RICAIP

Research and Innovation Centre
on Advanced Industrial Production

ANNUAL REPORT 2021

EU Project Creating a RICAIP Centre


DFKI
German Research Center for Artificial Intelligence
DFKI
German Research Centre for Artificial Intelligence
CTU
CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE
CIIRC CTU
Czech Institute of Informatics Robotics and Cybernetics CTU
ZeMA
Zentrum für Mechatronik und Automatisierungstechnik
ZeMA
Centre for Mechatronics and Automation Technology
BRNO UNIVERSITY OF TECHNOLOGY
CEITEC
CEITEC BUT
Central European Institute of Technology BUT

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 a 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.

Its backbone consists of multi-site experimental facilities

- Testbed for Industry 4.0 at CIIRC CTU in Prague,
- Testbed at CEITEC BUT in Brno,
- Joint testbed of DFKI and ZeMA in Saarbrücken.

RICAIP is a Czech-German centre hosted at CIIRC CTU in Prague with a maximum degree of autonomy and direct participation of all its four founding partners.

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

Contents

Forewords

With great pleasure, we welcome you to the second annual report of RICAIP. During the last year, we have worked hard on reaching our goals to install state-of-the-art equipment in Prague and Brno. Despite longer delivery times caused by market obstacles, more than 90 % of the contracted technologies have been delivered and installed. We have made further progress in setting up the organizational structure for RICAIP. The team has shown a great collaborative effort with contributions by all four partners, from the Czech Republic and Germany. As everyone, we had to deal with the ongoing COVID-19 pandemic, but I am happy to report that we have managed well, proceeding with great caution and a truly distributed effort - home office and video streams between the testbeds have become an integral part of our collaboration. Although dissemination could not always proceed in-person as planned, this report compiles an impressive list of activities.

We are now in a position where the testbeds are in full use and RICAIP has started to develop our own use cases. These will help to demonstrate implementations of the Industrie 4.0 ideas to our scientific and industrial stakeholders. All partners, in collaboration with our tenure track researchers, are collaborating on them. In 2022, we aim to show multiple demonstrations in already fully equipped testbeds in Prague and Brno.

Tilman Becker, PhD
RICAIP Director

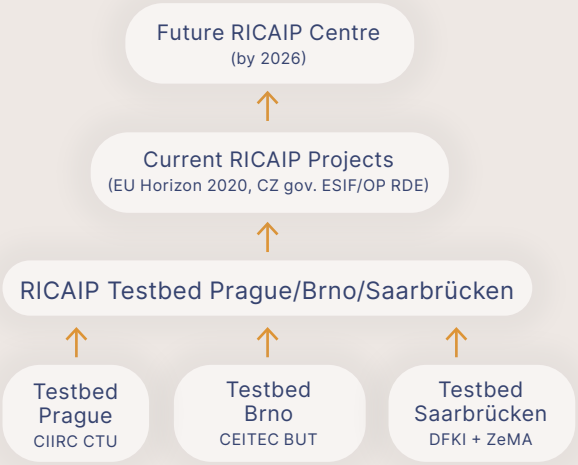
The RICAIP Project entered a new phase in the year 2021. The RICAIP testbeds at CIIRC CTU and CEITEC BUT have been strongly enhanced, the four tenure trackers started to build their teams and have brought the first results achieved under the RICAIP umbrella, the development of transparent and efficient joint use cases has started.

Besides this, the RICAIP facilities have been used in many EU projects, national research initiatives and – what is the most important – in cooperative projects with industry. Both the National Centre for Industry 4.0 and the National Centre of Competence NCK KUI have started to organise their research and know-how transfer around the RICAIP Project. They became the core of the AI Ecosystem for Manufacturing being built in the Czech Republic, including the EDIH and TEF projects submitted. This AI Ecosystem is considered as a basis for a long-term sustainability of the RICAIP Centre after the RICAIP Project is over. And, sustainability is entering in the very focus of our attention in 2022. The RICAIP project is on the right track.

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

Mission

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



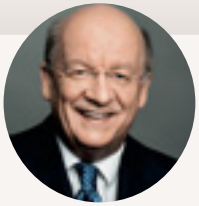
Vision

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

2	4	3
EU countries	Partners	Industrial Testbeds

The RICAIP projects and testbeds are a key innovation driver for the second decade of Industry 4.0 starting in 2022. The steadily growing RICAIP ecosystem makes sure that Industry 4.0 technologies remain a European export hit. Industrial AI, Team Robotics, Edge AI and Multi-agent Intralogistics are some of RICAIP's hot research topics for the next phase of Industry 4.0. With the help of migration tools developed by RICAIP and its partners, now also SMEs can afford to turn their legacy factories into Smart Factories for advanced manufacturing.



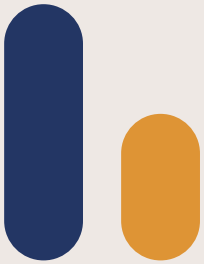
Prof. Dr. Dr. h.c. mult. Wolfgang Wahlster
Chief Executive Advisor (CEA), DFKI

RICAIP Project *(Duration 2019 - 2026)*

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

€48.47 mil.

Total funding 2019 – 2026



€27.89 mil.

Investments
(mostly technology equipment)
EUR rate 25.5 CZK

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

€14.99 mil.

CIIRC CTU	CEITEC BUT	DFKI	ZeMA
49%	26%	17%	8%

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.

CIIRC CTU	CEITEC BUT
59%	41%

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

CIIRC CTU

Czech Institute of Informatics, Robotics and Cybernetics
Czech Technical University in Prague
Český institut informatiky, robotiky a kybernetiky
České vysoké učení technické v Praze

CIIRC CTU concentrates on cutting-edge fundamental and applied research in a variety of fields in computer science and AI, manufacturing, energetics, smart cities, and a healthy society. CIIRC CTU builds a unique ecosystem for AI and advanced manufacturing, interconnecting industry and academia with the main European research and innovation networks.

www.ciirc.cvut.cz

210 FTE
255 Headcount

CEITEC BUT

Central European Institute of Technology
Brno University of Technology
Středoevropský technologický institut
Vysoké učení technické v Brně

CEITEC Brno University of Technology is part of the CEITEC Research Centre of Scientific Excellence. Since 2011, it has been a key part of a state-of-the-art research infrastructure with unique equipment and conditions for basic and applied research in the field of advanced nanotechnologies, advanced materials and cybernetics.

www.ceitec.eu

278 FTE
437 Headcount

German Research Center for Artificial Intelligence

DFKI

German Research Centre for Artificial Intelligence
Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

Based on application-oriented basic research, DFKI develops product functions, prototypes and patentable solutions in the field of information and communication technology. Research is committed to essential, future-oriented areas of application and socially relevant topics while developing the innovative software technologies and implementing the Industry 4.0 vision.

www.dfki.de

1,360
Employees

ZeMA
Zentrum für Mechatronik und Automatisierungstechnik

ZeMA

Centre for Mechatronics and Automation Technology
Zentrum für Mechatronik und Automatisierungstechnik gGmbH

ZeMA is an application-oriented research institute that transfers its research results directly to industrial and producing companies through active technology transfer. The work priorities are mechatronic systems, innovative production technologies, and Industry 4.0 applications. ZeMA has established an industrial testbed with a diverse demonstrator environment.

www.zema.de

115
Employees

Testbed for Industry 4.0, Prague

The Testbed for Industry 4.0 at CIIRC CTU is undergoing extensive modernization thanks to the RICAIP centre. The two specifically focused floors of the testbed together create a completely unique environment for testing, simulation and development of various scenarios for smart factories of the 21th century. The lower floor of the testbed in the basement is focused on production technologies and production machines, while one floor above there are modules designed for flexible production. The latest technologies are designed for research and development of applications for industrial practice. Universal robotic and production cells, including collaborative robots and machine tools, are intralogistically interconnected by a fleet of mobile robots and vehicles; by software and data also at the level of the so-called edge equipment and through server and cloud applications using artificial intelligence algorithms. The testbed enables experimentation with available devices or the connecting of new devices. Thanks to the versatility of production elements and the control system, the same resources can be used and optimized to perform different operations.

Research Focus of the Prague Testbed

Multiagent System for Planning of Production at Different Levels of Hierarchy

- Level of one machine, level of 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

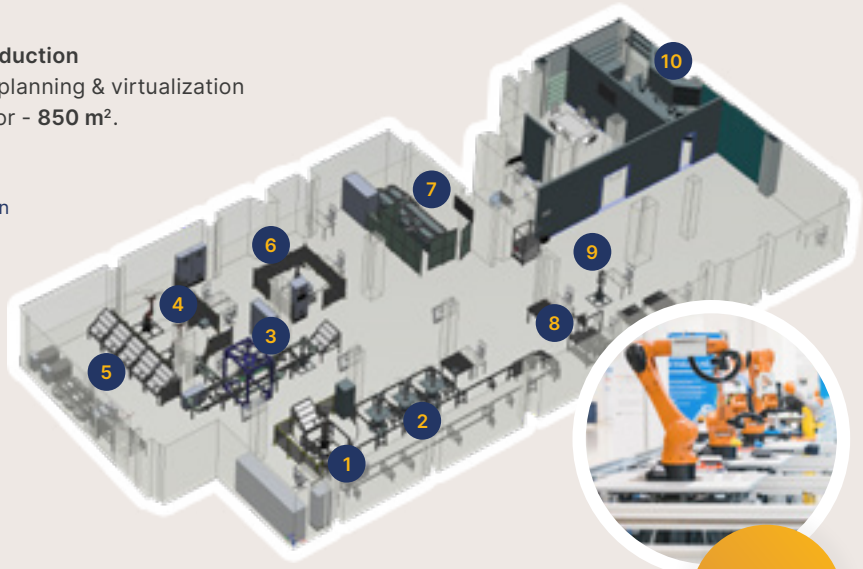
- Production machines
- Machining processes
- Laser technologies
- Additive and hybrid processes
- Advanced robotics for industrial production

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

Part I - Robotics and Flexible Production
Focuses on automatic assembly, planning & virtualization of production - on the ground floor - **850 m²**.

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



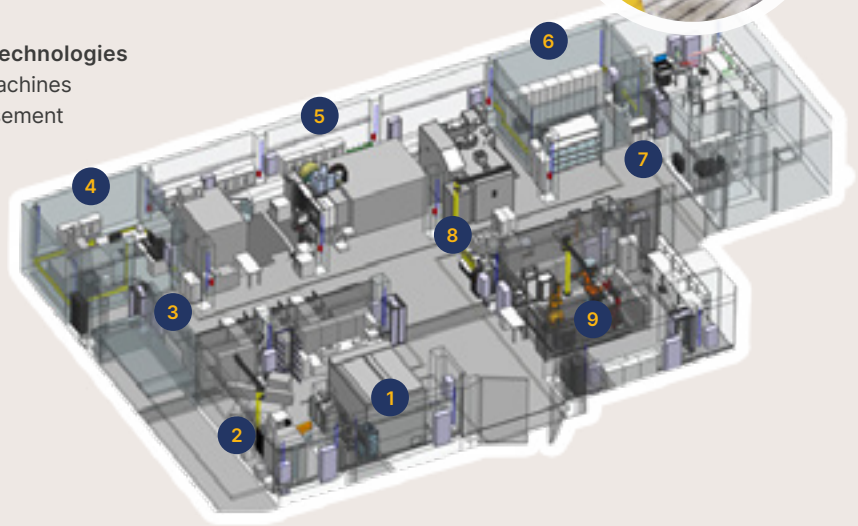
1,640 m²

+ 3D Printing Centre
With industrial 3D printers of various technologies (MJF, FDM, PolyJet, laser sintering) for plastic & metal printing - **130 m²**.

+ Smart Grid Lab
For advanced electricity distribution systems and optimization of production processes with regard to available energy sources, incl. photovoltaic systems - **90 m²**.

Part II - Robotics and Production Technologies
Laboratory focuses on production machines and technologies - located in the basement - **570 m²**.

1. Robotic laser cell
2. Femtosecond+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. EDM machine
9. Industrial robot area



Prague Testbed in 2021

Services

Test before Invest

- Prototyping
- Consulting services
- Equipment and infrastructure rental
- Lab & Testbed tours

Advanced Digital Skills & Training

- Educational activities in the field of digitalization and AI techniques and technologies
- Technology courses and consultations in the field of digitalization and technologies using artificial intelligence and machine learning

Support to Find Investments

- Information and consulting support in finding financial resources (especially grant schemes) for the implementation of digital innovation projects

Innovation Ecosystem & Networking

- Connections with organisations and partners in the field of AI in the Czech Republic and the EU
- Sharing best practice and tech transfer
- Connection with accelerators and technological integrators

Selected Experiment

Delta Robot

In cooperation with the industrial partners, a delta robot was put into operation in Testbed. It enables synchronization of its movements with the movement of the pallets on the conveyor. Researchers designed and fine-tuned a kinematic and dynamic model to compare the behavior of a real robot with the expected ones and to identify differences through machine learning algorithms. This serves as a basis for machine operation diagnostics, so-called condition monitoring. The dynamic model is used for feedback control based on the force exerted on the robot's end effector. 5G SA communication is used to transfer the image from the camera to the server (edge device) and transmit the necessary position data back to the robot in real time. The experiment also uses augmented reality for predictive maintenance using a HoloLens kit connected via campus 5G SA network.

Contracted and Delivered Technologies

09/2019 - 12/2021

12.79 mil EUR

Contracted from the beginning of the project until 31 December 2021

11.03 mil. EUR

Delivered from the beginning of the project until 31 December 2021

3.1 mil. EUR

Delivered in 2021 only

EUR Average ECB Rate (2021)
25,640 CZK
Amount excl. VAT

Most Unique Technology Purchased in 2021

- Photovoltaic panels, direct current sources & inverters
- Fast robot for Pick & Place operations with three axes of movement for end point positioning and two more axes for rotation and tilt
- The Multi Jet Fusion 3D Printing Solution - a 3D printer, a replaceable setting unit and a post-processing device with fast cooling
- Equipment for Augmented & Virtual Reality (AR/VR)
- Several collaborative and industrial robots including grippers, force sensors, camera systems and visualisation tools for research of innovative robotic assembly solutions
- Horizontal milling machine with liquid CO_2 cryogenic process cooling, machining dynamometers, sensory tool holders, equipment for vibration analyses
- Robotic cell with high-power laser source
- Laser micro processing machine with nano-, pico- and femtosecond laser

Testbed Industry 4.0, Brno

The testbed has been built by the modernizing of an industrial hall located within the Brno University of Technology campus. In 2021, the acquisition of technologies for additive and subtractive production was completed, as well as the equipment of the main robotic manipulators. The facility will deepen opportunities in the areas of cybernetics and robotics, smart sensors, advanced control technologies and their industry applications. The Brno testbed is connected to the regional innovation ecosystem oriented toward machinery and production technologies.

Research Focus of the Brno Testbed

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, workers
- Prediction of workers' intentions
- VR/AR techniques, human-machine interfaces

Machines & 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

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

Brno Testbed in 2021

Selected Experiment

Autonomous Mobile Robotic Agent

The robot fleet will be able to autonomously supply material or tools within the factory. During its journey, the robot will be prepared for unexpected situations, such as an obstacle in its path. It can determine its type, document it, measure it, call the security service. It can warn other robots to avoid obstacles. The goal is to develop a Plug & Play solution, where the mobile robot will be able to cope with narrow passages, sharp turns or people moving on the production area.

Contracted and Delivered Technologies

09/2019 - 12/2021

8.68 mil. EUR

Contracted from the beginning of the project until 31 December 2021

8.35 mil. EUR

Delivered from the beginning of the project until 31 December 2021

5.09 mil. EUR

Delivered in 2021 only

EUR Average ECB Rate (2021)
25,640 CZK
Amount excl. VAT

Most Unique Technology Purchased in 2021

- DMG MORI DMU 50 3rd Generation - a universal machining centre for 5-axis simultaneous machining
- DMG MORI CMX 600V - a vertical 3-axis machining centre
- DMG MORI CLX 350 V6 - a universal lathe with counter spindle equipped with part ejector and accompanied with a part catcher for the main spindle
- FANUC M900iB capable of manipulating 360 kgs payload
- Two ABB IRB-4600/40 kg manipulators that share a 19 meters long track
- Desktop Metal Studio System 2 technology for metal printing using the Bound Metal Deposition method
- 3D printer for printing from Fortus 450mc industrial thermoplastics
- Printer for full-color printing of Stratasys PolyJet J850 Prime design parts

Power4Production & HRC4.0 Lab, Saarbrücken

The testbed-area of over 3,000 m² includes two industrial halls and various areas for experimental demonstrators and prototypes for the factory and production of the future. The main focus is "Industrie 4.0", digitalization, AI applications in production as well as robotics. The Centre for Innovative Production Technologies (Power4Production), which is jointly operated by ZeMA and DFKI is also located on the ZeMA premises. DFKI's German-Czech Innovation Laboratory for Human-Robot Collaboration in Industry 4.0 (HRC4.0 Lab), which was founded in 2016 and funded by the German Ministry of Education and Research, is a part of Power4Production and of the RICAIP testbed. The HRC4.0 Lab hosts more than 25 robots of different kinds, including robotic arms, self-driving robots, humanoid robots and drones, and focuses on the human-robot collaboration and human-robot communication.

Research Focus of the Saarbrücken Testbed

Sensors & Actuators

- Deployment of intelligent materials to develop and innovate new products and applications

Robotics Applications

- Research in the area of human-robot-collaboration, sensitive robotics as well as 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

- Transfer of latest research results to producing companies especially in the field of Industry 4.0, digitalization, assistance systems, and AI

Saarbrücken Testbed in 2021

Selected Demonstrator

HRC Demonstrator: Transfer of control in distributed Industry 4.0 applications

Semi-autonomous robots occasionally need help from human supervisors. This demonstrator showed how humans and robots communicate about the transfer of control. The setting included remote support of a semi-autonomous robot in our partner lab at DFKI in Saarbrücken, Germany—including the launch of a drone in Saarbrücken to understand the situation. It demonstrates three-way communication between the robot, the expert in Prague, and a supporting worker in Saarbrücken. This demonstrator was prepared within the TRACTAT project and developed in cooperation with DFKI and CIIRC CTU. The first version was shown at the digital Hannover Messe in April 2021, the advanced version then on the occasion of the visit of German Federal President at RICAIP in August 2021.

Selected Experiment

In the frame of a human–robot collaboration-based assembly task, a robot is supposed to act like a team member in order to support the human worker in performing the task in a dynamic fashion. To that end, the robot-sensing capabilities are enhanced to observe and detect human activities and infer human intentions to plan helpful actions. As the assembly of the product can be carried out in different sequences, the robot shall be aware of that flexibility and be ready to actively replan its own actions if necessary.

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

Tilman Becker, PhD
Director, RICAIP

Executive Board

Tilman Becker, PhD
Director, RICAIP

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

Vít Dočkal, PhD
Strategic Projects Management, CIIRC CTU

Prof. Jana Koehler
Head of Research Department, DFKI

Ing. Jan Nedvěd
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

86
Headcount

Academic and Non-Academic Staff involved in RICAIP in 2021

Teams of RICAIP Testbeds

Pavel Burget
Director of Testbed for Industry 4.0, CIIRC CTU

Robotics and Flexible production, focus on the automatic assembly, planning and virtualization of production.

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

Robotics & Manufacturing technology, focus on the automated cyber-physical production.

Petr Kadera
Head of the Intelligent Systems for Industry Group, CIIRC CTU

Design & Development of distributed intelligent solutions for manufacturing control, transportation, and smart grids.

Jakub Hrabec
Head of Testbed Industry 4.0, CEITEC BUT

Advanced control technologies to develop an energy optimal, safe and reliable control of robotics systems and technological processes.

Research Leaders Involved in RICAIP

Petr Beneš
Researcher, CEITEC BUT

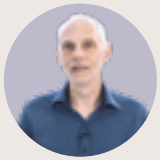
Petr Blaha
Researcher, CEITEC BUT

Anselm Blocher
Researcher and Project Manager, DFKI

Zdeněk Havránek
Researcher, CEITEC BUT

Khansa Rekik
Researcher, Robotics and Human-Machine Interaction Group, ZeMA

Sophia Saller
Research Department Manager, DFKI



Tim Schwartz
Head of Research Group Human-Robot-Communication, DFKI

Luděk Žalud
Researcher, CEITEC BUT

Project & Communication Team

Eva Doležalová
PR & Marketing Manager, CIIRC CTU

Andrey Girenko
R&D Administrator, DFKI

Lucie Kuljovská
Project Manager, CEITEC BUT

Heike Leonhard
PR Manager, DFKI

Petra Mikešová
Senior Financial Manager, CIIRC CTU

Svenja Nickolai
Marketing & Communication, ZeMA

Kateřina Soukupová
PR Manager, CEITEC BUT

Marie Svatoňová
Multimedia Specialist, CIIRC CTU

Johana Štěrbová
Financial Manager, CIIRC CTU

Jovana Jovic Tadic
Administration, RICAIP

Eva Troppová
Senior Project Manager, CIIRC CTU

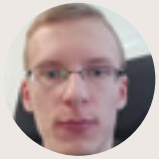
Testbed Interns

In order to motivate the HR environment and talents acquisition, testbeds in Prague and Brno provided internship opportunities to several students working in various fields in order to improve their skills and knowledge.

Václav Kubáček
CIIRC CTU
Precise measurement and real-time monitoring with Leica laser scanner

Filip Zítek
CIIRC CTU
Dynamic modelling of a Delta robot

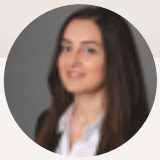
Dominik Friml
CEITEC BUT
Advanced algorithms for control and diagnostics of linear motor drives



Tomáš Horeličan
CEITEC BUT
Unmanned ground vehicle motion planning

Women of RICAIP Testbeds

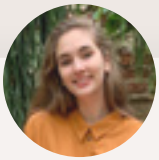
Responsible Research and Innovation principles are being incorporated into all stages of research and innovation in RICAIP. As the gender equality is also one of the United Nations 17 Sustainable Development Goals, our three selected female scientists shared how their research can impact sustainability.



Khansa's research focuses on creating intelligent human-robot collaboration solutions for assembly systems where robots are not just machines but rather smart and interactive team members.

"To me, in a general sense, sustainability is the ability to continue over a long period of time. A sustainable system is capable of ensuring through direct action or careful design its ability to continue to accomplish its goals in the future without additional intervention. That covers multiple steps from the type of raw material used and the modularity of the system to the possibility of recycling."

- Khansa Rekik
Research Assistant, Advanced Robotics Engineer, ZeMA



Elizaveta's research is related to robot-human interaction and collaboration. The development of this sphere can result in climate change deceleration by creating a robotic workforce. Machines can take over tasks from their human colleagues and carry them out more efficiently and in an environment-friendly way.

"To me, sustainability is the necessity to rectify mistakes of the past. By introducing new technologies, we should aim to restore the balance of nature and enhance the quality of life across the globe."

- Elizaveta Isianova
Student/Researcher, Testbed for Industry 4.0, CIIRC CTU

Sophia's research is currently strongly focused on discrete constraint satisfaction and optimization problems, such as scheduling problems or vehicle routing problems. For example, through the planning of routes of trucks on large construction sites to reduce the distance travelled, we can achieve the same result at lower fuel consumption.

"To me, sustainability is the challenge today to ensure the viability of tomorrow. Given its direct consequence for future generations, sustainability is a responsibility rather than simply something desirable for us to work towards."

- Sophia Saller
Deputy Head of the Research Department Algorithmic Business and Production, DFKI

Tenure Track Positions

Tenure Track positions have been established and filled in with four excellent scientists with international standing. Tenured positions are the key success element for the scientific leadership and mentorship.

Mikoláš Janota
CIIRC CTU

Focus

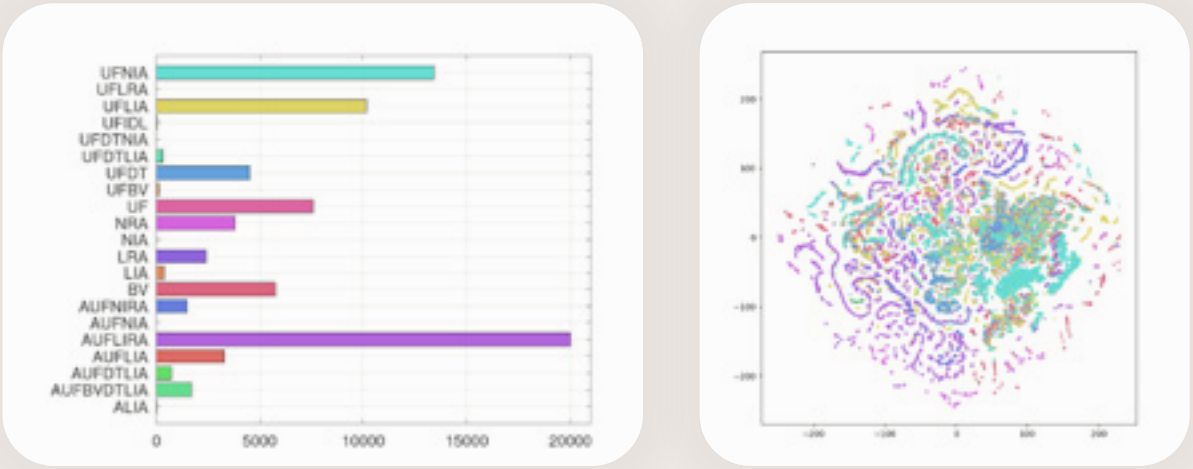
As a part of his research, Mikoláš started investigating the application of machine learning to optimization and planning problems. A PhD student was hired with this particular objective in mind, having started in September 2021. In industrial settings, they will be applying a combination of machine learning and combinatorial solving to patient-therapy scheduling. In terms of basic research, this translates to a variation of job-scheduling. More recently, they have also started investigating the application of machine learning to planning problems. Initially, this will be applied to textbook or puzzle-like problems with multiple agents, with the outlook of finding industrial applications.

Team

Nikolai Antonov, + 3 positions

Selected project

Mikoláš is now looking into joining the efforts with the Prague testbed teams in order to contribute to the RoboBar project. Implementation of the given microservices such as, for example, receiving orders or maintenance, a communication interface, a digital twin service, planner service, or device-control service could be very helpful. His team would focus on scheduling beverages with scheduled algorithms.



Representation of different logics in SMT-LIB benchmark problems (left) and visualization of problem similarities based on performance features (right).

Tomáš Mikolov
CIIRC CTU

Focus

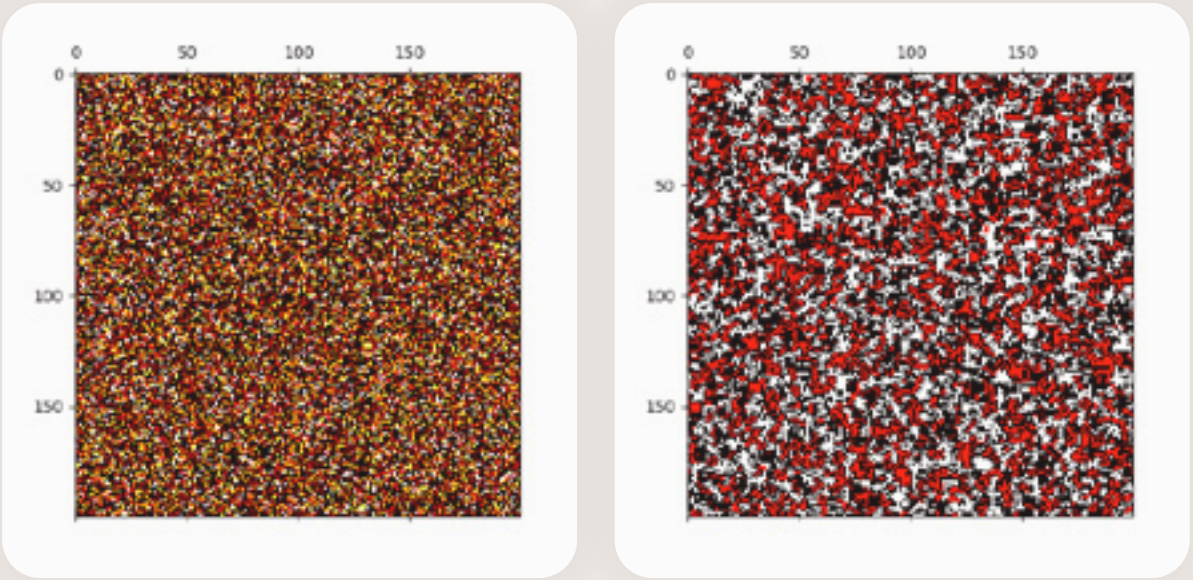
Tomáš's research focus is on advancing state of the art in AI & machine learning. Tomáš is interested in developing novel methods for unsupervised learning inspired by evolution. This includes the area of complex systems, where complexity emerges spontaneously from interactive applications of simple functions. The longer-term goal is to develop novel language models where memory is an emergent phenomenon.

Team

Barbora Hudcová, Hugo Cisneros, David Herel

Selected project

Tomáš is involved in developing chatbots and similar applications in cooperation with PromethistAI team at CIIRC CTU. At the same time, he is involved in a joint project to develop a new tool for measuring the opinion of people on all kinds of topics and how it changes over time.



Classification of Complex Systems Based on Transients: Hudcova, Mikolov, *ALIFE 25*

Torsten Sattler
CIIRC CTU

Focus

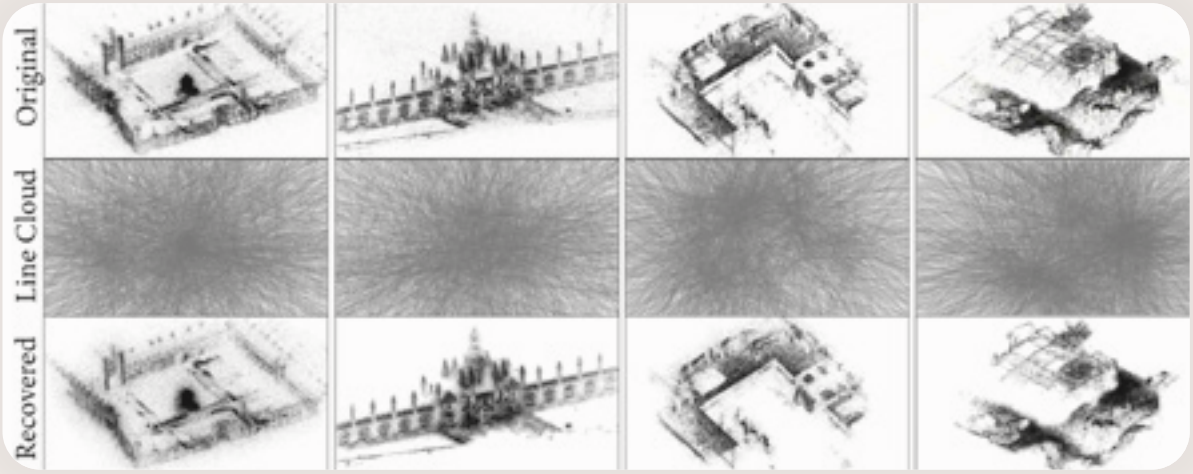
Torsten's focus is on 3D computer vision and machine learning. Torsten is interested in making 3D computer vision techniques such as 3D mapping and visual localization more robust, reliable, and more practically relevant, by incorporating higher-level scene understanding into these algorithms.
He is involved in some of the use cases of RICAP through co-supervising PhD students with Petr Kolář and Pavel Burget, research leaders in the Testbed for Industry 4.0 at CIIRC CTU. There he will contribute knowledge about 3D computer vision and machine learning for 3D vision to help automate industrial tasks. His work on mapping and localization has applications in both robotics and augmented reality systems, such as digital twins.

Team

Varun Burde (jointly supervised with Pavel Burget), Jonáš Kulhánek, Vojtěch Pánek, Maxime Pietrantoni, Kunal Chelani (jointly supervised with Fredrik Kahl at Chalmers University of Technology)

Selected project

With Zuzana Kukelova (Faculty of Electrical Engineering, CTU), Torsten has started a 1-year project as a principal investigator on multi-modal 6DOF visual relocalization in Mapillary Metropolis, funded by Meta (formerly Facebook) through the City-Scale 3D Map Making with Mapillary Metropolis request for proposals.



Kunal Chelani, Fredrik Kahl, Torsten Sattler, How Privacy-Preserving are Line Clouds? *Recovering Scene Details from 3D Lines, CVPR 2021*
© IEEE

Martin Suda
CIIRC CTU

Focus

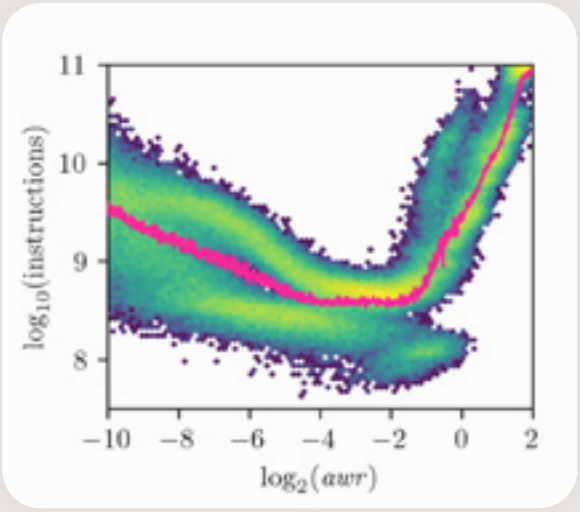
Martin's research focus is automatic theorem proving (ATP) and how it can be improved with the help of machine learning (ML). Martin is one of the developers of a world leading theorem prover for first-order logic (and beyond) called Vampire.
In 2021, Martin was mainly researching the possibilities of improving Vampire through machine guiding its clause selection heuristic.
Specifically, he showed that a large performance improvement can be achieved while learning to classify the clauses based solely on their derivation history. This success was observed on benchmarks coming from one of the current main application areas of ATPs, which is the formalization of mathematics and verification of systems in proof assistants.
For the next big goal, Martin will aim to explore the potential of reinforcement learning in a similar context.

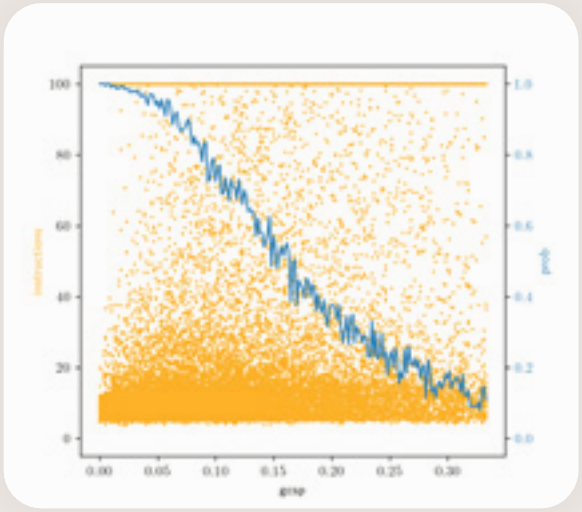
Team

Thibault Gauthier, Filip Bartek

Selected project

PowerATP: Powering Automatic Theorem Provers by Machine Learning - a JUNIOR grant project funded by Czech Science Foundation, with duration from January 2020 to December 2022. The project focuses on both the theoretical and practical power of existing learning approaches in reasoning tasks.





Randomizing proof search of a saturation-based theorem prover reveals new probabilistic patterns that would normally show up only as noise. This new technique promises to revolutionize prover evaluation similarly to how the quantum view changed our understanding of particle physics.

Selected Publications & Papers

Araújo, J.; Chow, C.; **Janota, M.:** "Filtering Isomorphic Models by Invariants. *In: 27th International Conference on Principles and Practice of Constraint Programming (CP 2021). The 27th International Conference on Principles and Practice of Constraint Programming, Montpellier, 2021-10-25/2021-10-29. Saarbrücken: Dagstuhl Publishing,, 2021. p. 1-9. vol. 210. ISSN 1868-8969. ISBN 978-3-95977-211-2.*

Bártek, F.; **Suda, M.**: Neural Precedence Recommender. *In: Automated Deduction – CADE 28. 28th International Conference on Automated Deduction, Pittsburgh, 2021-07-12/2021-07-15. Springer, Cham, 2021. p. 525-542. Lecture Notes in Artificial Intelligence. vol. 12699. ISSN 1611-3349. ISBN 978-3-030-79876-5.*

Bhayani, S.; **Sattler, T.**; Barath, D.; Beliansky, P.; Heikkila, J.; Kukelova, Z.: Calibrated and Partially Calibrated Semi-Generalized Homographies. *IEEE International Conference on Computer Vision, 2021.*

Brachmann, E.; Humenberger, M.; Rother, C.; **Sattler, T.:** On the Limits of Pseudo Ground Truth in Visual Camera Re-localisation. *IEEE International Conference on Computer Vision, 2021.*

Brown, C.E.; **Janota, M.**: First-Order Instantiation using Discriminating Terms. In: Proceedings of the 19th International Workshop on Satisfiability Modulo Theories co-located with 33rd International Conference on Computer Aided Verification(CAV 2021). 19th International Workshop on Satisfiability Modulo Theories, Los Angeles, 2021-07-18/2021-07-19. Aachen: CEUR Workshop Proceedings, 2021. p. 17-22. vol. 2908.ISSN 1613-0073.

Chelani, K.; Kahl, F.; **Sattler, T.:** How Privacy-Preserving are Line Clouds? Recovering Scene Details from 3D Lines. *Conference on Computer Vision and Pattern Recognition, 2021.*

Froleyks,N.; Heule, M.; Iser, M.; Järvisalo, M; **Suda, M.**: SAT Competition 2020. *Artificial Intelligence. 2021, 301 ISSN 0004-3702.*

Glos, J.; Otava, L.; **Václavek, P.:** Non-Linear Model Predictive Control of Cabin Temperature and Air Quality in Fully Electric Vehicles. IEEE Transactions on Vehicular Technology Volume: 70, Issue: 2, Feb. 2021.

Kozubík, M.; Friml, D.: Differential Evolution Based Nonlinear Model Predictive Speed Control of PMSM Implemented on GPU. *In Proceedings of 2021 IEEE 30th International Symposium on Industrial Electronics (ISIE). IEEE, 2021. p. 01-06. ISBN: 978-1-7281-9023-5.*

Guzov, V.; Mir, A.; **Sattler, T.**; Pons-Moll, G.: Human POSEitioning System (HPS): 3D Human Pose Estimation and Self-localization in Large Scenes from Body-Mounted Sensors. *Conference on Computer Vision and Pattern Recognition, 2021.*

Hůla, J.; Mojžíšek, D.; **Janota, M.**: Graph Neural Networks for Scheduling of SMT Solvers. *In: 2021 IEEE 33rd International Conference on Tools with Artificial Intelligence (ICTAI). The 33rd IEEE International Conference on Tools with Artificial Intelligence, Washington, 2021-11-01/2021-11-03. Los Alamitos: IEEE Computer Society, 2021. p. 447-451. ISSN 2375-0197. ISBN 978-1-6654-0898-1.*

Jafarzadeh, A.; López Antequera, M.; Gargallo, P.; Kuang Y.;Toft, C.; Kahl, F.; **Sattler, T.**: CrowdDriven: A New Challenging Dataset for Outdoor Visual Localization. *IEEE International Conference on Computer Vision, 2021.*

Jakubův, J.; **Janota, M.**; Reynolds, A.: Characteristic Subsets of SMT-LIB Benchmarks. *In: Proceedings of the 19th International Workshop on Satisfiability Modulo Theories co-located with 33rd International Conference on Computer Aided Verification(CAV 2021). 19th International Workshop on Satisfiability Modulo Theories, Los Angeles, 2021-07-18/2021-07-19. Aachen: CEUR Workshop Proceedings, 2021. p. 53-63. vol. 2908. ISSN 1613-0073.*

Janota, M.; Barbosa, H., Fontaine, P.; Reynolds, A.: Fair and Adventurous Enumeration of Quantifier Instantiations. *In: Proceedings of the 21stConference on Formal Methods in Computer-Aided Design – FMCAD 2021. 21st Conference on Formal Methods in Computer-Aided Design – FMCAD 2021, Yale, 2021-10-20/2021-10-22. Wien: TU Wien, 2021.p. 256-260. Conference Series: Formal Methods in Computer-Aided Design. ISBN 978-3-85448-046-4.*

Janota, M.; Morgado, A.; Fragoso, J.S.; Manquinho, V.: The Seesaw Algorithm: Function Optimization Using Implicit Hitting Sets. *In: 27th International Conference on Principles and Practice of Constraint Programming (CP 2021). The 27th International Conference on Principles and Practice of Constraint Programming, Montpellier, 2021-10- 25/2021-10-29. Saarbrücken: Dagstuhl Publishing,, 2021. p. 1-16. vol. 210. ISSN 1868-8969. ISBN 978-3- 95977-211-2.*

Kunz, J.; Fialka, J.; Pikula, S.; Beneš, P.; Krejcí, J.; **Klusácek, S.; Havránek, Z.**: A New Method to Perform Direct Efficiency Measurement and Power Flow Analysis in Vibration Energy Harvesters. *SENSORS, 2021, vol. 21, no. 7, p. 1-19. ISSN: 1424-8220.*

Mikolov, T.; Hudcová, B.: Computational Hierarchy of Elementary Cellular Automata, 2021

Sarlin, P.; Unagar, A.; Larsson, M.; Germain, H.; Toft, C.; Larsson, V.; Pollefeys, M.; Lepetit, V.; Hammarstrand, L.; Kahl, F.; **Sattler, T.:** Back to the Feature: Learning Robust Camera Localization from Pixels to Pose. *Conference on Computer Vision and Pattern Recognition, 2021.*

Skalský, M.; Fialka, J.; Kopečný, L.; **Havránek, Z.:** Scale-Factor Stability Control Technique for Closed-Loop All-Fiber Interferometric Optical Gyroscope. *In 2021 IEEE International Symposium on Inertial Sensors and Systems (INERTIAL). IEEE, 2021. p. 1-4. ISBN: 978-1-7281-5099-4.*

Suda, M.: Improving ENIGMA-style Clause Selection while Learning From History. *In: Platzer A., Sutcliffe G. (eds) Automated Deduction – CADE 28. CADE 2021. Lecture Notes in Computer Science, vol 12699. Springer, Cham.*

Suda, M.: Vampire with a Brain Is a Good ITP Hammer. *In: Frontiers of Combining Systems. 13th International Symposium, FroCoS 2021, Birmingham, 2021-09-08/2021-09-10. Cham: Springer, 2021. p. 192-209. 1. ISSN 0302-9743. ISBN 978-3-030-86204-6.*

Zhou, Q.; **Sattler, T.**; Leal-Taixe, L.: Patch2Pix: Epipolar-Guided Pixel-Level Correspondences, *Conference on Computer Vision and Pattern Recognition, 2021.*

Synergies & Cooperation

European AI Ecosystem

RICAIP and CIIRC CTU have developed strong collaborations and manifold networking across European networks, especially with CLAIRE and ELLIS initiatives.

National Centre for Industry 4.0 (NCI4.0)

CIIRC CTU & CEITEC BUT are partnering the national platform connecting stakeholders from academia & industrial sector. Synergies in dissemination activities with NCIP4.0 multiply the approach to SMEs & corporates in the Czech Republic.

The EIT's HEI Initiative: TANDEM+

Innovation Capacity Building for Higher Education is a joint EIT Community activity coordinated by EIT RawMaterials. TANDEM+ sets the path towards 2030 with a multi-dimensional, international Open Entrepreneurship Alliance for societal impact under the Sustainable Development Goals. CIIRC CTU is partnering this activity.

EIT Manufacturing

DFKI and CTU are full partners of EIT Manufacturing developing joint projects with the entire ecosystem including the RICAIP facilities.

Technical University of Ostrava (TUO)

Cooperation on a submission of RICAIP Large Research Infrastructures proposal and the connection of the Ostrava Testbed.

ESFRI

The Czech partners with the Technical University in Ostrava applied for the Czech national call for Large Research Infrastructures (LRI). RICAIP made a first step towards the ESFRI Roadmap.

EDIH

Given the success with national proposalas for the European Digital Innovation Hub (EDIH), all RICAIP partners have been preparing their proposals as they reached the national shortlists.

H2020 Teaming Projects Cooperation

Teaming Club initiative organized by the InnoRenew CoE, Slovenia

Cooperation with the CETOCOEN Excellence H2020 Teaming Phase II project supported in the Czech Republic in the area of environment and health.

Selected Synergic Projects

Acronym / ID	Project name	Provider	Budget of RICAIP partners in EUR ths	Project Duration
HumanE AI / 952026	HumanE AI Network	H2020	2,621.88	2020-2023
AI4CSM / 101007326	Automotive Intelligence for/at Connected Shared Mobility	H2020/ECSEL	1,160.00	2021-2024
ELISE / 951847	European Learning and Intelligent Systems Excellence	H2020	692.66	2020-2023
MAS4AI / 957204	Multi-Agent Systems for Pervasive Artificial Intelligence for assis-ting Humans in Modular Production Environments	H2020	861.68	2020-2023
Transform / 101007237	Trusted European SiC Value Chain for a greener Economy	H2020/ECSEL	443.70	2021-2024
VISION / 952070	Value and Impact through Synergy, Interaction and coOperation of Networks of AI Excellence Centres	H2020	502.50	2020-2023
BRAINE / 876967	Big data pRocessing and Artificial Intelligence at the Network Edge	H2020/ECSEL	238.75	2020-2023
IMOCO4.E / 101007311	Intelligent Motion Control under Industry 4.E	H2020/ECSEL	181.50	2021-2024
DIH4AI / 101017057	AI on-demand platform for regional interoperable DIHs Network	H2020	144.50	2021-2023
TAILOR / 952215	Trustworthy AI - Integrating Reasoning, Learning and Optimization	H2020	378.35	2020-2023
DIH-WORLD / 952176	DIH-World-Accelerating deployment and matureness of DIHs for the benefit of Digitisation of European SMEs	H2020	62.88	2020-2023
POSTMAN / LL1902	Powering SMT Solvers by Machine Learning	ERC CZ/MIT	1,431.84	2020-2024
CAMELOT / 01IW20008	Continuous Adaptive Machine-Learning of Transfer of Control Situations	BMBF	1,774.04	2020-2023
PowerATP / GJ20-06390Y	Powering Automatic Theorem Provers by Machine Learning	GA CR	249.40	2020-2022
SenRob WT/5-ZeMA-500-3/2021	Application of a sensitive robot for force-controlled surface treatment	Saarland Region	118.00	2021-2022
M-NEST-RIS-II / 21215	Network for Empowering People in Added-Value Manufacturing Systems and Technologies – Phase I	EIT Manufacturing	30.00	2021
ManuLearn II / 21166	Learning through manufacturing challenges II	EIT Manufacturing	29.00	2021

Selected projects, relevant to RICAIP, or using the RICAIP infrastructure, or involving the members of the RICAIP teams; implemented in 2021; started after the start of the RICAIP Teaming II project (09/2019).

European Commission | Horizon 2020 European Union funding for Research & Innovation

MINISTRY OF EDUCATION, YOUTH AND SPORTS

MINISTRY OF INDUSTRY AND TRADE

eit Manufacturing

Co-funded by the European Union

GAČR CZECH SCIENCE FOUNDATION

Federal Ministry of Education and Research

Staatskanzlei SAARLAND

Communication & Media Visibility

148
Appearances in online and printed media

12
Press releases

10
Original articles in media including interviews

Highlights

Signature of the Memorandum of Understanding between CIIRC CTU and DFKI

Signature of the Memorandum of Understanding between CIIRC CTU and DFKI at the high-level German-Polish-Czech Conference on R&D&I organised by the BMBF – German Federal Ministry of Education and Research in Dresden, Germany.

8 and 9 October 2021

German President Visited the RICAIP Research Centre at CIIRC CTU

German Federal President Frank-Walter Steinmeier and his wife Elke Büdenbender visited the RICAIP Centre on 27 August 2021 as part of their state visit to the Czech Republic. They saw six robotic experiments in the Testbed for Industry 4.0 at CIIRC CTU, some of which were prepared in cooperation with industrial companies. President Steinmeier met representatives of the academic and industrial sectors who participate in the research and development of modern technologies for industry.

"The demonstrations that we prepared for the president's visit cover a wide range of research of our teams at CIIRC CTU and within RICAIP. For example, with the DFKI team, we remotely connected the operator in Prague with the robots in the testbed in Saarbrücken to verify the feasibility of the principles of distributed production as well as remote human-robot cooperation."

- Dr. Tilman Becker, RICAIP Director

"The visit of the German President today is symbolic for us. Five years ago, almost to the day, in the presence of German Chancellor Angela Merkel, we signed the agreement on scientific cooperation with Prof. Wolfgang Wahlster, former director of DFKI. I am pleased that, after five years of hard work, we can present, in the same place, concrete results of our RICAIP joint centre, which transcend the borders of our two countries and demonstrate strong cooperation in Industry 4.0 at a truly international level."

- Prof. Vladimír Mařík, Scientific Director of CIIRC CTU

Roadshow - National Centre for Industry 4.0 Robotisation and Robotic Applications

Pavel Václavek & Luděk Žalud talked about robotics and its possibilities in an online seminar for companies.

IROS 2021 IEEE/RSJ International Conference

RICAIP was presented by a virtual booth at the digital IROS 2021 IEEE/RSJ International Conference on Intelligent Robots & Systems held for the first time organised in the Central European country.

Visit of the German Ambassador Mr. Andreas Künne at CEITEC BUT

The German Ambassador His Exellency Mr. Andreas Künne visited the RICAIP testbed at CEITEC BUT in Brno.

RICAIP Welcomed the Taiwanese Business Representatives at CIIRC CTU

Representatives of companies and business associations from Taiwan got an expert excursion through the Testbed for Industry 4.0 at CIIRC CTU.

Goethe-Institut: AI Residencies of Artists in RICAIP

RICAIP welcomed young talented artists who took part in a pan-European project "Generation A = Algorithm" of the German Goethe-Institut, which sent a total of fifteen carefully selected talents to thirteen prestigious European scientific and research institutions for one month in 2021.

Douna Lim & Théo Pesso *(FR)*
at CIIRC CTU, Sept 2021

Lily McCraith *(UK)*
at CIIRC CTU, Oct/Nov 2021

Valerie Wolf Gang *(SI)*
at DFKI, Sept/Oct 2021

RICAIP Seminar Series

Moderated hybrid events managed and streamed from the CEITEC BUT premises on actual topics related to the social impacts of science and technology. A rich playlist of videos with instructive lectures by speakers from all over Europe is available on the RICAIP Youtube channel.

12
Speakers from EU

3
Seminar series

Awards

European Parliament: European Citizen's Prize

The researchers from the CIIRC CTU received an award in 2020 for the protective mask "CIIRC RP95-3D".

The medal was awarded at a ceremony on 11 October 2021 by Dita Charanzová, Vice-President of the European Parliament (EP) and Chancellor of the European Citizen's Prize, since the act could not be held earlier due to pandemic restrictions.
The ceremony was organised in cooperation with the RICAIP team at CIIRC CTU.

The Award of the Engineering Academy of the Czech Republic

On 23 November 2021, during a ceremony in the Bethlehem Chapel in Prague, the Engineering Academy of the Czech Republic (EACR) presented the twenty-fourth edition of the award for an excellent technical project.
The team of the CIIRC CTU received the 2020 award for the RP95-3D protective half mask. As part of the ceremony, an honorary foreign member of the EACR was also appointed - Prof. Wolfgang Wahlster, DFKI.

Selected Activities in Numbers

13
Workshops
& Training Sessions

8
High-level visits
in testbeds

7
Public Events
& Fairs

6
Invited
Presentations

Prof. Wolfgang Wahlster on AI & the next decade of Industry 4.0 - a lecture streamed from the Prague testbed

Researchers Night at the Prague testbed

HRC laboratory for pupils in Saarbrücken

RICAIP Research and Innovation Centre on Advanced Industrial Production

RICAIP Annual Report 2021

Second edition of the RICAIP Annual Report. Published in April 2022.
Time period concerned: 01/2021 – 12/2021.

CIIRC CTU
Czech Institute of Informatics, Robotics and Cybernetics
Czech Technical University in Prague

Jugoslávských partyzánů 1580/3
160 00 Prague 6, Czech Republic

Business registration No.: 68407700
VAT: CZ68407700

Dr. Tilman Becker, RICAIP Director: info@ricaip.eu
Jovana Jovic Tadic, Administration matters: jovana.jovic.tadic@cvut.cz, +420 224 354 264
Eva Doležalová, PR matters: pr@ricaip.eu, +420 724 281 107
Graphic design: Marie Svatoňová, CIIRC CTU
Content editors: Eva Doležalová, Jovana Jovic Tadic, *using the details supplied by RICAIP partners and admin teams.*
Photos Copyright: Jan Ryszawy (CTU), Lukáš Legierski (www.lukaslegi.com), Jim Rakete (DFKI),
Jakub Zatloukal (EP), Marie Svatoňová, Roman Sejkot (both CIIRC CTU), archive of CEITEC BUT and ZeMA

www.ricaip.eu


KUKA

ricaip.eu info@ricaip.eu linkedin.com/company/ricaip twitter.com/ricaip_eu

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