NATIONAL NUCLEAR LABORATORY

Autonomous and Intelligent Systems Partnership

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Autonomous and Intelligent Systems Partnership

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CONTENTS

- Introduction to NNL
- NNL's remote nuclear deployment capability
- Tele-operation
- Autonomy
- Autonomous and Intelligent Systems Partnership (AISP)

NNL – Facts & Figures

- **History**
  - NNL was the R&D department of BNFL (British Nuclear Fuels Ltd)
  - Operated UK's nuclear fuel cycle
- **Size**
  - Around 780 staff
  - Over 60% have science or engineering degrees, Masters and PhDs
  - Annual turnover of approximately £80M
- **Key customers**
  - Sellafield Ltd, NDA, Magnox, Westinghouse, EDF Energy, MoD, UK Government, Regulators
- **Commercial business**
  - Operate as a commercial business
  - No direct funding or grants from UK government

NNL R&D nuclear programmes

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- Fuel and radioisotope technology – nuclear physics, reactor design, performance, new nuclear build
- Waste – vitrification, immobilisation, behaviour, chemical processes, characterisation
- Legacy and future decommissioning – robotics, remote handling, characterisation, decontamination
- Support operations of existing reactors and fuel cycle facilities e.g. fuel fabrication and reprocessing
- Asset care – impact, structural and thermo fluids modelling, robotics and remote handling
- Geological disposal, space propulsion systems

Where are our unique facilities?

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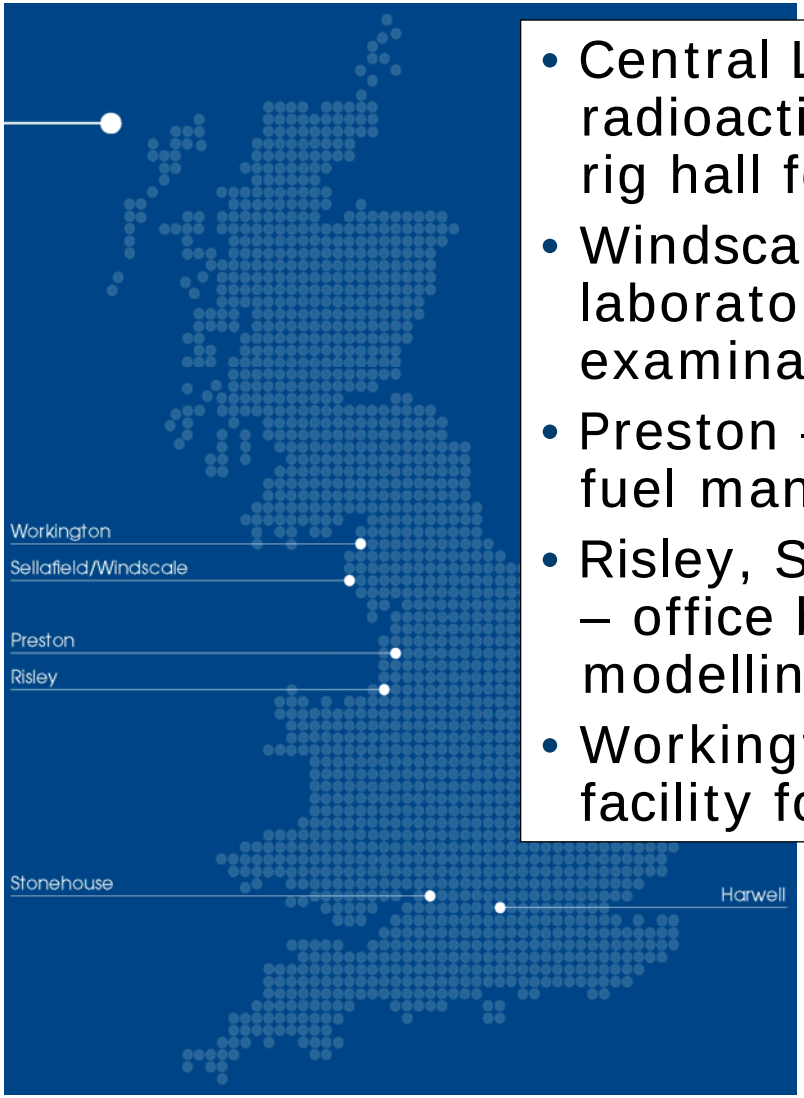
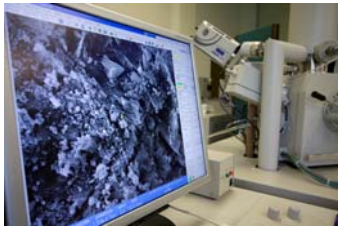


- Central Laboratory, Sellafield – radioactive laboratories and a rig hall for Pu, U, and α
- Windscale – radioactive laboratories for nuclear fuel, examination and testing
- Preston – radioactive facility for fuel manufacture and testing
- Risley, Stonehouse and Harwell – office based, simulation and modelling
- Workington – non-radiological facility for mechanical testing



NNL Remote Engineering

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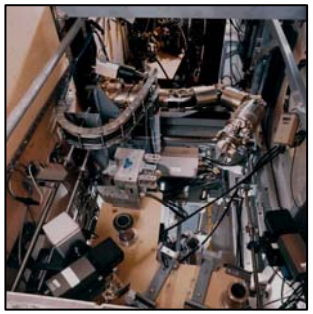
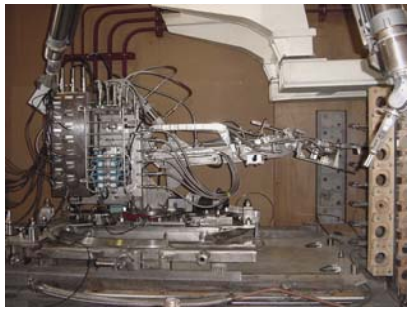
- Introduction to NNL's remote operations experience

  - Design and deployment of teleoperable systems.
  - Manipulator tooling development.
  - Remote intervention and repair.
  - Remote plant inspection and condition monitoring.
  - Sampling and characterisation.
  - Windscale Laboratory PIE caves.


NNL Remote Engineering

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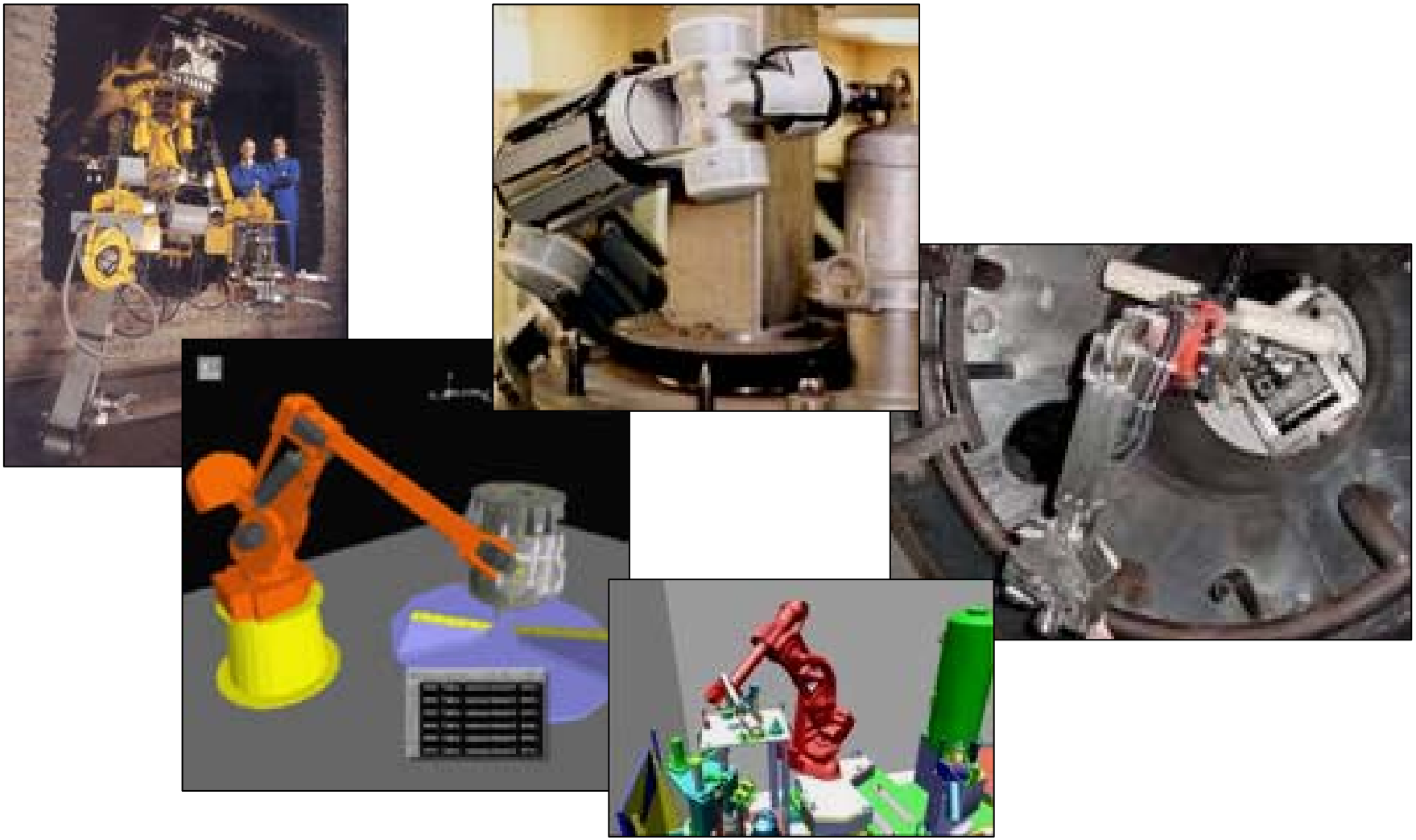

Tele-operation

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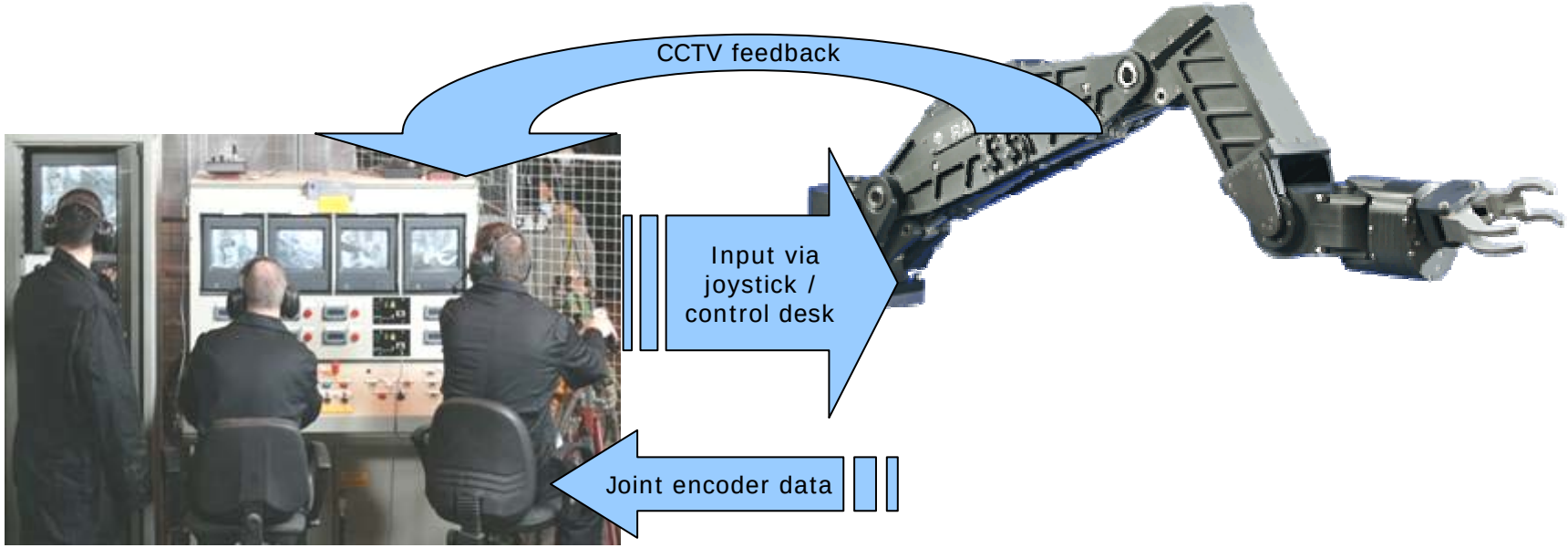
Tele-operation - manual control of a robot by an operator



Multiple highly skilled operators

Barrier:- distance, hazard, shielding

Single teleoperated device

Tele-operation – can be difficult

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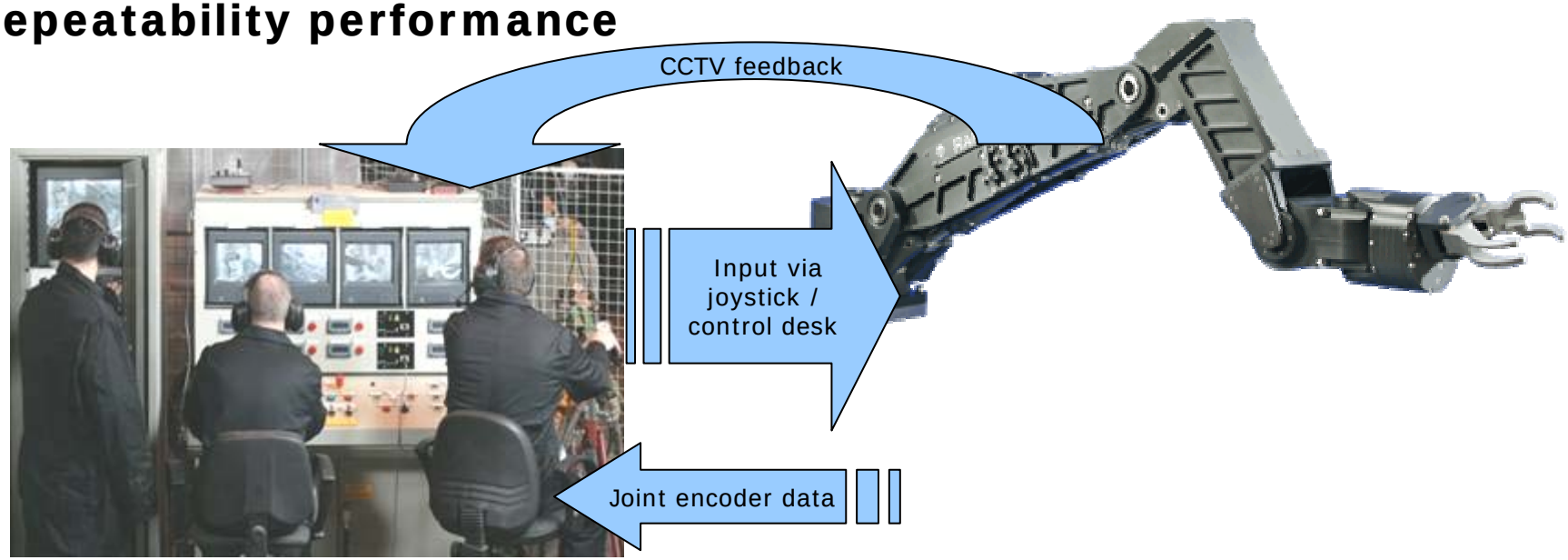
- **No visible line of sight**
- **Congested and hazardous environment**
- **Non-linear motion**
- **Response time**
- **Repeatability performance**



Multiple highly skilled operators

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Single teleoperated robot / device

Autonomous Systems

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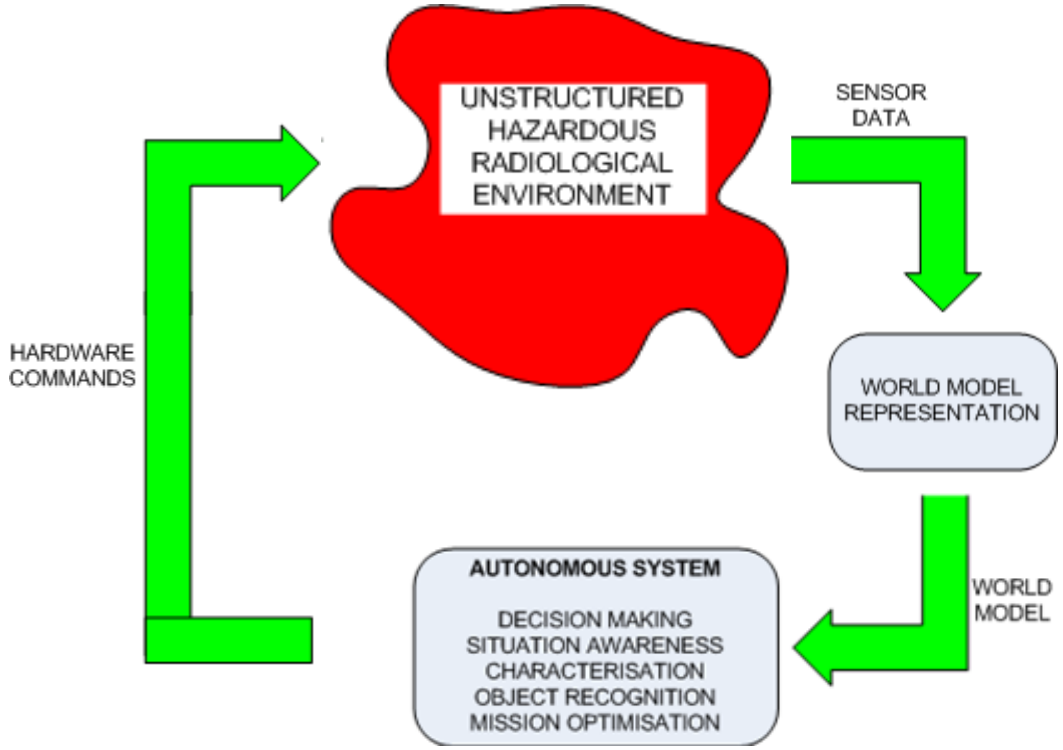
What is Autonomy?

'A system that can make decisions with some or no human intervention'



How are autonomous decisions made?

- Using complex mathematical formulations
- Neural networks
- Fuzzy logic
- Genetic and biologically inspired algorithms

Autonomous Systems

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Why do we need autonomy?

- Used for Dull, Dirty, Dangerous and Dark applications
- Remotely deploy complex hardware that present tele-operational challenges e.g. a multi-jointed robot in a highly congested nuclear cave is deployed to cut a pipe
- Such deployments are difficult for human operators – spatial awareness, positional control, avoid obstacles, avoid hazards
- Nuclear Decommissioning Authority (NDA) stated that decommissioning must be cheaper, faster and more reliable

Autonomous and Intelligent Systems Partnership (AISP)

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BAE SYSTEMS

EPSRC
Engineering and Physical Sciences Research Council

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Sellafield Ltd

Network Rail

[dstl]

Schlumberger

SCISYS

UK SPACE AGENCY





AISP History

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2010	Discussions BAE Systems and EPSRC
2010 / 2011	Formation of industrial partnerships
June 2011	Preparation of industrial scenarios
July 2011	EPSRC issued call with £6 million
August 2011	Call closes - 73 proposal submitted
August / December 2011	Proposals assessed
December 2011	EPSRC panel review
January 2012	8 projects funded with £8.65 million
February 2012	7 projects funded with £5.5 million
July 2012	Business agreements in place
July 2012	Launch at Schlumberger Cambridge
December 2012	Individual project starts

8 Proposals Co-Funded
£8.65 million

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University of Liverpool	Reconfigurable Autonomy
University of Cambridge	Autonomous behaviour and learning in an uncertain world
King's College London	Sustained Autonomy through Coupled Plan-based Control and World Modelling with Uncertainty
University of Huddersfield	Machine Learning and Adaptation of Domain Models to Support Real-Time Planning in Autonomous Systems
Loughborough University	Towards More Autonomy for Unmanned Vehicles: Situational Awareness and Decision Making under Uncertainty
University of Bath	Human-Autonomous Systems Collective Capability (HASCC)
University of Oxford	New Foundational Structures for Engineering Verified multi-UAVs
Cranfield University	AUTONOM: Integrated through-life support for high-value systems

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UNIVERSITY OF LIVERPOOL	**RECONFIGURABLE AUTONOMY**
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AISP Reconfigurable Autonomy

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- Academic Partners:
  - University of Liverpool
    - Centre for Autonomous Systems Technology
    - Logic and Computation Group
  - University of Sheffield
    - Automatic Control and Systems Engineering Department
  - University of Surrey Space Centre
    - AI Department and Autonomy Group

- Industrial Lead Partners:
  - National Nuclear Laboratory Ltd. and Sellafield Ltd.

Project Aims

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The Reconfigurable Autonomy Project aims to deliver:

- An open-source rational agent architecture that controls autonomous decision-making
- An architecture that is re-usable and generic, and can be reconfigured for many different autonomous platforms
- A verifiable core that is dynamically reconfigurable for mission goals, capabilities and control sub-systems
- Hardware can be exchanged / removed / added at run time

NNL's Simulator and AISP's Reconfigurable Autonomy

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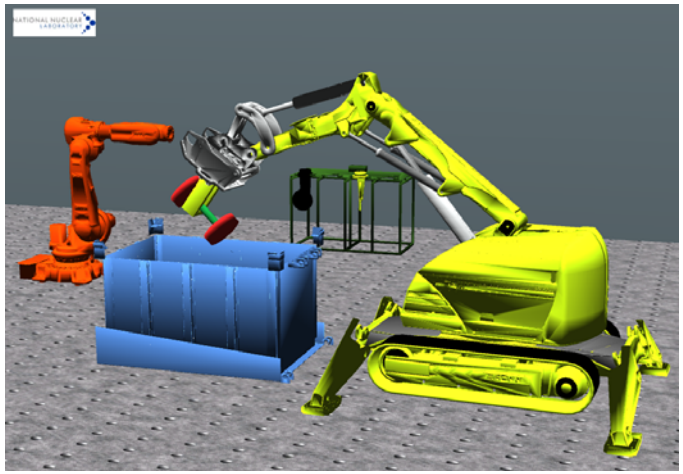
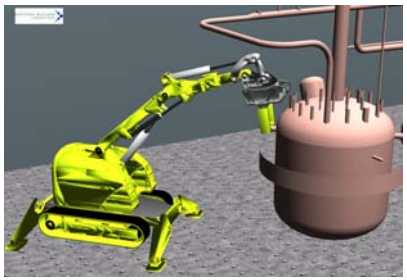
Why simulate autonomy?

- Autonomy is presently unacceptable within the nuclear industry
- Demonstrate task execution without damaging plant, equipment and people
- Demonstrate reliability and repeatability
- Test mathematical formulations and algorithms





Simulator Features

•Controlled by joystick

•Operator training

•Design phase - evaluate reach, dexterity, human factors, ergonomics

•Mission and task feasibility

•Controlled as a slave for AISP, research

Thank you for your attention!

Questions?