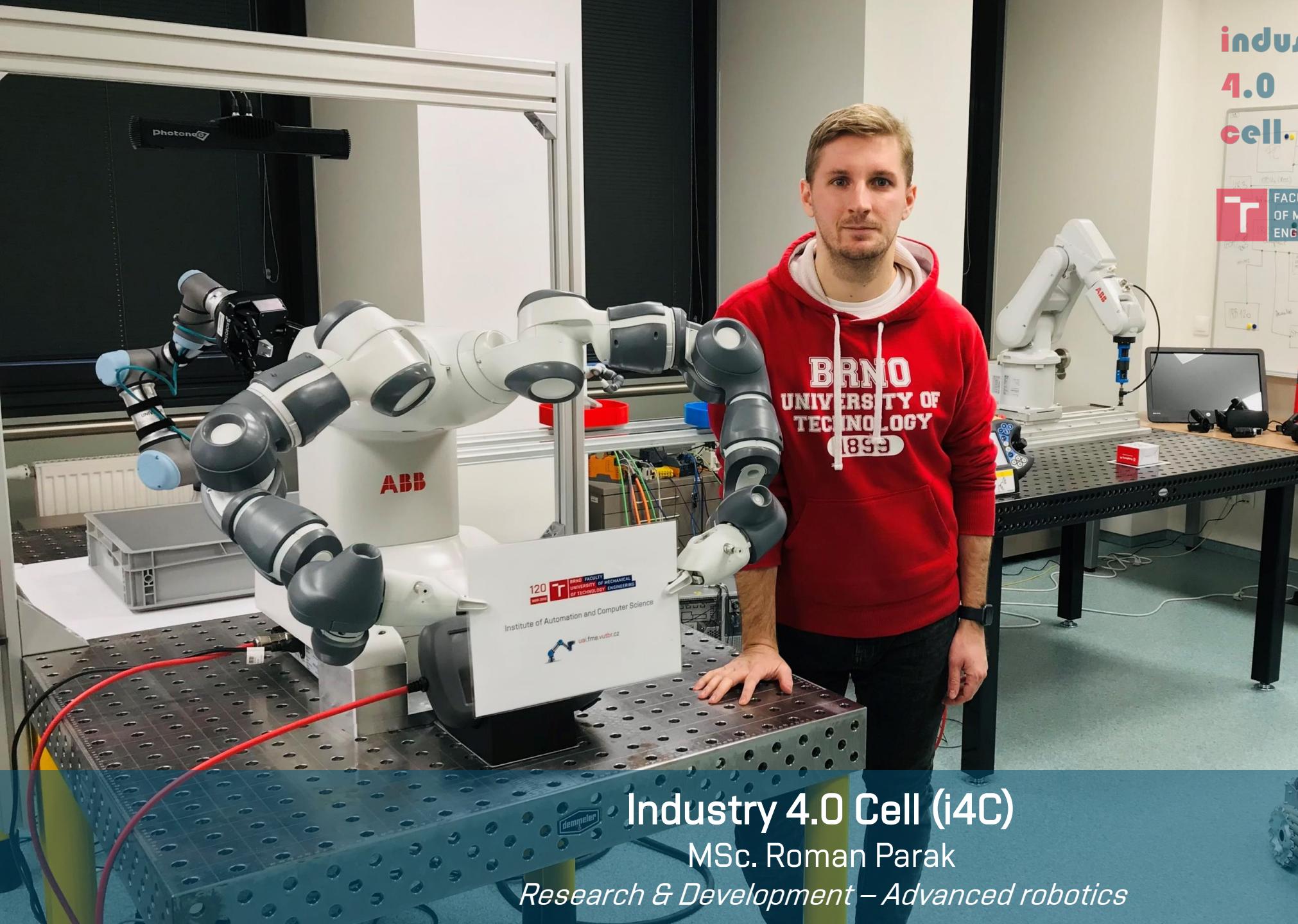




Industry 4.0 Cell (i4C)

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

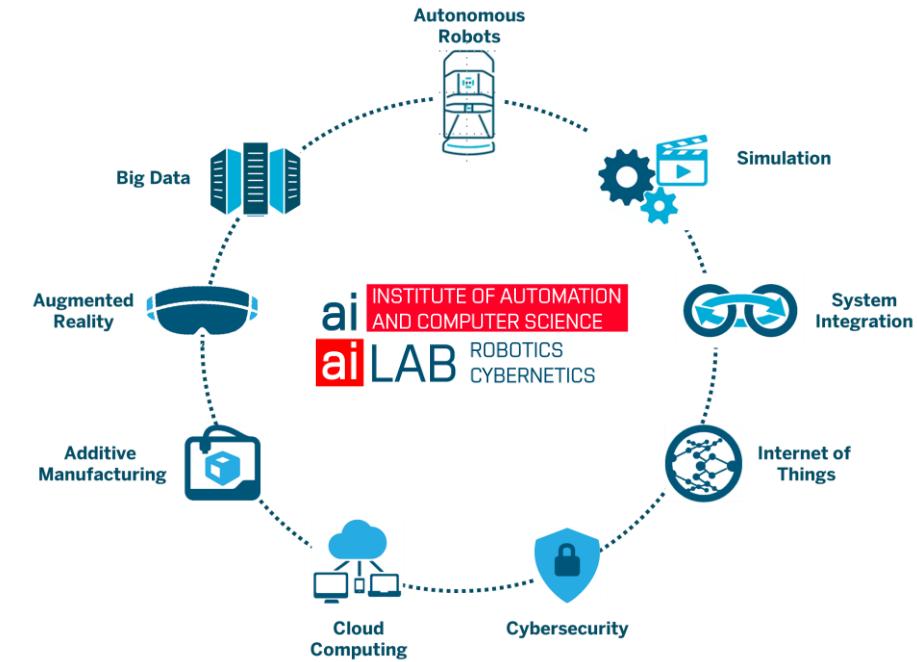


Institute of Automation and Computer Science

Faculty of Mechanical Engineering, Brno University of Technology

Organizational Structure:

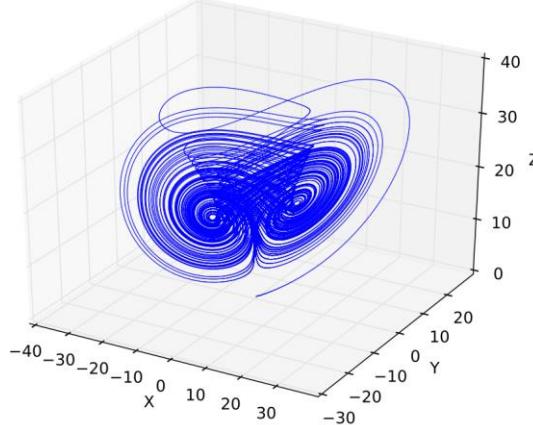
- Dept. of Automation
- Dept. of Applied Computer Science
- Dept. of Computer Networks
- NETME Centre – Cybernetics and Robotics Division



<https://medium.com/@shalinisreekanth/industry-4-0-the-top-9-technology-trends-28c1b3cf1a9a>

NETME Centre – Cybernetics and Robotics Division

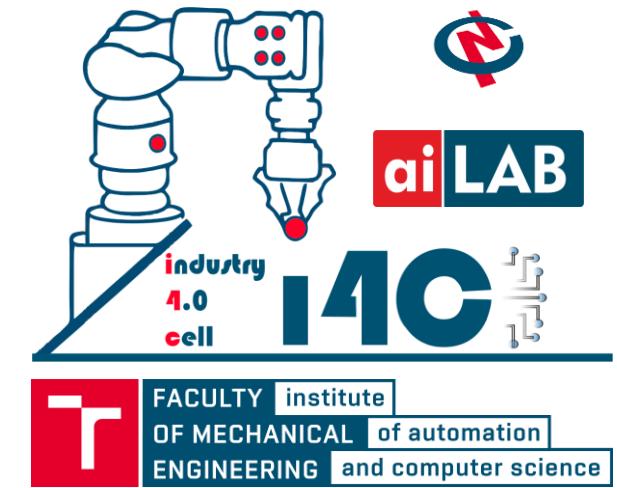
Faculty of Mechanical Engineering, Brno University of Technology
Institute of Automation and Computer Science



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

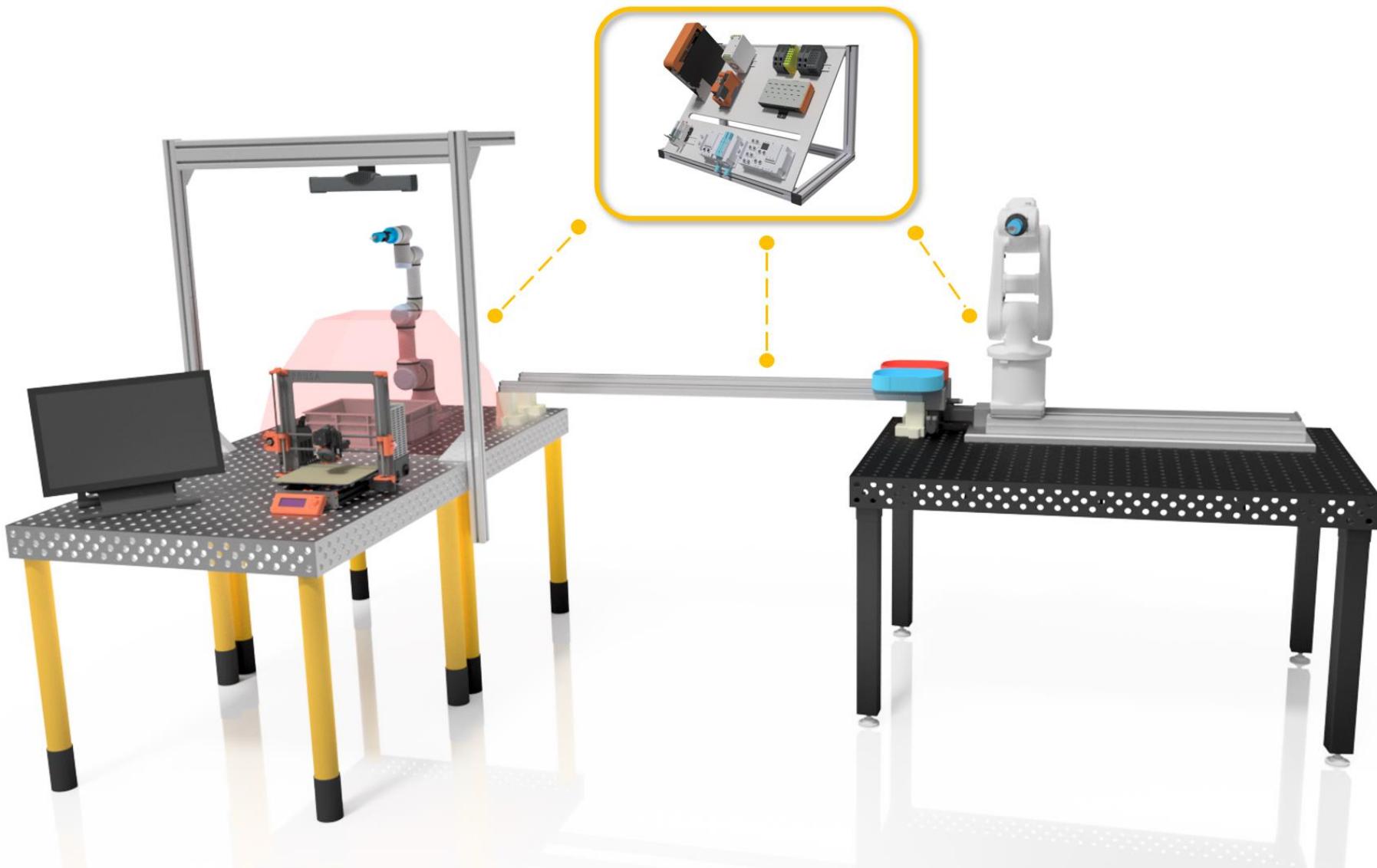
Assoc. Prof. Branislav Lacko, PhD.

Industry 4.0 Consultant

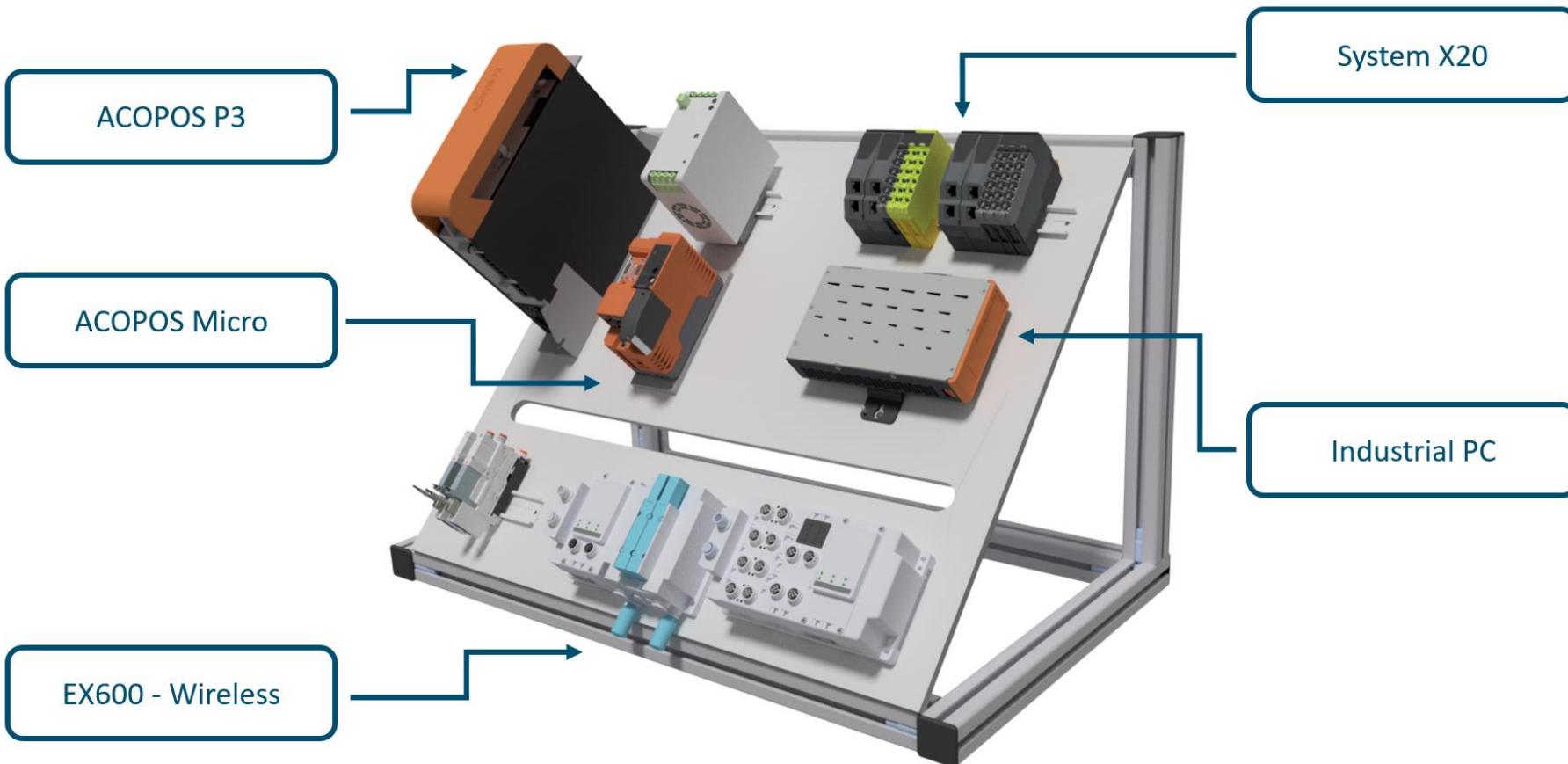
Contact: lacko@fme.vutbr.cz



Industry 4.0 Cell



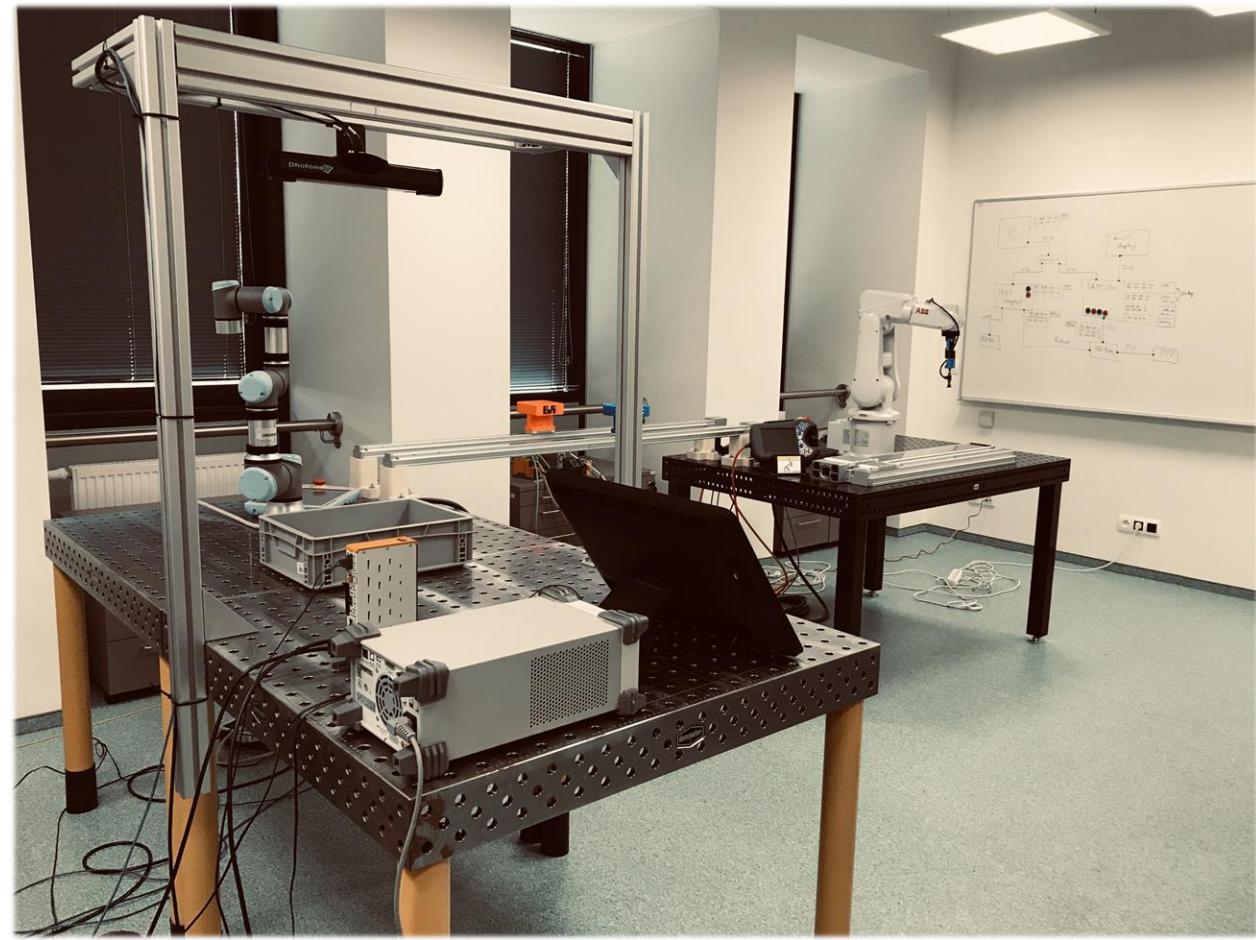
Electric switchboard



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 aspect of industrial control:

- 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), Control (HOME POSITION/MOVE), and Start/Stop are also present.
- Top Right (SMC PAD {MOVE}):** Shows a graphical representation of a cylinder's movement. A slider indicates a position of 5,810.00. Below it are buttons for Position (5,810.00 [Units]) and Velocity (8,000.00 [Units]). To the right are two graphs showing cylinder position and velocity over time. Below the graphs are parameters for Actual Position (5,810.00 [Units]), Actual Velocity (0.00 [Units/s]), Actual Position (5,810.00 [Units]), and Actual Velocity (0.00 [Units/s]).
- Bottom Left (Safety i4C):** Shows the Industry 4.0 Cell - Safety interface. It includes a "RESET" button, "Virtual Safety E-Stop" and "Safety E-Stop" buttons, and a "Safety" status indicator. It also shows UR3 - Safety State, SMCTrak - Safety, ABB - Safety State, and 7B Ax. - Safety State. A large "open SAFETY" logo is centered.
- Bottom Right (UR3 {MOVE}):** Shows controls for the UR3 robot. It includes Joint Control (Joint 1-6), Cartesian Control (TCP, ROLL, PITCH, YAW), and Joystick Control (X, Y, Z, ROLL, PITCH, YAW). It also shows a ZPR Vacuum Gripper component and its parameters (TCP X, Y, Z, QW, QX, QY, QZ). A graph on the right shows gripper position over time. Below the controls are parameters for Joint 1-6.

Each screenshot includes a header with the date (03. 11. 2020) and time (e.g., 08:50:05, 08:40:39, 08:41:24, 08:41:58), and a footer with standard icons for navigation and production status.

System Integration

System Integration



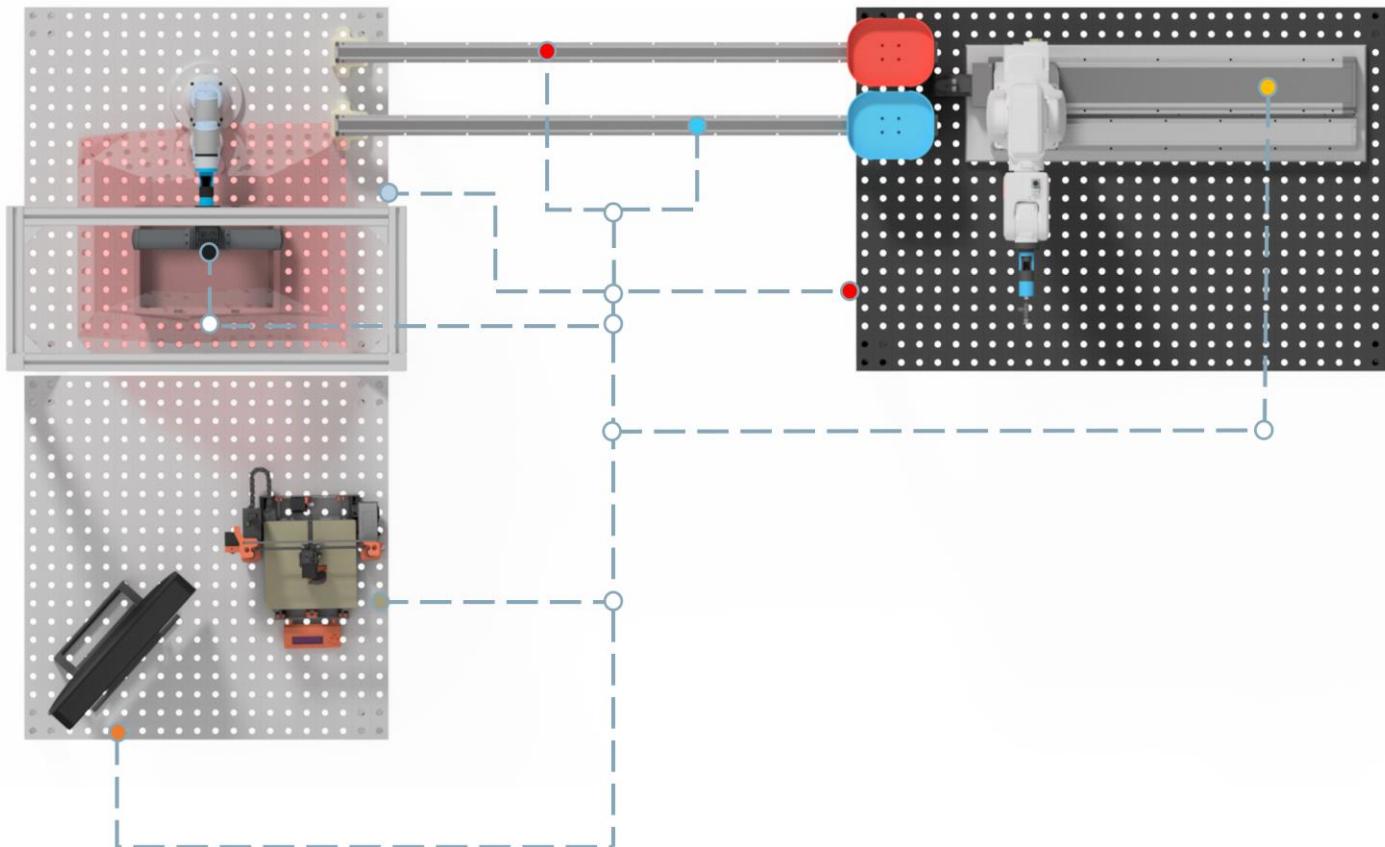
EtherNet/IP®



ETHERNET
POWERLINK

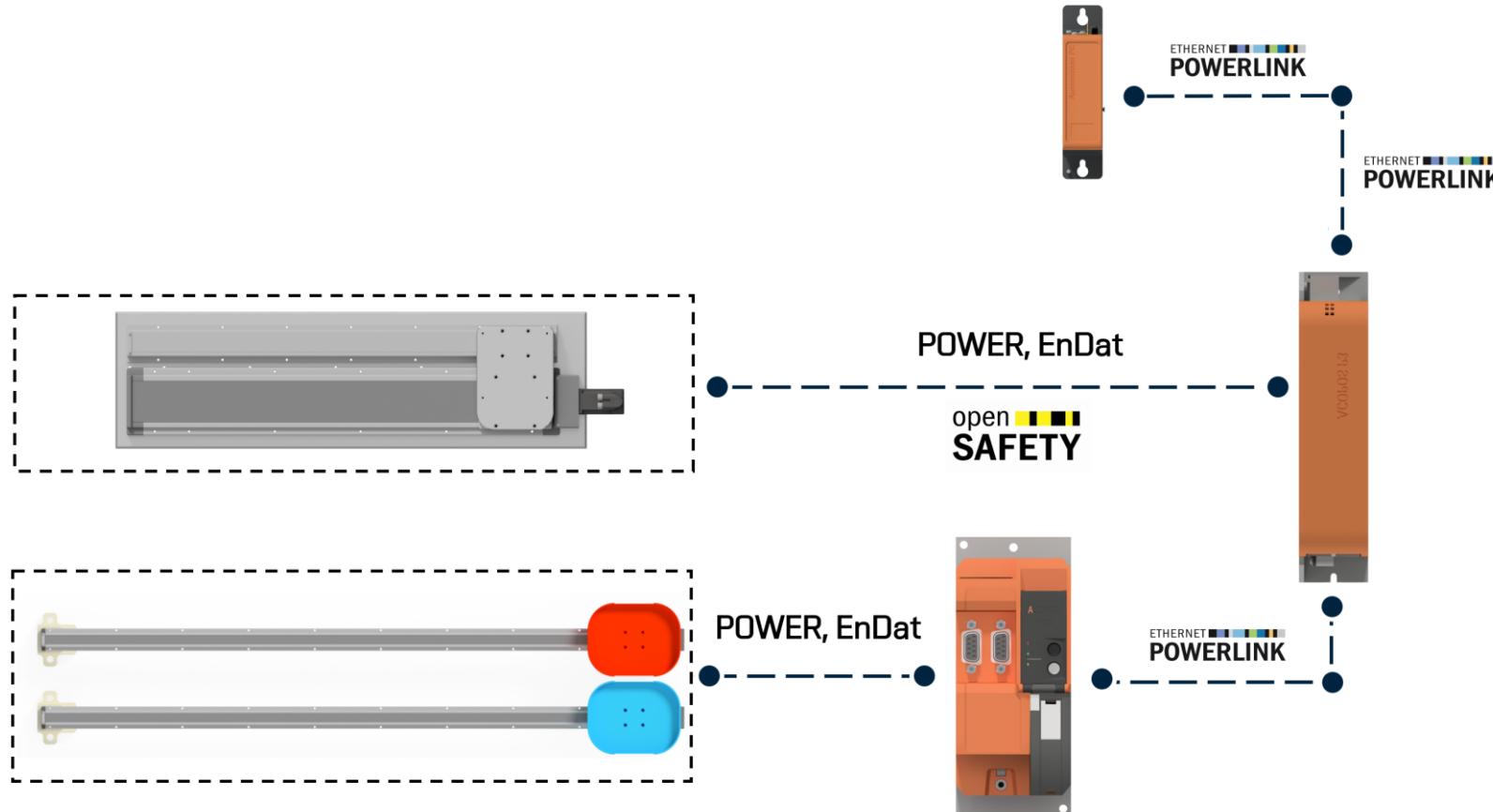


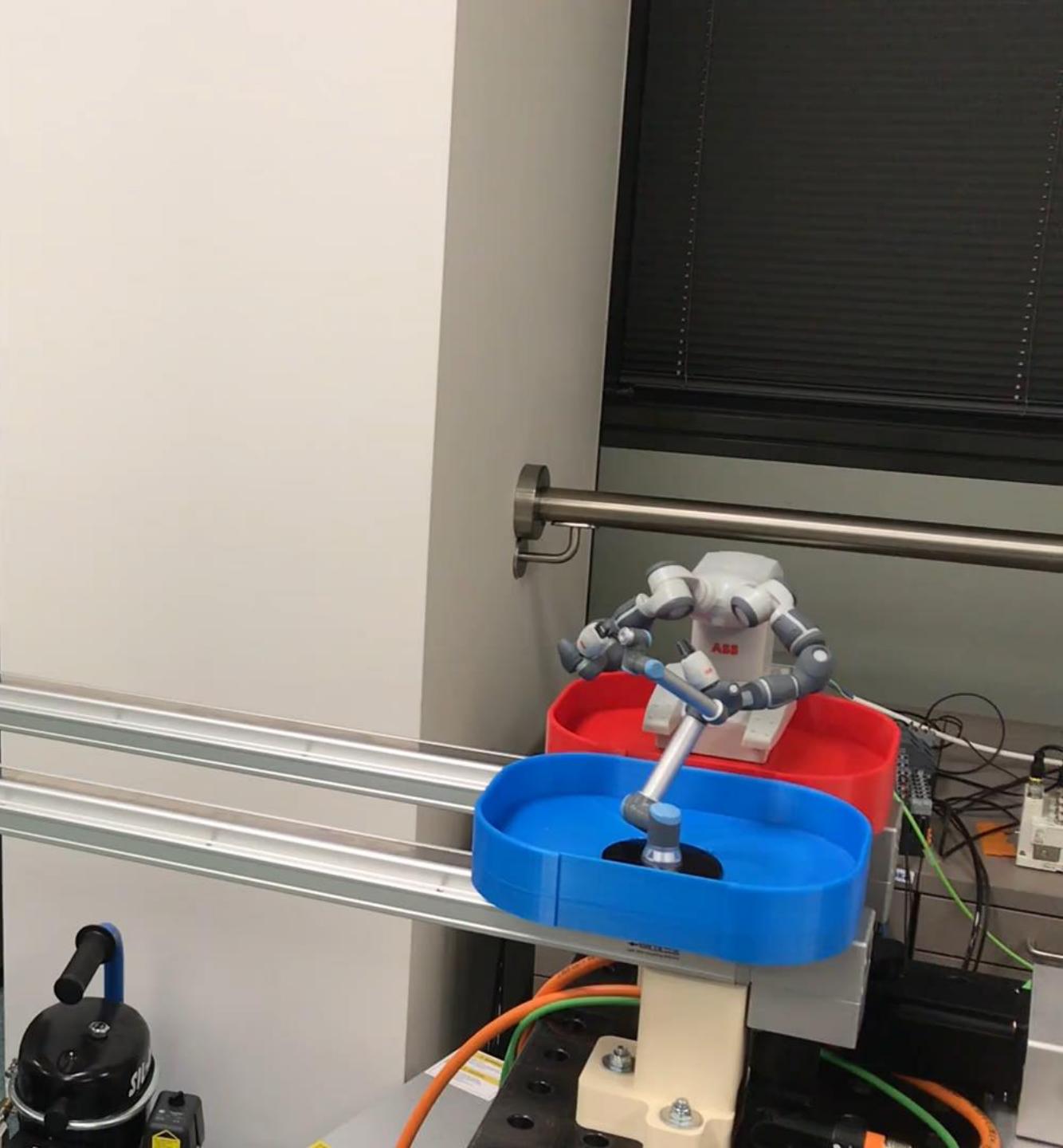
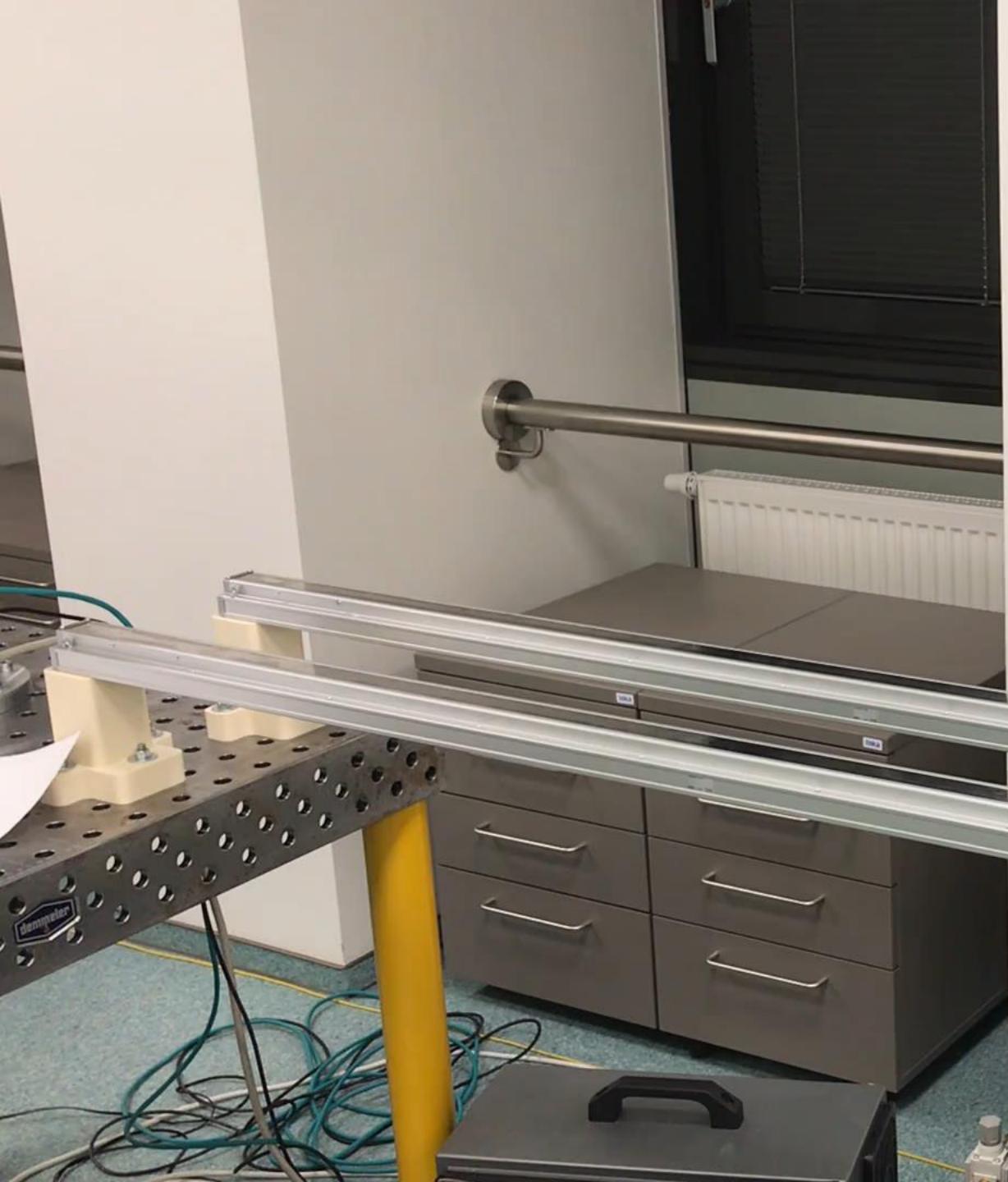
PROFI
NET®



System Integration

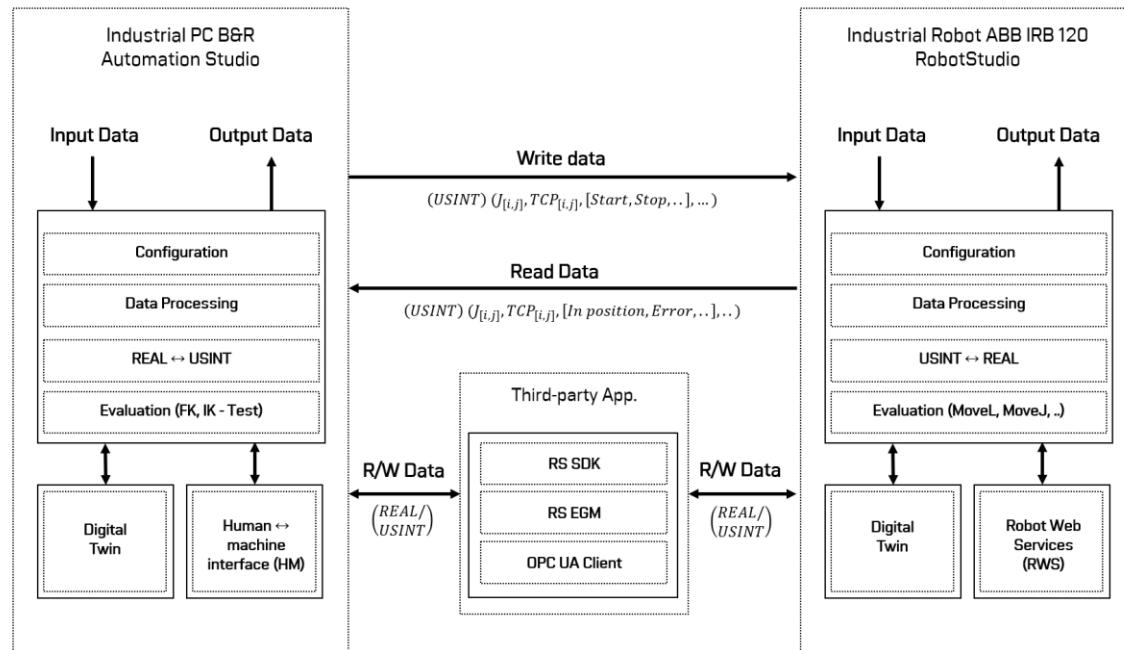
Industrial PC ↔ Synchronous motor:



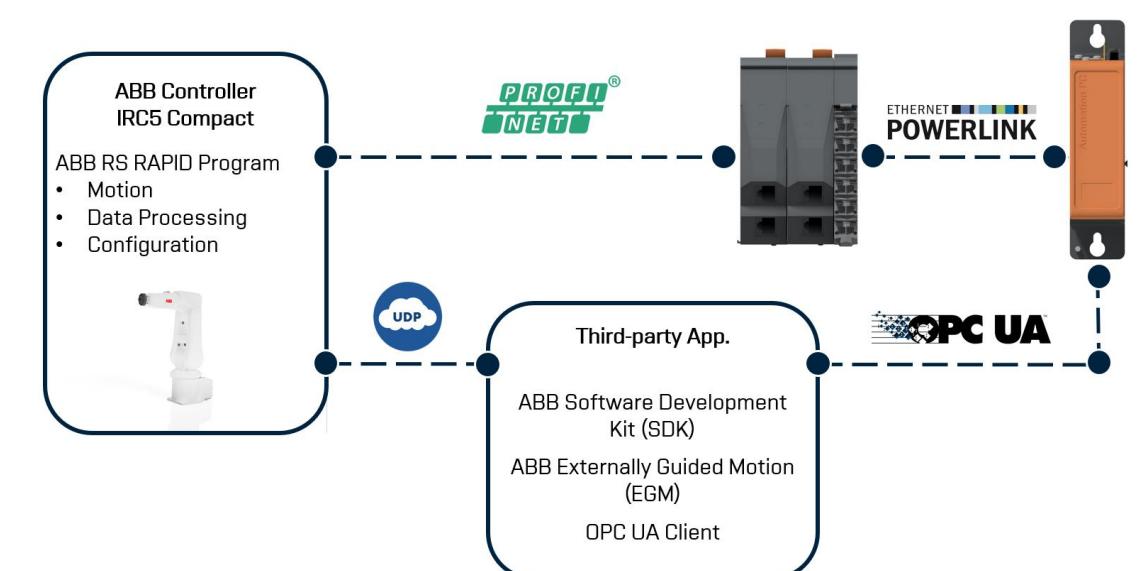


System Integration

Industrial PC ↔ ABB IRB 120:



Sys. Integration Scheme



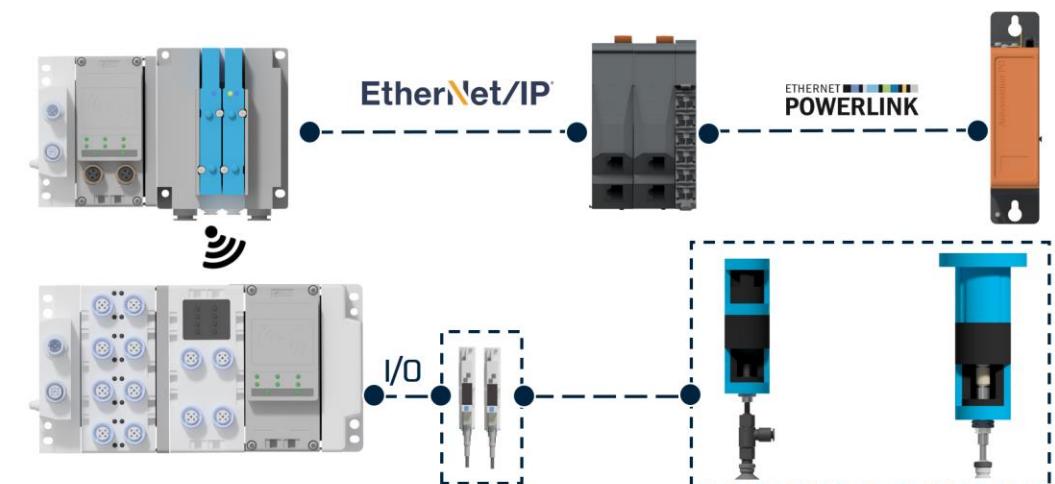
Wiring Diagram

System Integration

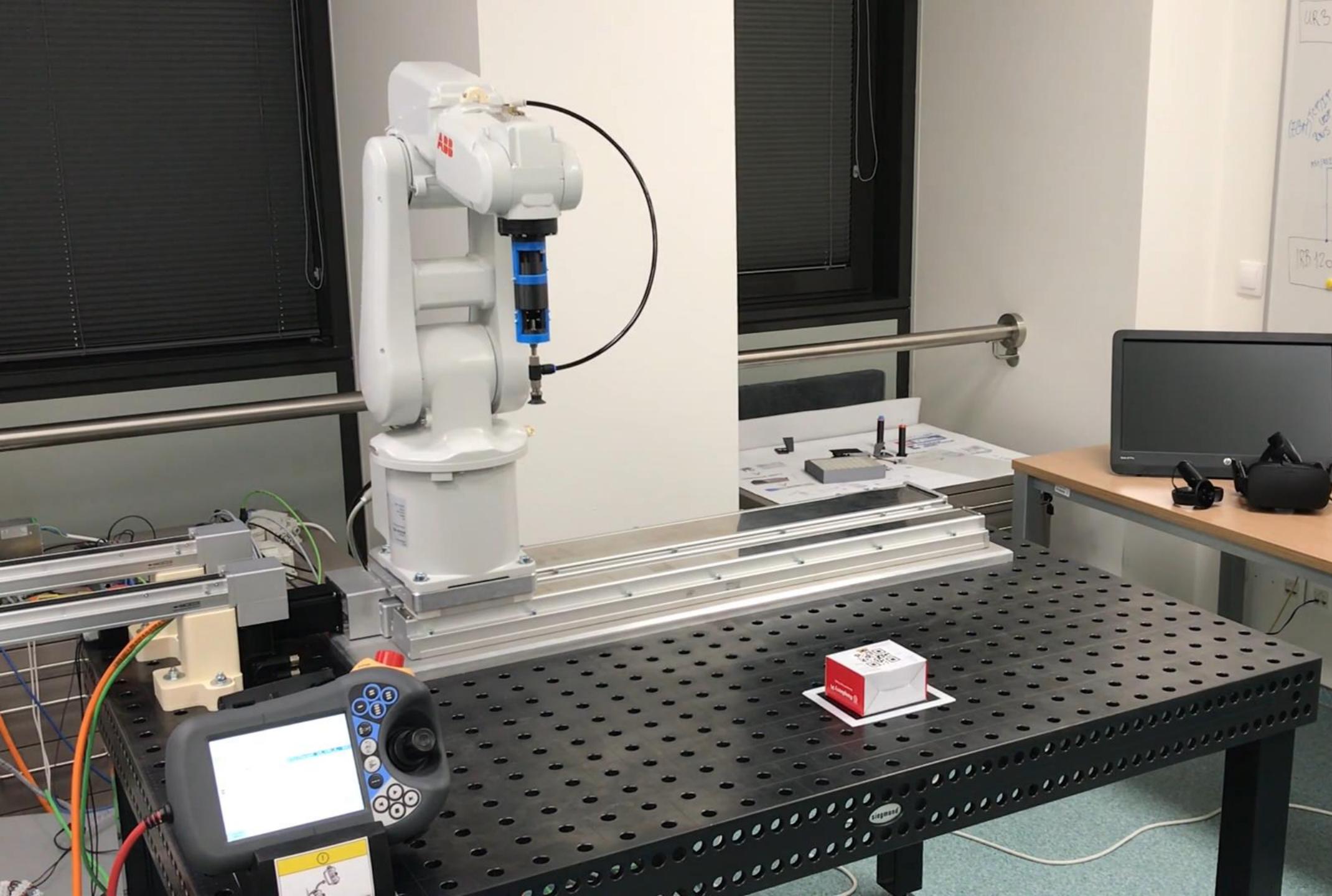
Industrial PC ↔ EX600 Wireless:



Sys. Integration Scheme

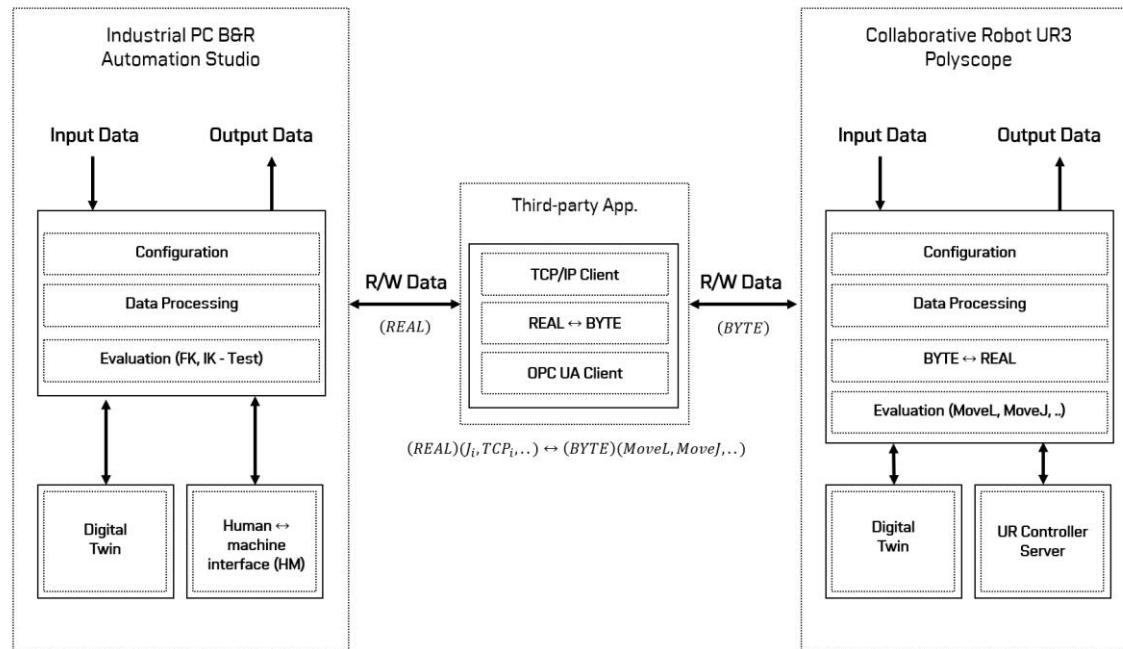


Wiring Diagram

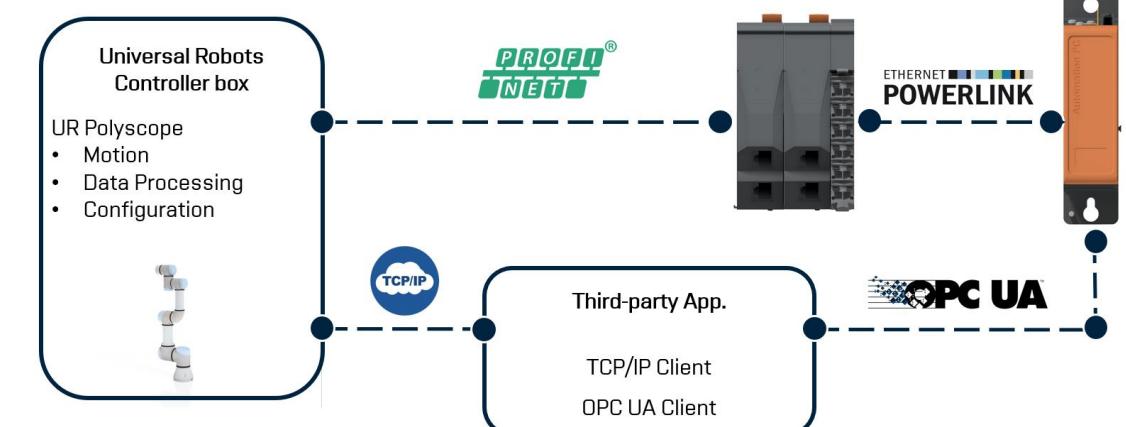


System Integration

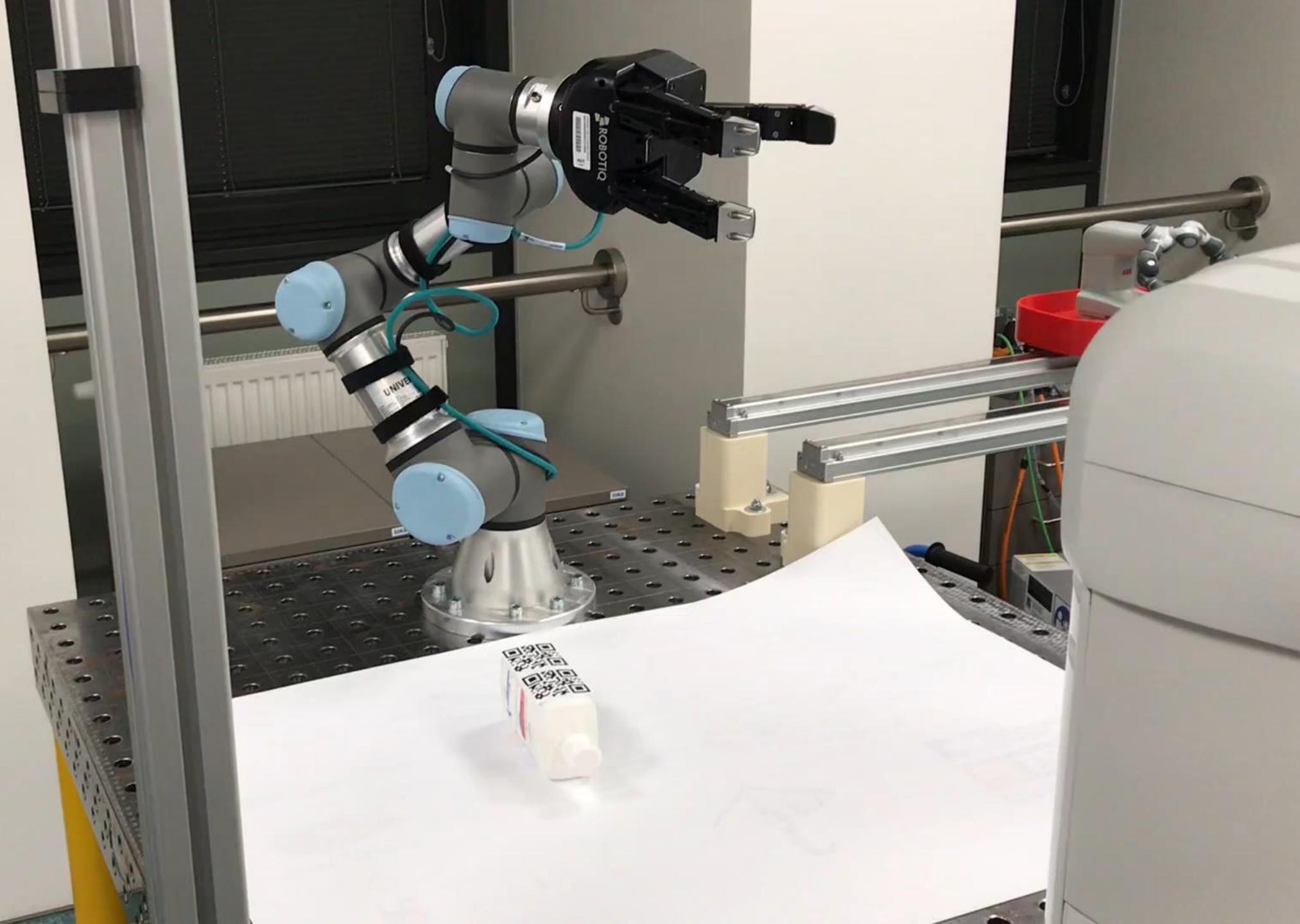
Industrial PC ↔ Universal Robots:



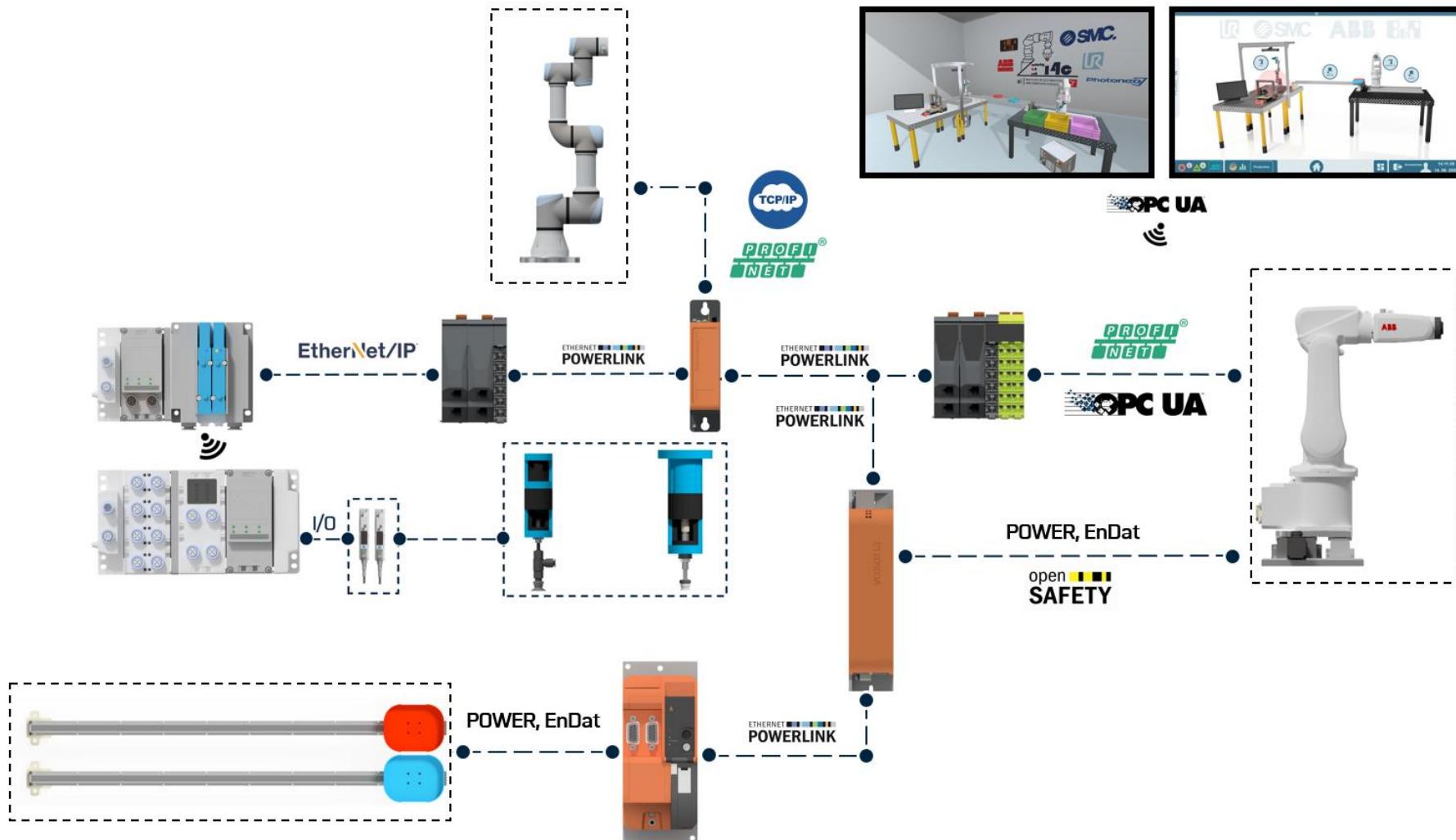
Sys. Integration Scheme



Wiring Diagram



System Integration



Virtual / Digital Twin

Virtual / Digital Twin

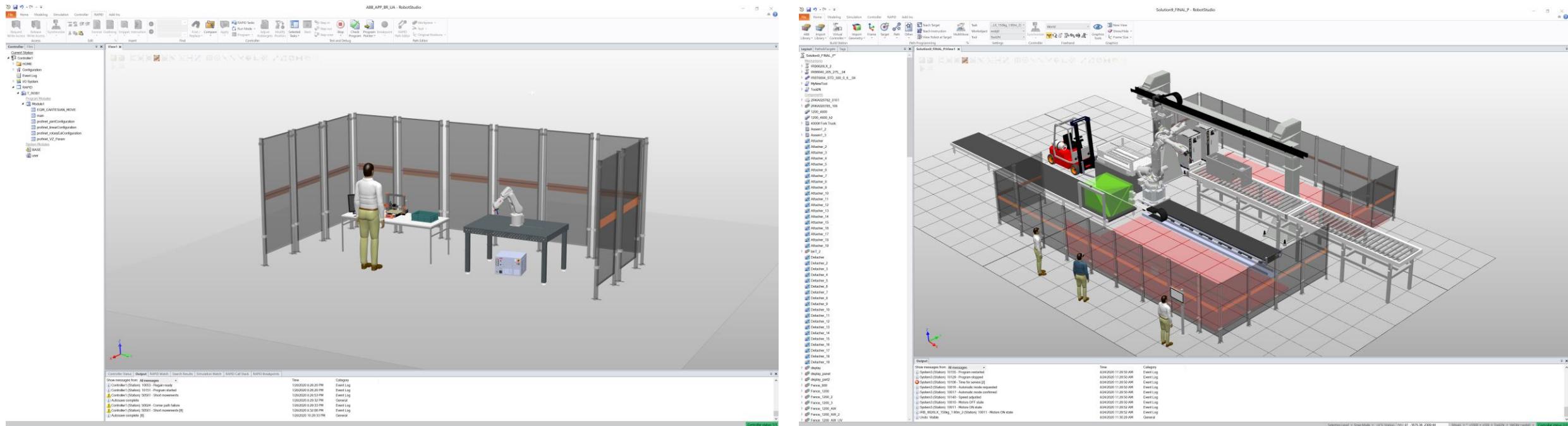


ABB RobotStudio

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

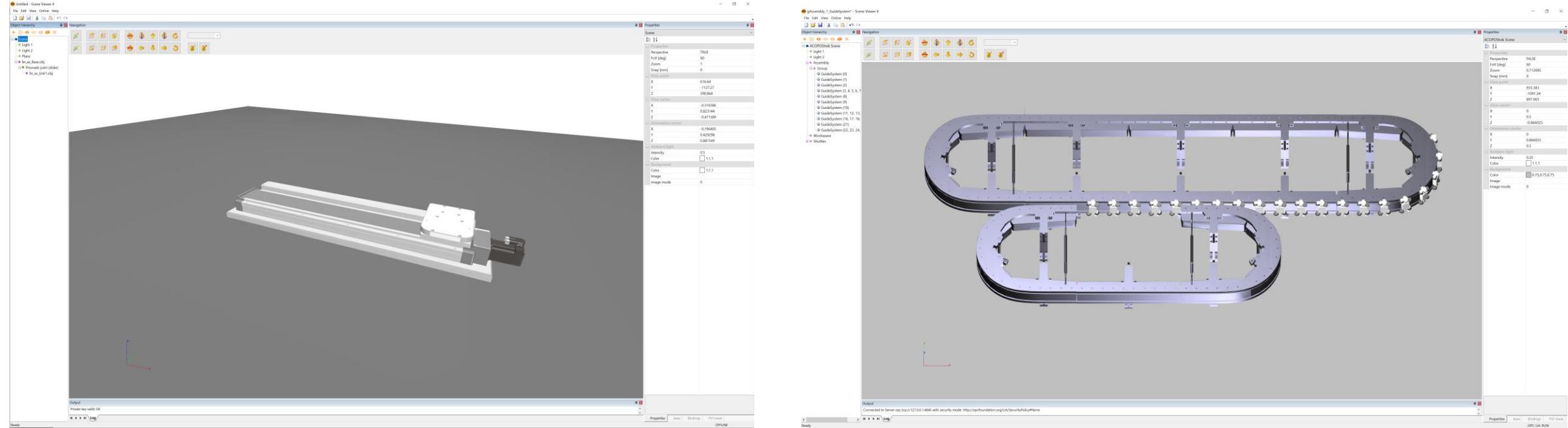
Controller1 (Station): 10125 - Program stopped
Controller1 (Station): 10002 - Program pointer has been reset

Time Category

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

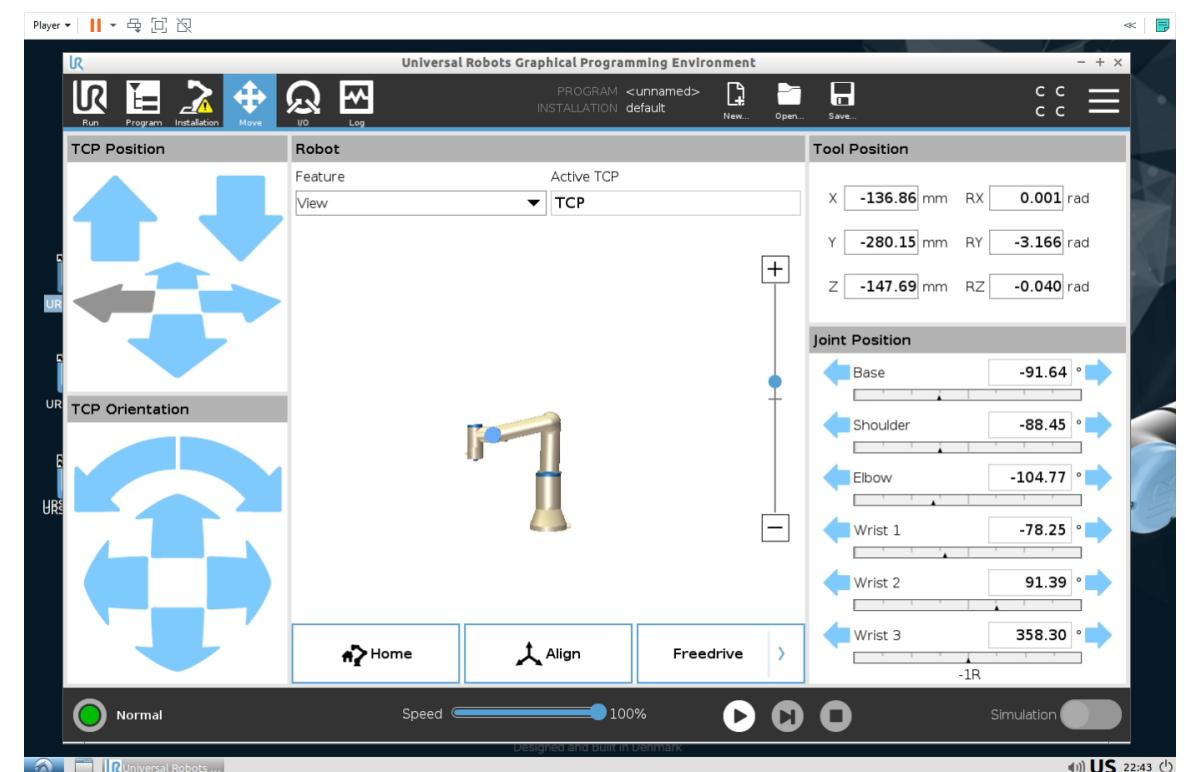
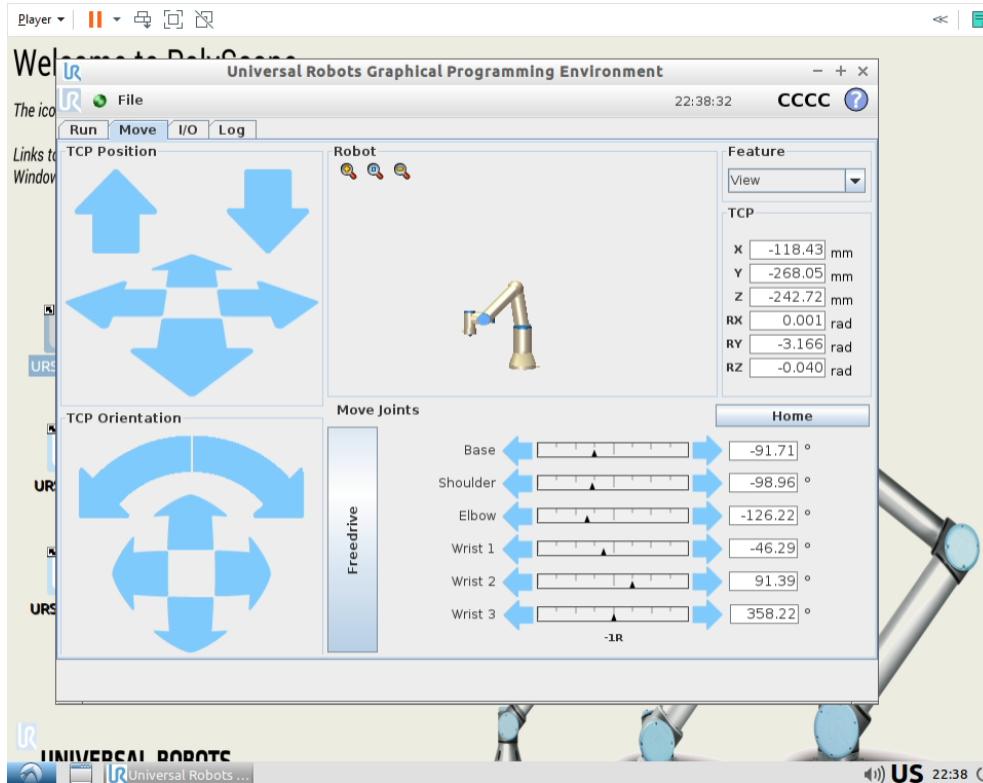
Selection Level Snap Mode UCS: Station 2.18 -170.27 1496.79 MoveL * v1000 z100 smc_gripper \WObj:=wobj0 Controller status: 1/1

Virtual / Digital Twin



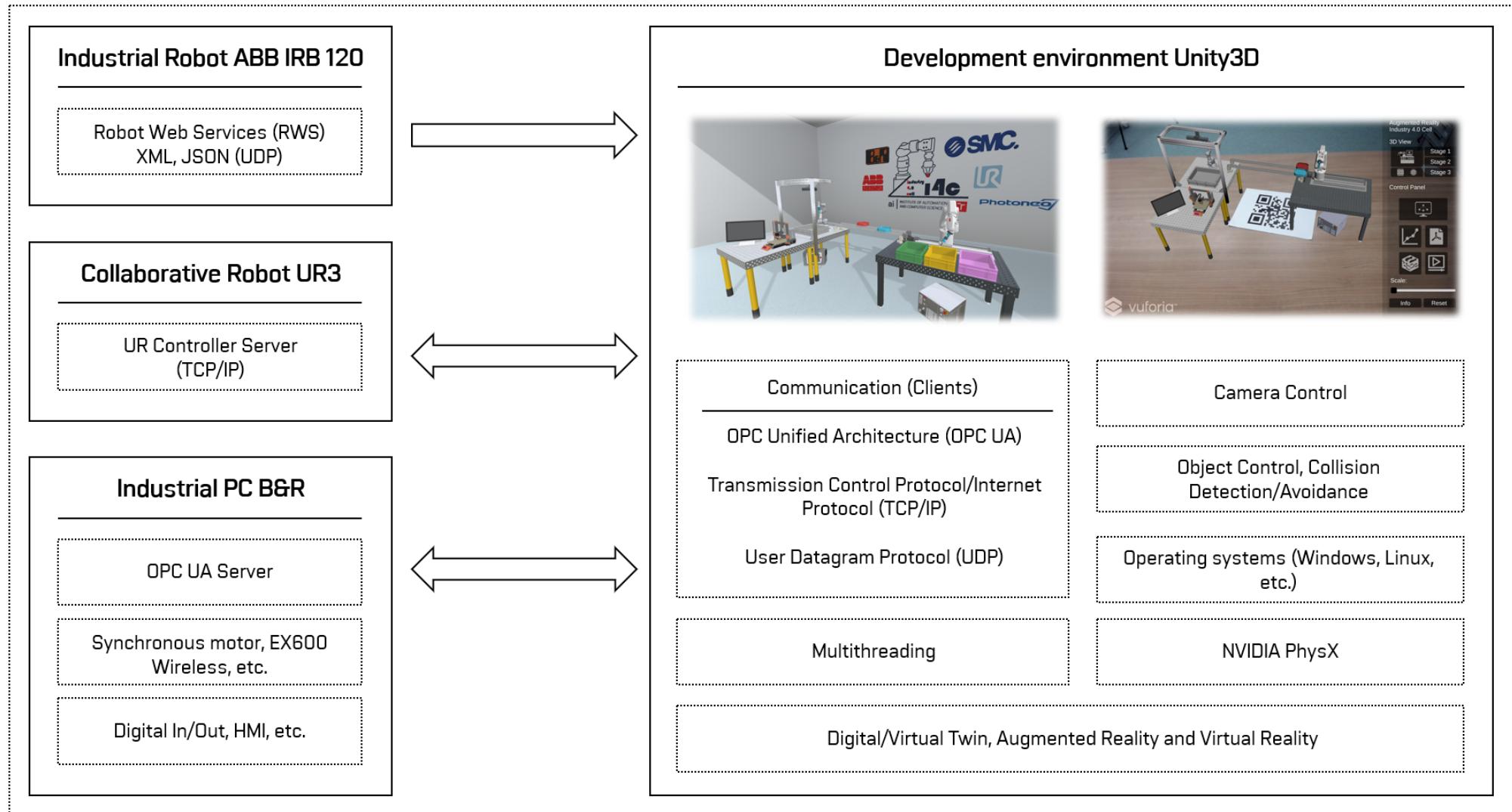
B&R Automation - SceneViewer

Virtual / Digital Twin



UR – Polyscope

Virtual / Digital Twin



Virtual / Digital Twin

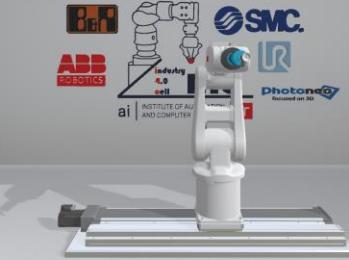
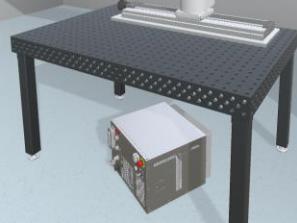
OPC UA™

unity

blender®



Virtual / Digital Twin



Virtual / Digital Twin



Object

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

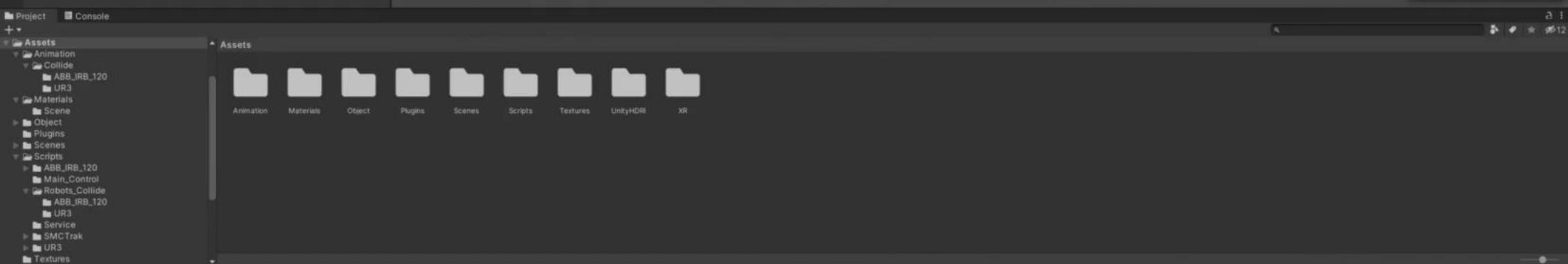
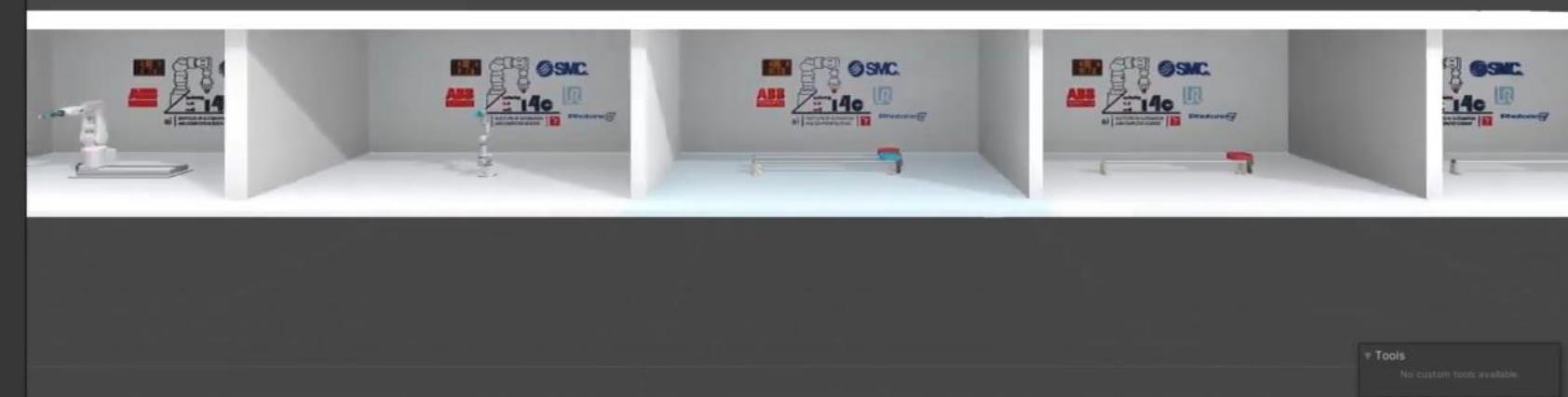
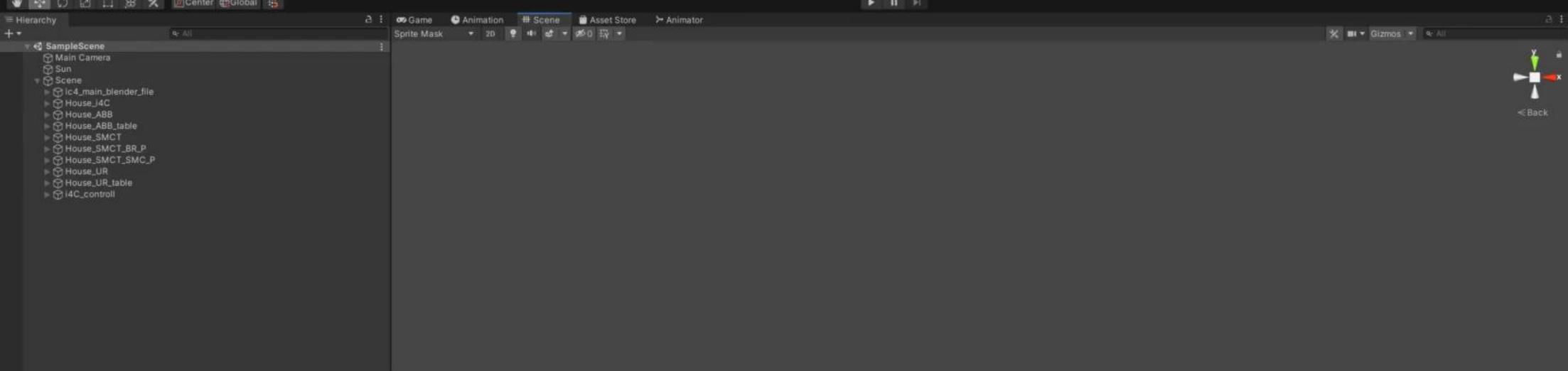
Set Parameters **Reset Parameters** **Default Parameters**

Object Control

Virtual / Digital Twin



Collision avoidance



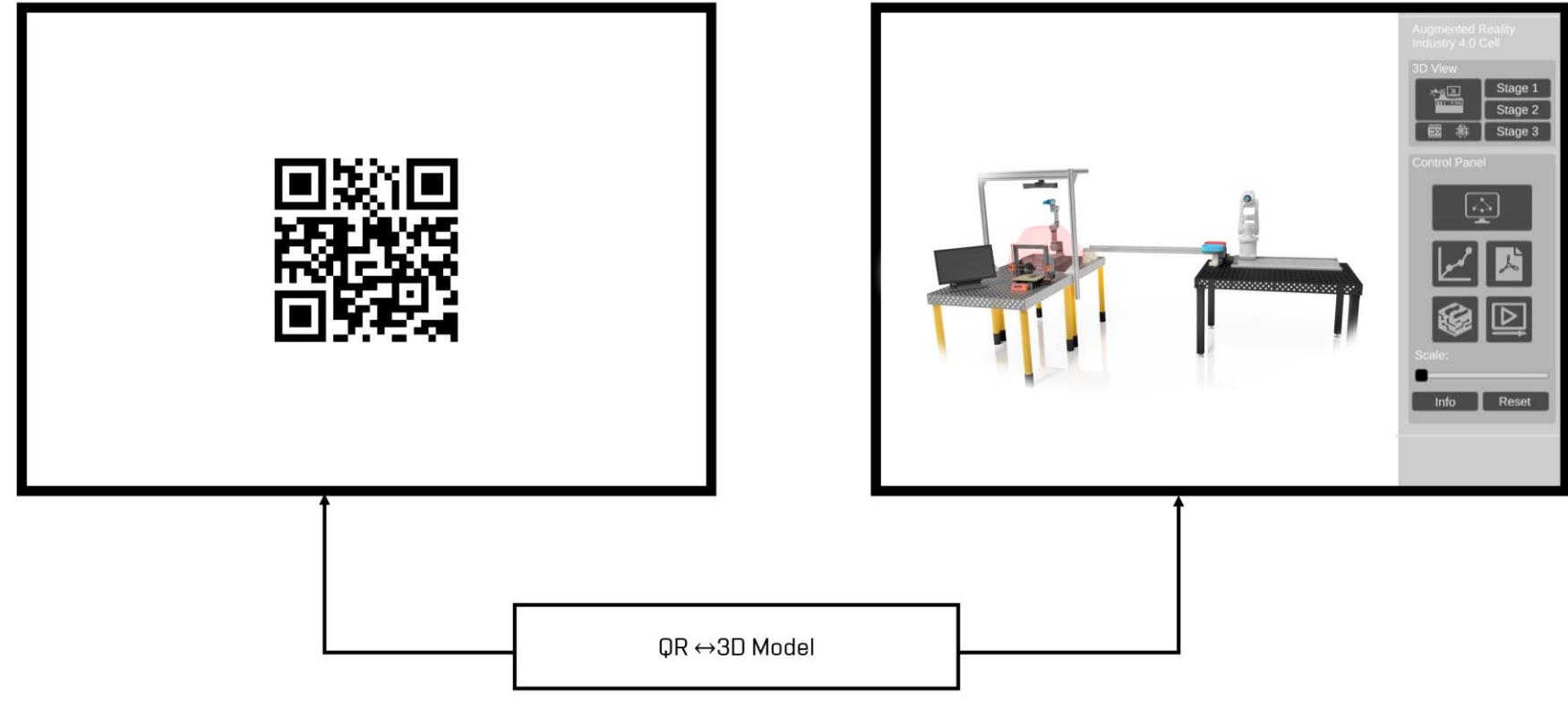
Augmented Reality

Augmented Reality

OPC UA™

unity

blender®



Augmented Reality



Diagnostic Panel

Stage 1: UR3	Stage 2: SMCTrak	Stage 3a: ABB IRB 120
X: 0.00	SMC PAD:	X: 0.00
Y: 0.00	Pos.: 0.00	Y: 0.00
Z: 0.00	Vel.: 0.00	Z: 0.00
RX: 0.00	B&R PAD:	q1: 0.0000000000
RY: 0.00	Pos.: 0.00	q2: 0.0000000000
RZ: 0.00	Vel.: 0.00	q3: 0.0000000000
Joint 1: 0.00	Stage 3b: 7th Axis ABB	q4: 0.0000000000
Joint 2: 0.00	Pos.: 0.00	Joint 1: 0.00
Joint 3: 0.00	Vel.: 0.00	Joint 2: 0.00
Joint 4: 0.00		Joint 3: 0.00
Joint 5: 0.00		Joint 4: 0.00
Joint 6: 0.00		Joint 5: 0.00
		Joint 6: 0.00



Advanced AR – Diagnostics (Industry 4.0 Cell)

Augmented Reality



Advanced AR – Diagnostics (Industry 4.0 Cell)

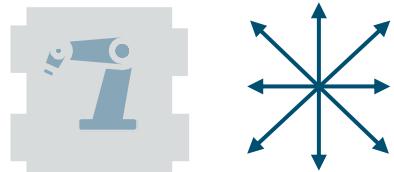
Vision of the future

Vision of the future



Autonomous Driving Industrial Robot

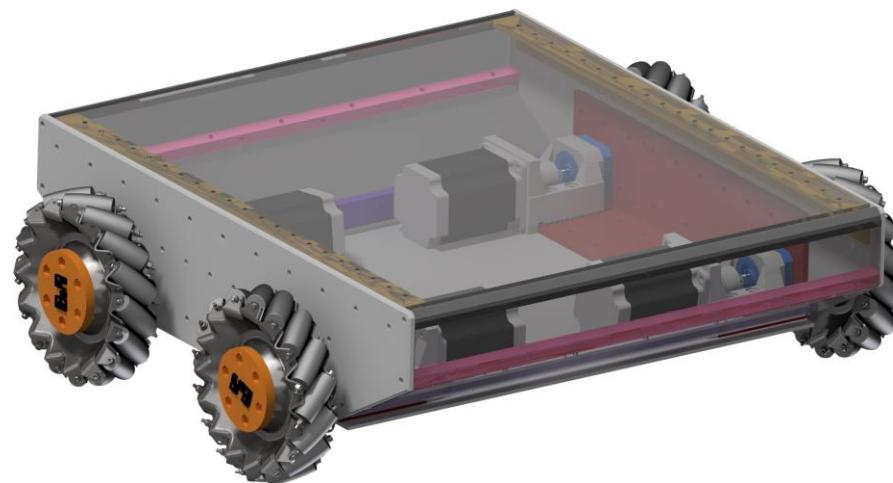
Autonomous Driving
Industrial Robot

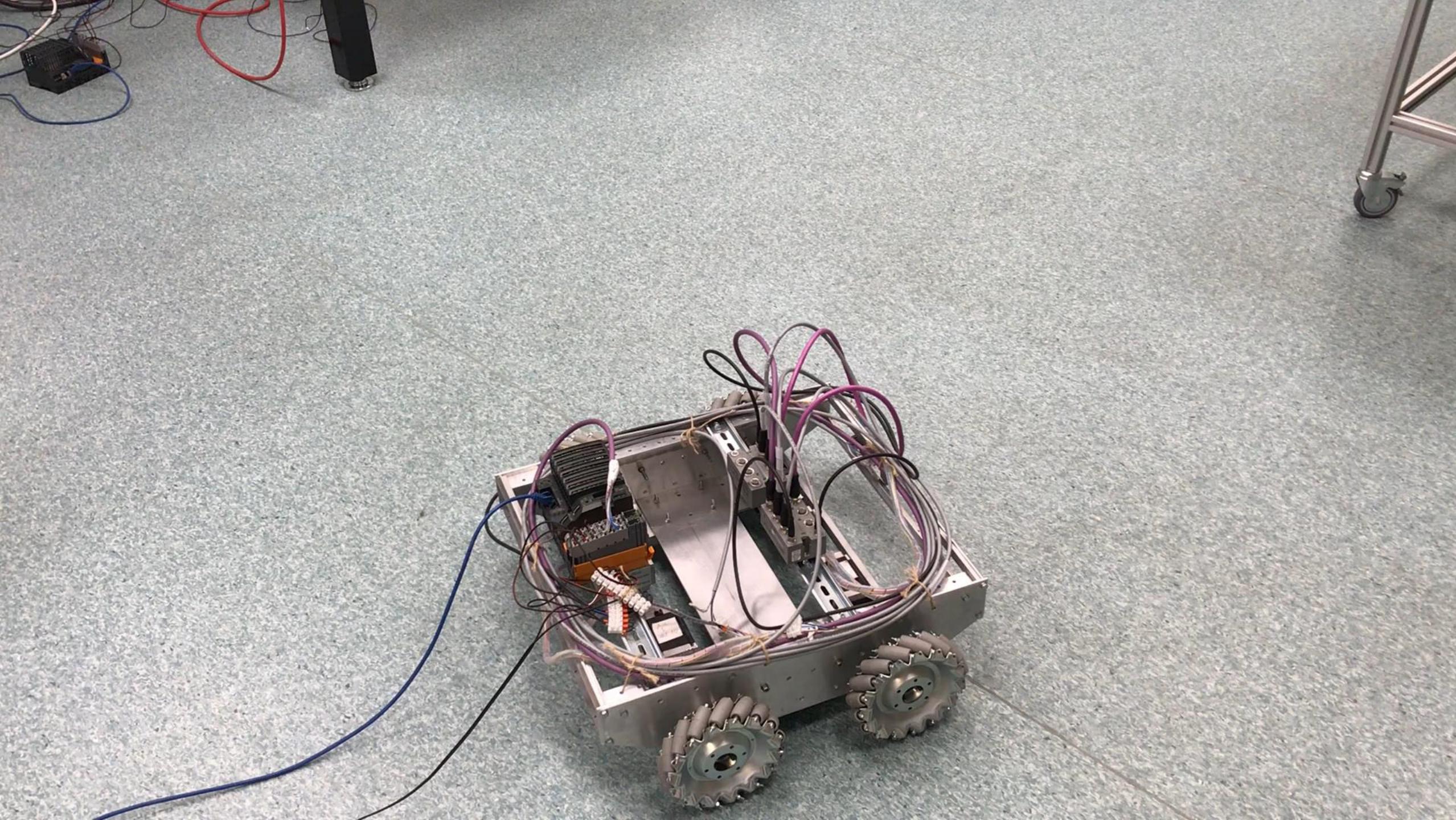


OPC UA™

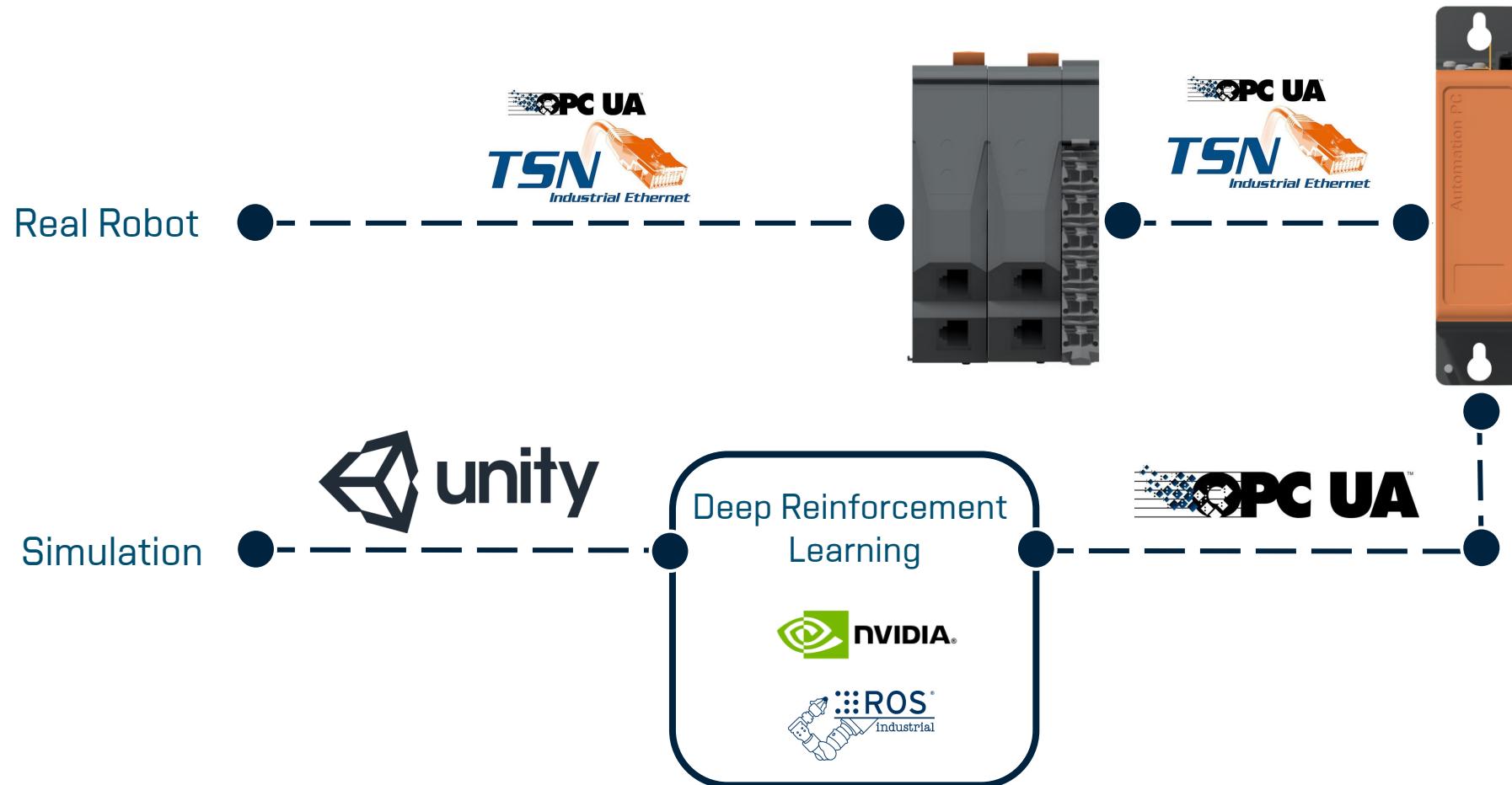
TSN
Industrial Ethernet

ETHERNET
POWERLINK

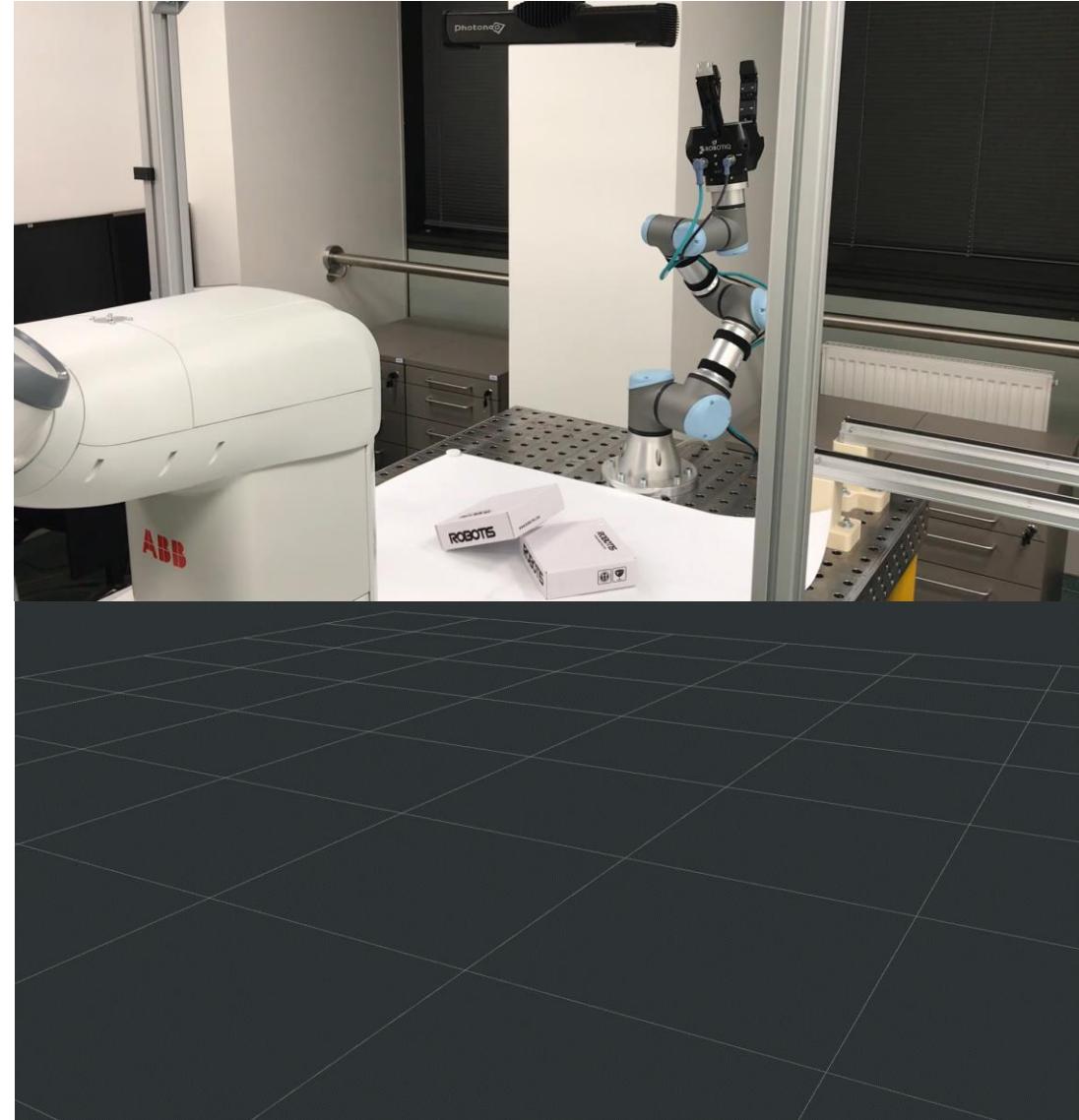
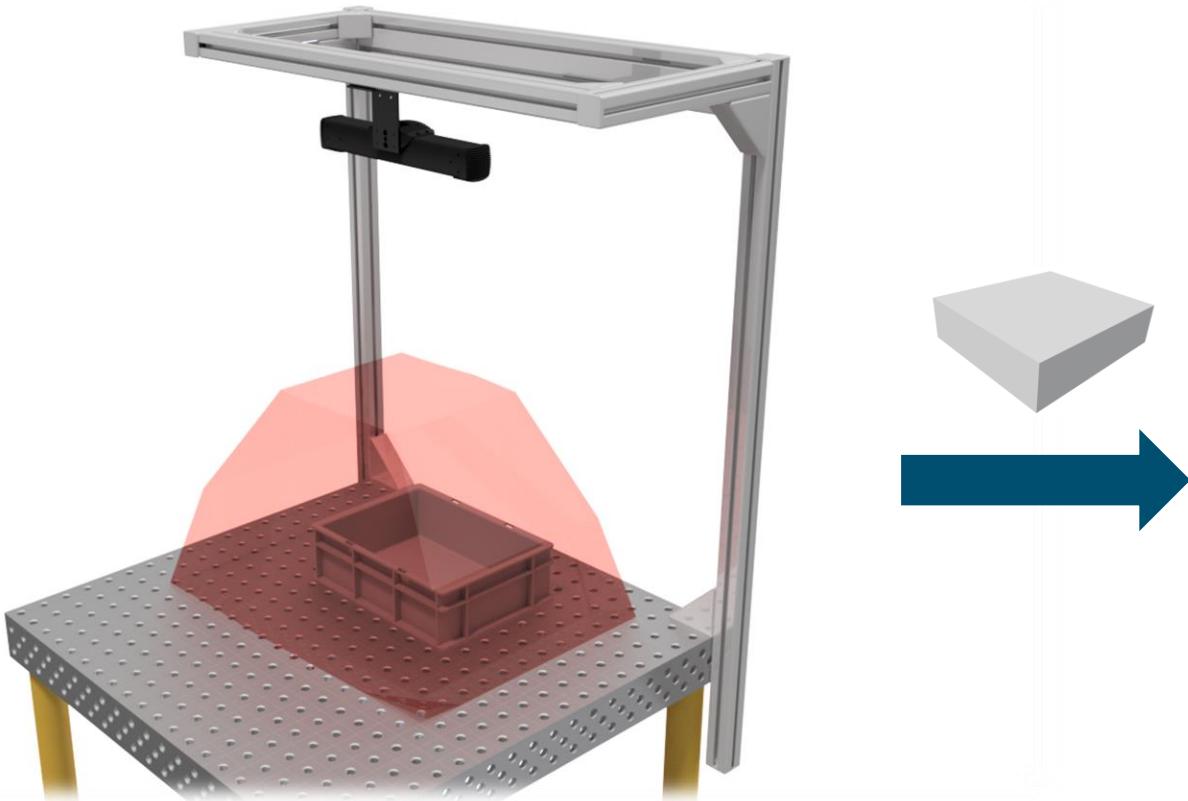




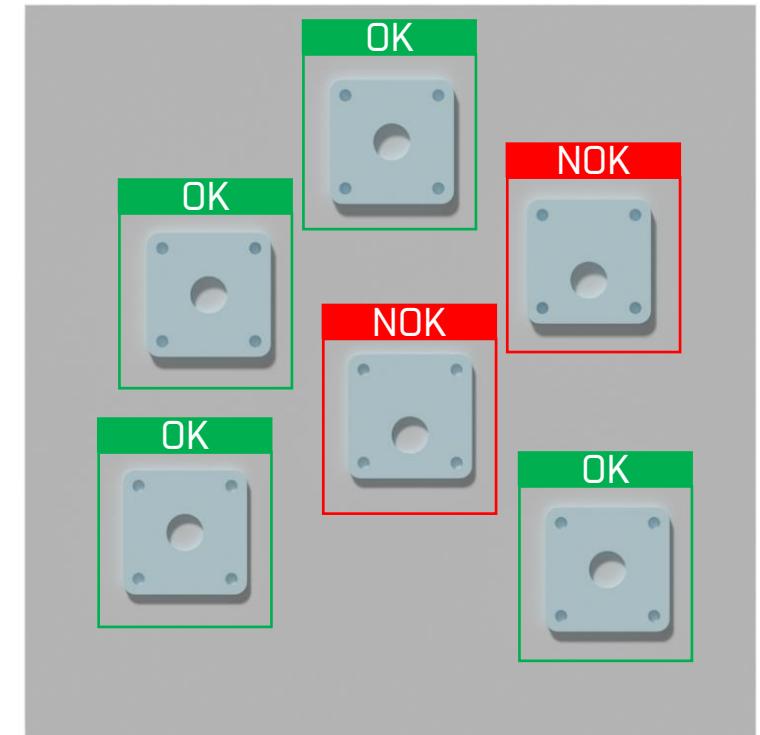
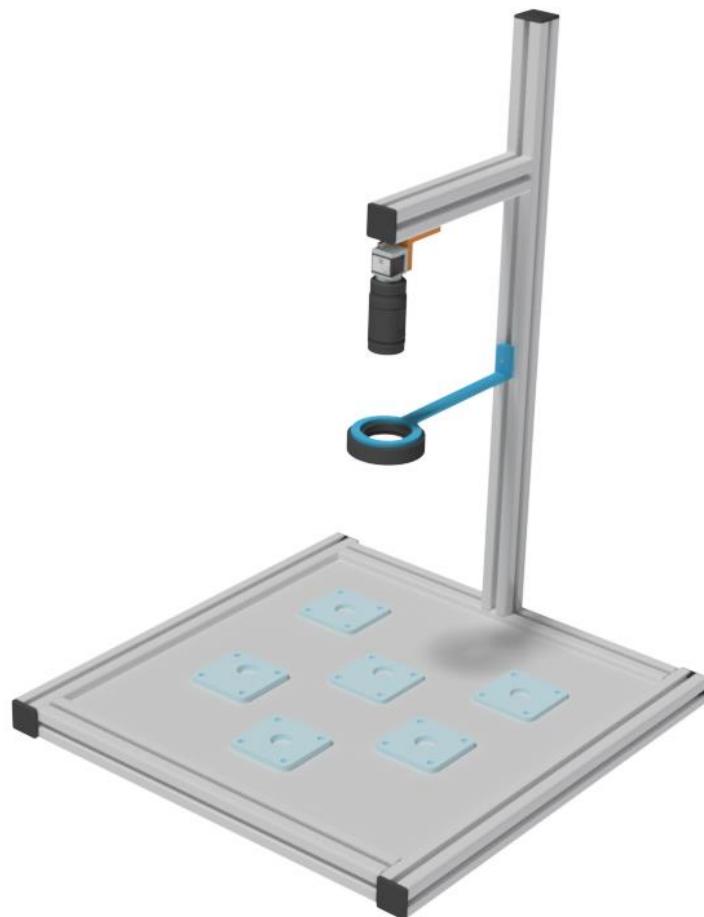
Trajectory optimization



3D object recognition (Bin-Picking)



Visual inspection



Projects

Projects

University Projects:

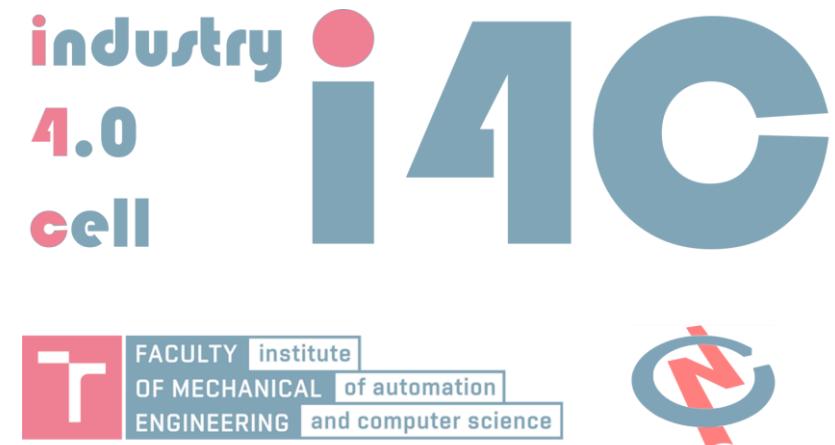
- Technology Agency of the Czech Republic (TACR), The Czech Science Foundation (GACR)
- Innovation Voucher
- Ministry of Industry and Trade
- etc.

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

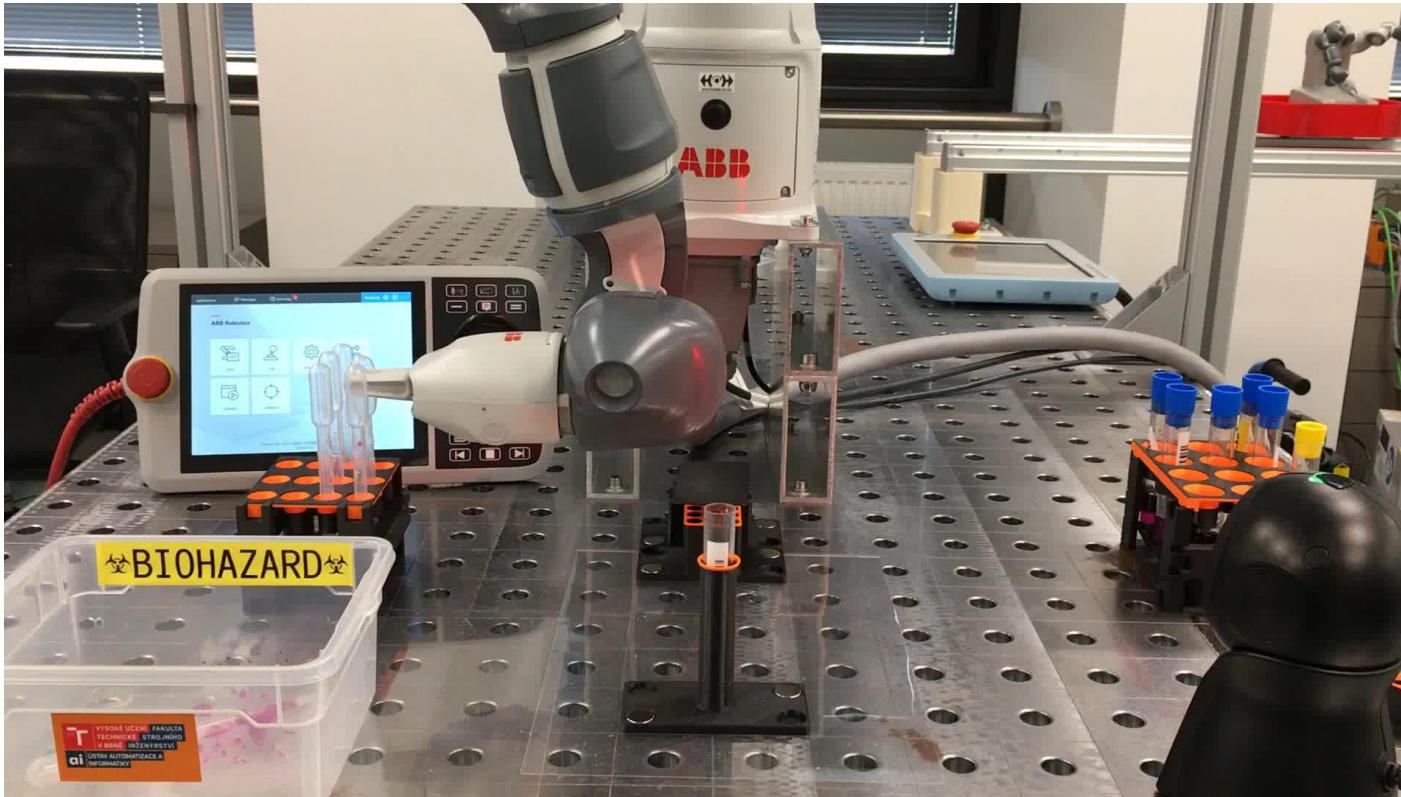
Product Overview

SMC Industrial Automation

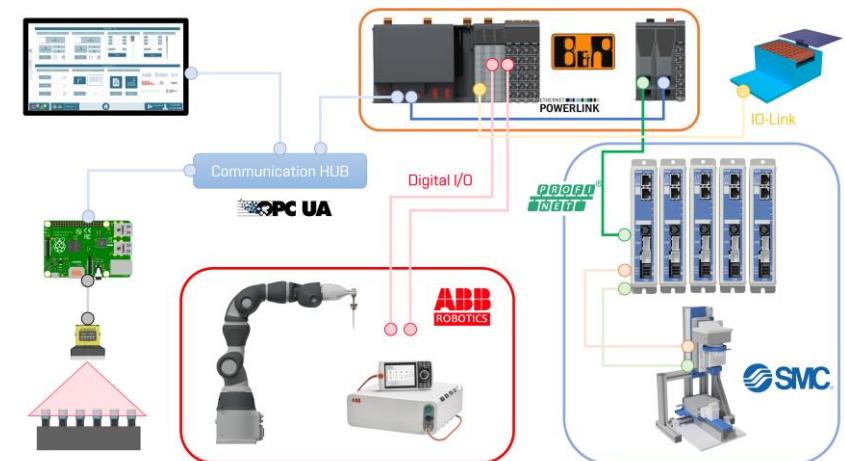
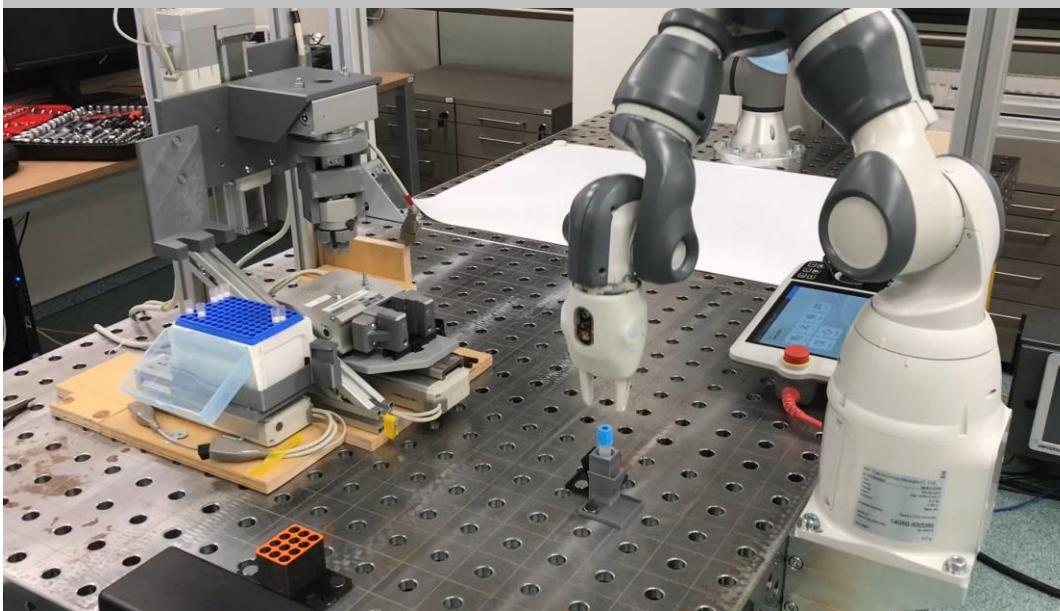
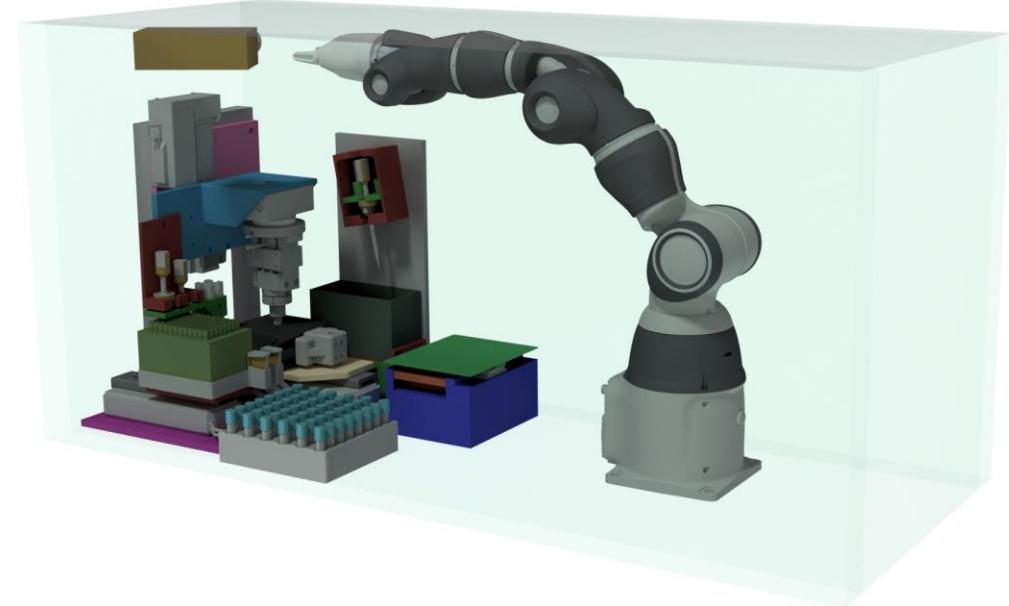
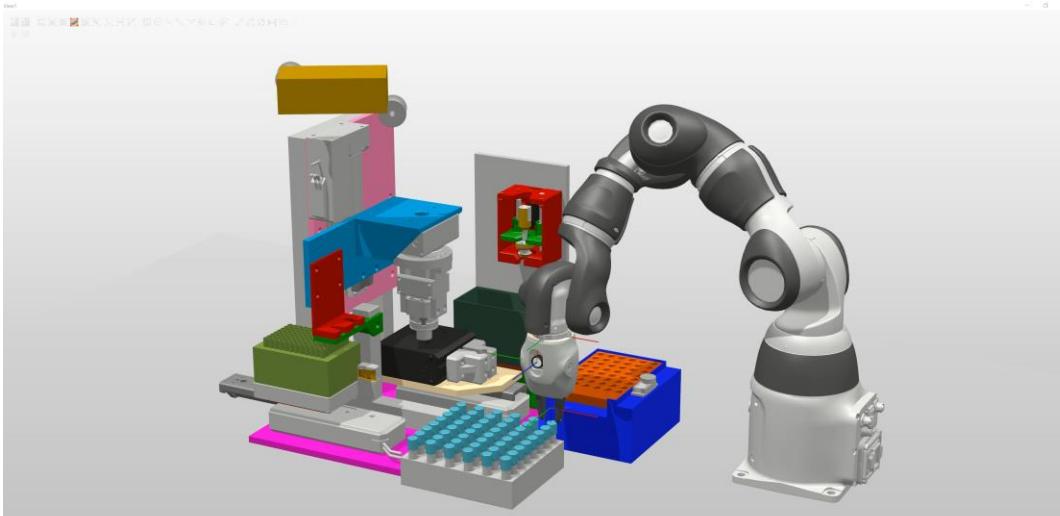
Projects

Other Projects:

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



Projects



Industry 4.0 cell

Contact



MSc. Roman Parak

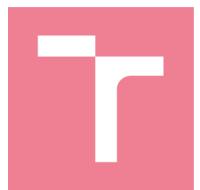
Research & Development
Cybernetics and Robotics Division

Contact:

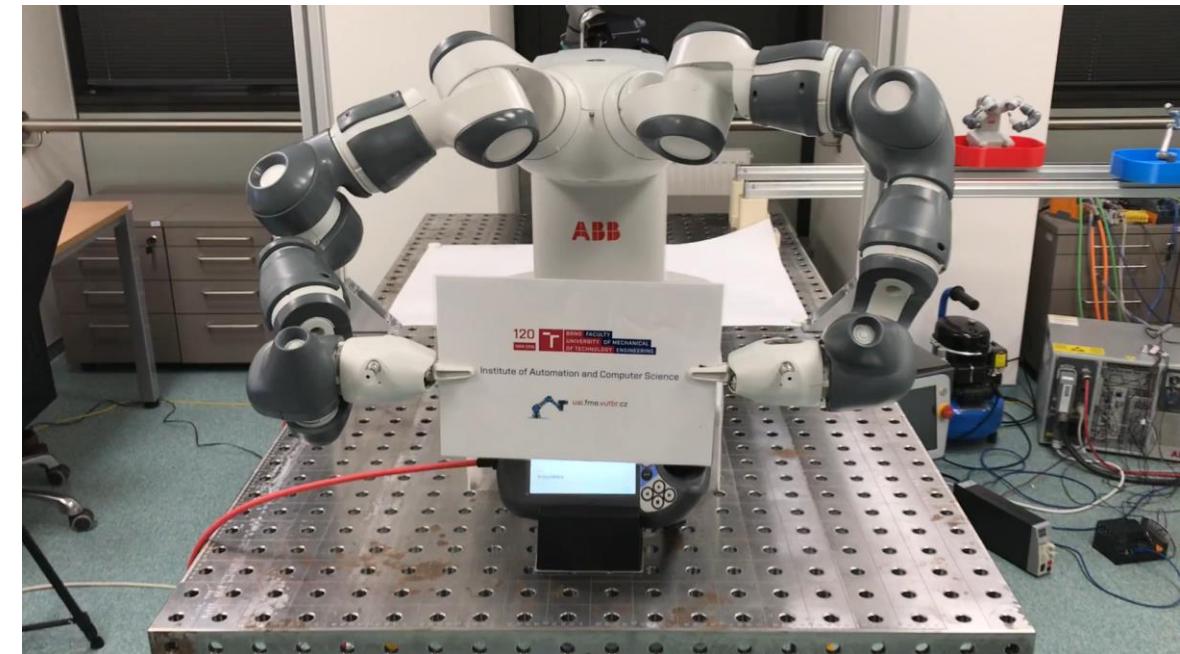
E-mail: Roman.Parak@vutbr.cz

Room:

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

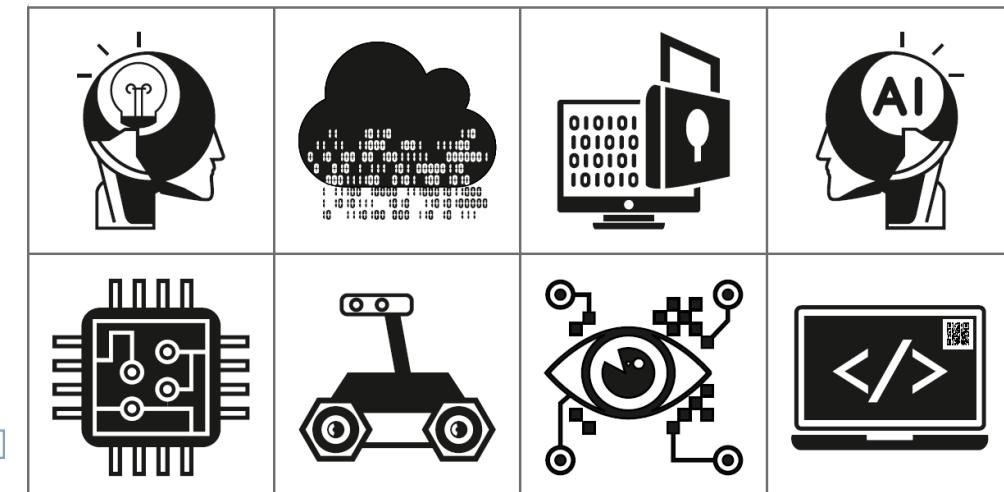
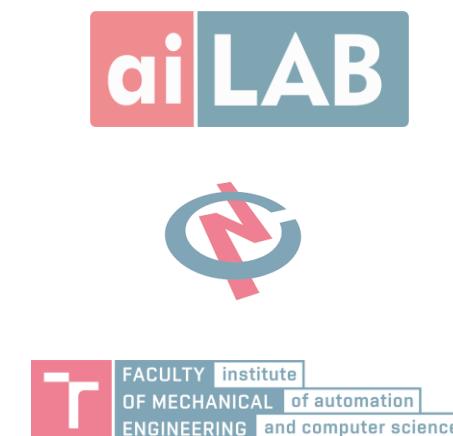
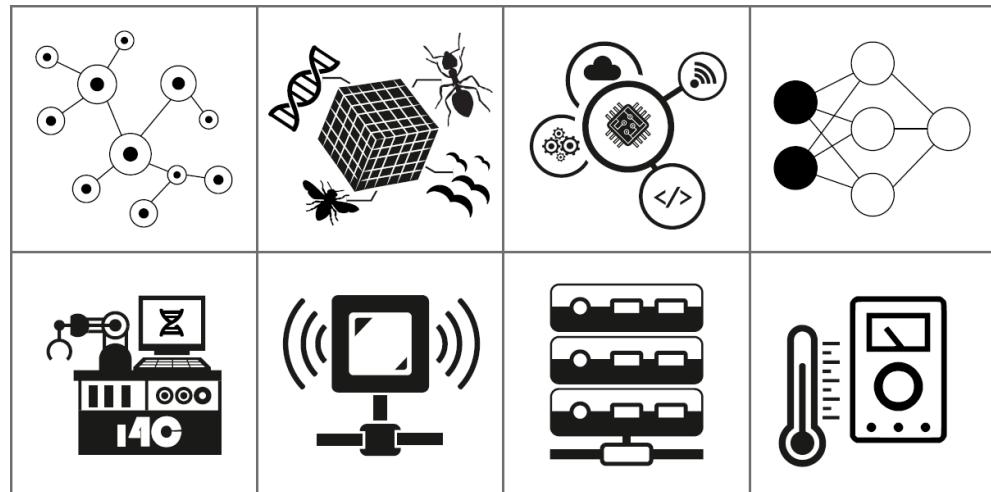


FACULTY institute
OF MECHANICAL of automation
ENGINEERING and computer science



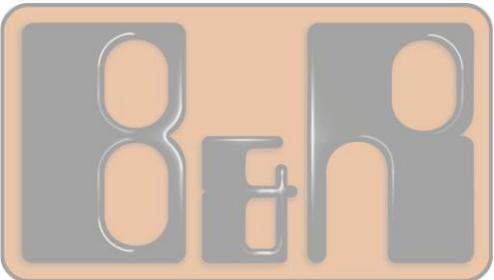


Roman Parak

Institute of
Automation and
Computer
Science

Partners

Our partners and references

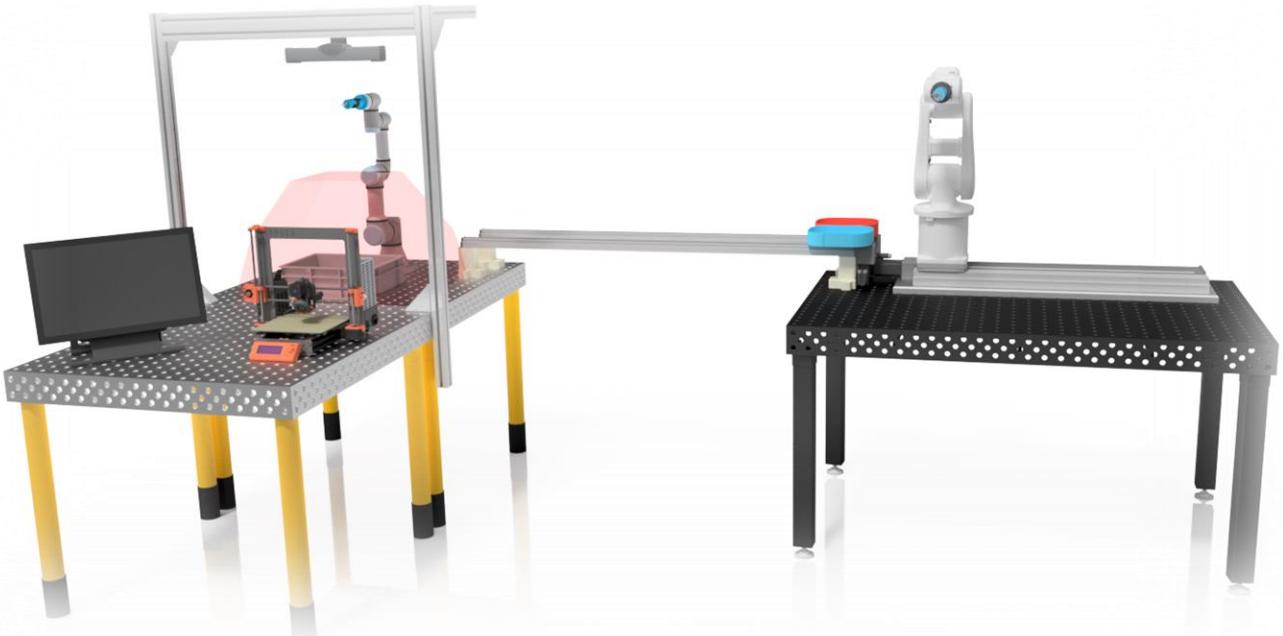


Amtech

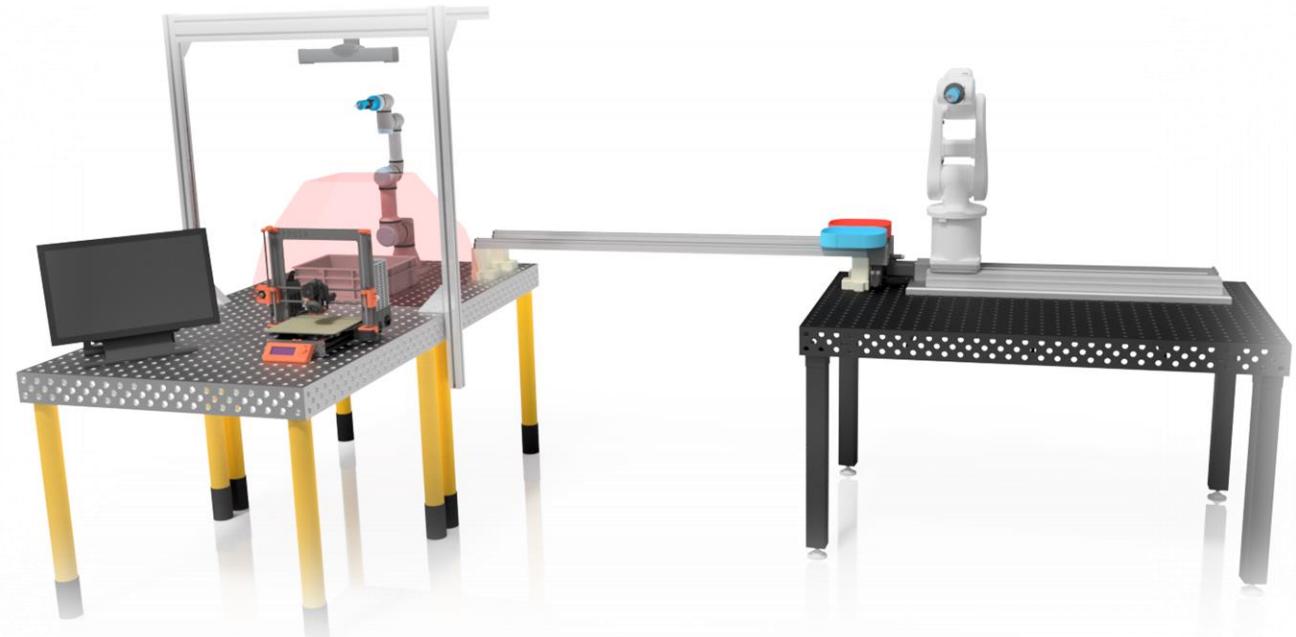


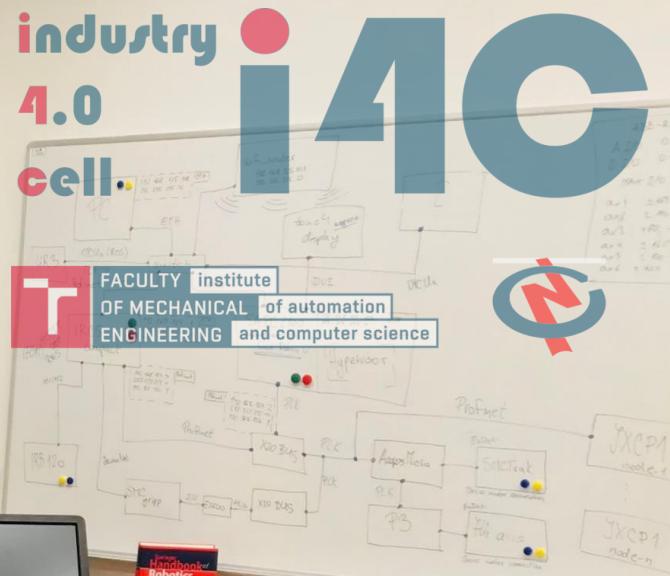
BRNO REGIONAL
CHAMBER
OF COMMERCE

Thank You!



Questions?





Industry 4.0 Cell (i4C)

MSc. Roman Parak

Research & Development – Advanced robotics

