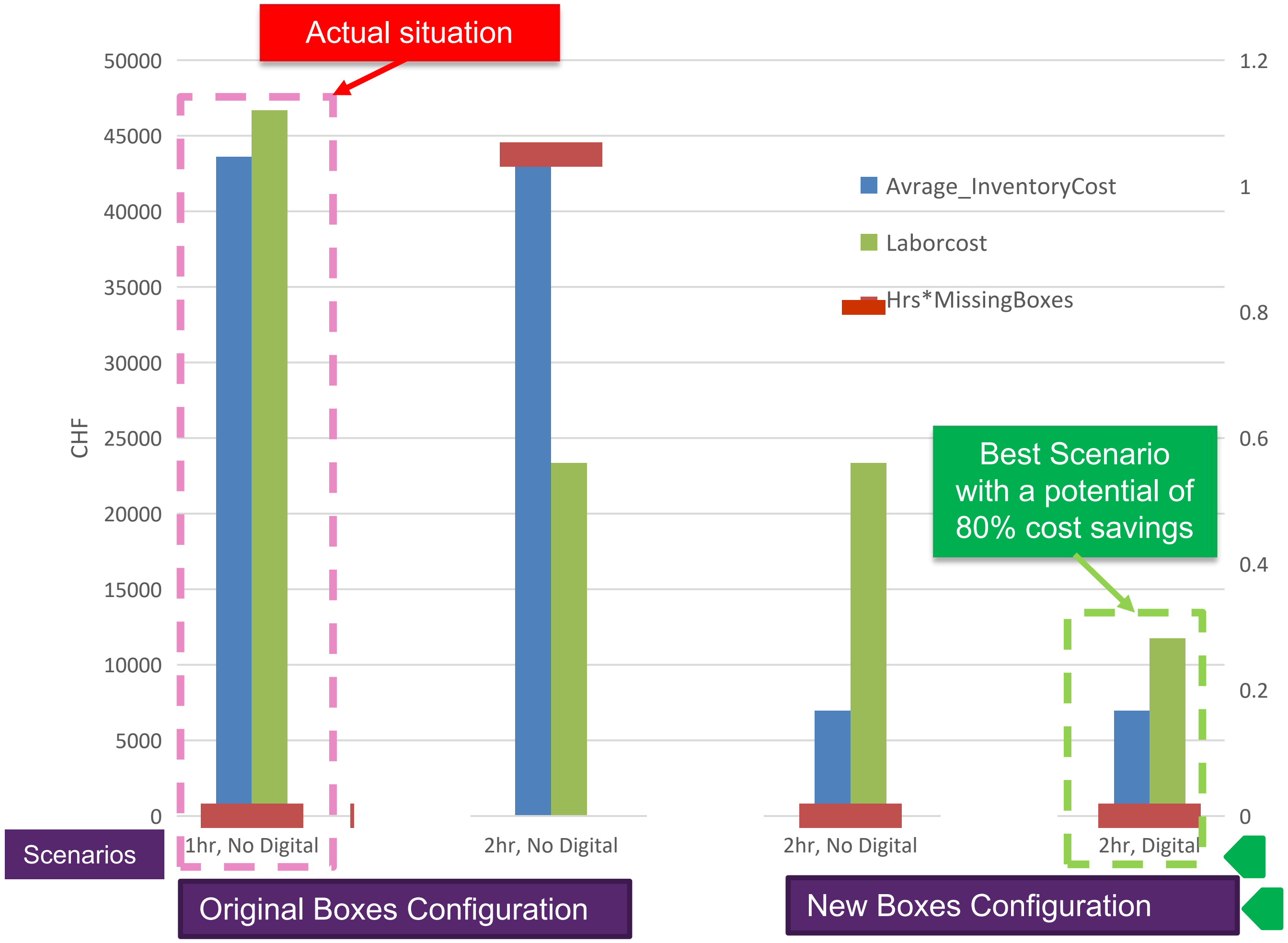
How to Solve the Problem? By Simulation



Results: Performance Comparison



Optimized Kanban box Quantities	the average inventory value in production line about 84%
Reduce the milk runs from hourly to 2 hour interval	reduces labor cost by 50%
Use the digital information about empty Kanban boxes	reduces labor cost for another 25%

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Outline

Basics

DES for process improvement

Simulation
Industrie 4.0
Smart Factory

Applications in Smart Factory

Traditional simulation applications

- Production planning:
  - Milkrun configuration
  - Lot sizing
- Production network management

Digital Twin

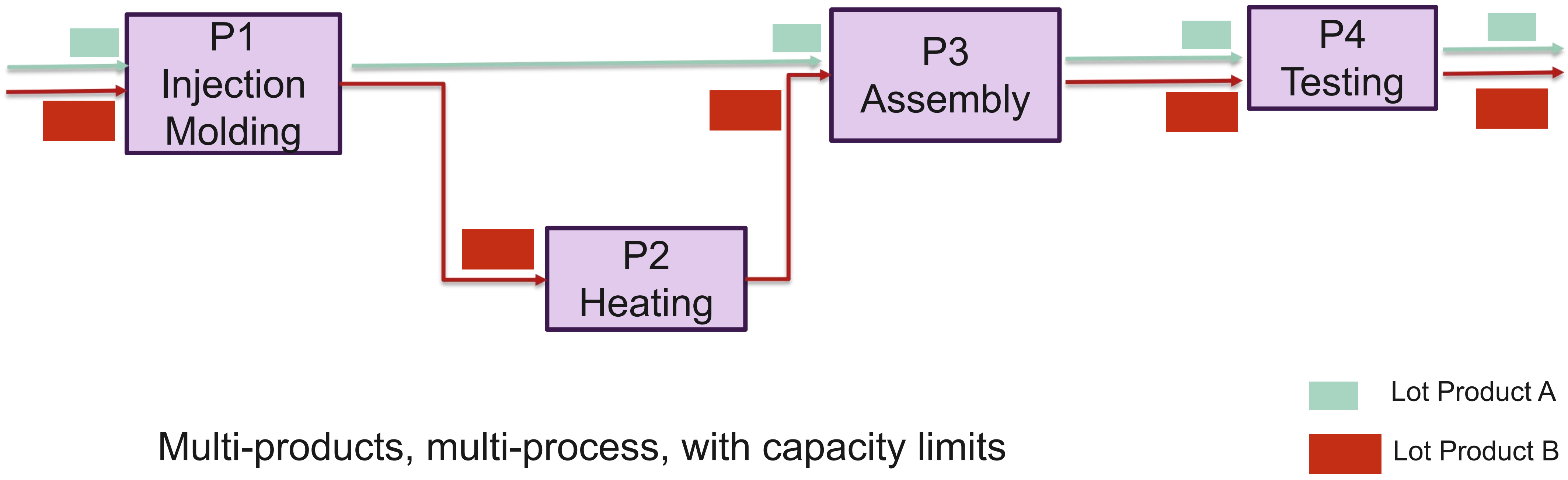
- Overview
- Applications

Perspective

Simulation for the Better:
The Future in Industry 4.0

Lot Size Configuration

The lot size (batch size) refers to the quantity of products or parts in one production order that are produced directly one after the other without an interruption in production.



Multi-products, multi-process, with capacity limits

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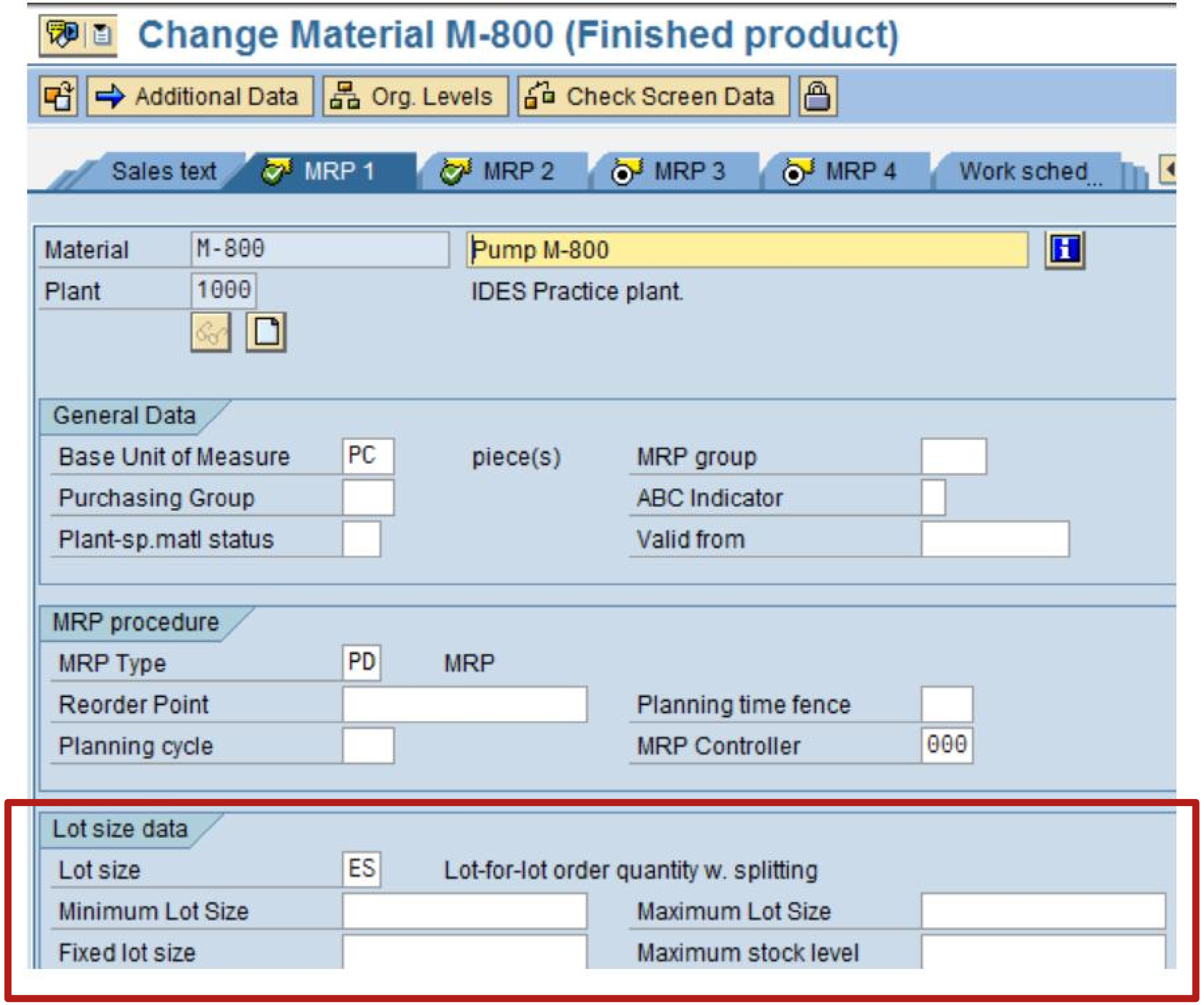
Lot Size in SAP



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Case Setting

Process:

- 12 products, 28 processes
- With capacity limits: most of processes has only 1 machine, working 2 shifts * 9 hrs/shift
- FIFO line before every resource: products are scheduled to be processes by FIFO rule
- A processing step is always completed for a given order before the next step is started (NO splitting)

Data:

- Demand: 36 months historical data
- Processing time: product and process specific
- Setup time: resource specific, not product specific
- Current lot-Size = Pieces per Coil
- Target lead time: 4 weeks
- Hourly rate: constant for each process (independent on tasks: setup or processing)
- Inventory cost: product specific

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Targets and Decisions

Problem:

- Low throughput, very low on-time-delivery rate
- High inventroy level for some product types

Targets:

1. Understand how is the capacity utlization: find the bottle-necks
2. Increase thoughputs and service level: Improve hourly produced and hourly delivered amounts, fill-rate and on-time delivery rate
3. Reduce costs

Decisions:

1. How many machines are needed for each process?
2. What are the reasonable lot sizes for each product?

How to Determine Lot Sizes

Lot sizing decisions thus are crucial to run operations competitively, but belong to one of the most difficult problems in production planning.

Examples of Lot Sizing Methods (Lean Production Course)

- Lot-for-lot
- Fixed Order Quantity and EOQ
- Fixed Order Period (Optimum Length of Order Cycle)
- Part-Period Balancing

EOQ

Parameters:

D = Yearly Demand (unit / year)

C = Purchasing price (CHF / unit)

Q = Order Quantity (unit)

A = Fixed ordering (setup) cost per Order (CHF)

p = Inventory interest cost (%)

Total cost = $Y(Q) = CD + pC\frac{Q}{2} + A\frac{D}{Q}$

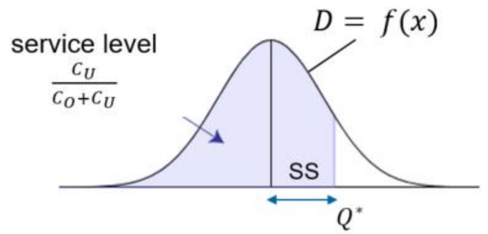
Net purchasing cost (Einkaufskosten)

Carrying cost (Lagerkosten)

Setup and Ordering cost (Bestellkosten)

Newsvendor

$$P(D \leq Q^*) = \frac{c_U}{c_O + c_U}$$



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How to Determine Lot Sizes

- Do you have any other approaches?
- Why you want to use another approach?

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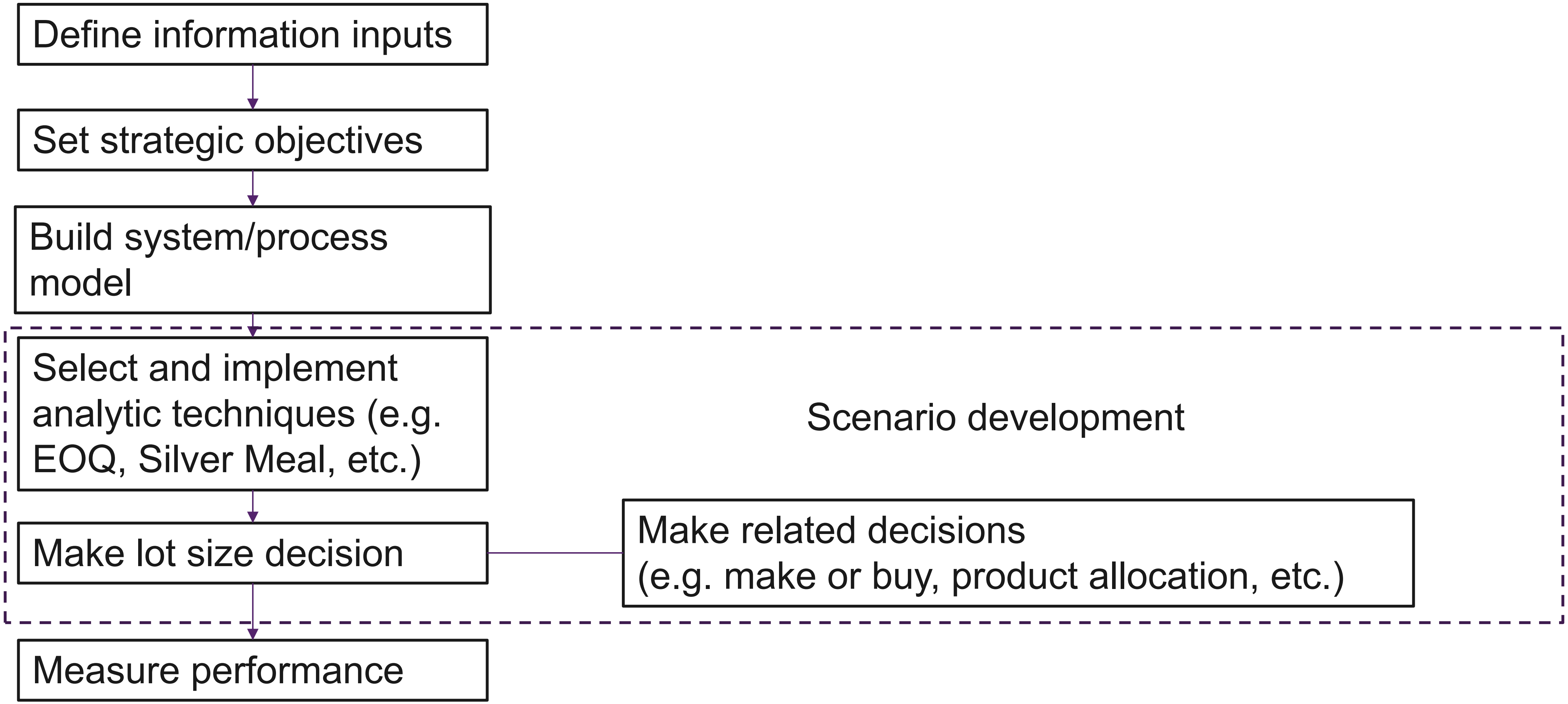
Simulation Approach:
Building Blocks for Lot Size Decision-Making with Simulation



Lot Size Configuration - Hands on

What are the input data, which you may need for a reasonable lot size configuration decision?

Product characteristics

- Number of products
- Bill of materials, material quality, necessary process sequence
- Historical demand, expected lead-time

System/Process characteristics

- System type: Pull or push system, production system levels, priority and sequencing rules in buffers and order splitting
- Resource parameters: setup time, processing time, resource working schedule, capacity and reliability

Costs

- Fixed cost: set-up cost
- Variable costs: processing cost, inventory cost

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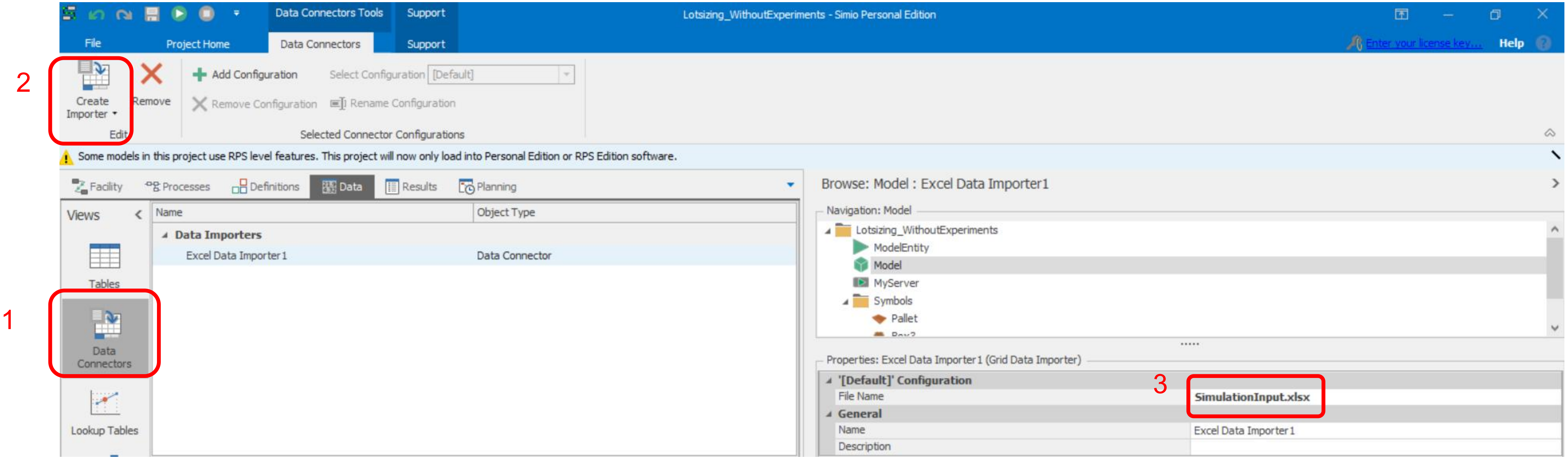
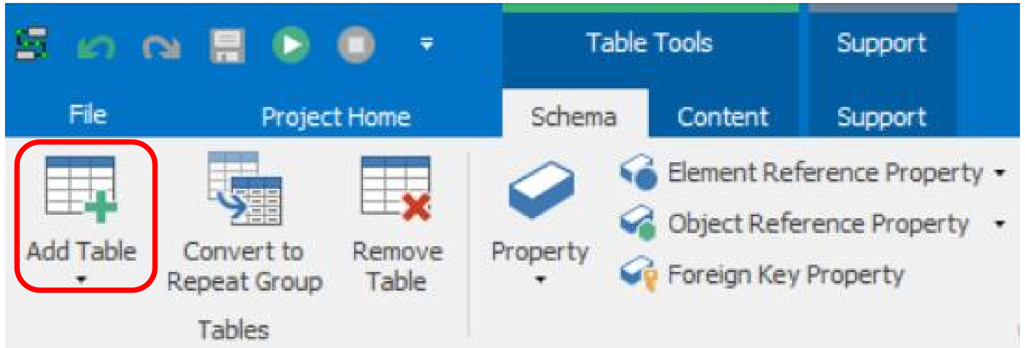
Data Import into Simio

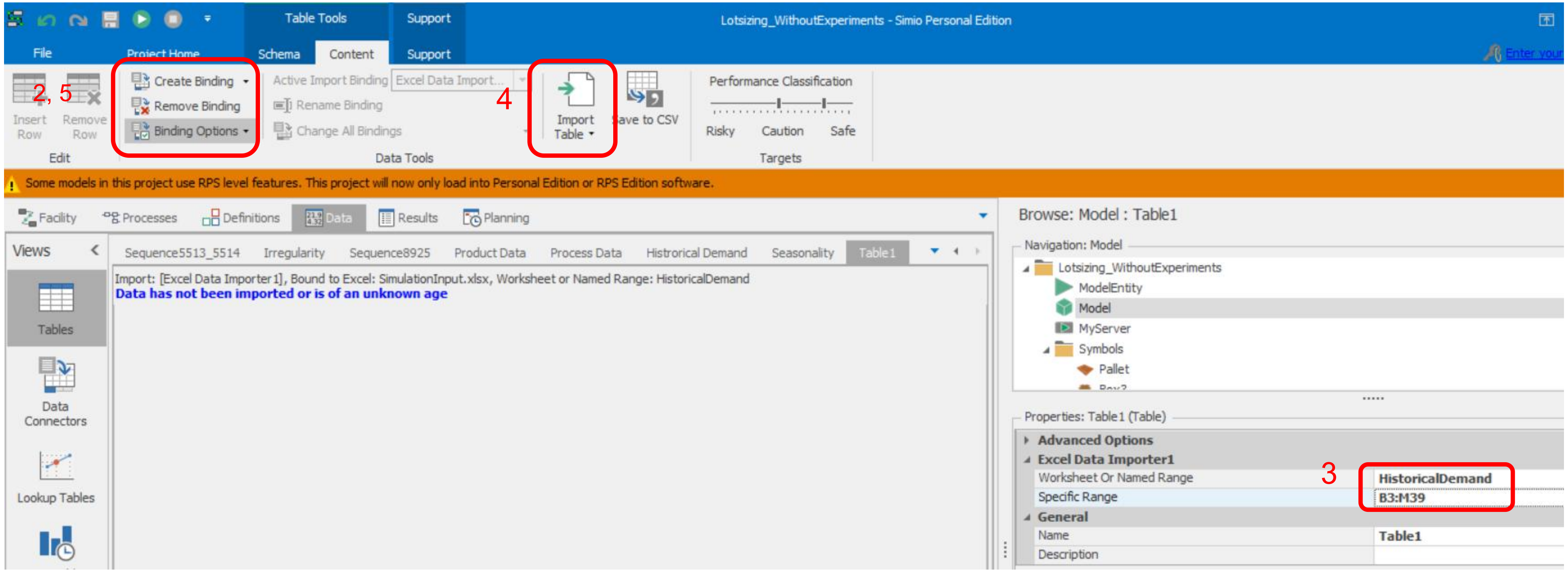
- Step 1: Creat Data Conectors



Data Import into Simio

- Step 2: Add Table and Create Binding





Lot Size Configuration - Hands on

What are the KPIs (targets), which could be of a production manager's interest?

- Costs: the total cost of the whole plant contains two parts: operations and inventory costs. The hourly rate for each process is modelled as constant (independent of product and task). The inventory costs depend on the product type.
- Throughput: hourly produced and hourly delivered amounts (for the whole plant) are calculated as the corresponding total amount divided by the time simulated.
- Fill rate: For the type of product and the whole plant, the corresponding fill rate is calculated as “delivered amount/ demanded amount”.
- OTD rate: For each product type and the whole plant, the fill rate can be calculated as “on time amount delivered / amount delivered”.
- Utilization: the utilization of each machine is calculated as (set-up time + process time) / (set-up time + process time + idle time).

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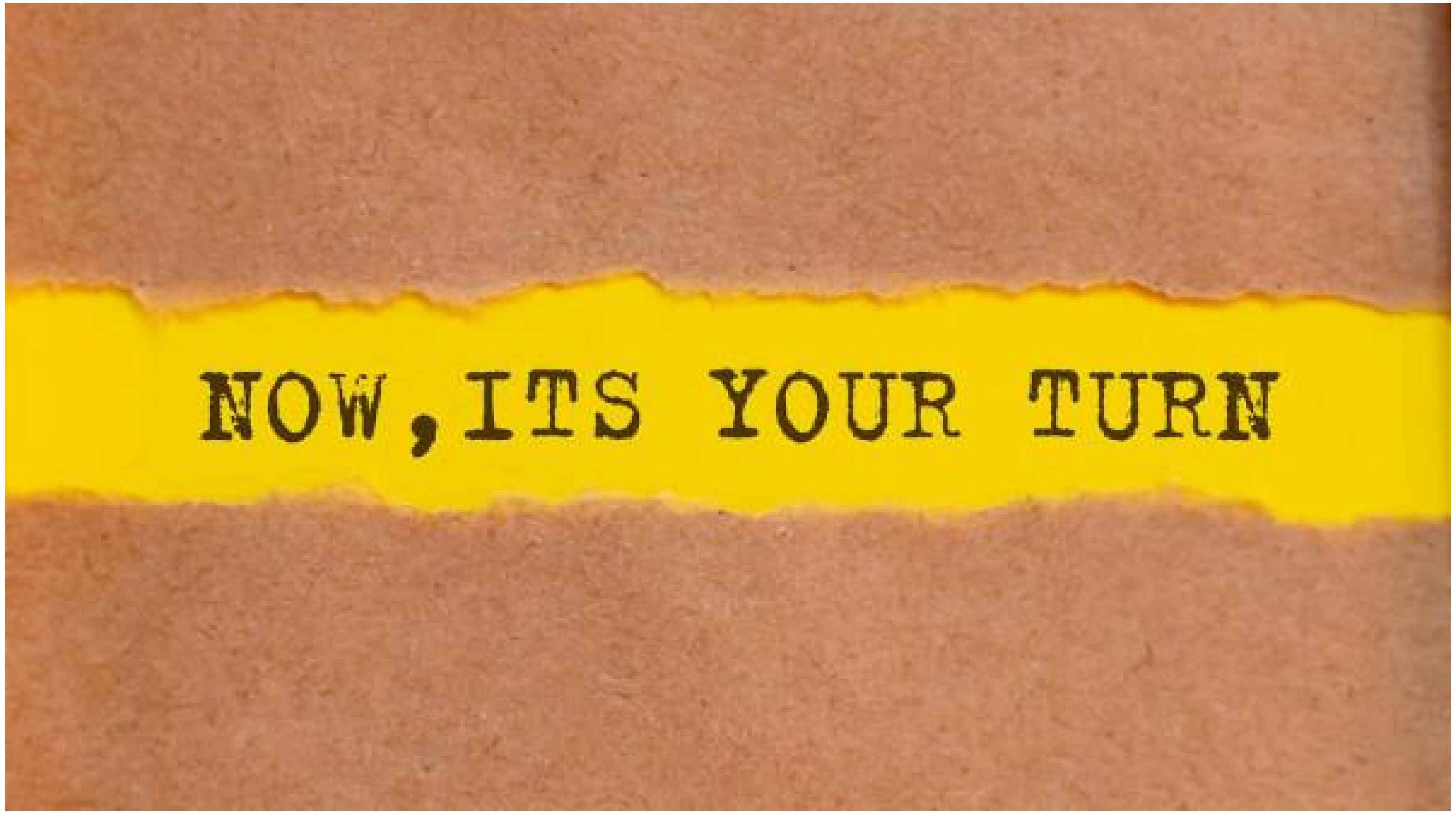
Lot Size Configuration - Hands on

With the data in hand, try to find a reasonable lot size for all types of products in our factory.

How you will do it?



Simulation Model

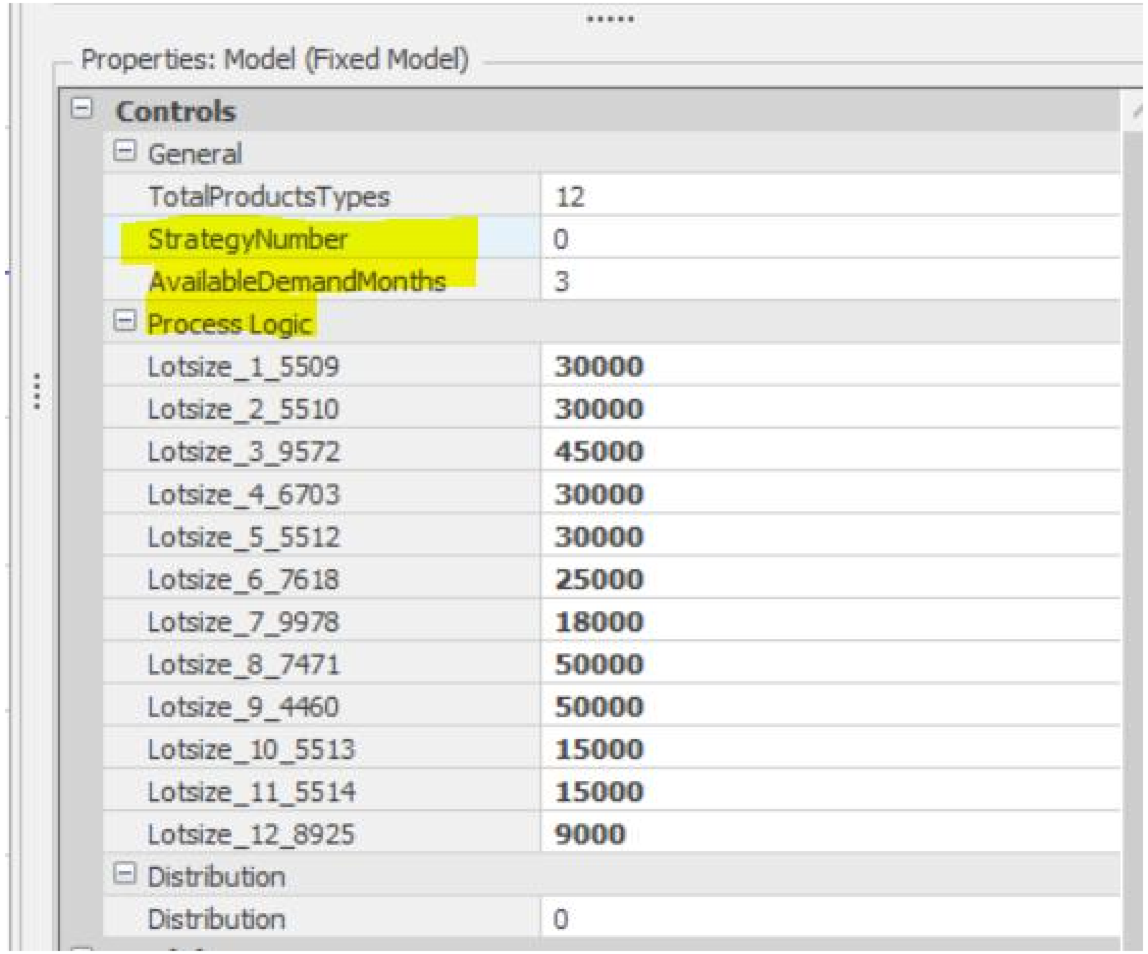
Display KPIs :

1. Capacity utlization
2. Thoughputs and service level: hourly produced and hourly delivered amounts, fill-rate and on-time delivery rate
3. Costs: prodcution cost, inventory cost

Controls:

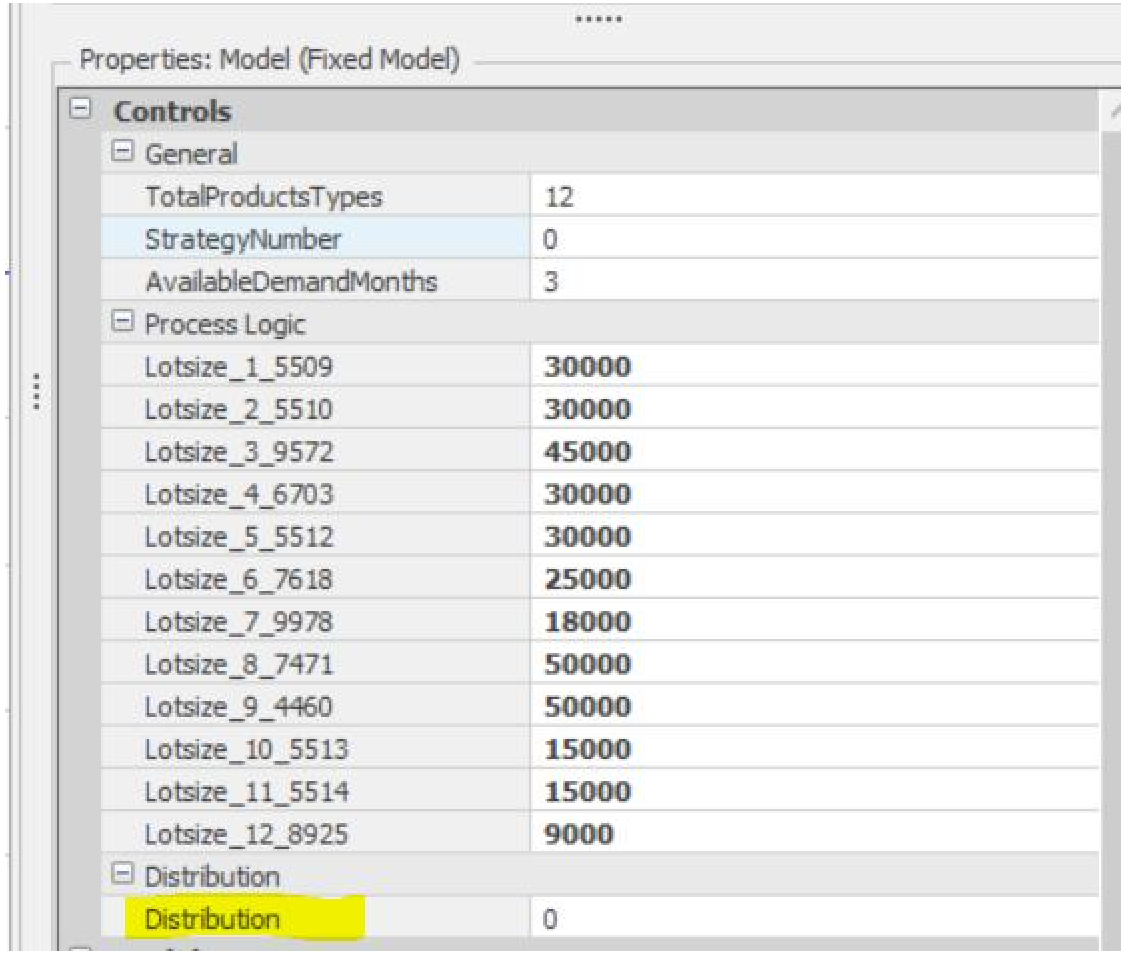
1. Process schedule
2. Lot size (amount, logic)
3. Inventory management logic (using order point or not)
4. Demand pattern (history data, or formulated distribution)

You can choose the strategy number and the corresponding parameters



Strategy number	Strategy Name	Details
0	Self defined lot size	Default value=current lot size, we can change the lot size in the facility window
1	Lot to lot	We can define the Window: =0, produce the demand amount of the current month = x, produce the demand amount of x month later
2	EOQ	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point
3	Fixed Order Period	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point
4	Silver-Meal heuristics	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point
5	Part period balancing	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point
6	Least Unit Cost	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point
7	Groff's Marginal Rule	Using Reorder point? =0, projected stock level goes to negative =1, projected stock level goes to lower than reorder point

You can choose the demand pattern by changing "distribution number "



Number	Distribution
0	History data
1	Constant demand
2	Normal (mean, std)
3	Uniform distribution [0.8*mean, 1.2*mean]
4	Sesonality
5	Irregularity

Summary

Basics:

1. What DES can do in a Smart Factory ?	⇨	To improve process
2. When to use simulation?	⇨	When process is known, but (some) inputs are unknown
3. Optimization vs. Simulation	⇨	Not the same
4. Simulation vs. Industrie 4.0	⇨	Very relevant

Hands-on:

1. Basic approach in using simulation to support smart factory decision-making

2. Import data from different data resources

3. Evaluate the performance of different solutions under various condition assumptions

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