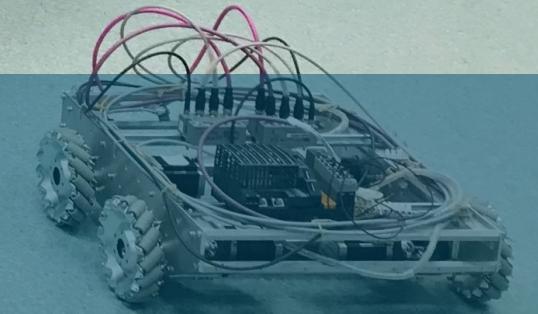
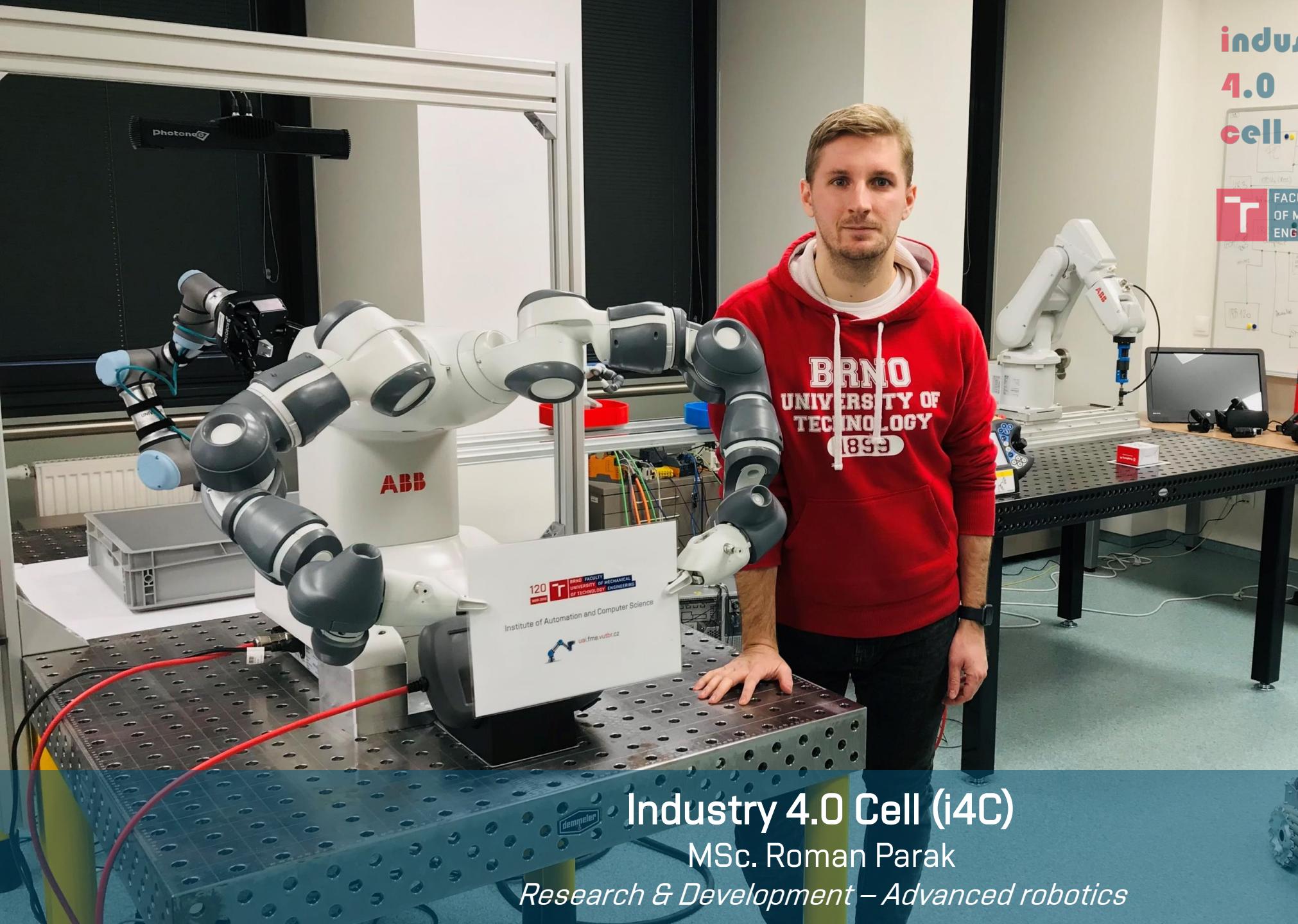




## Industry 4.0 Cell (i4C)

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

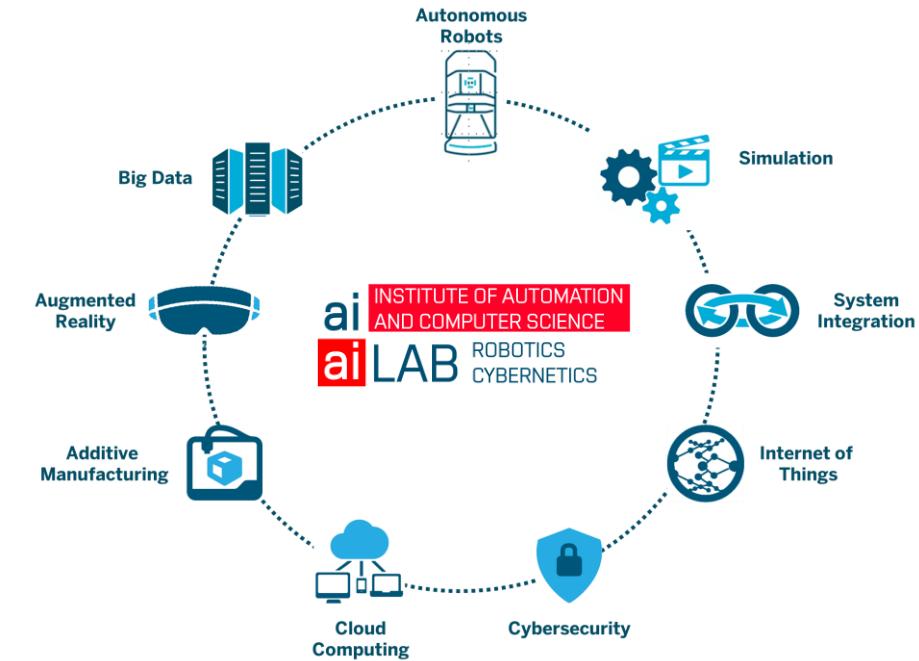


# Institute of Automation and Computer Science

## Faculty of Mechanical Engineering, Brno University of Technology

### Organizational Structure:

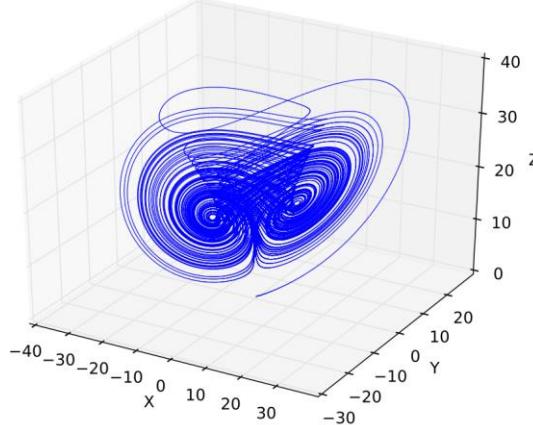
- Dept. of Automation
- Dept. of Applied Computer Science
- Dept. of Computer Networks
- NETME Centre – Cybernetics and Robotics Division



### Main pillars of Industry 4.0

# NETME Centre – Cybernetics and Robotics Division

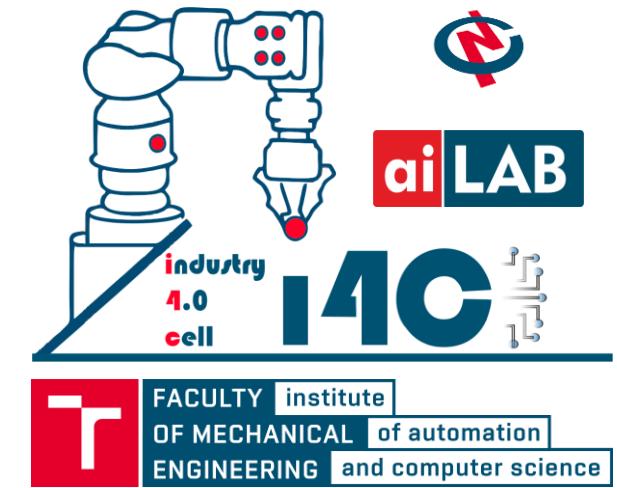
Faculty of Mechanical Engineering, Brno University of Technology  
Institute of Automation and Computer Science



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](mailto:matousek@fme.vutbr.cz)

**MSc. Roman Parak**

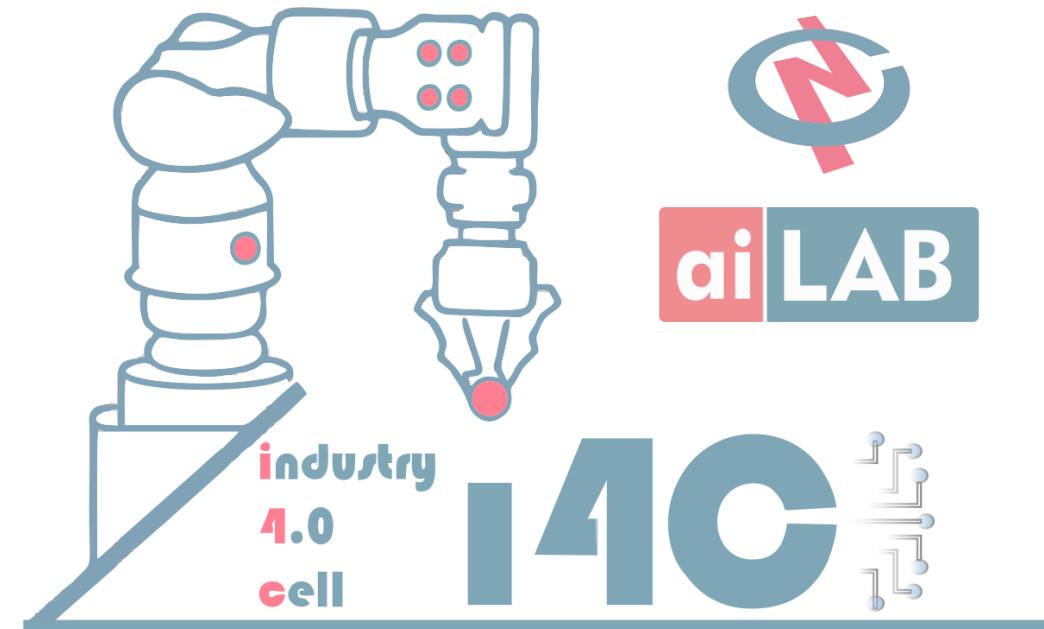
Research and Development (R&D)

Contact: [Roman.Parak@vutbr.cz](mailto:Roman.Parak@vutbr.cz)

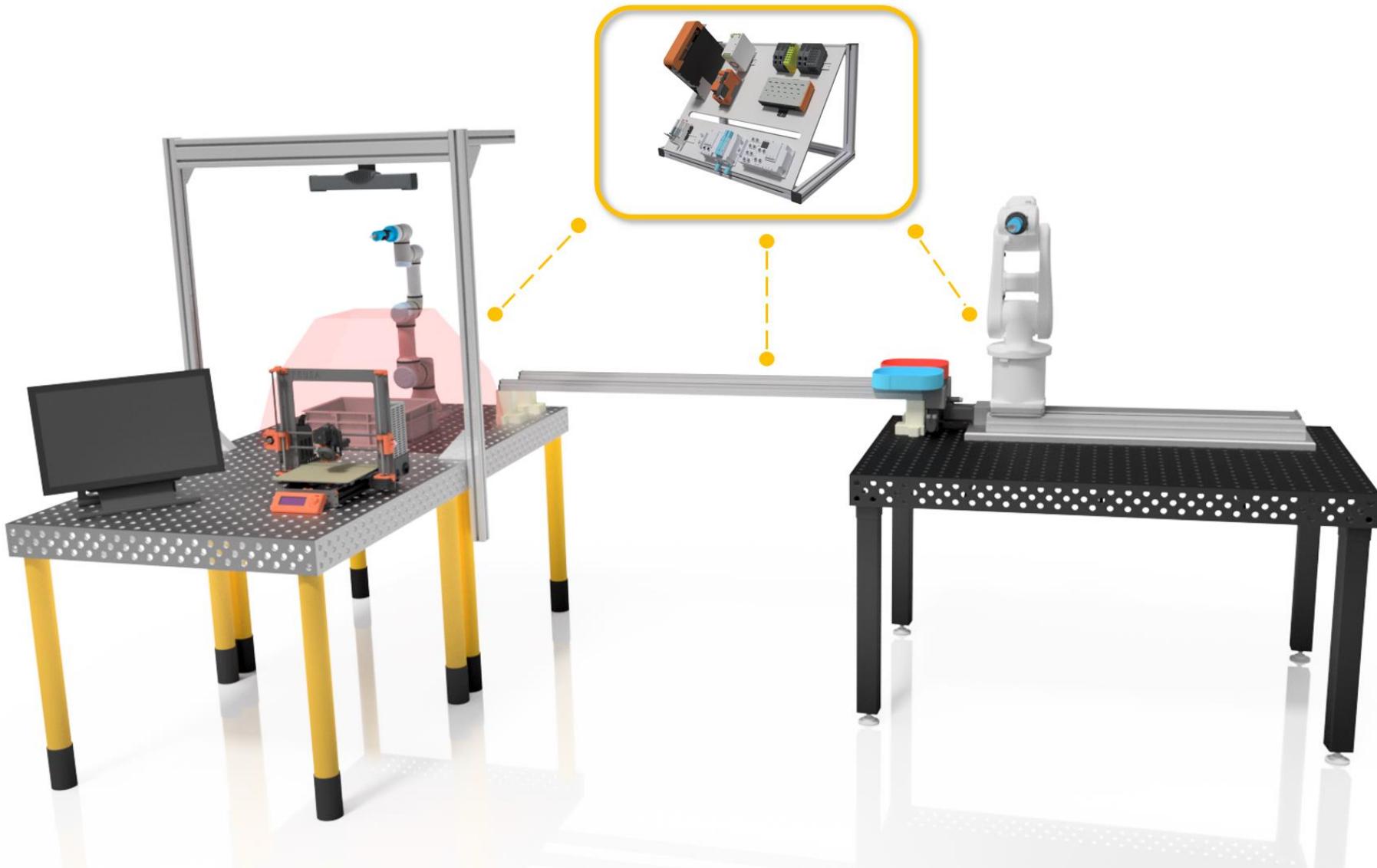
**Assoc. Prof. Branislav Lacko, PhD.**

Industry 4.0 Consultant

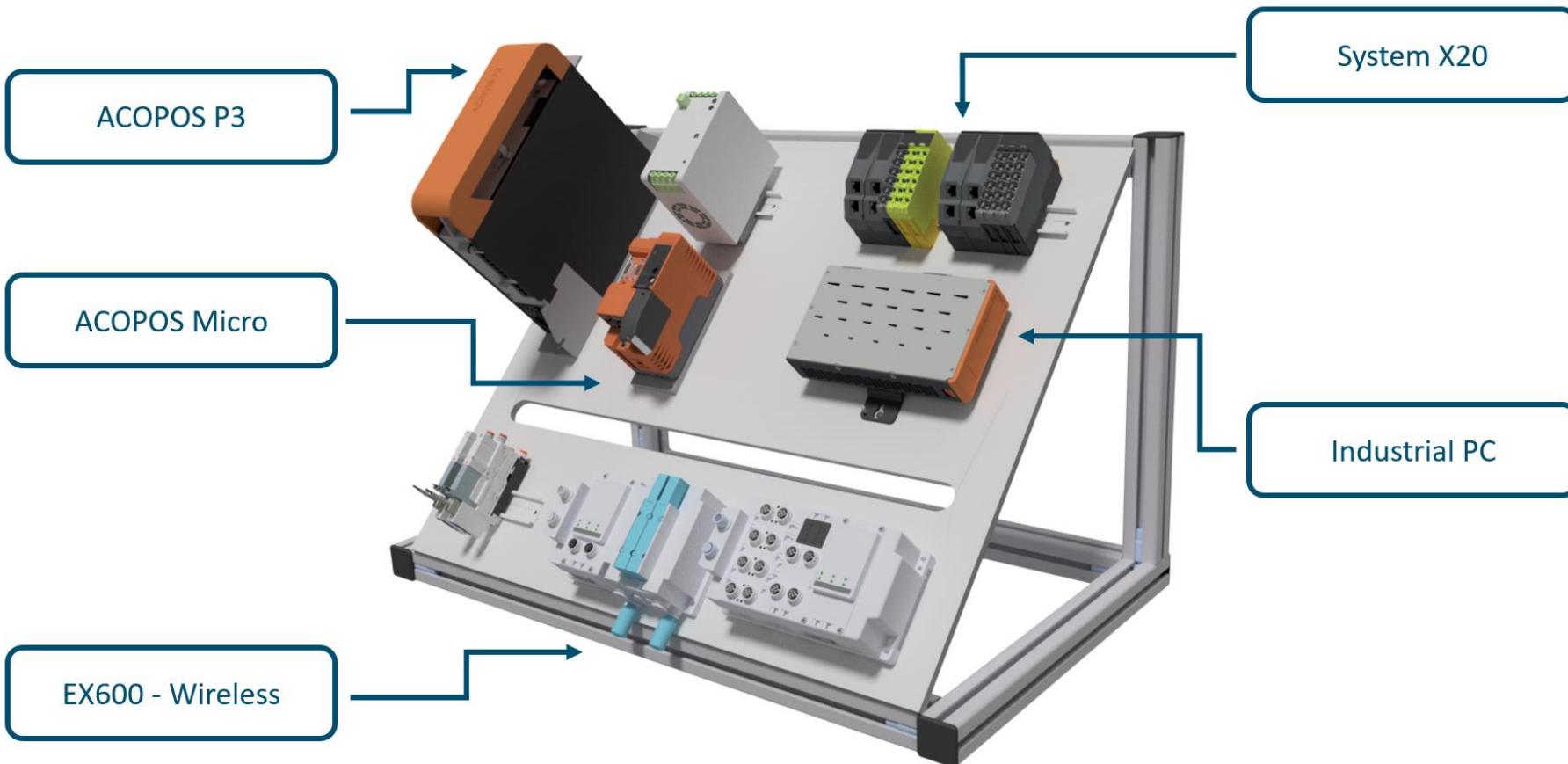
Contact: [lacko@fme.vutbr.cz](mailto:lacko@fme.vutbr.cz)



# Industry 4.0 Cell



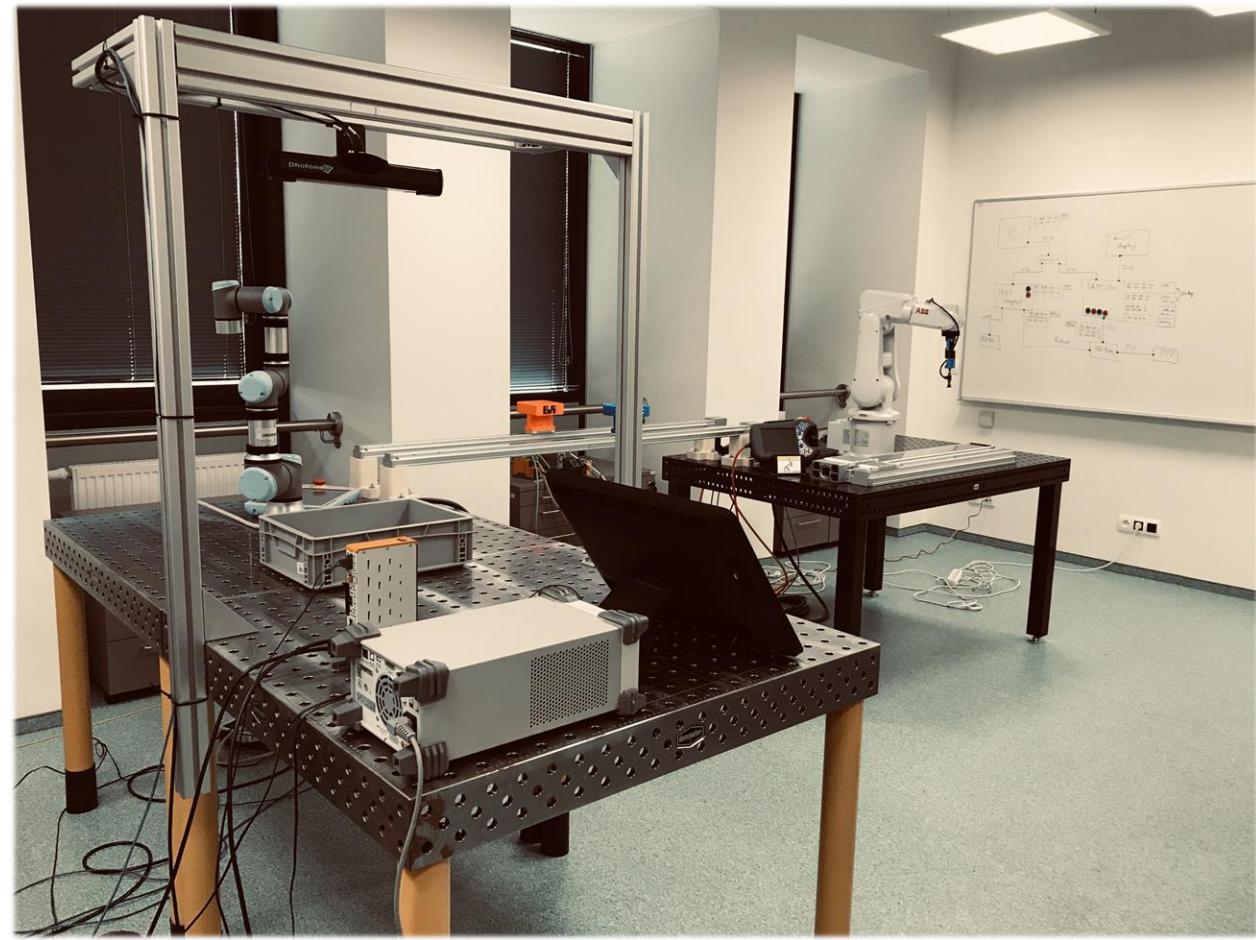
# Electric switchboard



# 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 HMI panels arranged in a 2x2 grid, each showing a different industrial control interface:

- Top Left Panel (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 displays 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 Panel (SMC PAD {MOVE}):** Shows a graphical representation of a cylinder with a slider for Position (5,810.0) and a button for Velocity (8000.0 [Units]). To the right are two line graphs showing cylinder position and velocity over time. Below the graphs are parameters for SMC Trak: Actual Position (5810.00 [Units]), Actual Velocity (0.00 [Units/s]), Actual Position (5810.00), and Actual Velocity (0.00).
- Bottom Left Panel (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 7th Ax. - Safety State. The "open SAFETY" logo is prominently displayed.
- Bottom Right Panel (UR3 {MOVE}):** Shows controls for the UR3 robot. It includes Joint Control (Joint 1-6), Cartesian Control (TCP/EA, X, Y, Z, RY, RZ), and Joystick Control (START (TCP), STOP (TCP), START (EA), STOP (EA)). A ZPR Vacuum Gripper component is shown with its TCP parameters (X, Y, Z, QW, QX, QY, QZ) and Attached status. Below the gripper are parameters for the SMC Gripper: ATTACH, DETACH, and various coordinate values.

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



# System Integration

# System Integration



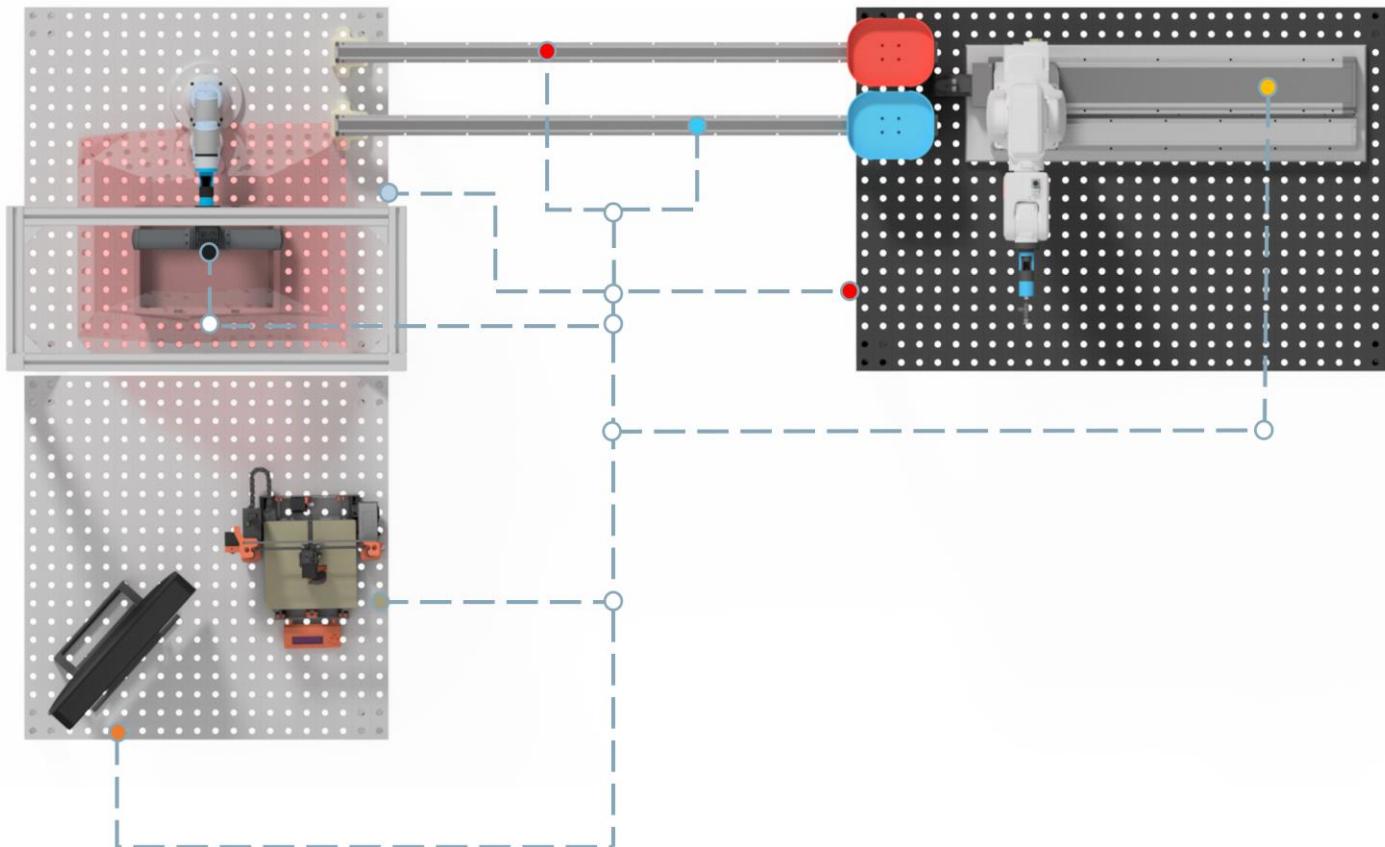
EtherNet/IP®



ETHERNET  
POWERLINK

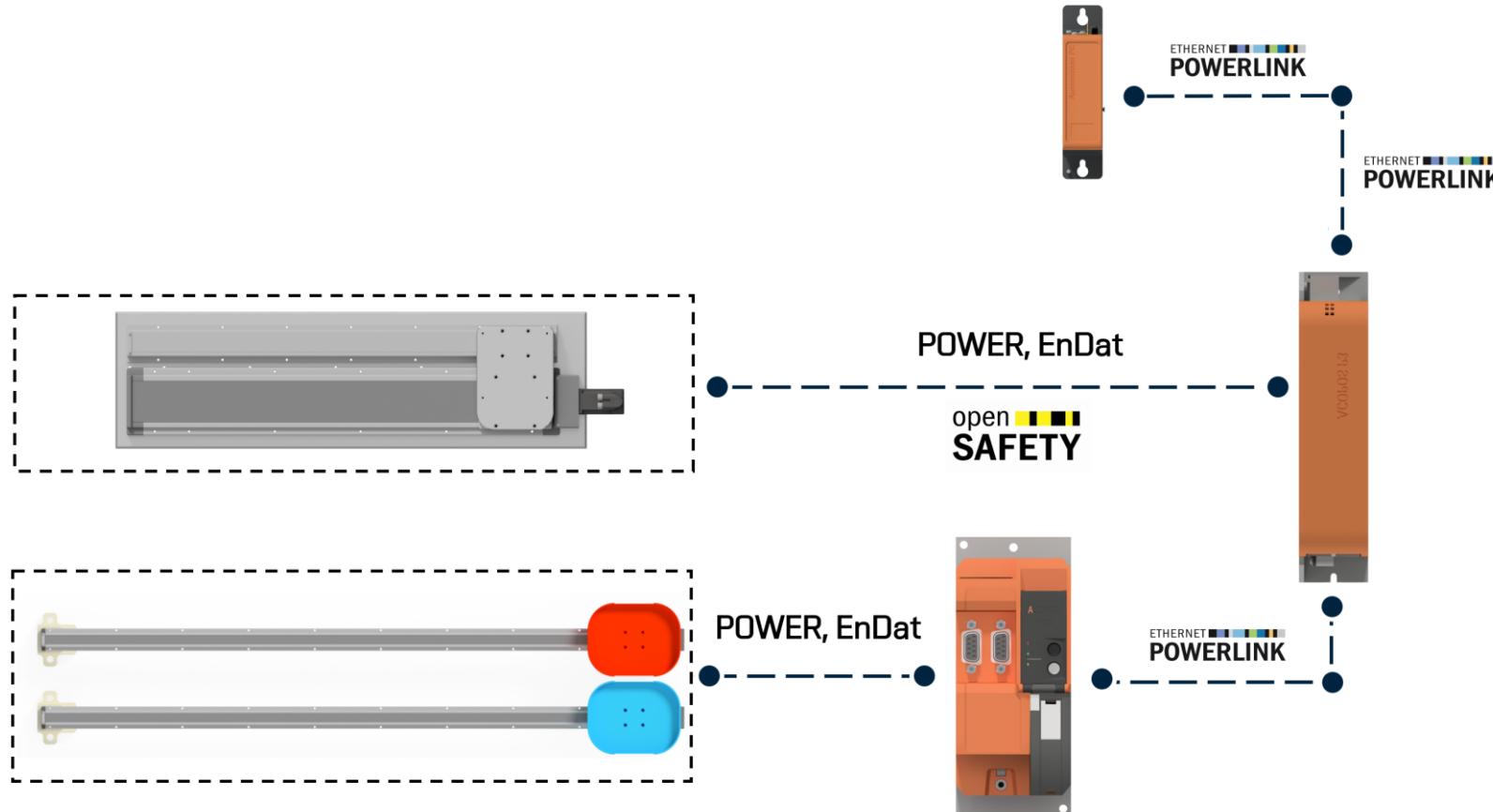


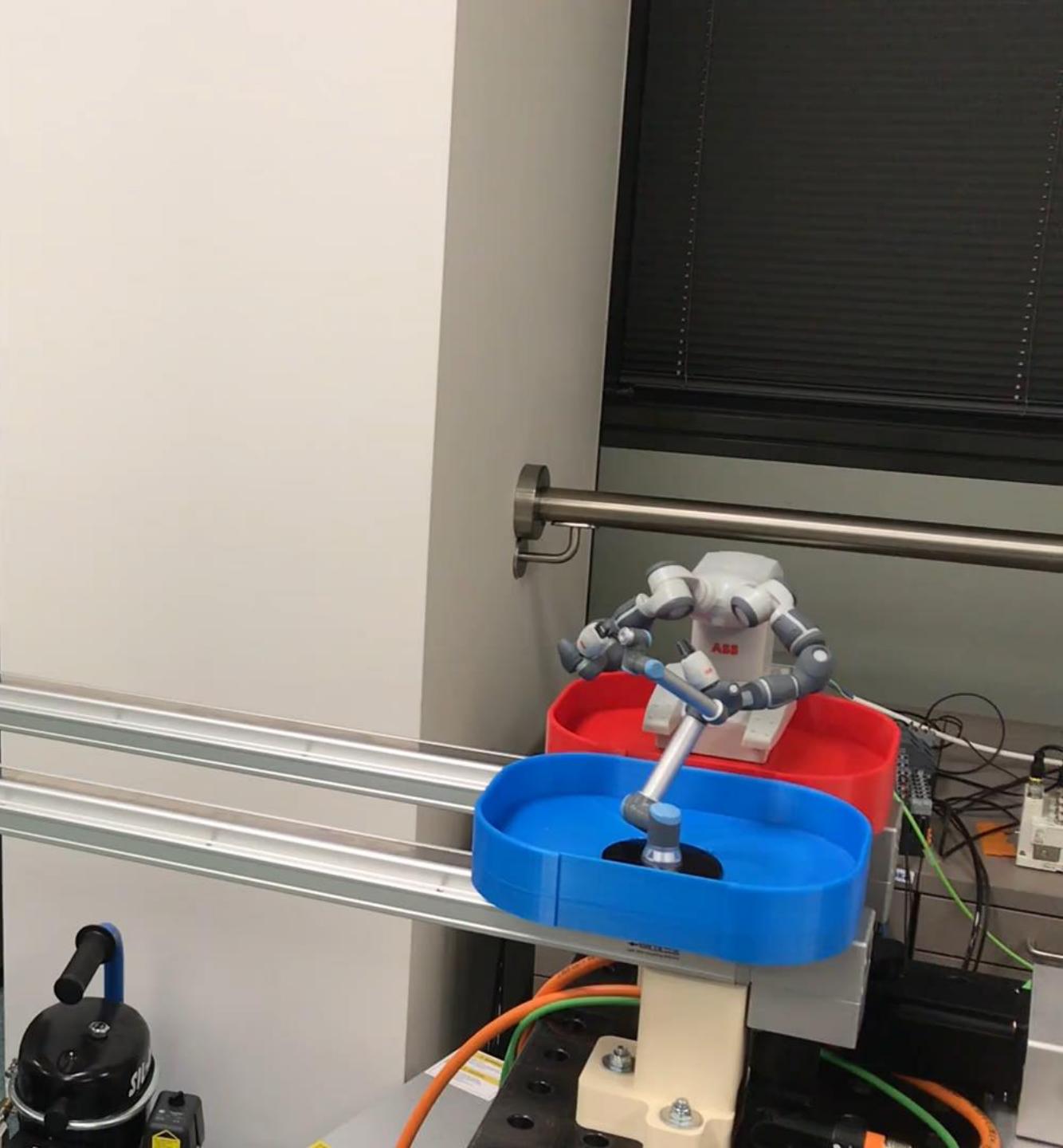
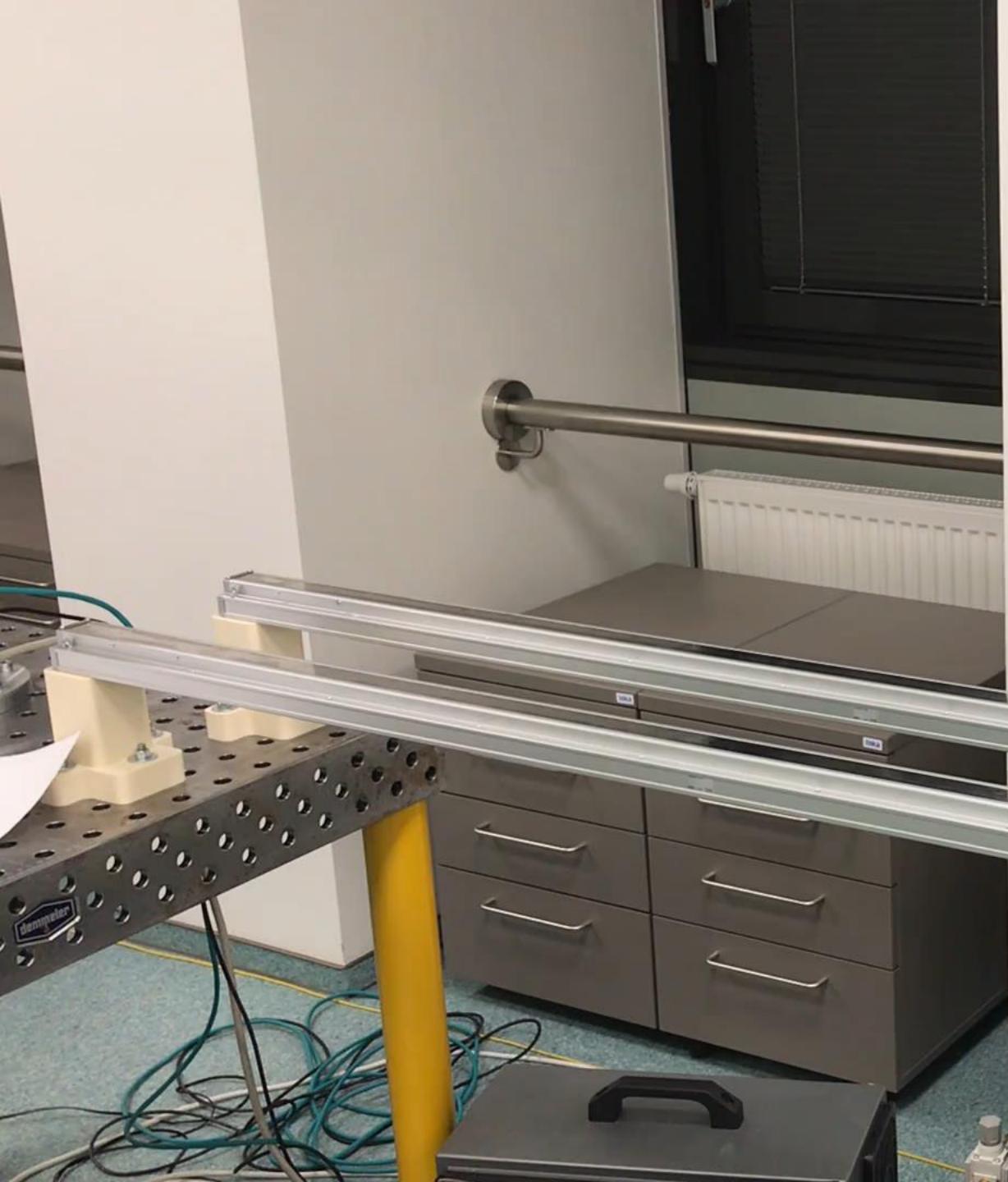
PROFI  
NET®



# System Integration

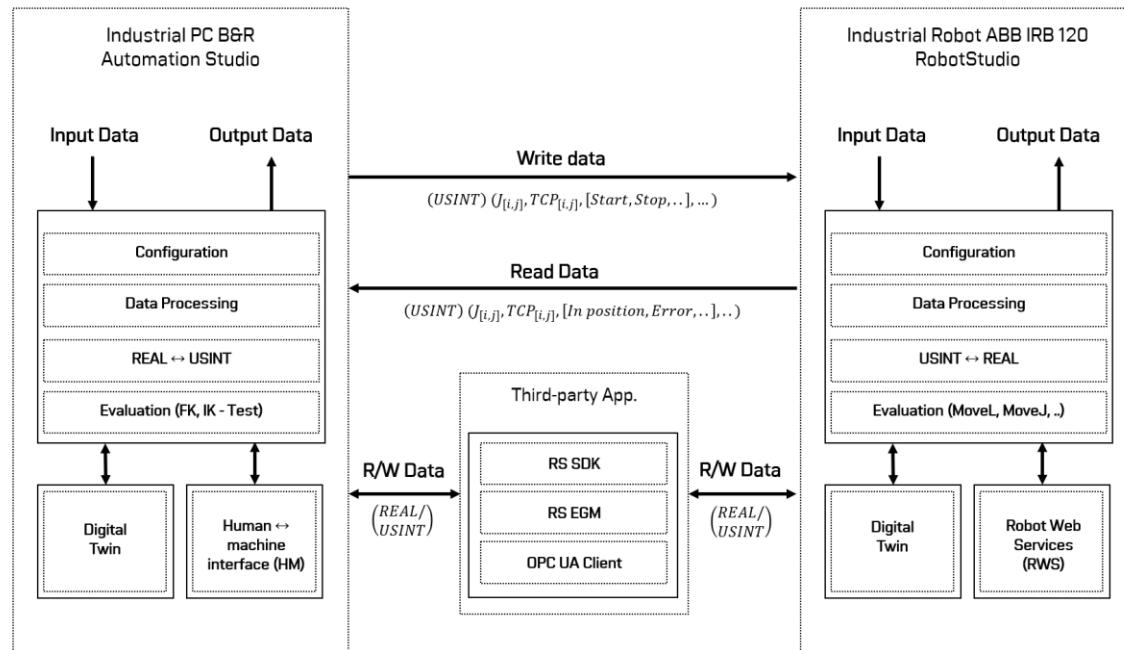
Industrial PC ↔ Synchronous motor:



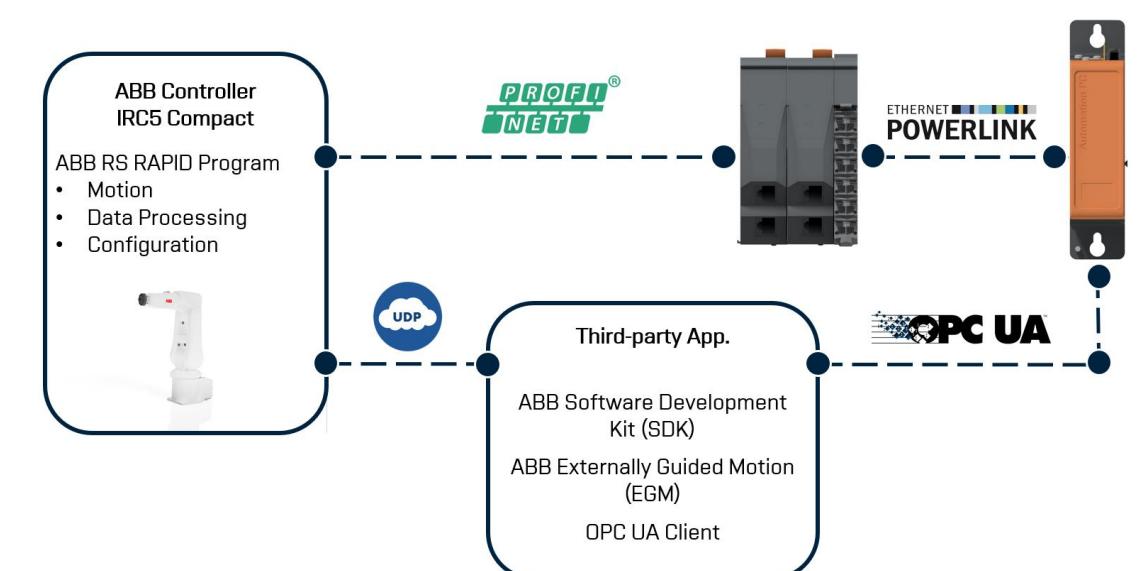


# System Integration

## Industrial PC ↔ ABB IRB 120:



Sys. Integration Scheme



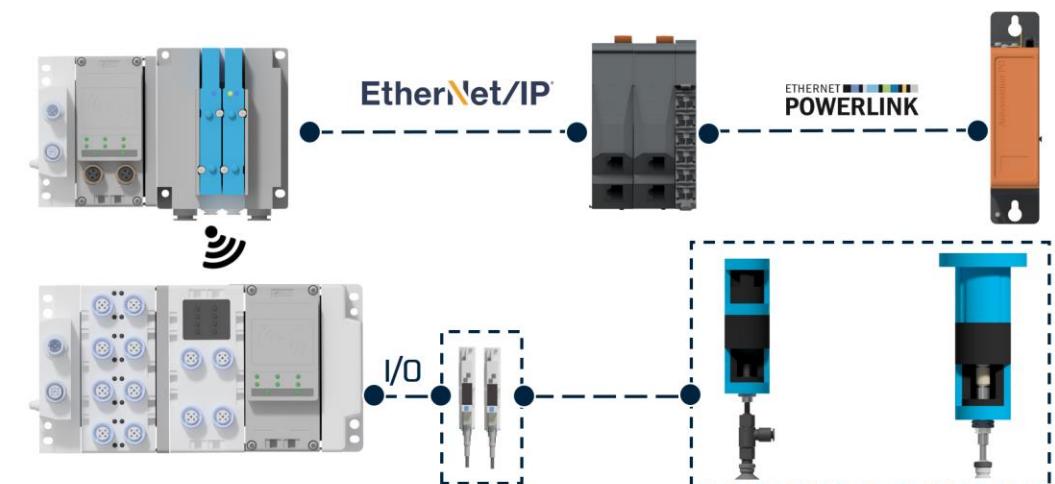
Wiring Diagram

# System Integration

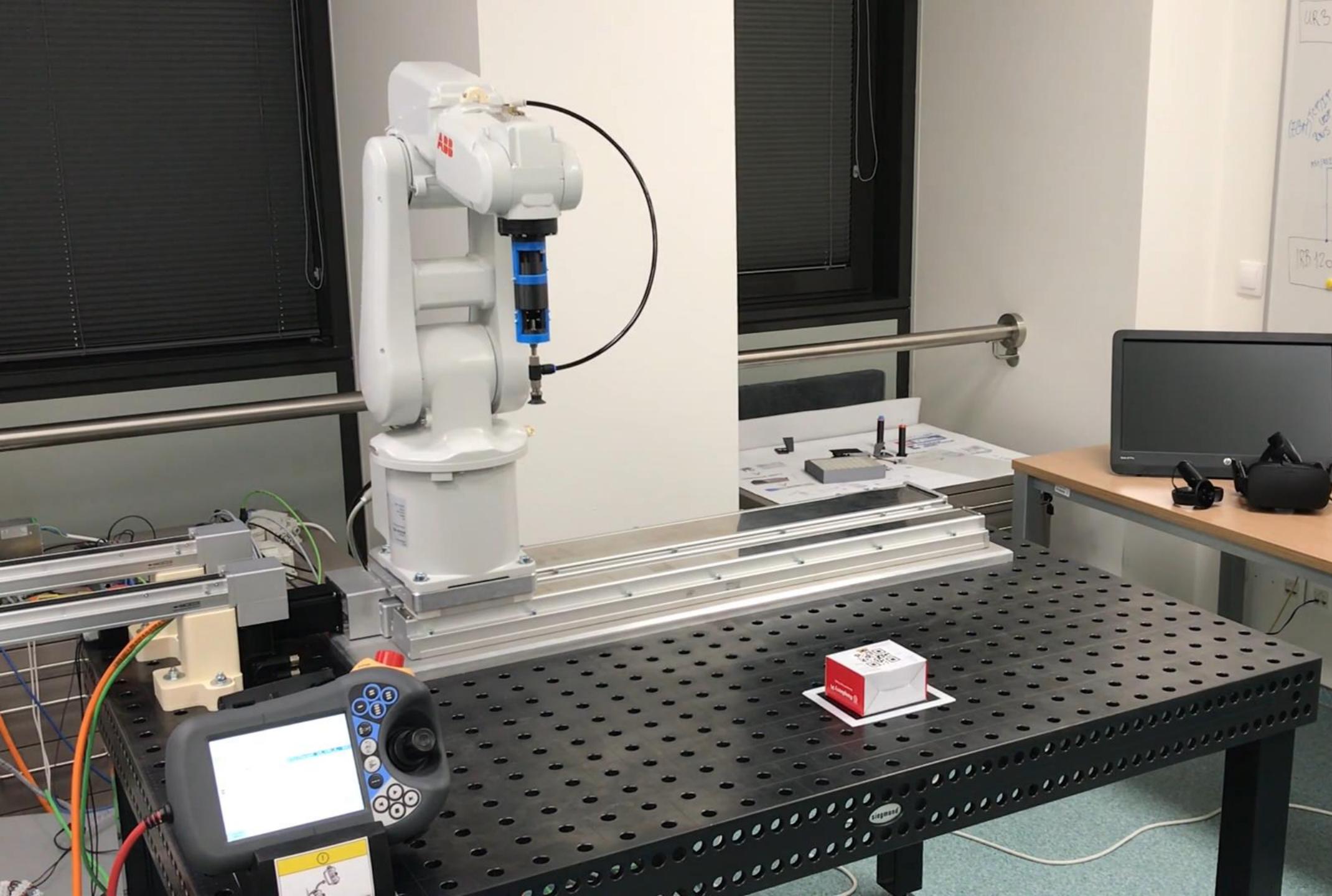
## Industrial PC ↔ EX600 Wireless:



# Sys. Integration Scheme



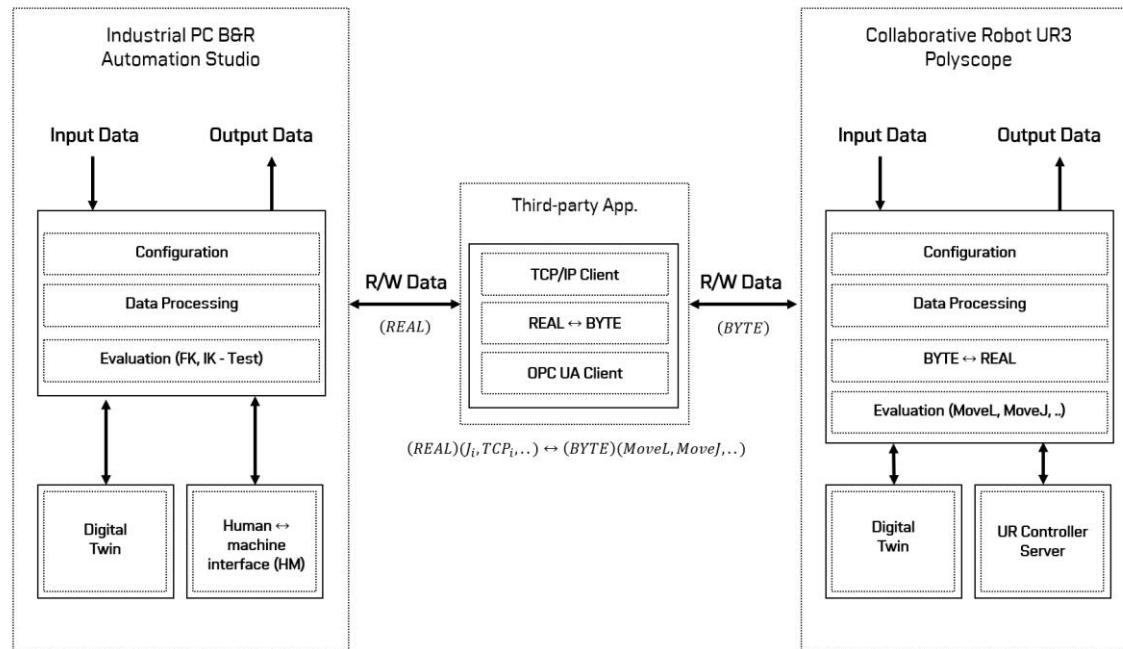
## Wiring Diagram



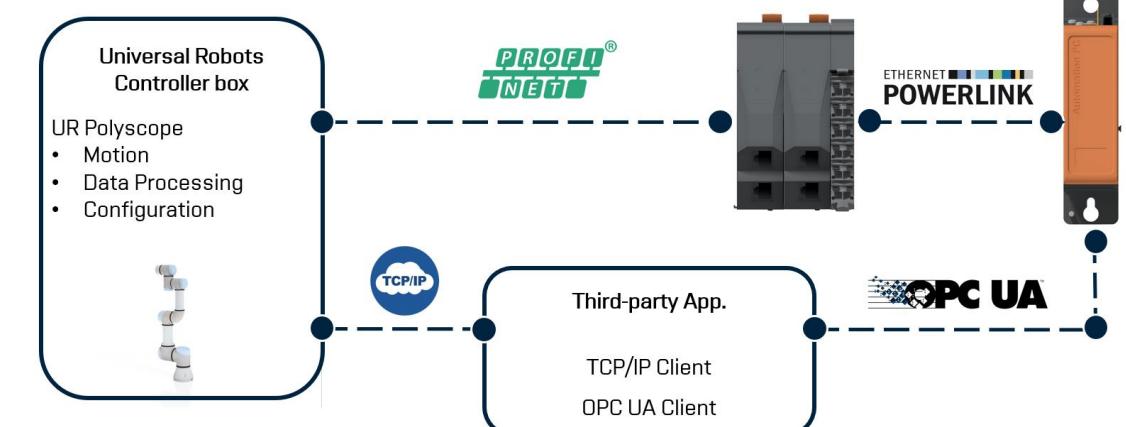
Springer  
**Handbook of  
Robotics**  
Bartosh, Elio, Eds.  
2nd Edition

# System Integration

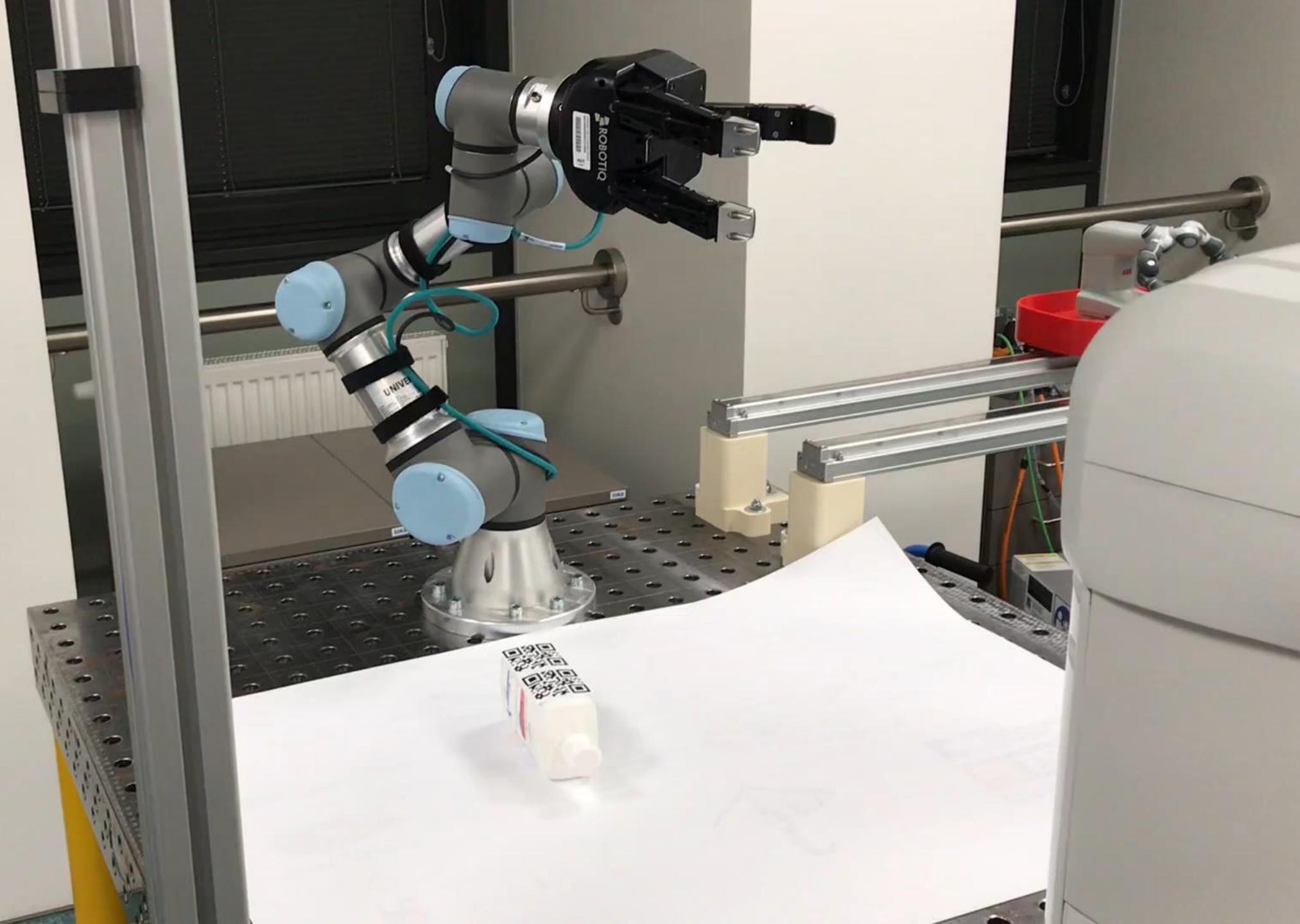
## Industrial PC ↔ Universal Robots:



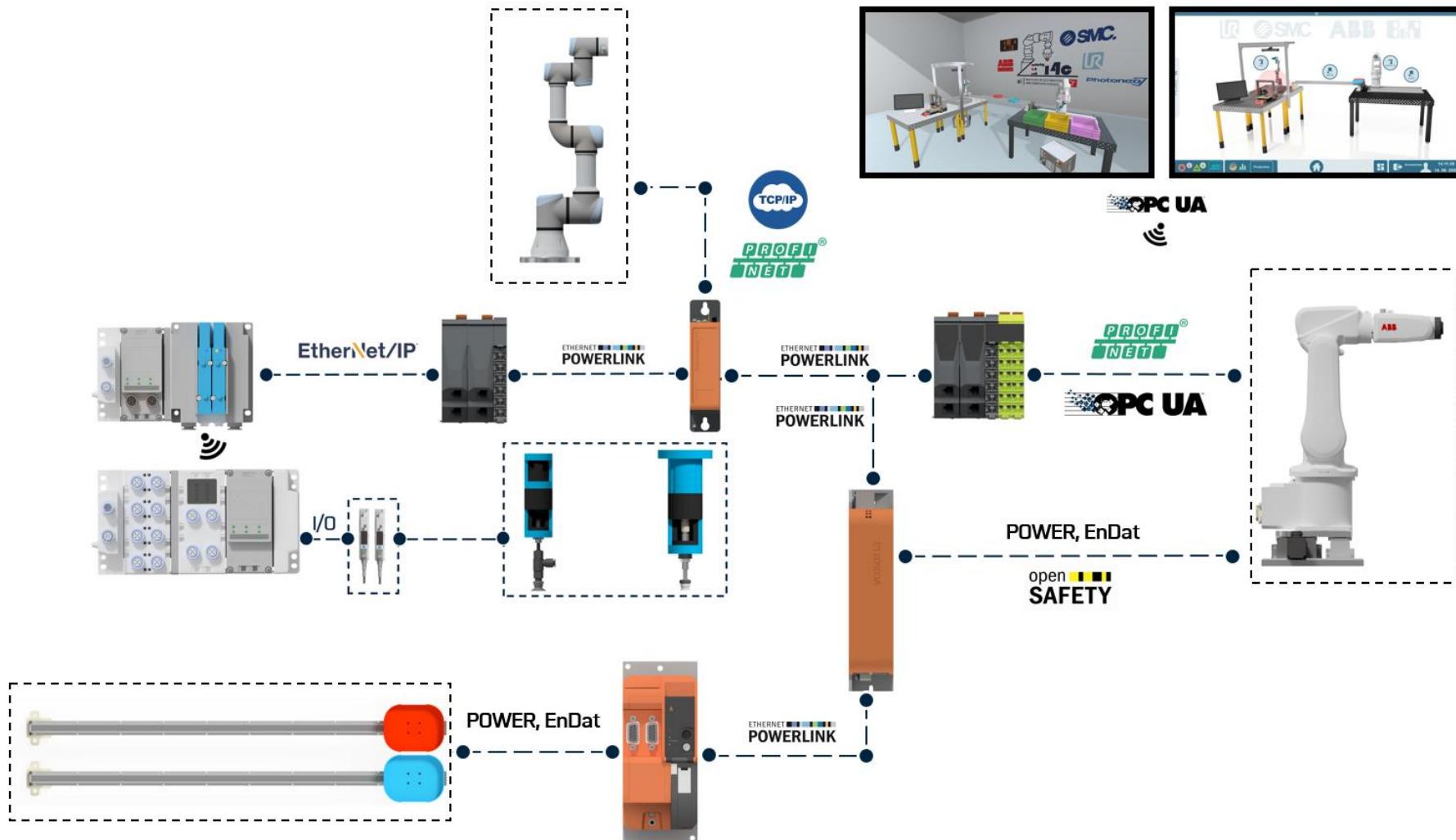
Sys. Integration Scheme



Wiring Diagram



# System Integration



# Virtual / Digital Twin

# Virtual / Digital Twin

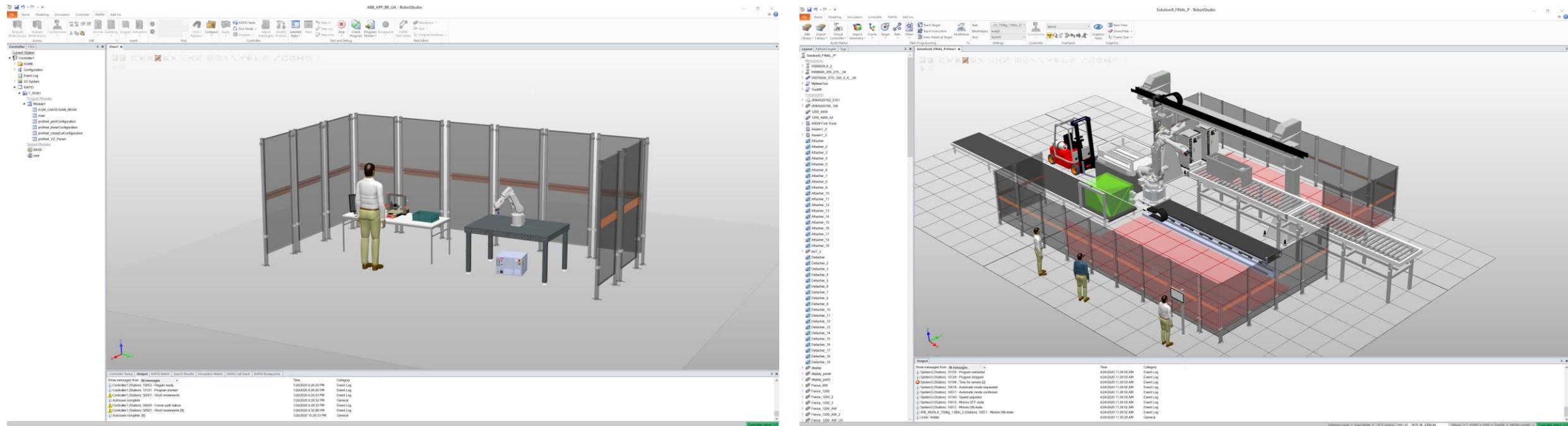


ABB RobotStudio

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

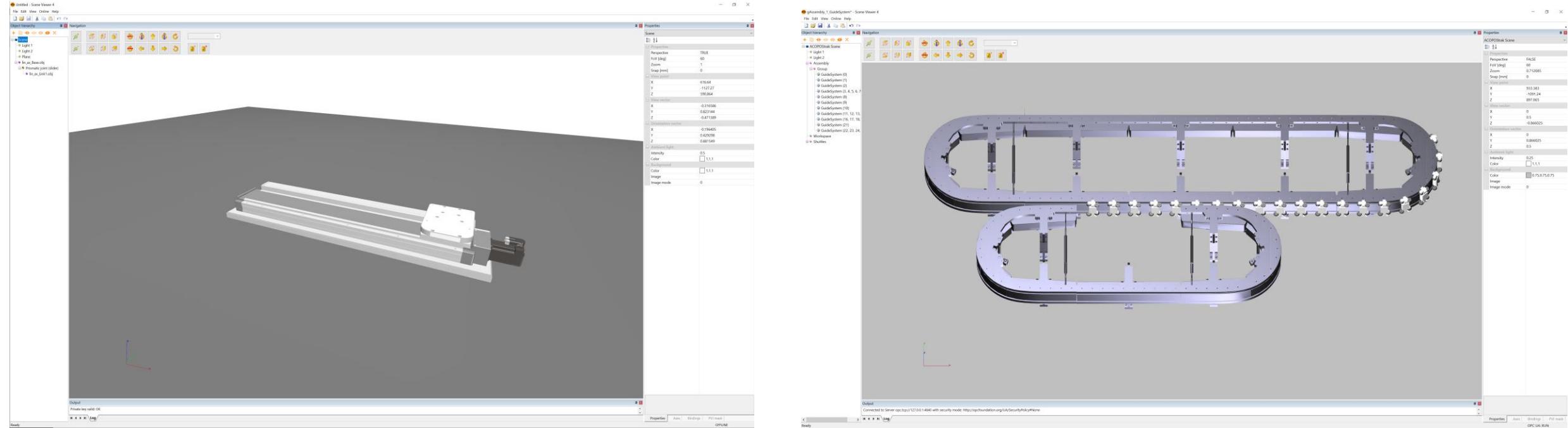
Controller1 (Station): 10125 - Program stopped  
Controller1 (Station): 10002 - Program pointer has been reset

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

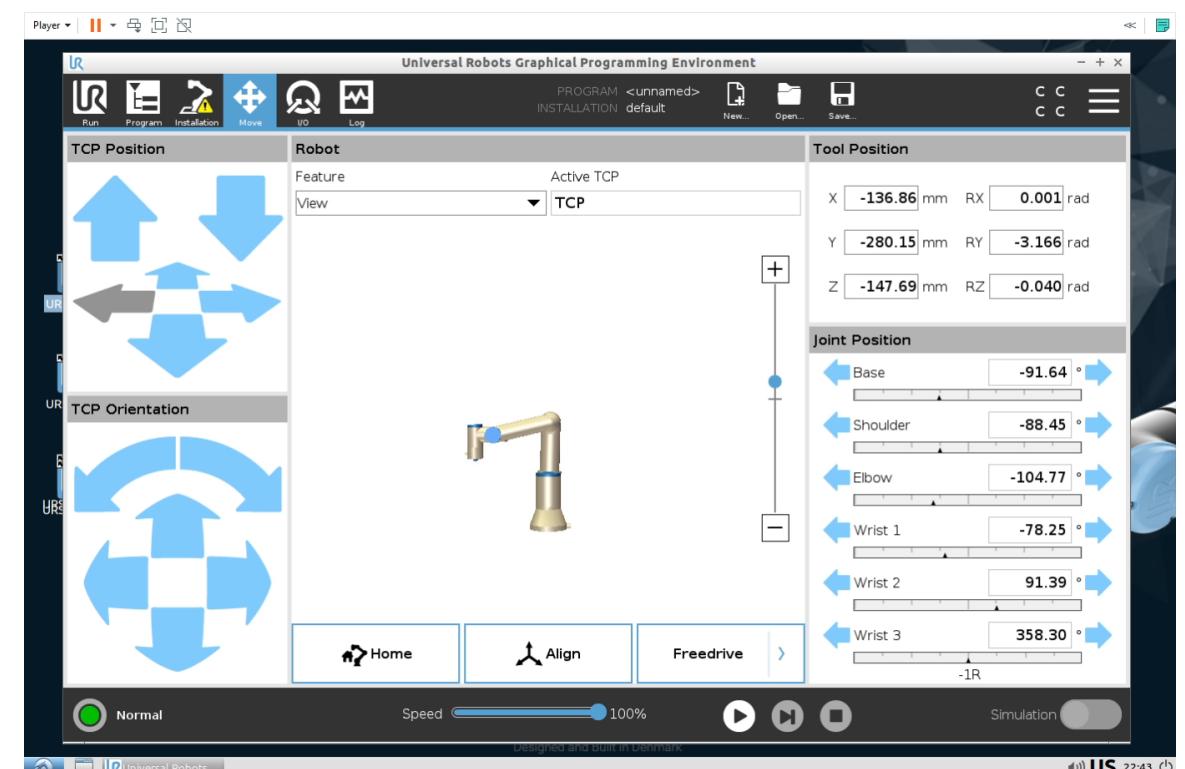
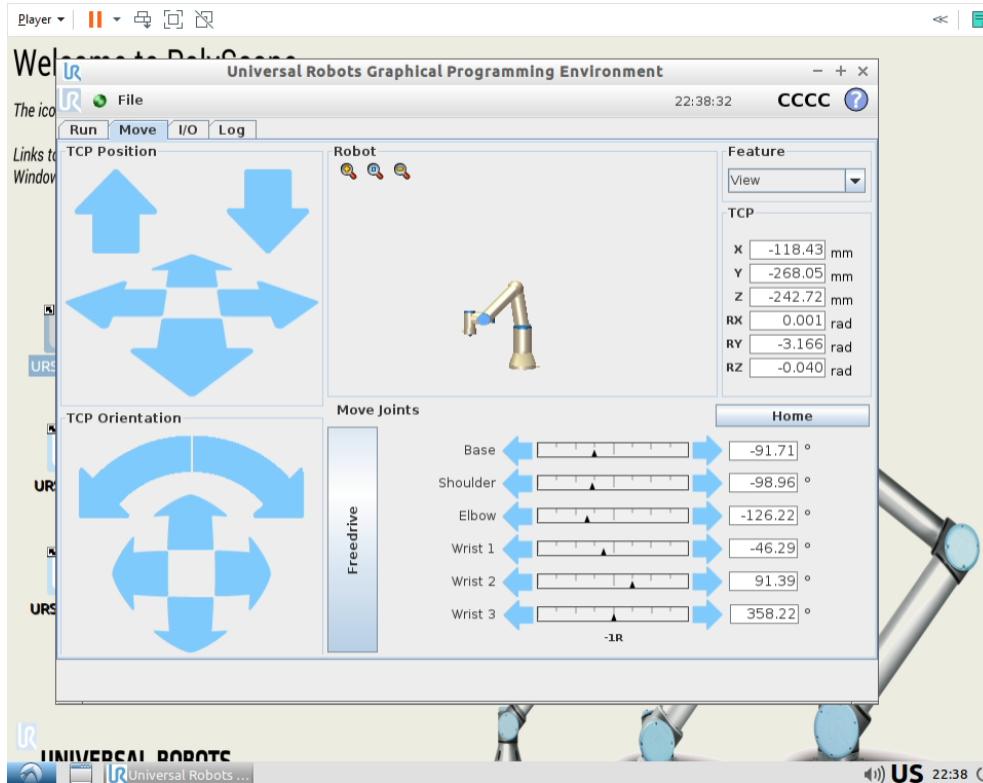
# Virtual / Digital Twin



B&R Automation - SceneViewer

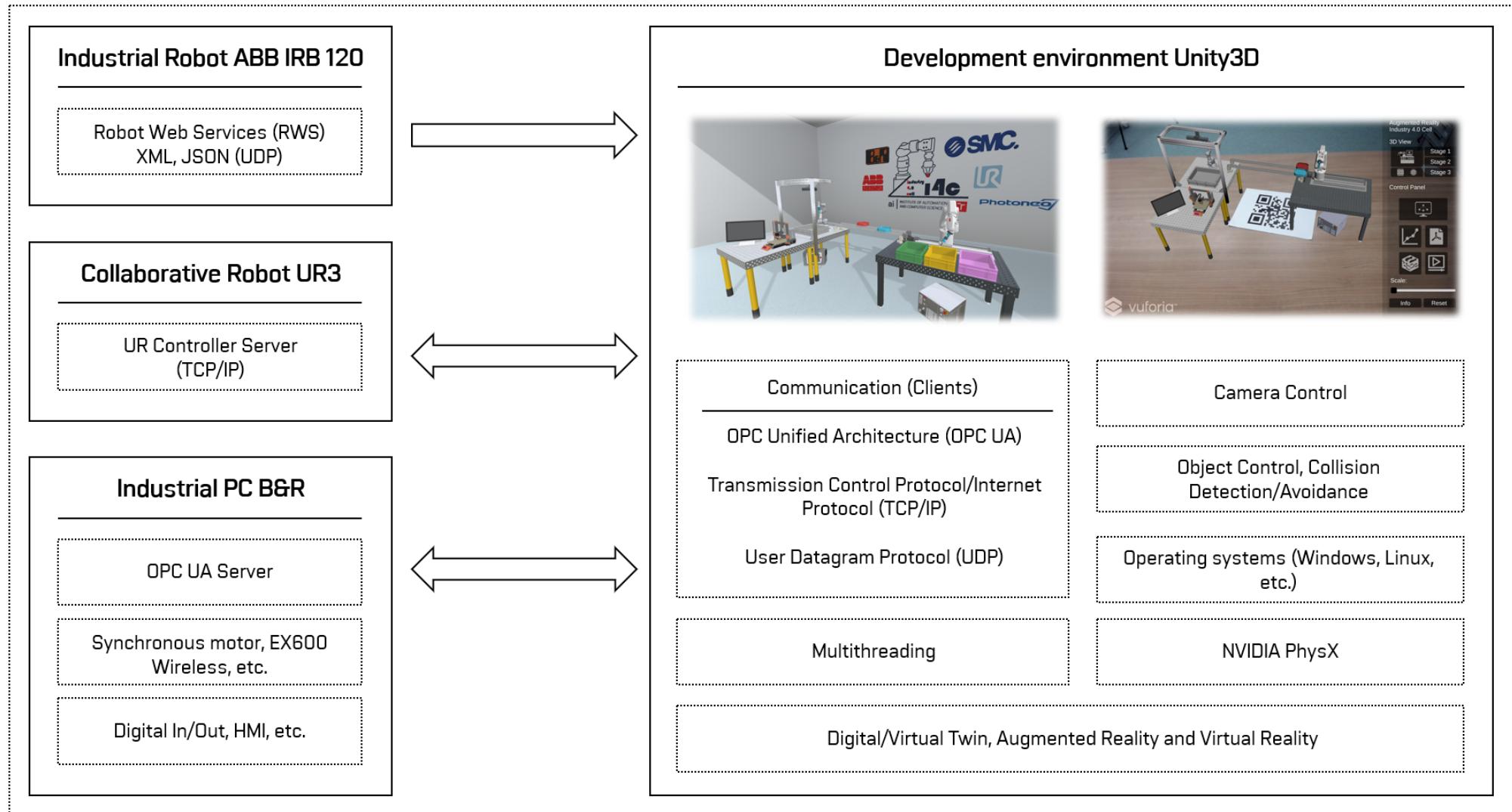


# Virtual / Digital Twin



UR – Polyscope

# Virtual / Digital Twin



# Virtual / Digital Twin

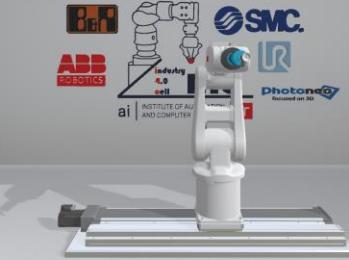
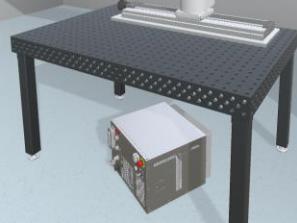
OPC UA™

unity

blender®



# Virtual / Digital Twin



# Virtual / Digital Twin



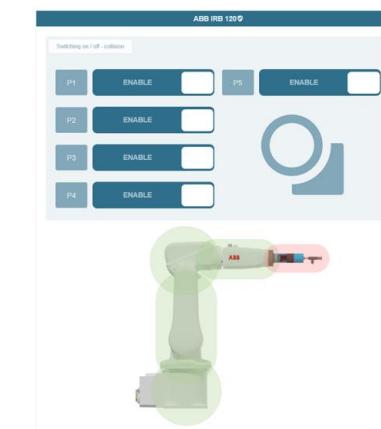
Object

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

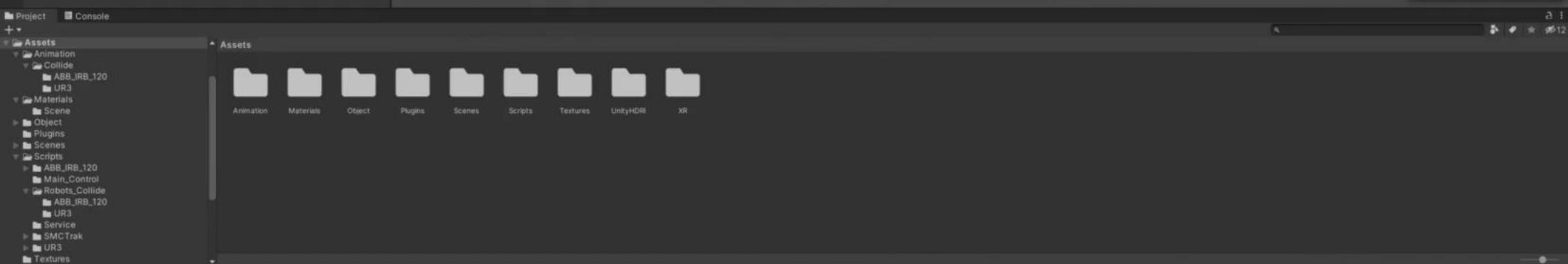
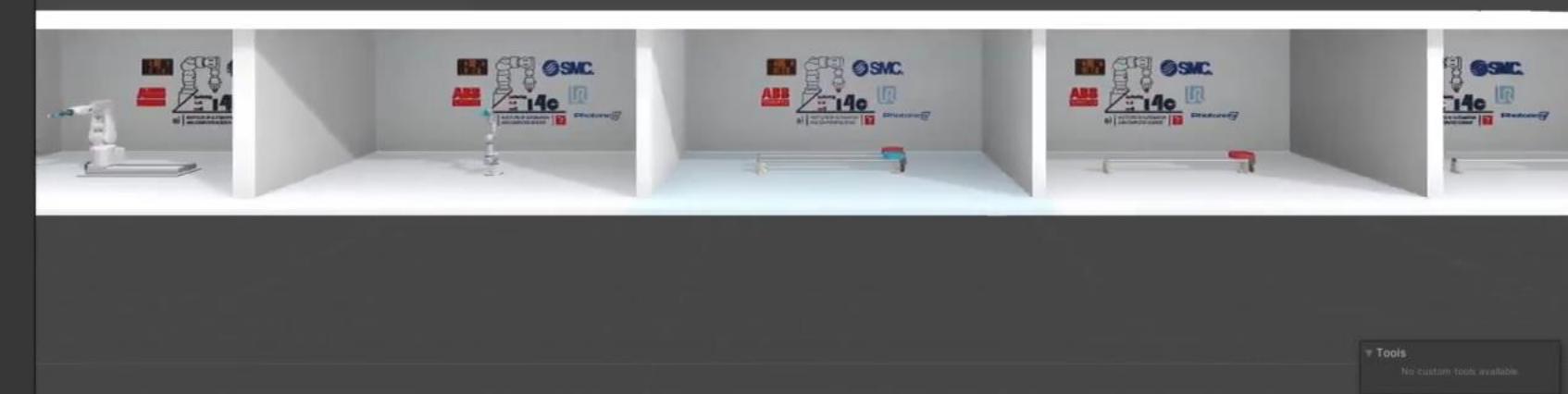
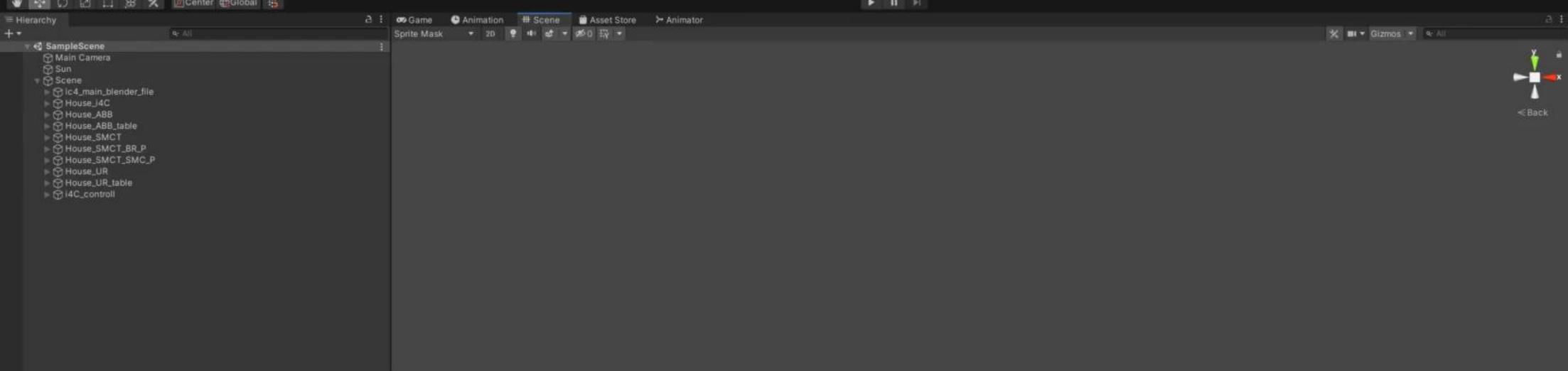
**Set Parameters**   **Reset Parameters**   **Default Parameters**

## Object Control

# Virtual / Digital Twin



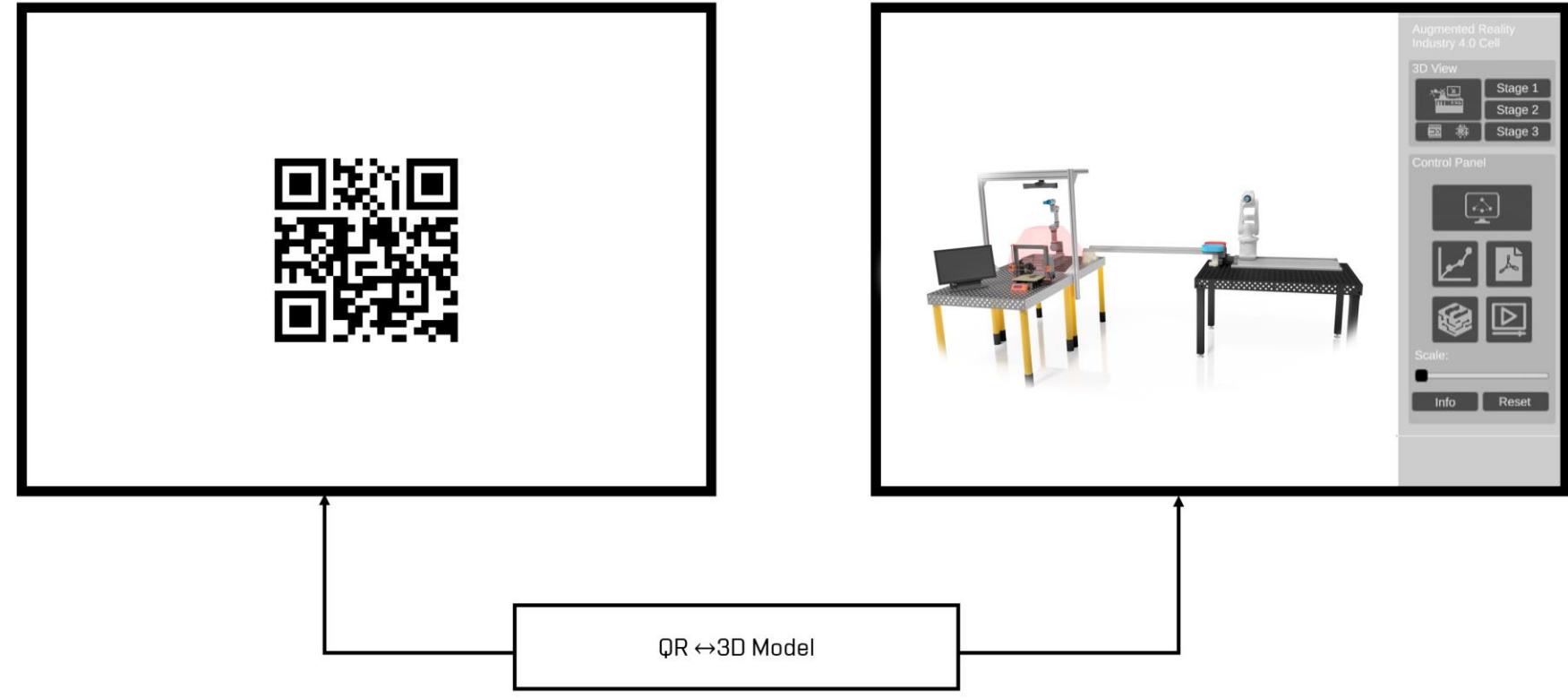
Collision avoidance





# Augmented Reality

# Augmented Reality



# Augmented Reality



Advanced AR – Diagnostics (Industry 4.0 Cell)

# Augmented Reality



Advanced AR – Diagnostics (Industry 4.0 Cell)



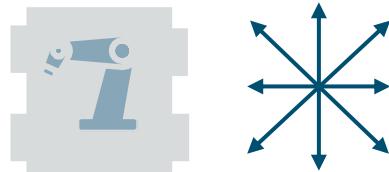
# Vision of the future

# Vision of the future



# Autonomous Driving Industrial Robot

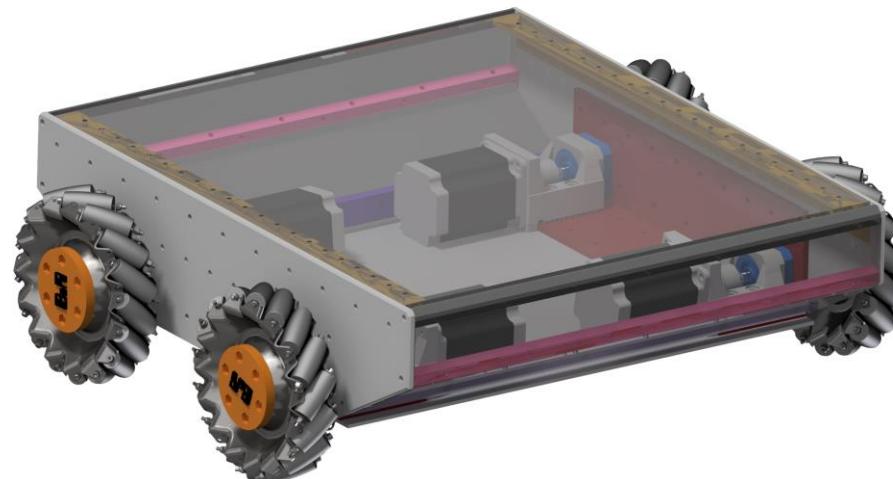
Autonomous Driving  
Industrial Robot

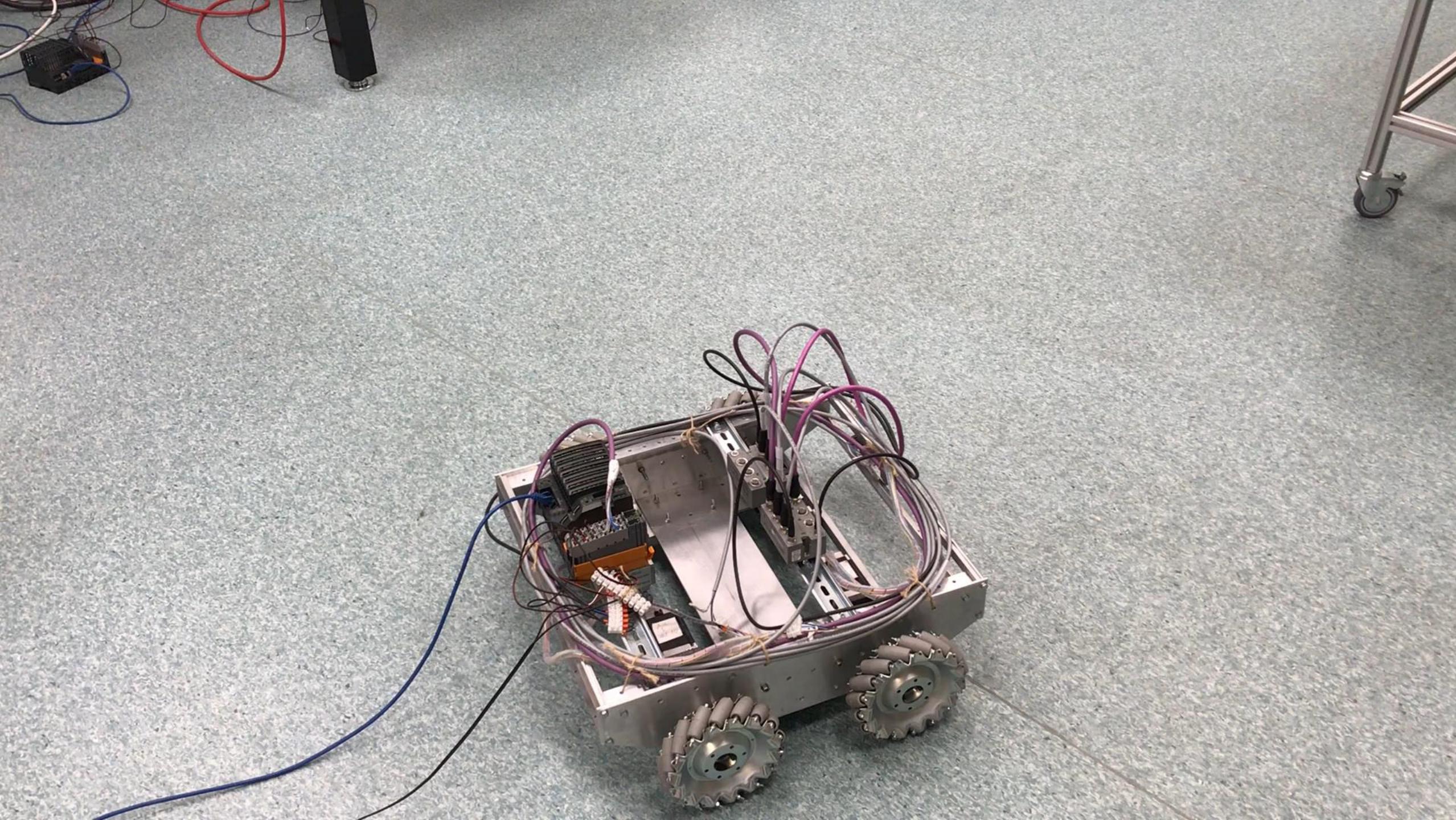


OPC UA™

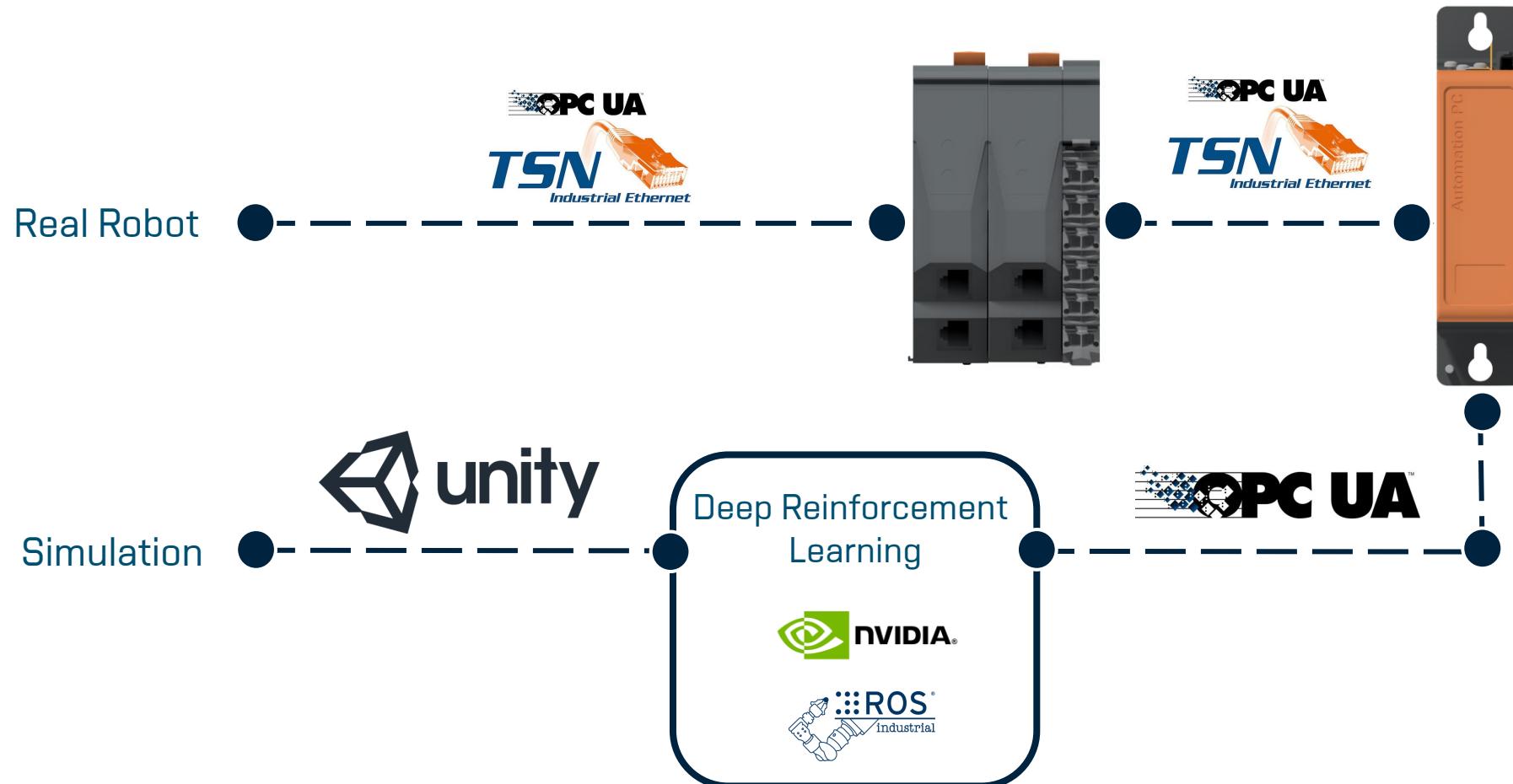
**TSN**  
Industrial Ethernet

ETHERNET  
**POWERLINK**

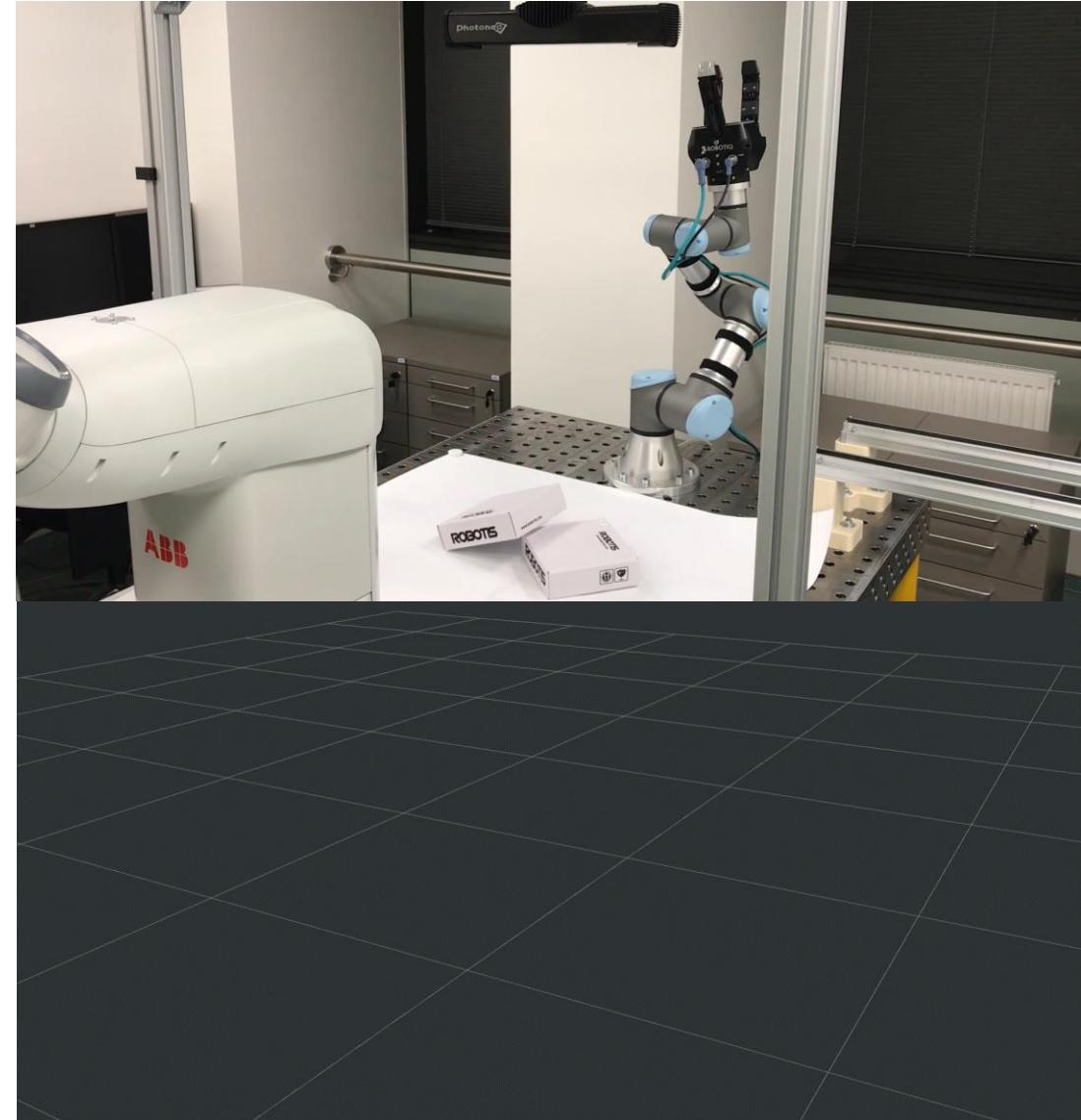
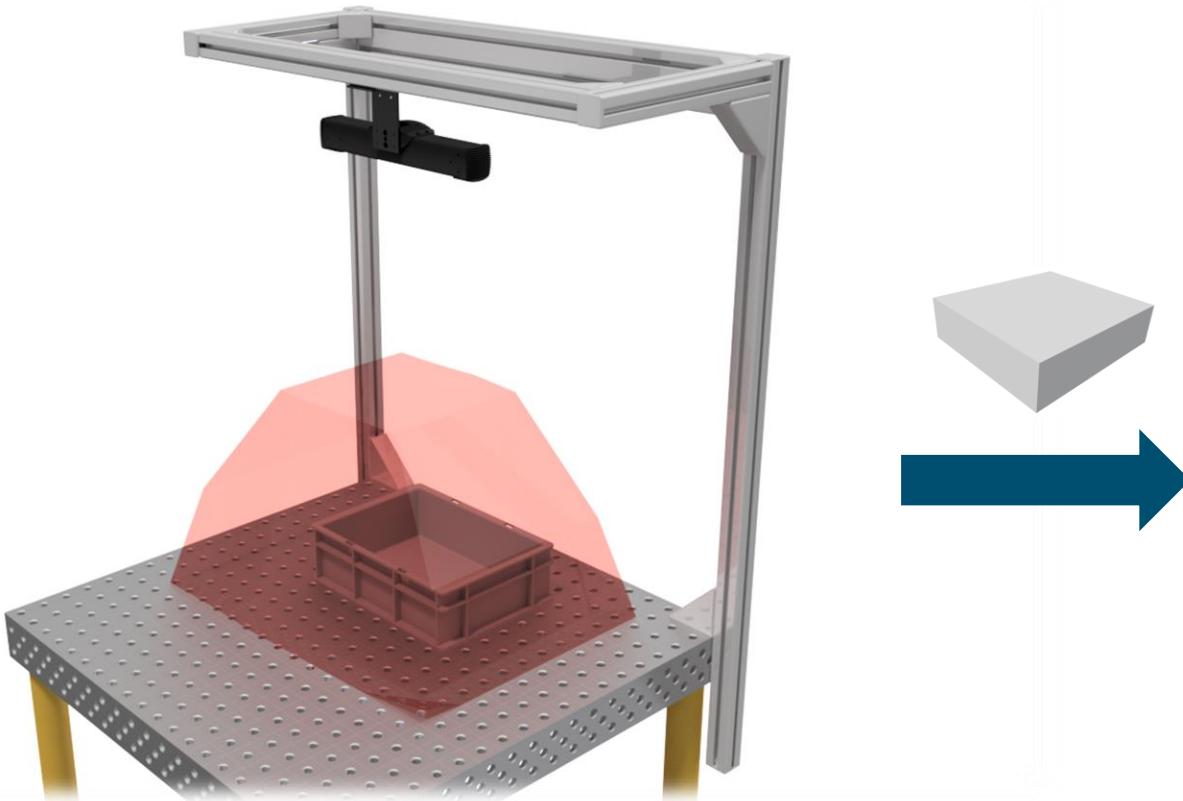




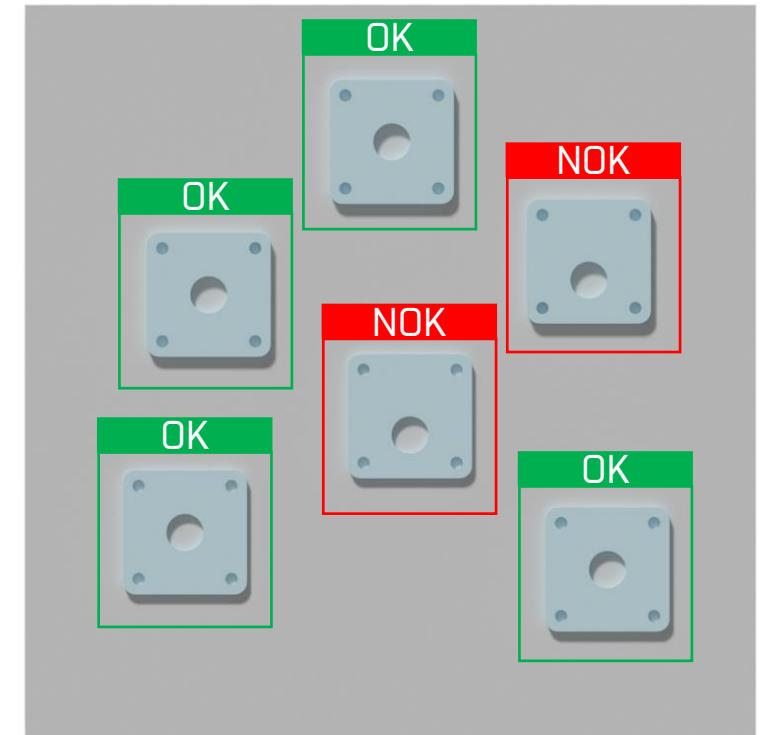
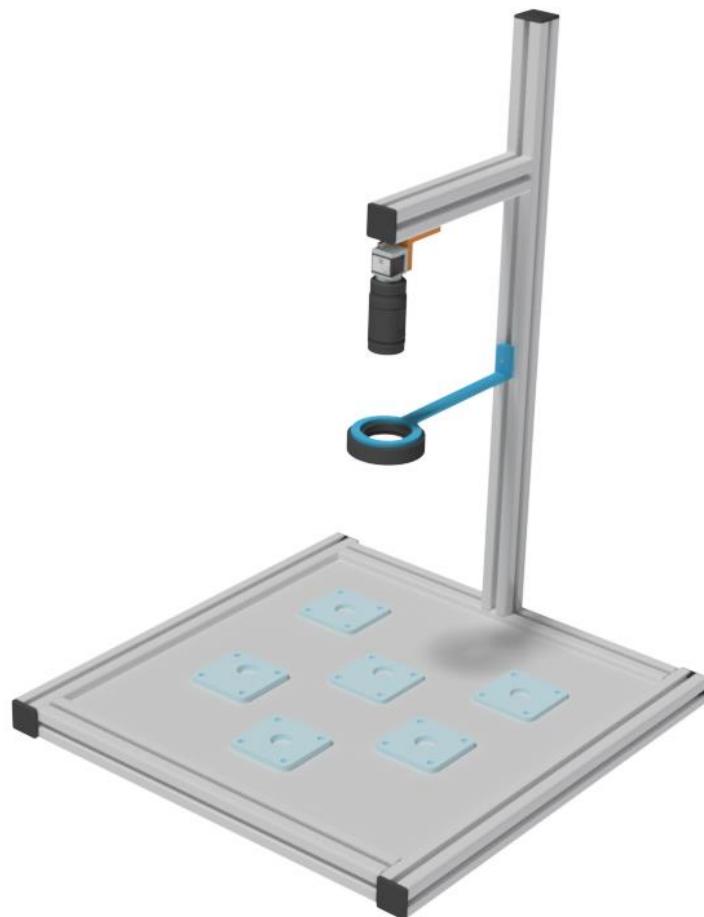
# Trajectory optimization



# 3D object recognition (Bin-Picking)



# Visual inspection



# Projects

# Projects

## University Projects:

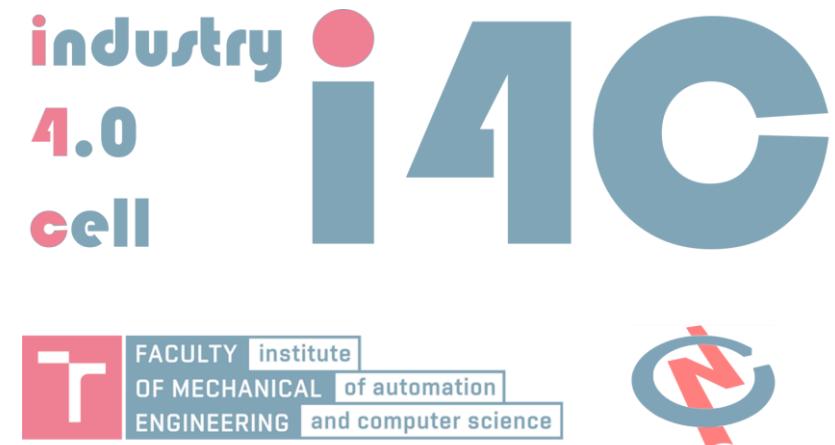
- Technology Agency of the Czech Republic (TACR), The Czech Science Foundation (GACR)
- Innovation Voucher
- Ministry of Industry and Trade
- etc.

## 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

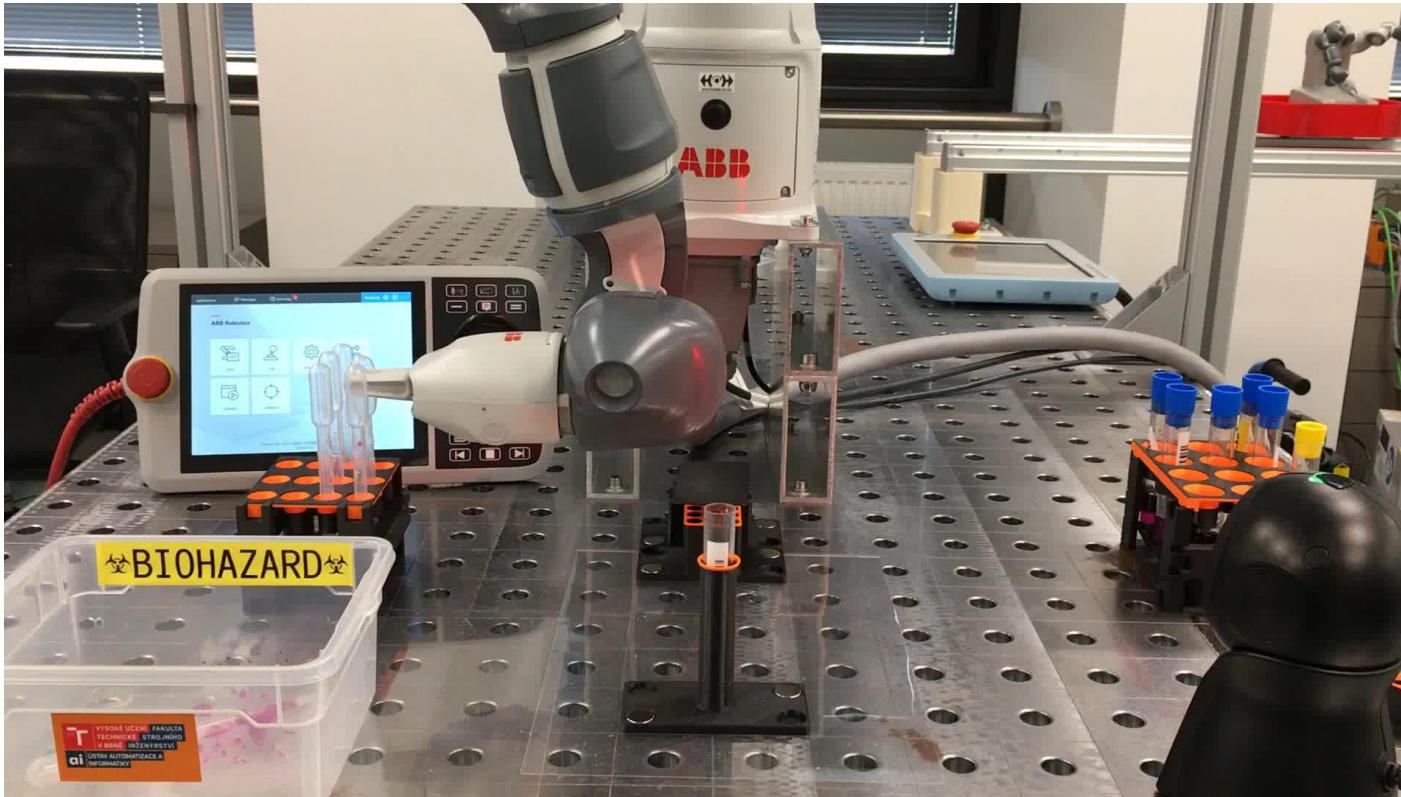
## Product Overview

SMC Industrial Automation

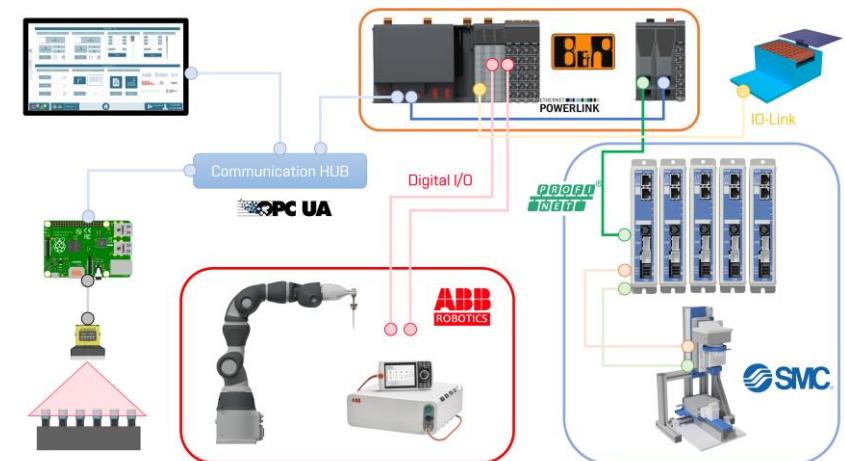
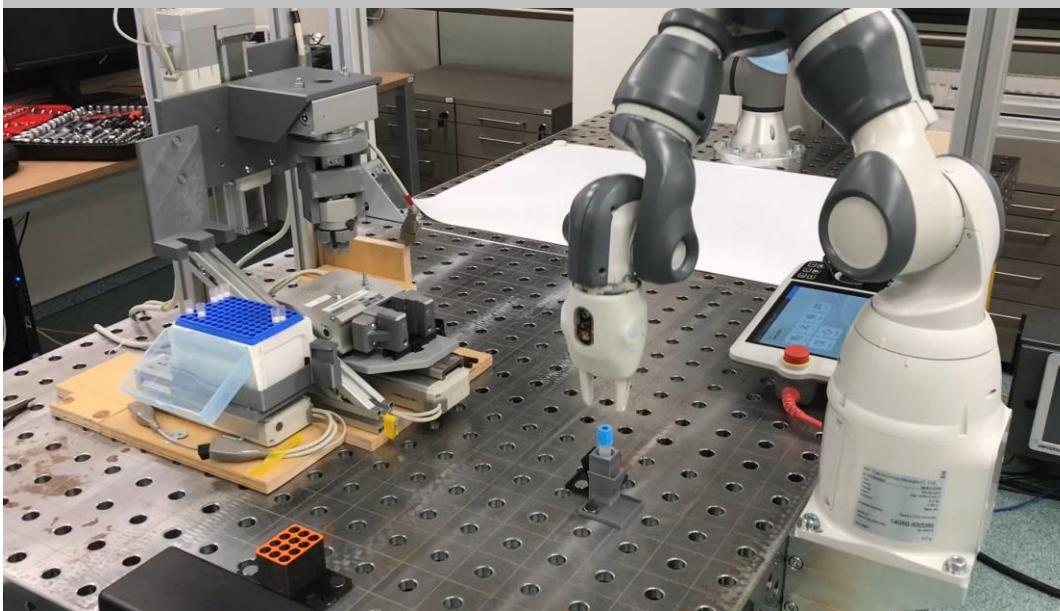
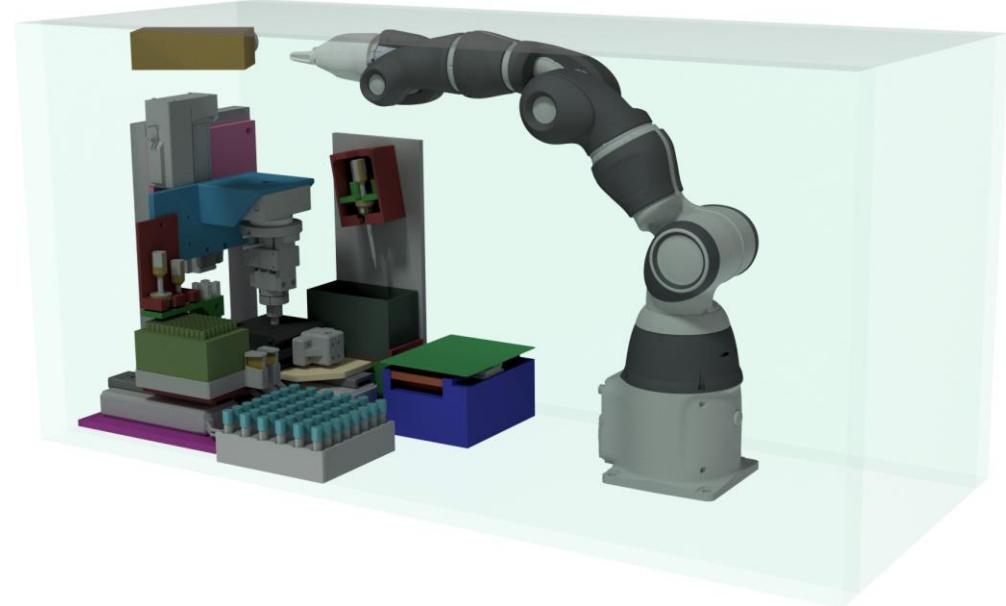
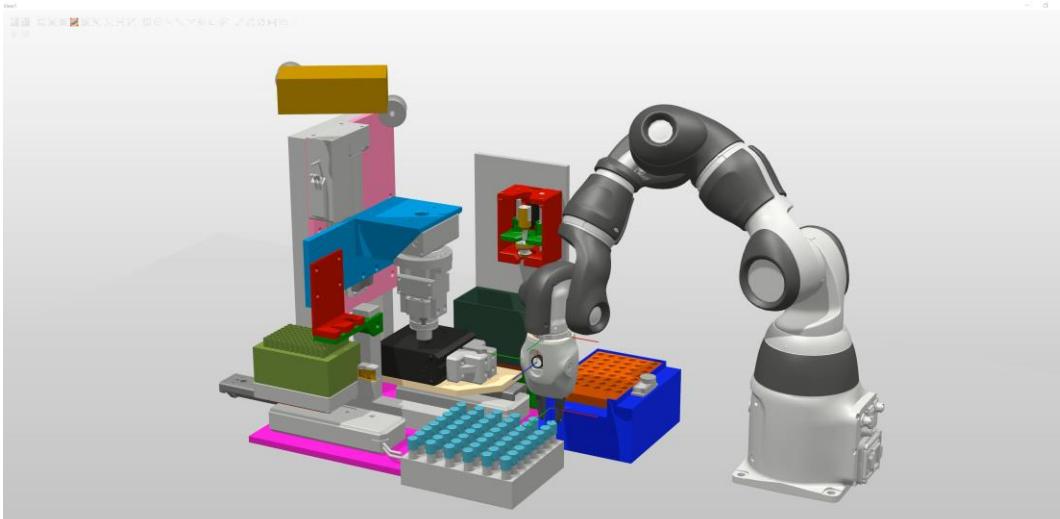
# Projects

## Other Projects:

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



# Projects



Industry 4.0 cell

# Contact



MSc. Roman Parak

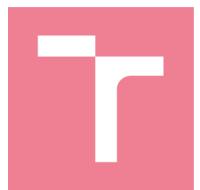
Research & Development  
Cybernetics and Robotics Division

Contact:

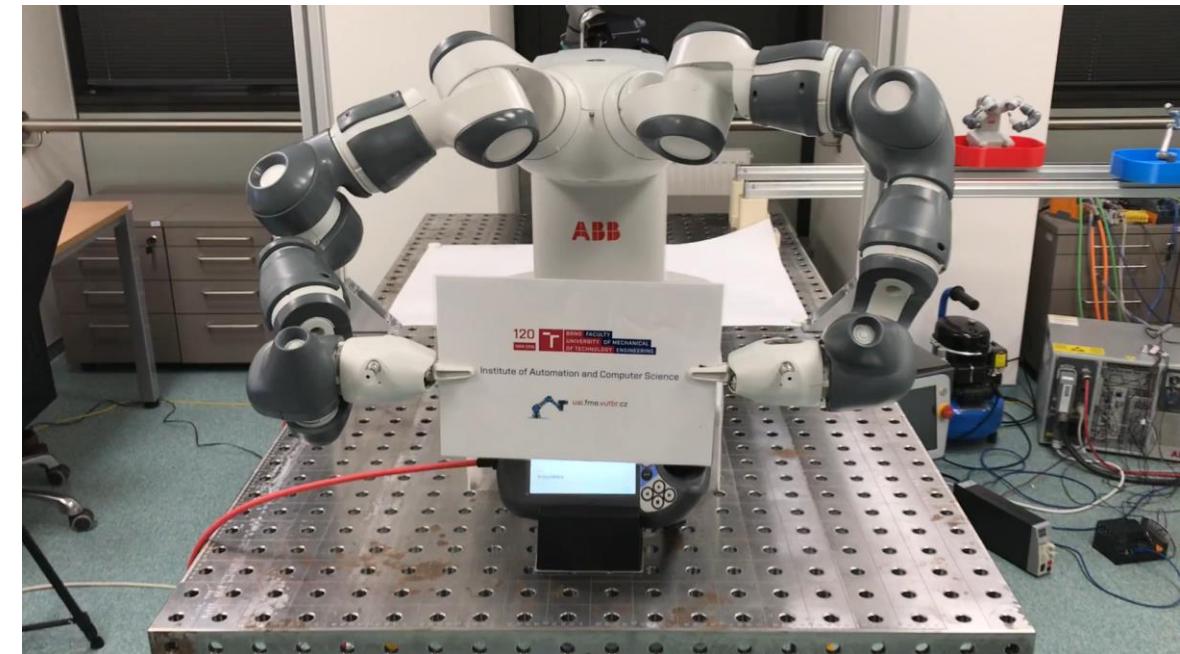
E-mail: [Roman.Parak@vutbr.cz](mailto:Roman.Parak@vutbr.cz)

Room:

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

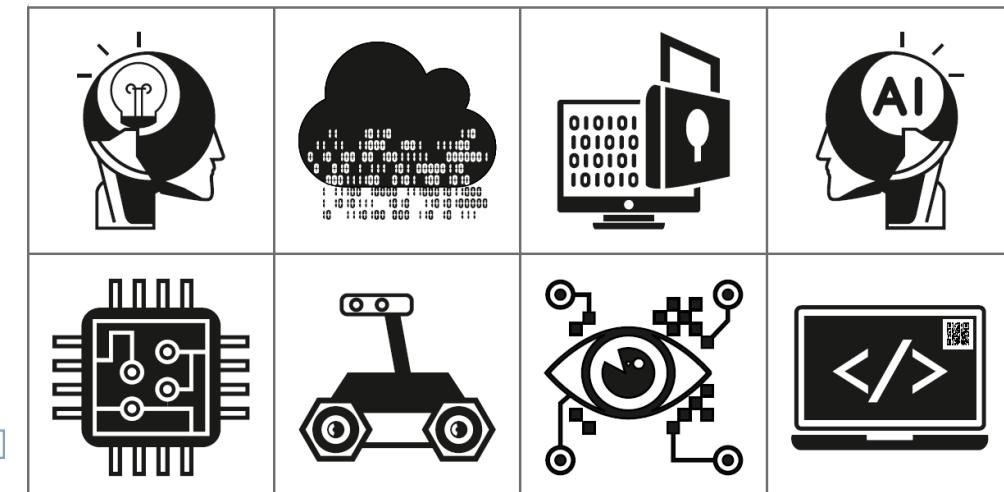
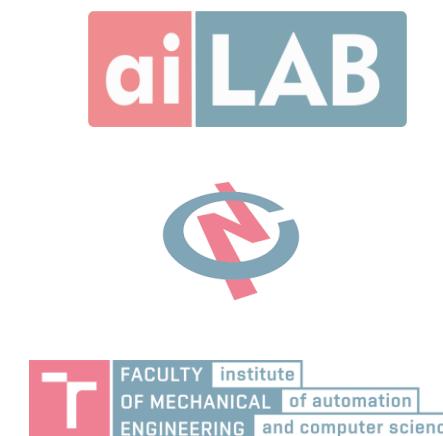
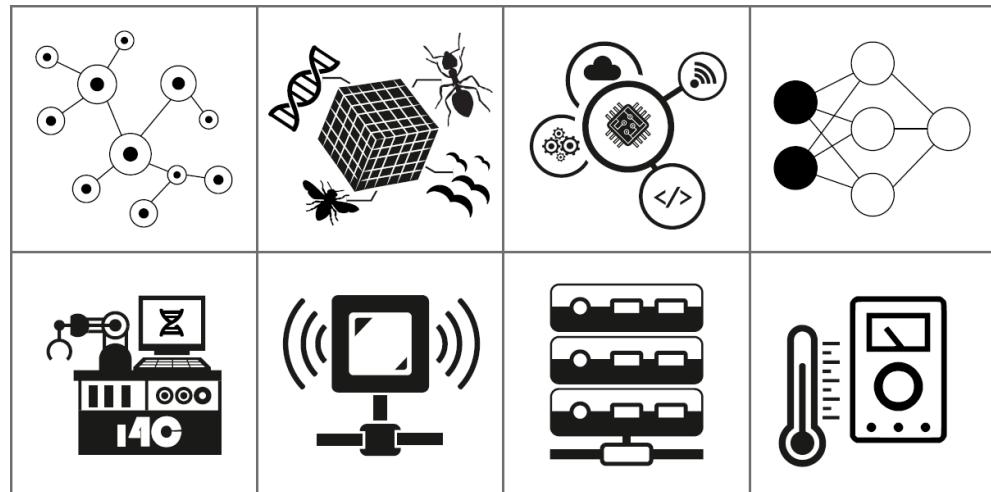


FACULTY institute  
OF MECHANICAL of automation  
ENGINEERING and computer science



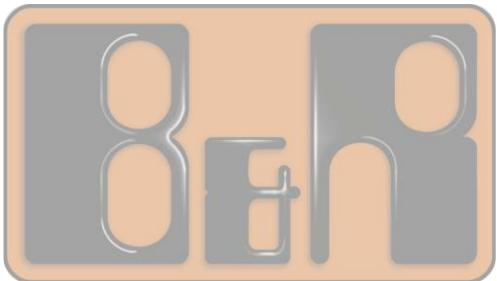


Roman Parak

Institute of  
Automation and  
Computer  
Science

# Partners

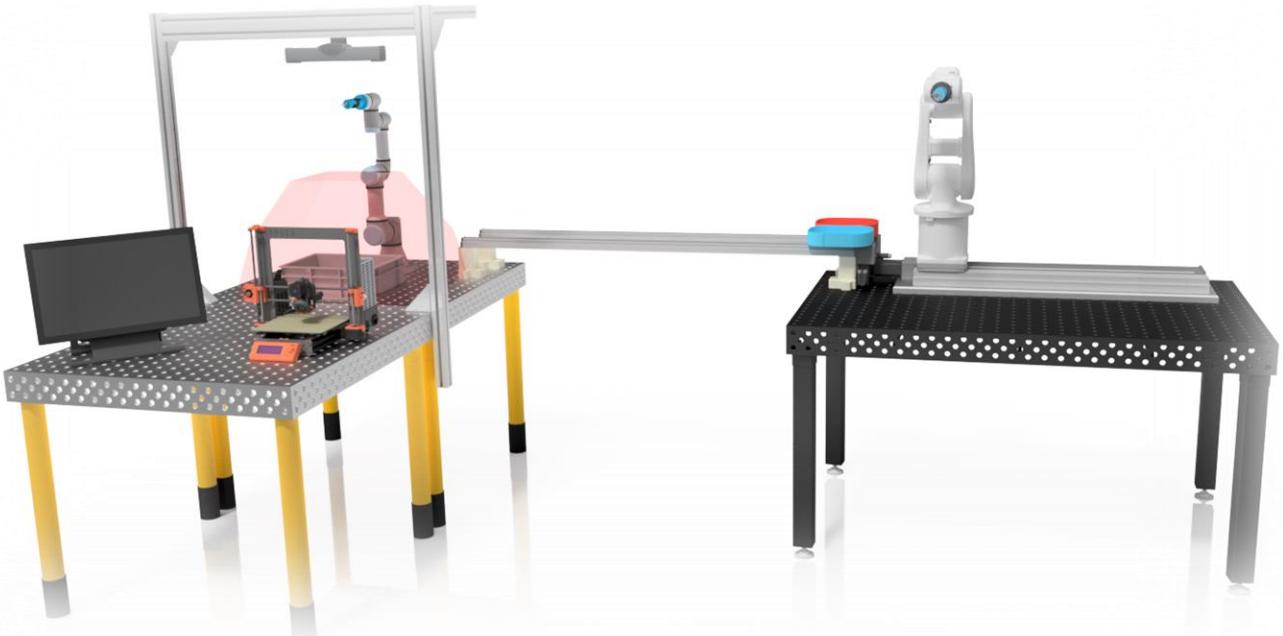
# Our partners and references



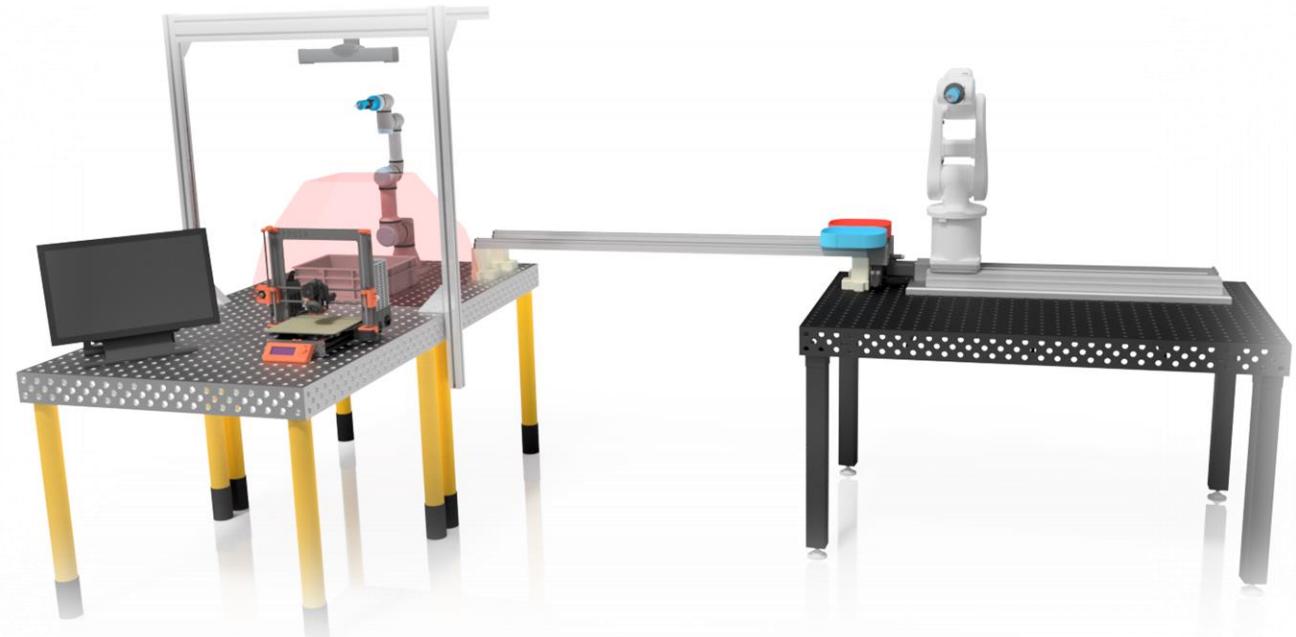
Amtech

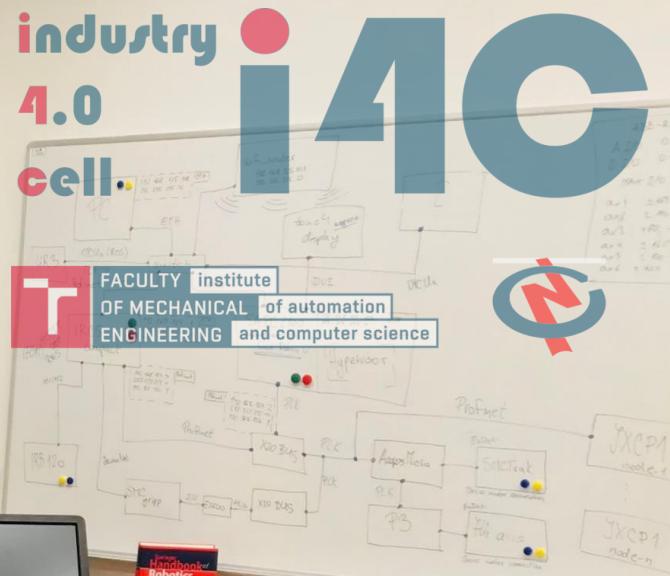


# Thank You!



# Questions?





## Industry 4.0 Cell (i4C)

MSc. Roman Parak

*Research & Development – Advanced robotics*

