Shared Autonomy to Enable Seamless Integration of Human Robot Workplaces

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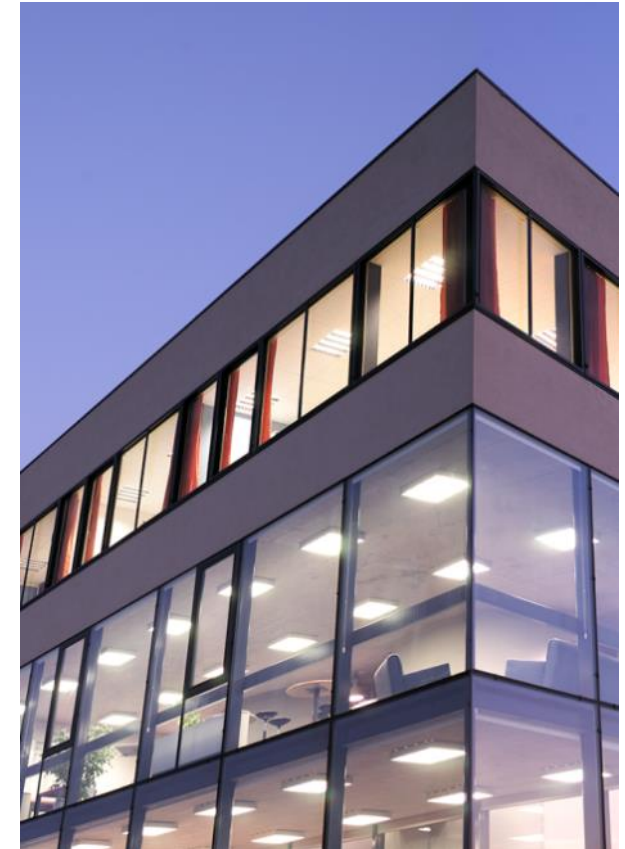EUROPEAN UNION
Smart Factory Hub

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Topics to be adressed

- ↗ From EU funded research to Industrial Application

- ↗ Robotic Co-worker Technologies development for industrial applications

- ↗ Workflow-based robot process design and execution

- ↗ Onboard process planning and configuration tools

- ↗ **Symbiotic** human-robot collaboration for multimodal Human Robot Interaction

- ↗ SmartFactory HUB – an Interreg project related to I4.0

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PROFACTOR Profil

- ↗ Austria's no. 1 in **applied production research**
- ↗ Multidisciplinary team with **74 employees**
- ↗ Business locations in **Steyr** and **Vienna**
- ↗ **6 Mio. EUR turn-over** (2015)
- ↗ Since 1995 **over 1,700 (inter-)national projects** in **industry (1,360)** und **research (350)**

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Research Area- Industrial Assistive Systems

↗ Increasing the competitiveness!

↗ Aim: to support human beings in a in a volatile, richly varied and highly flexible production

   ↗ Decision-making competence, knowledge and experience of workers
   ↗ Precision, endurance, speed or the power of the machine

↗ Intelligent Automatization for Mass Customization.

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Ergonomic Collaboration Human & Machine (LOCOBOT)

↗ **Initial situation**

  ↗ Reduction of "red" work places

↗ **Research approach**

  ↗ Solutions for practical division of work between human and machine, which is realizable with adequate use of resources

↗ **Results**

  ↗ **Improvement of ergonomics** through **development of assistant systems**

  ↗ Modular design of **intelligent hard- and software components** (e.g. compliant robot arm)

  ↗ Software environment for **user-friendly development of solutions and coordination** of component interaction
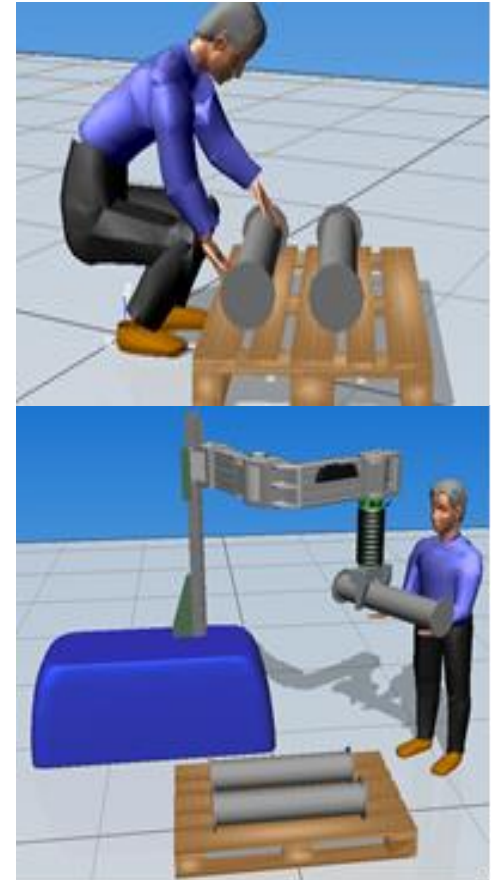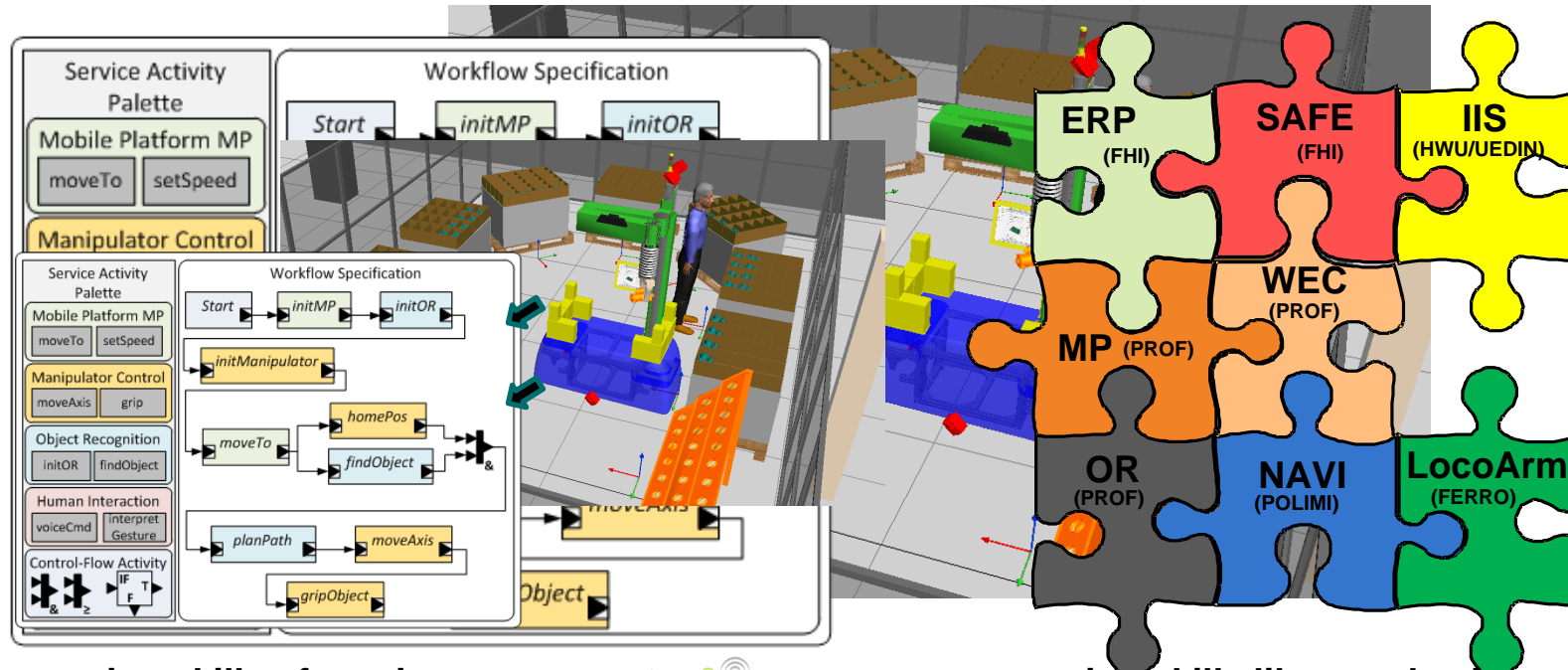
Locobot's application development

Modeling application logic

- user-friendly workflow modeling environment (WME)

Supervisory control is generated

- ‚workflow execution control' (WEC)

using skills of service components

= using skills like puzzle pieces for the application logic

Results – EuroNews Report

Challenges for flexible robotic systems

↗ Reduction of Invest

↗ Cover a wide area of use

↗ Shortest ramp up periods for on-demand applications

↗ Lower training, operating- and maintenance costs

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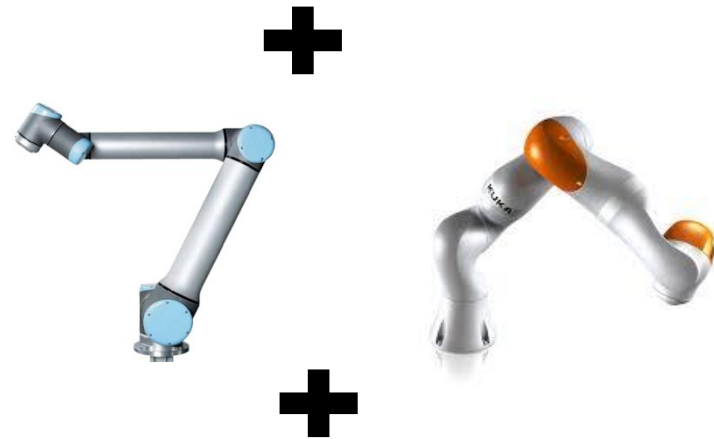# A robot for each working place (each garage) - features

↗ Movable, modulare Systems

↗ Short Ramp up (few hours)

↗ Modification in a few minutens

↗ Process execution also by Non Experts using only one Interface (HMI)

↗ Communication / Data Input using an intuitive HMI System with automatic functions
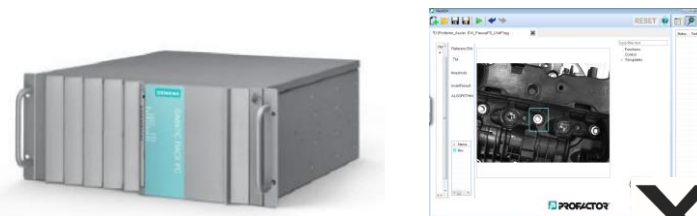
↗ Adaptive process execution

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XROB
EMPOWERING ROBOTS

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Solution– Software/Hardware construction kit

↗ Sensors & Tools

+

↗ Robots (UR, KUKA, nn)

+

↗ Control system (IPC, PC) + Software

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X R o B
EMPOWERING ROBOTS

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XRob – Features

↗ **Workflow – based,** intuitive und integrated **process mapping** and **execution** in **only one user Interface**

↗ **Consolidation of existing Input tools of the sub components** (Robot, Vision, Tool, usw…)

↗ **Intelligent, semi automatic tools** for process planning

↗ **Use of standardized IT Interfaces** (TCP/IP, DIO, ProfiNet,…) – fast integration to the Enviroment

XRob – Software Tool Kit

Workflow -Manager

Robotcontrol	**Tooling control**
Safety control	**Interfaces**
2D/3D-position detection	**Processsimulation**
Automatic path planning	**3D-Workspace scanning**

HMI-System

Cognitive Funktion	**Online - Tacking**

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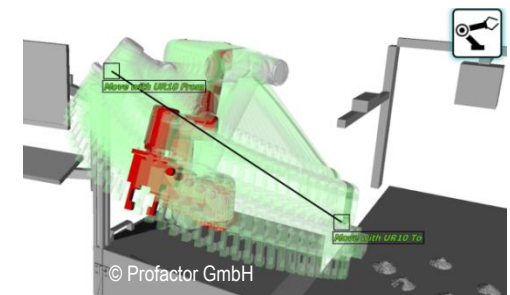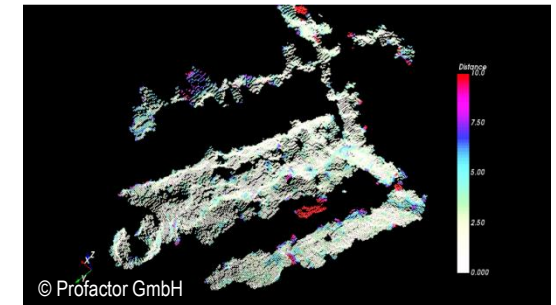
XRob – Technologies

Tool kit for quick setup and safe operation

↗ 3D scanning of the workspace

↗ Semi automatic creating of a collision model

↗ Inline - 2D/3D position detection
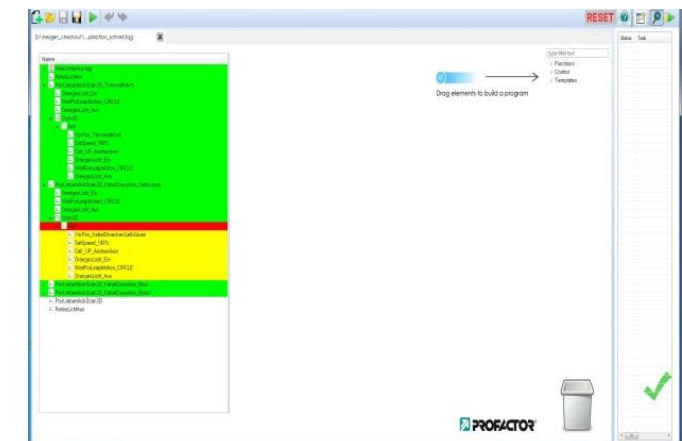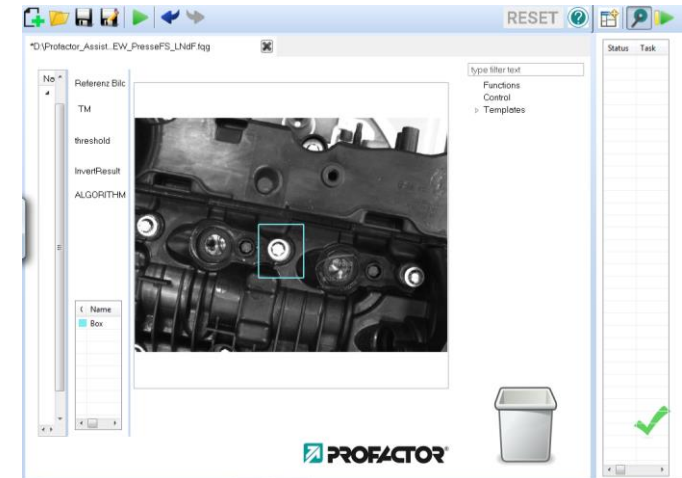
↗ Collision avoidance through automatic path planning

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XRob – Technologies

Tool kit for quick setup and safe operation

↗ Configuration all involved components via a user interface

↗ Workflow-based process

↗ Process status and progress mapping

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XRob EMPOWERING ROBOTS

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The Software system X Rob allows the creation of complex robot application within a few minutes
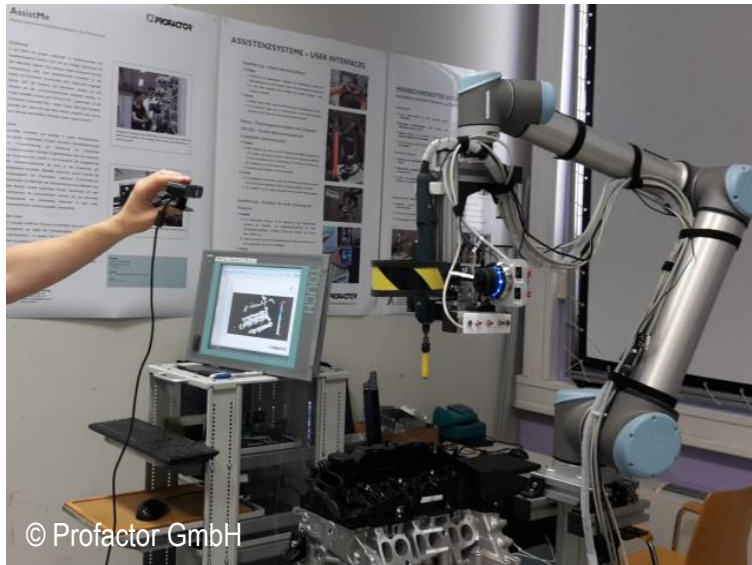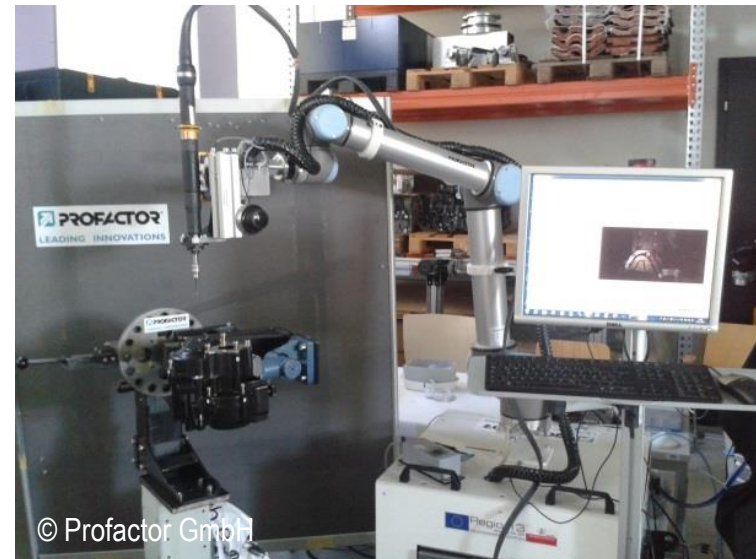
Screwing Assistant

↗ Screwing of covers and mouting parts on mobile workpiece holder in the assembly line

© Profactor GmbH

R&D Project AssitMe BMW Steyr 2015

© Profactor GmbH

Pilotsytem   Flexible Screwing Station BRP Rotax 2016

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XRob – Anwendungen

Screewing Assistant

↗ Screewing of accessories / Covers

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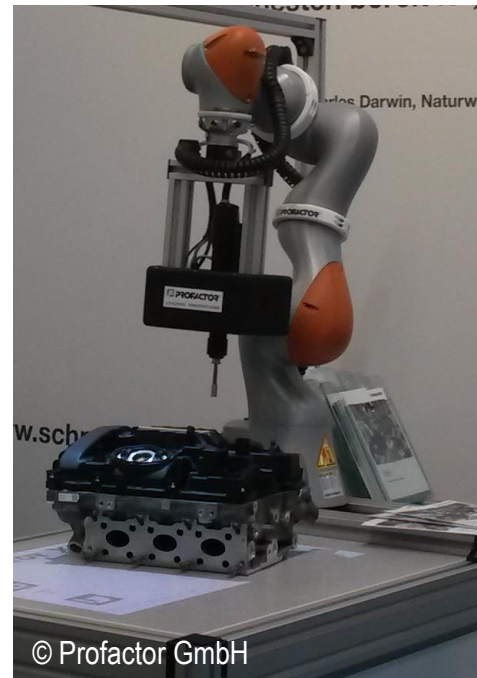
Inspection Assitant – Flexible Quality Gate

↗ 3D-Inspection of des locking conditions of plugs and oil cover plates (since autuum 2013)

© Profactor GmbH
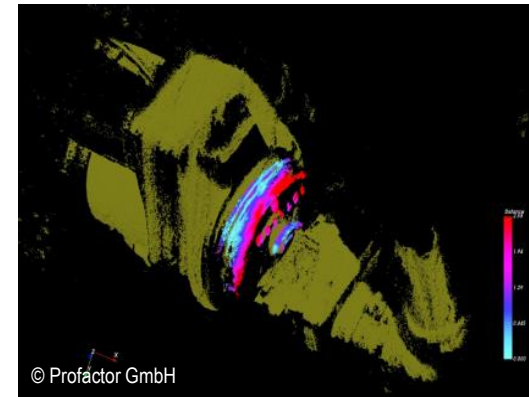
© Profactor GmbH

IO / NIO Auswertung der 3D-Daten

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XRob – Applications

Inspection Assistant

↗ 3D Inspection of Plugs and Oil cap on the engine

↗ Acustic Testing System for vehicel body parts

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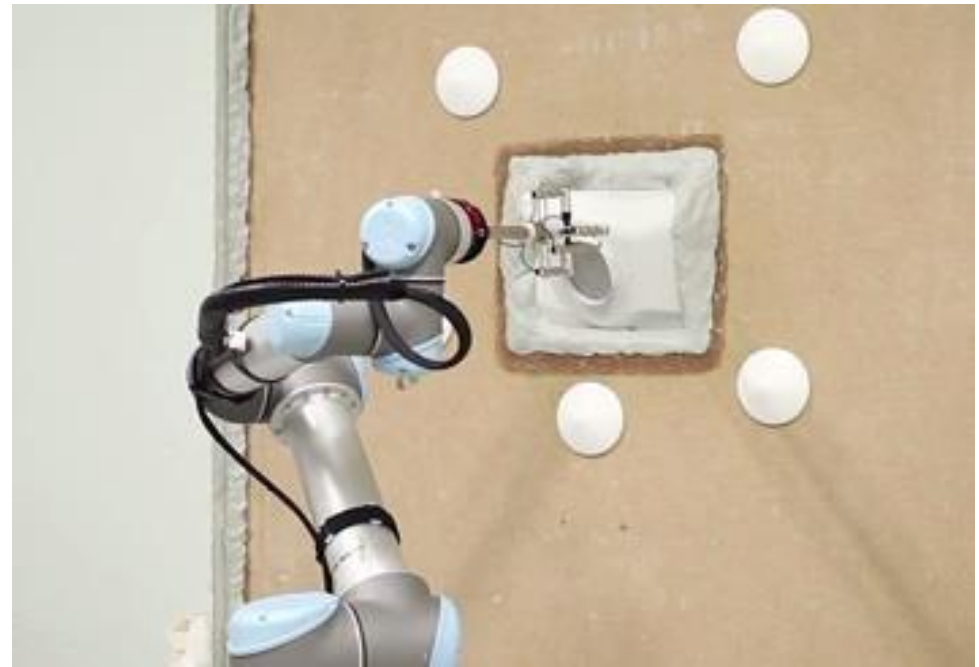
Pilotproject Flexible Quality Gate BMW Steyr 2013

Flexible Acustic Inspection Systems 2015

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Assembly Assistent

↗ 3rd Hand Support

© Profactor GmbH

R&D-Project 3rd -Hand Support 2016

XRob – Application

Handling Assistant

↗ Pin Picking (since 2009)
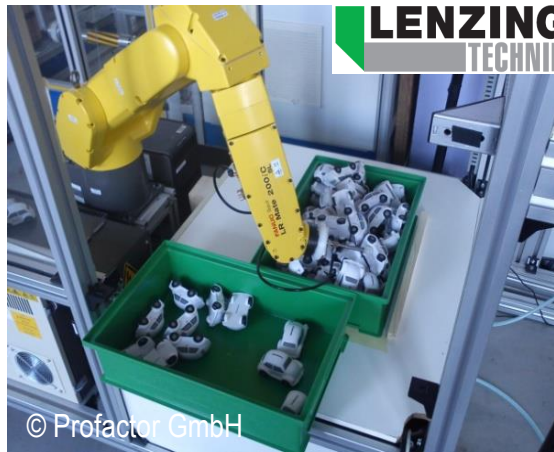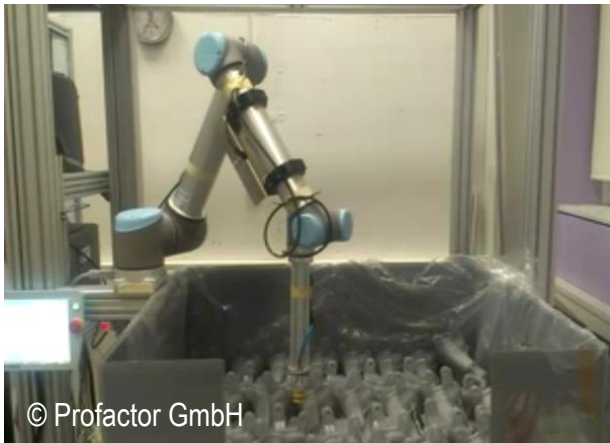
New: Selective Handling (AR-based)

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XRob – Application

Paint Assistant

↗ Painting of 3D-Objects
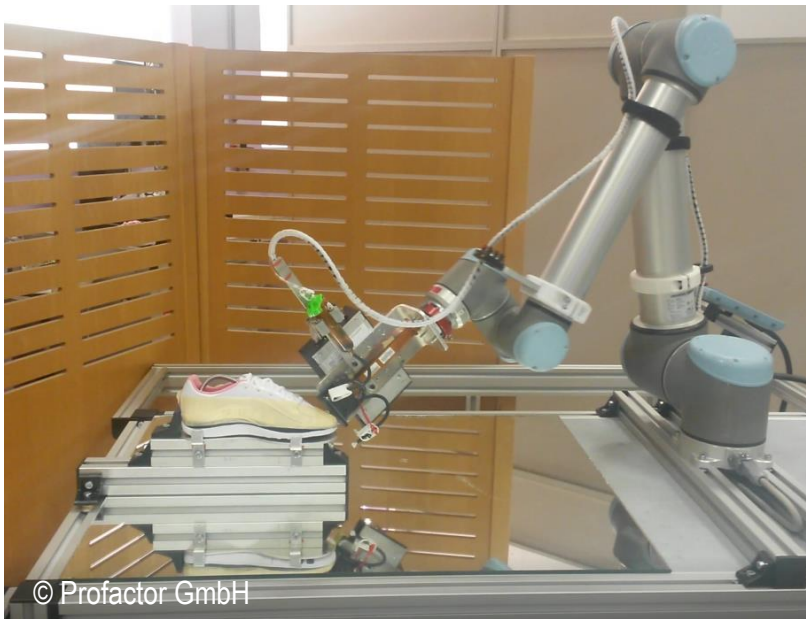
Printing on 3D Surfaces

addmanu

A result from the Austrian Lighthous project addmanu

www.addmanu.at

Research projects

↗ Cognitive interaction- robot knows user requirements
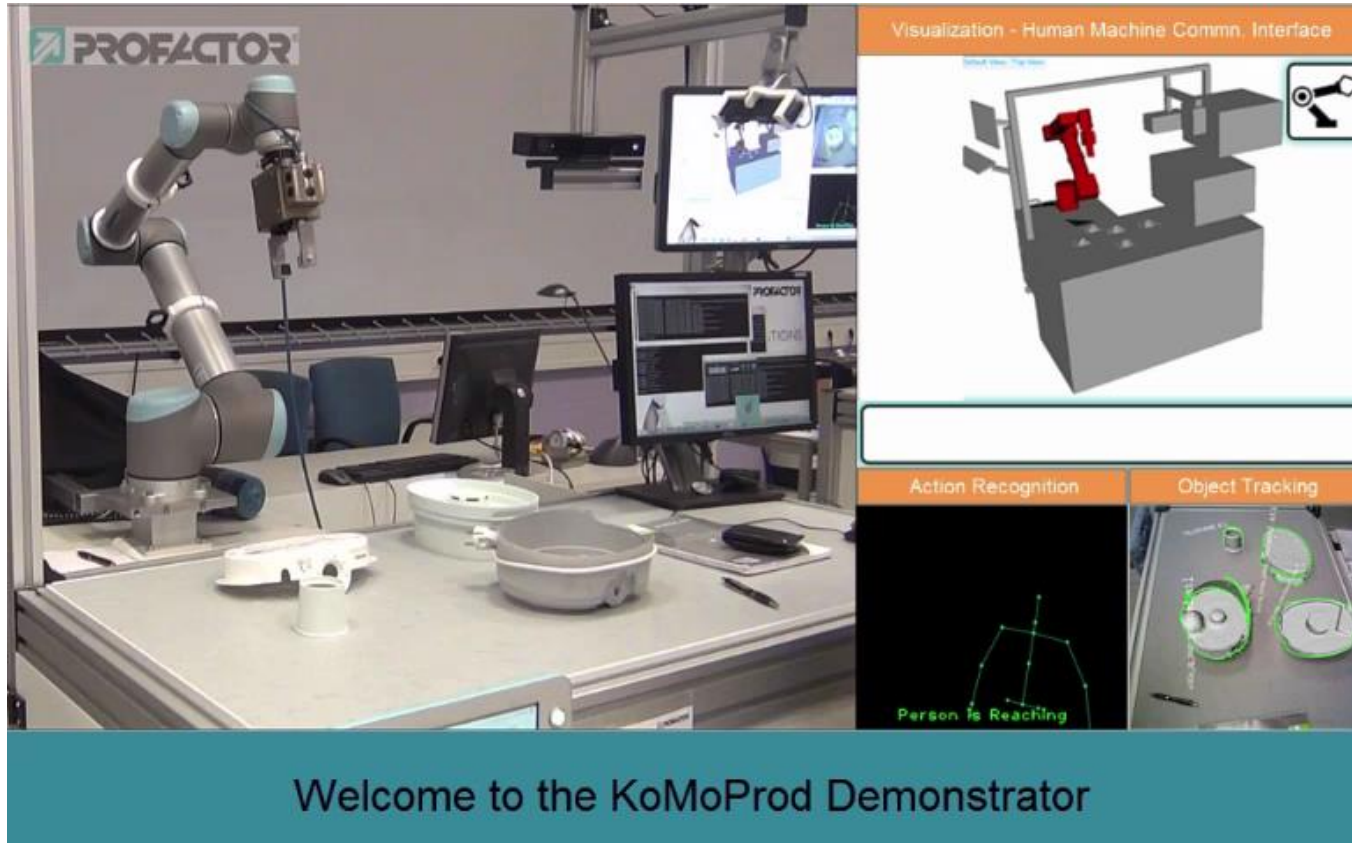
Welcome to the KoMoProd Demonstrator

Symbiotic human-robot collaboration for safe and dynamic multimodal manufacturing systems
(SYMBIOTIC)

Early results and outlook for human robot symbiosis

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Project Overview

- The project's final goal is to test and quantify the aforementioned four objectives in terms of:

  ➢ Safety

  ➢ Feasibility

  ➢ Intuitiveness

  ➢ Adaptability

  ➢ Scalability

- **Three demonstrators:**

  ➢ **Food-processing (Robomotion)**

  ➢ **Aeronautics (Aciturri)**

  ➢ **Automotive (Volvo Cars)**
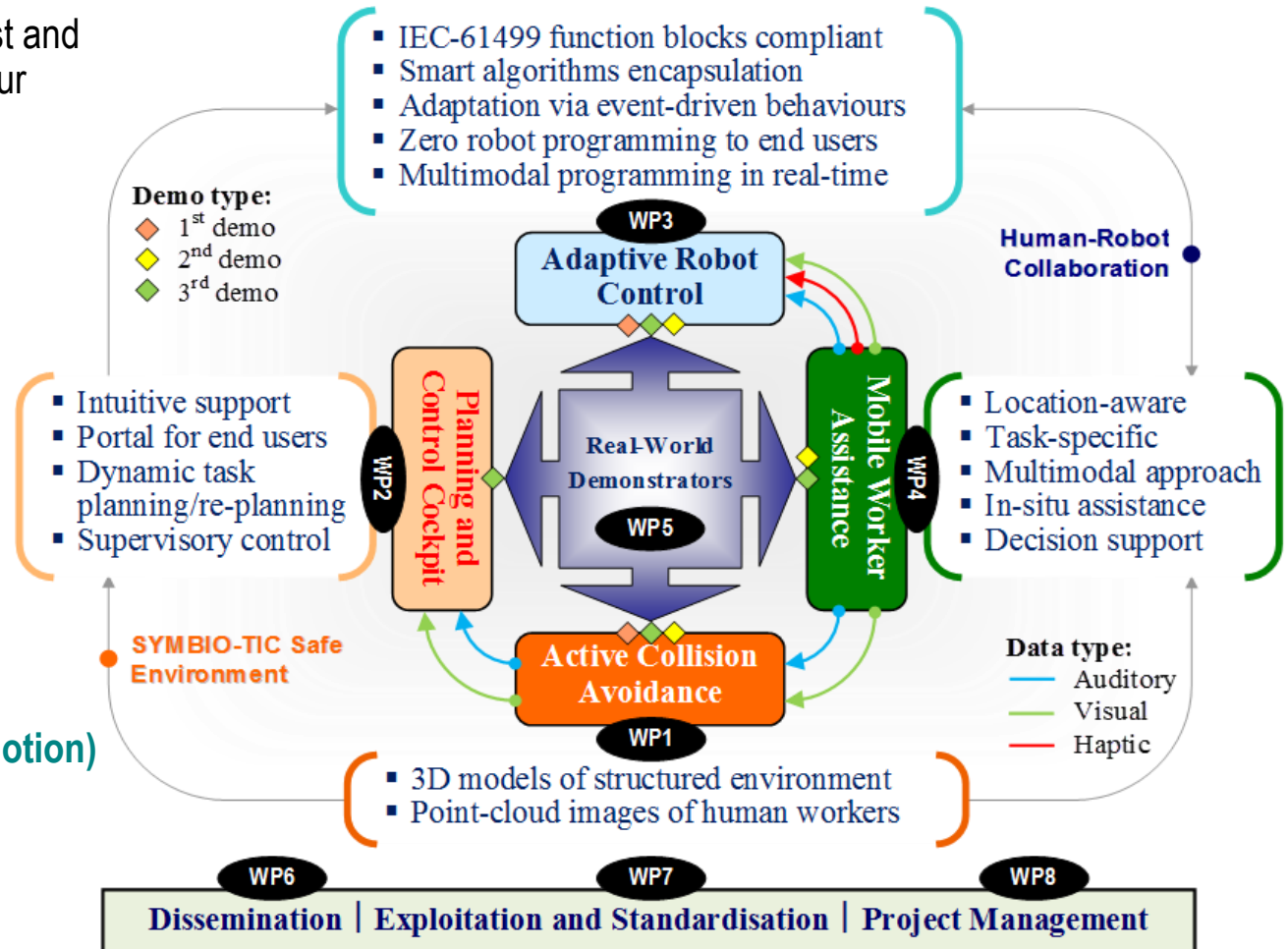
Project Objectives

Active collision avoidance for safe human robot collaboration in real time.

Dynamic adaptation to changes in the shop-floor environment with zero programming for the robot users.

Adaptive task plan generation for robots and human workers allowing collaboration.
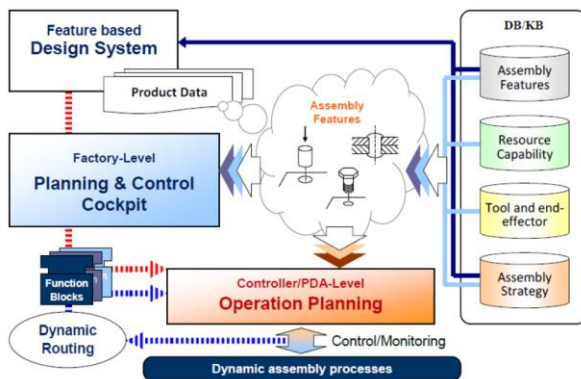
Instructions generation for supporting human workers on what and how to do.

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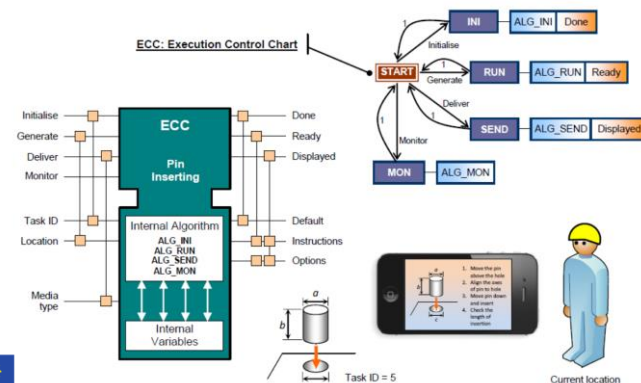
Smart Factory Hub overview
Presented by:

Christian Wögerer, Profactor

Project: Improving RD and business policy conditions for transnational cooperation in the manufacturing industry

Acronym: SMART FACTORY HUB

Budapest, 20.09.2017

Topics addressed

① Why factories? Why manufacturing sector?

② Global trends

③ What is Smart Factory?

④ Identified challenges

⑤ About Smart Factory Hub project

Source:
https://www.bitkom.org/Themen/Digitale-
Transformation-Branchen/Industrie-
40/Perspektive-der-Arbeit.html

www.interreg-danube.eu/Smart-Factory-Hub

MANUFACTURING INDUSTRY

- main generator of RD, innovation, growth and employment;
- in all regions contributes the highest share to the total regional value added;
- in average more than a 25% of service activities are directly linked to the industry,
- every 100 busiest jobs created in the industry create 60 to 200 new jobs in other industries.
- 80% of all private R&D investments is accounted for by industry.

HIGHEST POTENTIAL for growth, added value creation and new jobs!

INCREASING PRESSURE ON MANUFACTURERS to be **more efficient** and **innovative** in their processes.

The **cause of this pressure**:
1) increased production capacity in **low-cost economies** and
2) increased innovation and level of sophistication of supply chains in **high-cost economies**.

GLOBAL LEVEL

- Micro and small companies are facing problems with **QUALITY STANDARDS** (ISO 9001, TS, etc)
- **LOW PRODUCTION EFFICIENCY** (production failures, etc)
- Ineffective production process,
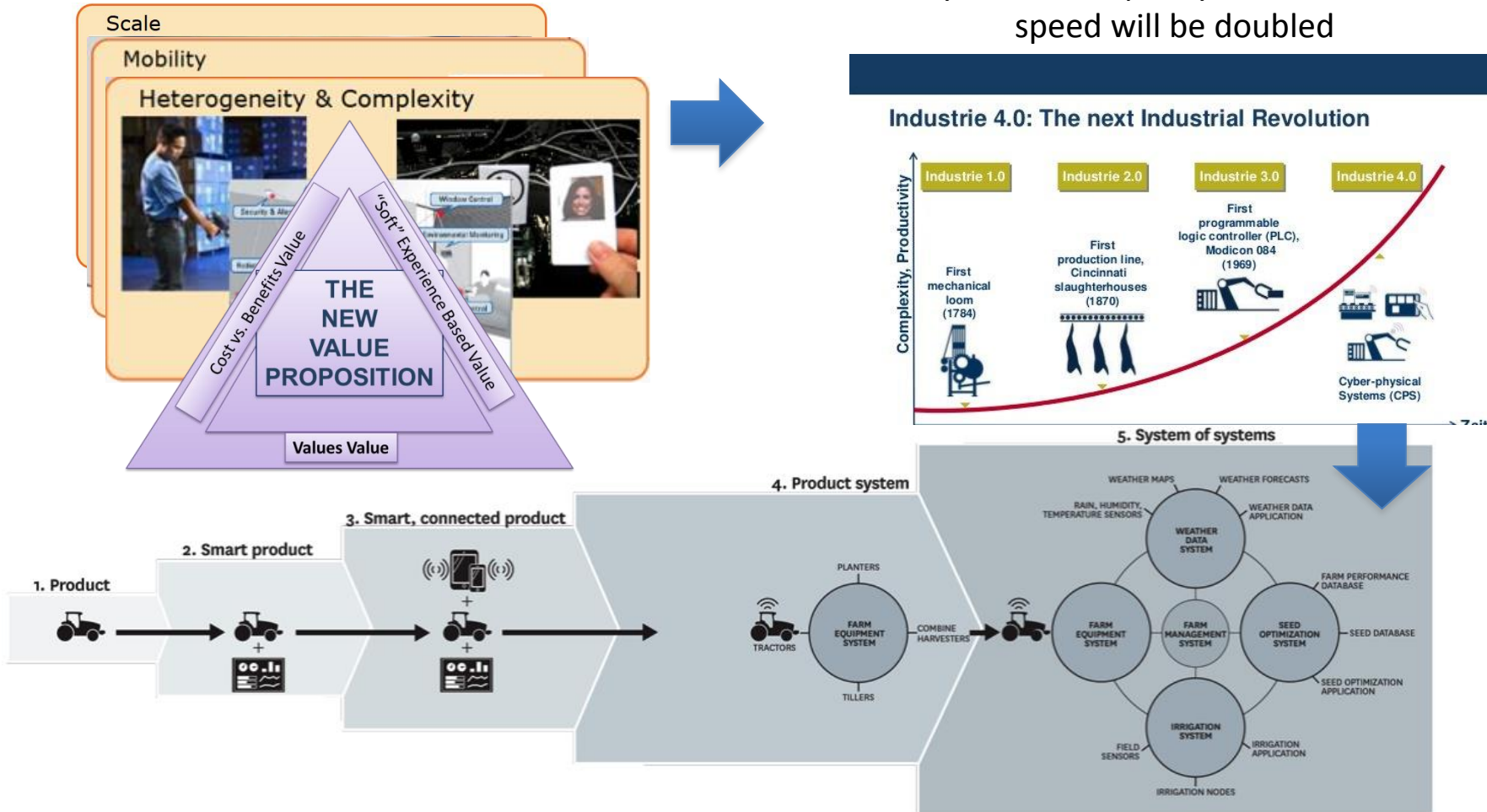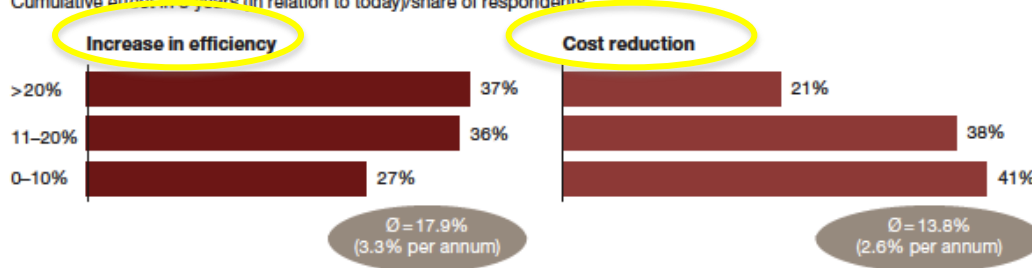- Problems with **HUMAN RESOURCE** management

REGIONAL LEVEL

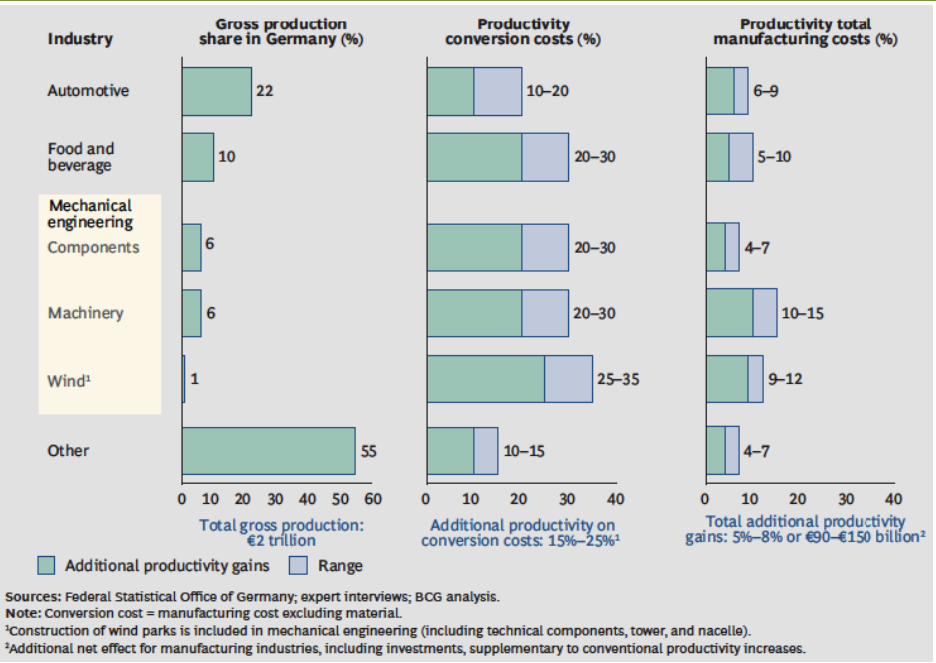in 3 years, the capacity and data transfer speed will be doubled

Expected quantitative benefit of Industry 4.0 applications
Cumulative effect in 5 years (in relation to today)/share of respondents

Increase in efficiency

>20%	37%
11–20%	36%
0–10%	27%

Ø = 17.9%
(3.3% per annum)

Cost reduction

>20%	21%
11–20%	38%
0–10%	41%

Ø = 13.8%
(2.6% per annum)

INCREASED DEMAND FOR SUPPLIERS !!!

Industry 4.0 will increase productivity in component manufacturing by 4-7%

In Germany, Industry 4.0 will generate significant productivity gains

Industry	Gross production share in Germany (%)	Productivity conversion costs (%)	Productivity total manufacturing costs (%)
Automotive	22	10–20	6–9
Food and beverage	10	20–30	5–10
Mechanical engineering Components	6	20–30	4–7
Machinery	6	20–30	10–15
Wind[1]	1	25–35	9–12
Other	55	10–15	4–7

Total gross production: €2 trillion
Additional productivity on conversion costs: 15%–25%[1]
Total additional productivity gains: 5%–8% or €90–€150 billion[2]

Additional productivity gains   Range

Sources: Federal Statistical Office of Germany; expert interviews; BCG analysis.
Note: Conversion cost = manufacturing cost excluding material.
[1]Construction of wind parks is included in mechanical engineering (including technical components, tower, and nacelle).
[2]Additional net effect for manufacturing industries, including investments, supplementary to conventional productivity increases.

Lever	Comments	Quantification (%)	
Integrated manufacturing and logistics processes	**Measure:** Complete vertical (internal) and horizontal (suppliers, customers) data integration	Labor cost: 100 / 65 / 75	Ø –30[1]
	Result: Frictionless reaction of manufacturing systems to changes in the production process	Depreciation: 100 / 120 / 160	Ø 40
Flexible small-batch manufacturing	**Measure:** Completely automated small-batch manufacturing	Operating cost: 100 / 60 / 80	Ø –30
	Result: Reduction of setup time and cost	Logistics cost: 100 / 45 / 55	Ø –50
Autonomous consignment systems	**Measure:** Automated logistics and consignment	Materials cost: 100 / 100	Ø ~0
	Result: Reduction of failures through media discontinuity as well as consignment time	Overhead: 100 / 65 / 75	Ø –30

The sum of the levers drives a reduction of cycle time from three days to one day

Total productivity increase in five to ten years

4%–7% of total cost
20%–30% of conversion cost

Today   Industry 4.0   Range

Source: BCG analysis.
Note: Conversion cost = manufacturing cost excluding material.
[1]Labor cost net effect is based on reduction and increase in the number of employees.

In Germany, Industry 4.0 will lead to increased manufacturing employment

Absolute development of employees

Thousands of employees

6,500 — 6% → 6,450

230

6,060 · 95 · 50 · 15 · Other · 6,450

Employees 2015 · Mechanical engineering · Food and beverage · Automotive · Other · Employees 2025

A significant shift in the skill profile is required to enable growth

Sources: Federal Statistical Office of Germany; BCG analysis.

Relative development

Industry	2015–2025 CAGR (%)
Mechanical engineering	0.9
Food and beverage	0.7
Automotive	0.2
Other	0.6

Return of production capacities back to Germany
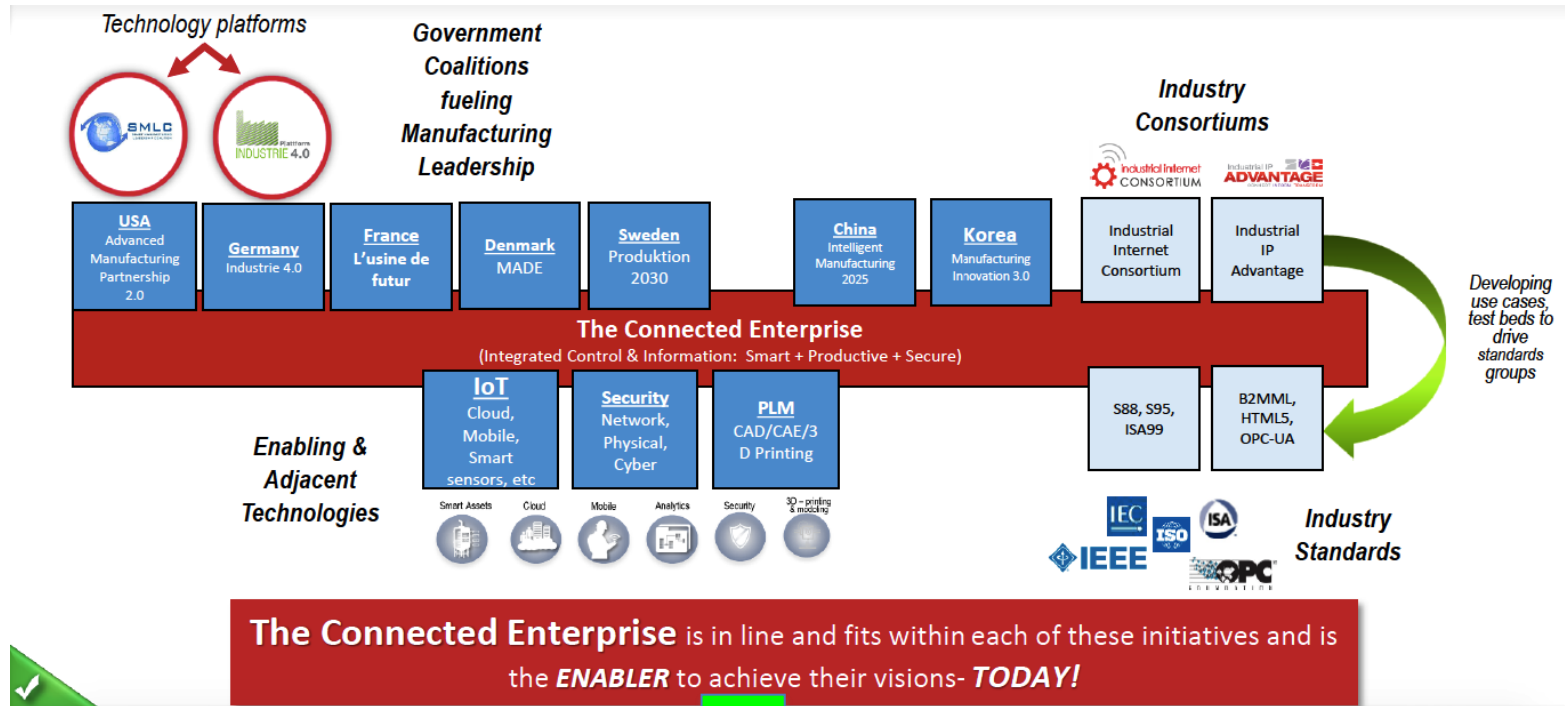
Our focus is oriented into SMEs!!!

1) **NOVEL TECHNOLOGIES** (improving efficiency, effectiveness, quality, flexibility, etc)

2) **EFFECTIVE PRODUCTION PROCESS** (applying industry standards, Lean manufacturing academy, etc)

3) **EFFECTIVE HUMAN RESOURCE MANAGEMENT** (effective system to motivate employees, monitoring employee performance, etc)

www.interreg-danube.eu/Smart-Factory-Hub

Smart Manufacturing describes the vision of what **industrial production will look like in the years to come**. It is a strategy which promotes **digitalization** and **computerization** of production with the strong customization of products under the conditions of **highly flexible (mass-) production**.

It's about connecting data, machines, people and processes!

Source: https://www.noser.com/2016/03/

www.interreg-danube.eu/Smart-Factory-Hub

Smart Manufacturing objectives (% of manufacturers), EU Analysis

Improve product quality	57.9%
Increase speed of operations	57.3%
Decrease manufacturing costs	57.0%
Improve maintenance/uptime	46.5%
Improve information for business analytics	41.6%
Improve agility and responsiveness	41.0%
Improve information for production decisions	40.7%
Improve coordination with customers	39.5%
Improve coordination with suppliers	34.9%
Develop remote monitoring capabilities	33.7%
Lower energy costs	29.1%
Improve safety	27.9%
Improve compliance (customer specifications or regulatory)	24.7%
Develop visualization capabilities	18.9%
Other	1.2%
None of the above	5.5%

Source:
https://www.linkedin.com/pulse/industry-40-4th-planetary-industrial-revolution-fernando

Industry 4.0 levers

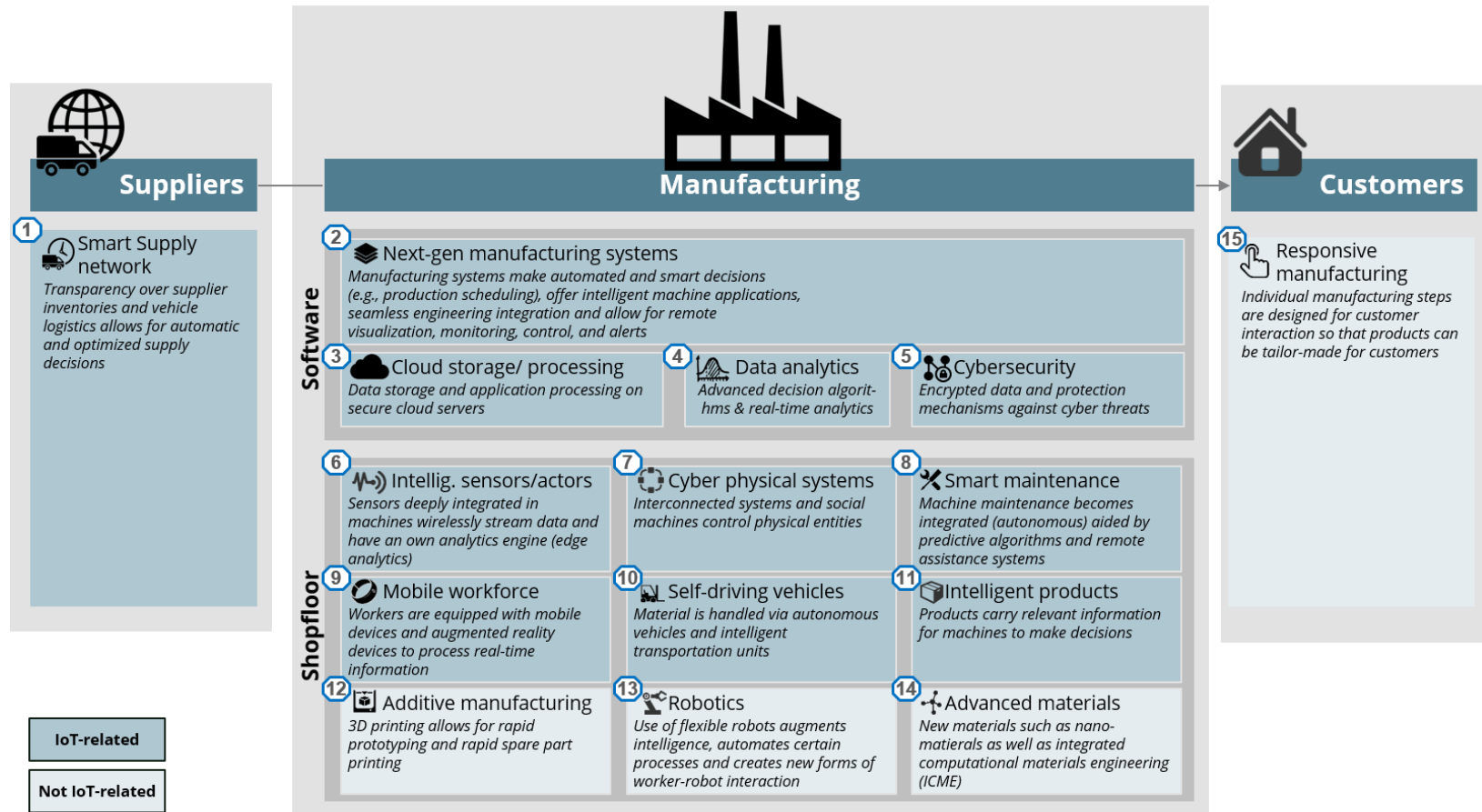Source: http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act

www.interreg-danube.eu/Smart-Factory-Hub

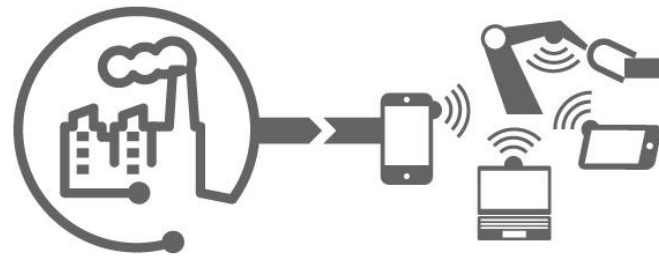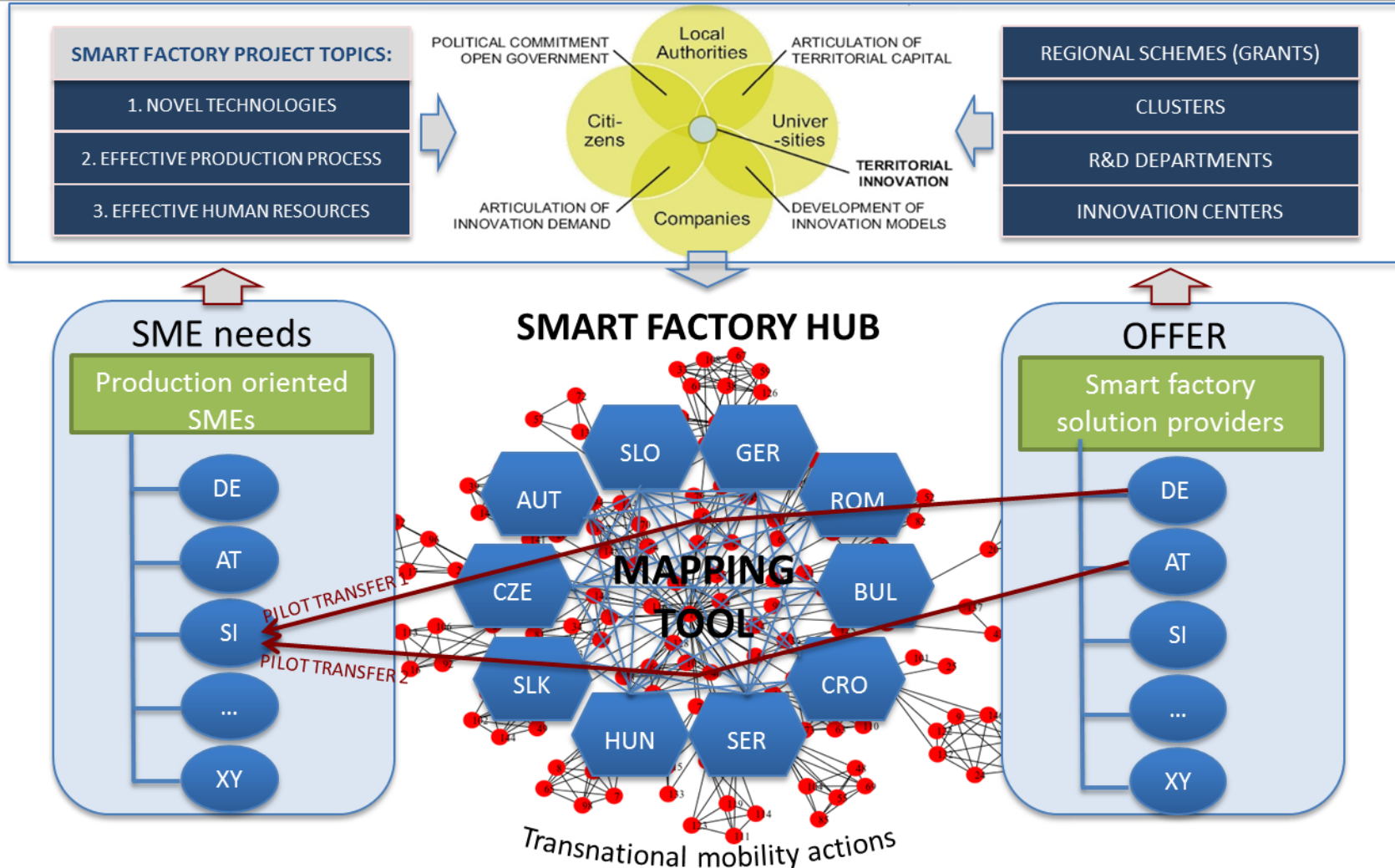# What is Smart Factory / Smart manufacturing?

15 areas of relevance

Suppliers — **Manufacturing** — **Customers**

1 Smart Supply network
Transparency over supplier inventories and vehicle logistics allows for automatic and optimized supply decisions

Software

2 Next-gen manufacturing systems
Manufacturing systems make automated and smart decisions (e.g., production scheduling), offer intelligent machine applications, seamless engineering integration and allow for remote visualization, monitoring, control, and alerts

3 Cloud storage/ processing
Data storage and application processing on secure cloud servers

4 Data analytics
Advanced decision algorithms & real-time analytics

5 Cybersecurity
Encrypted data and protection mechanisms against cyber threats

Shopfloor

6 Intellig. sensors/actors
Sensors deeply integrated in machines wirelessly stream data and have an own analytics engine (edge analytics)

7 Cyber physical systems
Interconnected systems and social machines control physical entities

8 Smart maintenance
Machine maintenance becomes integrated (autonomous) aided by predictive algorithms and remote assistance systems

9 Mobile workforce
Workers are equipped with mobile devices and augmented reality devices to process real-time information

10 Self-driving vehicles
Material is handled via autonomous vehicles and intelligent transportation units

11 Intelligent products
Products carry relevant information for machines to make decisions

12 Additive manufacturing
3D printing allows for rapid prototyping and rapid spare part printing

13 Robotics
Use of flexible robots augments intelligence, automates certain processes and creates new forms of worker-robot interaction

14 Advanced materials
New materials such as nano-matierals as well as integrated computational materials engineering (ICME)

15 Responsive manufacturing
Individual manufacturing steps are designed for customer interaction so that products can be tailor-made for customers

IoT-related

Not IoT-related

Source: https://iot-analytics.com/industrial-internet-disrupt-smart-factory/

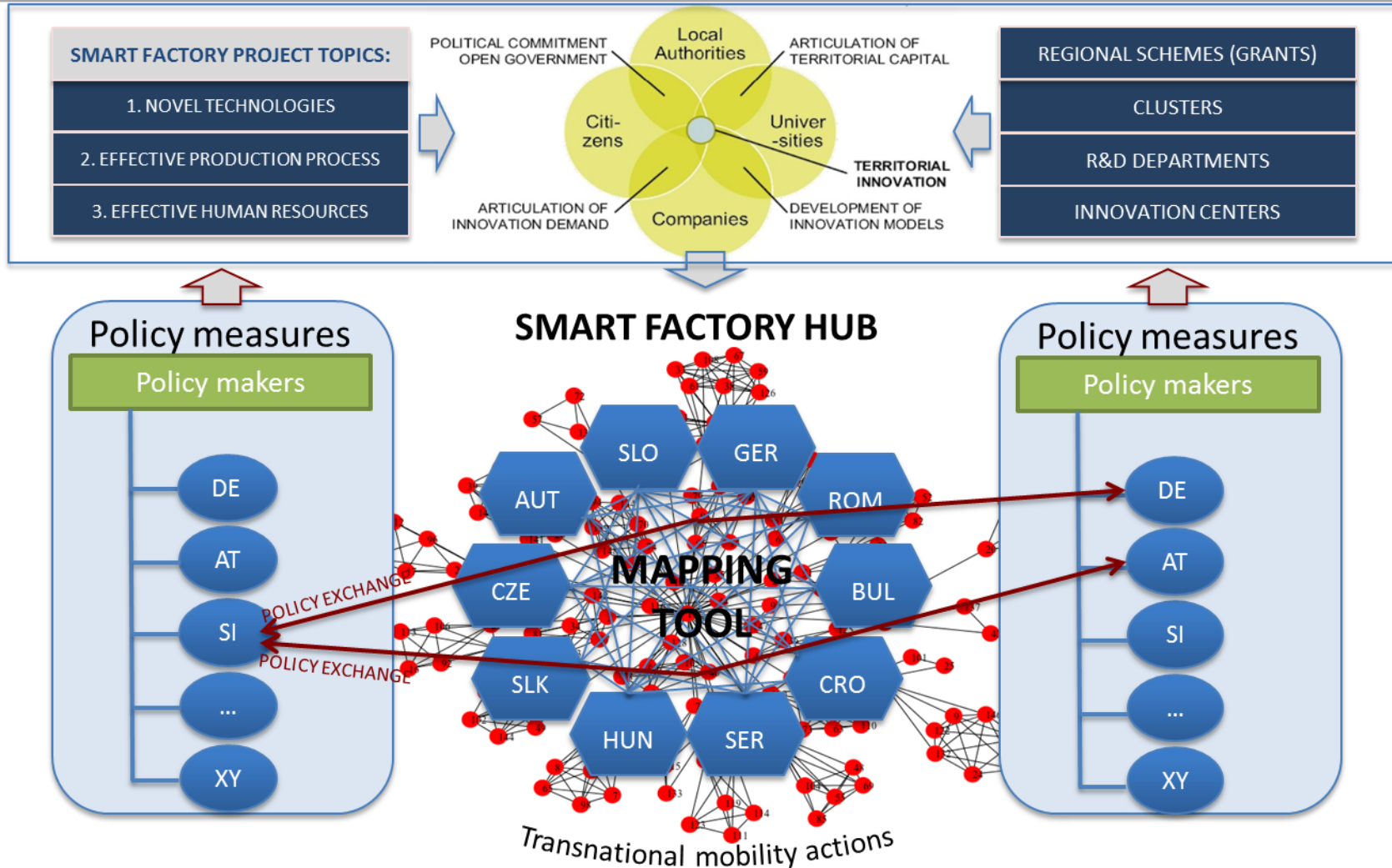www.interreg-danube.eu/Smart-Factory-Hub

- Policy makers translating strategies into concrete measures

- Smart Manufacturing is complex (vertical – horizontal)

- Production SMEs have concrete problems:

  – Need to develop due to competition

  – Faced with micro problems in their existing productions

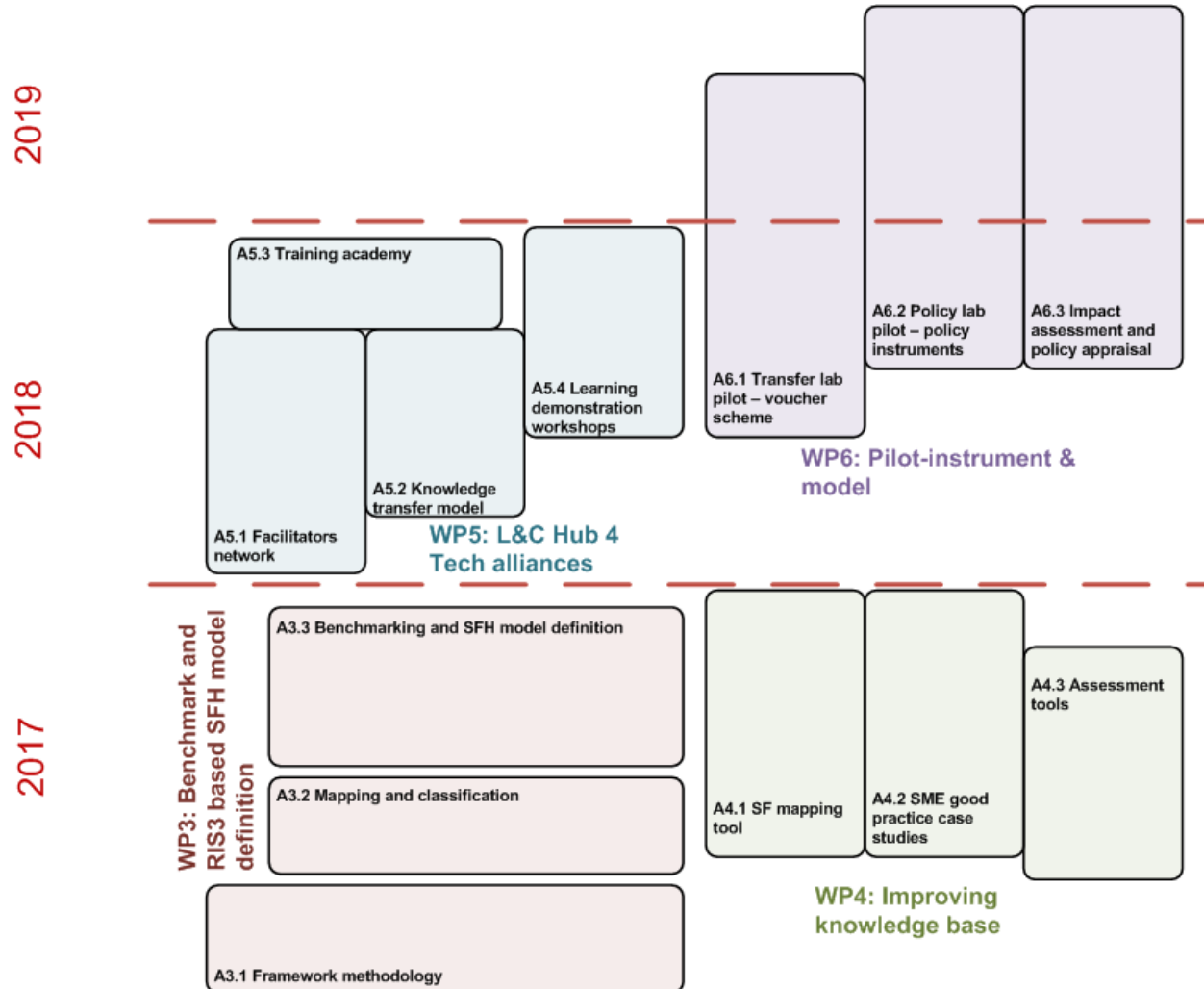 – Lack of knowledge and resources to move forward

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SMART FACTORY PROJECT TOPICS:

1. NOVEL TECHNOLOGIES
2. EFFECTIVE PRODUCTION PROCESS
3. EFFECTIVE HUMAN RESOURCES

POLITICAL COMMITMENT OPEN GOVERNMENT

Local Authorities

ARTICULATION OF TERRITORIAL CAPITAL

Citi-zens

Univer-sities

TERRITORIAL INNOVATION

ARTICULATION OF INNOVATION DEMAND

Companies

DEVELOPMENT OF INNOVATION MODELS

REGIONAL SCHEMES (GRANTS)
CLUSTERS
R&D DEPARTMENTS
INNOVATION CENTERS

Policy measures

Policy makers

DE

AT

SI

...

XY

SMART FACTORY HUB

SLO GER

AUT ROM

CZE **MAPPING TOOL** BUL

SLK CRO

HUN SER

POLICY EXCHANGE

POLICY EXCHANGE

Transnational mobility actions

Policy measures

Policy makers

DE

AT

SI

...

XY

Partners and geographical area
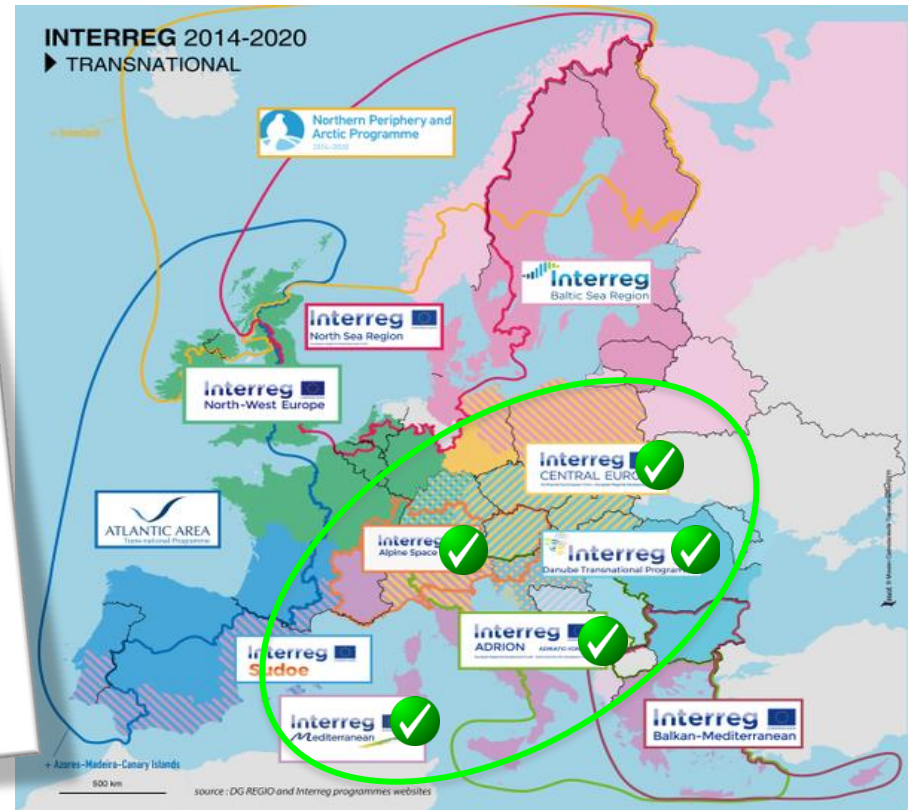
Thank You !

Contact

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Visit X - Rob on HMI In Hannover

Hall 2, Booth A44 - 24.-28. April, Hannover

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