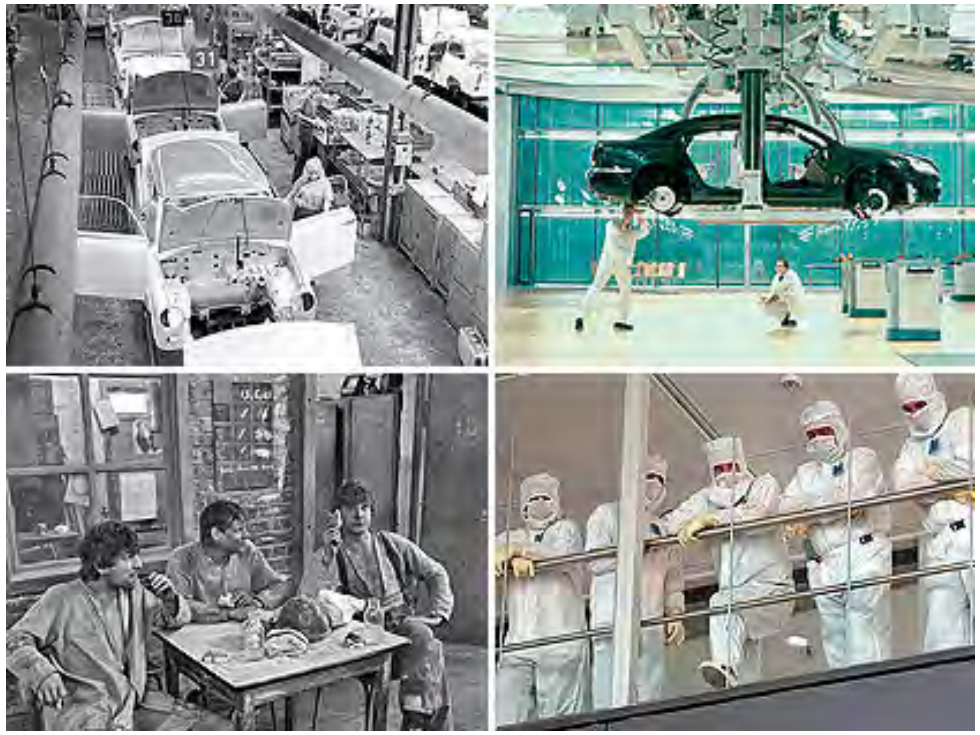
Implications for Learning Factories from Industry 4.0
Challenges for the human factor in future production scenarios



Andreas Jäger, MSc, MBA
Prof. Dr. Wilfried Sihn

Fraunhofer Austria Research GmbH
Vienna University of Technology

Fabian Ranz, MSc
Prof. Dr. Vera Hummel

ESB Business School, Reutlingen University

Industry 4.0

The human factor in cooperation with CPPS

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Industry 4.0

The human factor in cooperation with CPPS

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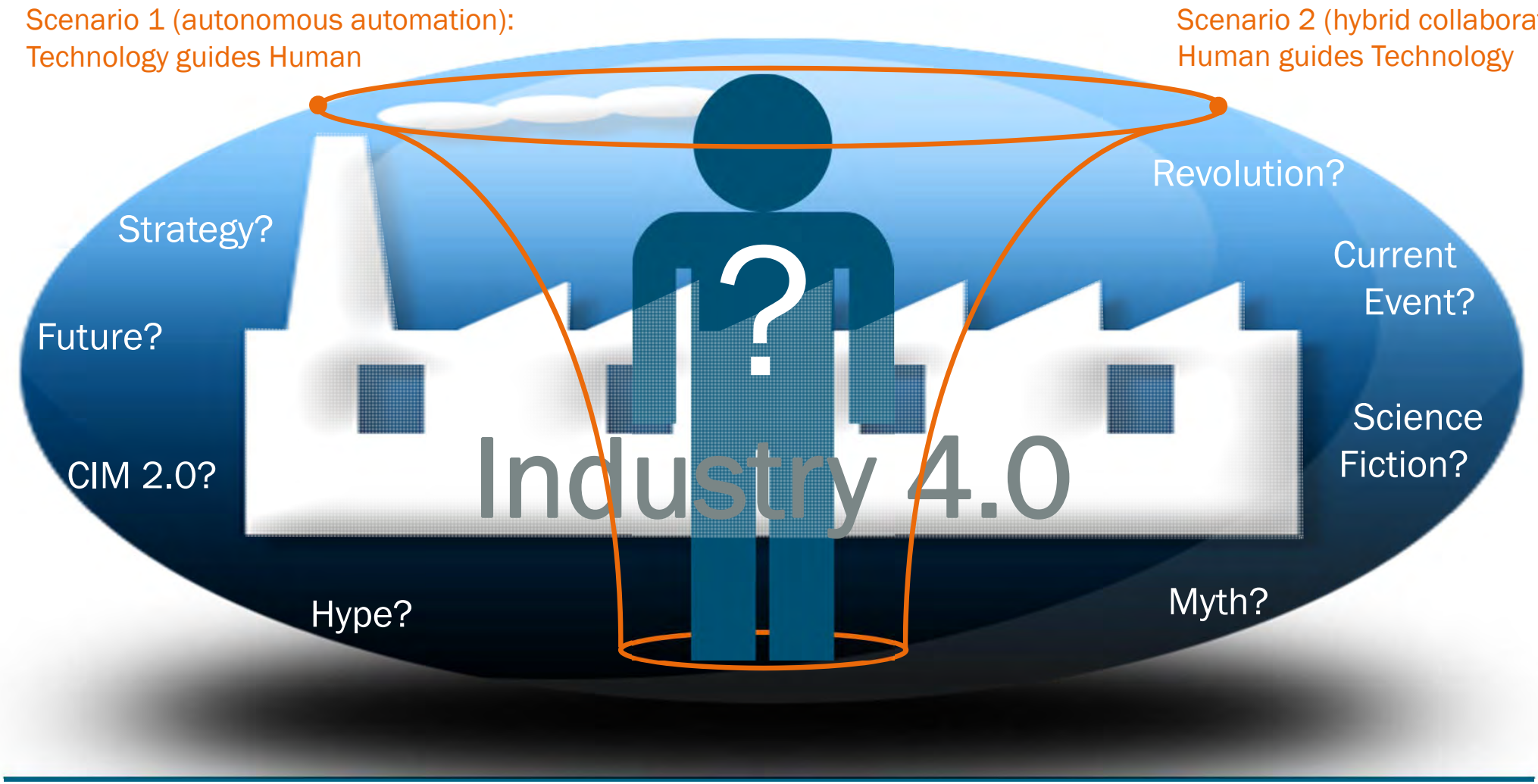
The human factor in cooperation with CPPS



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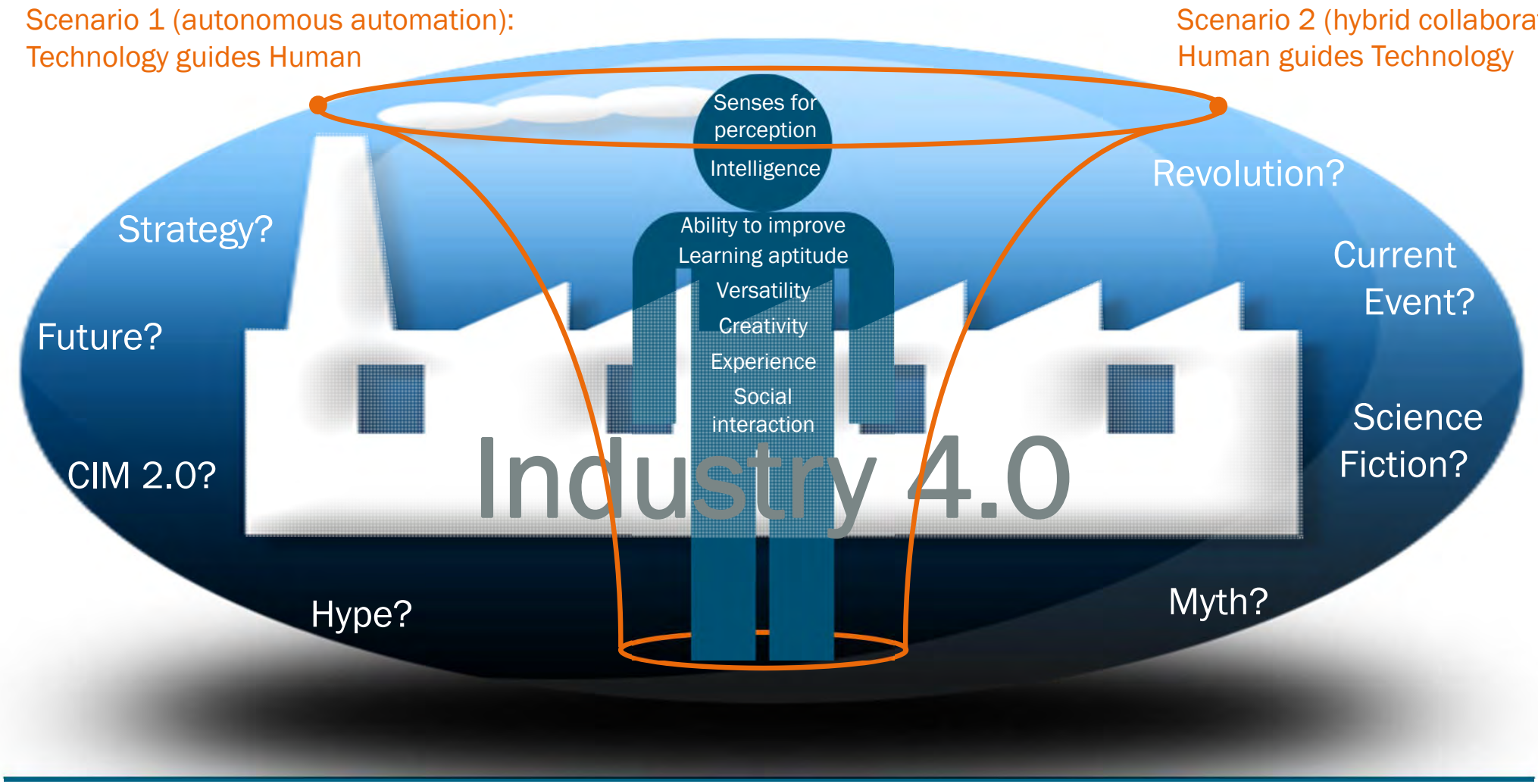
Industry 4.0

The human factor in cooperation with CPPS



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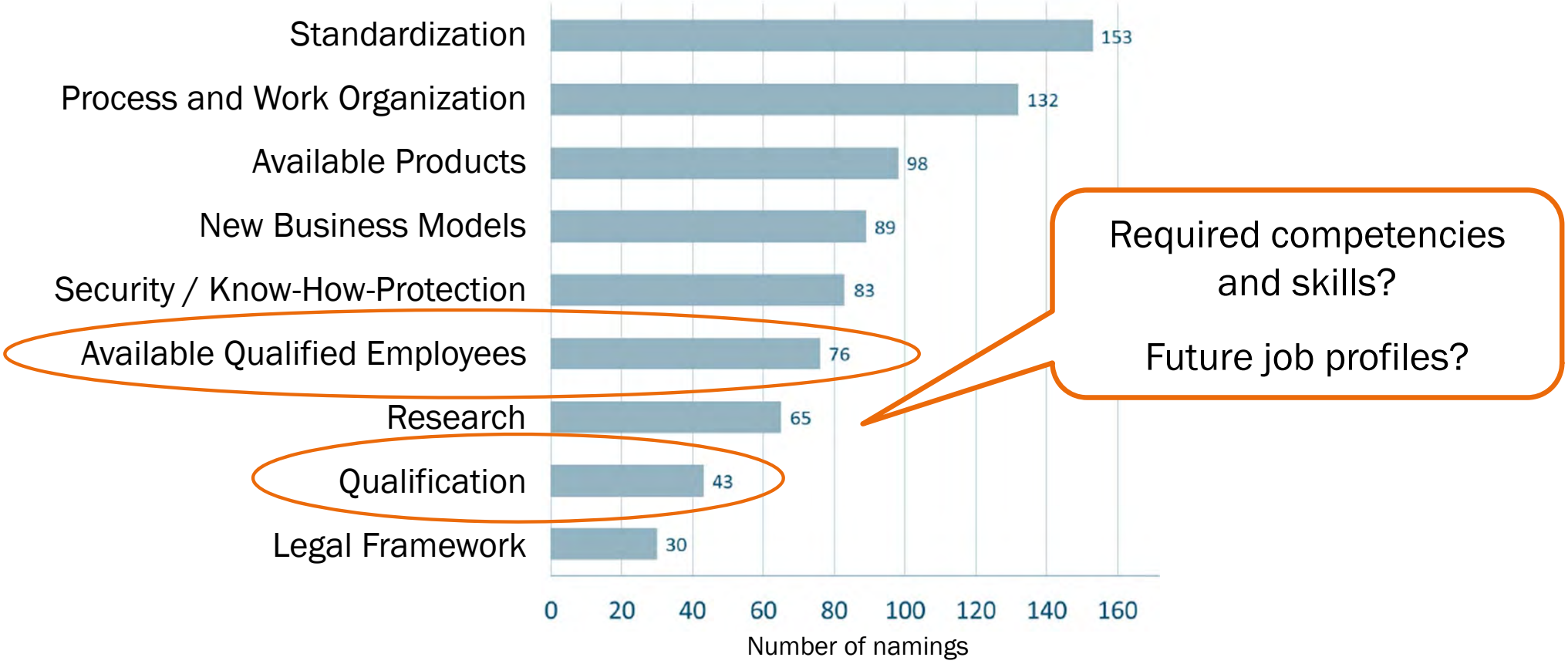
Industry 4.0

Challanges – Qualification and Education



Source: Survey by plattform-i40 (BITKOM, VDA, ZVEI) January 2013, Responses: 284 / Quote 9,2%

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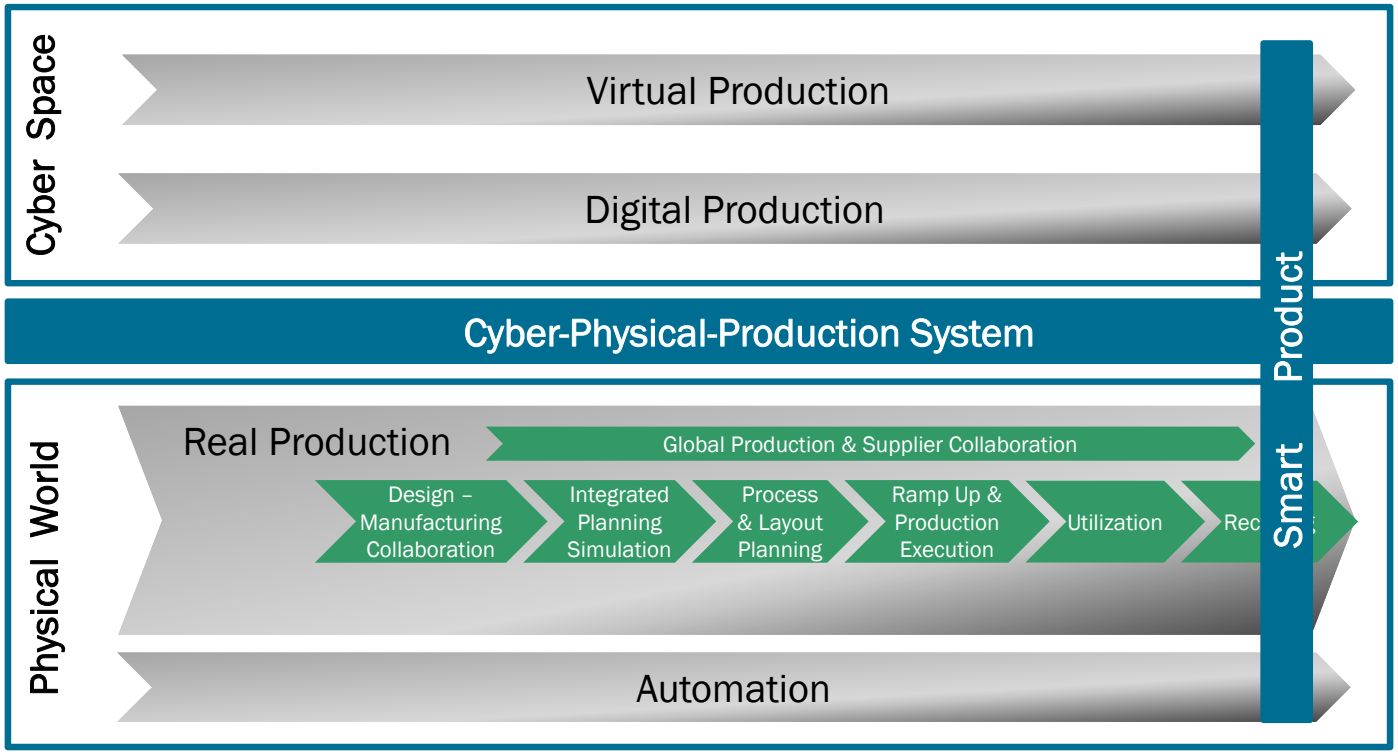
Industry 4.0

Essential competence requirements



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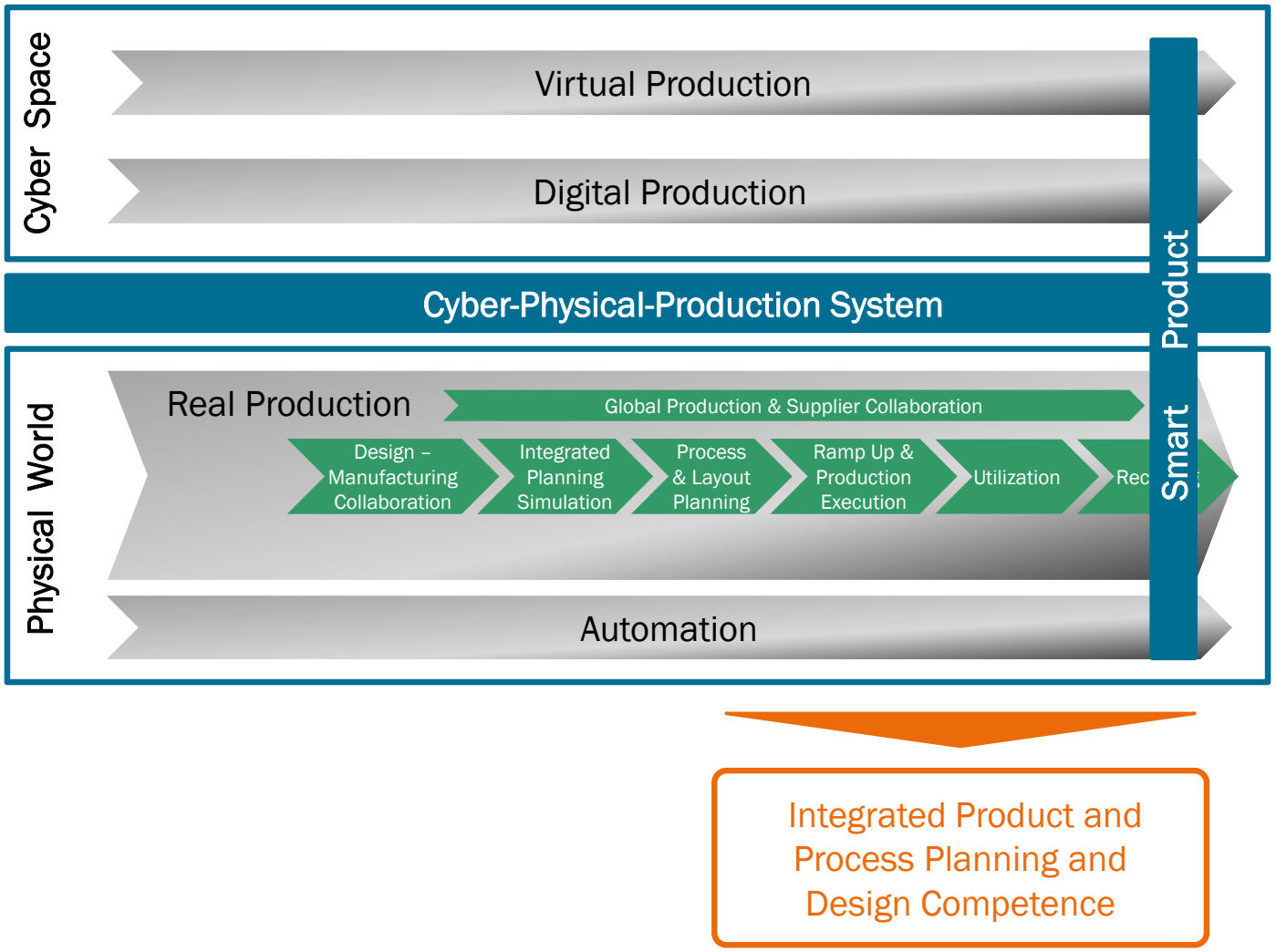
Industry 4.0

Essential competence requirements



Integrated Product and Process Planning and Design Competence

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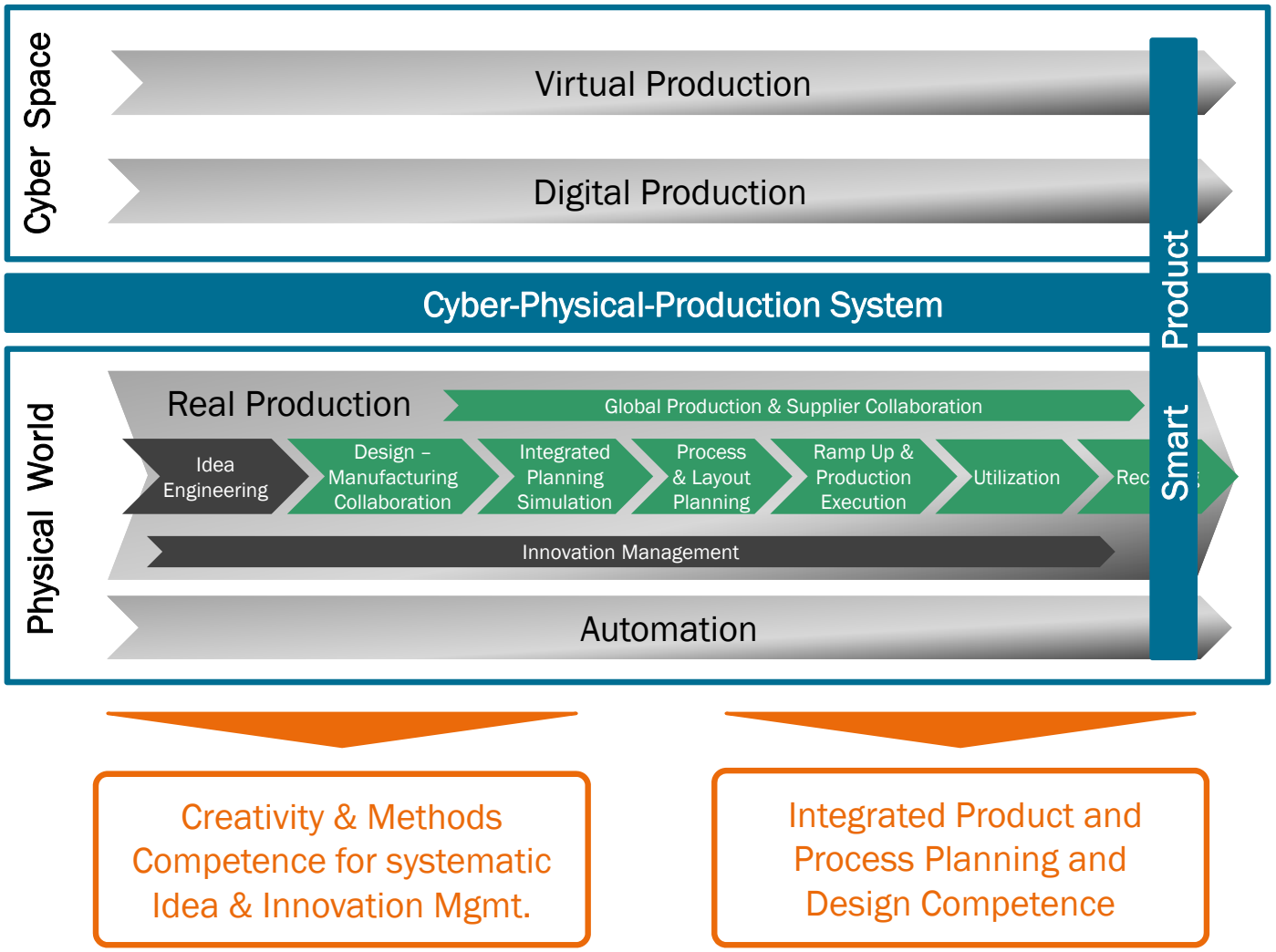
Industry 4.0

Essential competence requirements



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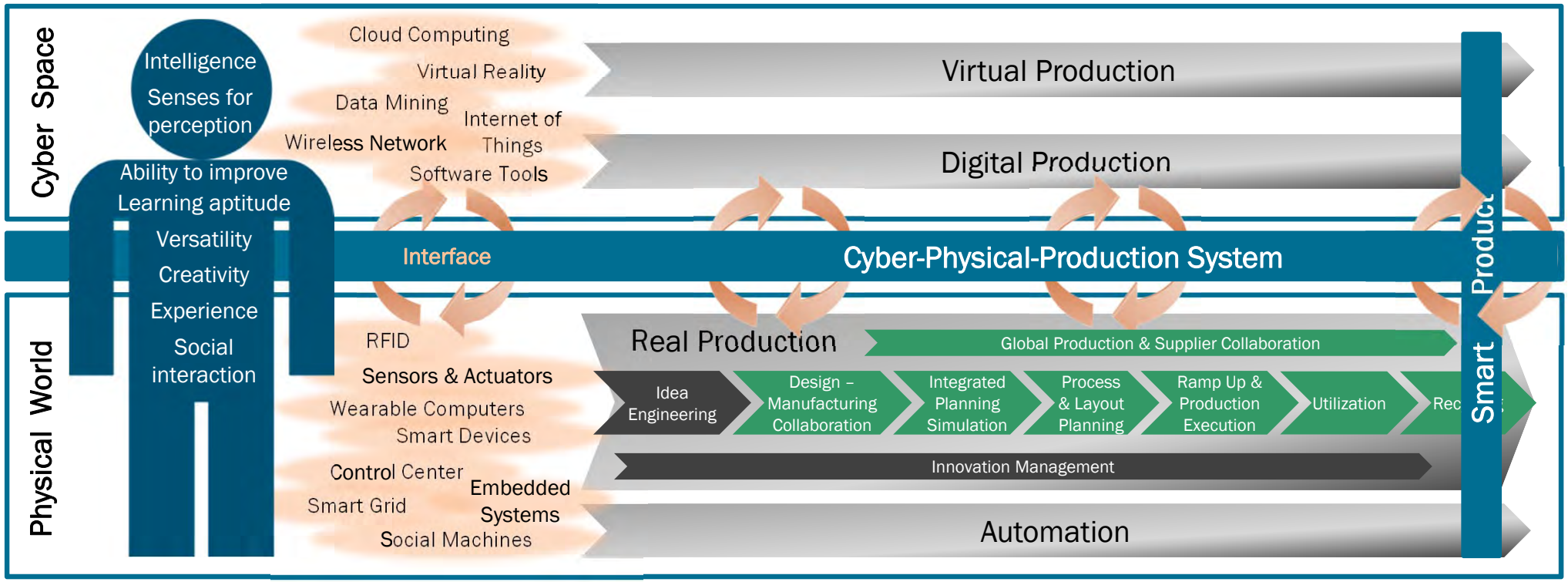
Industry 4.0

Essential competence requirements



Systems and Interface Competence

Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

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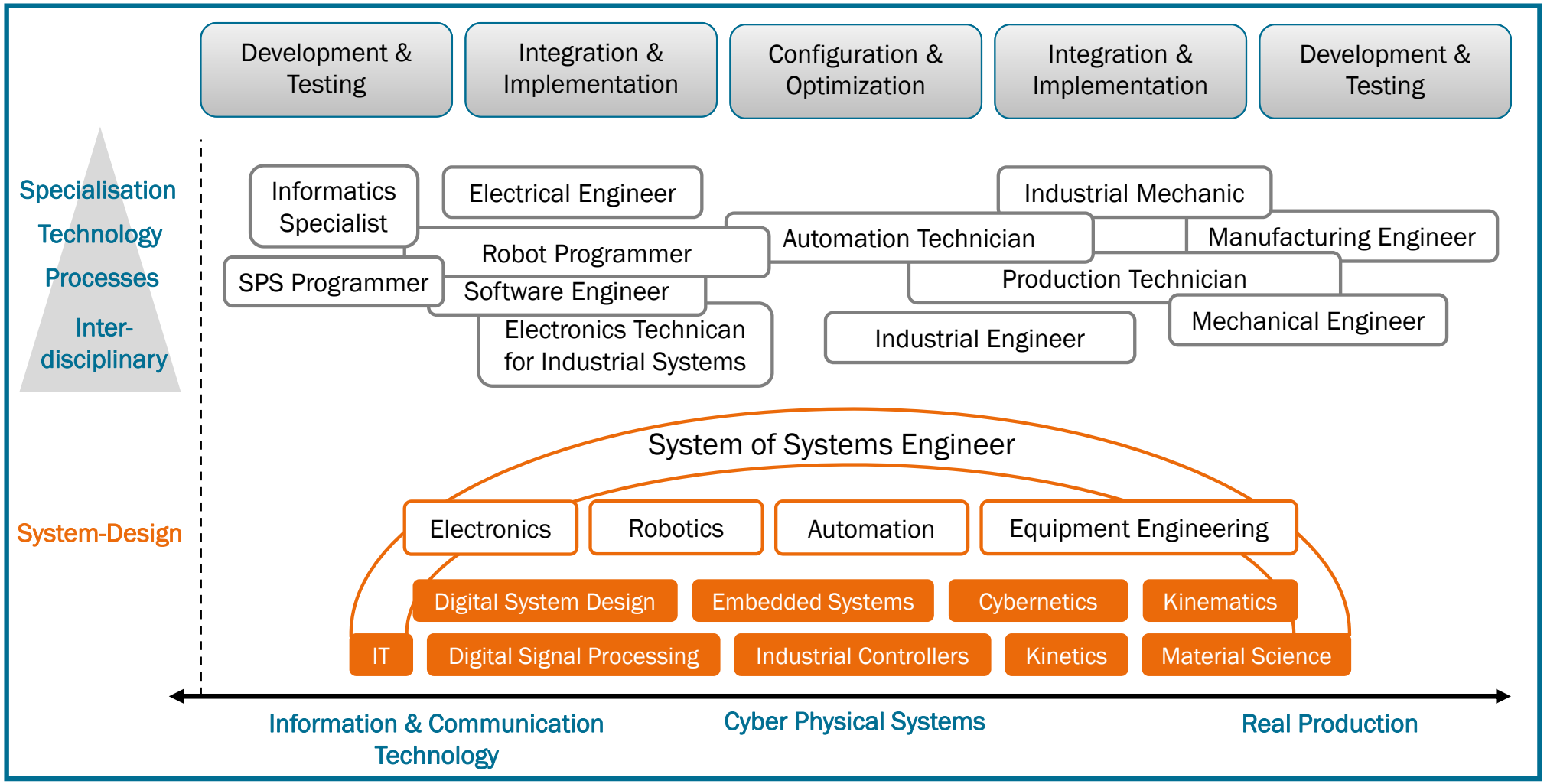
Industry 4.0

Job profiles (excerpt) for a cyber-physical working environment



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ESB Logistics-Learning-Factory

Holistic Approach from Product to Factory

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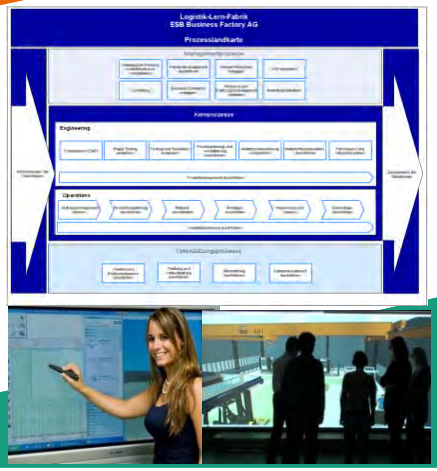
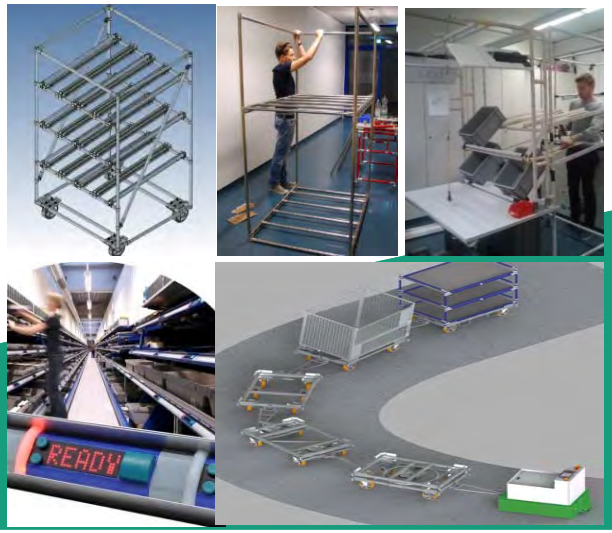
Customization of adaptable product (high variance)

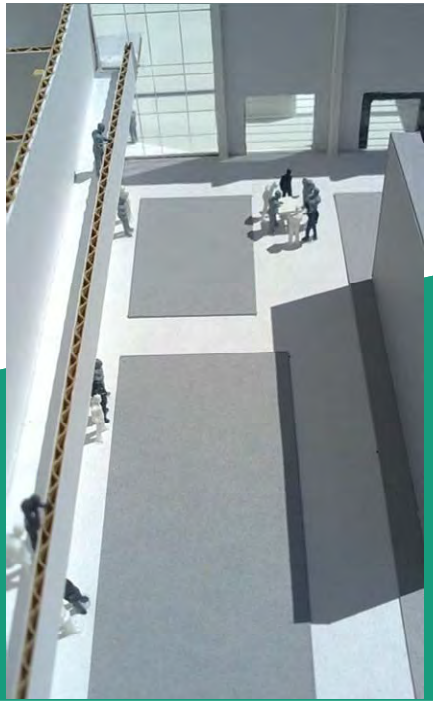
Process Design & Validation



Assembly and intralogistics systems, Jigs & Fixtures Design & Realization



System realization and ramp-up



Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

Systems and Interface Competence

Education | Training | Research | Industry Projects

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ESB Logistics-Learning-Factory

Integrative tie-in of virtual factory and physical system

Engineering & Operations Cockpit

Physical System Learning Factory

Customer requirements

Customer orders

CAS / CAD / PDM

Order Data

Production Program

Configuration of production system

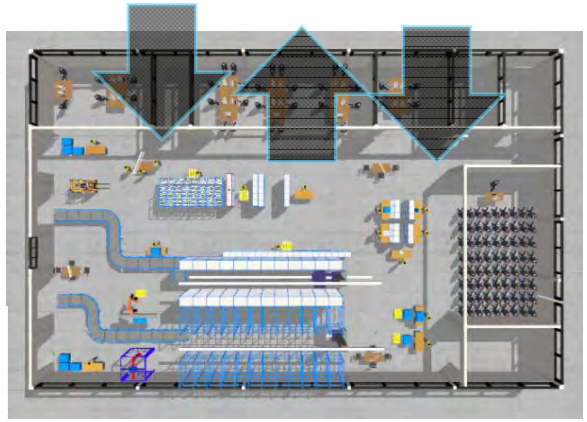
Simulation

Process- and work station design

Manufacturing Execution

Quick Adaption to Turbulences

Exemplary aspects of Industry 4.0



Transparency & Traceability

Smart, low-cost solutions for SME requirements

2013 New team & suppliers	Spring 2014 Hardware installation	Spring 2014 Software installation	July 2014 First system run	Oct 2014 First trainings with students	Nov 2014 First Industry 4.0 workshop for external	2015 New building	SS 2015 System expansion	2015 Regular operation

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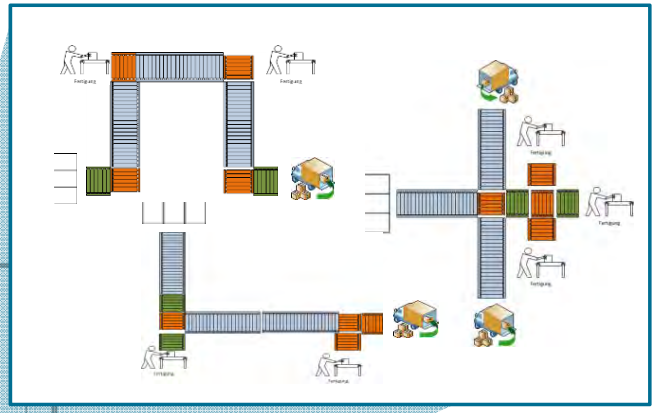
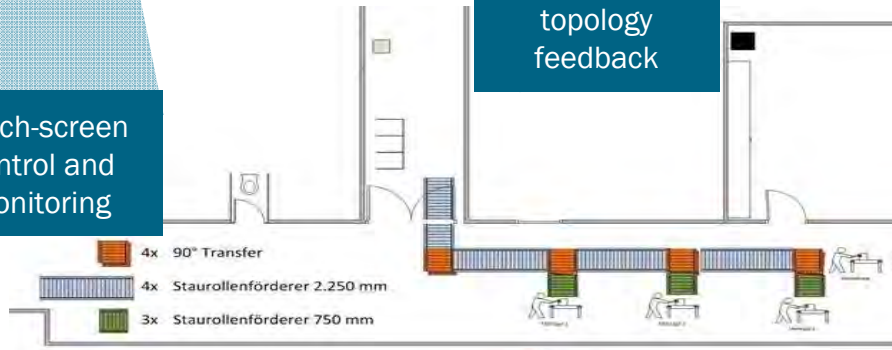
Industry 4.0– Flexible conveyor system

Forerunner-Follower-Identification

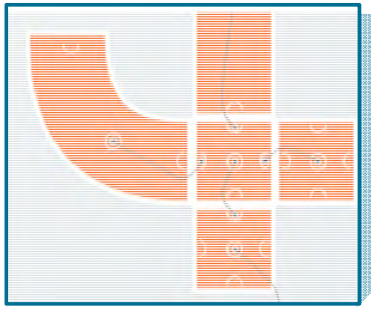


Automated topology feedback

Touch-screen control and monitoring



Unlimited layout opportunities with minimized changeover times

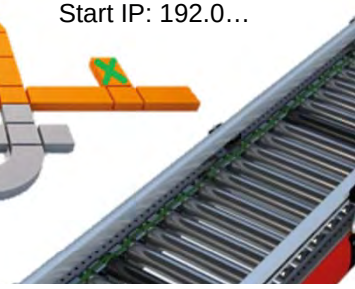


Plug-and-play for goods, power & information flow

Autonomous routing with no dead-locks

Start IP: 192.0…

Destination IP: 192.1…



Integrated Product and Process Planning and Design Competence

Systems and Interface Competence

Pictures courtesy of:

FLEXLOG

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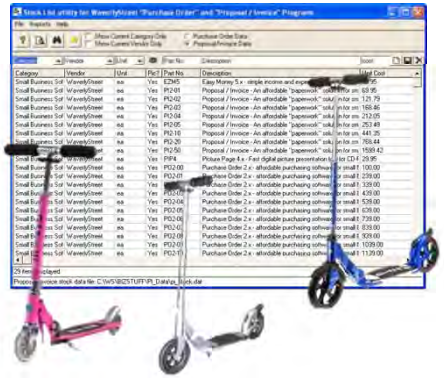
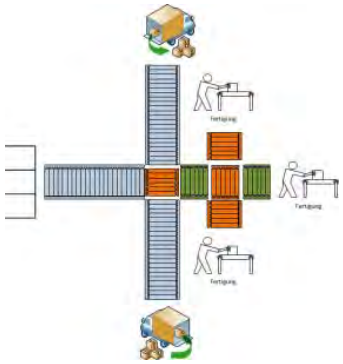
Industry 4.0– Flexible conveyor system Use Case

Flexible conveyor for changing logistical requirements

Initial order scenario (quantity, variants, dates)



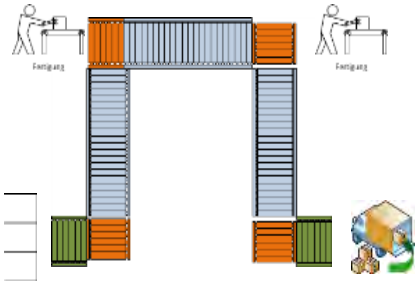
Realization of ideal plant layout



Turbulences affecting the scenario

- Demand change
- Supply outage
- Equipment defect
- Technological change
- …

Result: adapted production system



Integrated Product and Process Planning and Design Competence

Aspects for Education, Research and Industry

E Short-cyclical re-design of logistical systems, including planning as well as technical realization

R Automated planning of multimodal intralogistics systems (e.g. with unsteady conveyor)

I Development of use applications for the industry

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Industry 4.0– Technical Assistance System

Technical assistance with collaborative robots

Conventional robots	Fit for the future robots	Use Case ESB Logistics Learning Factory
 © v-quadrat.	 © Kawada Industries.	
Stationary use	Autonomous routing and navigation within the system	2D-Laser for auto-movement
Complex config	High-level programming	Intuitive teaching: Job enrichment for operators
Fenced operation	Shoulder-to-Shoulder collaboration	Tactile sensors and cognitive capabilities
Defined task	Flexible deployment	Situative integration into assembly, logistics, QC...

Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Open-source ROS for creative solutions & innovation sharing

Systems and Interface Competence

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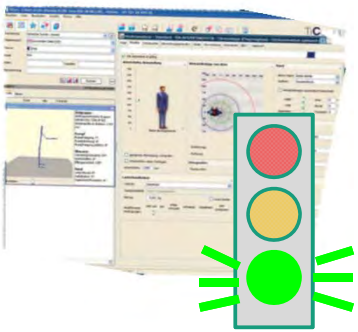
Industry 4.0– Technical Assistance System Use Case

Technical assistance with collaborative robots

Work tasks (required abillity) → Design and planning of collaborative Works Systems → MTM-based ergonomic workload analysis → Task-specific teaching and deployment of the assisting system → Result



© Onexia, Inc.

- Demographic-change ready workplaces
- Technology follows the worker, not worker the technology
- Situative assistance instead of human substitution -> standardized CWSM

[VDI2860] Assembly:

- Mating (e.g.. Screwing, Plugging,, Gluing, Clipsing)
- Handling (e.g. Picking, Placing)
- Checking (e.g.. Measuring)
- Adjusting (e.g. Tuning)
- Support Ops (e.g. Cleaning)

Functions of handling:

- Store
- Adjust quantity
- Move
- Check

Aspects for Education, Research and Industry

E Integral workplace optimization and expertise enhancement in the deployment of smart local automation solutions

R Development of „ability and attribute based" standardized modules for collaborative workings systems (CWSM)

I Cost-benefit evaluation of collaborative assisting systems and best-practices of application

Systems and Interface Competence

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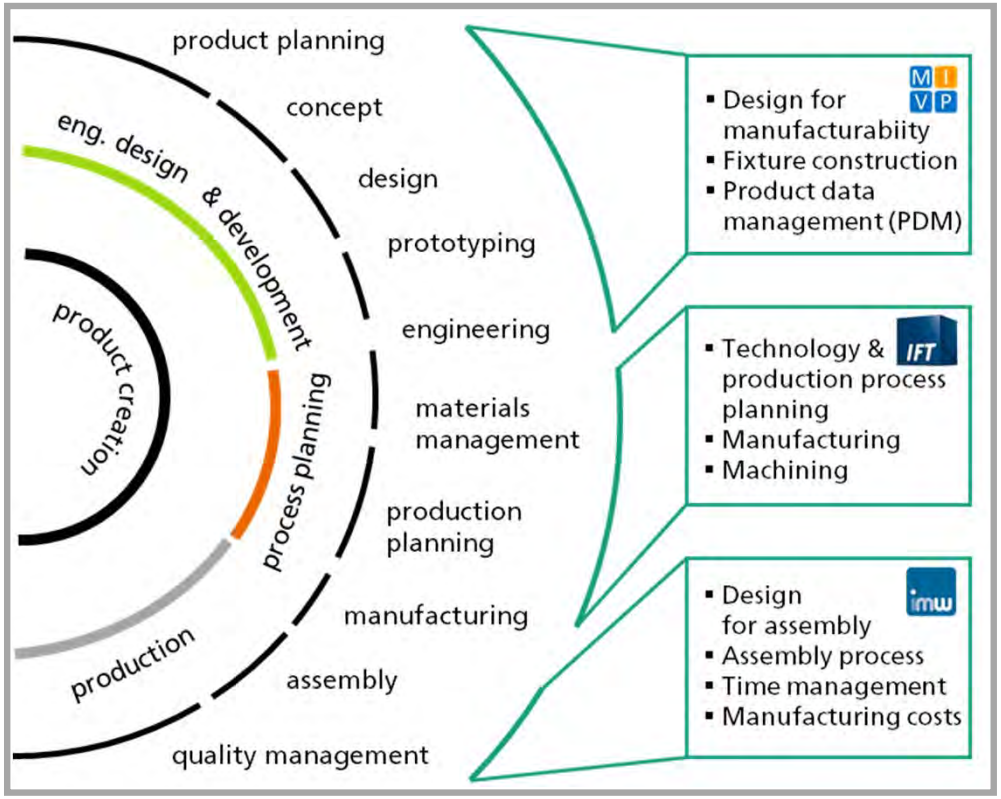
„i-PEP“ (integrative product emergence process)

Learning & Innovation Factory for Integrative Production Education

Process Steps



From Idea to Product

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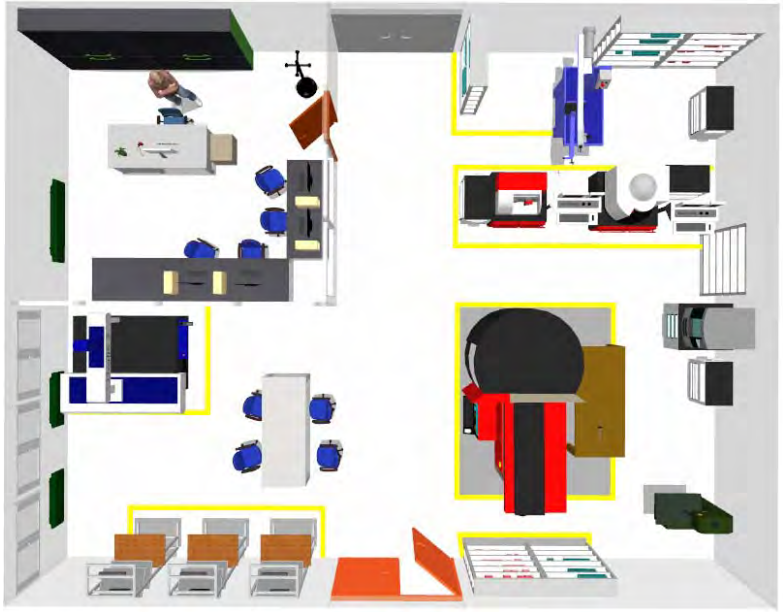
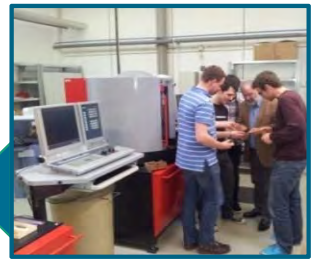
„i-PEP“ (integrative product emergence process)



Didactic Approach

Lecture for content preparation



Hands-on training

Independent learning

Presentation with feedback

Teamwork

Teambuilding

2011 Formation & initiation	2011 / 2012 Development & installation	April 2012 Pilot Run	10th May 2012 2nd Conference on LF in Vienna	2012 / 2013 Optimization of training concept	April 2013 2nd lecture	2013 / 2014 Integration of PM & creative tools	May 2014 3rd lecture	2014 - 2016 Industry 4.0 use cases

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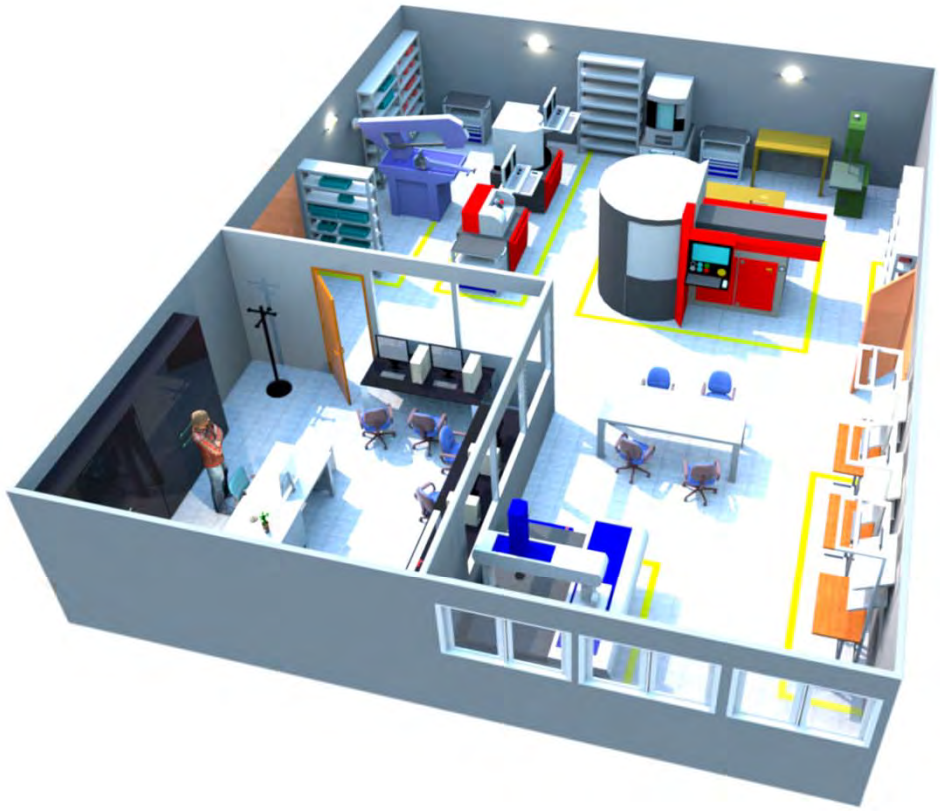
Proceeding

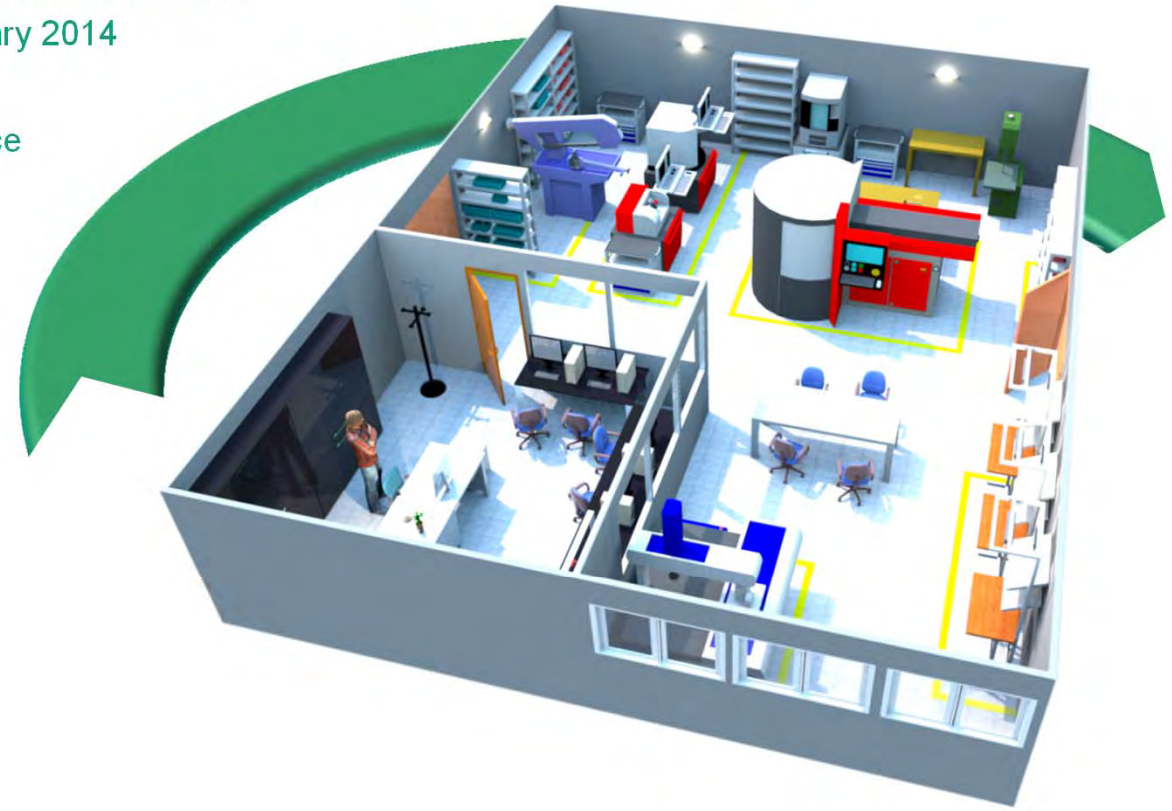


TU Wien Learning & Innovation Factory

Proceeding

Funding of physical equipment and digital infrastracture:

- Austrian Ministry for Science & Research
- 3 years, started in January 2014
- 300k€ for investments
- 170k€ inkind performance



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- Ressources (Students) for CPPS research
- Transfer of use cases into the Learning Factory

TU Wien Learning & Innovation Factory

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PhD College:

- Ressources (Students) for CPPS research
- Transfer of use cases into the Learning Factory

Endowed Professorship:

- Focus: Production of the Future
- Supervison of I4.0 qualification and development activities

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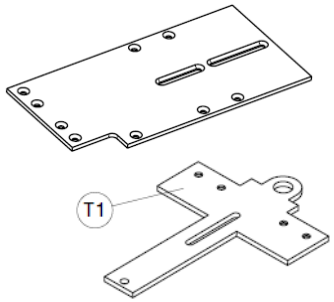
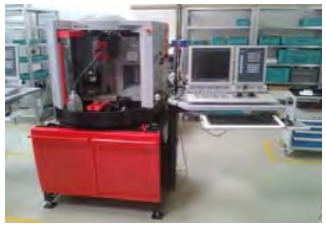
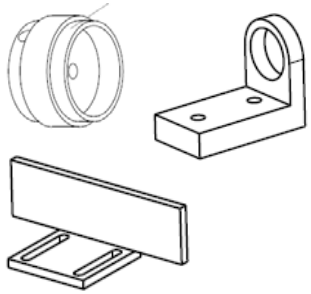
Expansion of Manufacturing Technologies

Initial situation

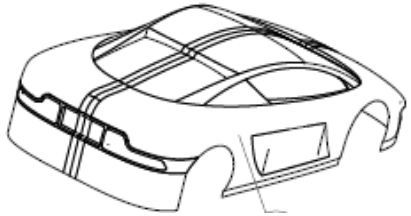


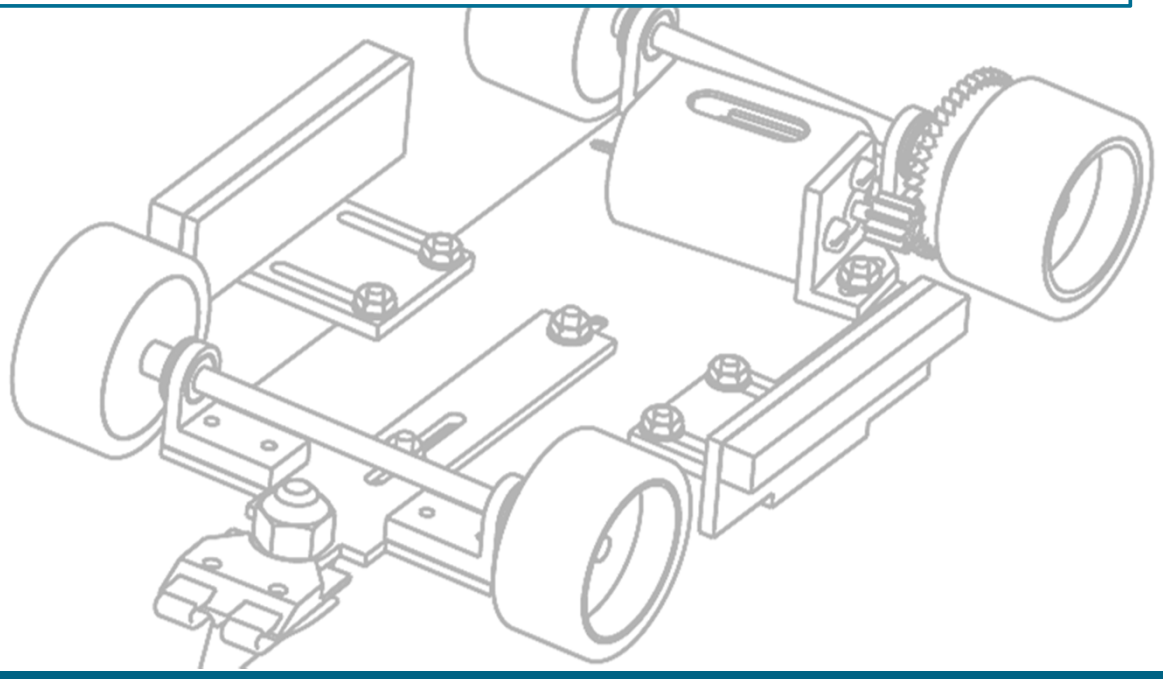
NC -turning machine & milling machine





External procurement





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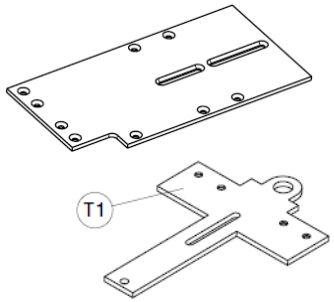
Expansion of Manufacturing Technologies

Initial situation



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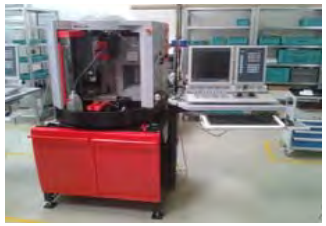

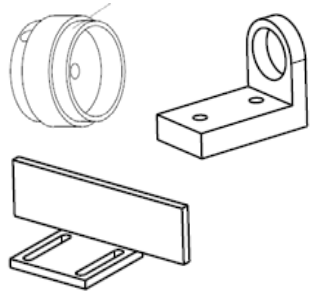

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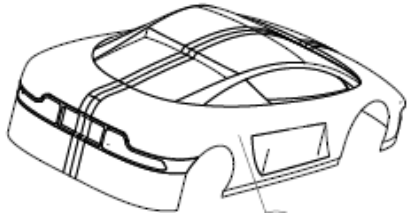

Target situation

Laser cutting machine

Laser welding system

Bending machine

Thermoforming machine

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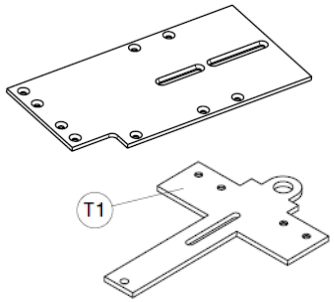
TU Vienna Learning & Innovation Factory
Expansion of Manufacturing Technologies

Integrated Product and Process Planning and Design Competence

Initial situation



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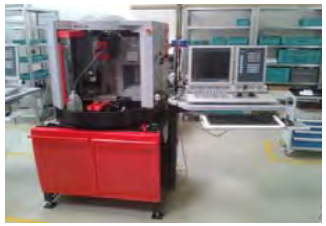

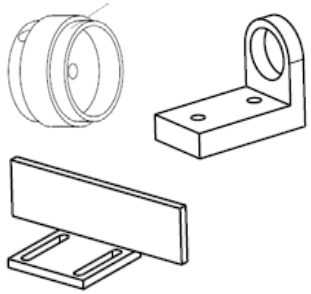

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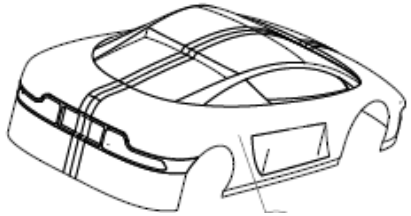

Preliminary, activity-based costing vs. post calculation with **real time data**

Comparision of production costs from different manufacturing methods

Make-or-buy decision

Target situation

Laser cutting machine

Laser welding system

Bending machine

Thermoforming machine

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TU Vienna Learning & Innovation Factory

Installation of Software – Siemens Teamcenter

Red Bull Racing Team

Integrated Idea Capture and Management

Collaborative Data Management

Project Management

Digital Product Development

Real-time Engineering Collaboration

TU Vienna Slotcar Teams

Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

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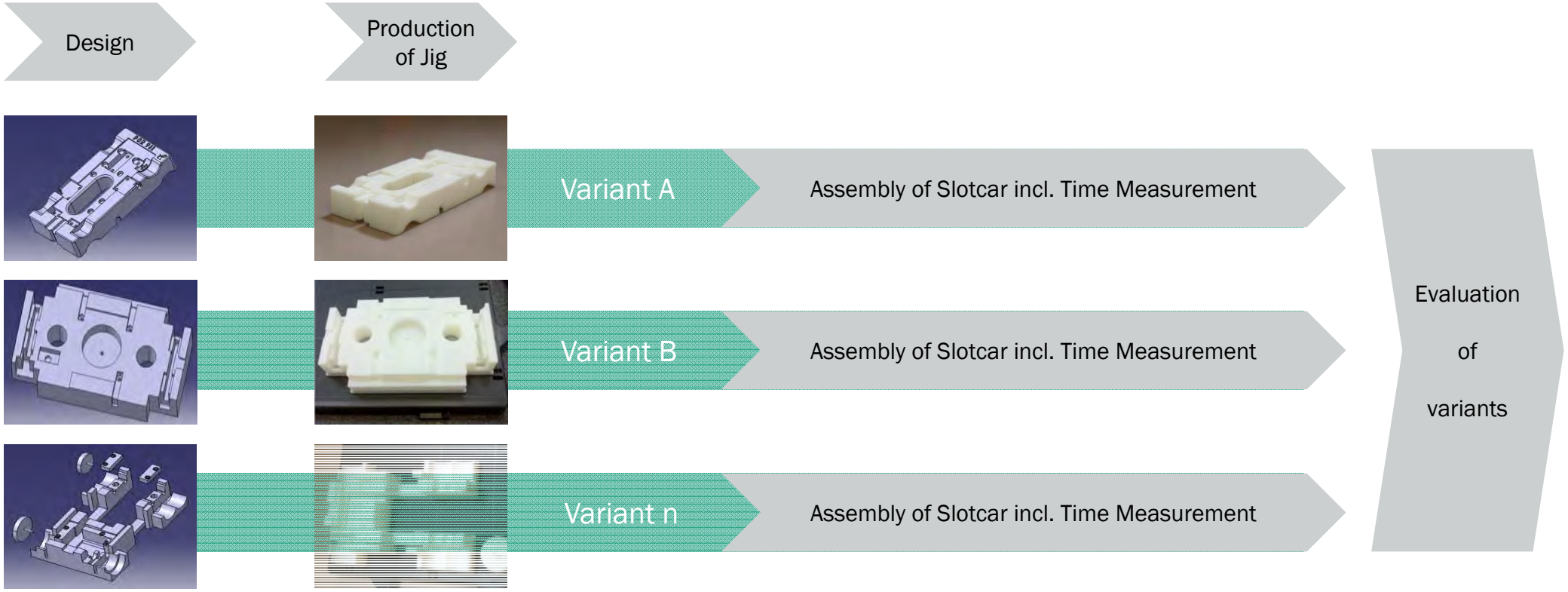
Industry 4.0 Use Case – Siemens Process Designer (Tecnomatix)



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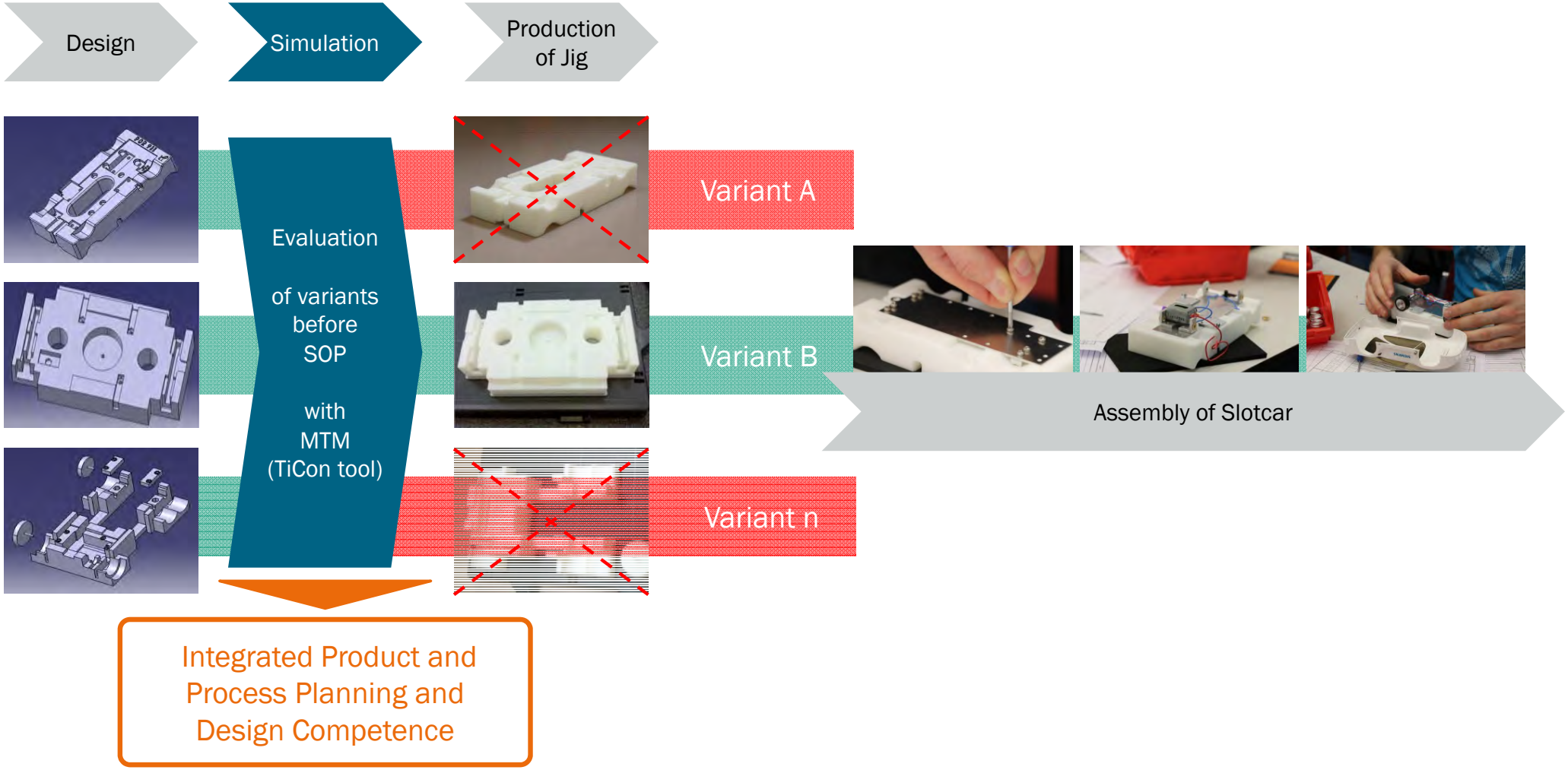
Industry 4.0 Use Case – Siemens Process Designer (Tecnomatix)



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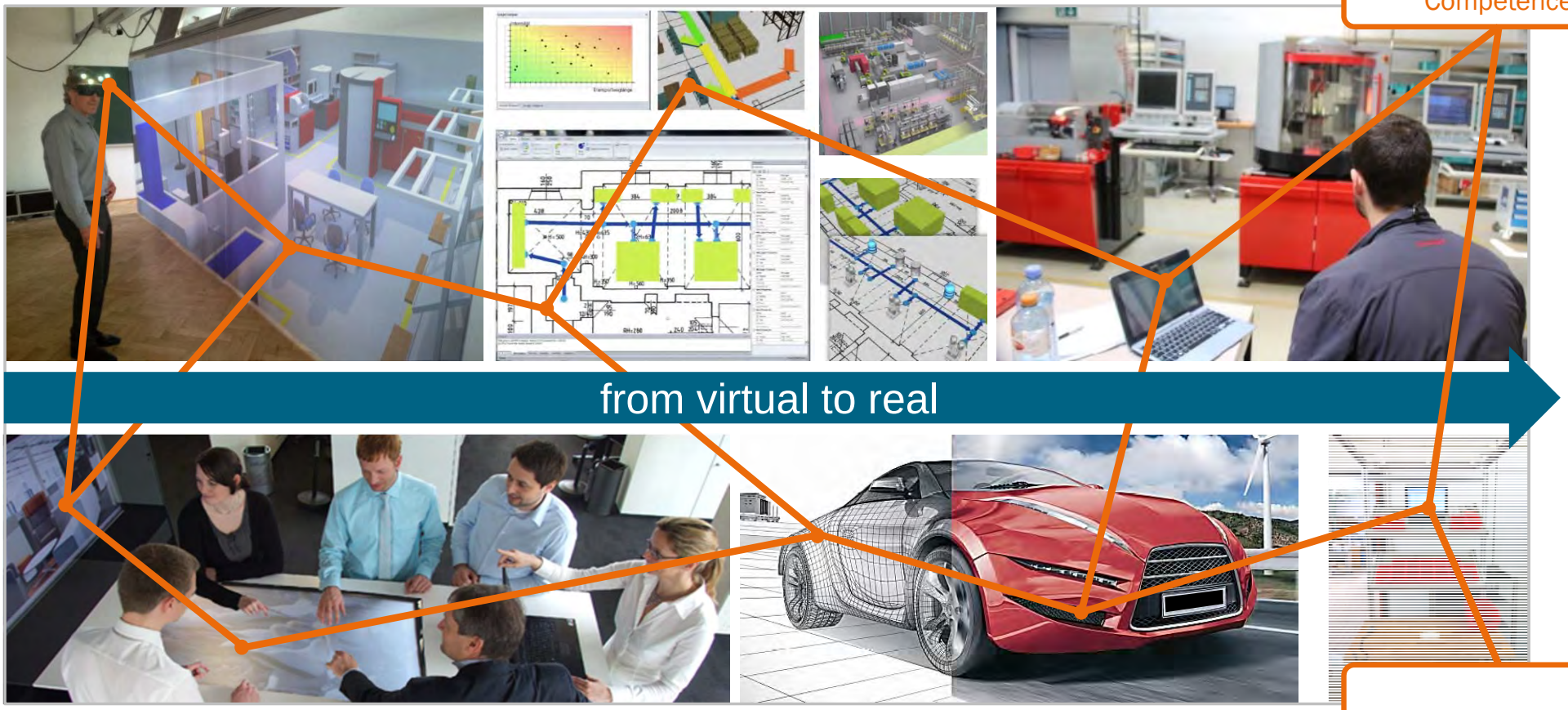
Industry 4.0 Use Case



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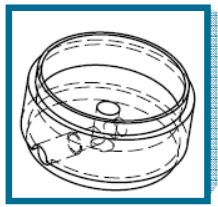
Industry 4.0 Use Case

Physical Automated and Digital / Virtual Production Cell



Slotcar Component: Wheel Rim

Articulated Robot

Driverless Transport System with integrated Roller Conveyor

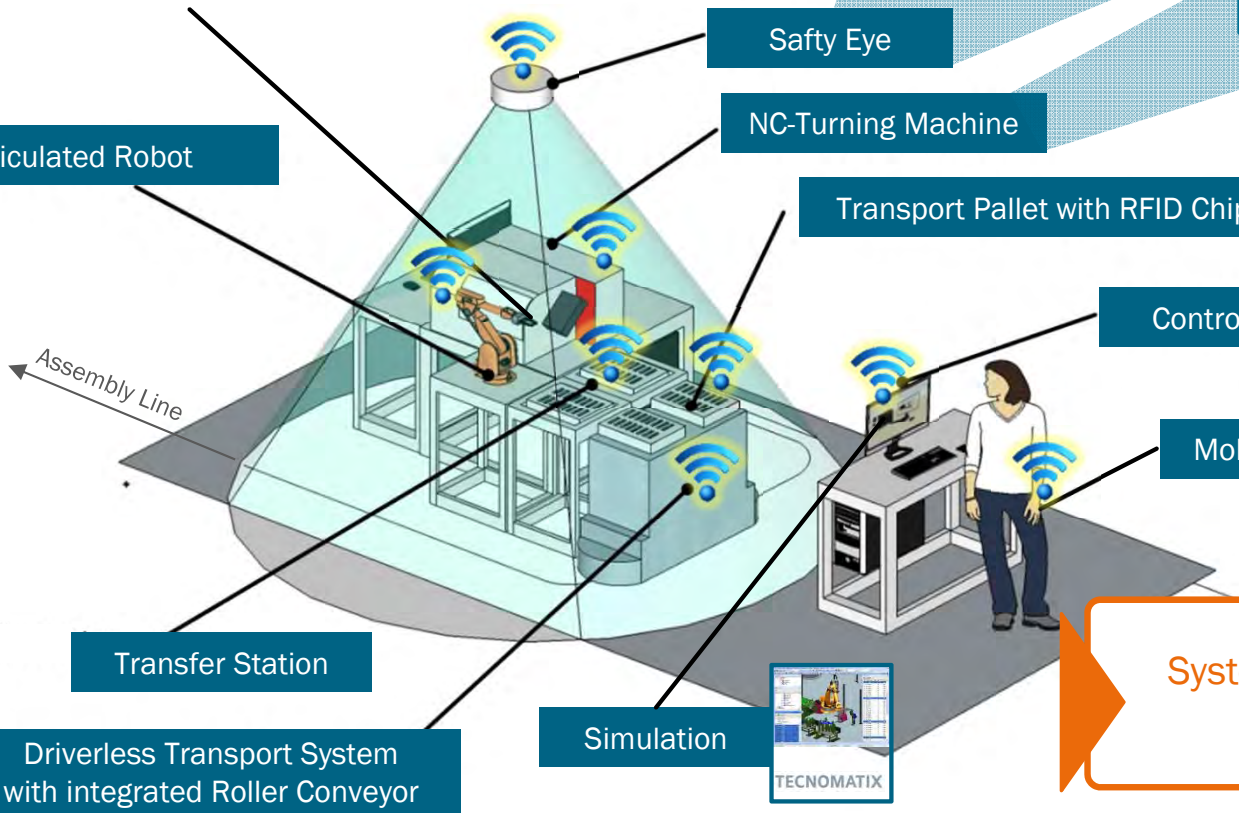
Safty Eye

NC-Turning Machine

Transport Pallet with RFID Chip

Control Center

Mobile Device with App



Transfer Station

Simulation

Systems and Interface Competence

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Thank you!

Questions

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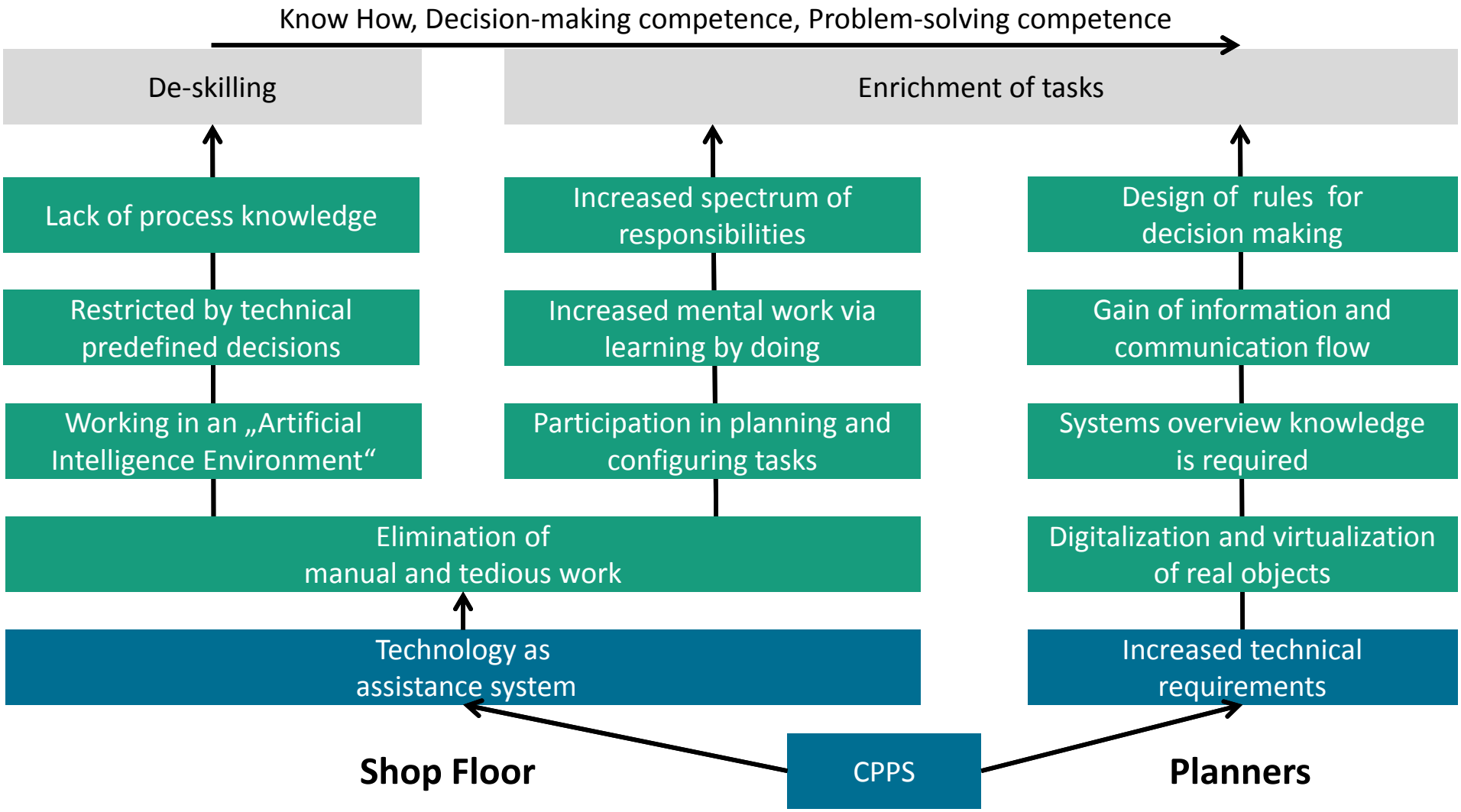
Industry 4.0

Change of qualification requirements



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Applied Research / Mobility Project

Network of Innovative Learning Factories (NIL)

- Activities related to Learning Factories:
  - Standardization of the „System Learning-Factory“, including joint development of learning modules on Industry 4.0
  - Intensification of academic exchange between the involved institutes on the level of researchers and students, including a summer school on Learning Factories (start: summer 2015)
  - Dissemination of related research results in a series of papers on Learning Factories (start: Summer 2014)

NIL
Netzwerk Innovativer Lernfabriken

Members

Sponsors

DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Applied Research Project
LOPEC

Logistics Personal Excellence by continuous Self-Assessment

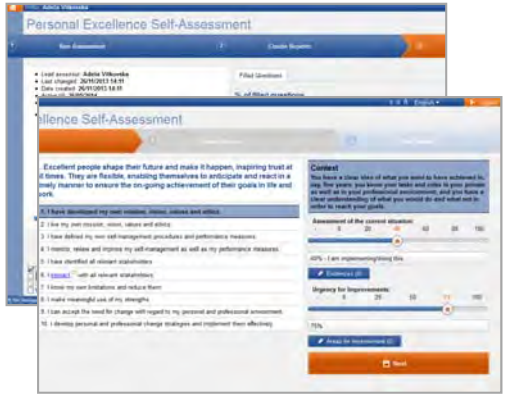
LOPEC

Education and Culture DG
Lifelong Learning Programme

- Human specific addressed aspects of Industry 4.0:
  - Initiating of lifelong-learning through a blended learning approach
    -> self studying via an LMS
    -> hands-on training in the LF
  - Fostering work-life balance by self-assessment of personal, professional and business objectives
  - Sensitizing of demographic change on shop floor level with the initiation of knowledge transfer between different age groups

Learning Mgmt. System

Self-Assessment Tool



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