RICAIP

Research and Innovation Centre
on Advanced Industrial Production

RICAIP

Funded under WIDESPREAD-01-2018-2019 - Teaming Phase 2 (CSA)

Teaming of Excellent Research Institutions and Low-performing RDI Regions

With the support from European Union's Horizon 2020 and from the ESIF OP RDE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 857306.

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research, Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

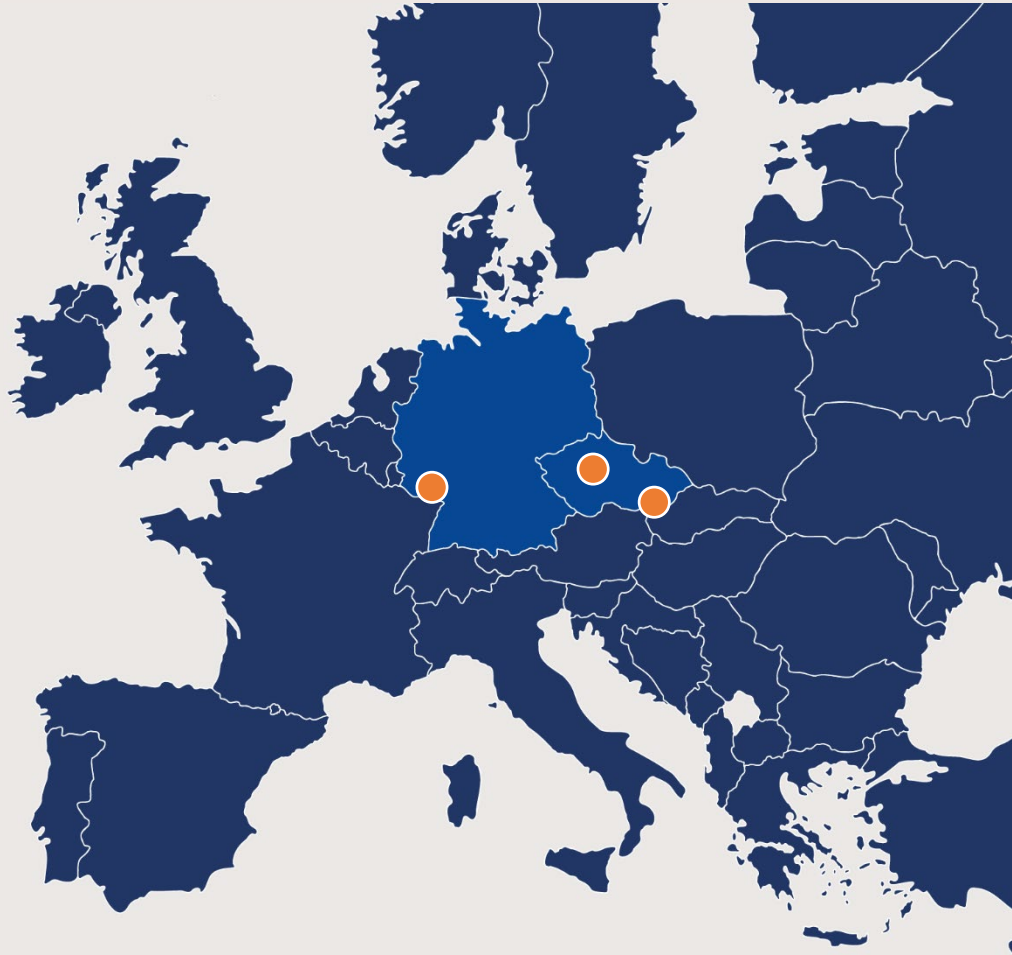
ricaip_eu

www.ricaip.eu

RICAIP

Research and Innovation Centre
on Advanced Industrial Production

- **RICAIP** is an international distributed research centre of excellence (CoE) that focuses on research in robotics and artificial intelligence (AI).
- **RICAIP** develops strong cooperation at an international level, evolving the concept of Industry 4.0 and addressing current needs, gaps, and demands of the industrial sector and society.
- To simulate and practically verify the concept of distributed production, RICAIP creates a virtually interconnected state-of-the-art R&D infrastructure in the form of the **RICAIP Industrial Testbed Core** with:
  - ✓ Testbed for Industry 4.0 at CIIRC CTU **in Prague,**
  - ✓ Testbed at CEITEC BUT **in Brno,**
  - ✓ Joint testbed of DFKI and ZeMA **in Saarbrücken.**



CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE

CEITEC
Central European Institute of Technology
BRNO | CZECH REPUBLIC

BRNO UNIVERSITY OF TECHNOLOGY

DFKI German Research Center for Artificial Intelligence

ZeMA
Zentrum für Mechatronik und Automatisierungstechnik

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on Advanced Industrial Production

- **RICAIP Project** is the largest EU project in the field of Artificial Intelligence (AI) and Industry 4.0 (2019-2026)
- **RICAIP Centre** is a newly established international multi-site centre of excellence that supports and connects Testbeds in Prague, Brno, and Saarbrücken.
- The RICAIP Centre will enable remote industrial production control or its rapid adaptation according to current needs or available means of production.

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Research and Innovation Centre
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RICAIP Research and Innovation Centre on Advanced Industrial Production

RICAIP Mission

- To make a significant contribution to fundamental and applied research in artificial intelligence, machine learning, computer science and robotics for advanced industry;
- To create a collaborative ecosystem where academia, strategic industries, SMEs and national and regional authorities produce high-impact results addressing the key challenges of the economy and society;
- To promote interdisciplinary research and collaboration with non-technical scientific disciplines to address the current needs and demands of society;
- To contribute to the education & training of highly qualified professionals for research, industry, and public;
- To develop EU R&D Infrastructure for advanced industrial production (RICAIP Industrial Testbed Core) and also to support other related European research infrastructures.

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on Advanced Industrial Production

CIIRC CTU
Czech Institute of Informatics,
Robotics and Cybernetics, CTU

DFKI
German Research Center for
Artificial Intelligence

ZeMA
Center for Mechatronics and
Automation Technology

CEITEC BUT
Central European Institute
of Technology, BUT

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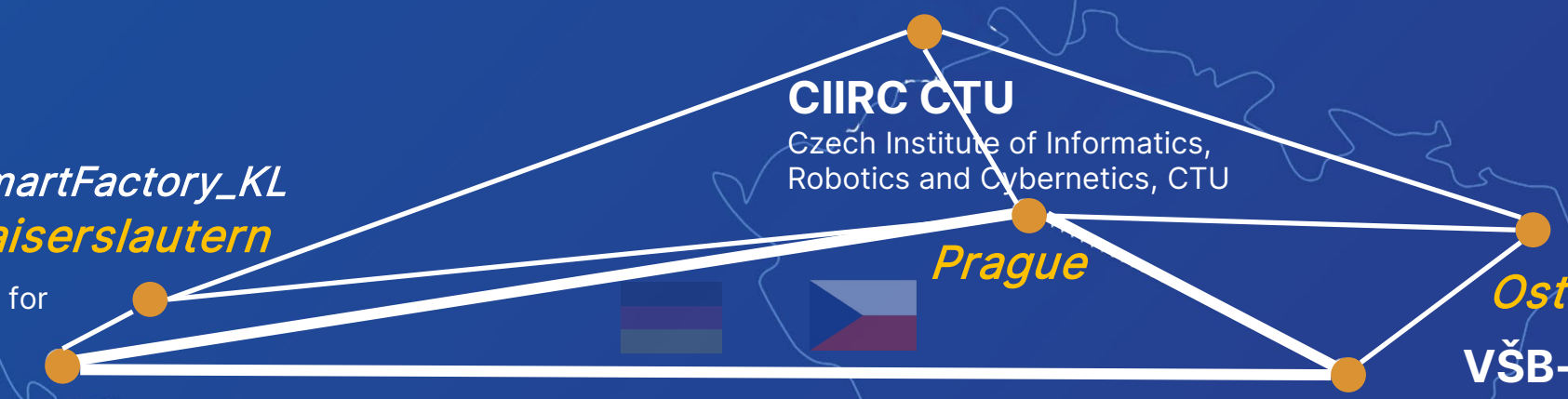
The network of collaborating nodes has been growing since 2022:



Fraunhofer IWU
Dresden

CIIRC CTU
Czech Institute of Informatics, Robotics and Cybernetics, CTU

Prague

SmartFactory_KL
Kaiserslautern

DFKI
German Research Center for Artificial Intelligence

Saarbrücken

ZeMA
Center for Mechatronics and Automation Technology

Ostrava

VŠB-TUO
Technical University Ostrava

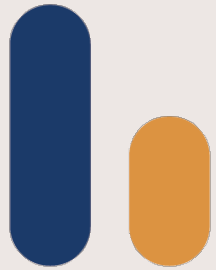
Brno

CEITEC BUT
Central European Institute of Technology, BUT

RICAIP Research and Innovation Centre on Advanced Industrial Production

Financing

€48.47 mil.
Total funding 2019 – 2026



€27.89 mil.
Investments
(mostly technology equipment)
EUR rate 25.5 CZK

RICAIP Project (2019-2026)

Principal Investigator:
Prof. Vladimír Mařík, Scientific Director, CIIRC CTU

The establishment of the RICAIP Centre is the main objective of the RICAIP Project that received funding from the **European Union's Horizon 2020** (No. 857306) and from the **ESIF OP RDE** (European Structural and Investment Funds) (CZ.02.1.01/0.0/0.0/17_043/0010085).

European Commission
EU Horizon2020: H2020-WIDESPREAD-01-2018-2019 – Teaming Phase 2 (09/2019 - 02/2026)
Grant Agreement No. 857306
€14.99 mil.

EU & Czech Ministry of Education, Youth, and Sports
Complementary funding from ESIF OP RDE
(09/2019 - 06/2023)
Project No. CZ.02.1.01/0.0/0.0/17_043/0010085
€33.48 mil.

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreements No. 857306.

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Operational Programme Research, Development and Education

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RICAIP Research and Innovation Centre on Advanced Industrial Production

Three megatrends motivating R&D

Resource-efficient production and waste management

Workforce ageing and continuous education

Increasing complexity of production processes

Production processes

Industrial automation

Energy management

Human-machine collaboration

AI for production

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Research and Innovation Centre
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CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

Saarbrücken

Prague

Brno

German Research Center for Artificial Intelligence

ZeMA
Zentrum für Mechatronik und Automatisierungstechnik

CEITEC
Central European Institute of Technology
BRNO | CZECH REPUBLIC

BRNO UNIVERSITY OF TECHNOLOGY

Prague:
Testbed for Industry 4.0 at CIIRC CTU

RICAIP TESTBED PRAGUE

Part I: Robotics & Flexible Production Laboratory

1. Assembly line for flexible production
2. Automatic loading robotic station
3. Multi-axis motion system with a delta robot
4. Universal robotic cell
5. Automated warehouse with a fleet of mobile robots
6. Robotic multi-axis additive manufacturing and measurement
7. Assembly line for flexible fast production
8. Cell for assisted assembly with collaborative robots
9. Robotic vision cells
10. Robobar | Workplace for solutions in gastro industry

1 640 m²

+ 3D Printing Centre

- Industrial 3D printers of various technologies
- Plastic and metal printing
  130 m2

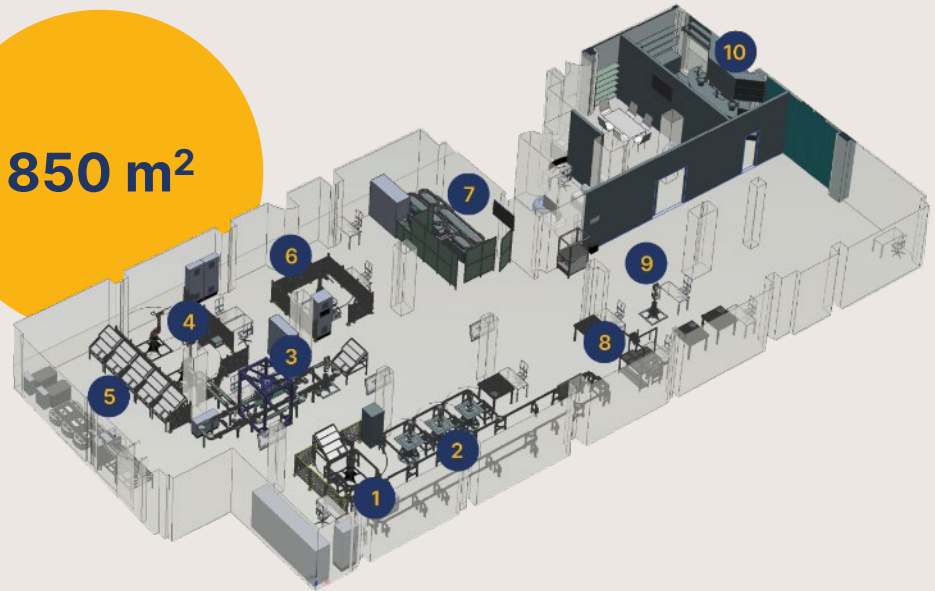
+ Smart Grid Lab

- For advanced electricity distribution systems
- Optimization of production processes regarding available energy sources, incl. photovoltaic systems
  90 m2

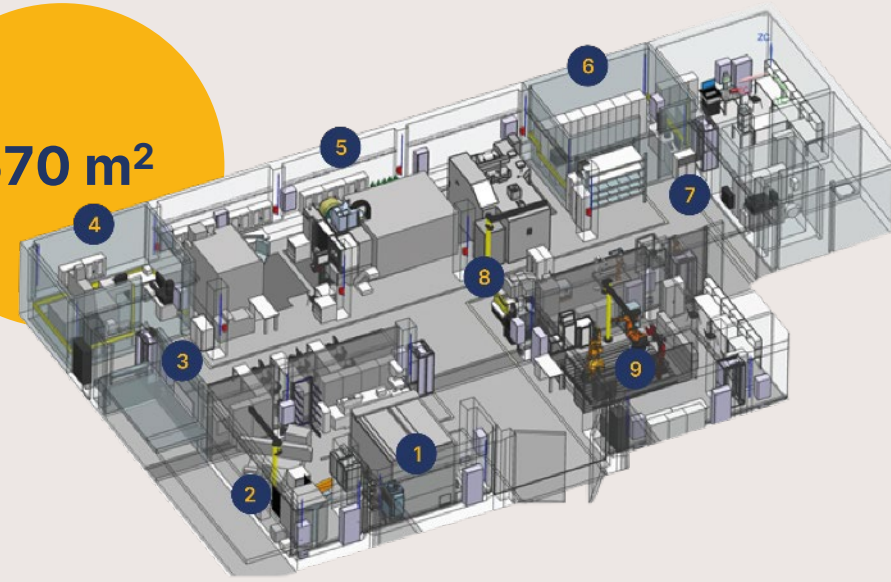
Part II: Robotics and Production Technologies Laboratory

1. Robotic laser cell
2. Femtosecond and nanosecond laser machine
3. Education and training area
4. Metrology laboratory
5. Machining and hybrid processes area
6. Tool setting area
7. Collaborative robot area
8. High precision CNC wire EDM
9. Industrial robot area

850 m²



570 m²



Prague:
Testbed for Industry 4.0 at CIIRC CTU

RICAIP
TESTBED PRAGUE

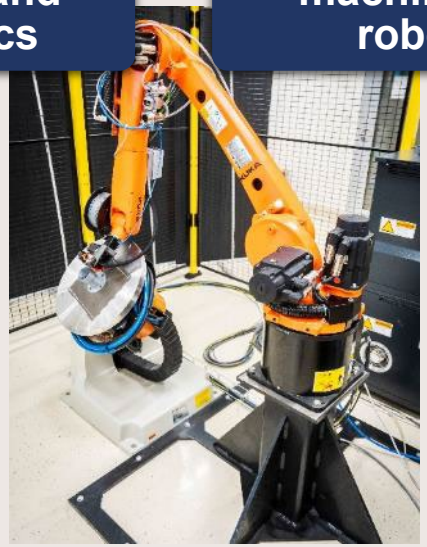
Grand Opening in April 2022

Assembly processes

Production processes

Planning of production and intralogistics

Production machines and robotics



Prague: Research Focus

RICAIP TESTBED PRAGUE

- Multiagent System for Planning of Production at Different Levels of Hierarchy:
  - Level of one machine, level of the production site, distributed production
  - Process & machine diagnostics, process optimization
- Digital Twin and Digital Shadow
  - Processing of production data, process state analysis, production scenarios, Manufacturing processes, metrology solutions, statistical process control
- Production Processes and Production Machines
  - Production machines
  - Machining processes
  - Laser technologies
  - Additive and hybrid processes
  - Advanced robotics for industrial production
  - Distributed Production
- Production as an interconnected ecosystem of productions sites, logistics & customers, autonomous distributed decisions and production plans
  - Production as a service – next stage of distributed production

Brno:
Industry 4.0 Testbed at CEITEC BUT

RICAIP TESTBED BRNO

- Brno testbed is located in an industrial hall within the Brno University of Technology campus
- The hall is equipped with a precise optical localisation system and provides enterprise-level SW solutions for products and production line design, simulation and operation, as well as a state-of-the-art automation network
- Automated warehouse
- Production line with laser cutting / welding, 5-axis and 3-axis machining, CNC turning
- Precise 3D scanning
- AR/VR equipment
- Optical localisation system
- Automation network, PLM SW
- Omnidirectional mobile robots/manipulators
- Private 5G network
- 3D printing (metal, plastics, design printer)
- Dynamometers: Unique linear-motor dynamometer (up to 15m/s speed and 10 kN force); Set of rotational dynamometers, unique dynamometer 20 kRPM, 250 kW

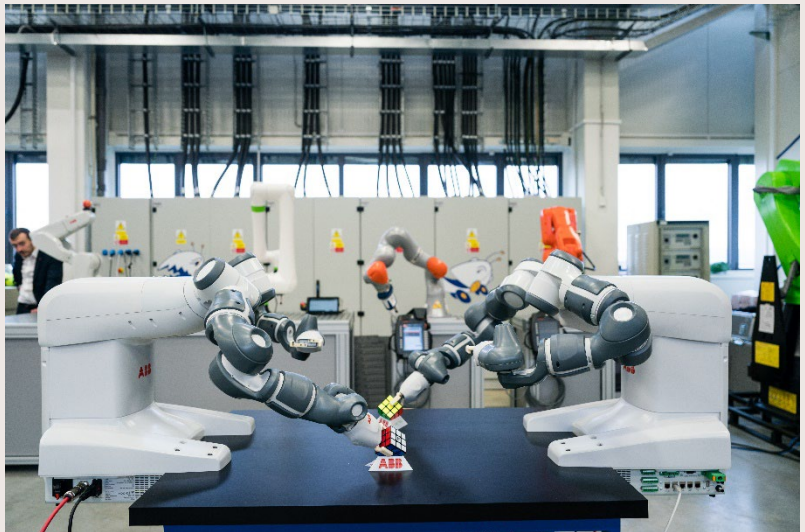
460 m²

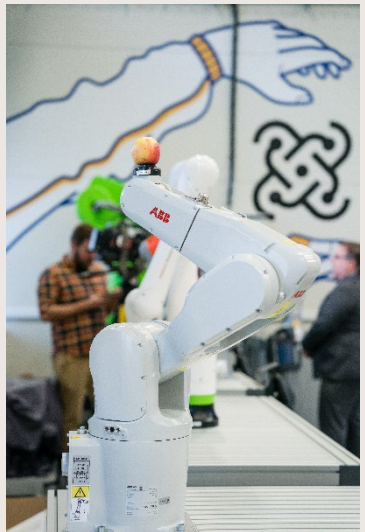
1. Dynamometers for industrial linear and rotational actuators
2. 3-axis machining center
3. Assembly line with collaborative robots
4. 5-axis machining center
5. AR/VR
6. Precise measurement of dimensions
7. Robotised warehouse
8. Laser cutting/welding
9. Turning machine

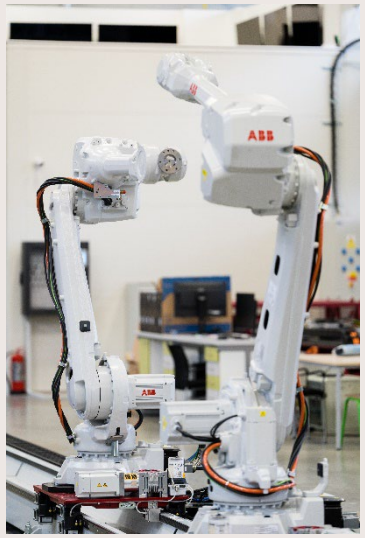
BRNO:
Industry 4.0 Testbed at CEITEC BUT

RICAIP TESTBED BRNO

Grand Opening in November 2022







Brno: Research focus

- Flexible production systems
  - Additive/subtractive technologies combination
  - Flexible transport systems – AGVs, AUVs, mobile manipulators
- Human-machine-robot cooperation
  - Precise 3D localisation of robots, machines, tools, and workers
  - Prediction of workers' intentions
  - VR/AR techniques, human-machine interfaces
- Machines and mechatronic systems diagnostics
  - Vibro-diagnostics, AI-based machine health estimation/prediction
  - Acoustic holography, acoustic emission analysis, sensors for diagnostics
- Advanced actuators
  - High-performance rotational and linear motor drives
  - Fail-operational actuators in production systems
  - AI-based control optimization, fault detection and fault mitigation

Saarbrücken: Power4Production & HRC4.0 Lab – DFKI & ZeMA

RICAIP TESTBED SAARBRÜCKEN

- The Centre for Innovative Production Technologies (Power4Production) is jointly operated by ZeMA and DFKI and located on the ZeMA premises.
- DFKI's German-Czech Innovation Laboratory for Human-Robot Collaboration in Industry 4.0 (HRC4.0 Lab) was founded in 2016 and funded by the German Ministry of Education and Research.
- HRC4.0 Lab is a part of Power4Production and the core of the RICAIP node in Saarbrücken.
- HRC4.0 Lab hosts more than 25 robots of different kinds, including robotic arms, self-driving robots, humanoid robots and drones.

HRC4.0 Lab: >25 robots

RICAIP
TESTBED SAARBRÜCKEN

Saarbrücken: Research focus

- Main focus: "Industrie 4.0", digitalization, AI applications in production as well as robotics.

- Sensors & Actuators
  - Deployment of intelligent materials
- Robotics Applications
  - Human-robot collaboration
  - Human-robot communication
  - Sensitive robotics
  - AI applications for robotic applications
- Automotive Production
  - Development of new production and commission technologies for the next generation of cars
- Industry 4.0 & Digitalization
  - Research and development of solutions for a digitized and human-centred and reconfigurable production
- Technology Transfer

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Selected Use-cases and Demonstrators

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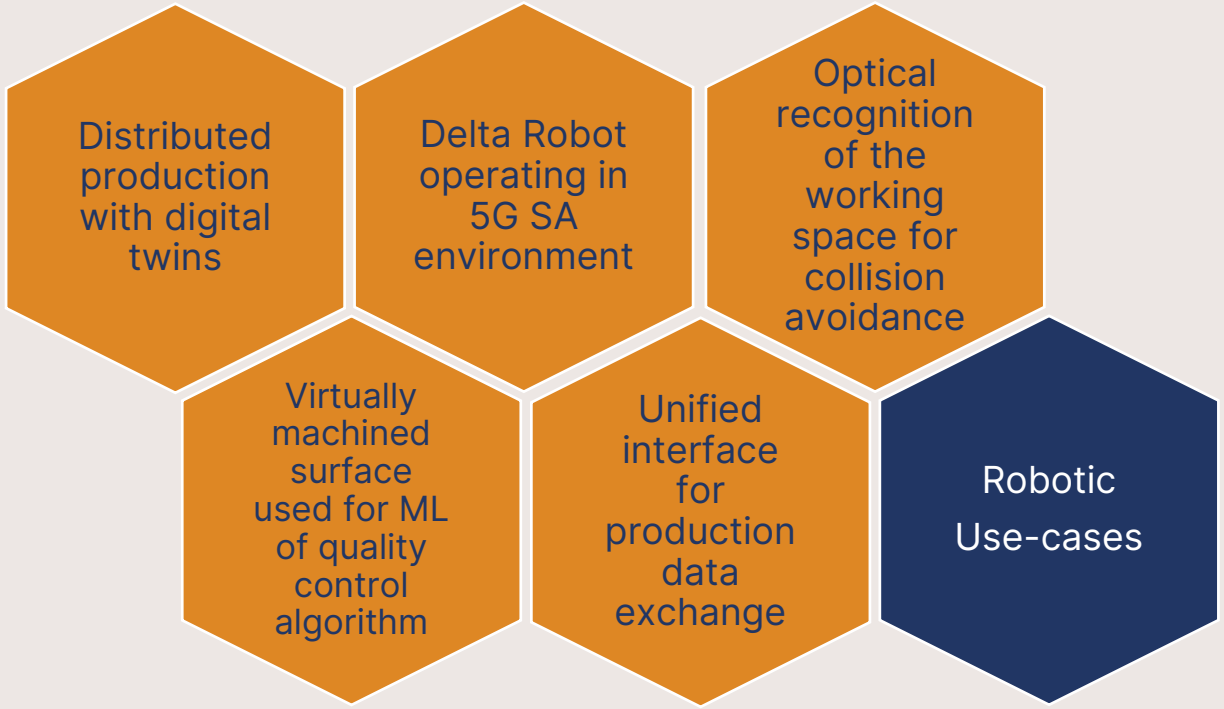
Selected Use-cases and Demonstrators



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Distributed production with digital twins

Entire new concept of multi-site production:

- Each machine has a digital wtinw that reflects its characteristics
- It communicates with other digital twins
- Digital twins are used for individual machines, entire manufacturing units and other entities involved in production
- The entire production process can be simulated to eliminate the occurence of errors and share knowledge with the use of AI to optimize the production and respond quickly to changing environments

Delta robot operating in 5G SA environment

- Delta robots are used for applications where fast operations are required.
- This demonstrator is equipped with a conveyor whose pallets can be precisely tracked and the robot's movements can be synchronized with those of the pallets.
- The robot can be equipped with a handle to perform what is called a "manual guide" to learn the trajectories to be performed during normal operations.

Delta Robot – Technical Parameters

- 5 DoF Delta robot with excellent dynamics and precision
- Two types of conveyors are combined together: Festo MCS and FlexLink
- Multi-Carrier-System based on linear motors
- SIMATIC PLC technology
- Automatic tool changing and identification of tools
- Digital twin in Simulink Simscape

Delta Robot hand guiding

- Neural network and computer vision edge-computing on the GPU server
- Precise real-time localization of objects
- Visual quality control via neural network
- Physical quality control via force-torque data
- Hand guide for „no code“ programming of the robot
- 5G SA network for stable and low-latency connection to GPU server

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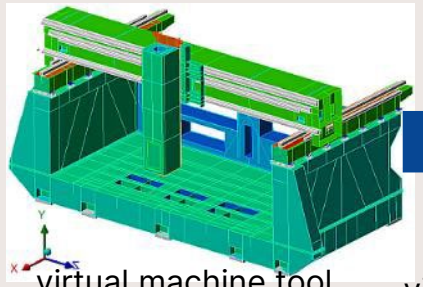
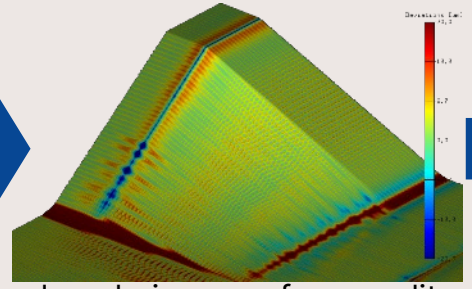
Virtually machined surface used for machine learning of quality control algorithm

- Complex shaped parts have complex surface errors after machining. These errors can be checked using ML methods. The virtual machining models can produce group of learning data for ML. Main advantage: source of surface errors is know from the virtual model. I.e. ML algorithm can recommend the improvement.



virtual machine tool (incl. control system)



virtual workpiece: surface quality, information about the machine and process setting

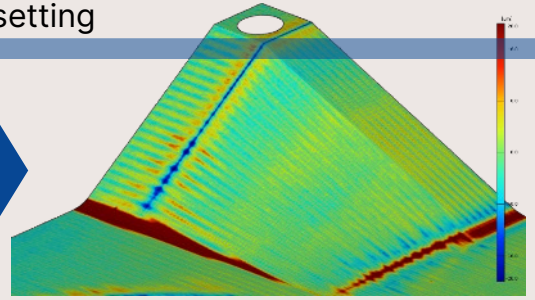
ML algorithm for learning of:
- final quality OK/NOK
- relation between NOK feature and machine/process setting

Quality check of the real part. If NOK quality identified, feedback to the real machine/process setting

NC code

real machine tool

real part



scanned surface

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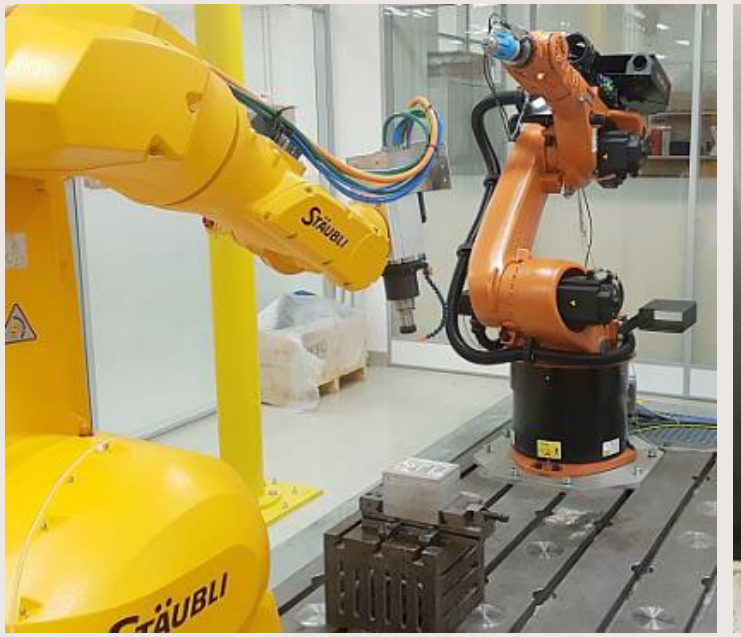
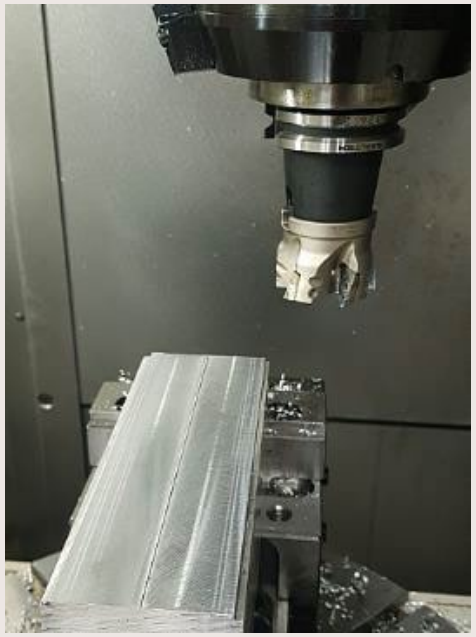
Optical recognition of the robot/machine tool working space for collision avoidance

„Machines can see and can avoid collision“.

- A visual system for identification of machine tool workspace, fixture device and workpiece.
- A quick setting of the machining zero point.
- 3D vision for machine tool/collaborative robot workspace control for collision avoidance.
- The 3D vision is to be reinforced with CAD data about ideal/theoretical situations (semantic definition needed).
- Algorithm transfer of collision avoidance between various sites.





algorithm transfer,
virtual machine tool

CAD data + vision system

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RICAIP TESTBED BRNO

Robotic demonstrators – Fully autonomous path planning

LOKI

- No significant payload capacity
- RFully autonomous
- OS compatible
- Velodyne Lidar
- Cooperates with Vicon
- Simulation in ROS-Gazebo

ODIN

- Omni-wheel drive
- Four wheels
- 3 robots
- Custom solution (TG Drives)
- Wireless communication
- Industrial-grade, safe motor controllers

VICON

- No significant payload capacity
- Fully autonomous
- OS compatible
- Velodyne Lidar
- Cooperates with Vicon
- Simulation in ROS-Gazebo