Opportunities for Autonomous Robotics

Michael Fisher

Department of Computer Science, University of Manchester, UK
https://web.cs.manchester.ac.uk/~michael

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The University of Manchester

Royal Academy of Engineering

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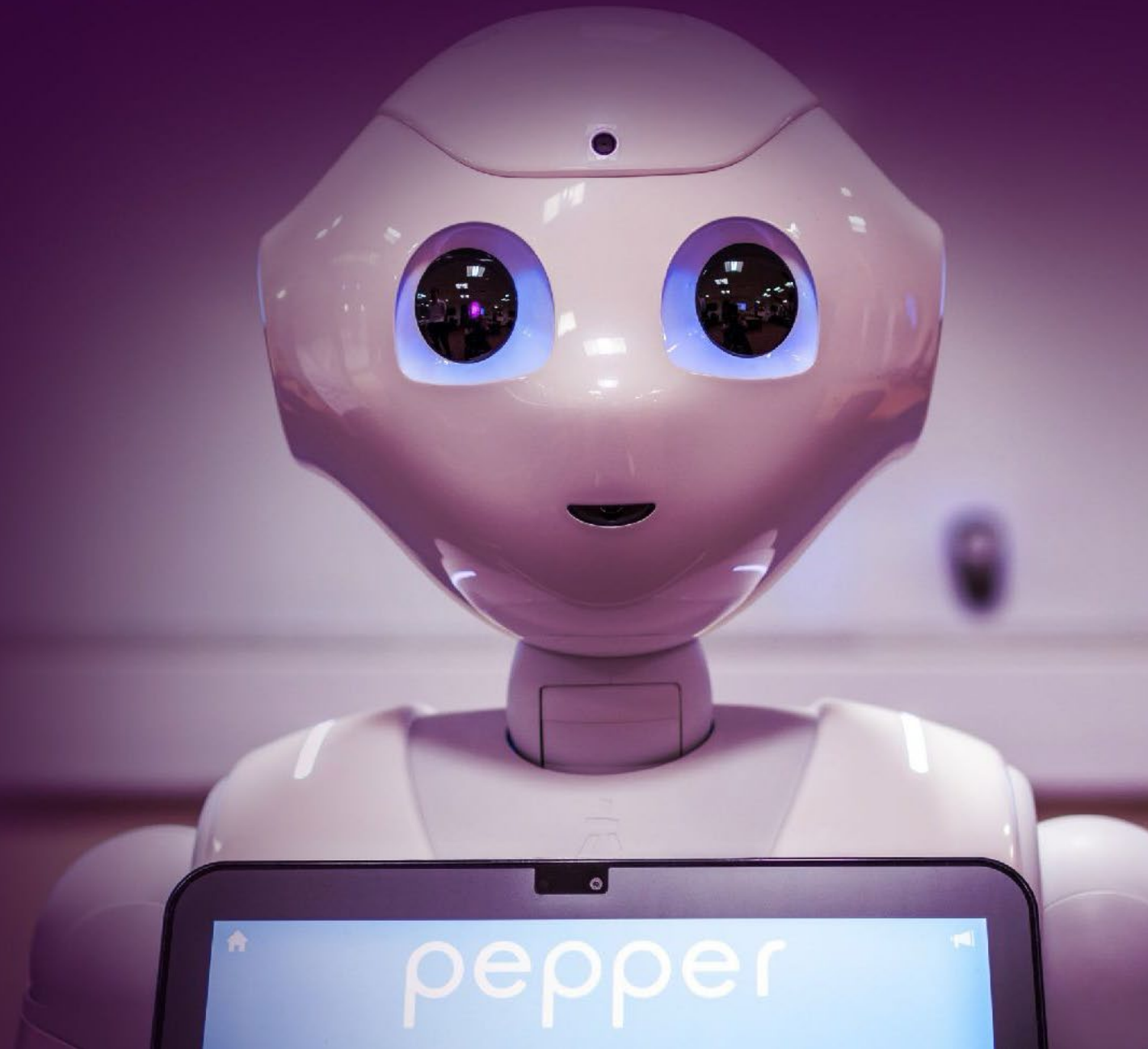
Welcome to the Manchester Centre for Robotics and AI

Distinctive profile cutting **across many disciplines** in science and engineering, reaching out to social science and healthcare (>100 members)

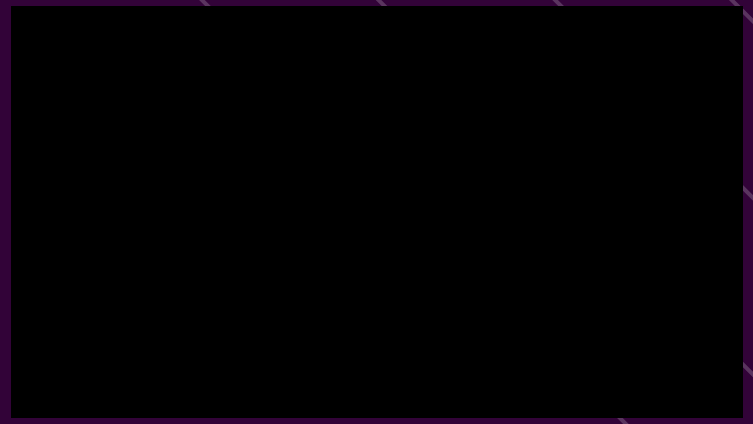
Focus is on the development, integration and application of **Human-Centred AI** approaches in the design of robots and autonomous systems for real world applications.

We work extensively with **industry and users** in various sectors, including nuclear, healthcare, infrastructure and space.

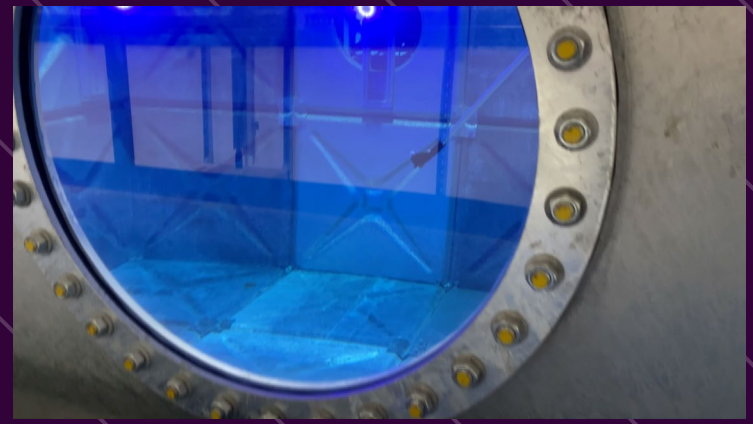


Aquatic Robots

MALLARD
Autonomous Aquatic Surface Vehicle for Inspection and Monitoring of Wet Nuclear Storage Facilities



AVEXIS
Aqua Vehicle for Exploration and In-Situ Sensing



CORAL
Collaborative Robot Autonomy and Localisation

TAARN
Tetherless Autonomous Aquatic Robot Navigation

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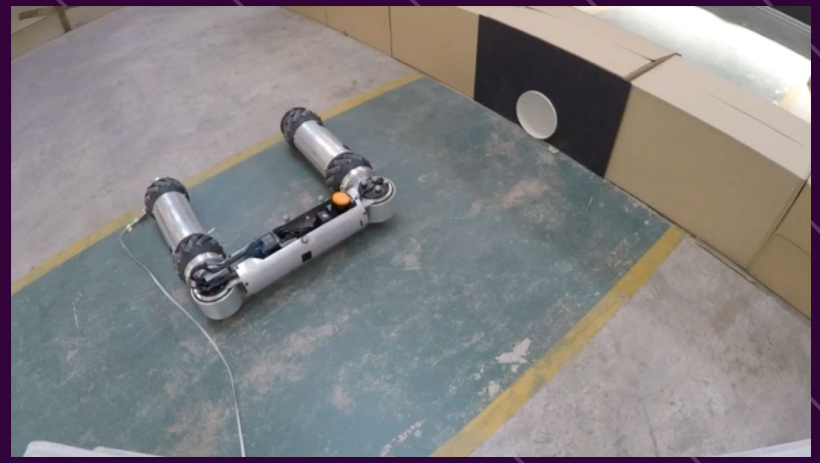
Ground Robots

[redacted]

CORIN - Mobile Hexapod for Remote Inspection and Object Manipulation



MIRRAX - MIniature Robot for Restricted Access EXploration

[redacted]

LYRA - Exploration Platform Capable of Deployment in Hazardous Confined Spaces

TORONE - TOtal characterisation by Remote Observation in Nuclear Environments

CARMA - Exploration Platform Capable of Deployment in Hazardous Confined Spaces

icenine
ROBOTIC SOLUTIONS

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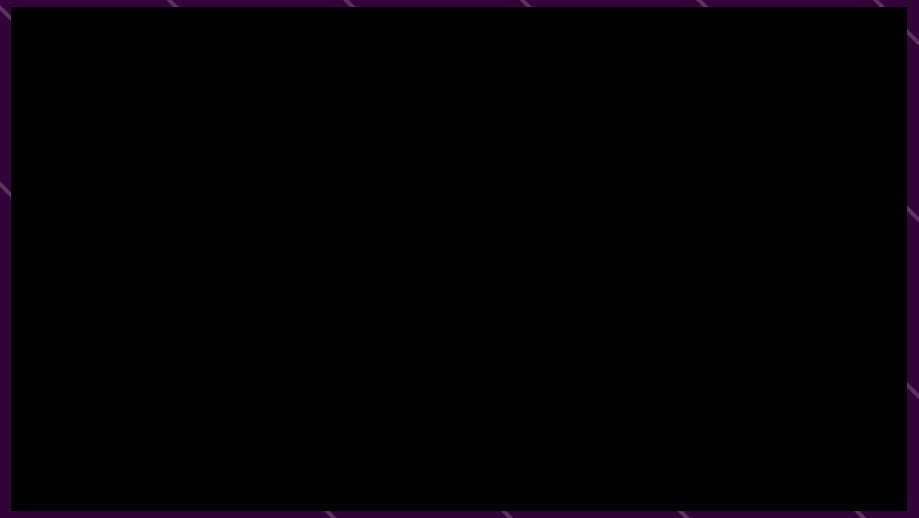
Aerial Robots

MIMREE
Multi-Platform Inspection, Maintenance and Repair in Extreme Environments



PROMETHEUS
Multi-Platform Inspection, Maintenance and Repair in Extreme Environments

UK Robotics and Autonomous Systems

UK-RAS: UK Robotics & Autonomous Systems Network

The EPSRC UK Robotics and Autonomous Systems (RAS) Network was established in March 2015 with the mission to provide academic leadership in RAS, expand collaboration with industry and integrate and coordinate EPSRC activities.

The Network aims to build on internationalisation, foundational research, and aid the development of Early Career Researchers.

Robotics and AI for Net Zero (RAINZ)

RAINZ CDT (Centre for Doctoral Training)

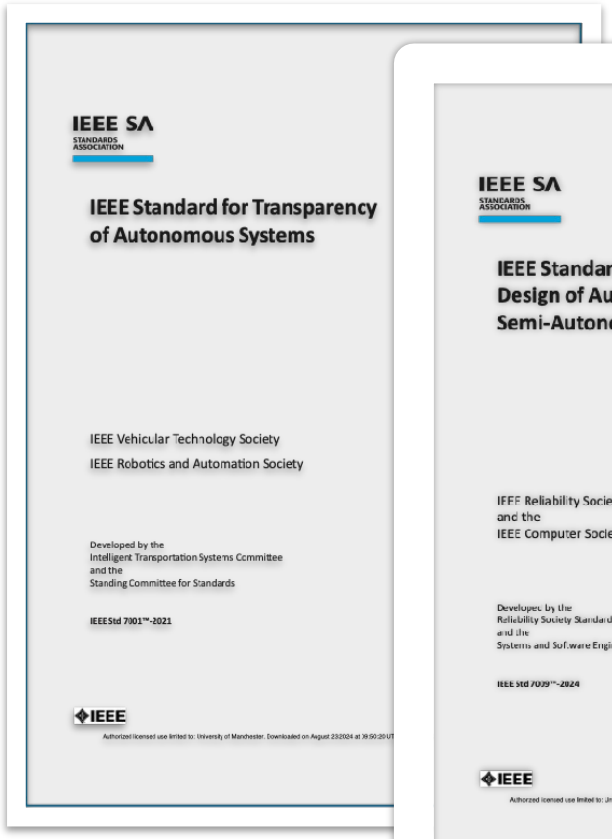
The RAINZ CDT will train the next generation of multi-disciplinary robotic systems engineers to conduct research which will help revolutionise lifecycle asset management of Net Zero infrastructure, with a focus on Nuclear, Wind and Solar energy.

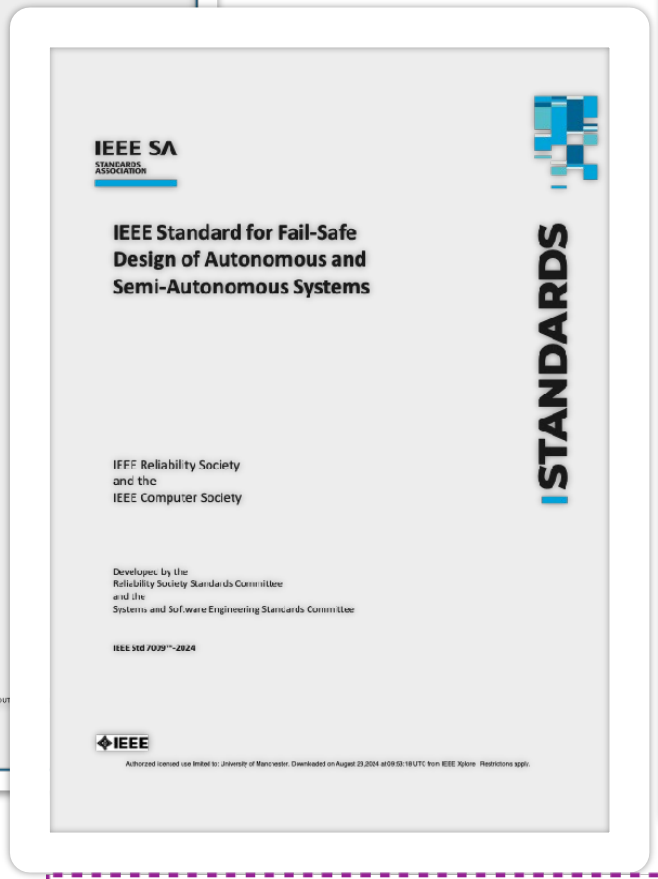
The RAINZ CDT will adopt an innovative cohort training and research model.

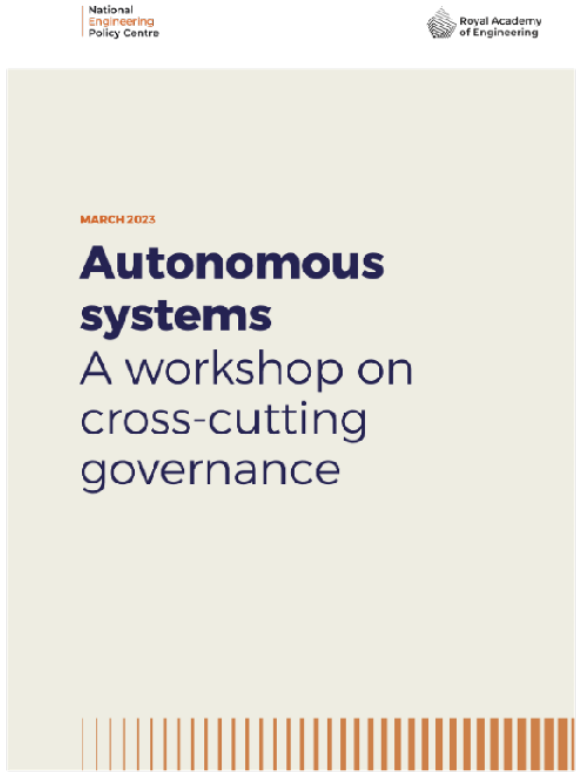
Each cohort will be recruited to conduct research directed towards a different **industry defined cross-cutting challenge** which will change for each new cohort, for example

– *Autonomous Maintenance in Confined Spaces*
– *Long-Term Autonomous Inspections*
– *Scalable Fleets of Inspection, Maintenance and Repair Robots*

Developing National and International Standards & Policy







IEEE

TECHNICAL COMMITTEE FOR
VERIFICATION OF AUTONOMOUS SYSTEMS

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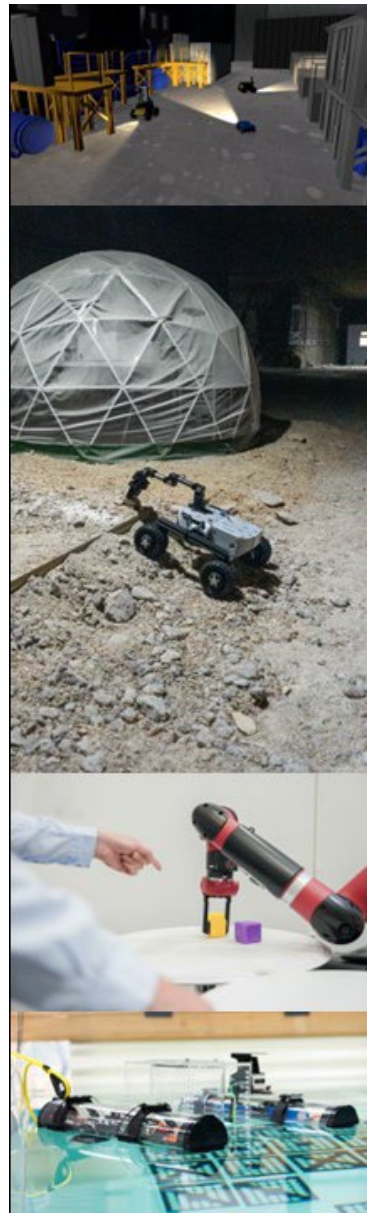
What is CRADLE?

- 5-year programme commencing July 2023
- Five work packages:
  1. Components
  2. Architectures
  3. Interactions
  4. Assurance
  5. Demonstrators
- 12 PhDs, 10 full-time Post Doctoral Researchers
- Core research programme stimulated by (short-term and long-term) industry needs

Empowering UK and global industries with advanced robotics and autonomous systems

- Our **vision** for CRADLE is that it will deliver novel and transformational technology for demanding environments, allowing its benefits to be realised across wide sectors of UK markets and beyond.
- Sector agnostic – focus on demanding, dirty and dangerous environments, removing humans from harm.
- CRADLE's funding mechanism gives us a unique opportunity to offer expert R&D support to our clients in a targeted, responsive and agile way.

Space | Nuclear | Energy | Transport | Infrastructure



For more details, visit www.cradlerobotics.co.uk

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THE PWI

Railway Research

Railway research to support sustainable mobility

Prof Y. BEZIN

(Prof G. Tucker, Dr H. Faham)

Developing New Technologies: Robotics and AI

The Queen's Anniversary Prizes
For Higher and Further Education
2019

Route to Change
Navigating Technology, Infrastructure and Behaviour

10th April 2025, University of Manchester

University of HUDDERSFIELD
Inspiring global professionals

Areas of expertise

- Vehicle & Track Dynamics
- Traction, Braking & Energy Systems
- Pantograph & Overhead Systems
- Data Science and Machine Learning
- Smart Maintenance and Automation
- Technology Development & Innovation

Facilities

HAROLD: Full-Scale Bogie Contact, Adhesion and Braking Rig

THOMoS: Train Hi-fidelity Motion Simulator

PANTOGRAPH: Full-Scale High-Performance Test Bench

SMART MAINTENANCE: Robotics and automation facility

https://my.scene3d.co.uk/tour/institute-of-railway-research

University of HUDDERSFIELD

Institute of Railway Research

- Established in 2012
- 35 staff with mix of academic & industrial experience
- Broad portfolio of Research, applied R&D & direct consultancy
- Centre of excellence in Rolling Stock of UKRRIN
- Wide network of GB & international customers and research collaborators

UKRRIN

UK RAIL RESEARCH AND INNOVATION NETWORK

Smart Rolling Stock Maintenance Research Facility

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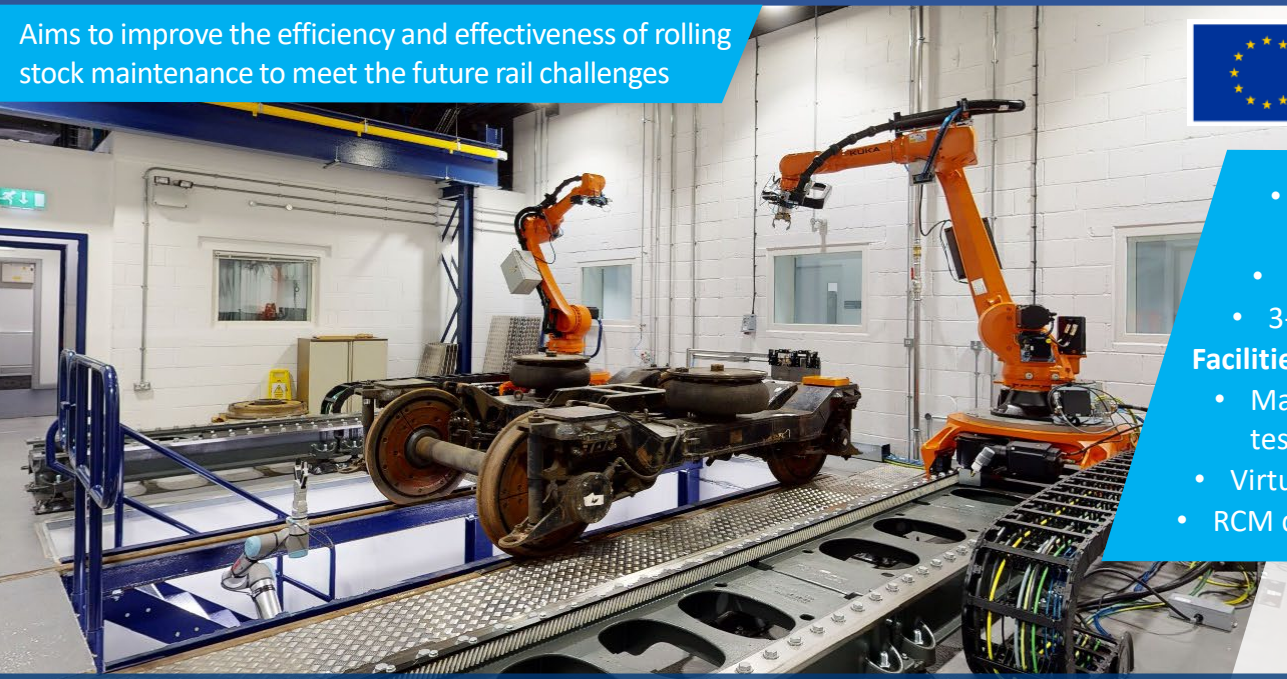
Aims to improve the efficiency and effectiveness of rolling stock maintenance to meet the future rail challenges

European Union
European Regional Development Fund

NORTHERN POWERHOUSE
HM Government



- £1.8 million project to establish a 'Smart Rolling Stock Maintenance Research Facility'
- £0.9m ERDF funding, £0.9m match funding
- 3-year project completed in June 2023

Facilities include:

- Maintenance optimisation and automation test facility (robotics lab)
- Virtual depot/digital twin
- RCM data processing and development

The Robotics Lab is part of the ERDF Smart Rolling Stock Maintenance Research Facility (SRSMRF) and represents a short section of a typical train depot maintenance road including an inspection pit. It provides the test bench to demonstrate the SRSMRF's concepts for robotic train maintenance and includes two Kuka KR50 robots mounted on linear tracks and a UR10 robot mounted on a linear track in the inspection pit. The whole robot cell is controlled through a Siemens PLC.

The Queen's Anniversary Prizes
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Back

Smart Rolling Stock Maintenance Research Facility

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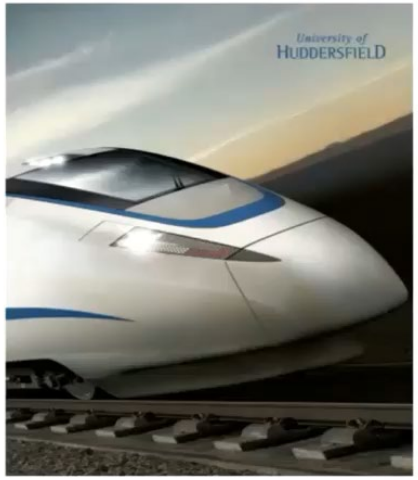
Railway Research to support sustainable mobility

NORTHERN POWERHOUSE

European Union
European Regional Development Fund



Scaled initial demo using 3D printed material

Full scaled demonstration

Benefits of robotics

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- Increased productivity
- Increase accuracy and repeatability of maintenance tasks
- Reduce workforce exposure to dangerous or repetitive tasks
- Carry out maintenance quicker ∴ increase train availably
- More efficient use of land (maintain bigger fleet size in same size of depot)
- Can be directly connected with maintenance management and RCM tools to help achieve maximum component life and resource usage
- May in future contribute to fully autonomous train maintenance depots

Application areas of robotics

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Cleaning	Inspection	Servicing	Regular Maintenance	‘Off-train’ component overhaul

Application areas of robotics

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Cleaning	Inspection	Servicing	Regular Maintenance	'Off-train' component overhaul
• Interior • Front end • Underframe • roof	• Image recognition • Surface shape scanning • Ultrasonics • Identification of missing/broken components • Torque checking bolts • Data processing connecting to work planning • Axle inspection incl. bearing axle cap removal/replace • Oil sampling	• Fuelling • Sanding • CET emptying • Water top up	• Replace missing bolts / torque tightening • Changin brake pads • Replacing pantograph carbon strips • Changing air and oil filters • Delivering parts and tools to work stations	• Wheelsets • Bogie frame

Robot control with AR headset

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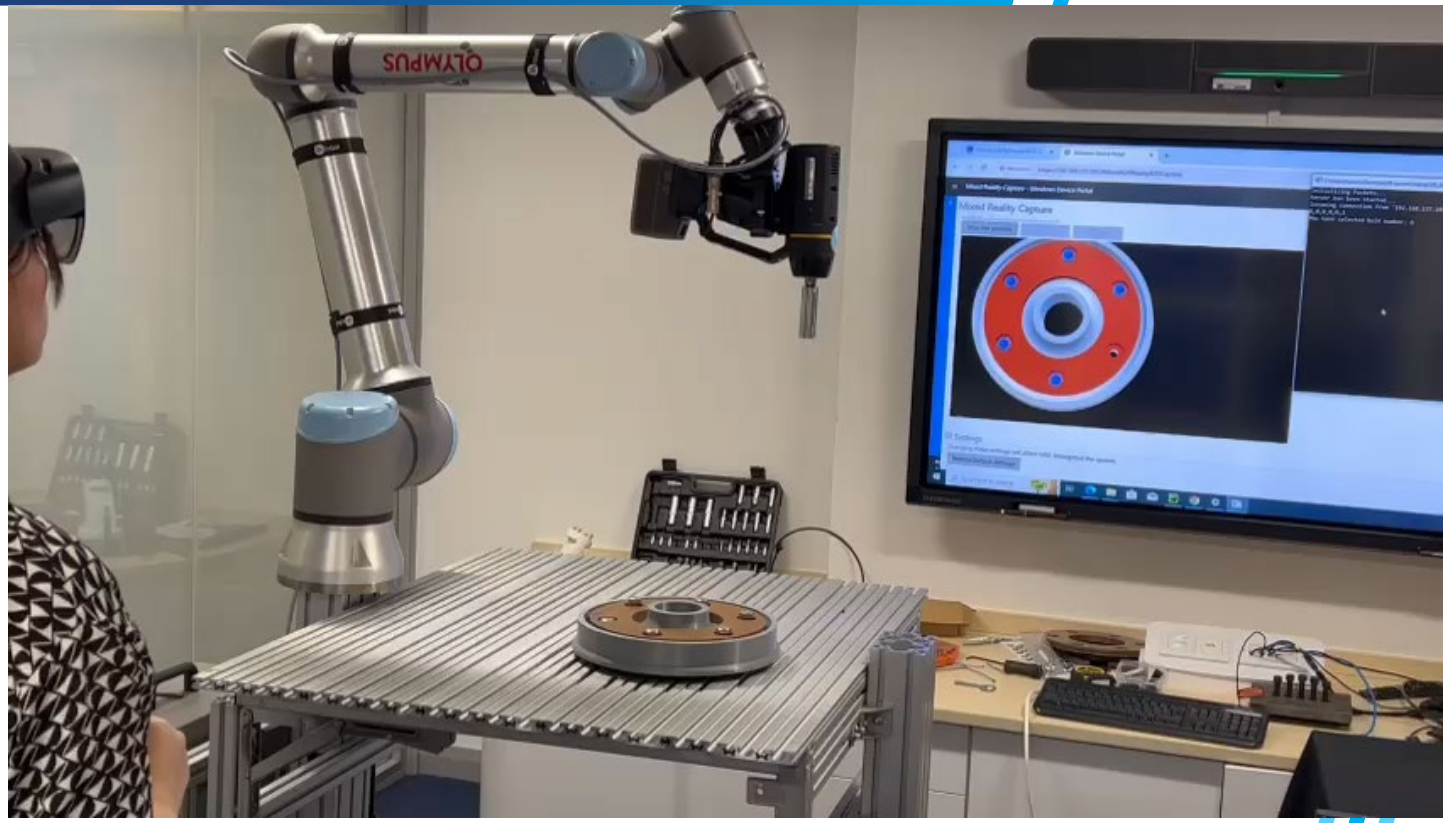
Initial testing with UR10 and Microsoft Hololens



Using Robot with Computer Vision & AI

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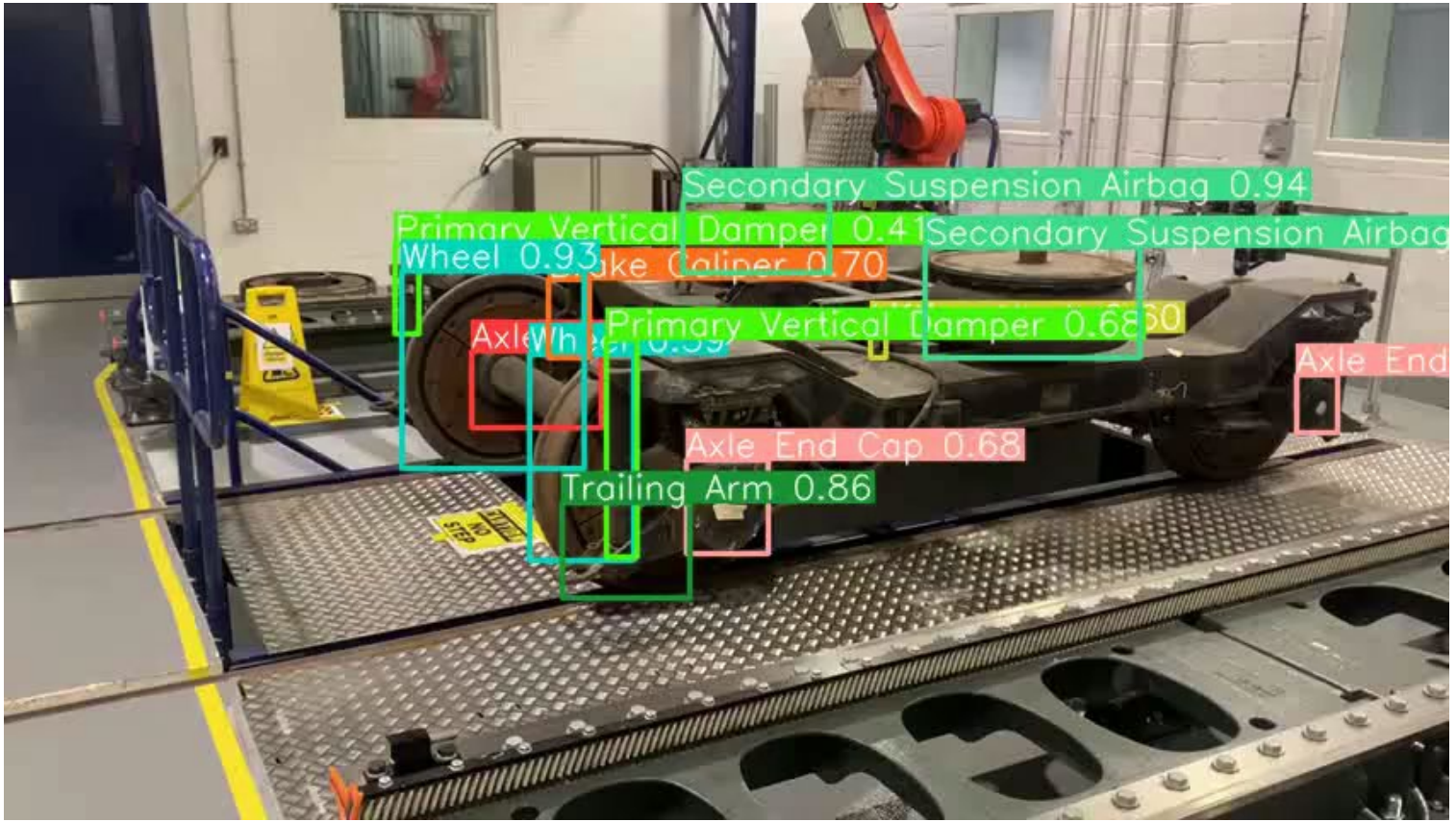

Three demo case studies

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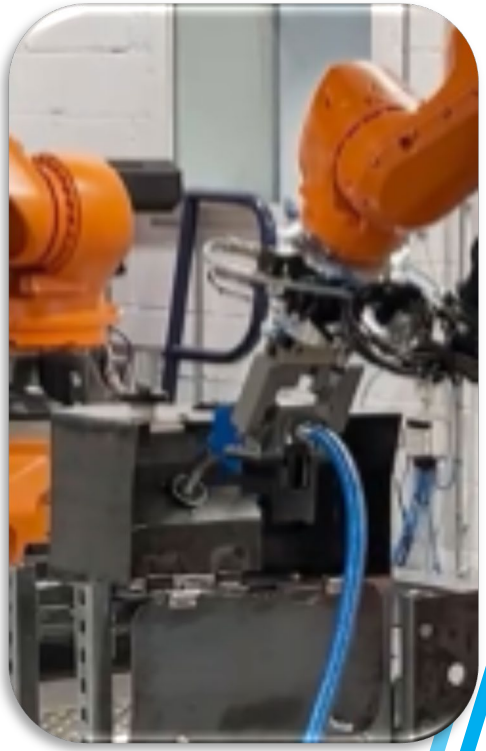
(1) Pantograph dynamic testing

(2) Brake pad (carrier) change

(3) Fuelling and servicing



Three demo case studies

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Testing Pantograph for a range of defects

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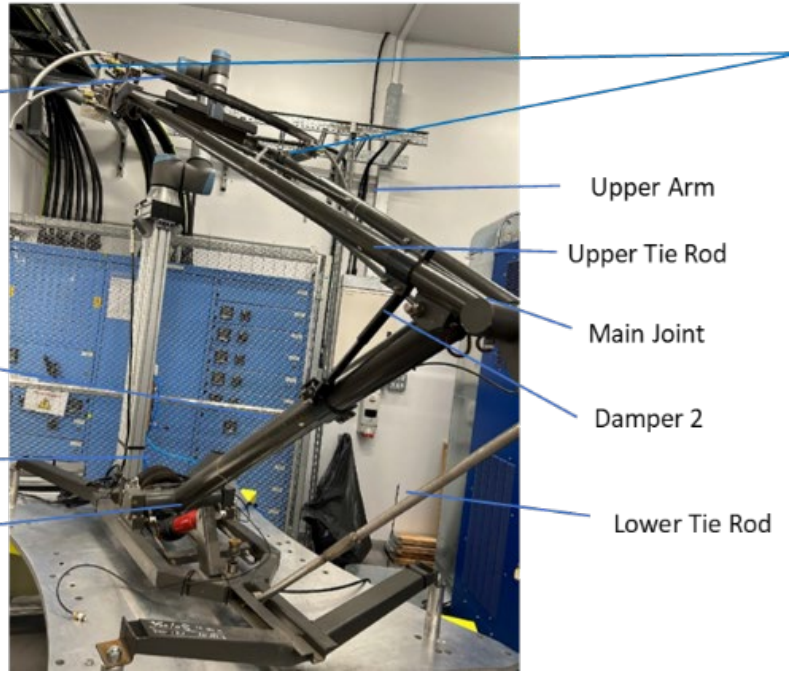

ID	Component	Defect	How to Simulate?
1	Frame Kinematics	High friction in Main Joint bearing	String connected between upper and lower arms. Wound around the main joint with tension applied to the string to simulate friction.
2		High friction in Lower Tie Rod connection to Main Joint	High friction surfaces added between the rotating joint and the main rod.
3		Loose joint between Lower Tie Rod and Main Joint	Lower tie rod replaced by a modified version that creates a 2 mm tolerance in the joint.
4		Lower Tie Rod bent or too short	Length adjustment to 15 mm shorter
5		Lower Tie Rod too long	Length adjustment to 15 mm longer
6		Upper Tie Rod bent or too short	Length adjustment to 10 mm shorter
7		Upper Tie Rod too long	Length adjustment to 10 mm longer
8	Dampers	Damper 1 (bottom damper) defective	Removal of damper 1
9		Damper 2 (Main Joint damper) defective	Removal of damper 2
10	Head Suspension	Broken back left spring	Removal of back left springs
11		Broken back right spring	Removal of back right springs
12		Broken back left levelling spring	Removal of back left levelling spring
13		Broken back right levelling spring	Removal of back right levelling spring
14		Poorly adjusted spring	Adjustment to reduce length of the back right spring by 5 mm
15	Air Supply	Supply pressure too high	Adjustment of regulator supply pressure to 4.2 bar
16		Supply pressure too low	Adjustment of regulator supply pressure to 3.8 bar
17		Faulty regulator	Replacement of supply regulator with an alternative regulator that has a wider supply tolerance (i.e. +/- 0.5 bar vs +/- 0.1 bar)
18		Leak at pantograph air system supply	Bleed valve added between the supply regulator and pantograph pneumatic system inlet, to create a leak with the rate of 20 litres/s.

Lab based test set up and potential future layout

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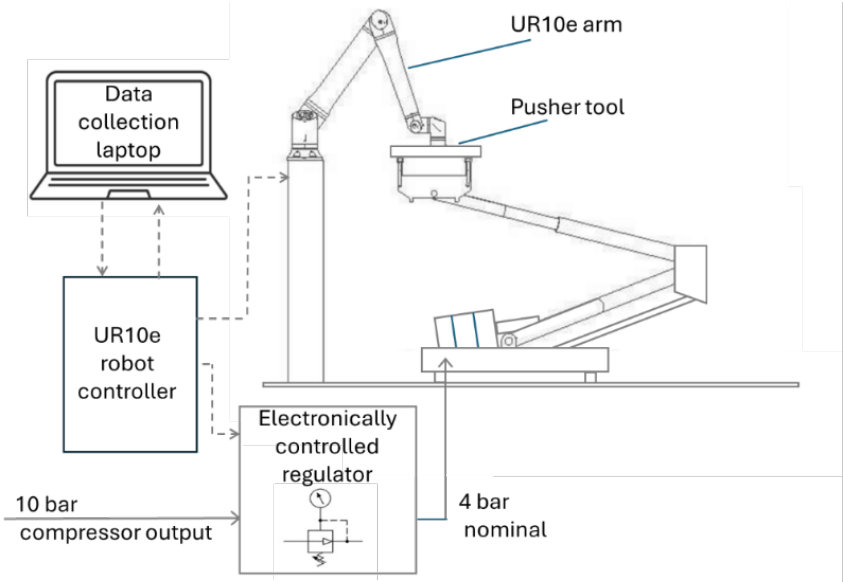

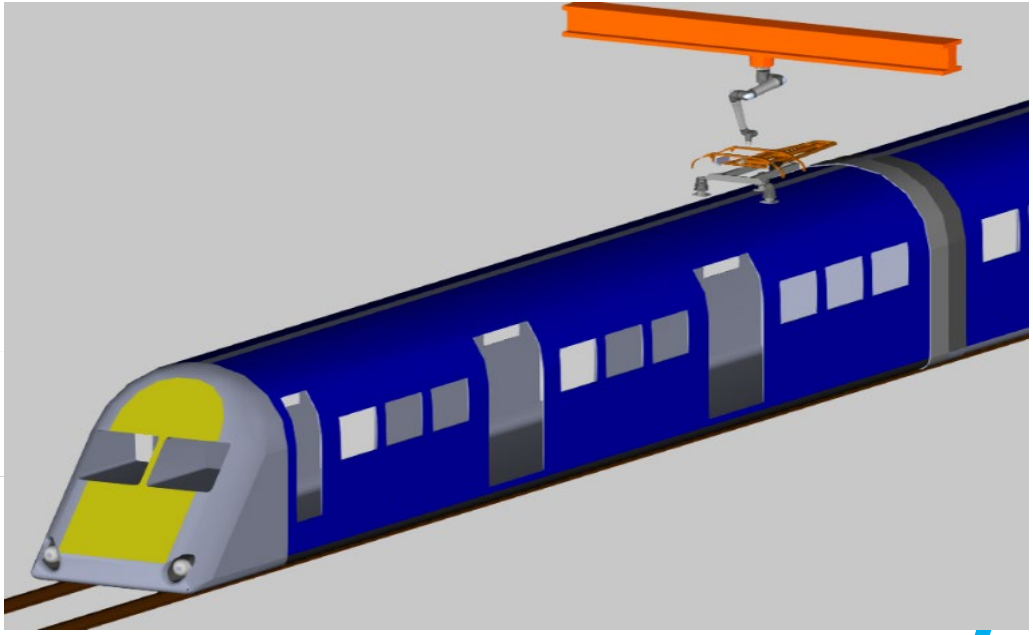

Pantograph dynamic testing

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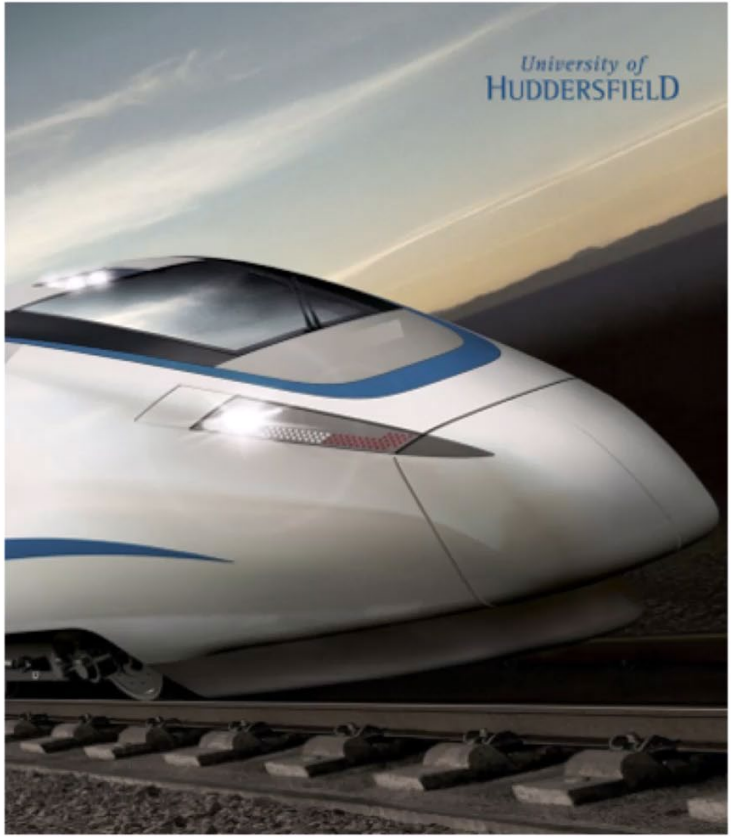
Railway Research to support sustainable mobility

NORTHERN POWERHOUSE

European Union
European Regional Development Fund



Results processing – benchmark good performance

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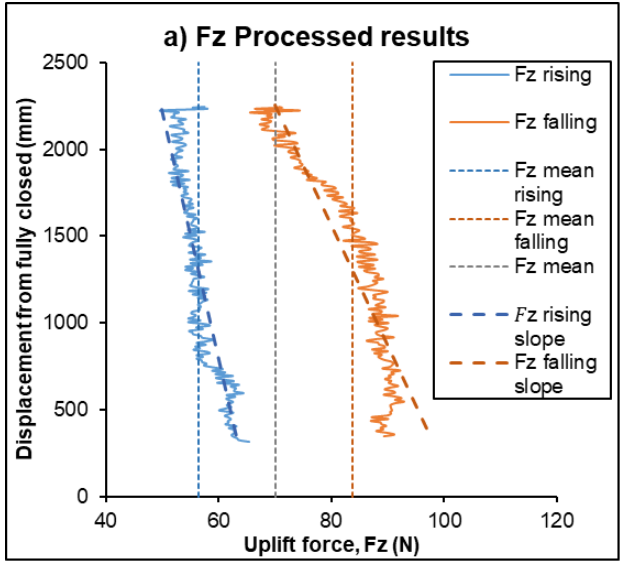

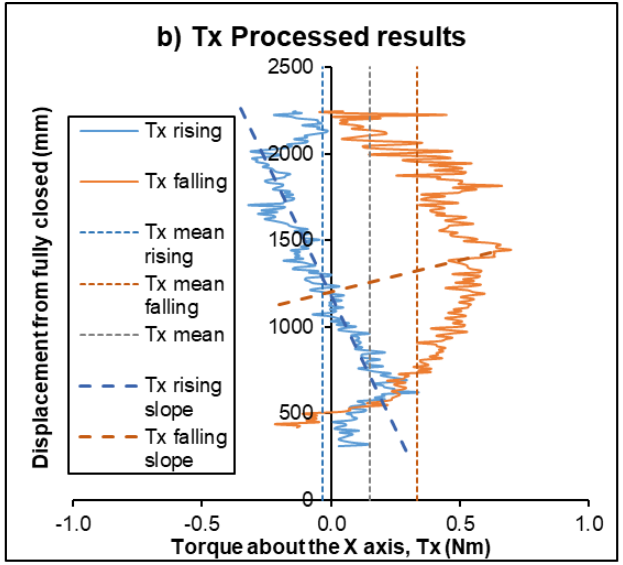

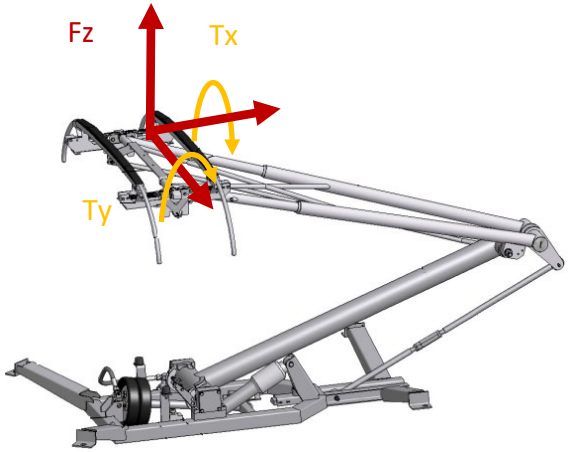

Three demo case studies

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(1) Pantograph dynamic testing

(2) Brake pad (carrier) change

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Brake pad (carrier) change

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- **Changing brake pads is a repetitive, time consuming task, involving cramped working conditions and not ideal ergonomics**
- **This is a potential candidate for automation**

Modification of mechanical design

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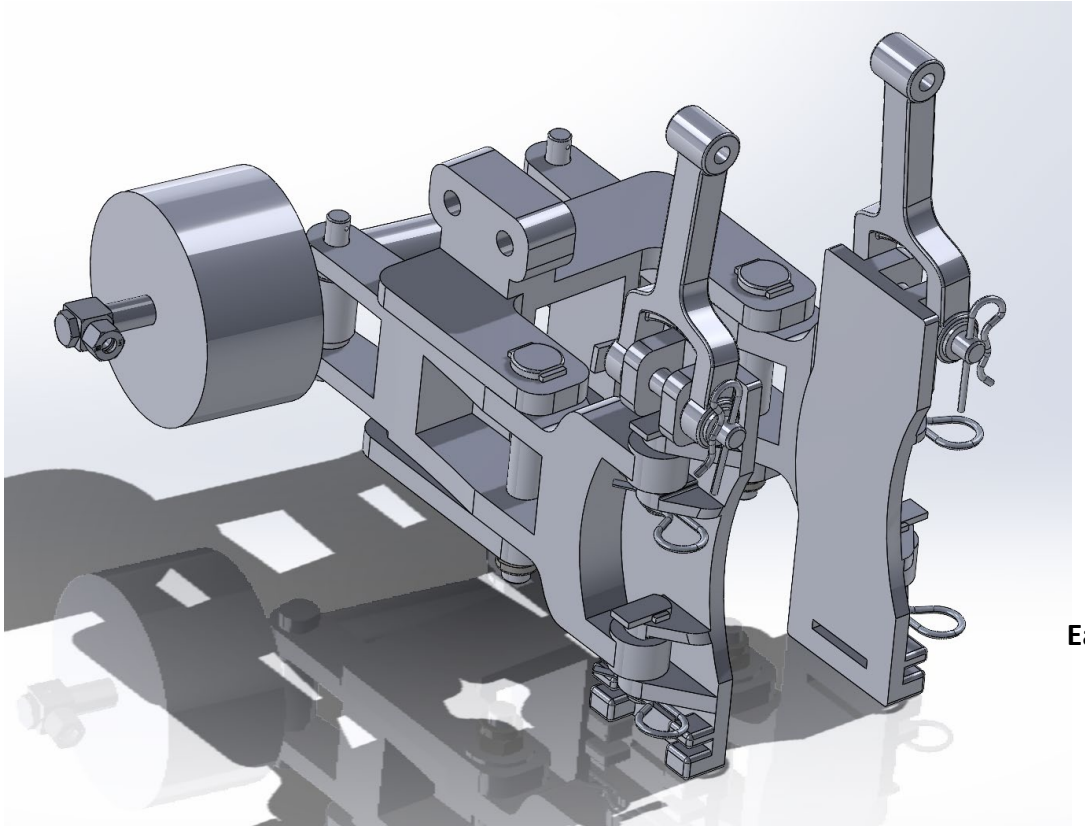
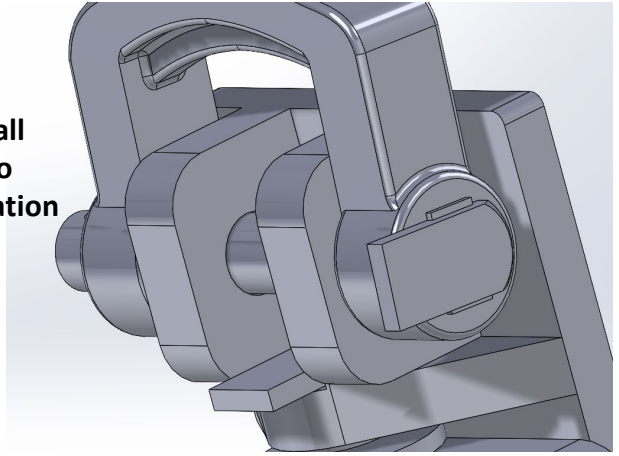
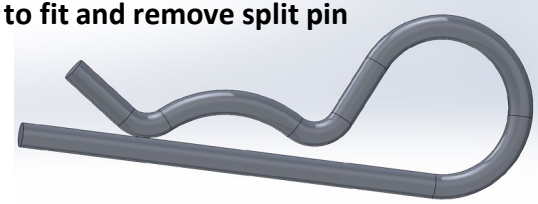


Create a small protrusion to lock the rotation of the pins



Modifying the shape of the pin heads

Easy to fit and remove split pin



Simulation in Octopuz

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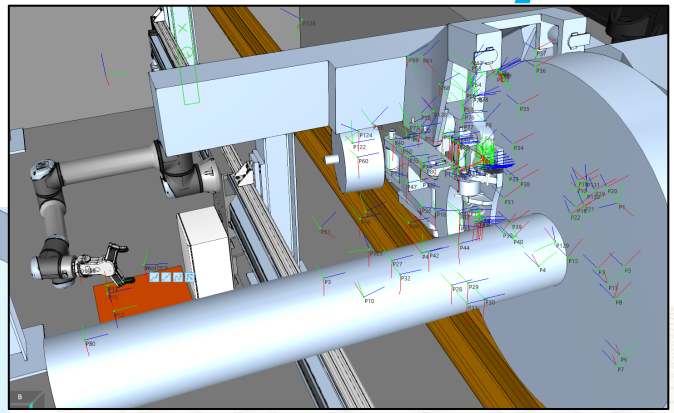

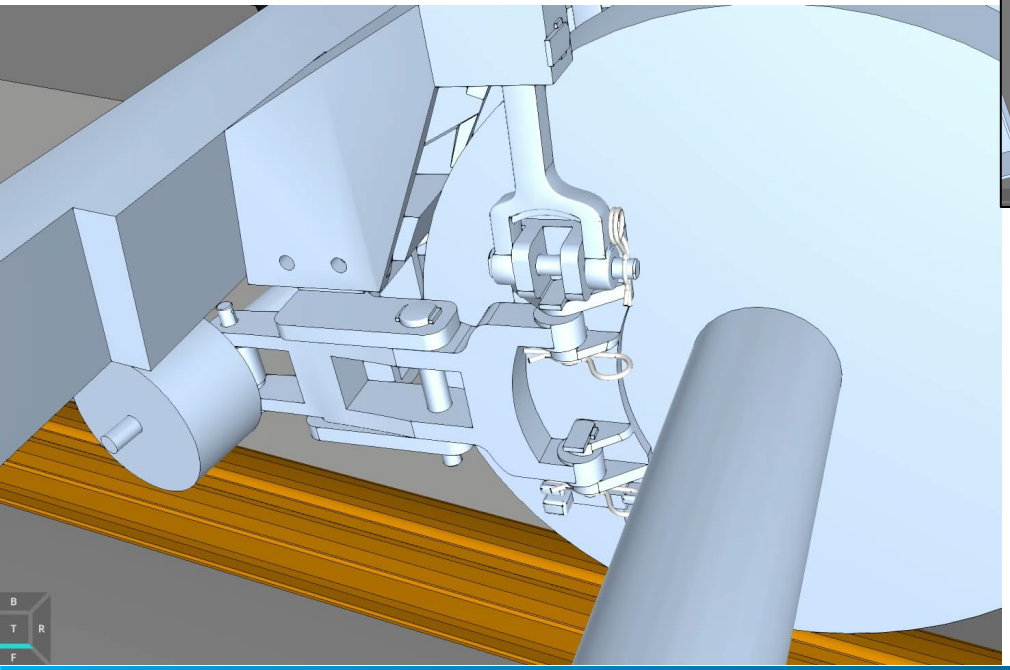

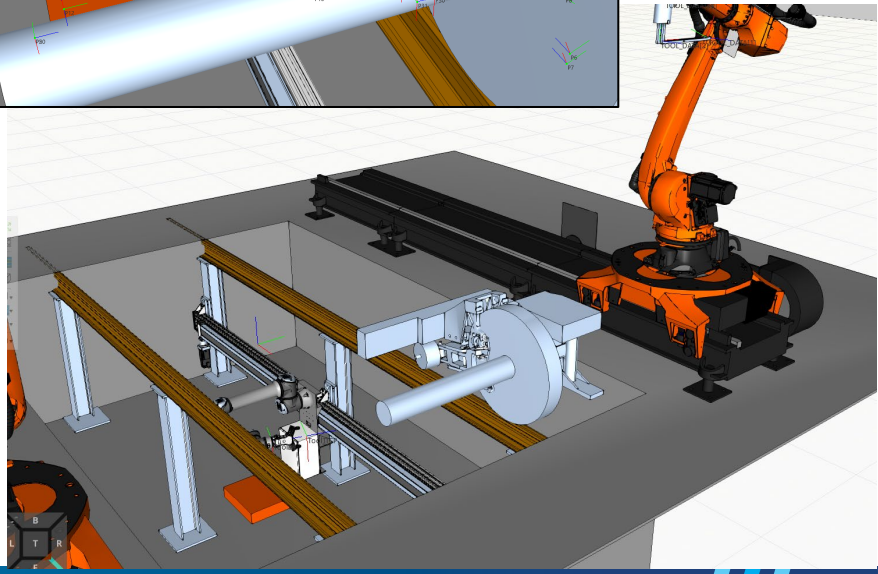

Beginning the robot program

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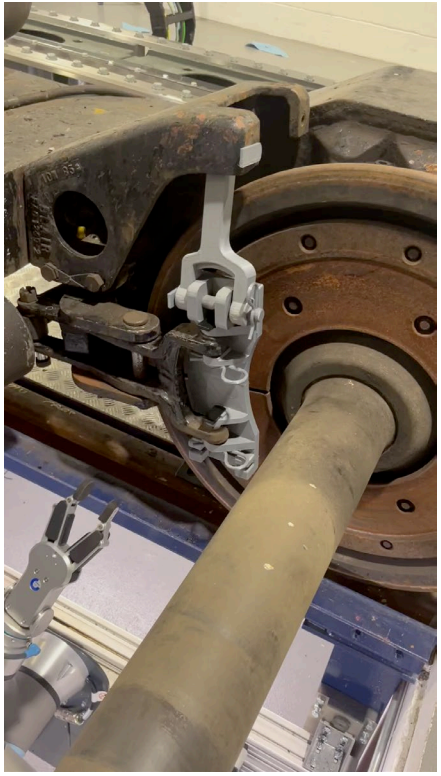
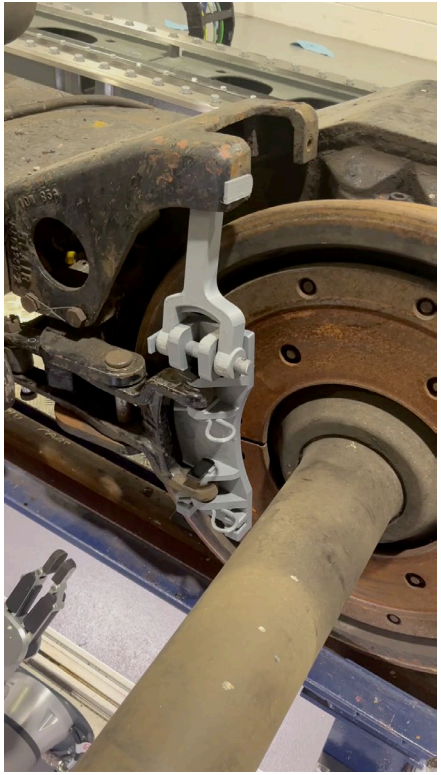

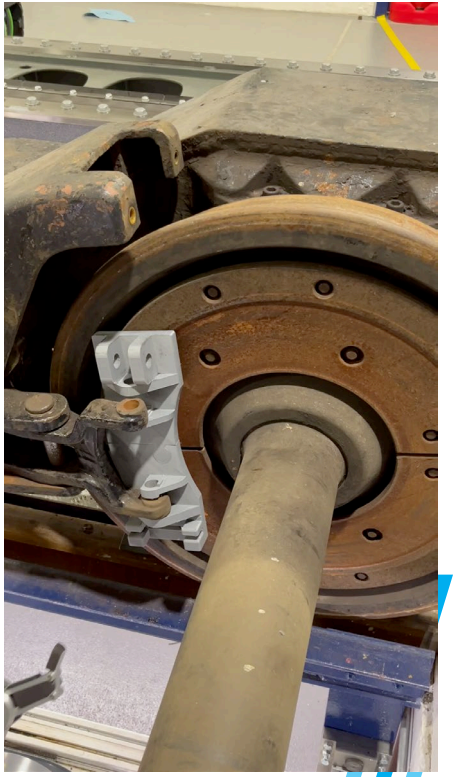

Three demo case studies

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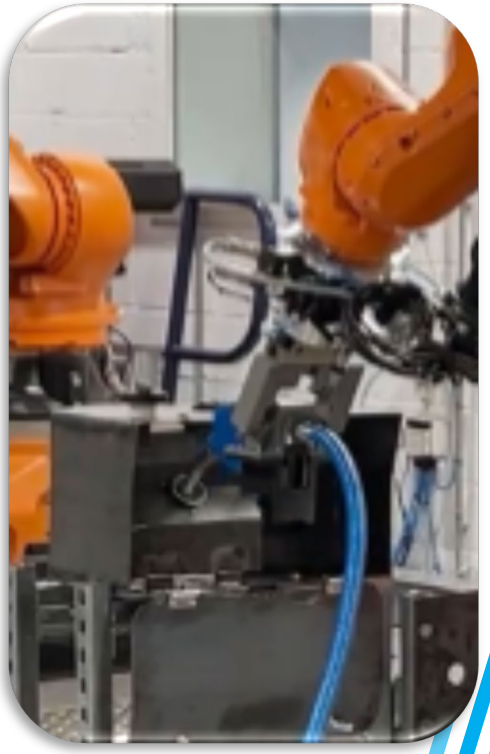

Hose ends and train side ports

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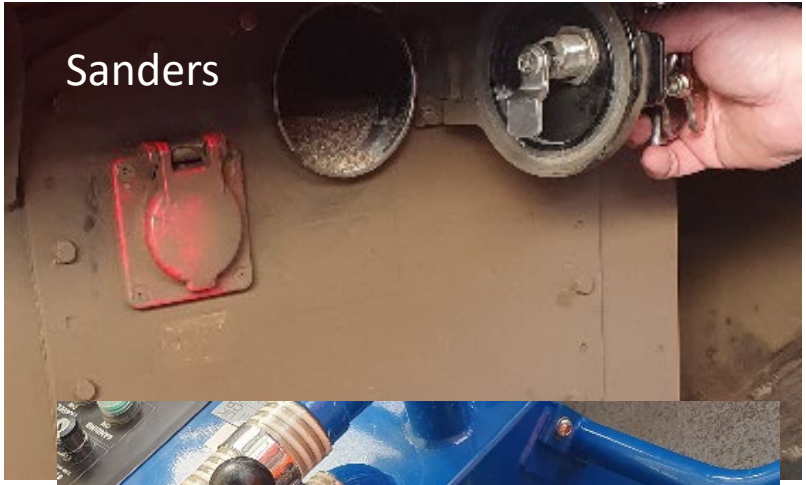
Sanders



AdBlue

Water

Overall concept: depot scale – along train deployment

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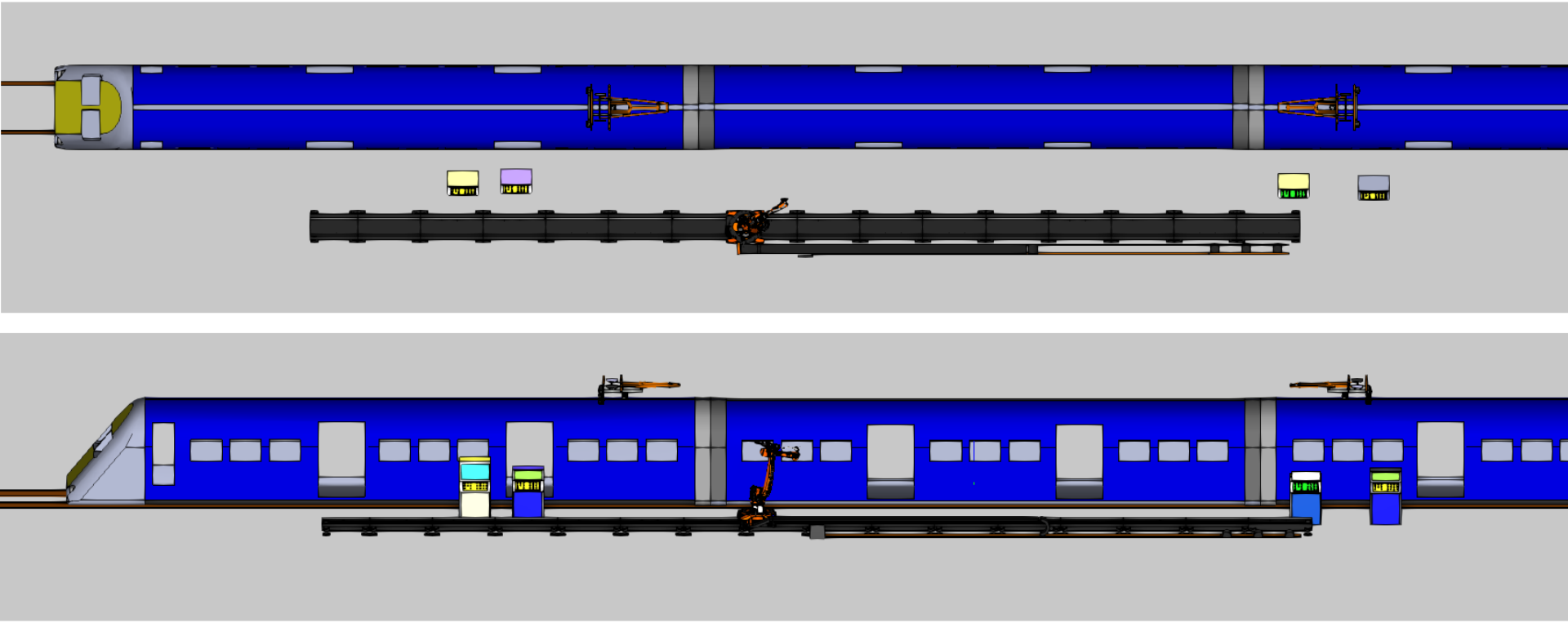

Initial development with simulation

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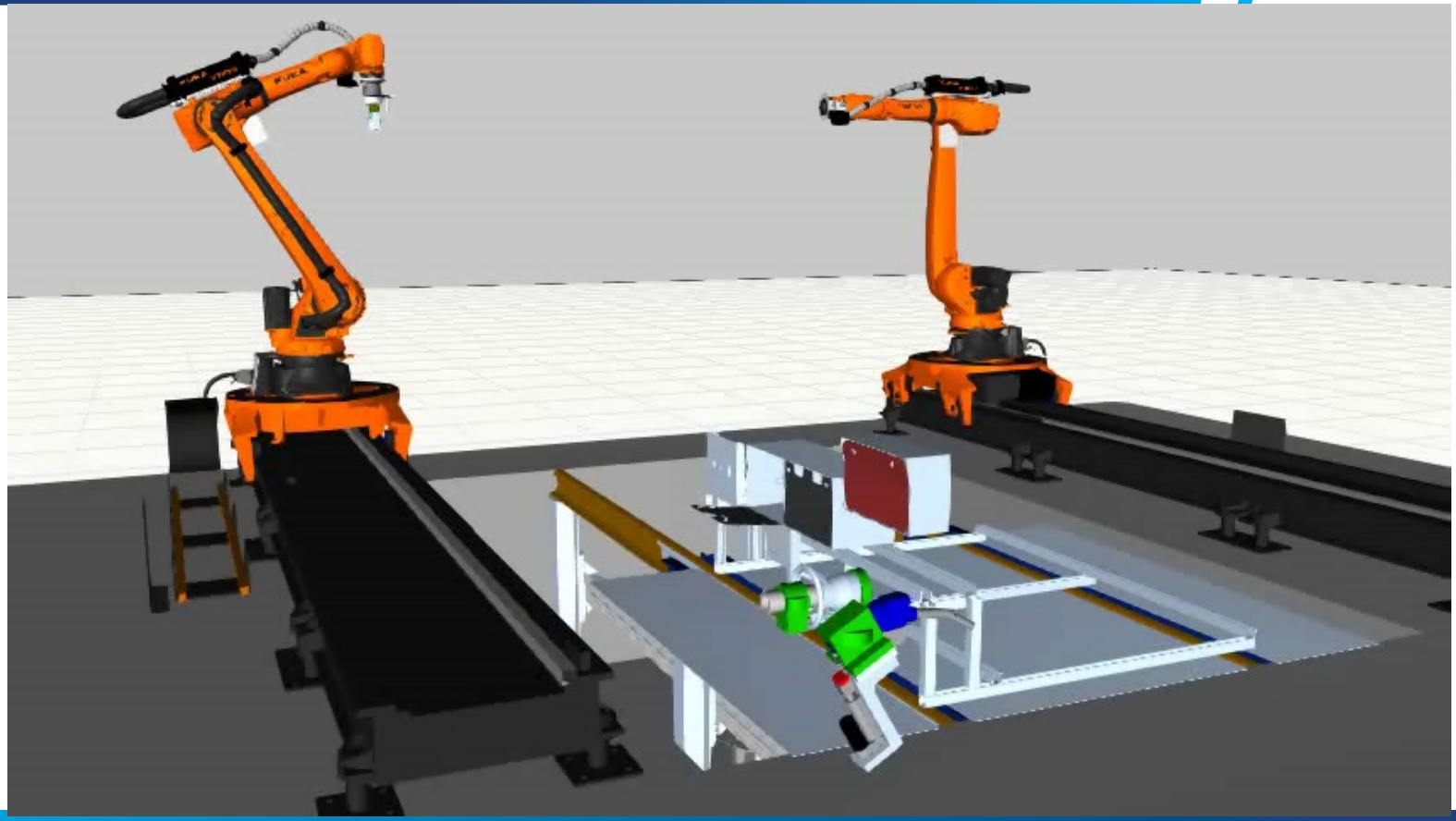

Application to the lab environment

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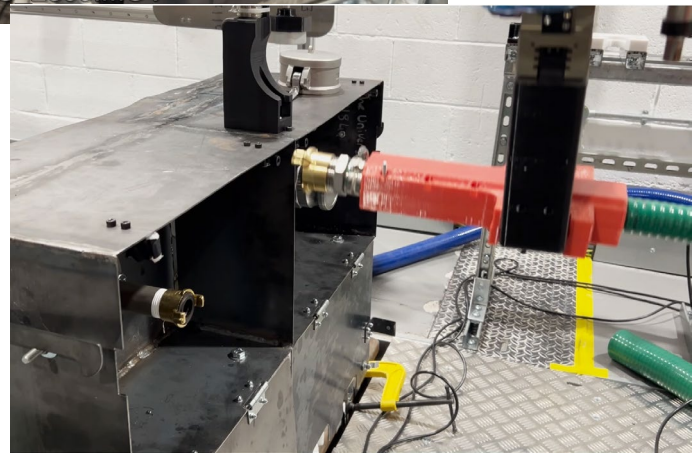
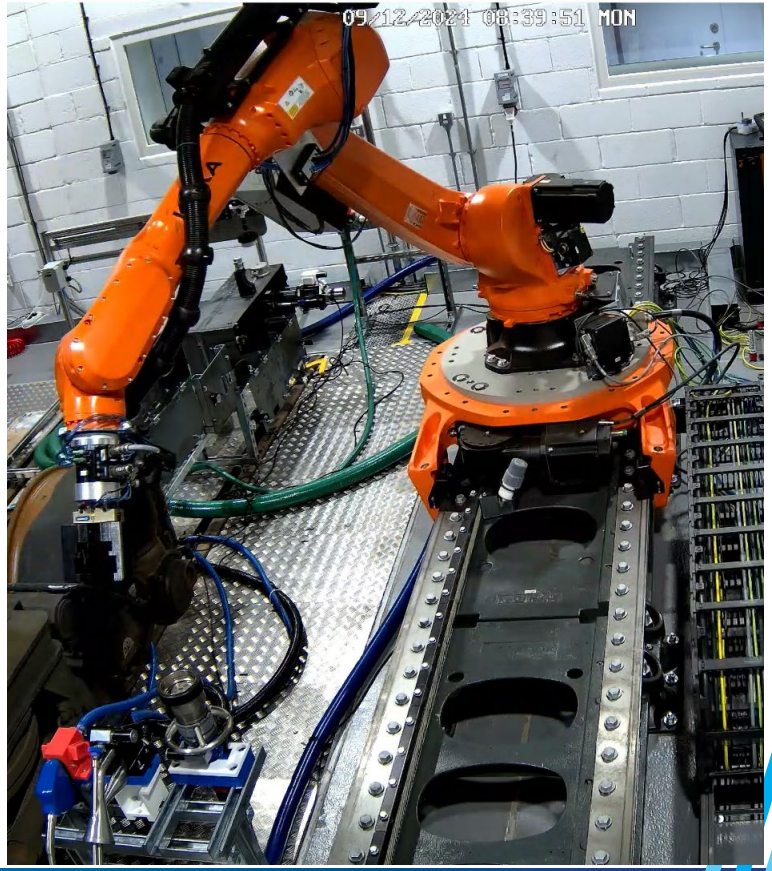
Open the side locks



Connecting Water Nozzle

Filling up AdBlue



Challenges for robotics implementation in train maintenance

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Technical

- Trains not stopping in exactly the same place every time at depot road / sidings / fuel point
- Components may be dirty / worn / damage / missing
- Trains not designed to accept robotic maintenance
- Due to volumes of work each robot arm will need to do multiple jobs to create the required cost benefit
- Robotic systems in a particular depot may need to work on multiple fleet types (and vehicle types within a fleet)
- It may be necessary for multiple robot arms to interact to deliver more complex tasks
- For cleaning/working outside robot systems will require suitable IP rating

Business

- Lack of demonstrators to clearly show feasibility and realistic benefits
- Difficult to demonstrate a business case
- Shorter contracts can make it difficult to justify upfront investments that give longer term benefits
- No clear leadership/drive/critical mass in this area
- Difficulty to implement significant changes to working practice in the rail industry

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Contact Us

If you would like to know more about our areas of expertise or wish to discuss research opportunities with the Institute of Railway Research then please contact us on the details below:

General enquiries

Institute of Railway Research University of Huddersfield Queensgate, Huddersfield HD1 3DH

Tel: +44 (0)1484 472030
Email: irr.info@hud.ac.uk
Twitter: @IRRHud

YouTube