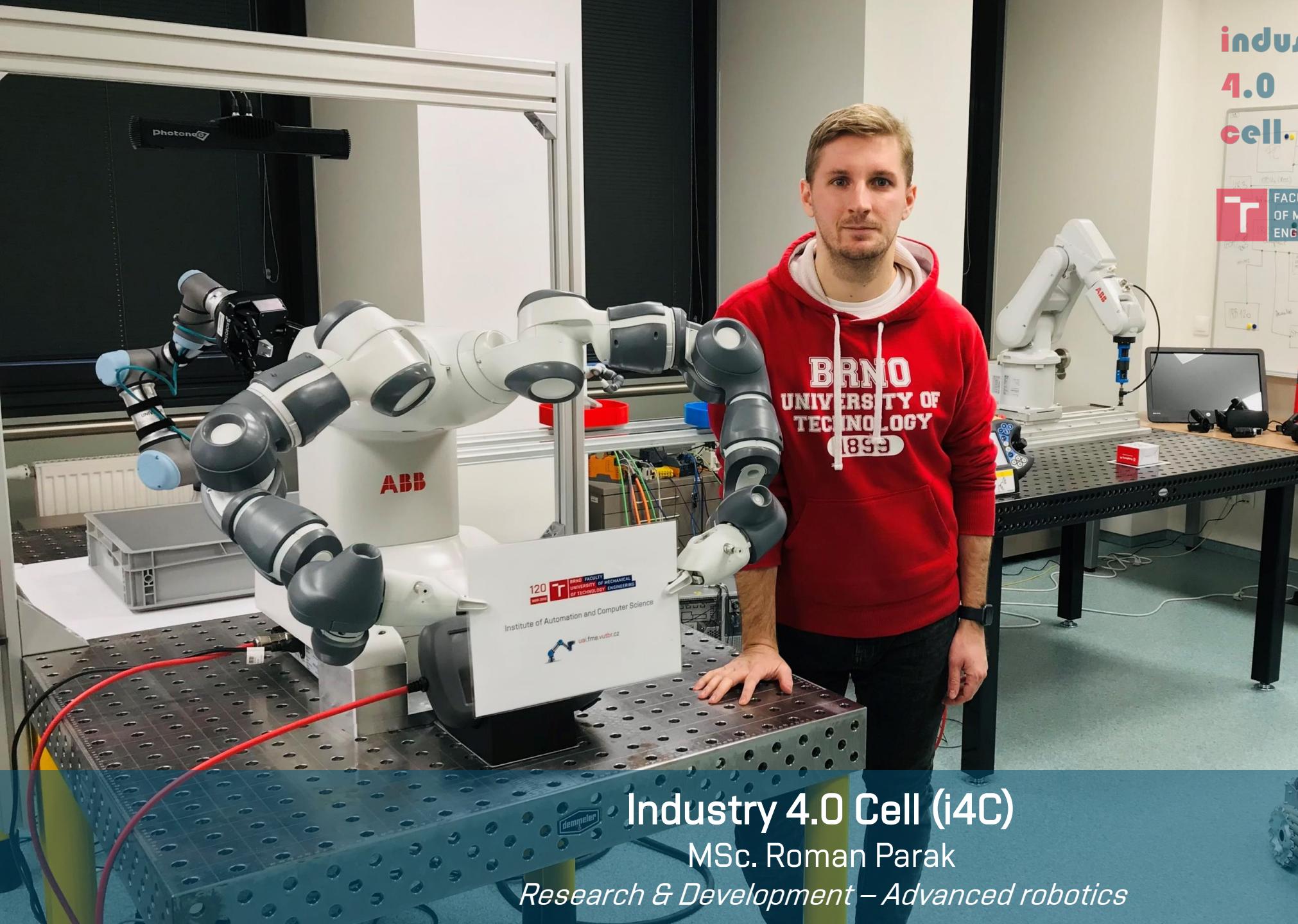




Industry 4.0 Cell (i4C)

MSc. Roman Parak

Research & Development – Advanced robotics



Content

1. Institute of Automation and Computer Science
2. Industry 4.0 Cell
 - 2.1 Human-Machine Interface
 - 2.2 System Integration
 - 2.3 Virtual / Digital Twin
 - 2.4 Augmented Reality
 - 2.5 Vision of the future
3. Projects

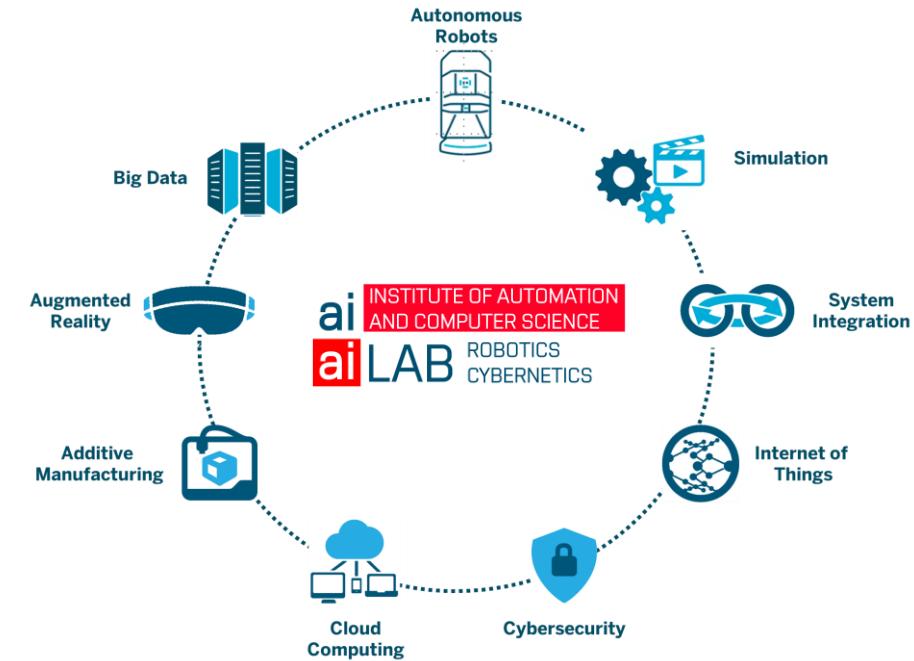


Institute of Automation and Computer Science

Faculty of Mechanical Engineering, Brno University of Technology

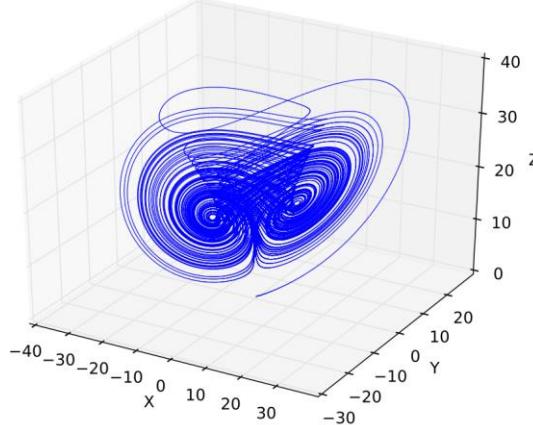
Organizational Structure:

- Dept. of Automation
- Dept. of Applied Computer Science
- Dept. of Computer Networks
- NETME Centre – Cybernetics and Robotics Division



NETME Centre – Cybernetics and Robotics Division

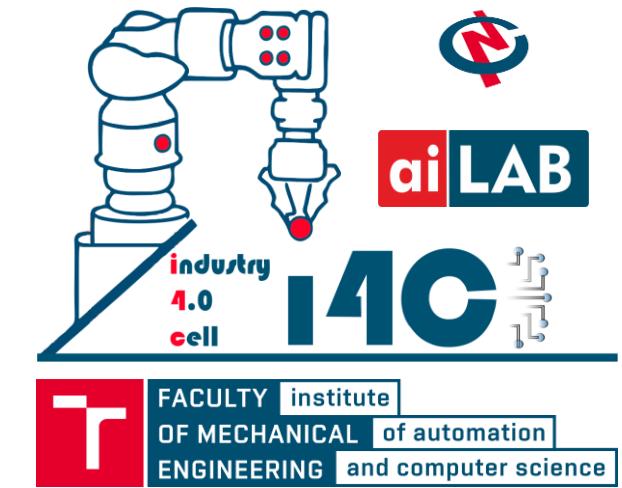
Faculty of Mechanical Engineering, Brno University of Technology
Institute of Automation and Computer Science



Advanced Control Systems



Bio-inspired robotics



Industry 4.0 Cell

Industry 4.0 Cell

Industry 4.0 Cell

Organizational structure of team members:

Assoc. Prof. Radomil Matousek, PhD.

Head of laboratory

Contact: matousek@fme.vutbr.cz

MSc. Roman Parak

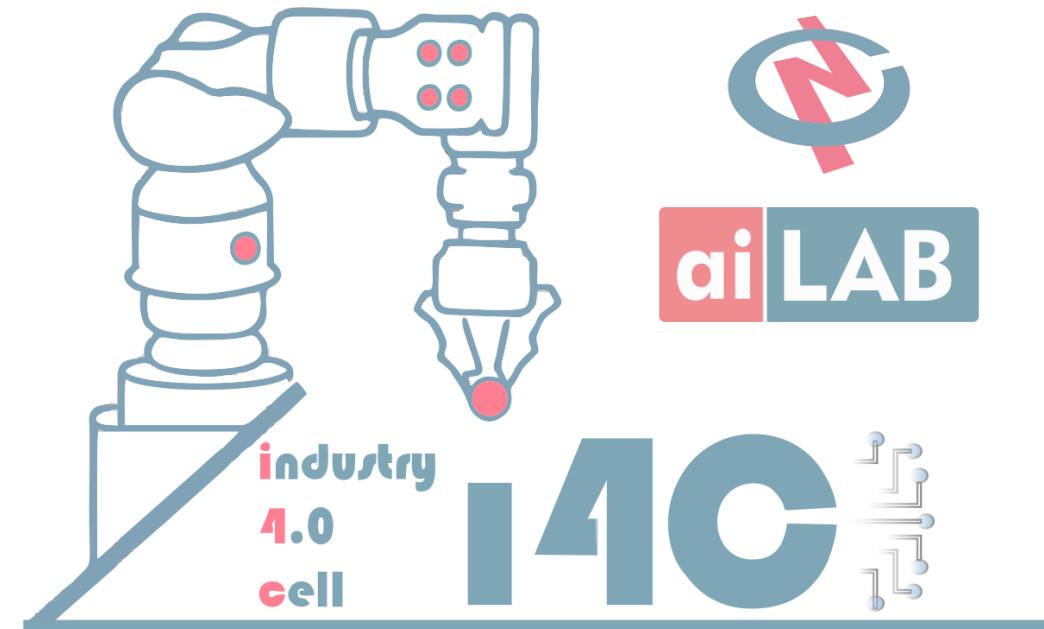
Research and Development (R&D)

Contact: Roman.Parak@vutbr.cz

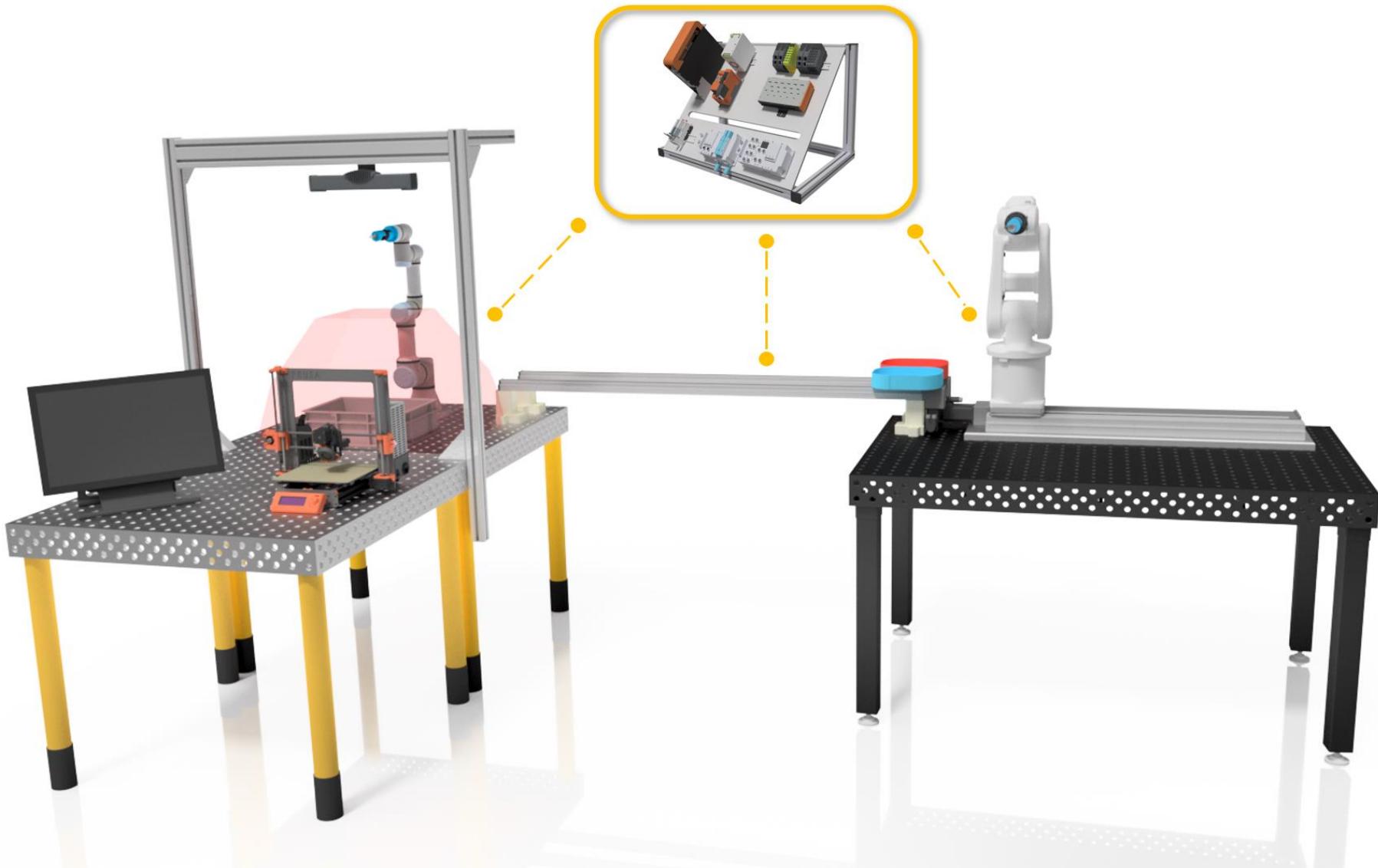
Assoc. Prof. Branislav Lacko, PhD.

Industry 4.0 Consultant

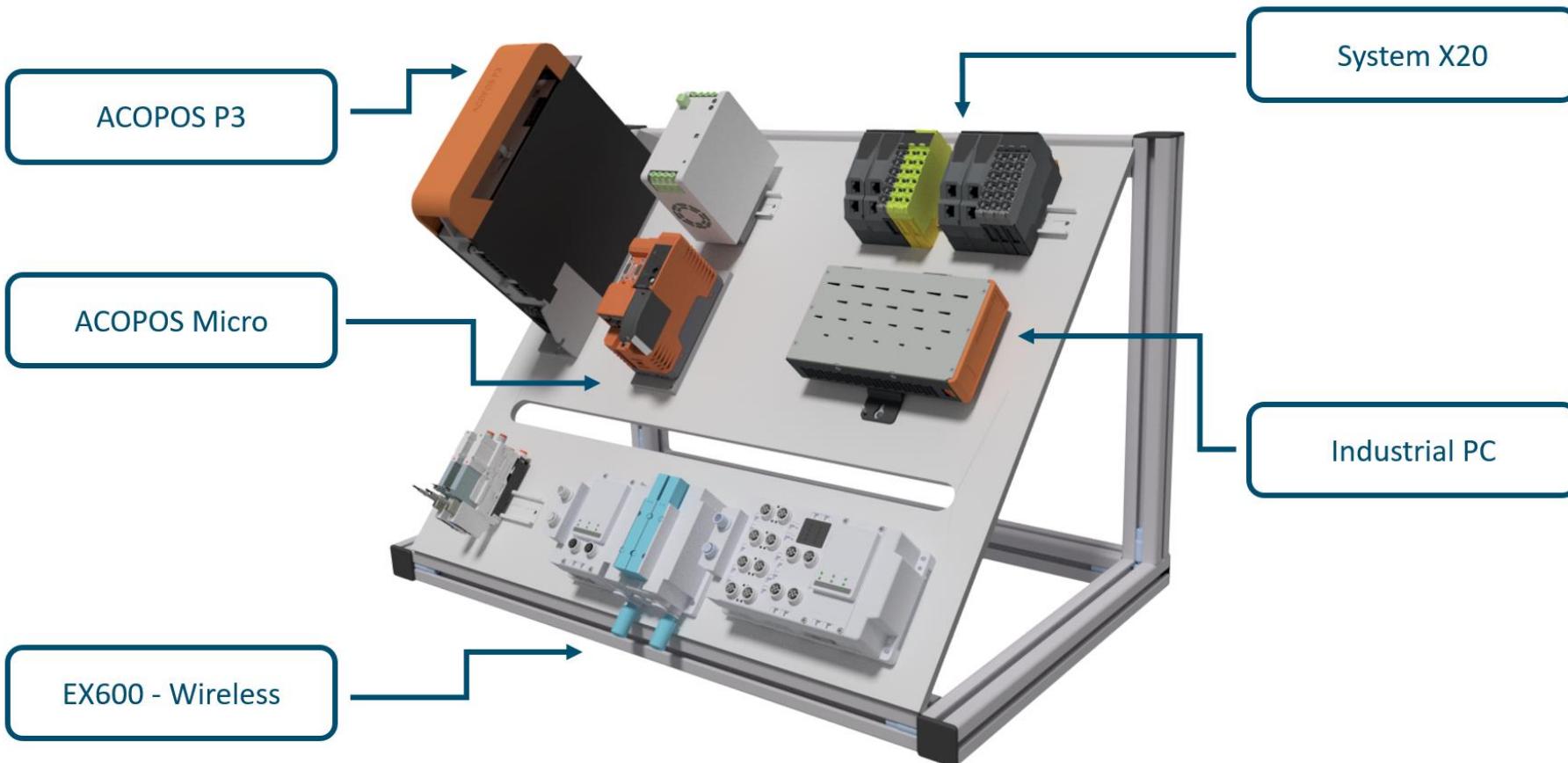
Contact: lacko@fme.vutbr.cz



Industry 4.0 Cell



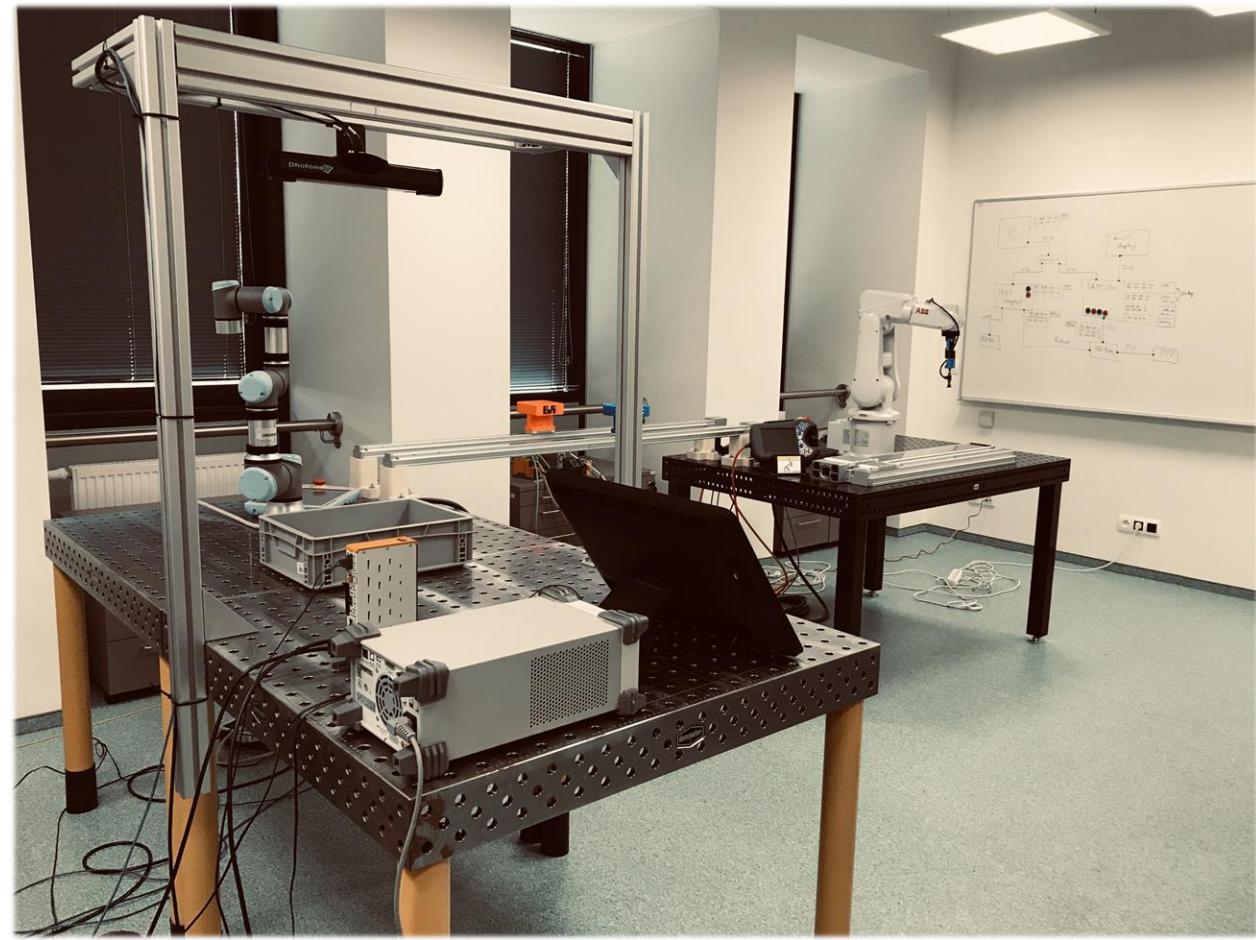
Electric switchboard



The project started: 2018



Completion of the first goal: 2019



Completion of the second goal: 2020



Current situation of the i4C: 2021



Laboratory Activities

Main activities:

- Lectured courses (Programmable Logic Controllers, Machine Vision, Artificial Intelligence Algorithms, Neural Networks and Evolution Methods, Industry 4.0, etc.)
- Bachelor's / Master's theses

Other activities:

- Workshops, Open Days, Science enjoys us, Night of Scientists, Robotics Conferences etc.



Research activities

Industrial robotics/Mobile robotics:

- Trajectory optimization (Multi-criteria optimization, Artificial intelligence, etc.)
- Virtual / Digital twin, Autonomous Robotics
- System Integration (OPC UA, POWERLINK, PROFINET, Ethernet/IP, etc.)
- ROS-Industrial (Robot Operating System - Industrial)
- PLC (Programmable logic controller)
- Human-machine collaboration
- Data processing, Safety

Computer vision / Image processing:

- 2D/3D
- Bin-Picking
- Visual inspection

Other:

- Virtual / Augmented reality
- 5G networks , etc.



Technologies



TensorFlow

P Y T H O N



Human-Machine Interface

Human-Machine Interface



mapp
VIEW

OPC UA™

Human-Machine Interface

The image displays four separate screenshots of an HMI interface, each showing a different industrial control screen:

- Top Left (7th Axis):** Shows controls for the 7th Axis (ABB IRB 120). It includes buttons for POWER OFF and HOME OFF, a status indicator (checkmark), and SMC logos. It also shows parameters like Max position (8,000.0 [Units]), Min position (0.0 [Units]), Max velocity (8,000.0 [Units]), and Min velocity (100.0 [Units]). Buttons for Mode (Manual/Automatic), Real-Time, and Control (HOME POSITION, MOVE, START, STOP) are present.
- Top Right (SMC PAD {MOVE}):** Shows a graphical representation of a cylinder with a stroke length of 5,810.0. It includes buttons for Position (5,810.0 [Units]) and Velocity (8,000.0 [Units]). A graph on the right shows Position over Time [s] with two traces: one for Position and one for Velocity.
- Bottom Left (Safety i4C):** Shows the Industry 4.0 Cell - Safety interface. It includes buttons for Control Component - OFF and Control Reset - OFF, a RESET button, and two yellow buttons for Virtual Safety E-Stop and Safety E-Stop. It also shows UR3 - Safety State, SMCTrak - Safety, ABB - Safety State, and 7th Ax. - Safety State. A Safety icon with a checkmark is shown.
- Bottom Right (UR3 {MOVE}):** Shows Joint Control, Cartesian Control, and Joystick Control for the UR3 robot. It includes buttons for Joint 1-6, START (J1-J6), STOP (J1-J6), and STOP. It also shows a 3D coordinate system with X, Y, Z, RY, and RZ axes. A ZPR Vacuum Gripper component is shown with TCP parameters (X: 0.00 [mm], Y: 0.00 [mm], Z: 160.00 [mm]). A Parameters section lists values for Joint 1 through 6. A graph on the right shows Position over Time [s].

Each screenshot includes a header bar with icons for safety (stop, warning, emergency stop), production (chart, bar chart), and navigation (home, user, date/time).

System Integration

System Integration

OPC UA

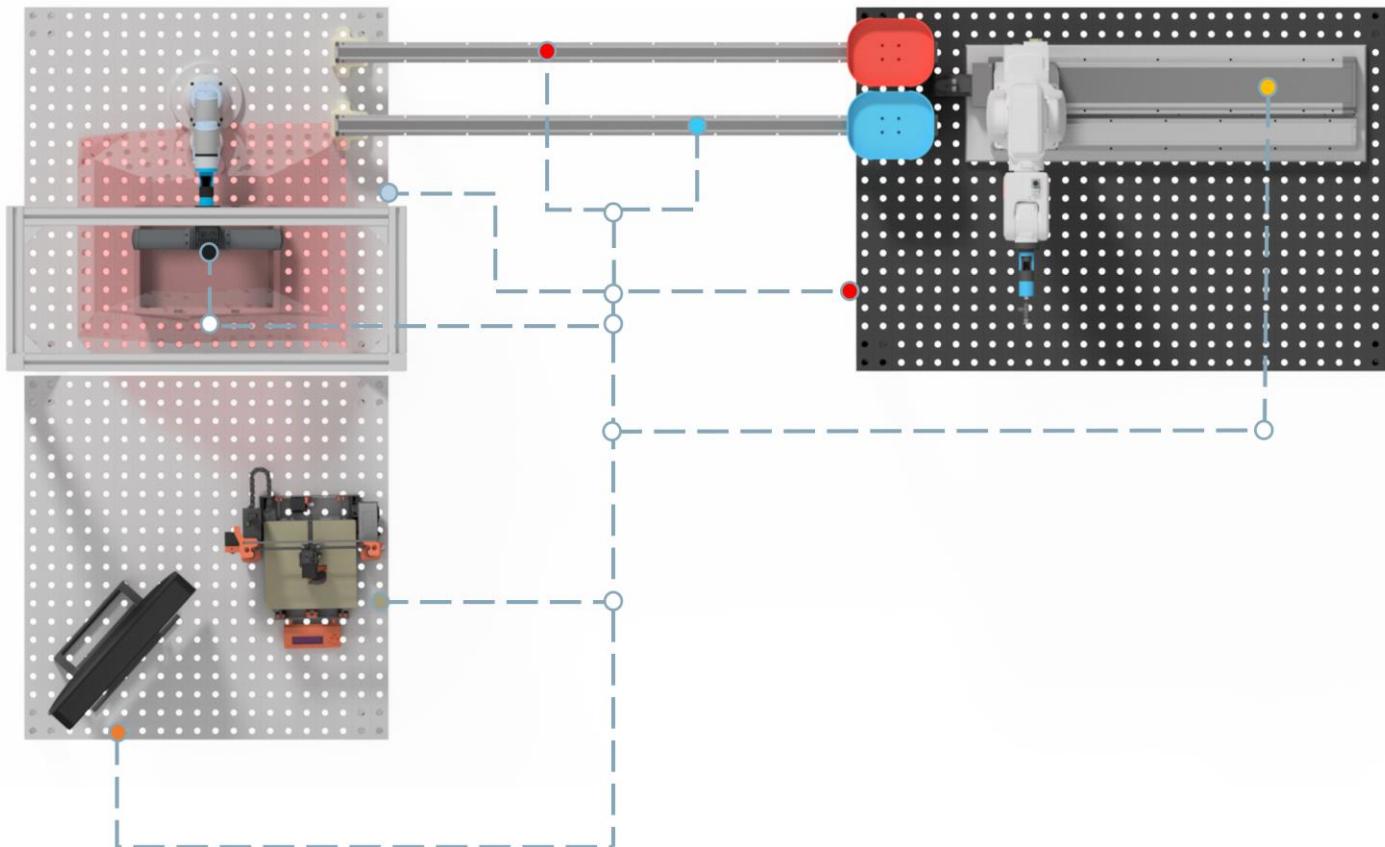
EtherNet/IP®



ETHERNET
POWERLINK

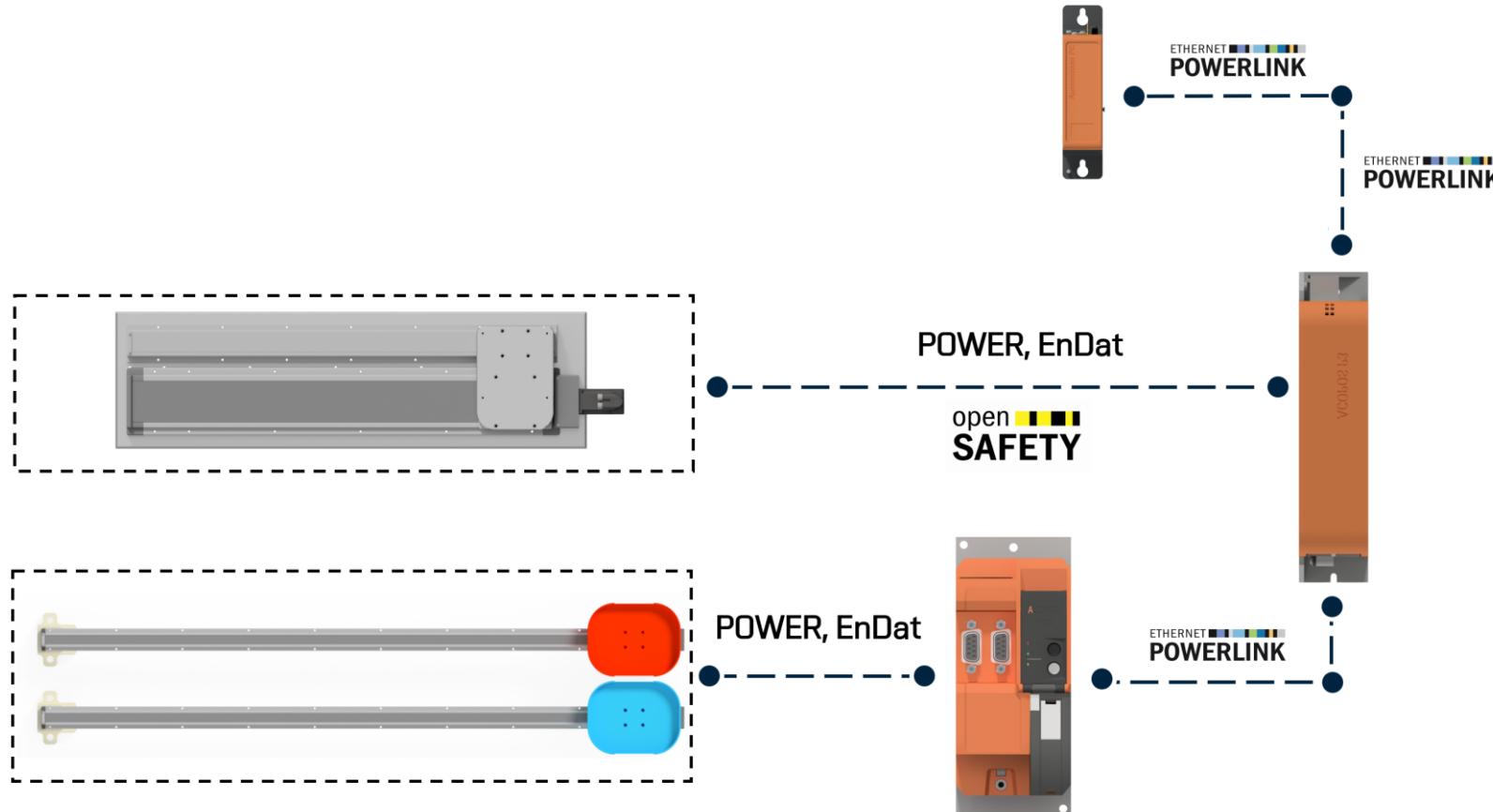


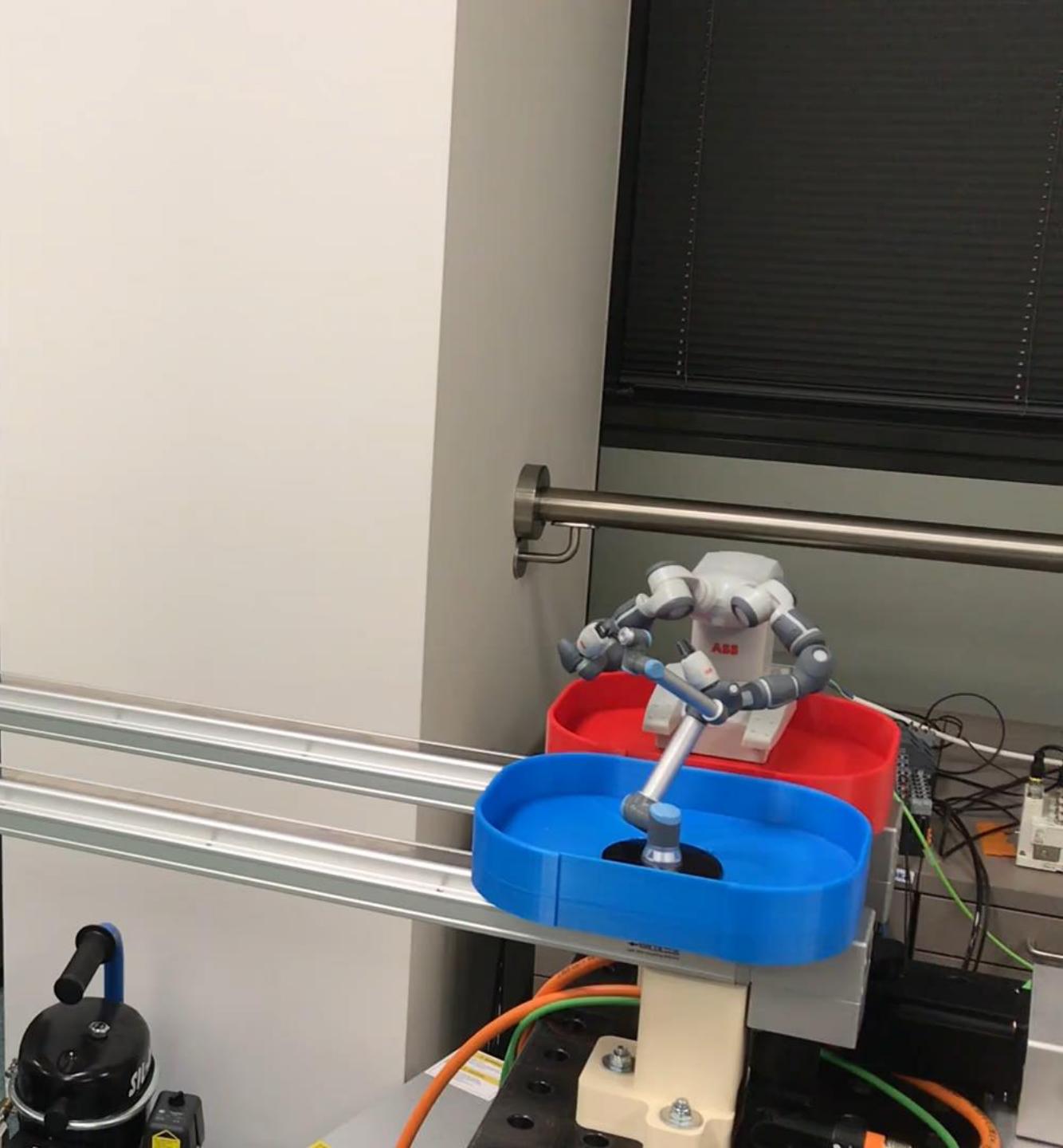
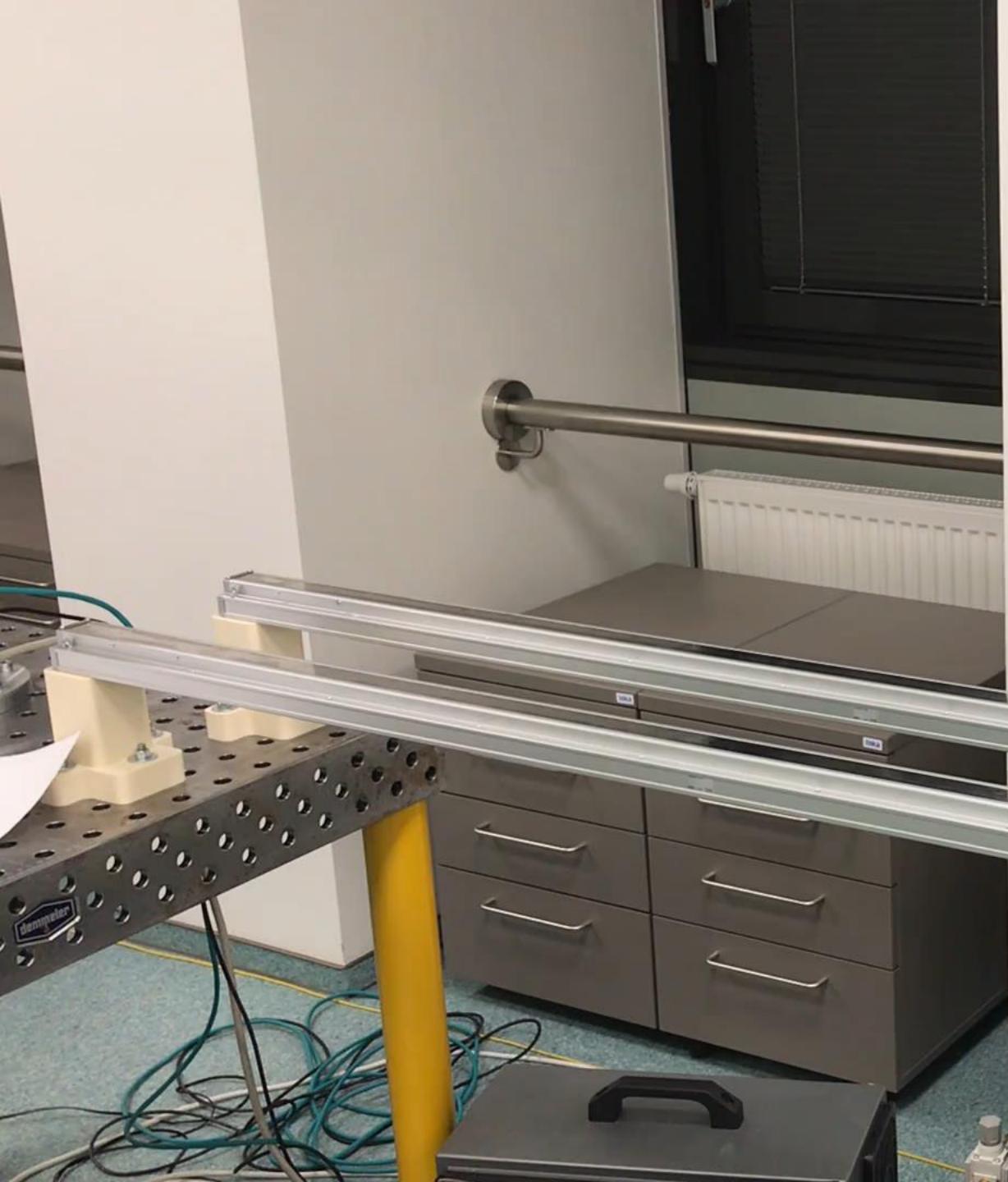
PROFI
NET®



System Integration

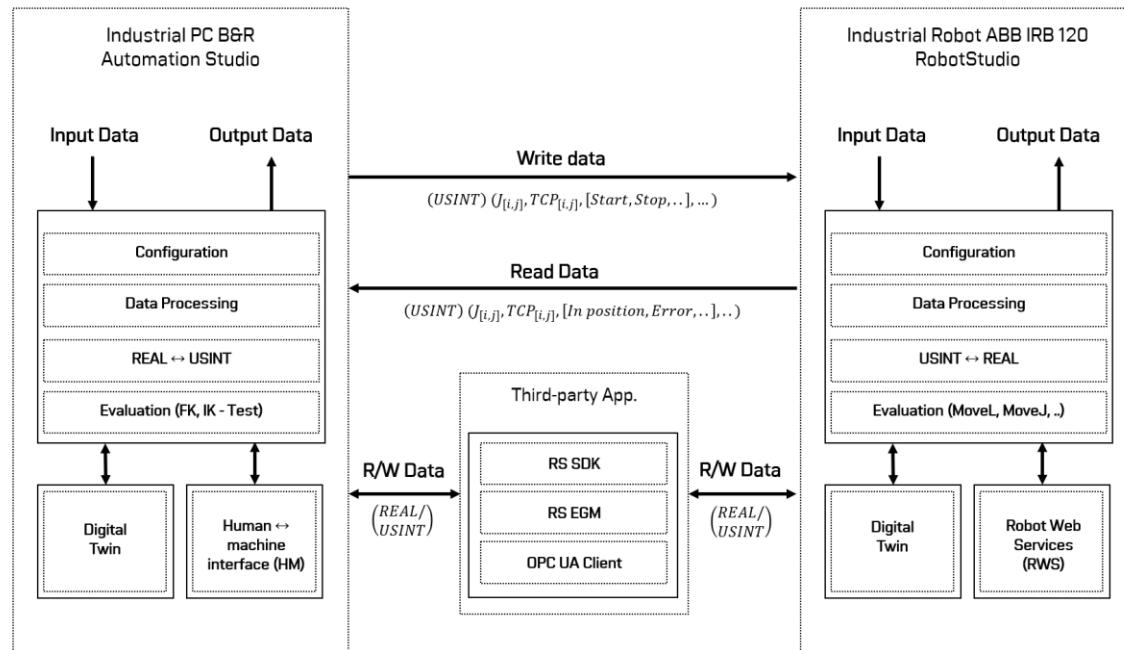
Industrial PC ↔ Synchronous motor:



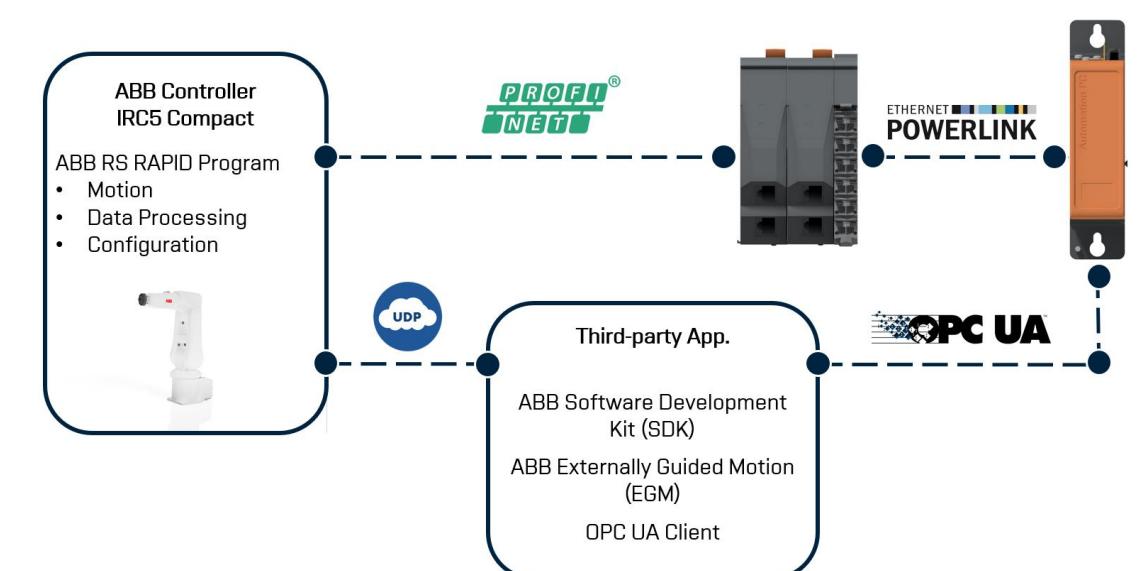


System Integration

Industrial PC ↔ ABB IRB 120:



Sys. Integration Scheme



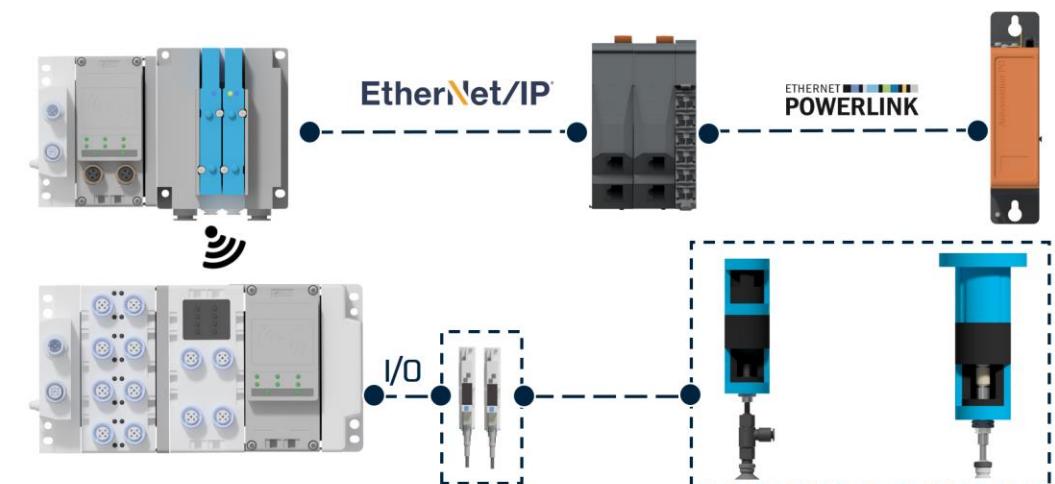
Wiring Diagram

System Integration

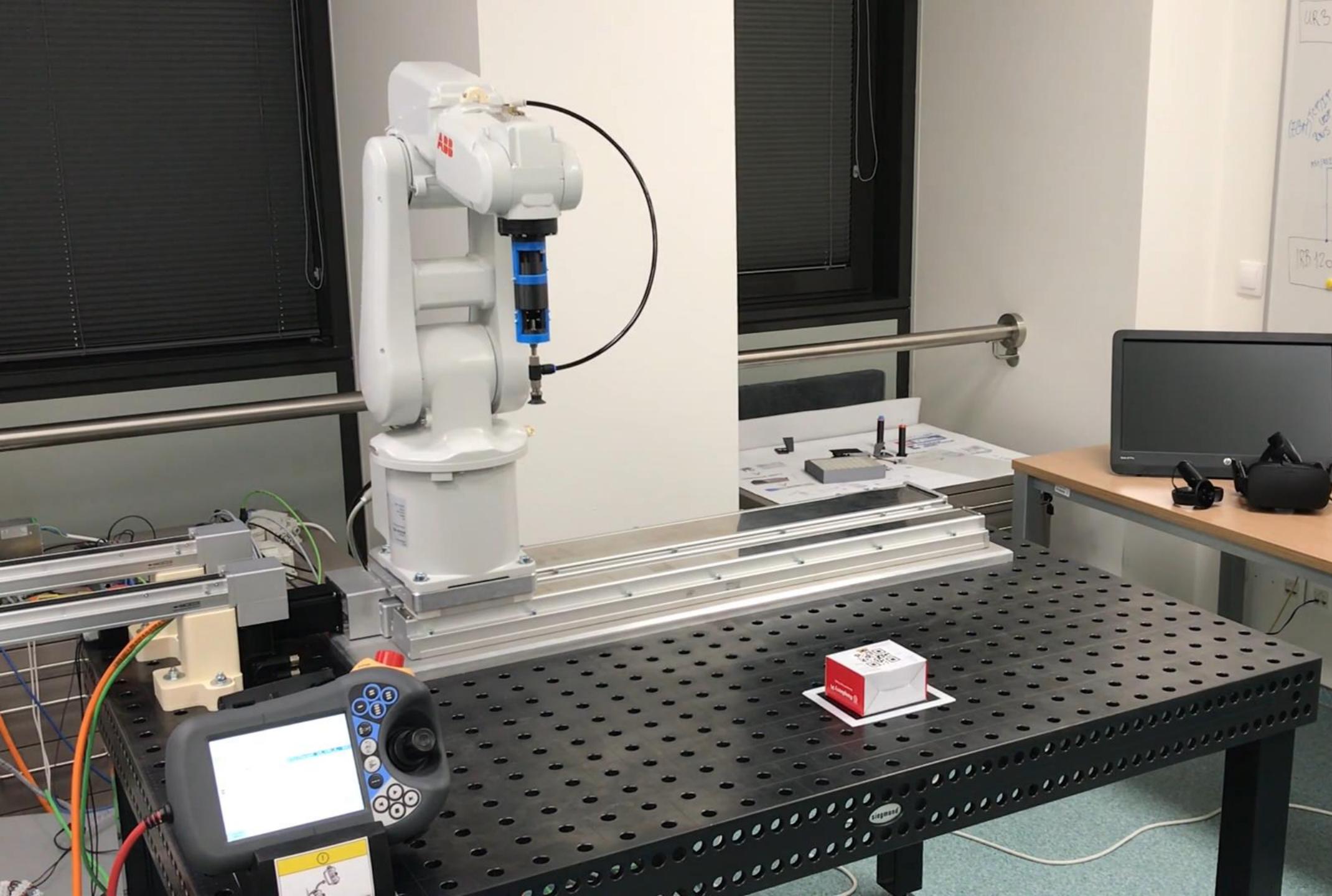
Industrial PC ↔ EX600 Wireless:



Sys. Integration Scheme



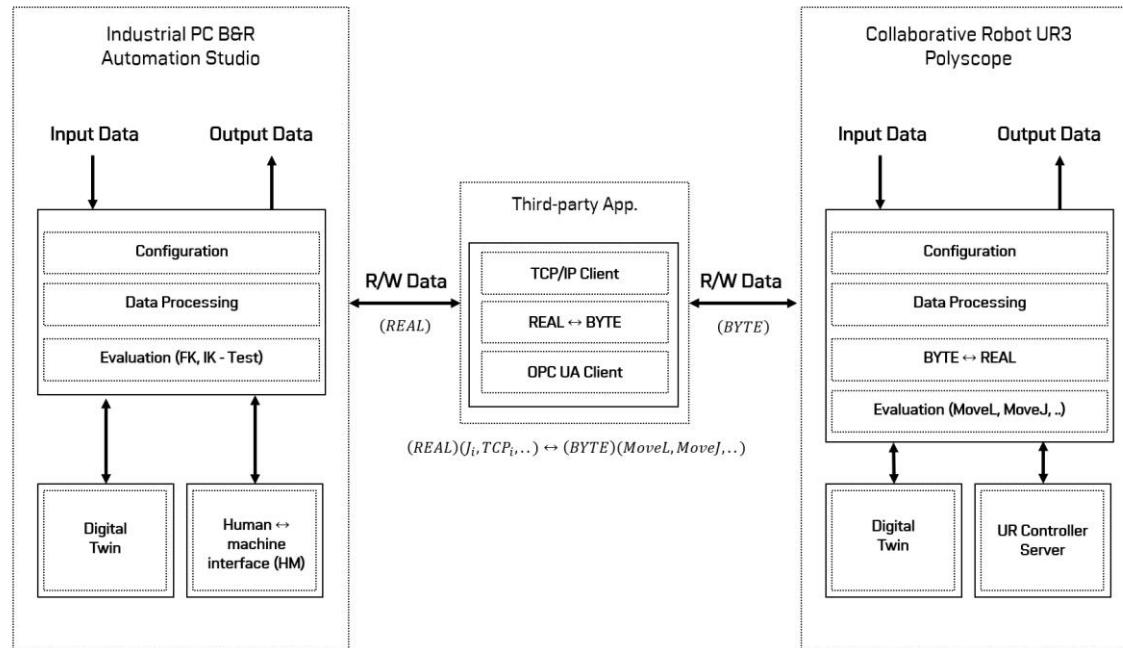
Wiring Diagram



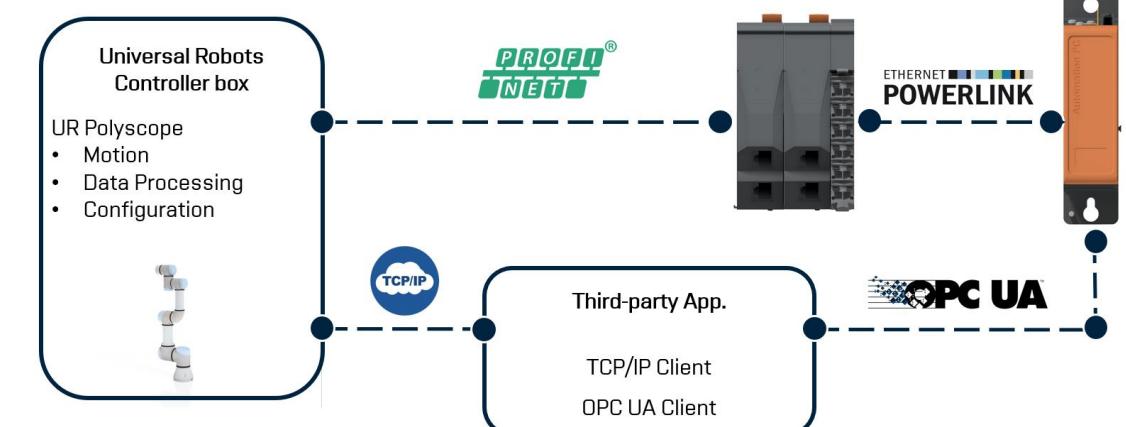
Springer
**Handbook of
Robotics**
Bartovský, Eberhard (Eds.)
2nd Edition

System Integration

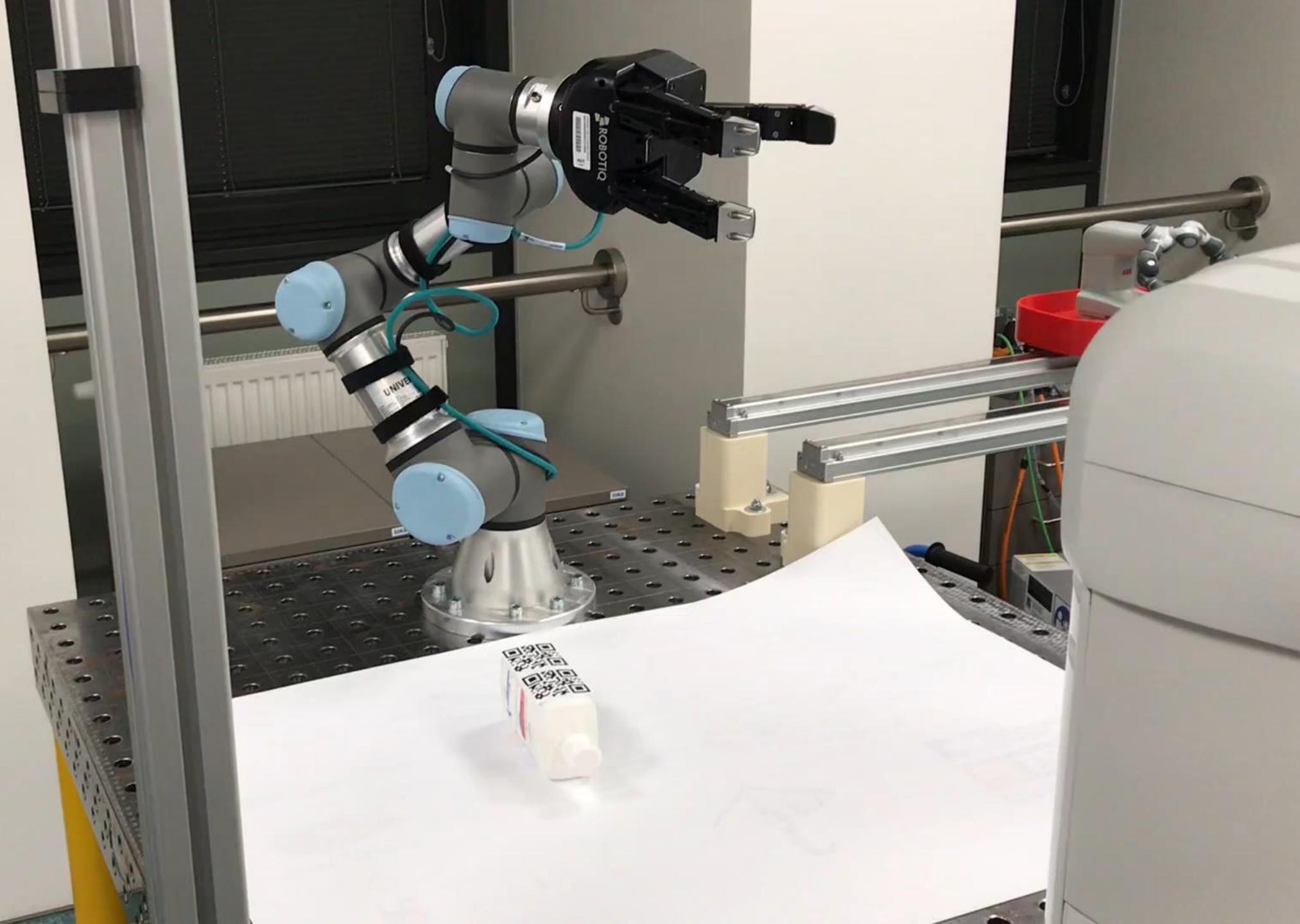
Industrial PC ↔ Universal Robots:



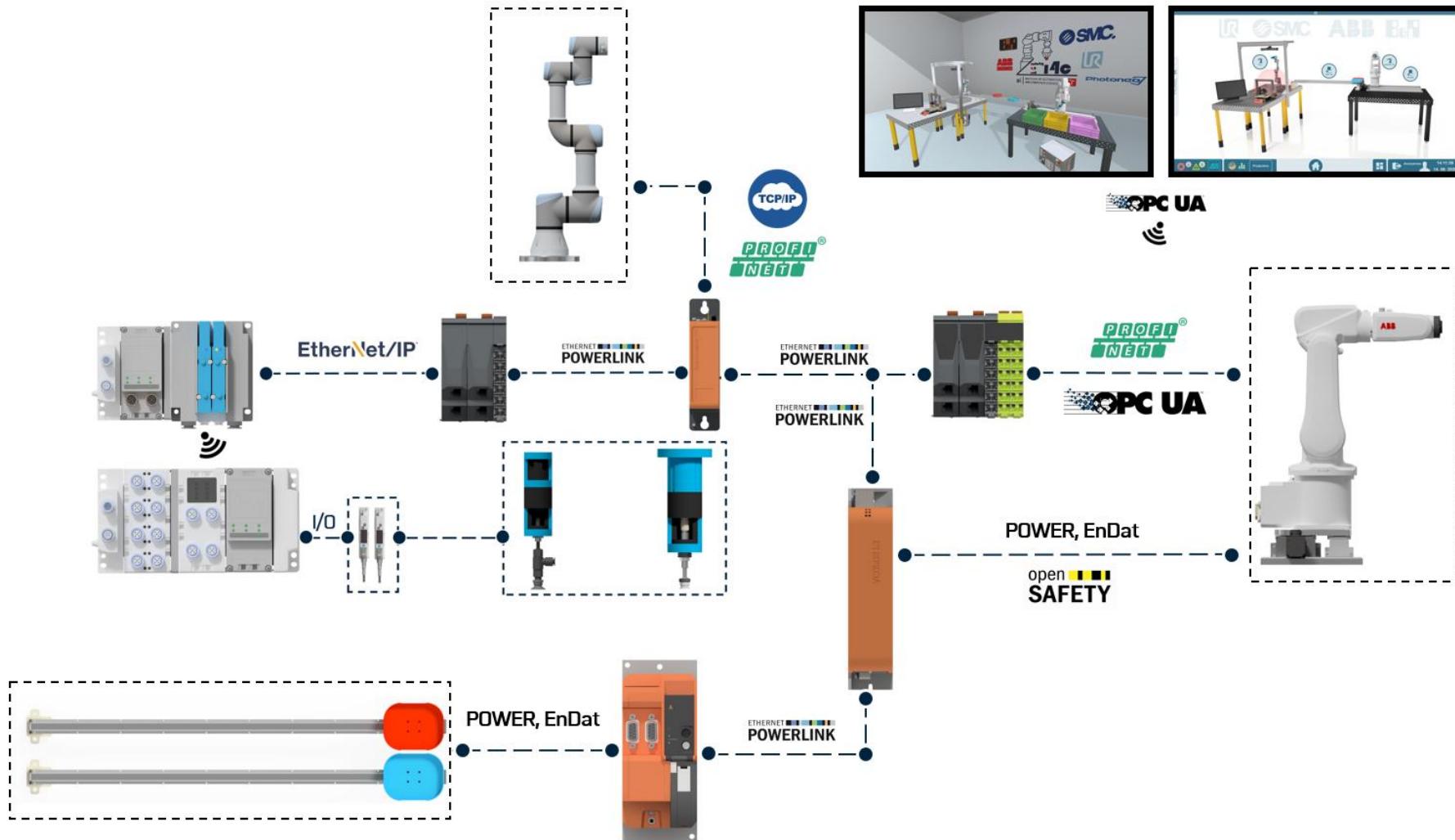
Sys. Integration Scheme



Wiring Diagram



System Integration



Virtual / Digital Twin

Virtual / Digital Twin

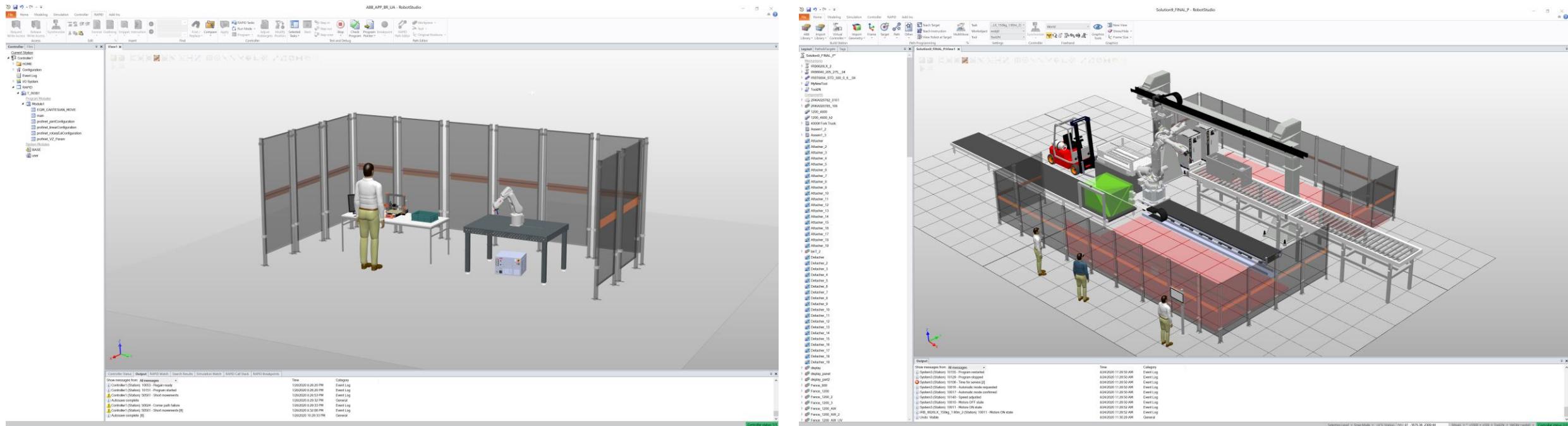


ABB RobotStudio

Solution_1_Final - RobotStudio

File Home Modeling Simulation Controller RAPID Add-Ins

ABB Library Import Library Virtual Controller Import Geometry Frame Target Path Other Teach Target Teach Instruction View Robot at Target Task Workobject Tool T_ROB1(Controller1) wobj0 smc_gripper Synchronize Controller World New View Show/Hide Frame Size Graphics Tools Graphics Freehand Add Virtual SmartGripper SmartGripper Settings

Layout Paths&Targets Tags Solution_1_Tutorial:View1

Solution_1_Final*

Mechanisms

- IRB120_3_58_01
 - Links
- smc_gripper
 - Links

Components

- Attacher_obj_1
- Attacher_obj_2
- Attacher_obj_3
- Detacher_obj_1
- Detacher_obj_2
- Detacher_obj_3
- object_1
- object_2
- object_3
- object_11
- object_22
- object_33
- Positioner_obj_1
- Positioner_obj_2
- Positioner_obj_3
- siegmund_1500_1000
- table

Station Signals

Select Controller: Station Signals

Filter Edit Signals... I/O Range 1-16

Inputs

object 1 position object 2 position object 3 position

Output

Show messages from All messages

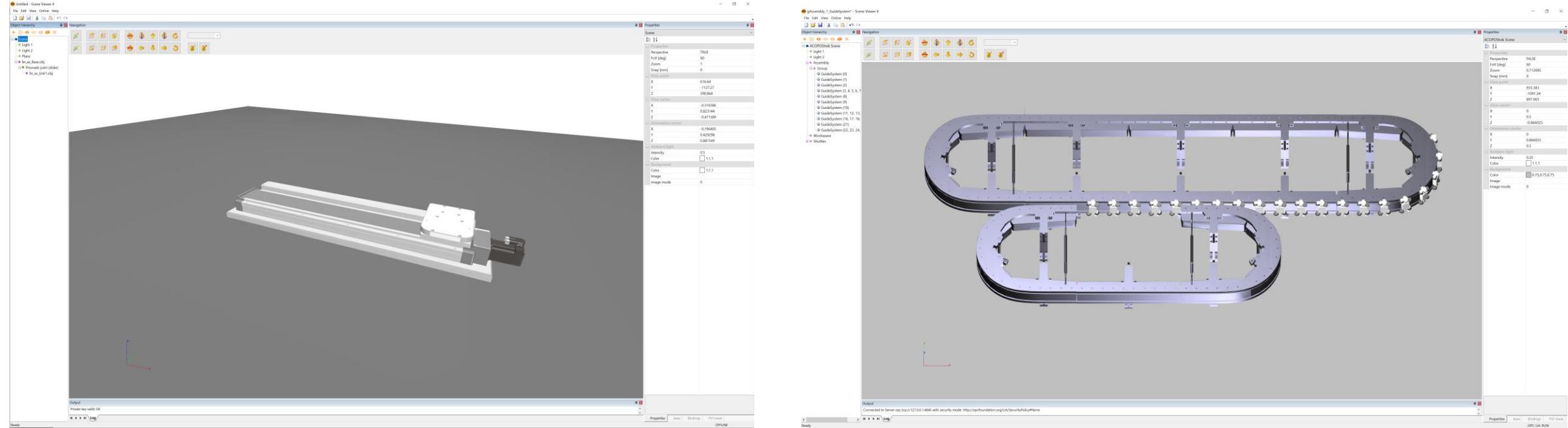
(i) Controller1 (Station): 10125 - Program stopped
(i) Controller1 (Station): 10002 - Program pointer has been reset

Time Category

27/01/2021 14:17:51 Event Log
27/01/2021 14:17:53 Event Log

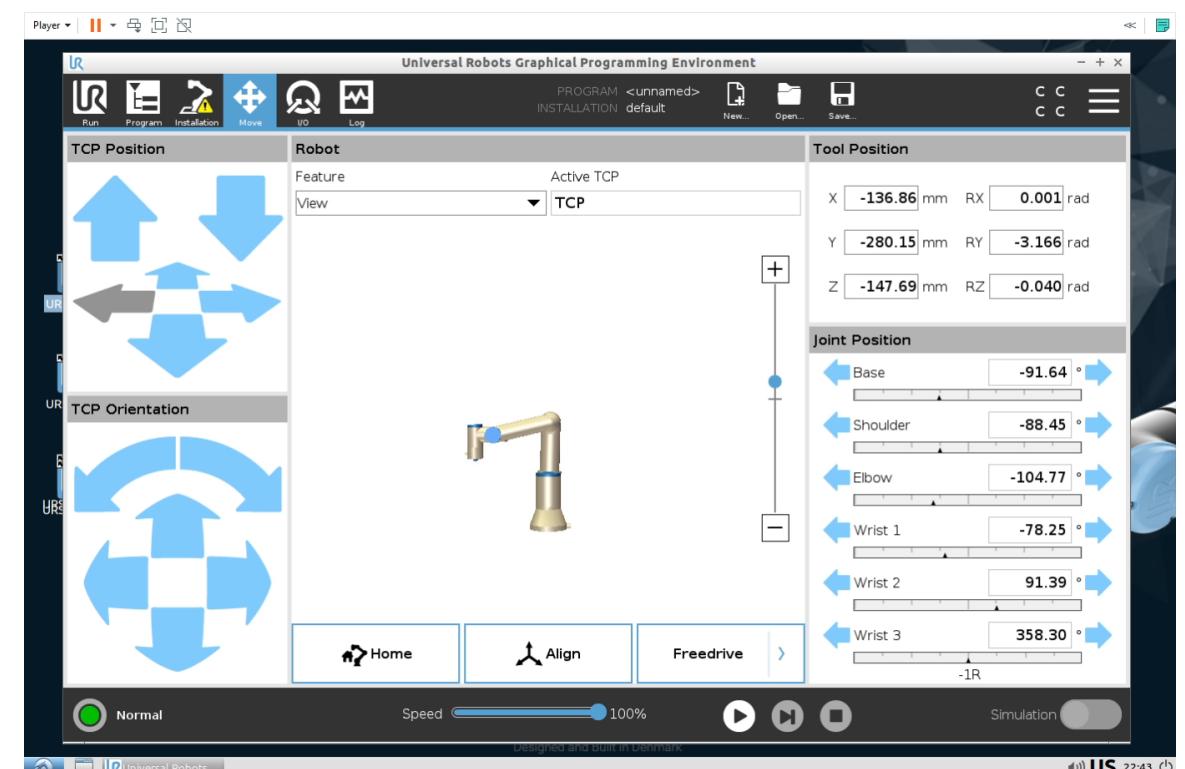
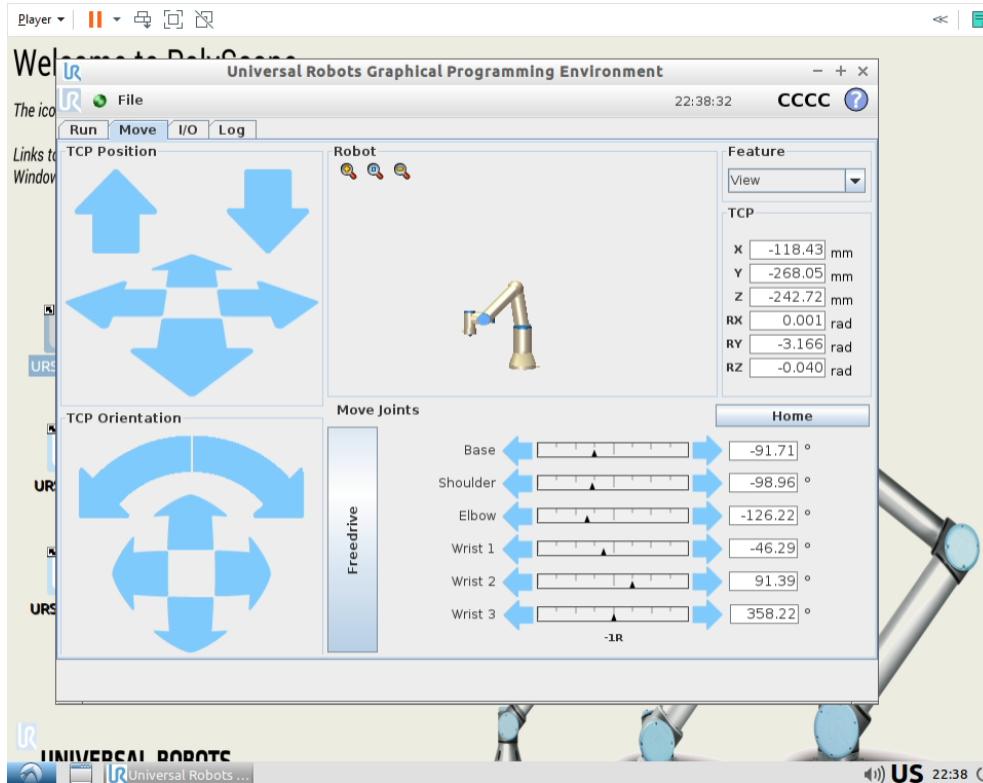
Selection Level Snap Mode UCS: Station 2.18 -170.27 1496.79 MoveL * v1000 z100 smc_gripper \WObj:=wobj0 Controller status: 1/1

Virtual / Digital Twin



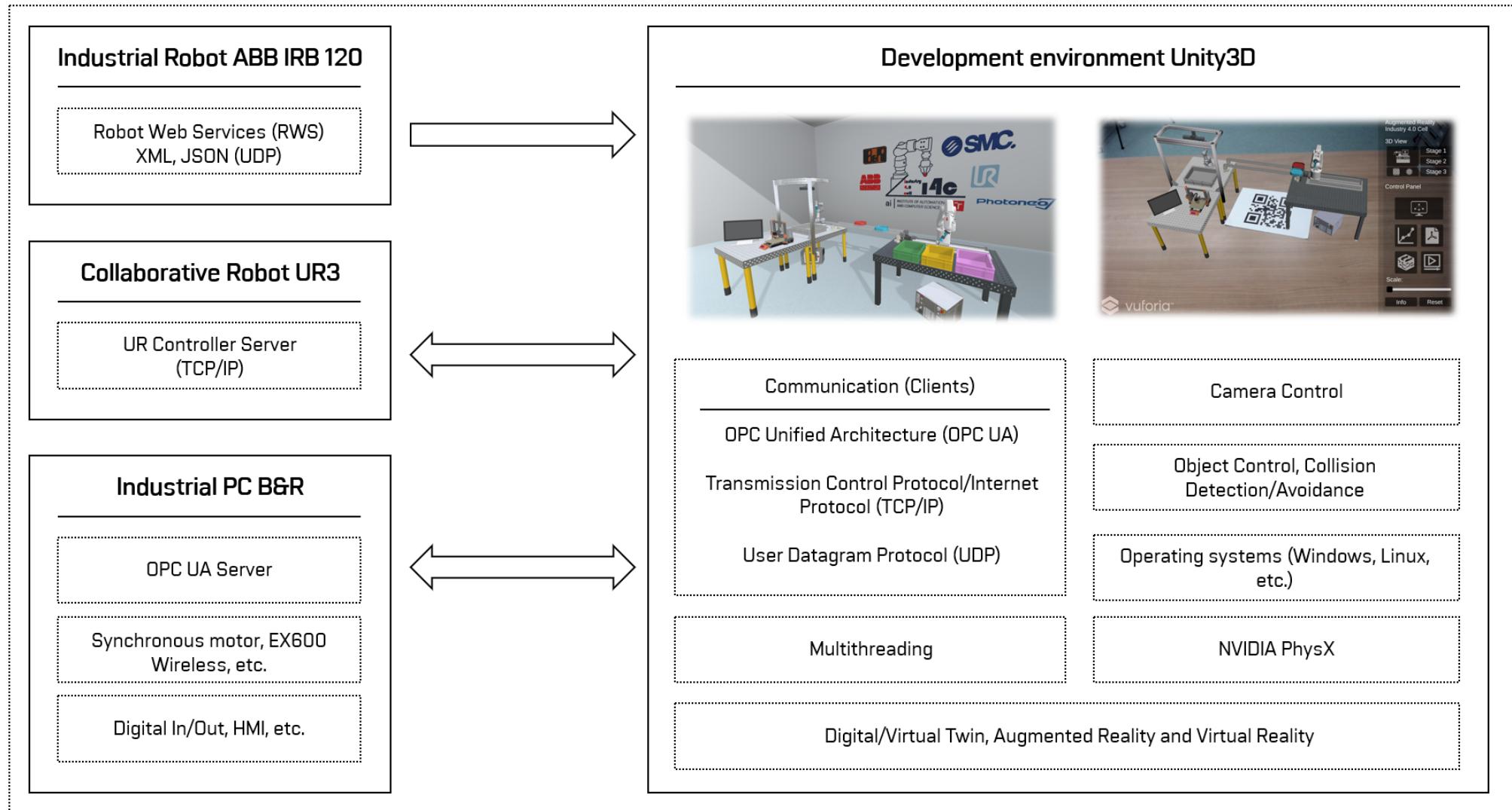
B&R Automation - SceneViewer

Virtual / Digital Twin



UR – Polyscope

Virtual / Digital Twin



Virtual / Digital Twin

OPC UA™

unity

blender®



Virtual / Digital Twin

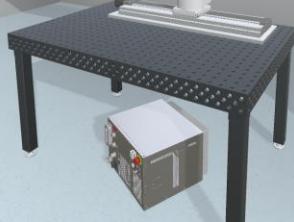


ABB
Robotics
Industria 4.0 cell
i4c
INSTITUTE OF AUTOMATION
AND COMPUTER SCIENCE | T

SMC.
UR
Photoneo
focused on 3D

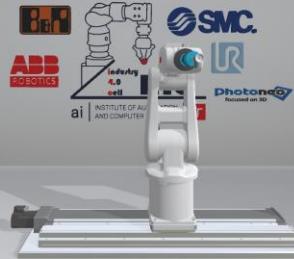


ABB
Robotics
Industria 4.0 cell
i4c
INSTITUTE OF AUTOMATION
AND COMPUTER SCIENCE | T

SMC.
UR
Photoneo
focused on 3D



Virtual / Digital Twin



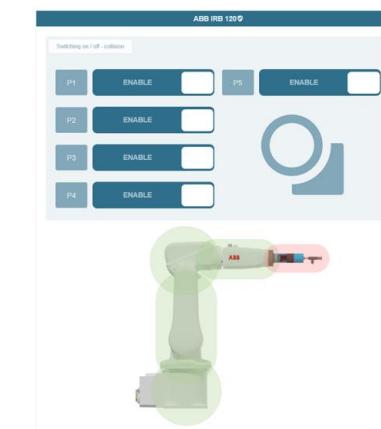
Object

Visibility	Material
Visible - ON	Green
Position [mm]	Scale [mm]
X: 350.00	X: 75.00
Y: 300.00	Y: 150.00
Z: 150.00	

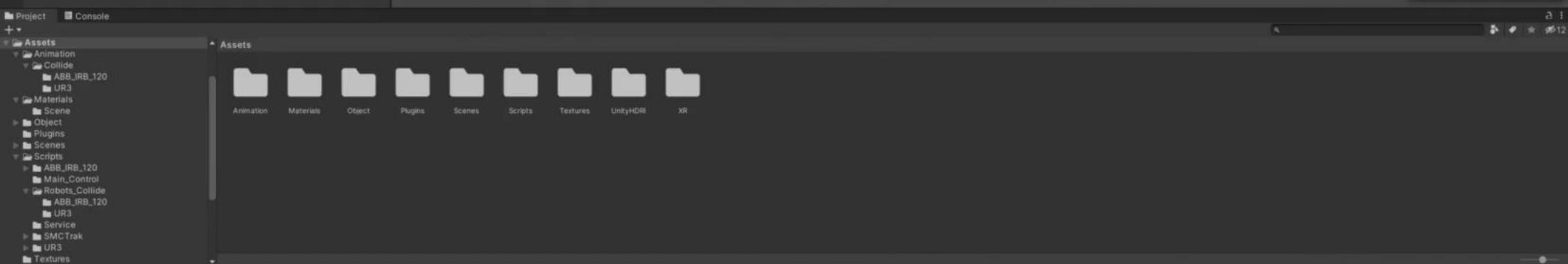
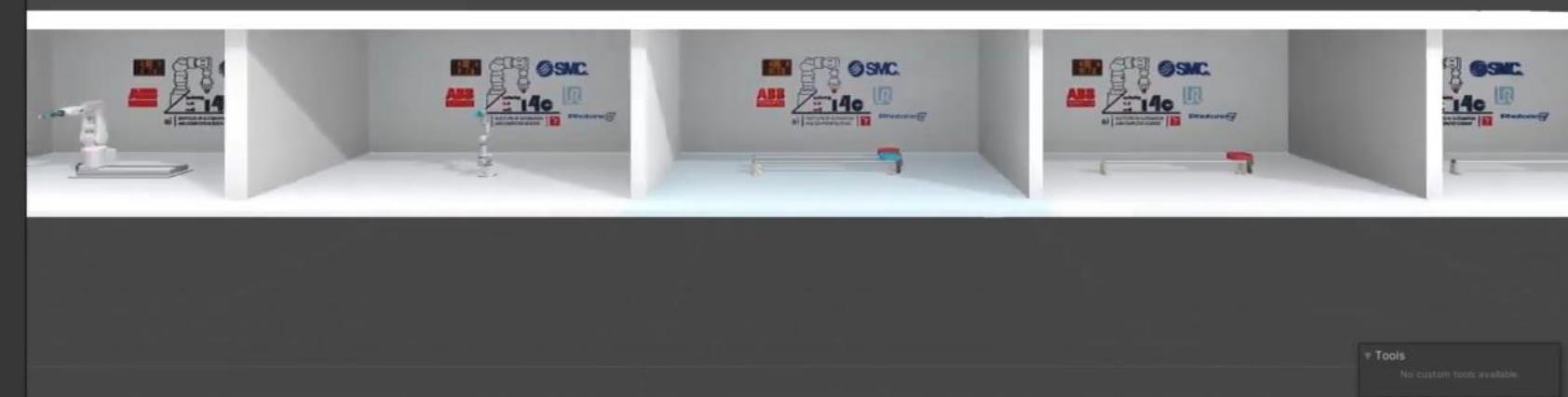
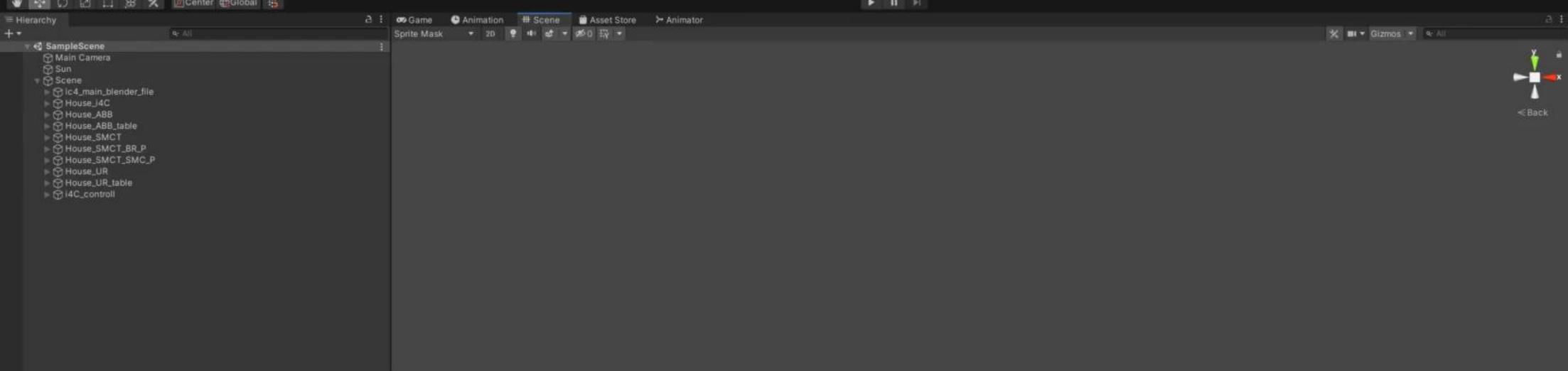
Set Parameters **Reset Parameters** **Default Parameters**

Object Control

Virtual / Digital Twin

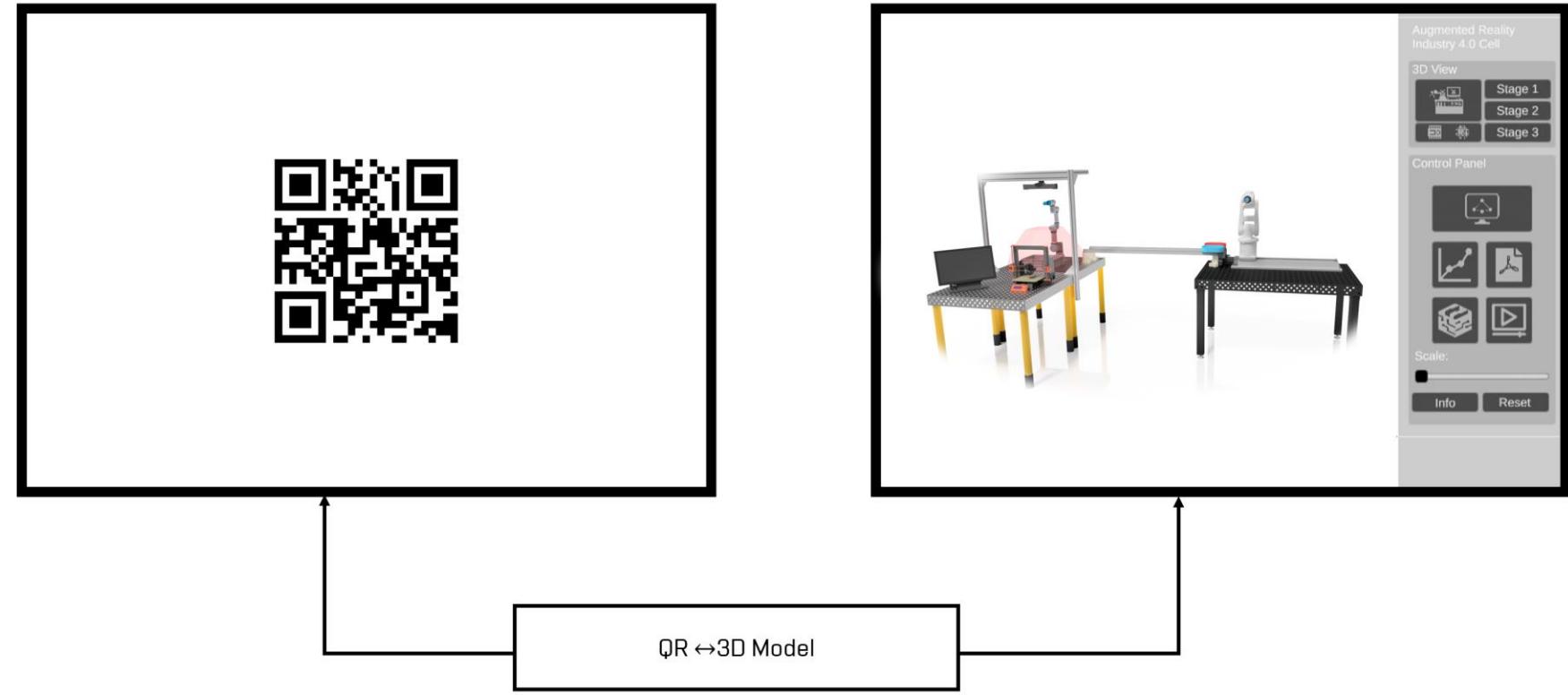


Collision avoidance



Augmented Reality

Augmented Reality



Augmented Reality



Advanced AR – Diagnostics (Industry 4.0 Cell)

Augmented Reality



Advanced AR – Diagnostics (Industry 4.0 Cell)

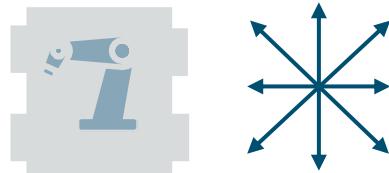
Vision of the future

Vision of the future



Autonomous Driving Industrial Robot

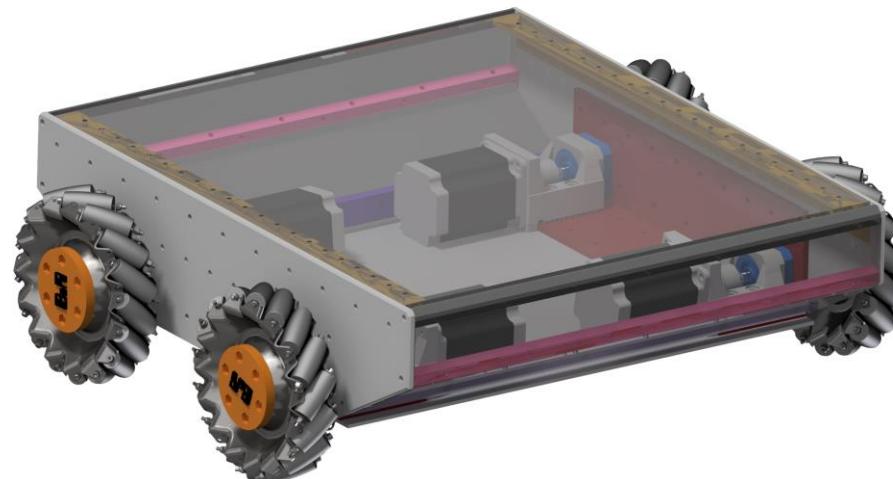
Autonomous Driving
Industrial Robot

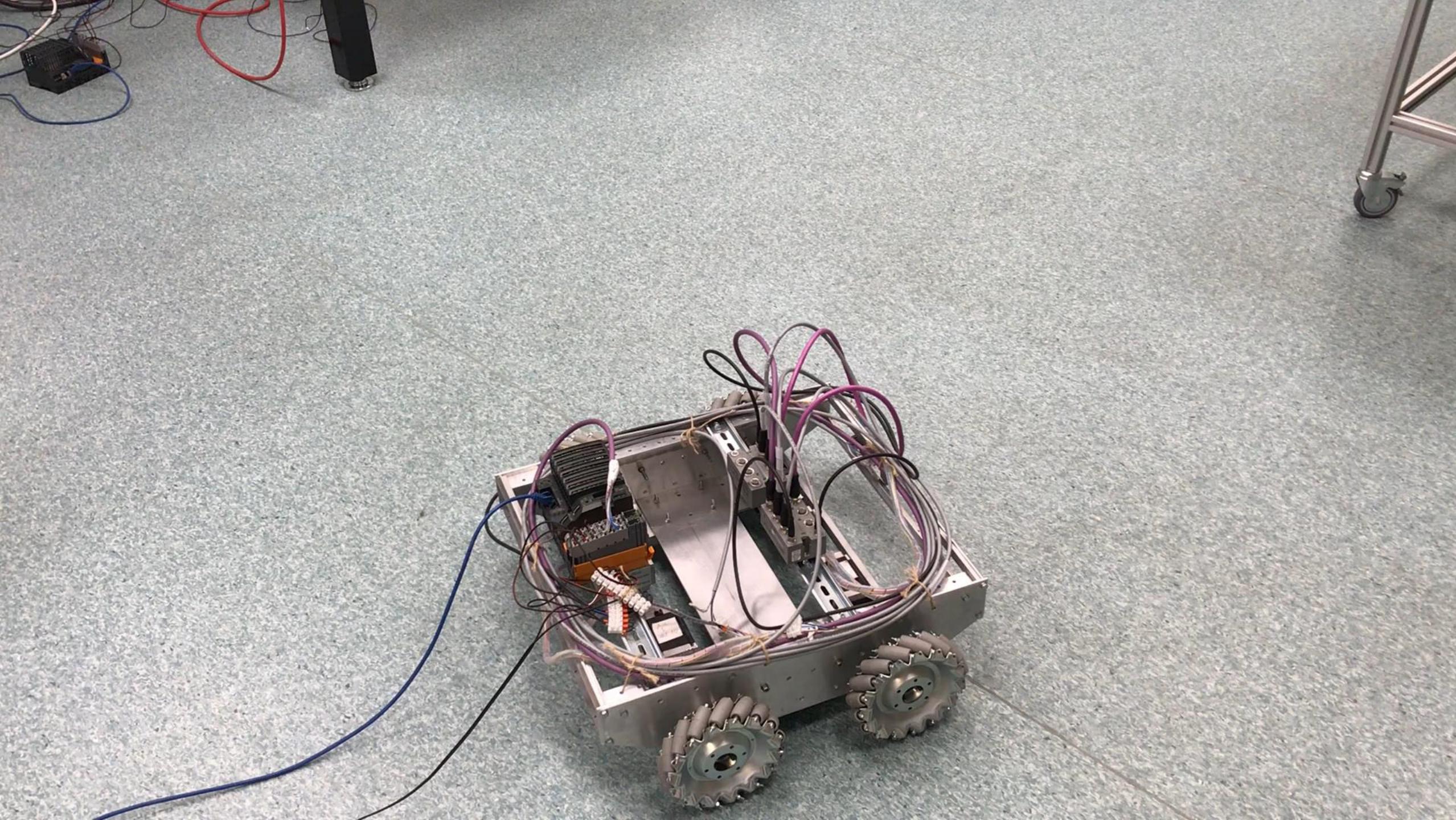


OPC UA™

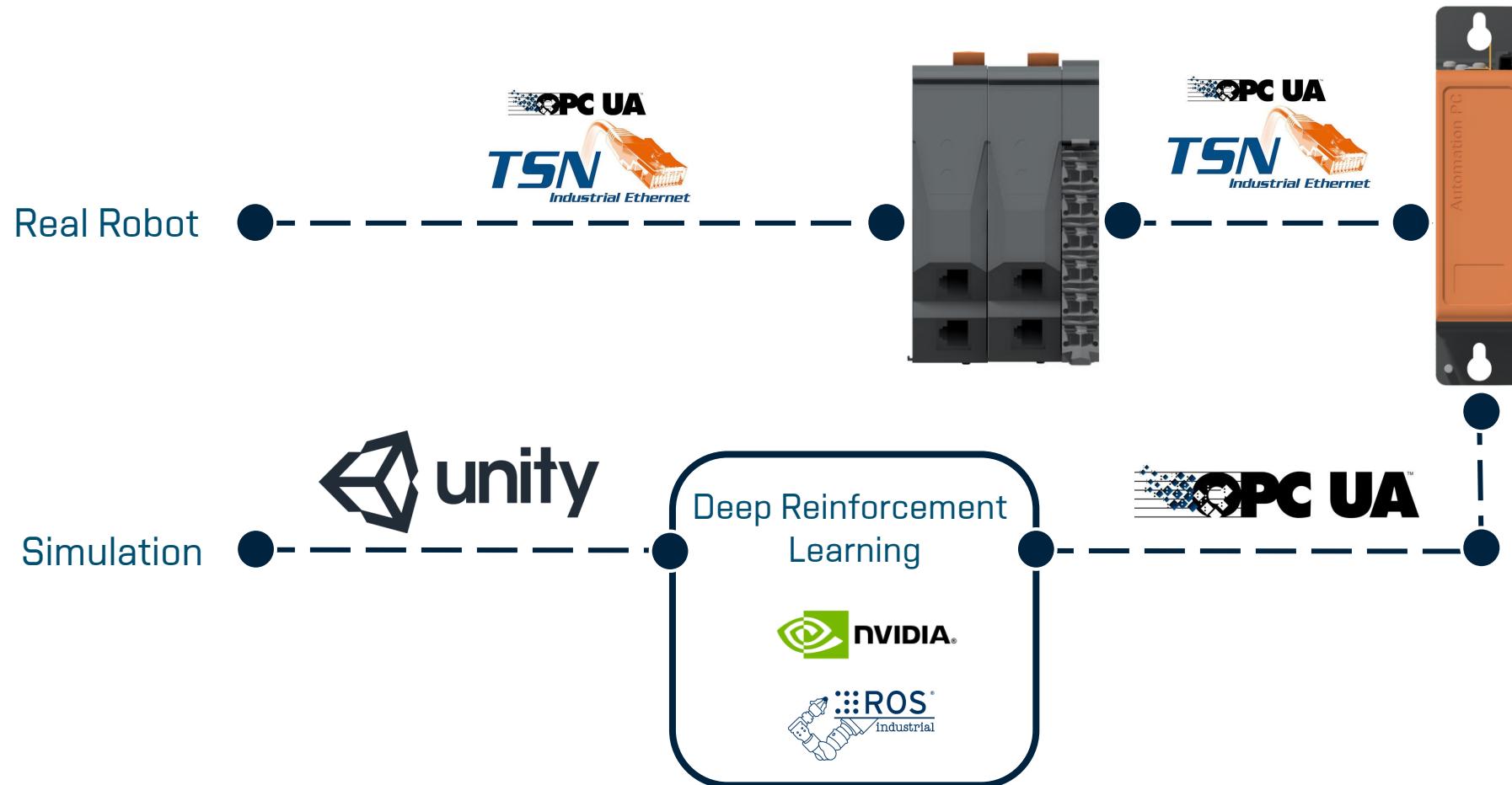
TSN
Industrial Ethernet

ETHERNET
POWERLINK

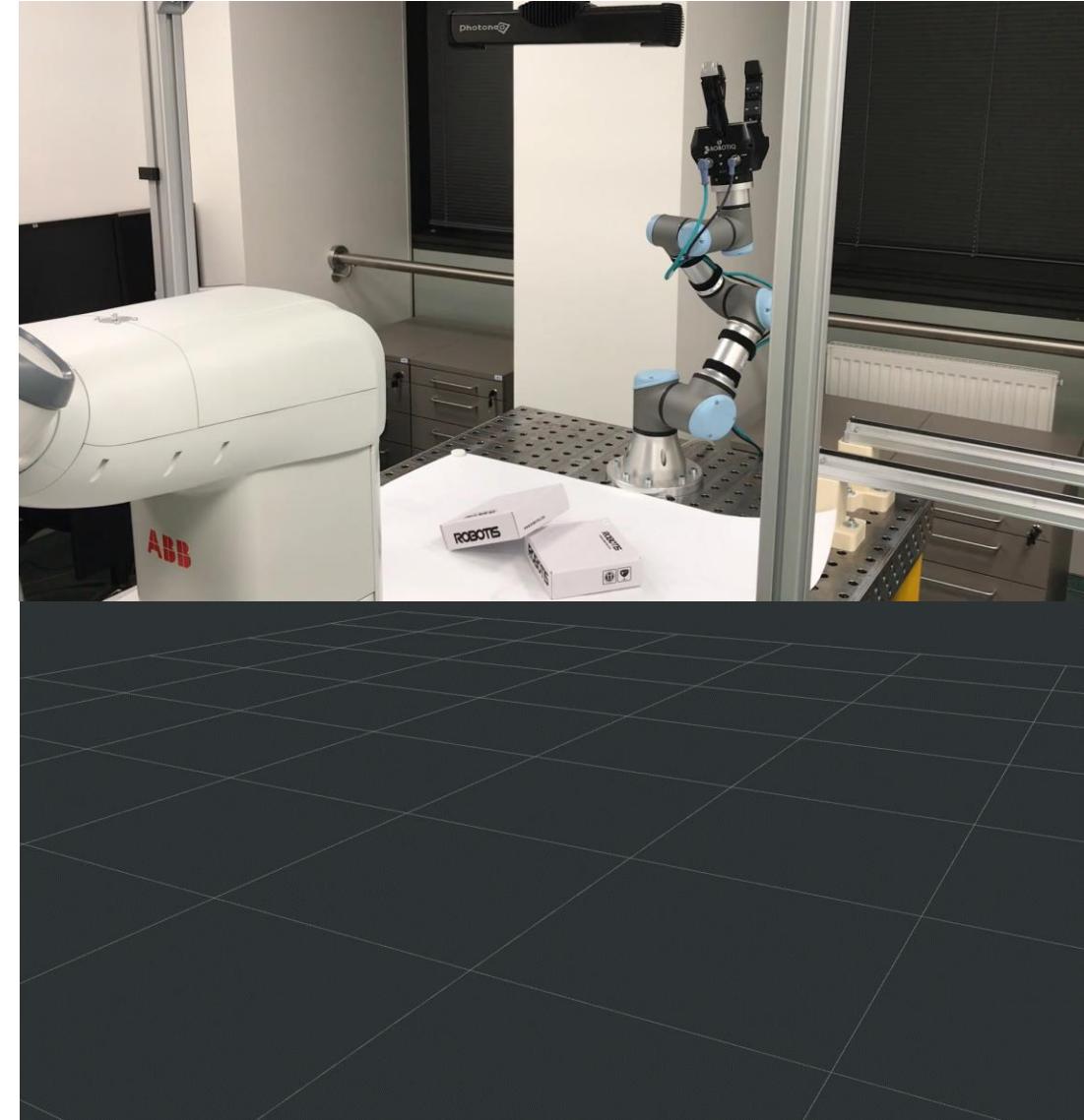
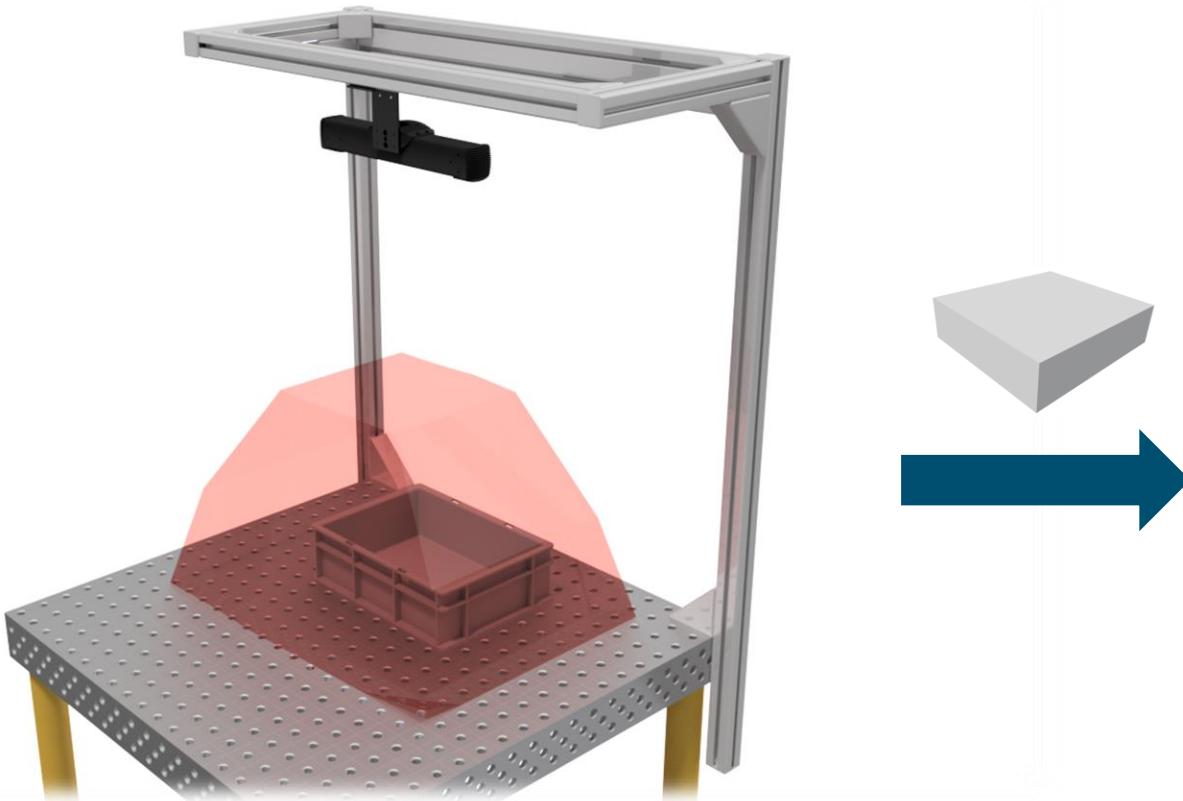




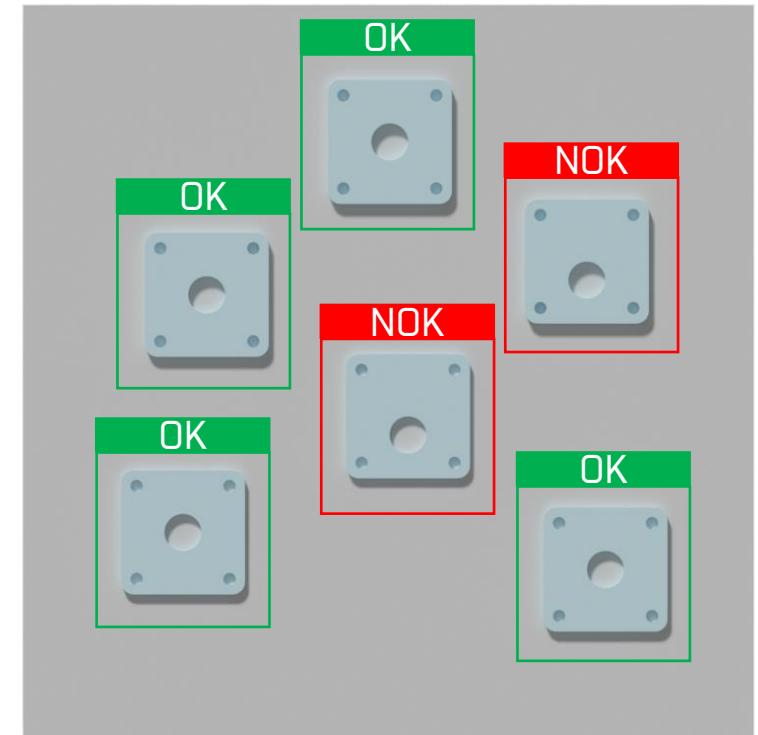
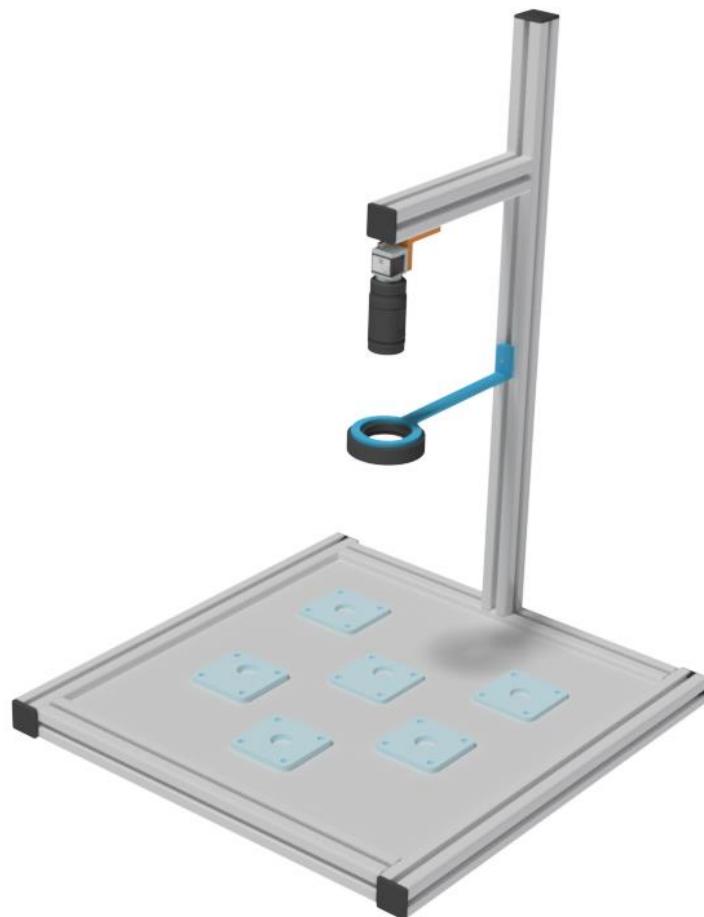
Trajectory optimization



3D object recognition (Bin-Picking)



Visual inspection



Projects

Projects

University Projects:

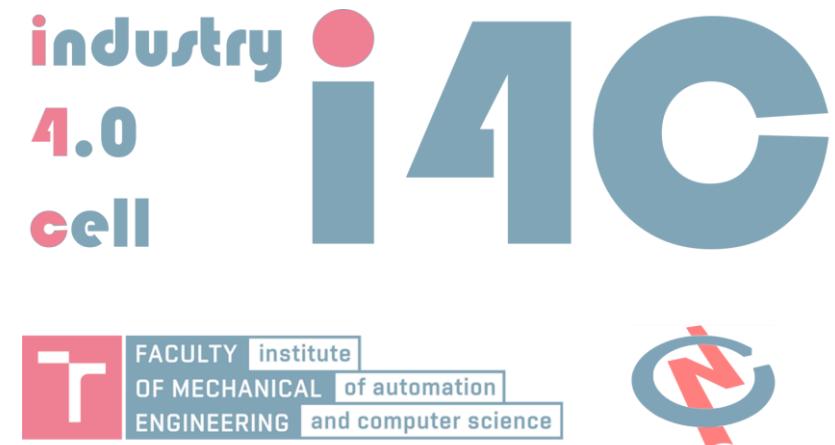
- Technology Agency of the Czech Republic (TACR), The Czech Science Foundation (GACR)
- Innovation Voucher
- Ministry of Industry and Trade
- etc.

Industry Projects:

- ABB Group
- SMC Industrial Automation
- etc.

Other Projects:

- Collaborative Robot YuMi (IRB 14050) analyzes test samples
- UV-C emitter for hospital
- etc.



Industry Projects



ABB Group

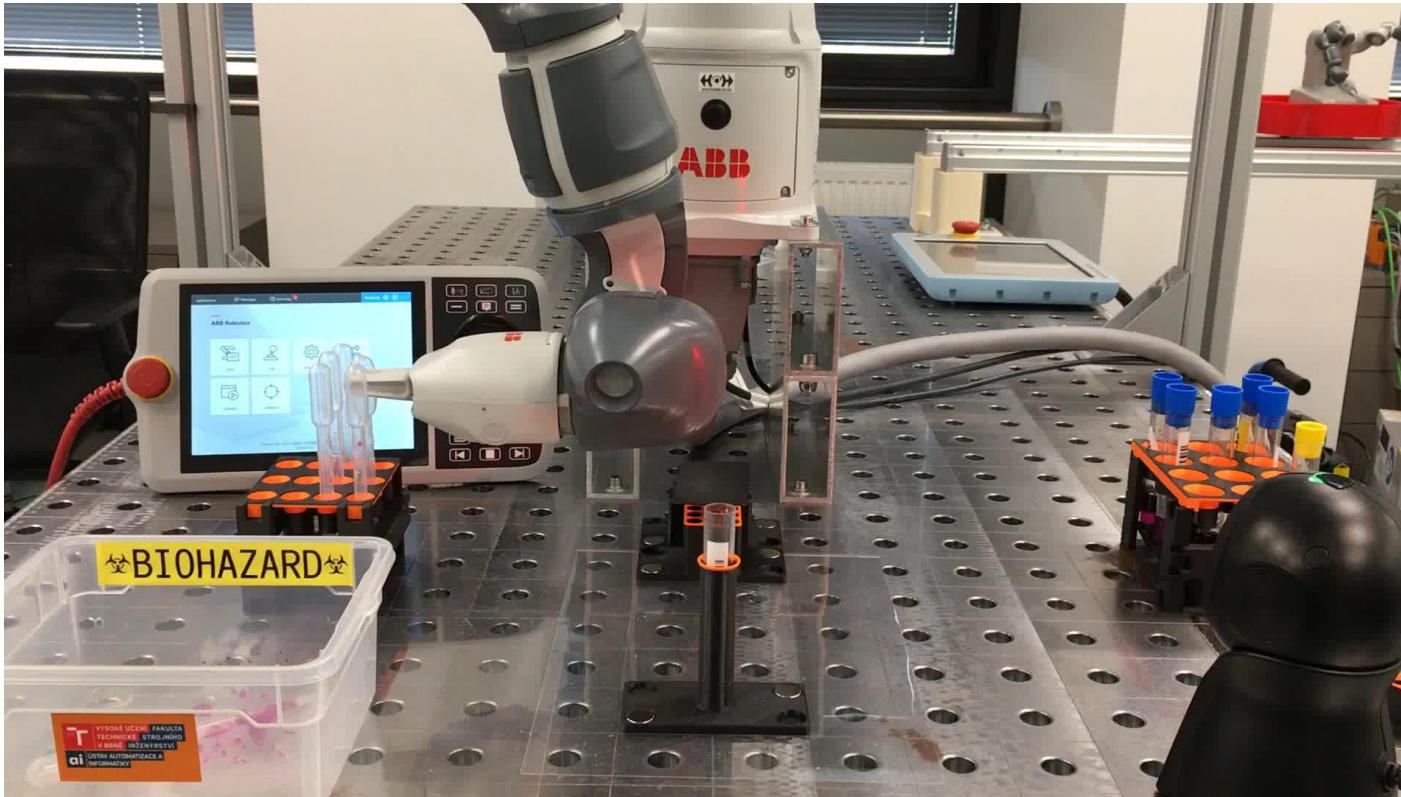
Product Overview

SMC Industrial Automation

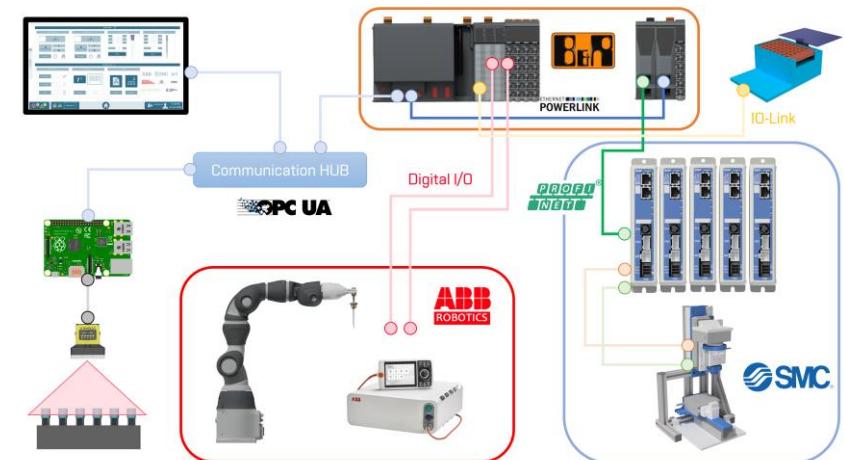
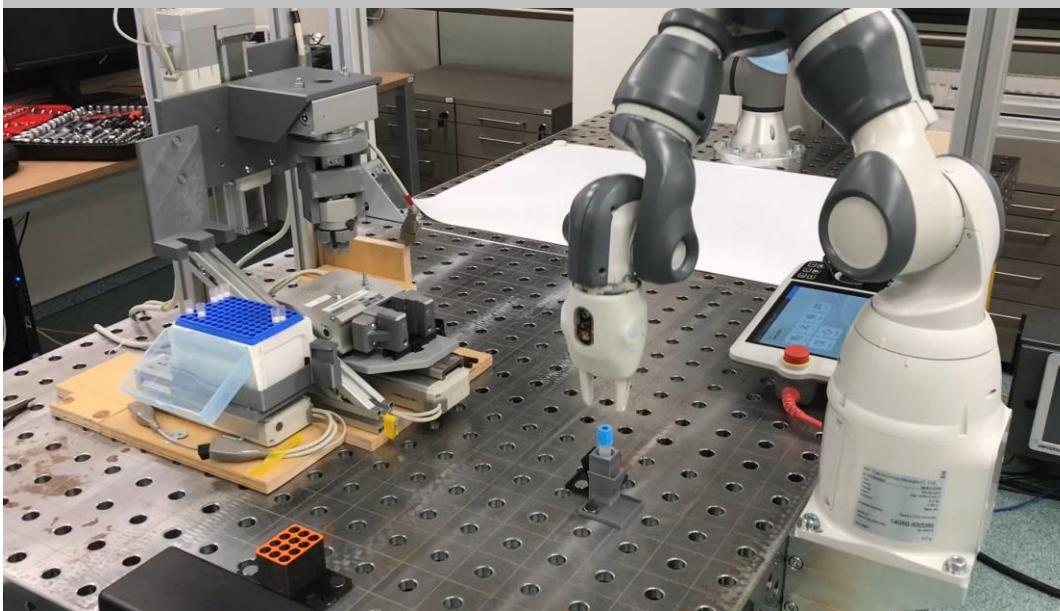
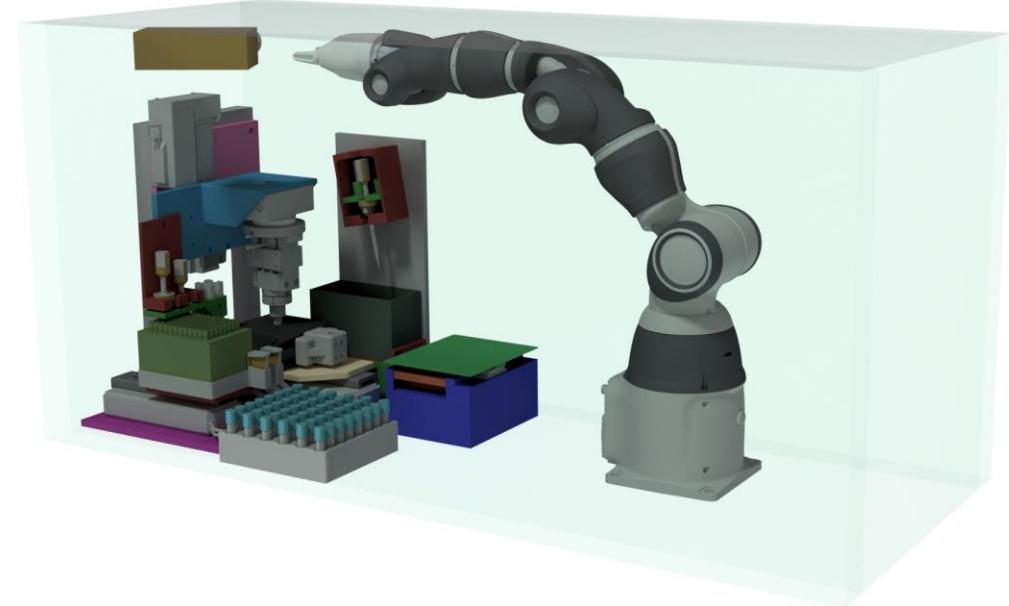
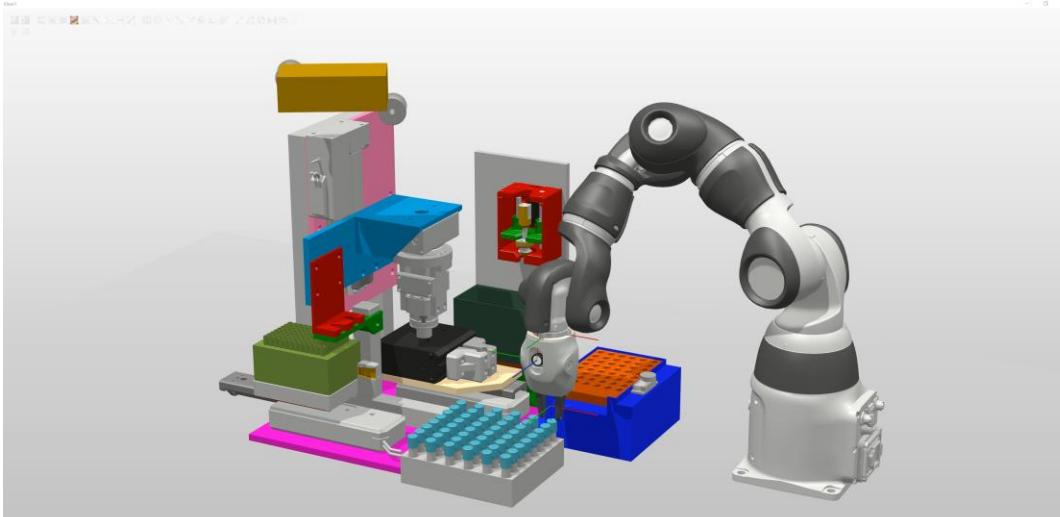
Projects

Other Projects:

- Collaborative Robot YuMi (IRB 14050) analyzes test samples (The University Hospital Brno)



Projects



Industry 4.0 cell

Contact



MSc. Roman Parak

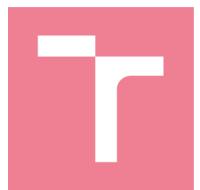
Research & Development
Cybernetics and Robotics Division

Contact:

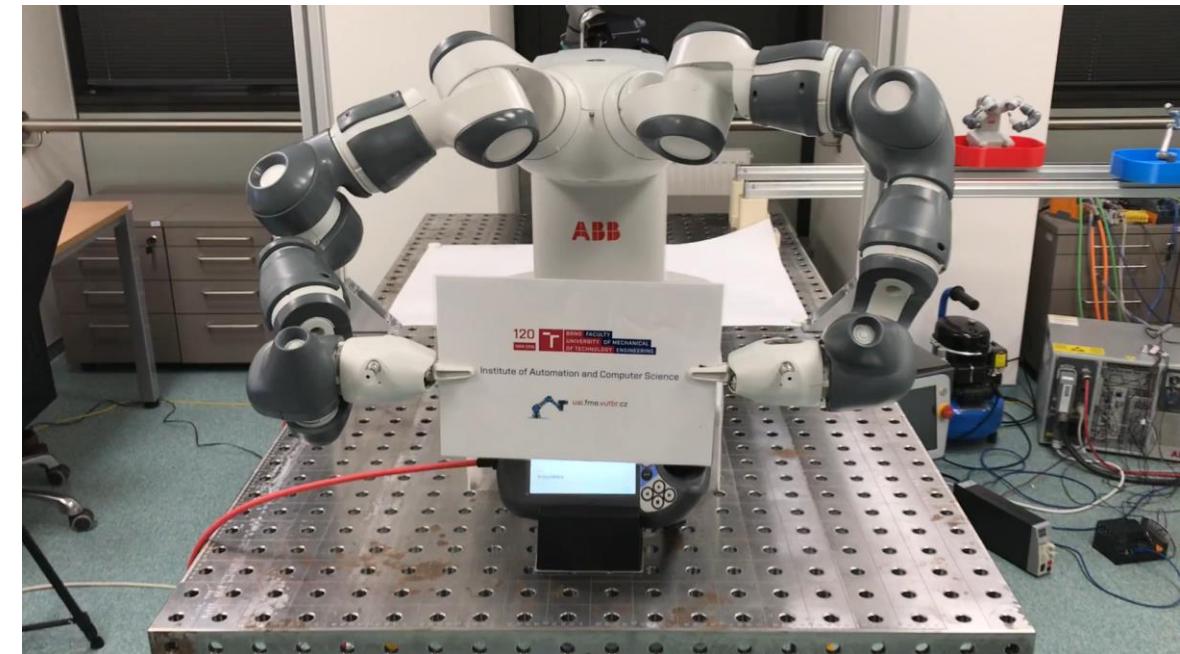
E-mail: Roman.Parak@vutbr.cz

Room:

A1/0642 (Technická 2896/2, Brno 616 69)

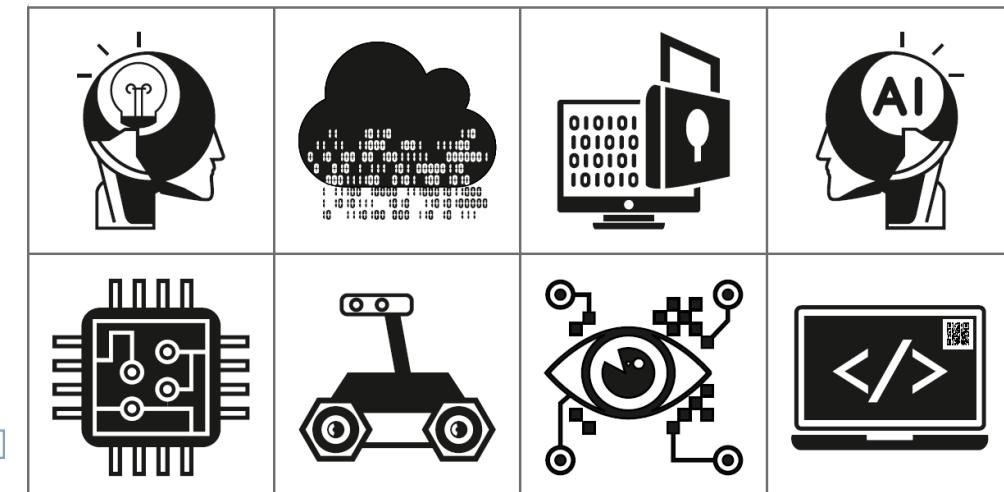
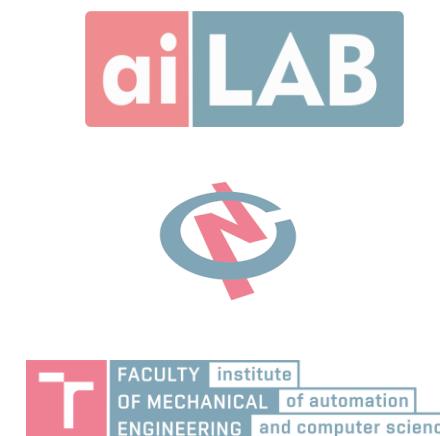
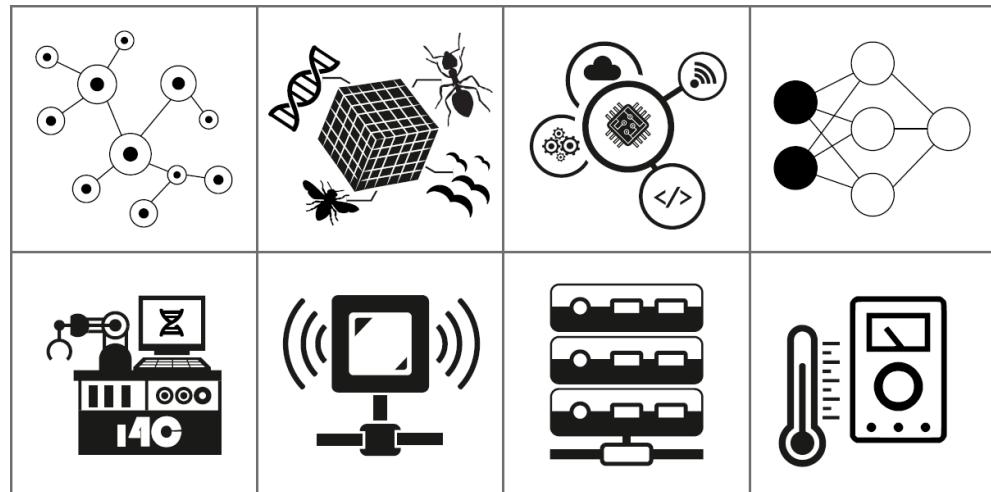


FACULTY institute
OF MECHANICAL of automation
ENGINEERING and computer science





Roman Parak

Institute of
Automation and
Computer
Science

Partners

Our partners and references

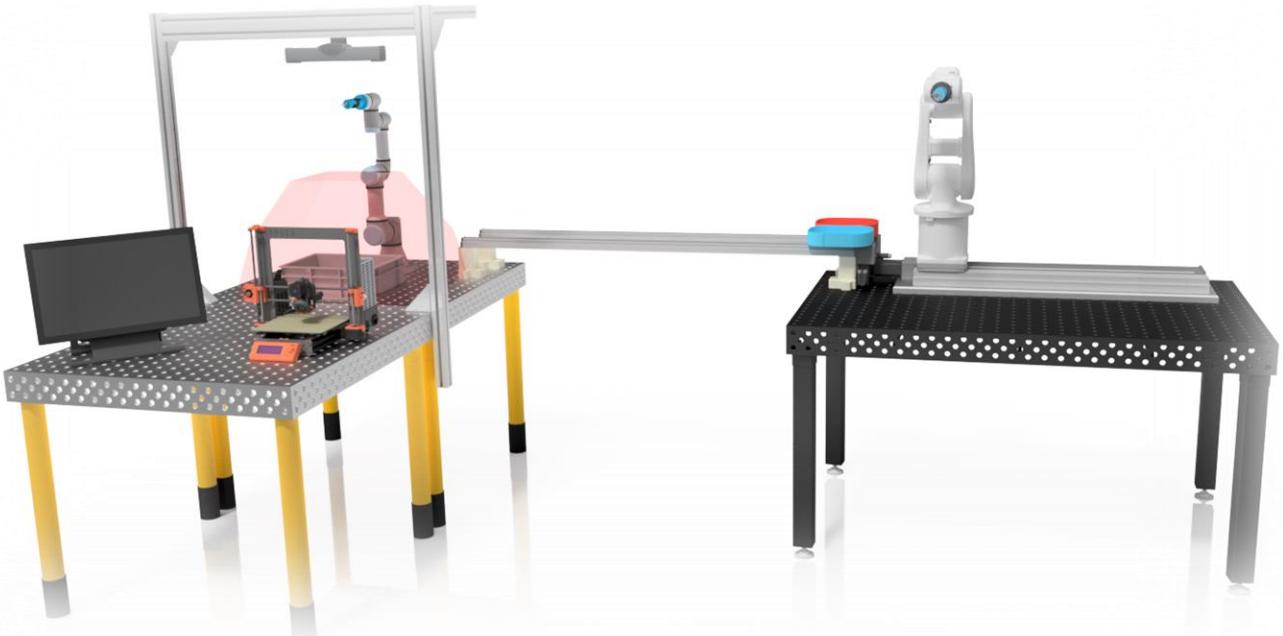


Amtech

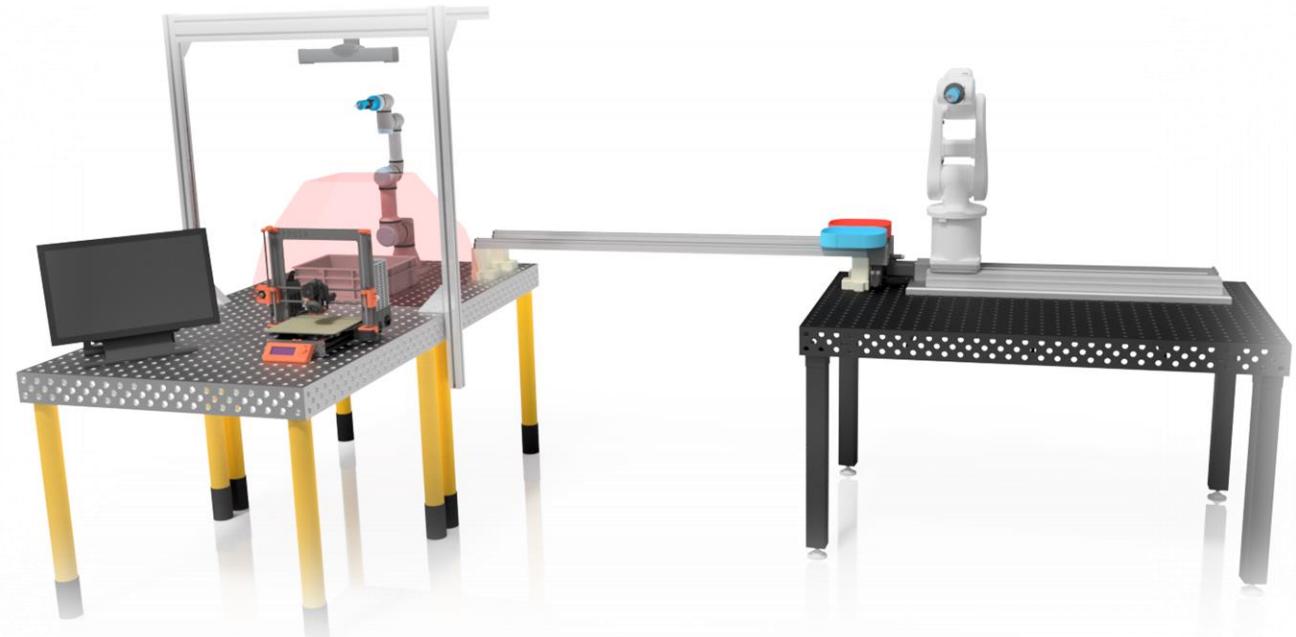


BRNO REGIONAL
CHAMBER
OF COMMERCE

Thank You!



Questions?





Industry 4.0 Cell (i4C)

MSc. Roman Parak

Research & Development – Advanced robotics

