



Research and Innovation Centre  
on Advanced Industrial Production

# ANNUAL REPORT 2023

EU Project Creating a RICAIP Centre





**RICAIP**

Research and Innovation Centre  
on Advanced Industrial Production



**CTU**  
CZECH TECHNICAL  
UNIVERSITY  
IN PRAGUE



**CZECH INSTITUTE  
OF INFORMATICS  
ROBOTICS AND  
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German Research Center for  
Artificial Intelligence

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**ZeMA**  
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und Automatisierungstechnik

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**VSB TECHNICAL  
UNIVERSITY  
OF OSTRAVA**

[www.vsb.cz](http://www.vsb.cz)

# 2023 Highlights

- **30 January 2023**  
**Visit of Ivan Bartoš, Prague**  
Czech Deputy Prime Minister for Digitisation, Minister of Regional Development
- **29 March 2023**  
**RICAIP Training: Intelligent Robotic System using Hand tracking for Picking Parts in a Bin**
- **12 April 2023**  
**Women in Tech: The Gender Algorithm Event, Prague**  
co-organised together with French Embassy
- **11 May 2023**  
**Visit of European Network of Science Advisors & Science Diplomacy Coordinators, Prague**
- **23 May 2023**  
**Visit of Rear Admiral Lorin Selby, Prague**  
Chief of the US Office of Naval Research (ONR)
- **25-26 May 2023**  
**TEF AI-MATTERS 1st General Assembly, Prague**
- **30 May-1 June 2023**  
**Industry-AI Days & CIIRC CTU 10th Anniversary, Prague**  
AI Symposium, Industry 4.0 Open Day
- **14 June 2023**  
**Visit of the participants to the European Business & Innovation Centre Network Congress, Brno**
- **19&24 July 2023**  
**Visits of a Taiwanese Scientific and Industrial Delegation, Prague**
- **28-29 September 2023**  
**2nd Teaming Club Conference in InnoRenew CoE, Izola, Slovenia**
- **6 October 2023**  
**Researchers' Night, Prague | Brno**
- **10-13 October 2023**  
**MSV Brno 2023 – International Engineering Fair**  
joint exhibition within Digital Factory 2.0
- **30-31 October 2023**  
**Technology Literacy Programme for students, Prague**
- **8 November 2023**  
**DFKI.AI Days, Saarbrücken**
- **20-21 November 2023**  
**RICAIP Use-Cases Workshop, Nürnberg**



**Dr. Tilman Becker**  
*RICAIP Director*

We have seen another very busy year in setting up the RICAIP Centre. With our testbeds in Prague and Brno fully operational, we are concentrating on developing demonstrators for our use cases: distributed production and production as a service. They are used to communicate the advances in production technology, including AI methods, to our partners, collaborators and visitors.

An important step towards the future sustainability of the RICAIP Centre has been reached by establishing European Digital Innovation Hubs at all partners and the Czech partners, including our associated partner in Ostrava, are members of the European Testing and Experimentation Facility for Manufacturing. With these instruments, we are in a position to provide local services to industrial customers, integrated into a European-wide network.

We are looking forward to take part in defining the second decade of Industry 4.0 with the RICAIP Centre!



**Prof. Vladimír Mařík**  
*Scientific Director, CIIRC CTU*  
*Principal Investigator, RICAIP Project, Member of the RICAIP Steering Committee*

The activities of the RICAIP Centre were extremely rich and successful in 2023. We were continuing in fulfilling the project plan and intensified the dissemination activities.

In June 2023, CIIRC CTU celebrated ten years of activity (est. 2013). The RICAIP Testbed Prague team enriched a part of the celebration programme with a unique presentation of distributed modular manufacturing and a live demonstrator of the remote control system connecting RICAIP testbeds in Prague, Saarbrücken, and Brno.

The RICAIP team was present at Brno MSV Fair and invoked a deep interest of the Fair visitors including the Chairman of the Senate of the Czech Republic Mr. Miloš Vystrčil. The Brno CEITEC team offered tours of their nearby testbed.

The year 2023 was also very important from another point of view: The RICAIP Centre had entered 3 newly established EDIH infrastructures (EDIH DIGIMAT in Brno, EDIH CTU in Prague, EDIH SAARLAND in Saarbrücken). The RICAIP teams are also very active in the TEF project AI-MATTERS and hosted the 1st AI-MATTERS General Assembly.

All the RICAIP activities did confirm that the RICAIP project is on a good track.

# About RICAIP

The Research and Innovation Centre on Advanced Industrial Production - RICAIP - is a European distributed research centre of excellence focusing on R&D in robotics and artificial intelligence applications for distributed production. RICAIP creates a unique research environment for the development and testing of innovative solutions for advanced, modular and fully integrated industrial production.

## Mission

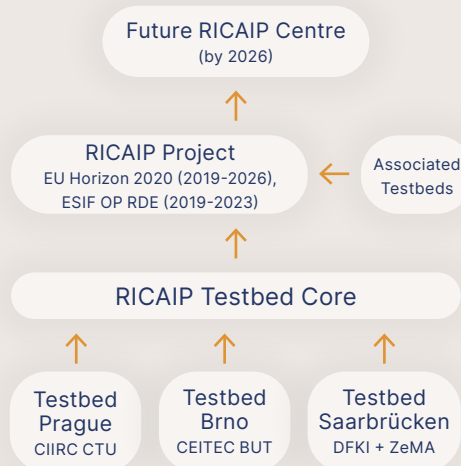
To create a collaborative ecosystem for academia, industry (large and small caps) as well as for national and regional authorities to produce valuable high-impact and application-oriented research results for producing and manufacturing companies.



## Vision

To establish RICAIP as a key entity in major European research infrastructures for artificial intelligence, robotics, machine learning and computer science for advanced industry and production.

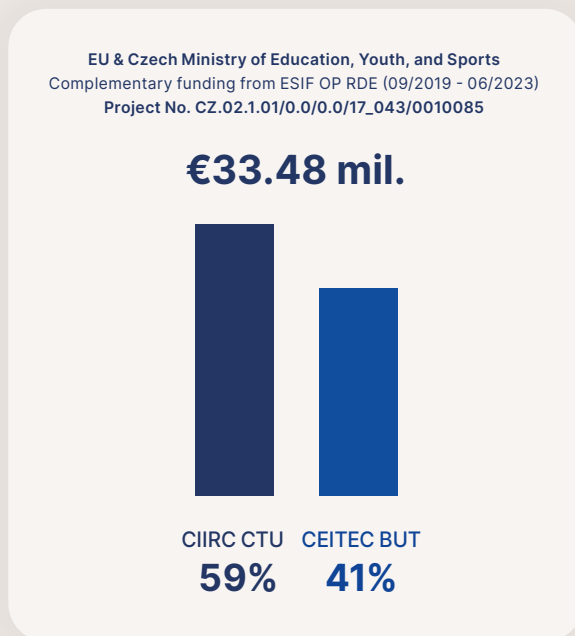
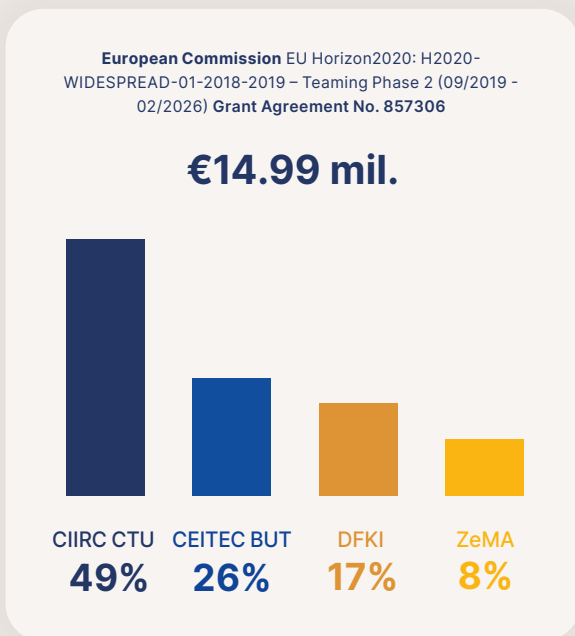
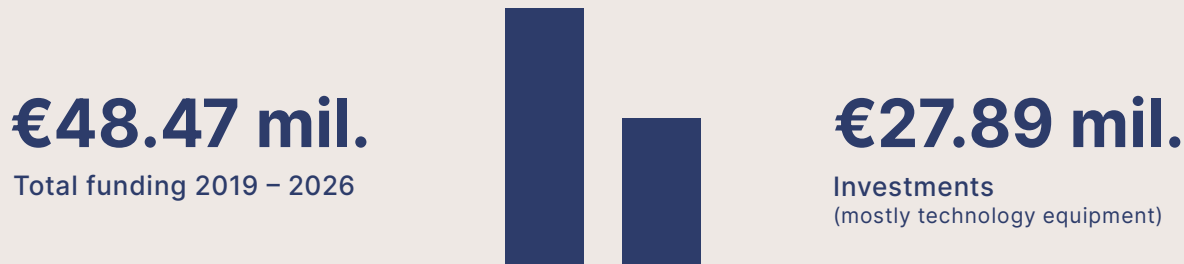
- Building an AI ecosystem for industrial manufacturing
- Research infrastructure for various projects and funding
- Latest technology usable by both large corporates and SMEs
- Networking across the European AI community
- Synergic activities with major European AI and manufacturing initiatives





# RICAIP Project (2019 - 2026) Total Funding EUR rate 25.5 CZK

The establishment of the RICAIP centre is the main objective of the RICAIP project - jointly funded by the EU Horizon 2020 and OP RDE of the Ministry of Education, Youth and Sports with EUR 48.5 million for 2019-2026.

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



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

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

  
MINISTRY OF EDUCATION,  
YOUTH AND SPORTS

# ESIF OP Research, Development, Education 2019-2023

Czech ESIF OP RDE complementary funding mainly for new technology equipment in Prague & Brno testbeds ended in June 2023. The final list of purchased technologies includes more than **250 public contracts** totalling over **300 technology equipment items**, from small items to complex technology units, both investment and non-investment.

	CIIRC	CEITEC
Machines	43	13
HW	144	54
SW	17	3
Other	32	1
Total	236	71



56

Machinery items



198

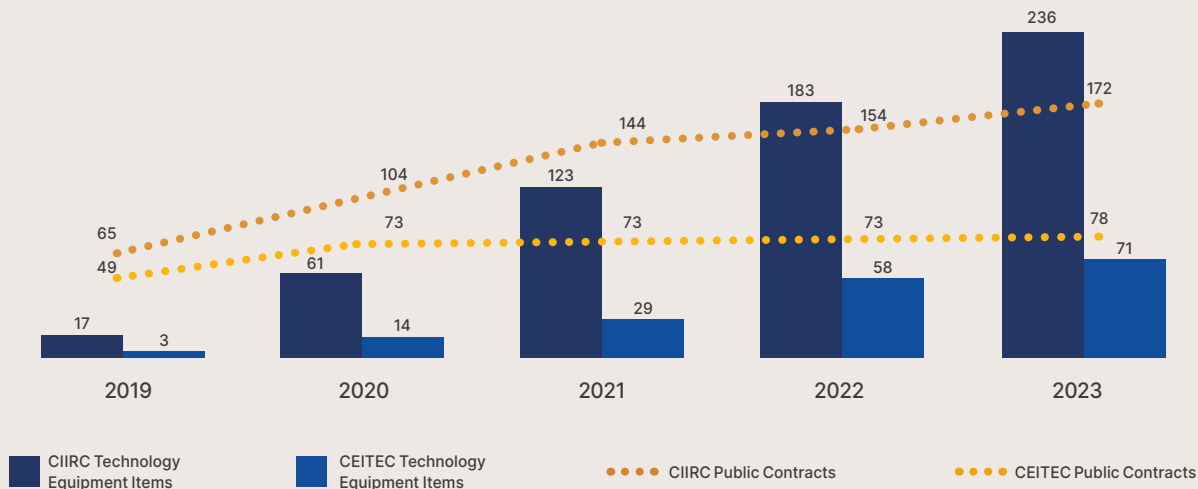
Hardware



20

Software

## Technology equipment items contracted and delivered



## Most important technology units procured

Testbeds are equipped with specific technologies according to their focus, ranging from various types of industrial, collaborative and mobile robots and robotic cells for manufacturing, assembly, integrated intralogistics and warehousing, multi-axis motion systems, machine vision systems and other applications, to production machines for machining, hybrid processes and manufacturing technologies.

In both Czech testbeds, a **private campus 5G SA (standalone) network** for data transfer to the application/edge server with guaranteed latency and bandwidth was installed in cooperation with T-Mobile CZ. The high computing power of the server can be

used for industrial computer vision applications or other neural network deployments.

Each testbed provides a variety of 3D printing technologies for **additive manufacturing** in plastics and metals, including 3D robotic printing – for prototyping, small batch production or custom parts. Other facilities include industrial manipulators, AR/VR and virtualization technologies as well as a metrology laboratory with automated 3D scanning systems for precision measurements or laser technologies and solutions for welding in Prague, rotary and linear dynamometers, actuators and traction drives in Brno.

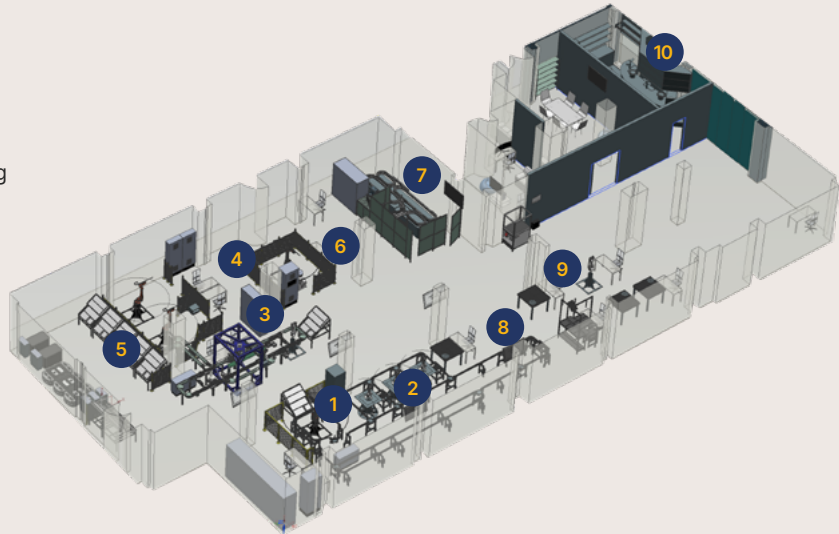


Industry 4.0 Testbed, CIIRC CTU

### Robotics and Flexible production Lab

Located on the groundfloor, 850 m<sup>2</sup>  
Focuses on automatic assembly, planning  
& virtualisation of production

1. Automatic loading station
2. Robotic cells for flexible production
3. Multi-axis motion system – Delta robot and conveyor with AI & 5G
4. Universal robotic cells with AI & machine vision
5. Automated warehouse with a fleet of mobile robots
6. Robotic 3D scanning and printing
7. Flexible assembly line with a collaborative robot
8. Human-Robot Collaboration of the Future
9. Robotic cells for machine vision Pick & Place
10. Robotic workplace for gastronomy



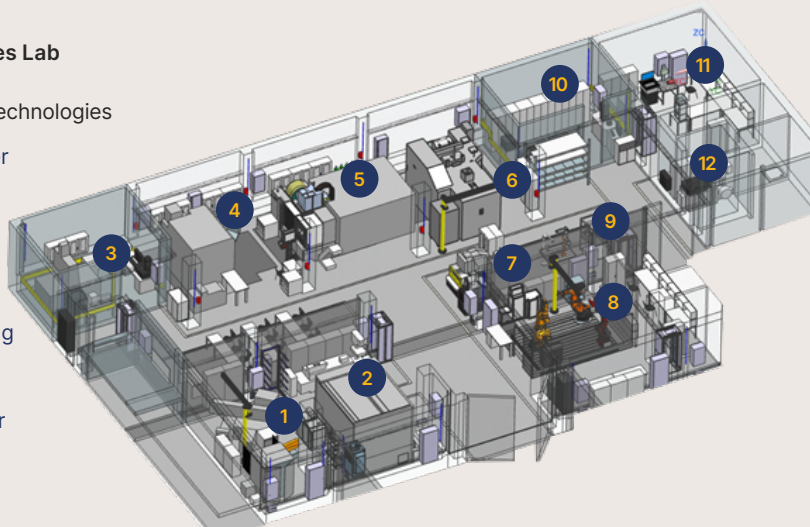


### Robotics and Production technologies Lab

Located in the basement, 570 m2

Focuses on production machines and technologies

1. Femtosecond and nanosecond laser machine
2. Robotic laser cell
3. Metrology laboratory
4. Machining and hybrid processes
5. Weldprint hybrid technology
6. TAJMAC ZPS H630 horizontal milling machine with pallet changer
7. High precision CNC wire EDM
8. Industrial robots with a laser tracker
9. Collaborative robots
10. Tool setting area
11. 3D Scanning and printing
12. Metallographic grinder



### + 3D Printing Centre (130 m2)

Industrial 3D printers of various technologies

- MJF, FDM, PolyJet, laser sintering

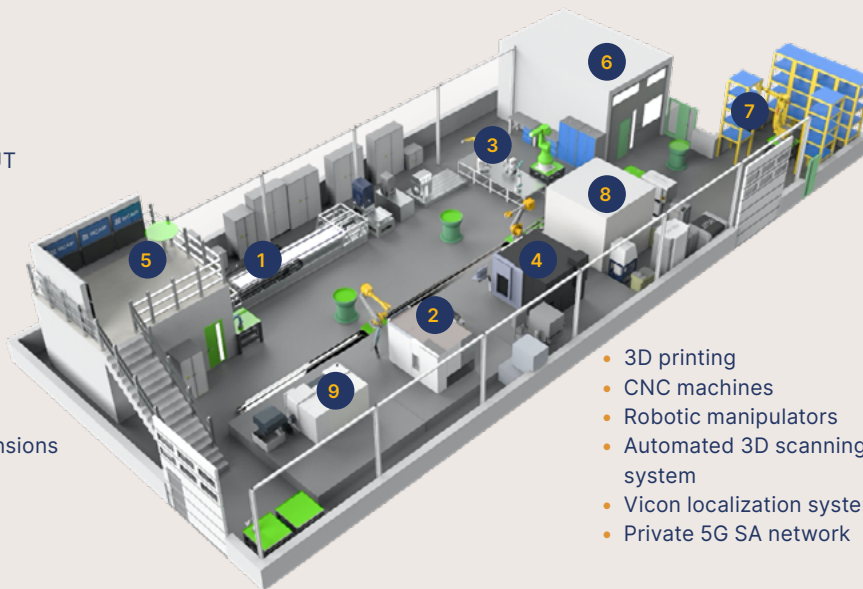
### + Smart Grid Lab (90 m2)

For advanced electricity distribution systems and optimisation of production processes



Industry 4.0 Testbed, CEITEC BUT  
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



- 3D printing
- CNC machines
- Robotic manipulators
- Automated 3D scanning system
- Vicon localization system
- Private 5G SA network

# Demonstrators

For more information visit  
[ricaip.eu/demonstrators](https://ricaip.eu/demonstrators)



RICAIP uses AI methods and other technologies to develop new solutions tackling two major use cases: (i) foundational technologies for **distributed production** and (ii) new approaches to production by providing **Production as a Service (PaaS)**. To showcase these concepts, the RICAIP teams develop several demonstrators considering real challenges from industrial settings. The teams collaborate on these solutions across the testbeds.

The RICAIP testbeds also showcase the implementation of the software integration architecture in practice and provide a testing and validation environment, while emphasizing human-machine collaboration in remote-control scenarios.

## Selected Demonstrators

- Fail-aware actuators
- Virtually machined surface used for quality control algorithm
- Remote inspection robot
- Human-robot collaboration with robot path planning
- Laboratory for robotics and flexible production
- Remote human-human collaboration with robotic embodiment
- (Dis-)Assembly of battery pack
- Local human-robot collaboration
- Bin picking
- Raspberry Pi assembly
- Robotic cell for demonstrating modular production



Watch the video on distributed manufacturing on [RICAIP YouTube Channel](#)

## RICAIP Concept of Distributed Manufacturing

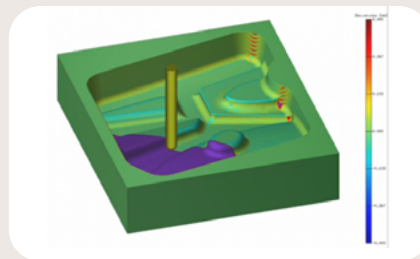
In 2023, RICAIP launched a new video introducing the concept of distributed modular manufacturing that enables production to dynamically adapt to sudden changes and maintain smooth operations automatically.





### Remote inspection robot

The robot can transport objects in the factory in autonomous mode, handling even heavy material or bulky objects. A telepresence operation mode is also provided to enable the remote inspection of production technologies, as well as object manipulation using immersive telepresence. Its application reduces maintenance costs in highly/fully automated, remote production facilities.



### Virtually machined surface used for quality control algorithm

Complex shaped parts have complex surface errors after machining. Virtual machining models predict these surface errors, allowing for pre-production tuning and improved real-world machining. During the real machining process data are recorded and used for future validation algorithm and inspection purposes. This demonstrator showcases distributed production by optimizing machine settings virtually and validating the final product for customers.



### Remote human-human collaboration with robotic embodiment

The system shows how AR/VR technologies can be used to remote-control a robot such that workers at different locations can physically work together. The base system has been demonstrated at Hannover Fair and several events in Prague.



### Robotic cell for demonstrating modular production

Intelligent robotic system consisting of two collaborative robots that autonomously disassemble electric car batteries. It can adapt to new situations and battery types thanks to ontological descriptions and collaborative robots with 3D cameras, using a 5G private campus network to transmit control signals and images from cameras over PROFINET. The cell was showcased at the Brno Engineering Fair MSV 2023 and formed the technological core and the main attraction of the joint exhibition.

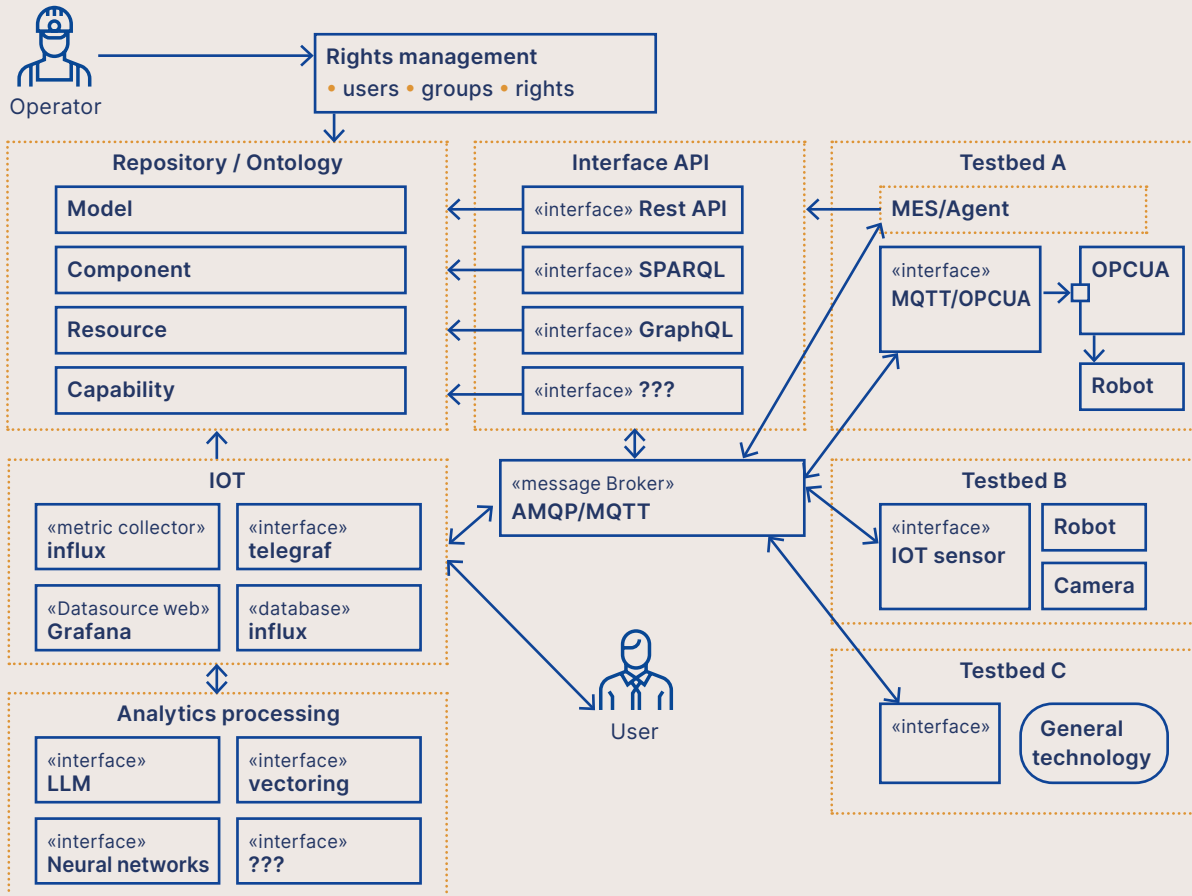


Watch on [RICAIP YouTube Channel](#)

# Software Integration

Digitization and integration of diverse software systems are core challenges for distributed manufacturing and new business models such as **Production as a Service (PaaS)**. The **RICAIP Software Integration Architecture** is a top-down approach to integrating production sites, local production lines, workstations, machines and individual sensors. Distributed production sites - RICAIP testbeds - are interconnected by message

brokers considering human interfaces in their various roles as workers, operators, controllers and management. RICAIP draws on the experience of its partners and builds on the **Multi-Agent Systems (MAS)** approach and on **Asset-Administration Shells (ASS)** for increased modularity, including a hierarchical approach with a holonic MAS.



# Services for SMEs: From Lab to Practice

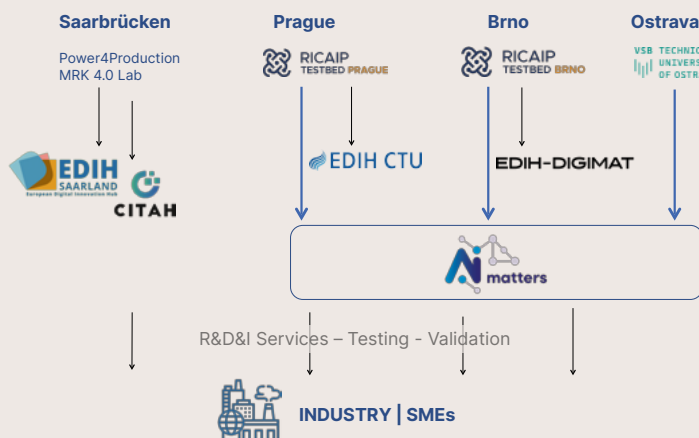
The EU prioritizes equipping manufacturers, especially small and medium-sized enterprises (SMEs), with AI-powered tools and digital technologies to strengthen the innovations in Europe. RICAIP testbeds play an important role by providing an experimentation environment for the development, testing and validation of innovative digital solutions in real-world settings. In 2023, the RICAIP partners started to utilise the RICAIP infrastructure by providing tailor-made services and activities within **European Digital Innovation Hubs (EDIH)** and **Testing and Experimentation Facilities (TEF)** projects.

Thanks to **TEF AI-MATTERS** project, start-ups and SMEs can develop and test AI-driven industrial applications in real-life scenarios before putting the solution into operation or on the market. RICAIP Testbeds Prague and Brno, together with RICAIP associated partner, the Technical University of Ostrava,

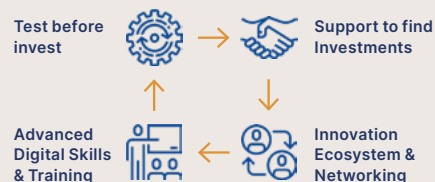
form the basis of the Czech node in the pan-European technology network AI-MATTERS, connecting facilities across eight European countries.

Through their partners involved in four different **EDIH projects**, RICAIP testbeds in Prague, Brno and Saarbrücken act also as provider of access to technological expertise and testing (“test before invest”) as well as innovation services such as training and digital skills development within **EDIH CTU**, **EDIH DIGIMAT**, **EDIH CITAH**, and **EDIH Saarland**.

For more information visit [ricaip.eu/edih](https://ricaip.eu/edih)

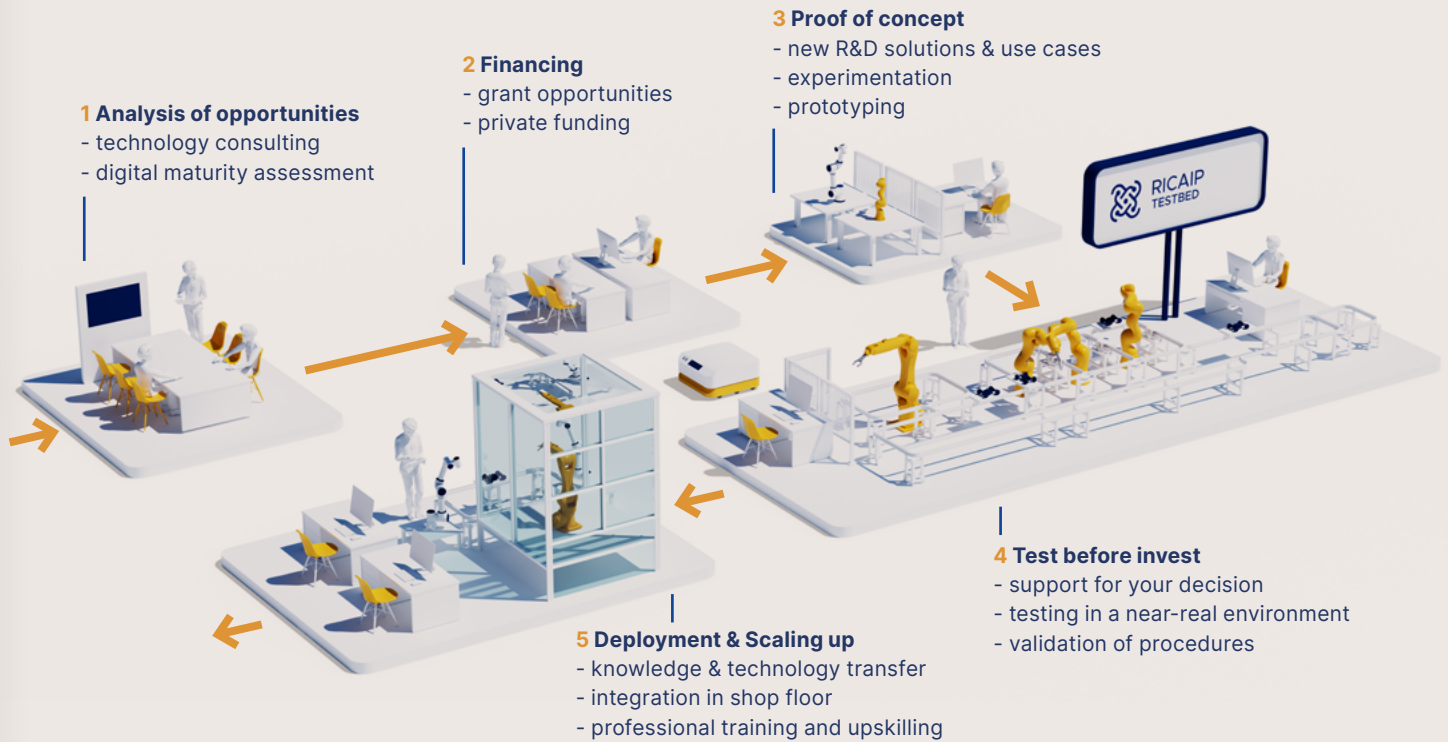


## Categories of EDIH services



# RICAIP Innovation Ecosystem

The state-of-the-art infrastructure, together with the deep-tech knowledge of the RICAIP research teams, is well complemented by the expertise of the technology companies that collaborate with testbeds, namely within the ecosystem of the National Centre for Industry 4.0. Thanks to RICAIP testbeds, manufacturers, innovators, technology providers and system integrators have access to the full range of services in every stage of their **innovation cycle**.



## Example of services

- 5G Industrial Communications Testing and Development Support
- Data-driven ESG reporting
- Edge-continuum Apps Testing and Development Support
- Monitoring and Quality Evaluation of Production Processes
- Robotic Intra-logistics Testing

## Steering Committee



**Prof. Vladimír Mařík**  
Scientific Director,  
CIIRC CTU



**Prof. Radimír Vrba**  
Director, CEITEC BUT



**Prof. Antonio Krüger**  
Director, DFKI



**Prof. Rainer Müller**  
Chair of Assembly Systems UdS,  
Head of the Assembly Systems  
Research Department, ZeMA

## Director



**Dr. Tilman Becker**  
Director, RICAIP



**Pavel Burget, PhD**  
Head of Testbed for Industry 4.0,  
CIIRC CTU



**Vít Dočkal, PhD**  
Strategic Projects  
Management, CIIRC CTU



**Andrey Girenko, PhD**  
R&D Administration, DFKI



**Ing. Jan Nedvěď**  
Chief Financial Officer,  
Secretary of Institute,  
CEITEC BUT



**Dipl.-Ing. Christoph  
Speicher**  
Research Group Leader, ZeMA



**Prof. Pavel Václavek**  
Research Group Leader,  
Research Area Coordinator,  
CEITEC BUT

## RICAIP Tenure Track Position Holders at CIIRC CTU



**Tomáš Mikolov, PhD**  
Artificial intelligence, Machine  
Learning, Neural Networks and  
Complex Systems



**Torsten Sattler, Dr. rer. nat.**  
Computer Vision, 3D  
Reconstruction & Visual  
Localisation



**Mikoláš Janota, PhD**  
Formal Methods, Automated  
Reasoning & SAT Solving



**RNDr. Martin Suda, PhD**  
Machine Learning & Automated  
Reasoning



### RICAIP Testbed Prague



**Pavel Burget**  
Director of Testbed for Industry 4.0, CIIRC CTU



**Petr Kolář**  
Deputy Head of Industrial Production & Automation Department (IPA), CIIRC CTU



**Petr Kadera**  
Head of Smart Grid Labs, CIIRC CTU



**Tomáš Jochman**  
Virtual Commissioning, Digital Twins, Industrial Metaverse, CIIRC CTU



**Alexandr Lazarov**  
Head of 3D Printing Center, CIIRC CTU

### RICAIP Testbed Brno



**Prof. Pavel Václavek**  
Research Group Leader, Research Area Coordinator, CEITEC BUT



**Jakub Hrabec**  
Head of Testbed Industry 4.0, CEITEC BUT



**Prof. Ludek Zalud**  
Computer Science, Robotics, Automation & Control Systems, CEITEC BUT



**Zdeněk Havránek**  
Instruments & Instrumentation, Acoustics, CEITEC BUT



**Petr Beneš**  
Instruments & Instrumentation, Acoustics, Automation & Control Systems, Materials Science, CEITEC BUT

### RICAIP Testbed Saarbrücken & Kaiserslautern



**Tim Schwartz**  
Artificial Intelligence, Automotive, User Modeling & Human-Robot Interaction, DFKI



**Raja Moktafi**  
Human Robot collaboration, ZeMA



**Achim Wagner**  
Deputy Head of Innovative Factory Systems, DFKI



**Alexis Bernhard**  
Innovative Factory Systems, DFKI



**Prof. Martin Ruskowski**  
Head of Innovative Factory Systems, DFKI



# Selected Publications and Synergies

## Selected Publications

Jakub Dokoupil, Pavel Václavek. Recursive Identification of Time-Varying Hammerstein Systems With Matrix Forgetting. *IEEE Transactions on Automatic Control*, 2023

Jiří Vyskočil, Petr Douda, Petr Novák and Bernhard Wally. A Digital Twin-Based Distributed Manufacturing Execution System for Industry 4.0 with AI-Powered On-The-Fly Replanning Capabilities. *Sustainability*, 2023

Julian Parsert, Chad E. Brown, Mikolas Janota, Cezary Kaliszky. Experiments on Infinite Model Finding in SMT Solving, EPiC Series in Computing, 2023

David Hereł, Hugo Cisneros, Tomas Mikolov. Preserving Semantics in Textual Adversarial Attacks. ECAI 2023

Varun Burde, David Martinez Lema, Vit Zeman, Lars Kahlert, Tomas Jochman, Pavel Burget. Automatic Workspace Calibration Using Homography for Pick and Place. IEEE International Conference on Automation Science and Engineering (CASE) 2023.

Jonathan Ventura, Zuzana Kukelova, Torsten Sattler, Daniel Barath. P1AC: Revisiting Absolute Pose From a Single Affine Correspondence. International Conference on Computer Vision (ICCV) 2023.

Kunal Chelani, Torsten Sattler, Fredrik Kahl, Zuzana Kukelova. Privacy-Preserving Representations Are Not Enough: Recovering Scene Content From Camera Poses, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2023

Pavel Hradecky, Vojtech Janu, Pavel Burget, Tomas Jochman, Tilman Becker. Description and Evaluation of Production Goals, 22nd IFAC World Congress 2023

Filip Bártek, Martin Suda. How Much Should This Symbol Weigh? A GNN-Advised Clause Selection, 24th International Conference on Logic for Programming, Artificial Intelligence and Reasoning - LPAR, 2023

M. Janota, A. Morgado, P. Vojtěchovský. Computing Generating Sets of Minimal Size in Finite Algebras, Journal of Symbolic Computation, 2023

S Bhayani, V Larsson, T Sattler, J Heikkila, Z Kukelova. Partially calibrated semi-generalized pose from hybrid point correspondences. IEEE/CVF Winter Conference on Applications of Computer Vision (WACV), 2023.

## Selected Synergic Projects

For more information  
visit [ricaip.eu/research/synergic-projects](https://ricaip.eu/research/synergic-projects)



## Selected Highlights

[ricaip.eu/news](https://ricaip.eu/news)



### MSV International Engineering Fair in Brno

RICAIP Testbed Prague prepared a joint presentation together with the partners of the National Centre for Industry 4.0 and was presented as the main partner of the joint booth. Concrete technological solutions on flexible production and functional robotics demonstrators were presented to visitors as well as policy makers. The main objective was to showcase the entire set of services that RICAIP testbeds offers to SMEs in collaboration with industrial partners. In parallel, the teams from RICAIP Testbed Brno offered tours of infrastructure as an accompanied programme of the fair.

### 10th Anniversary of CIIRC CTU

On 30 June 2023, the CIIRC Institute celebrated ten years of activity since its establishment in 2013. The RICAIP Centre enriched part of the celebration programme with a presentation of distributed modular manufacturing and a live demonstrator of the remote control system connecting testbeds in Prague, Saarbrücken, and Brno. Several other events took place within the following days, including the National Summit of Industry, the AI Symposium and the Open Day for Industry 4.0, where RICAIP infrastructure and research teams were also involved.

## 2023 Communication and Dissemination activities in numbers

55

Visits

5

Workshops

7

Conferences

2

Seminars on societal topics

12

Press releases  
Articles on website

Technologies showcased about **130** times to more than **4000** people



# RICAIP

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on Advanced Industrial Production

## RICAIP Annual Report 2023

*Fourth edition of the RICAIP Annual Report. Published in May 2024.  
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Czech Technical University in Prague

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