

MAVRiC

Multi-Agent and Advanced
Robotics Centre

A DfE-funded HERC State-of-the-Art Teaching
and Research Facility

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Vice-Chair, IEEE UK and Ireland Control Systems Chapter

EPSRC ILN+ Researcher in Residence with Digital Catapult

20th October 2025



Main Centrepiece

- 2x ER-FLEX Systems
 - UR5e robotic arms mounted on MiR250 AGVs
 - Arm payload \approx 5 kg
 - Vehicle payload \approx 180 kg
 - Operation time up to 20 hours per day
 - Automation in manufacturing and digital twinning
 - Automate lab/hospital tasks to limit human presence and reduce risk of contamination
 - Home assistance



Main Centrepiece

- 1st HEI on Island of Ireland to utilise **Collaborative Robots (Cobot) + Autonomous Mobile Robots (AMRs) Combo** for Research and Teaching*



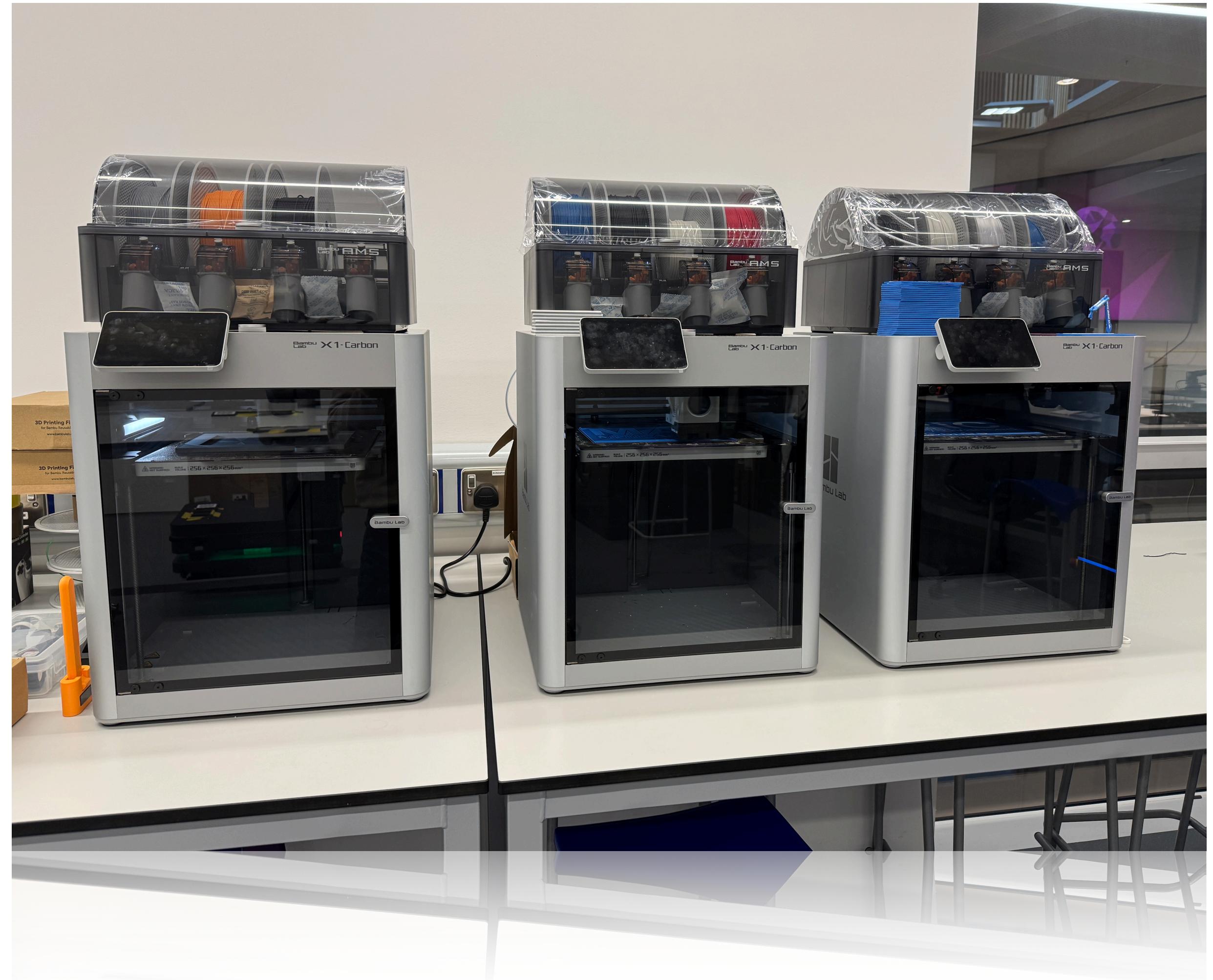
Key Equipment

- 4x Turtlebot4
 - Multi-sensor equipped AMRs
 - Max. payload \approx 9 kg
 - Operation time: Up to 4 hours
 - LiDAR and depth camera



Key Equipment

- 3x Bambulab X1
 - Multi-Filament 3D Printers
 - 7µm LiDAR-assisted automatic calibration and inspection
 - CoreXY motion system
 - High-speed multicolor printing with AMS
 - Multi-material printing



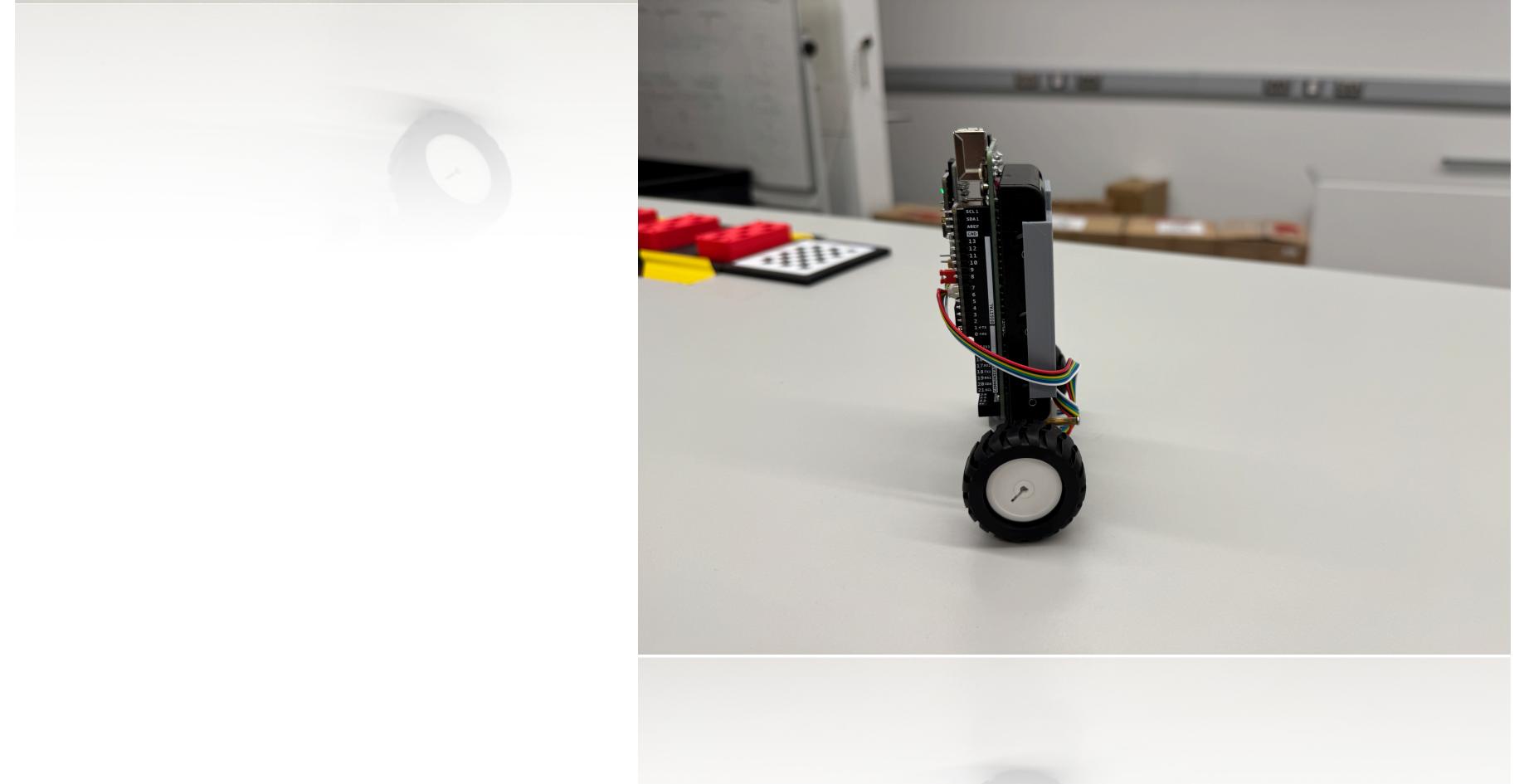
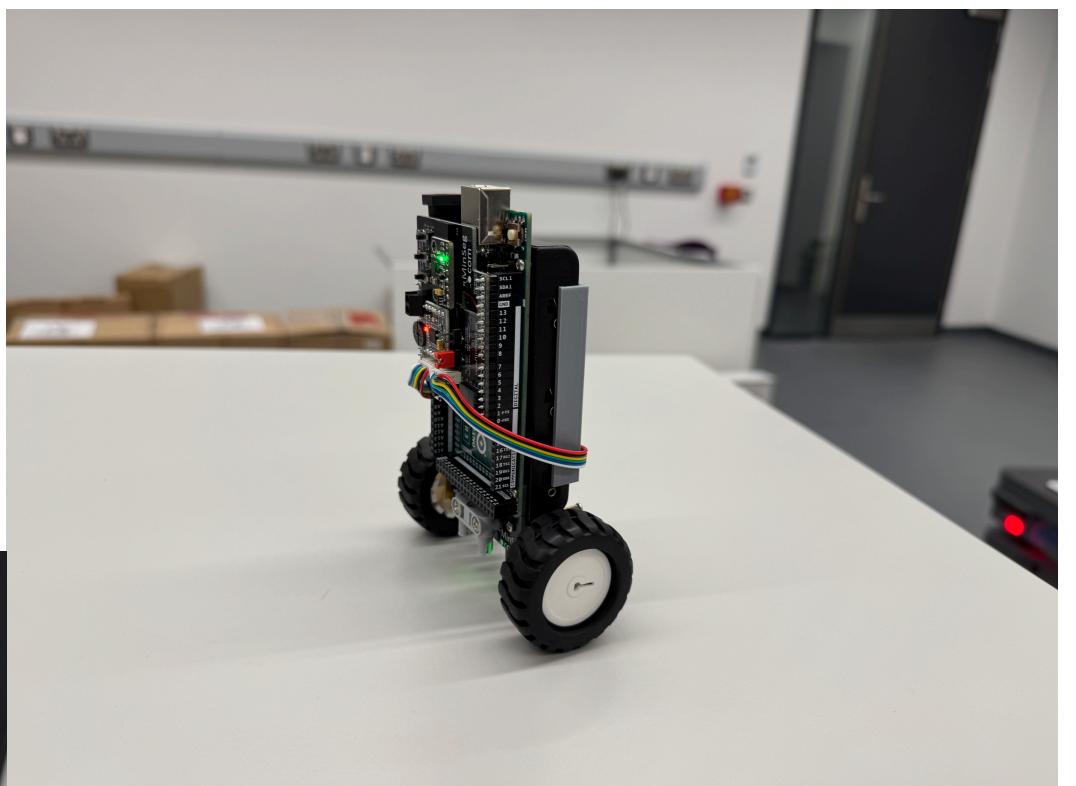
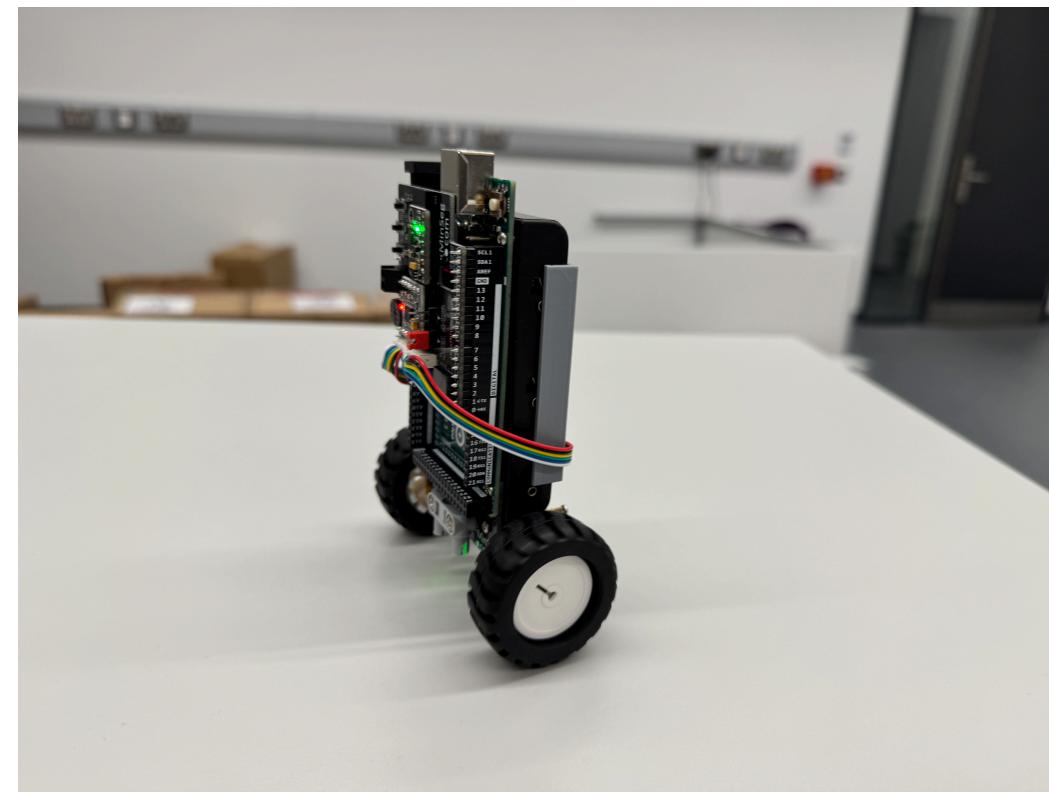
Key Equipment

- 3x OrangeApps Robotic Arms
 - Mini KUKA-Compatible Robotic Systems
 - KUKA® OfficeLite, the virtual robot controller from KUKA®
 - Gearbox and kinematics to mimic actual industrial robots



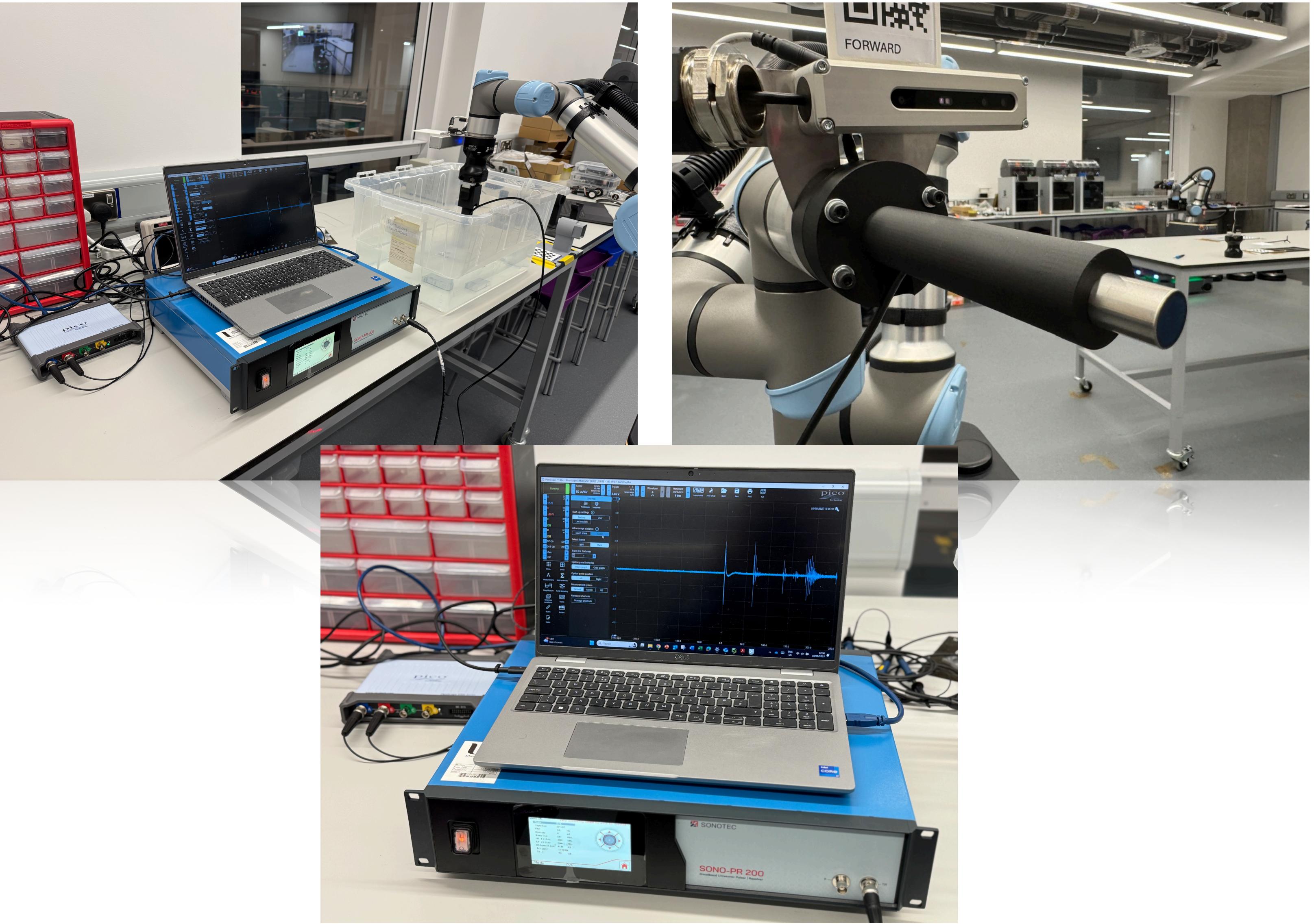
Key Equipment

- 4x MinSeg Robotic System
 - Multi-purpose advanced mini robots
 - Inverted pendulums – rockets, humanoids, etc.
 - Autonomous maneuverability
 - Real-time observation and control



Key Equipment

- Sonotec PR 200 Combi Pulser
- Picoscope 5443D Oscilloscope
- Ultrasonic immersion and contact transducers



Other Existing Equipment

- Festo CP LAB
 - 6x pallet transfer system
 - 4x system trainers
 - 2x CP Bridge
 - 1x Robotino + SIM Environment
 - 2x magazine modules
 - 1x measurement module
 - 1x muscle press module
 - 1x tunnel furnace module
 - 1x output module



Other Existing Equipment

- Inteco Control Systems
 - 1x helicopter system
 - 1x ABS braking system



Key Achievements Thus Far...

- Outreach activities
- Encourage STEM in NI and ROI
- Produce future talents and tech-equipped workforce
 - UCAS Open Day 2025
 - East Belfast Summer School 2025



UCAS Open Day 2025

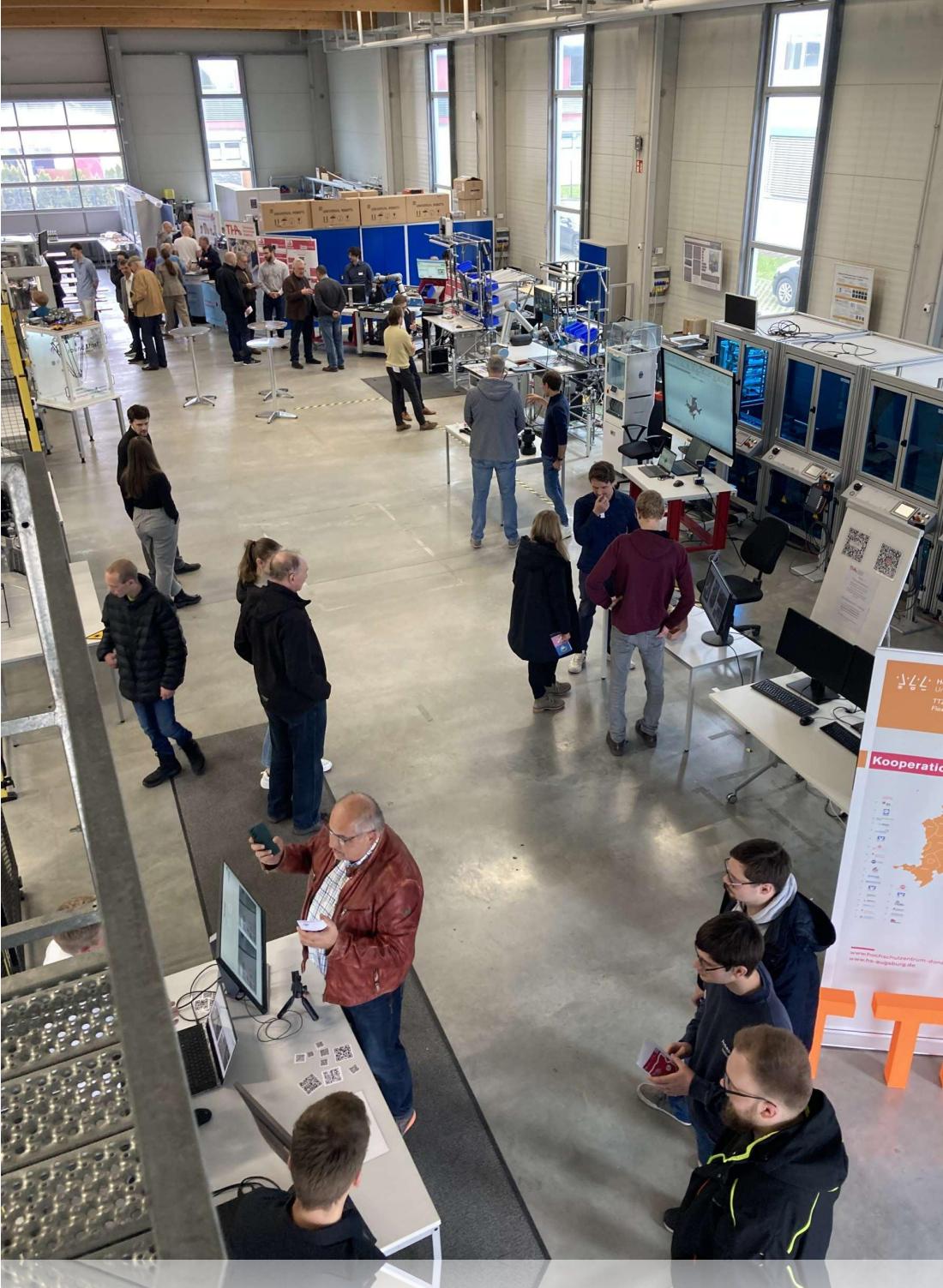
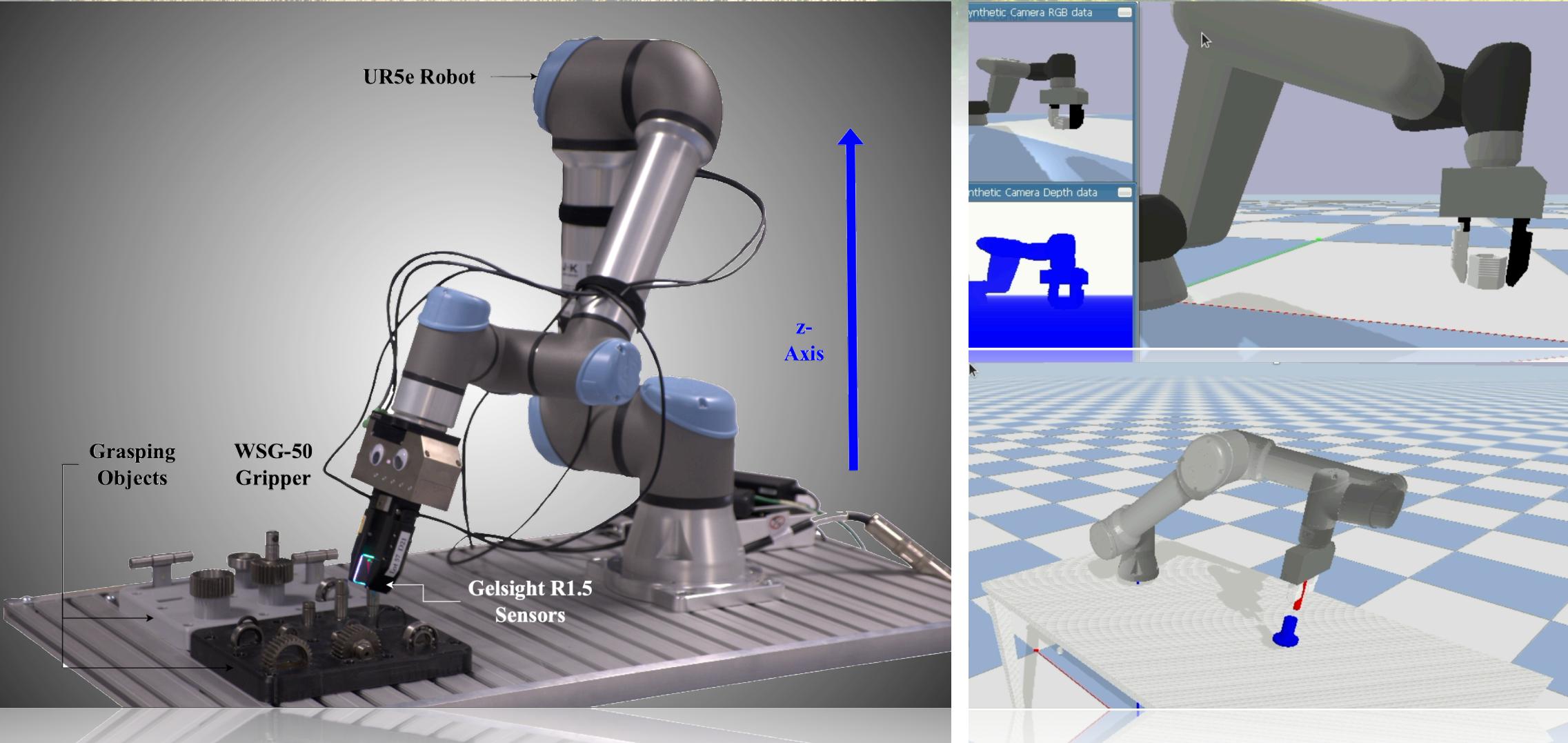
Key Achievements Thus Far...

- Hosted 2 exchange students via **EU Erasmus+ Traineeship Programme** (June–August 2025)



Key Achievements Thus Far...

- Further enhanced existing collaboration with **TTZ @ Nördlingen, Germany**
 - Joint PhD supervision
 - Multiple publications and organisation of conferences



Key Achievements Thus Far...

- DfT showcased and featured research from the lab at the **OECD Int. Transport Forum** (21–23 May 2025) as part of current UK research related to transport digital twinning

Digital Twin of a Turbocharged Spark-Ignited Engine System for Control and Fault Diagnosis

Dr Mark Ng SMIEEE
Reader, School of Engineering, Ulster University, UK
Vice-Chair, IEEE Control Systems Society (UK & Ireland Chapter)
ILN+ Researcher in Residence with Digital Catapult, UK

[Research Website](#)



Physical Automotive Vehicle



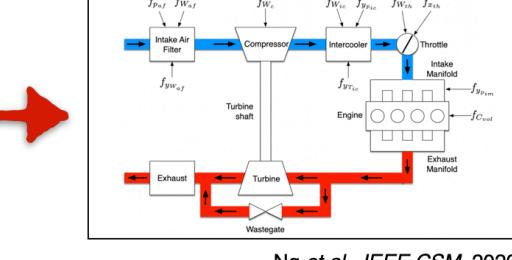
volvocars.com

Understanding of Engine Dynamics



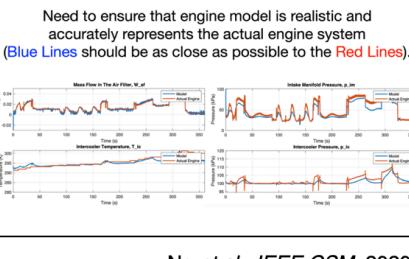
volvocars.com

Identifying Faults of Interest



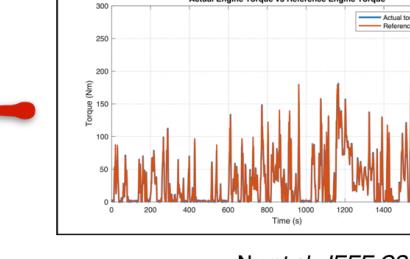
Ng et al., IEEE CSM, 2020.

Verification of Engine Model and Controller Design



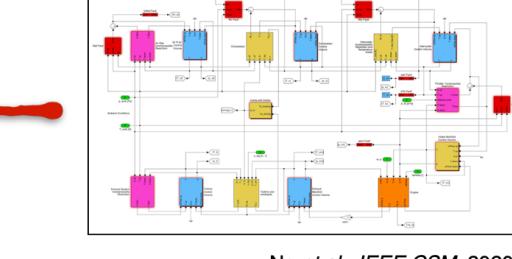
Ng et al., IEEE CSM, 2020.

Controller Design



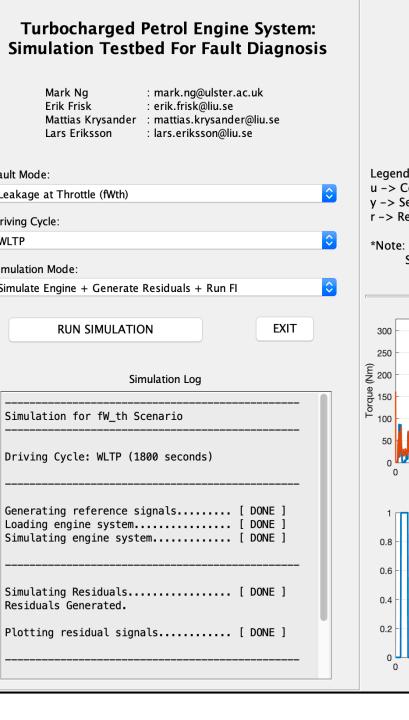
Ng et al., IEEE CSM, 2020.

Modeling of Engine System



Ng et al., IEEE CSM, 2020.

Turbocharged Petrol Engine System: Simulation Tested for Fault Diagnosis



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Mathias Rylander : mathias.rylander@ulster.ac.uk
Lars Eriksson : lars.eriksson@ulster.ac.uk

Fault Mode: Leakage at Throttle (fWth)
Driving Cycle: WLTP
Simulation Mode: Simulate Engine + Generate Residuals + Run FI

RUN SIMULATION EXIT

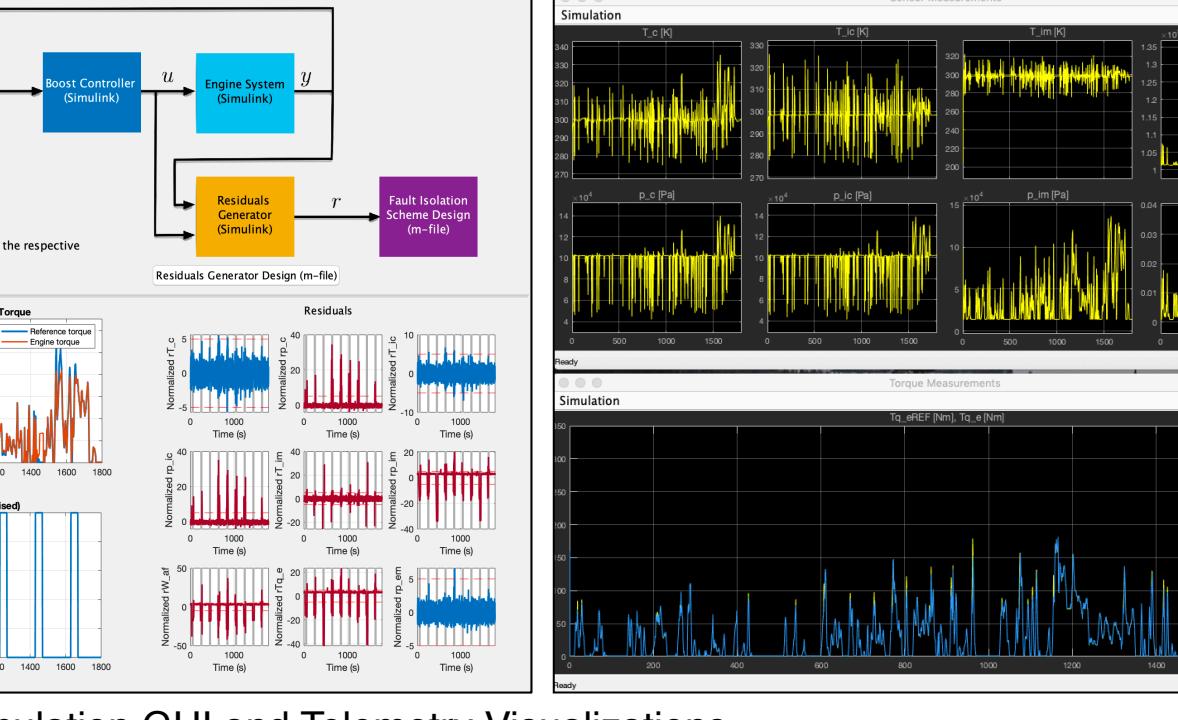
Simulation Log

Simulation for fW_th Scenario
Driving Cycle: WLTP (1886 seconds)

Generating reference signals..... [DONE]
Loading engine system..... [DONE]
Simulating engine system..... [DONE]

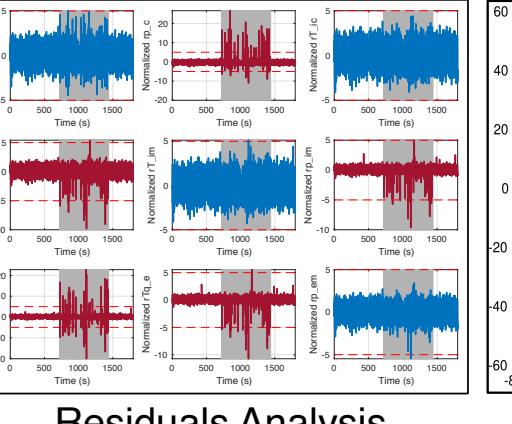
Residuals Generated..... [DONE]
Plotting residual signals..... [DONE]

Simulation GUI and Telemetry Visualizations

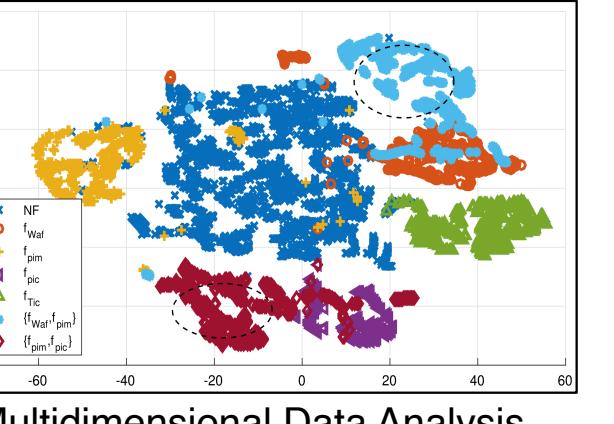


Sample based: T=1800.000

Residuals Analysis



Multidimensional Data Analysis



Legend: NF, fWaf, fWc, fWic, fWth, fpaf, fxth, fyTic, fyWaf, typic, fypim

Classification and Diagnosis

Confusion Chart (Gaussian)											
True Class	Predicted Class										
	Fault-free	fVol	fWaf	fWc	fWic	fWth	fpaf	fxth	fyTic	fyWaf	typic
Fault-free	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fVol	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fWaf	911	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fWc	1000	1000	447	1000	153	1000	1	3	573	1000	1000
fWic	121	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fWth	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fpaf	715	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fxth	919	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fyTic	988	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fyWaf	128	1	1000	1000	1000	1000	1000	1000	1000	1000	1000
typic	23	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
fypim	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

100.0%
97.8% 2.2%
90.3% 9.7% 9.8%
89.2% 10.8%
88.6% 11.4%
86.3% 13.7%
85.0% 15.0%
83.3% 16.7%
82.0% 17.0%
80.0% 18.0%
78.0% 20.0%
76.0% 22.0%
74.0% 24.0%
72.0% 26.0%
70.0% 28.0%
68.0% 30.0%
66.0% 32.0%
64.0% 34.0%
62.0% 36.0%
60.0% 38.0%
58.0% 40.0%
56.0% 42.0%
54.0% 44.0%
52.0% 46.0%
50.0% 48.0%
48.0% 50.0%
46.0% 52.0%
44.0% 54.0%
42.0% 56.0%
40.0% 58.0%
38.0% 60.0%
36.0% 62.0%
34.0% 64.0%
32.0% 66.0%
30.0% 68.0%
28.0% 70.0%
26.0% 72.0%
24.0% 74.0%
22.0% 76.0%
20.0% 78.0%
18.0% 80.0%
16.0% 82.0%
14.0% 84.0%
12.0% 86.0%
10.0% 88.0%
8.0% 90.0%
6.0% 92.0%
4.0% 94.0%
2.0% 96.0%
0.0% 98.0%

IEEE CSM Paper



Classification and Diagnosis



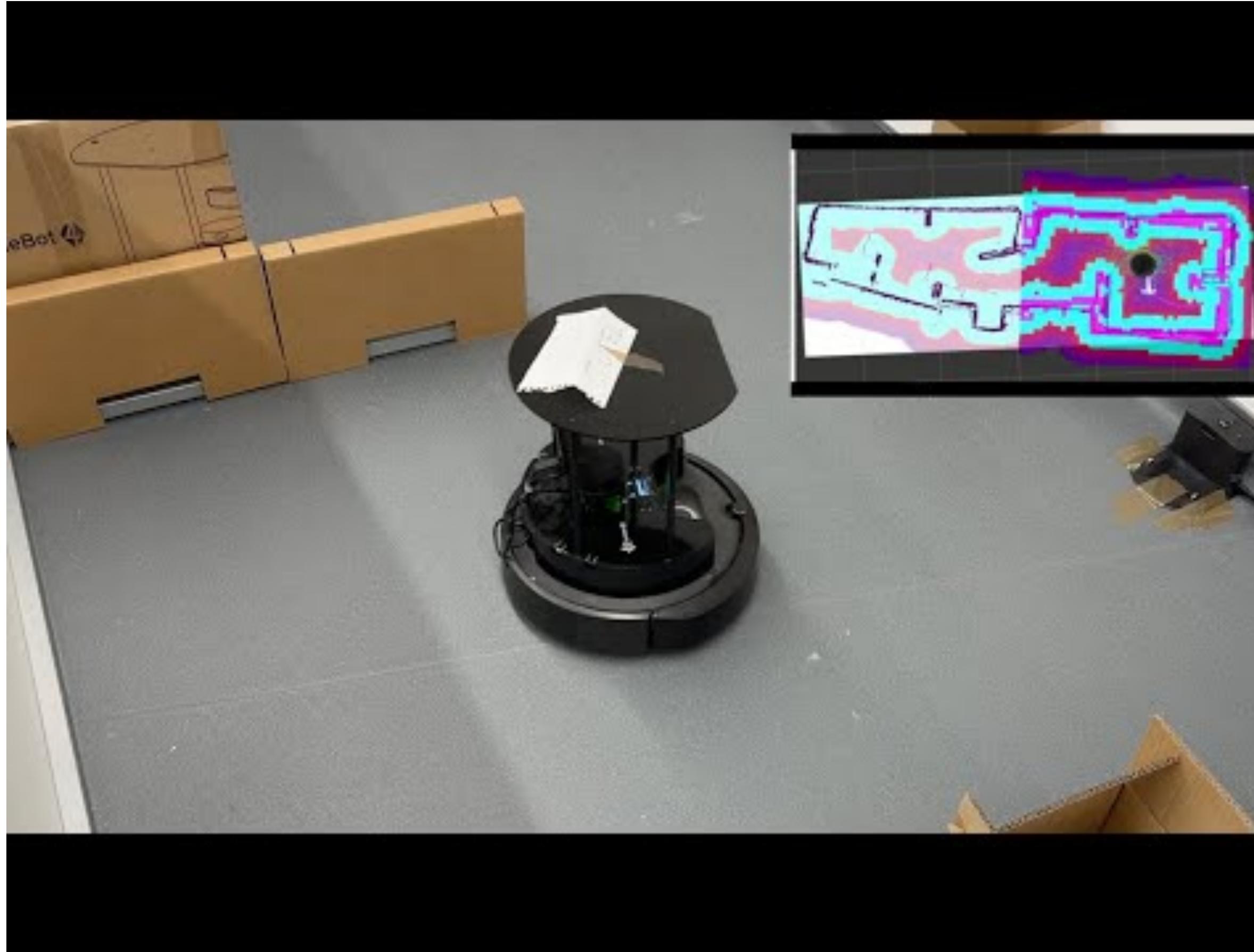
Key Achievements Thus Far...



<https://youtu.be/Q9RnzF0kwnM?si=OaTWwnjr1jn8MSKf>

Non-verbal robot-robot communication (Research paper in writing)

Key Achievements Thus Far...



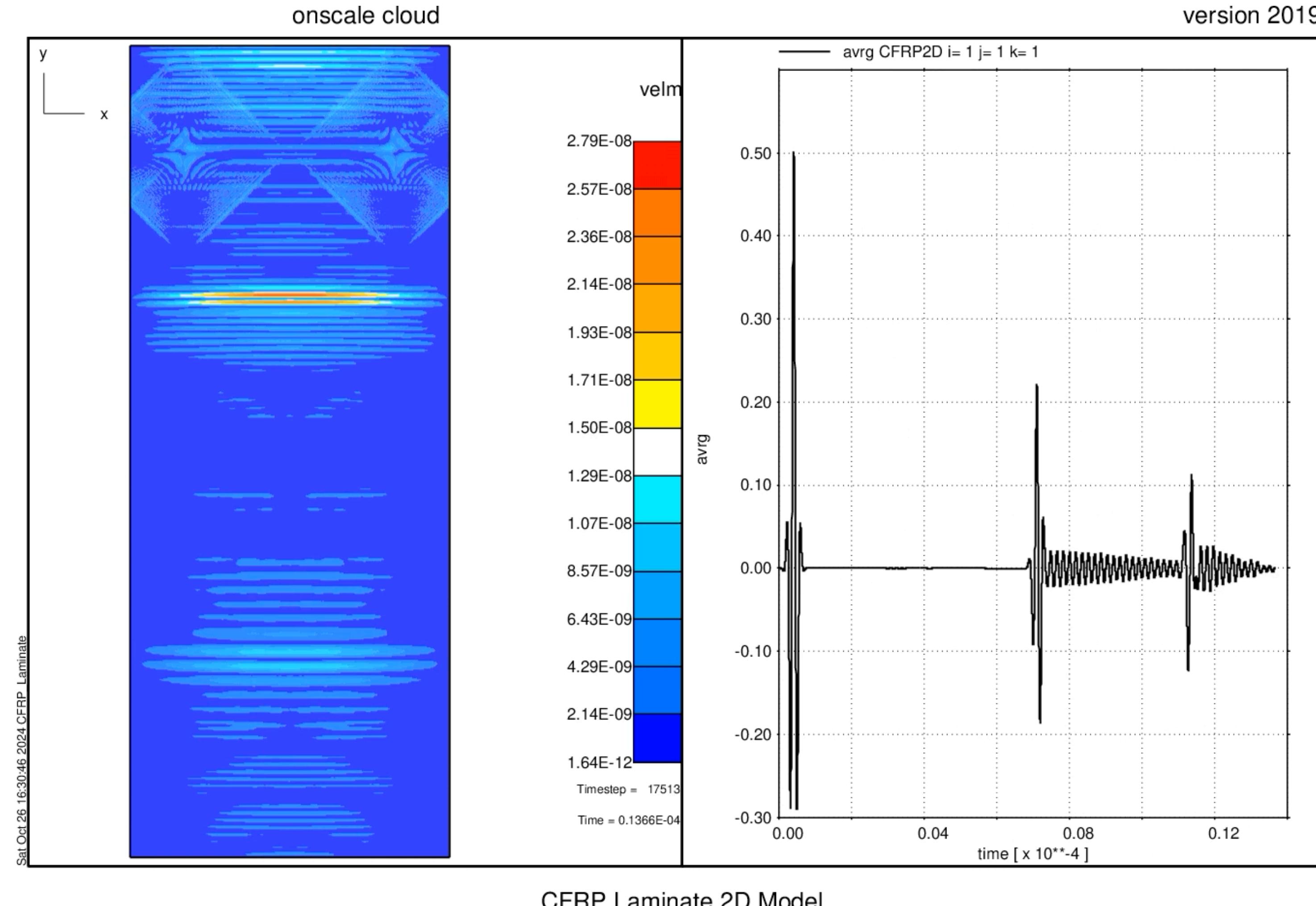
https://youtu.be/6QJiKrzK9bY?si=wmC_Io8Rxvqpczrt

Real-time Autonomous SLAM

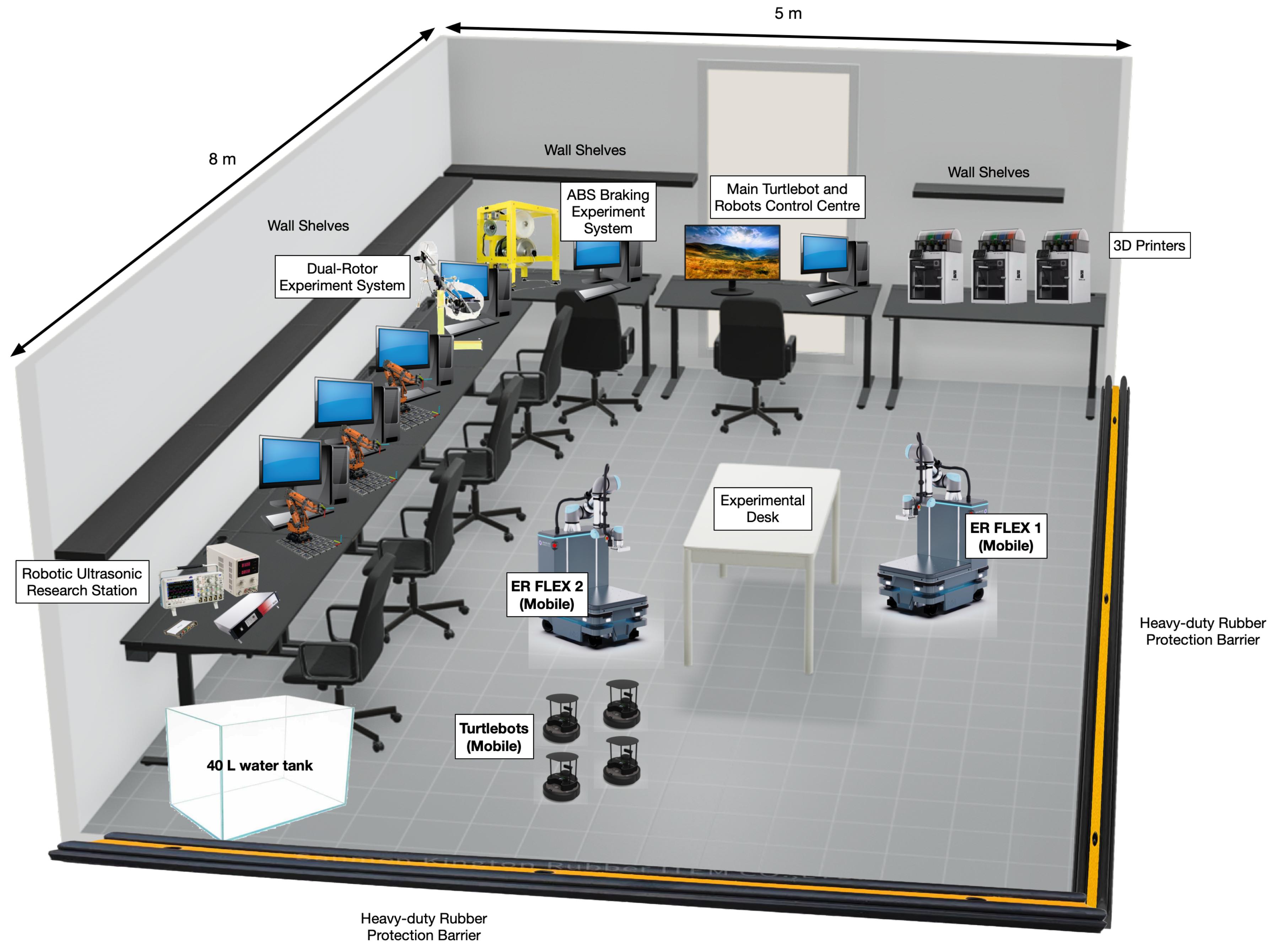
UT and Characterisation for NDT in Manufacturing and Healthcare Diagnosis



Key Achievements Thus Far...



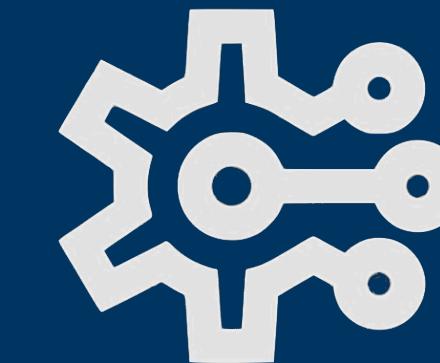
NDT of Composites Using UT



Research Collaborators and Partners

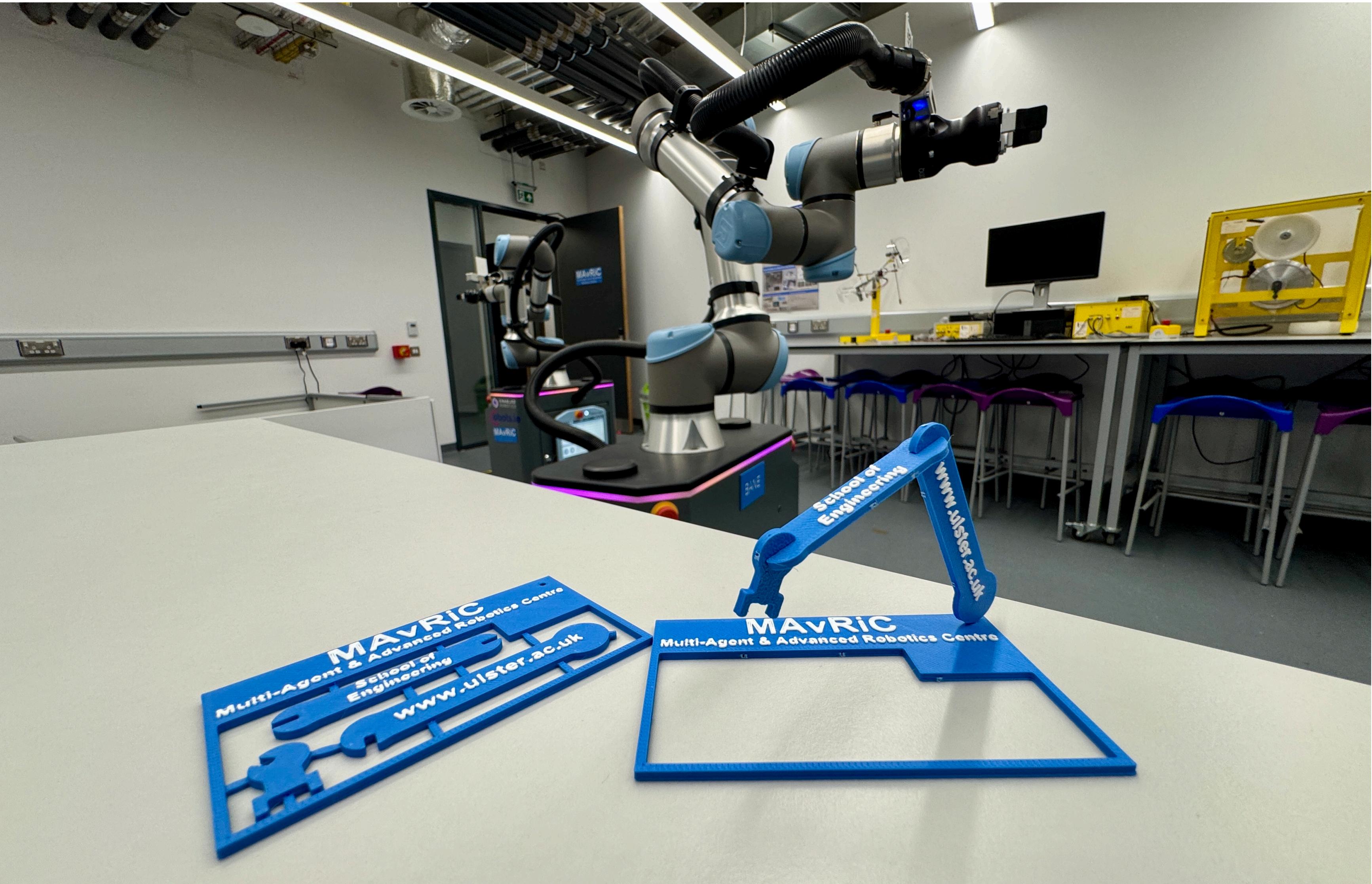


Technische
Hochschule
Augsburg



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Flexible Automation





Thank You