IMIM
International Master in Industrial Management

Industry 4.0 Lab

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POLITECNICO DI MILANO
GRADUATE SCHOOL
OF BUSINESS

HERIOT WATT UNIVERSITY

POLITÉCNICA

School of Economics and Management
Beijing Jiaotong University
北京交通大学

Technical University of Munich

tbs Toulouse Business School

FT Executive Education Ranking 2017

FT European Business Schools Ranking 2017

EFMD EQUIS ACCREDITED

ASSOCIATION AMBA ACCREDITED

EFMD GLOBAL NETWORK EOCCS CERTIFIED

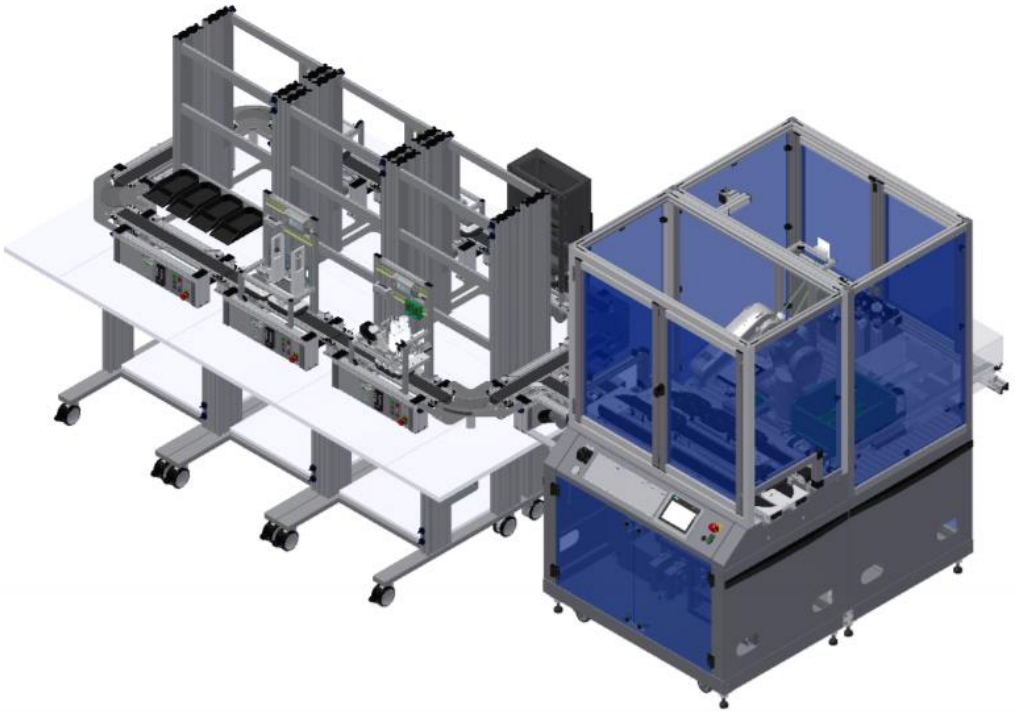
Agenda

- I4.0Lab @ SOM: what, why and people working around
- The plant structure
- Key features
- Exercise

What: I4.0Lab @ SOM at POLIMI

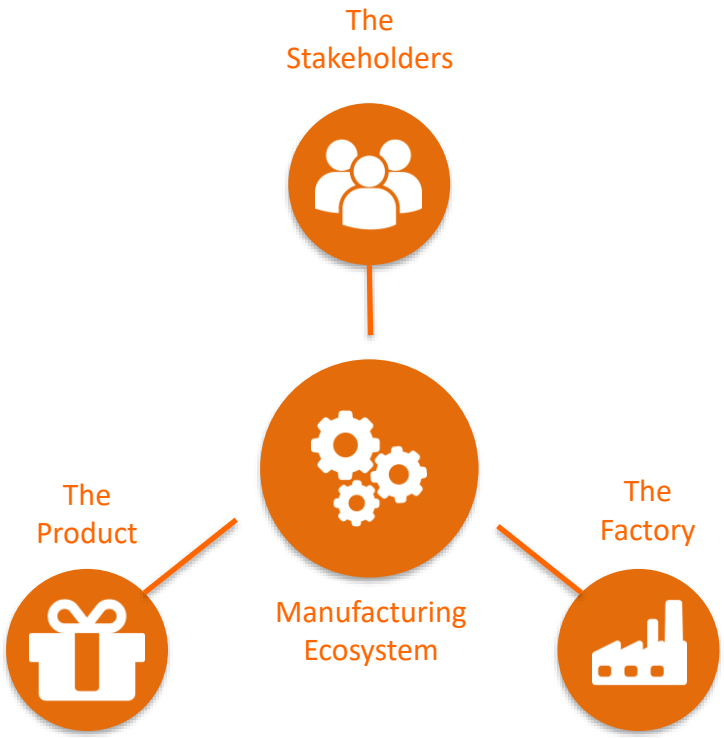
- **I4.0Lab @ SOM** is promoted and developed by Manufacturing Group of the School of Management of Politecnico di Milano

It is implementing a **tangible physical entity** where the research activity in the innovative manufacturing management and planning approaches can be carried out in conjunction with a **practical implementation in a "real-like" environment**



Why: Vision at I4.0Lab @ SOM

The Manufacturing EcoSystem where **I4.0Lab @ SOM** is positioned includes 3 major dimensions to consider: the **human factor**, the **product**, the **process/plant**



The product and the factory are two main pillars to consider both in term of **management**, **control** and **monitoring**, but also in terms of **complete Life Cycle** to centralize the human factor within the Manufacturing EcoSystem

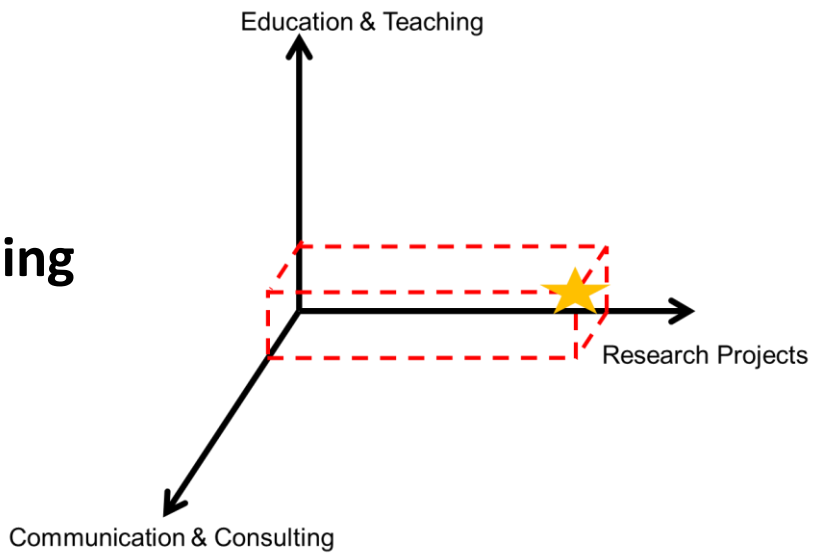
Why: Mission at I4.0 Lab

- For the exploitation perspective we expect I4.0Lab @ SOM addresses **3 main purposes**:

Education & Training

Communication and Consulting

Research Projects related activities



People working around I4.0Lab @ SOM

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Fixed staff (2 people)

4 Master's candidate

SOM MFG-Group Team

Researchers senior &assistant

5 PhD students

Working on different European Project
PERFORM; MAYA; PSYMBIOSYS; BEinCPPS; L4MS; MIDIH; M2020; Fenix; 5G; Fasten.

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Collaborations and external connections

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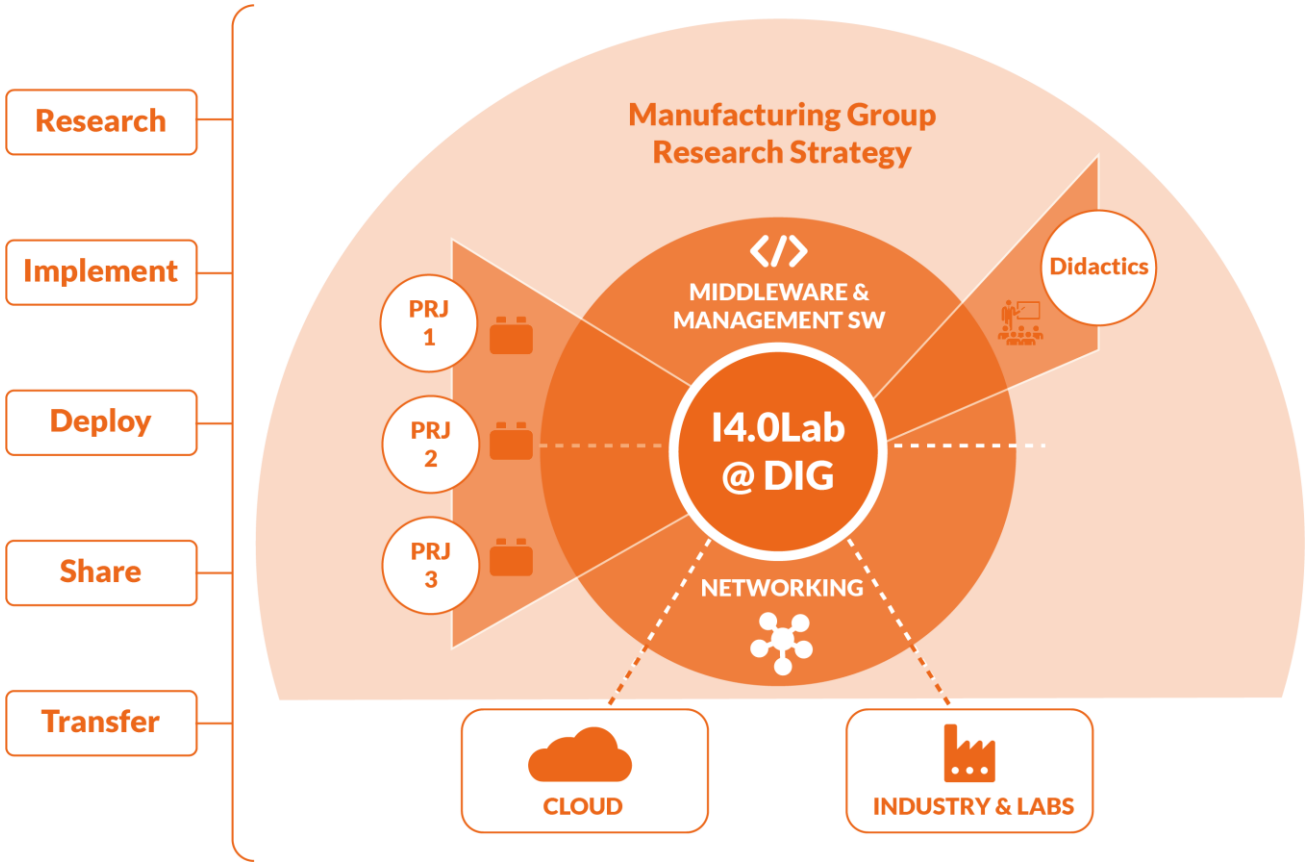
Enterprises

Competence Centres

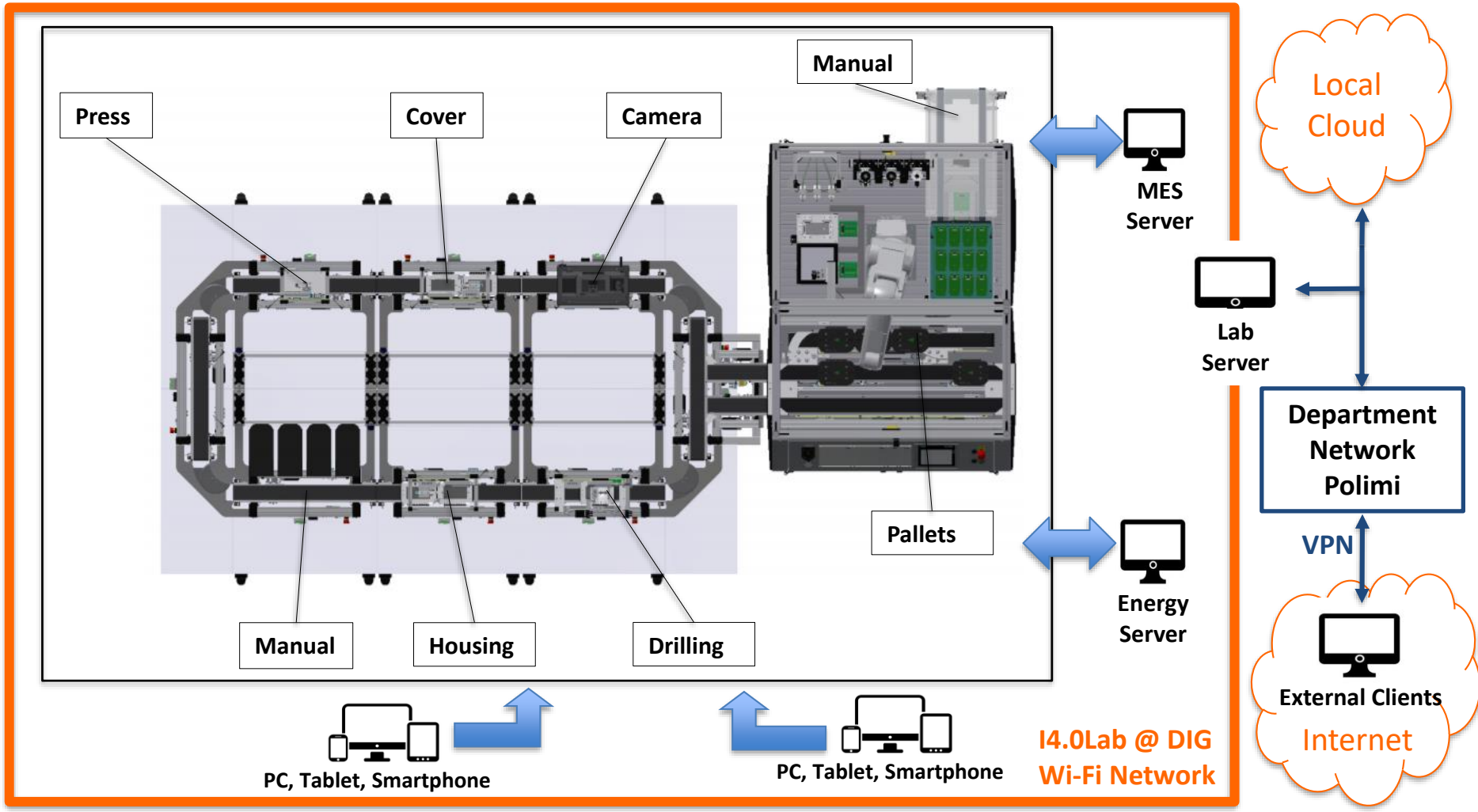
Other Universities

Other Polimi Departments

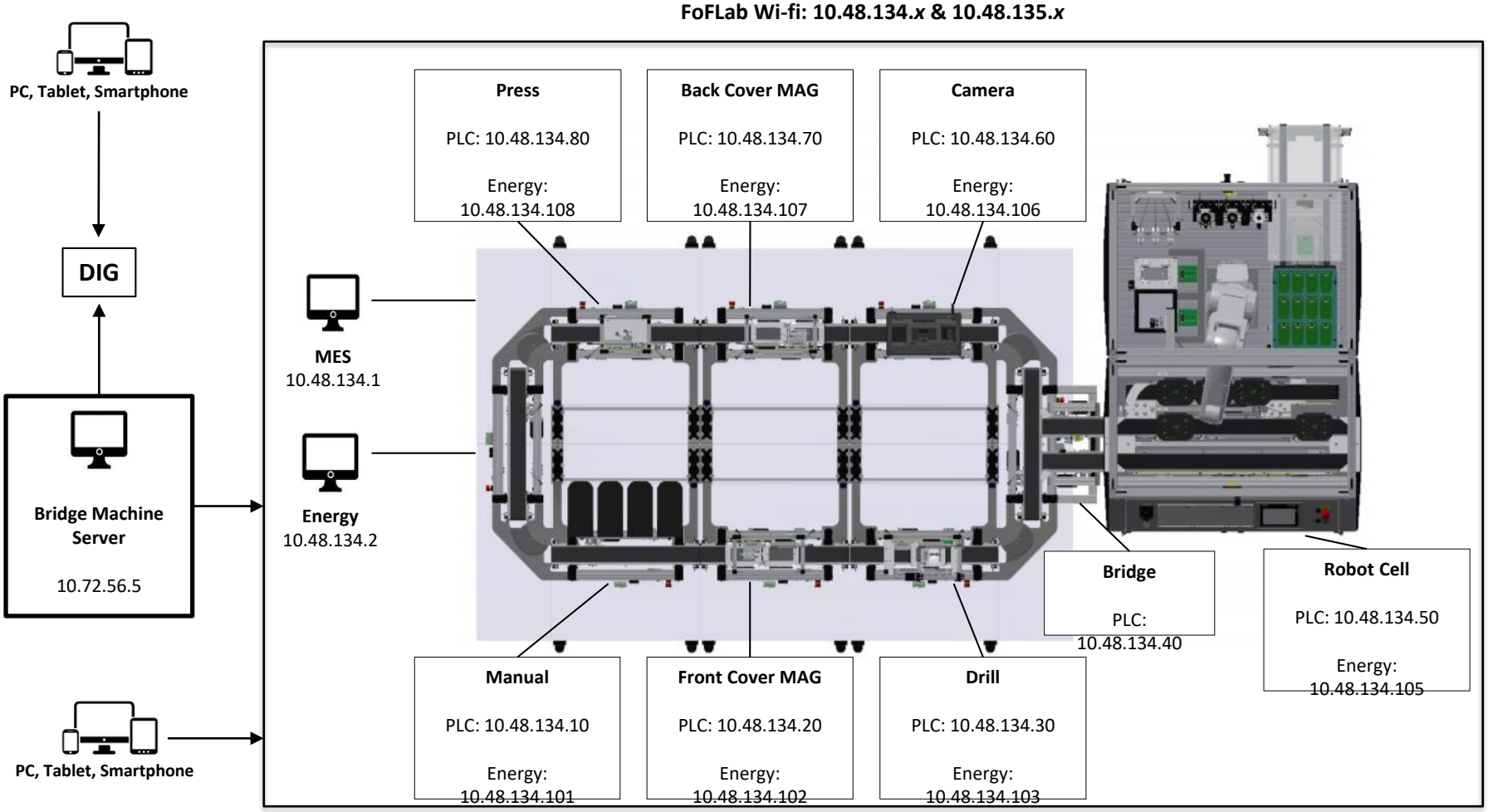
I4.0 Lab in the knowledge value chain of SOM-MFG Group



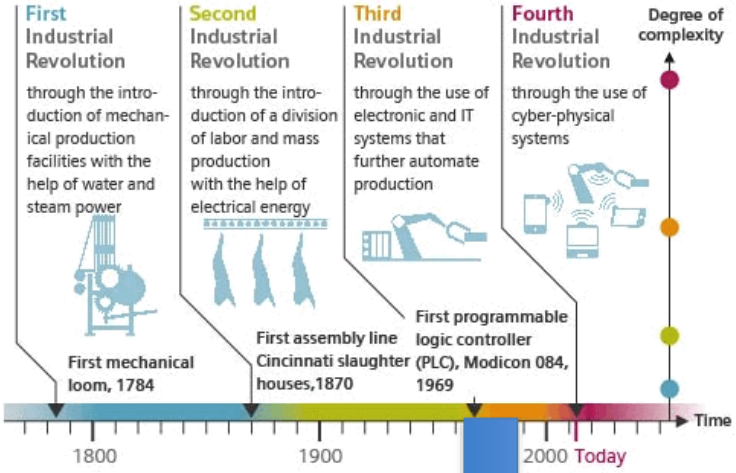
I4.0Lab Structure: Equipment Layout

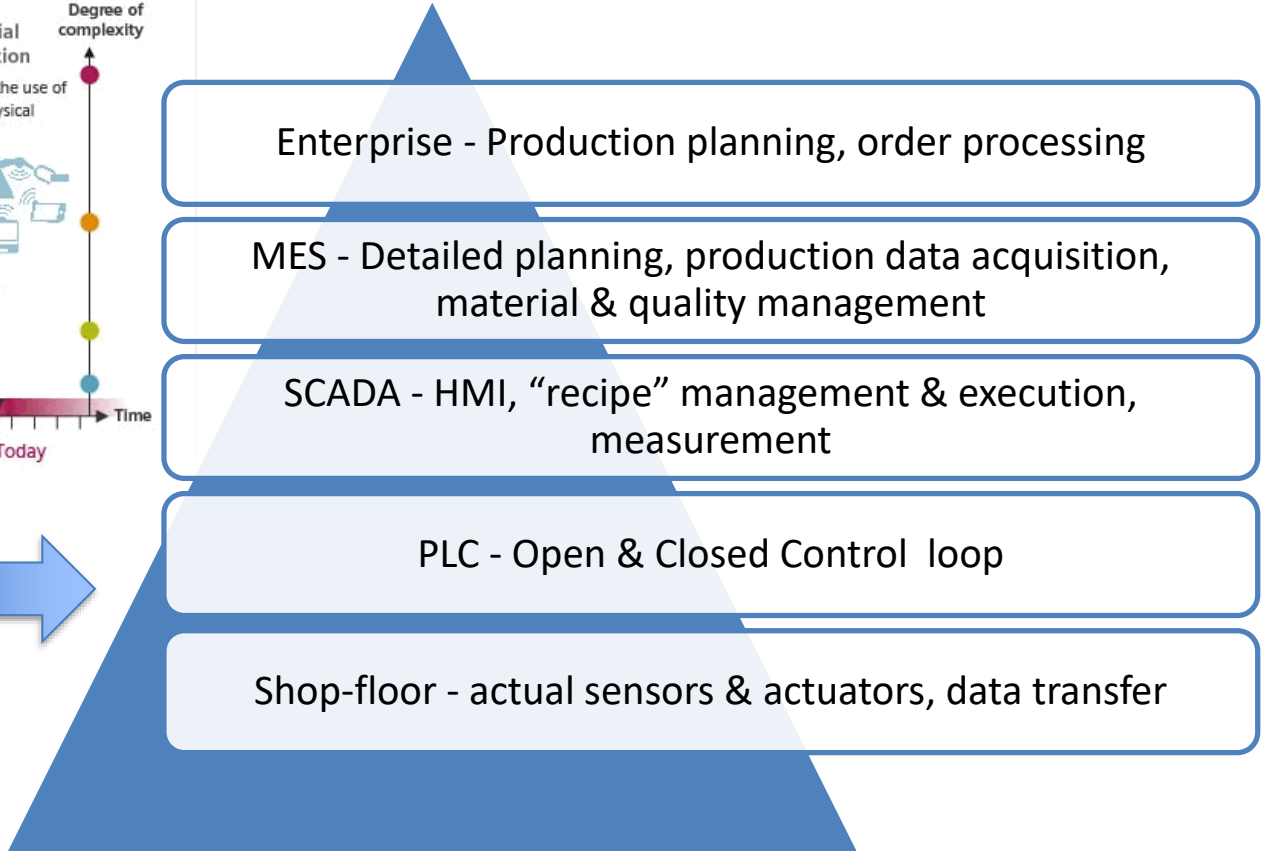


I4.0Lab Structure: Equipment Layout (2)



Automation Pyramid

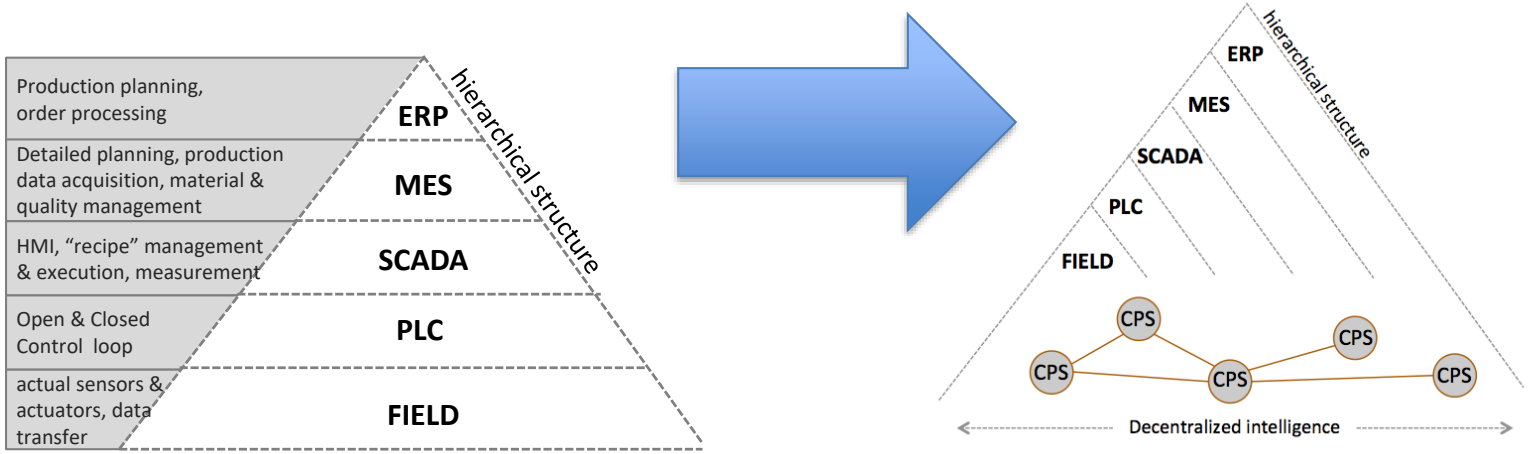




Multilayered, hierarchical, functional oriented

CPS paradigm shift

- The Automation pyramid concept, traditionally used to describe the different system levels of an overall automation solution, needs to evolve.
- CPS overcome the concept of rigid hierarchical levels, being each CPS capable of complex functions across all layers.



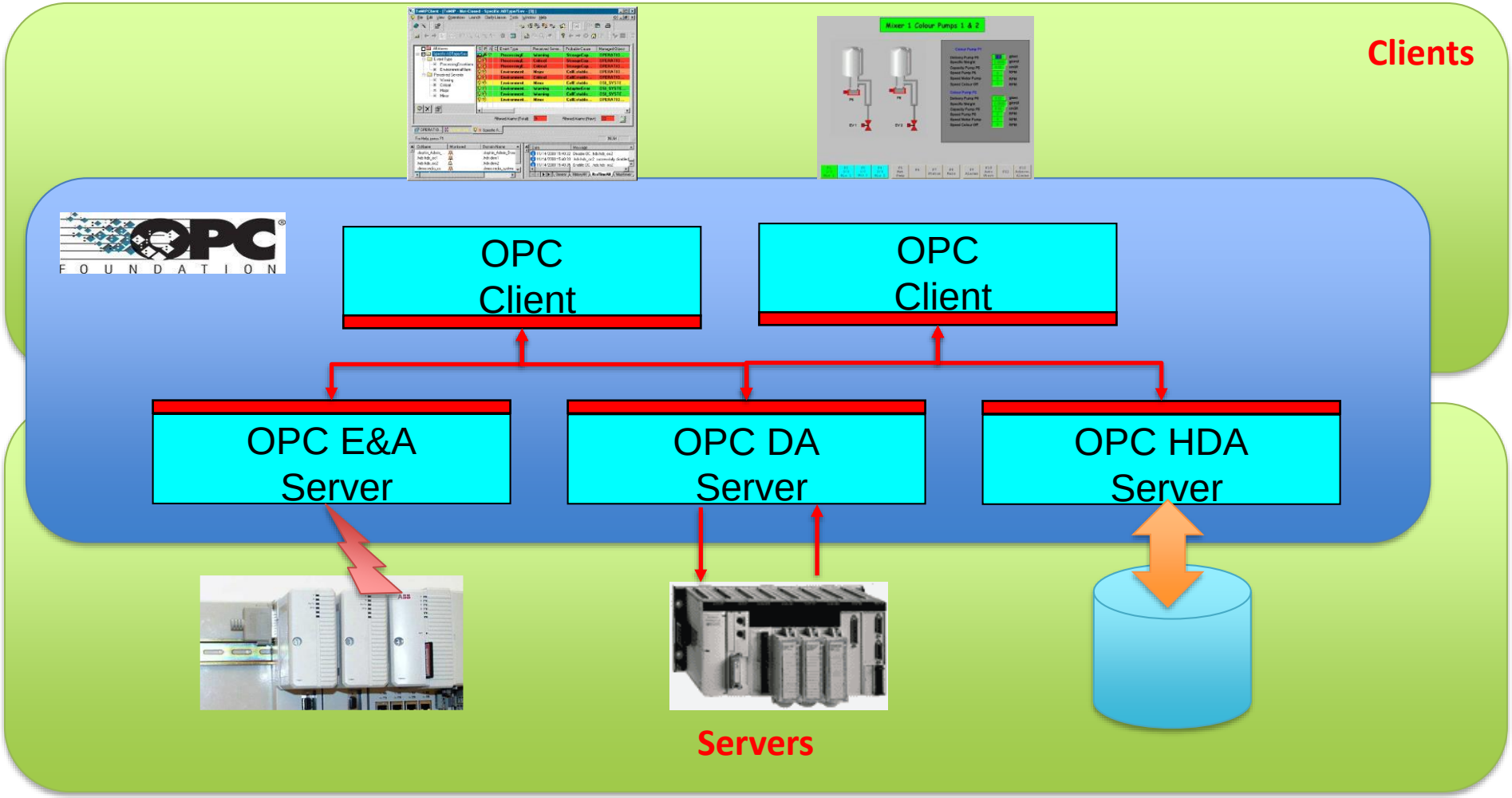
OPC UA

- OPC Unified Architecture (OPC-UA) is the data exchange standard for safe, reliable, manufacturer- and platform-independent industrial communication. It enables data exchange between products from different manufacturers and across operating systems. The OPC-UA standard is based on specifications that were developed in close cooperation between manufacturers, users, research institutes and consortia, in order to enable safe information ex- change in heterogeneous systems.

- OPC is popular in the industry and also becoming more popular in other markets like the Internet of Things (IoT). With the introduction of Service-Oriented-Architecture (SOA) in industrial automation systems in 2007, OPC-UA started to offer a scalable, platform-independent solution which combines the benefits of web services and integrated security with a consistent data model.

- OPC-UA is an IEC standard.

OPC-UA Reference Architecture



OPC UA Characteristics

- Independent Platform For Information Exchange
- Vendor Independent
- Standardized Communication
- Service-oriented Architecture
- Semantic Annotation of Information
- Protection Against Unauthorized Access
- Reliable

www.opcfoundation.org

I4.0Lab @ SOM Structure: Key features

- Embedded sensors and monitoring systems (RFID, QRCODE and Power consumption)
- OPC-UA interface
- SW suite for modeling, simulation and control application set
- Seamless interfaces of single hardware module to enable transparent plag&play of new modules or reconfiguration of the production system
- Open architecture for integrating 3rd parties software and devices (e.g. robots or machineries)

I4.0Lab @ SOM Structure: Main processes implemented

- Flow control (bar-code, RFId, Visual) of individual products and assembled
- Processing operations emulation or real
- Final product assembly using robot
- Quality control using optical camera
- Intelligent handling system

I4.0Lab @ SOM Structure: Main components

- Warehouse management input raw products (input materials) / outgoing finished products
- Finished / assembled (product output) or flow control of individual products as the assembled or operations processing of the raw products, which is executed by real CNC machine or operation of assembly and final finishing of the product via anthropomorphic robot
- Quality control with optical method by camera

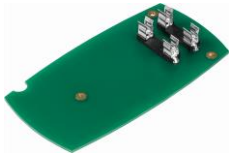
I4.0Lab @ SOM Structure: Main components

- Control flows of individual products and monitoring via RFID and barcode
- Intelligent handling of parts made by motorized conveyors and pallets
- Possibility to measure the energy consumption of the various constituent parts of the system

I4.0Lab @ SOM Structure: Product

- **Product:**
- the main task is to produce a symbolic product of Smartphone or remote control. The symbolic product consists of 4 parts:

Housing



Platine

Fuses

Cover

I4.0Lab @ SOM Structure: Process

Process:

The system is designed for transporting workpieces on carriers, which are equipped with RFID-tag. The production process coming from MES is saved on the RFID-tag.

The system will be delivered with the following standard process:

1. Distributing of housing
2. Drilling of housing (simulated)
3. Assembly of Platine and fuses by the robot assembly station
4. Camera inspection if workpiece is right
5. Distribution of covers
6. Press the cover
7. Manual workplace (packing/disassembly of finished parts)

I4.0Lab @ SOM Structure: Key components features

- **Robot Assembly Cell:**
- 6 axis robot
- Two parallel conveyors
- The action on the robot cell takes place thanks to the RFID chip mounted on the workpiece carrier, where the parametrers are stored
- With the help of the patented, passive redirection at the ends of the conveyors, the linear transfer module can be changed within some seconds to a closed loop material flow.
- Magazines and fixtures for assembly process, gripper for robot
- Control panel consisting of Siemens Touchpanel
- Robot gripper exchanger 3
- Camera system - Colour camera Resolution 752x480
- Sensorless collision detection
- Payload 4 kg

I4.0Lab @ SOM Structure: Key components features (2)

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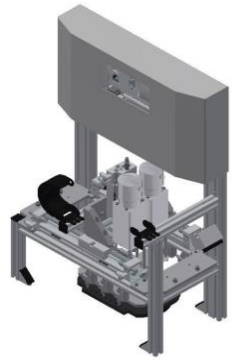
Application module Drilling CPS

- Two drilling spindels can be moved in z-direction, as well as in x-direction
- Controller with web functionality for Cyber Physical System operation: self diagnosis inside of the application, web visualization



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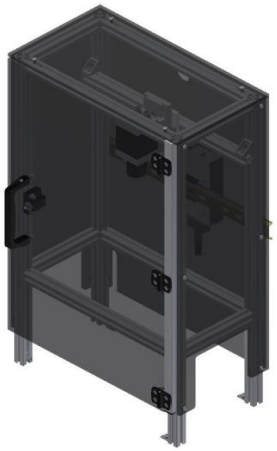
I4.0Lab @ SOM Structure: Key components features (3)

Application Module Camera Inspection

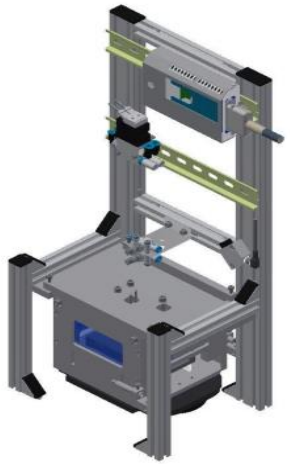
- A powerful industrial vision inspection system checks the workpieces with an optical check:
  open system to Image&Visual Management through the camera



I4.0Lab @ SOM Structure: Key components features (4)

Application Module Press

- The two covers arriving on the carrier on the conveyor are assembled with the help of a pneumatic press



I4.0Lab @ SOM Structure: Key components features (5)

CP Pallet transfer system and Touch Panel TP700

- Ready for Industry 4.0
- Pallet identification with BCD (Bar Code) and RFID
- Bi-directional + slow-speed
- 6 x The touch panel TP700 Comfort is a 7" touch panel and comes from the Siemens HMI series for advanced applications

I4.0Lab @ SOM Structure: Key components features (6)

Manual station

- With control panel for process synchronization

Power consuption measuraments

- Energy monitoring on all stations

Set of workpieces

- 16 x Pallet
- 6 x Workpiece carrier
- 10 x printed circuit board + housing: cover; housing: base plate
- Fuses

I4.0Lab @ SOM Structure: Software features

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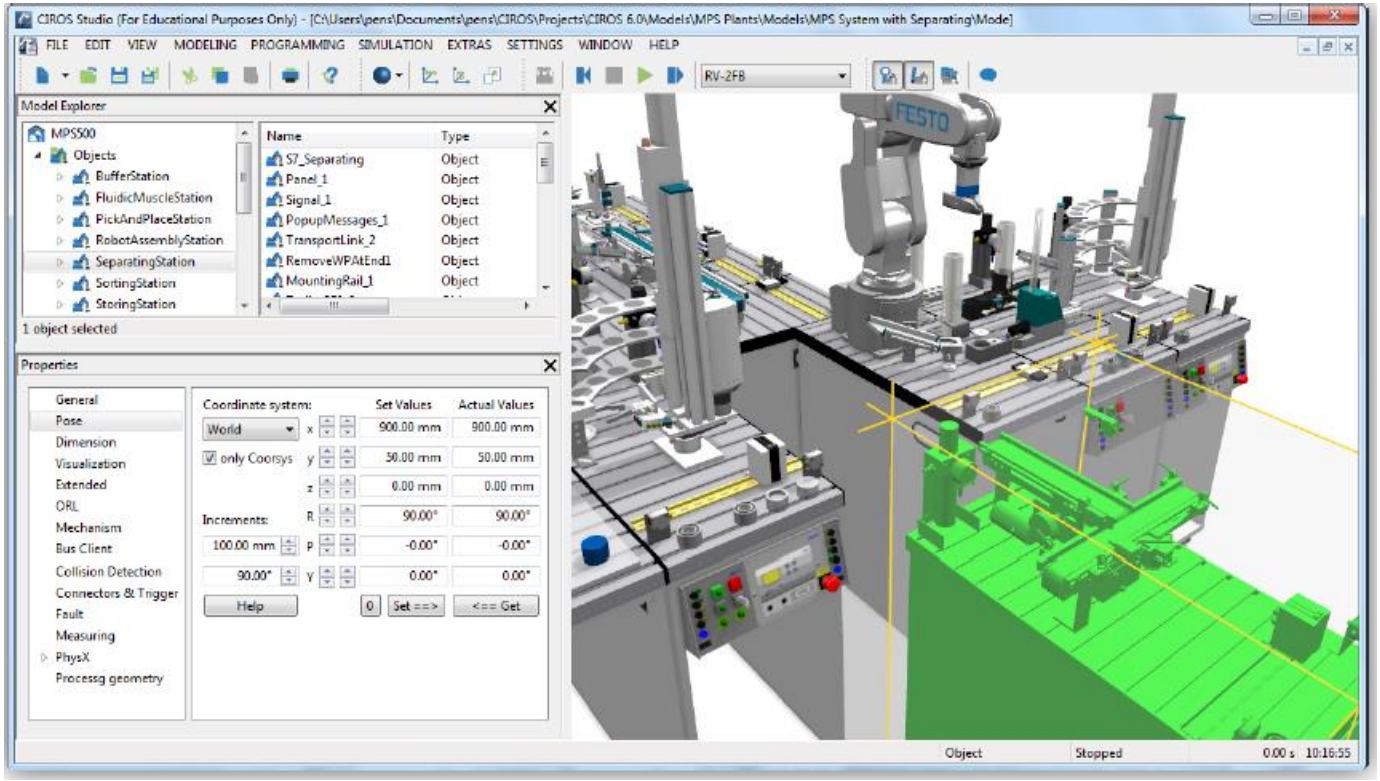
Design, Modelling and Simulation

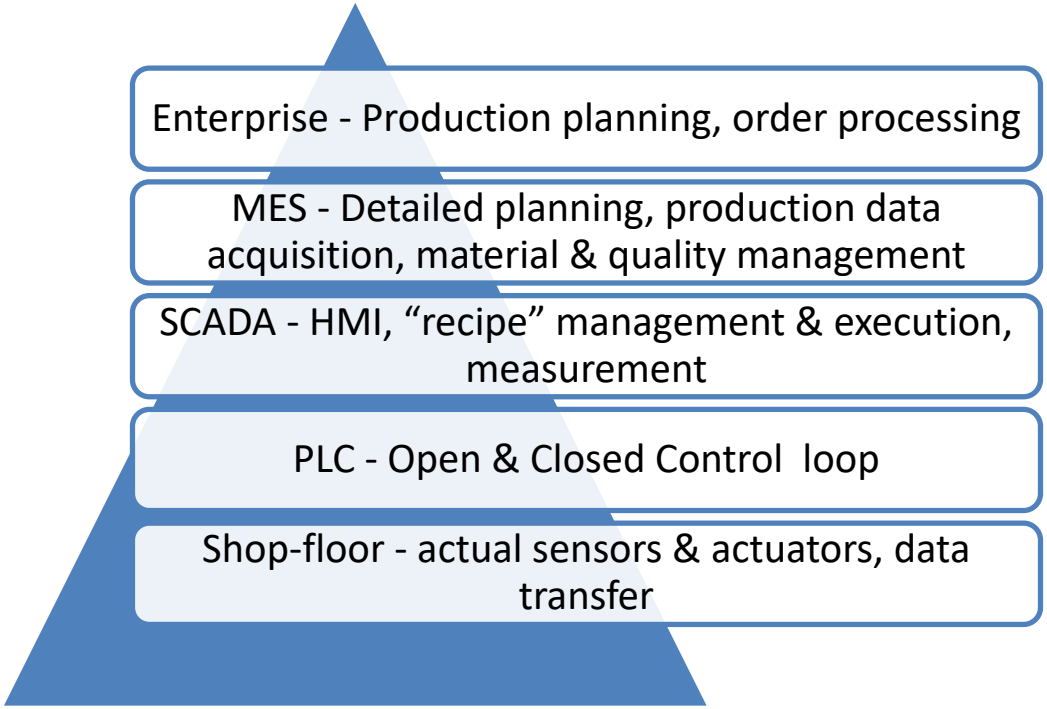
- 3D real-time simulation and modelling
- Import filters for STEP, IGES, STL, VRML
- Export filters for DXF, STEP, IGES, STL, ...
- Plug-in for Autodesk Inventor and Autodesk
- Robot programming in the programming languages: - Industrial Robot Language (IRL) - Mitsubishi Movemaster Command Language (MRL) - Mitsubishi MELFA BASIC III, IV and V - Kuka Robot Language (KRL) - ABB Rapid - V+ (for Adept and Stäubli)
- Communication via OPC client/server
- Virtual human with 30 independent degrees of freedom
- Online connection to Mitsubishi robot control systems for upload and download of robot programs and position lists
  It is the program version for the trainer who creates new models, tests the virtual learning environments and releases programs for the connected robots and transfers them to the robot control system

I4.0Lab @ SOM Structure: Software features



Plant!!!

Exercise



Which data are needed for **MRP**, **Scheduling** and **Inventory**?

Where can I take these data and **how**?

Exercise (2)

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Stations Sensor and Actuators:

- Inductive input sensor for each station
- Inductive output sensor for each station
- Operation position sensor for each station
- RFID sensor for each station
- Buffer sensors (infrared) for station_1 (first magazine: front cover)
- Buffer sensors for station_5 (robot station: PCB and fuses)
- Buffer sensors (infrared) for station_7 (second magazine: back cover)
- Stopper actuator for each station
- Buffer actuators for station_1 (first magazine: front cover)
- Buffer actuators for station_7 (second magazine: back cover)
- Different operational actuator for station_3 (i.e. drilling actuator) and for station_8 (i.e. pneumatic press actuator)
- Other sensors and actuators for station_5 (i.e. change tool)
- …

Exercise (3)

Pallet and Component tracking:

- Carrier ID
- RFID sensor for each pallet
- Part Number
- Part Description
- QRcode on each product component
- Barcode on each product component
- …

Product component conformity:

- Camera check for station_5 (robot station)
- Camera check for station_6 (camera station): presence, shape, colour, writings, QRcode, Barcode, …, on each component

Exercise (4)

Product, Machine and Line:

- Machine ID
- State of the machine
- Operation
- Errors and scrap
- Order Number
- Order Position
- Work Plan number
- Work Plan description
- Times (Planed start/end, start/end, …)
- …

Exercise (5)

Energy monitoring:

- Voltage
- Current
- Power
- Pressure
- Flow
- …