Sellafield Ltd

NATIONAL NUCLEAR LABORATORY

Box Encapsulation Robotics Project

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Contents

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- Overview of Sellafield site and Operations
- Why Remote Intervention?
- Box Encapsulation Plant Project
- Step Change Box Encapsulation Robotic Project
- Waste Treatment Cell and Robot Operations
- Robot Selection Criteria
- BEP Robot Trial Results
- Future Robotic Project Work
- Supporting Research

Sellafield – One of The World's Most Challenging Nuclear Sites

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THE CHALLENGE	• 1200 buildings in 6 sq km:
	  • 200 hold nuclear inventory
	  • 100 equivalent or greater than a nuclear reactor in terms of hazards and security
	• Ageing infrastructure, 60+ years
	• Poor historical record keeping

LARGEST UK CONSTRUCTION SITE	• Multi-billion facilities being built for clean-up • 450 engineering and construction projects • 17 valued over £100 million

Source data: Nuclear Management Partners Performance and Progress at Sellafield (http://nuclearmanagementpartners.com)

Why Remote Intervention?

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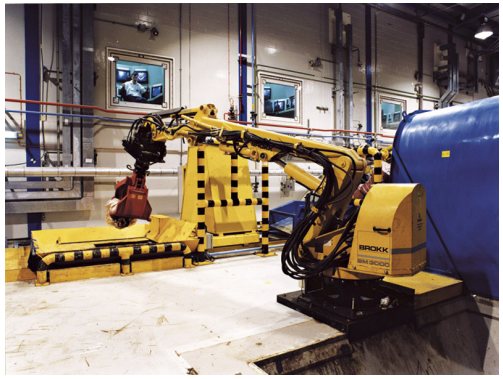
- Decommissioning the UK's current nuclear facilities including waste storage will cost £115 billion over the next 100 years.
- The cost of a UK geological disposal facility is circa £12 billion
- UK investment in new nuclear build before 2030 is circa £60 billion

- Clearly a step change is required to make improvements in risk reduction, safety, reliability, efficiency and cost across the entire UK nuclear cycle.

- Robotics has the potential to make that step change for deployment in harsh environments.



Box Encapsulation Plant Project

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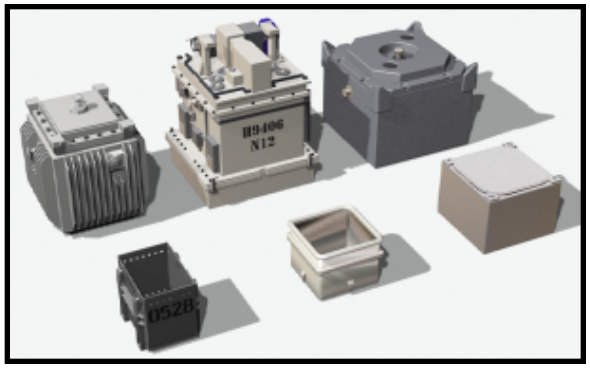
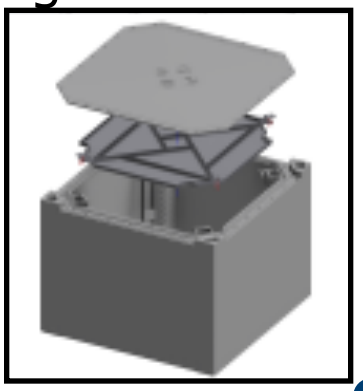
- Box Encapsulation Plant is being constructed to accelerate the Sellafield High Hazard and Risk Reduction legacy Beta/Gamma waste programme.
- BEP expectations:
  - Accelerate delivery: BEP commissioned 2018 and operate for 50 years.
  - Receive waste from numerous donor plants in differing import skips.
  - Recover, identify and flood grout the processed waste.
  - Transfer the encapsulated waste for interim storage before GDF disposal.





Step Change:
Box Encapsulation Robot Project

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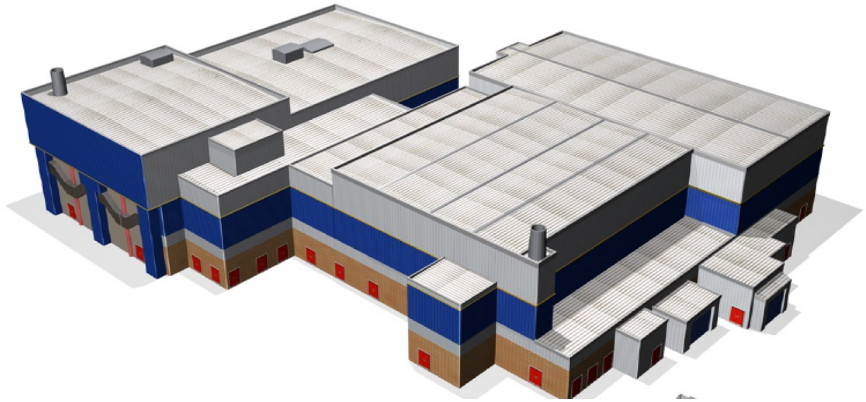
- BEP Robotic project involves the development of a robotic system that operates in both the tele-operation and automated modes
- Capable of handling legacy nuclear waste in a new plant at Sellafield to be commissioned by 2018.
- The project will run for 5 years and is being delivered in a collaborative approach between Sellafield Limited, NNL & KUKA on behalf of the NDA



Box Encapsulation Plant: Waste Treatment Cell (WTC)

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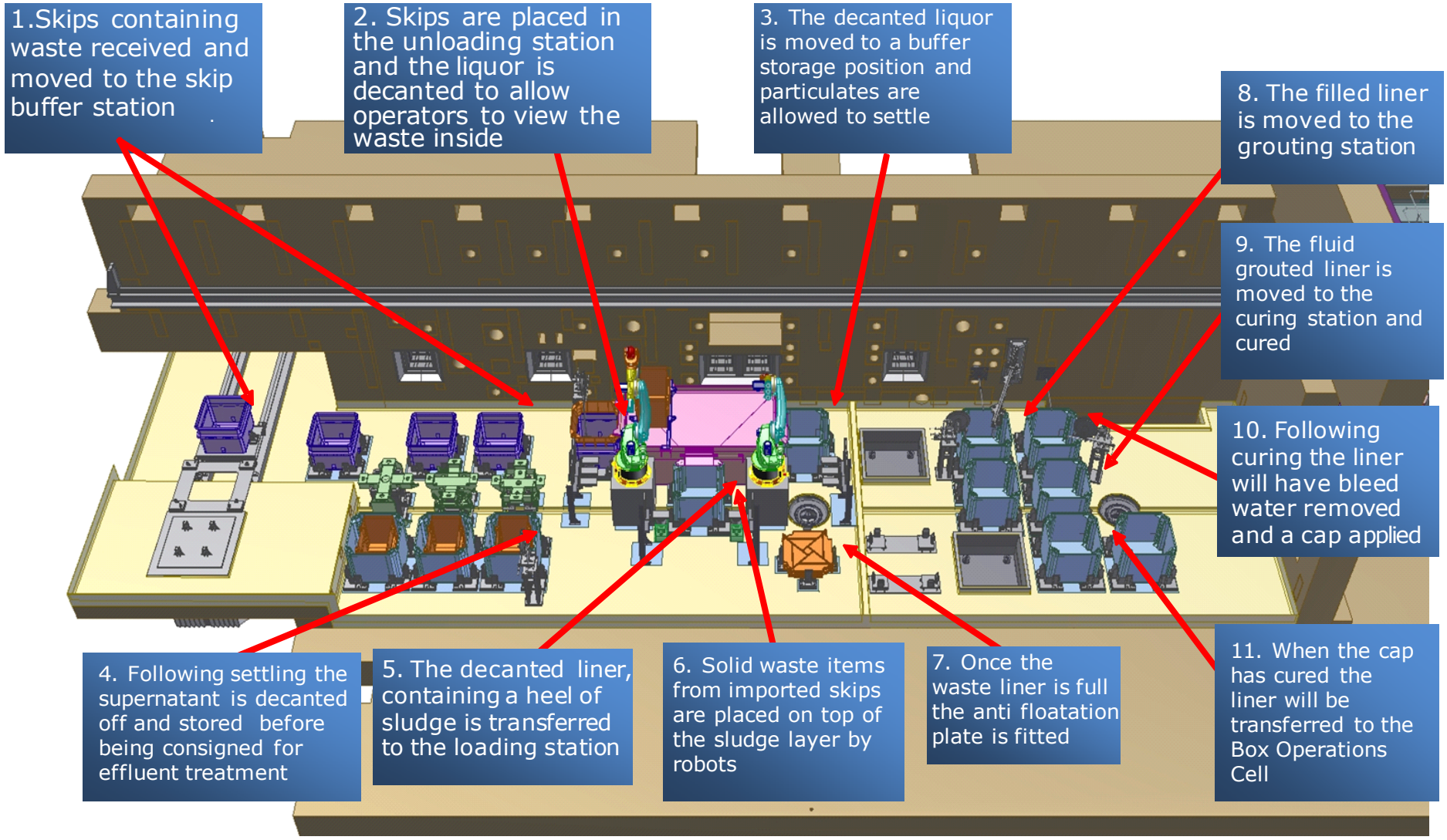

Project Significant Features and Robot Operations

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- Develop BEP robots designed for structured environments, to operate in unstructured environments.
- Minimise development and trials, and utilise LFE from elsewhere.
- Adopted systematic approach to technical development separate to project delivery.
- Utilise and nuclearise proven commercial ‘off the shelf’ technology.
- Very high reliability of robots and ancillary equipment required.
- No man access is possible:
- Use CCTV cameras to identify the waste items
- Process the waste by disruption of items to release trapped liquors and ensure full grout infiltration to minimise voidage

Robot Selection Criteria

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Robots had to demonstrate operability in a high radiation and contaminated environment. They must meet the following criteria:

- Demonstrable history of proven, technology, high reliability, service provision and prior nuclear applications.
- High payload (0.5 tonne), but robot weighs less than 3 tonnes.
- Use of resolvers rather than encoders.
- Operate in both tele-operation and programme mode with Force feedback, zoning and collision avoidance features.
- High accuracy and repeatability e.g. 0.08mm.
- IP67/65 rating for wet and sludgy environment.
- 3D live simulation of robots and environment.
- Good supplier support.
- Supplier of choice KUKA.

BEP Robot:
Waste Recovery Trials

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- All of the test materials trialled have been successfully recovered, handled, disrupted and deposited in export liner, remotely using cameras, and at acceptable throughput rates, using 2 robots.
- Graphite blocks, Magnox swarf, Aluminium doughnuts
- Sludge carryover
- Zeolite skips, Ionsiv cartridges, swarf bins, Filters
- Drums, cans, boxes and containers (tins and fuel bottles)
- Plant equipment valves, motors, gearboxes, pumps etc.)
- Generic scrap: Pipes, hoses, tubing, plastic bags and sheeting, wire rope, reels, cables, slings, chains etc.

BEP Robot: Disruption Trials

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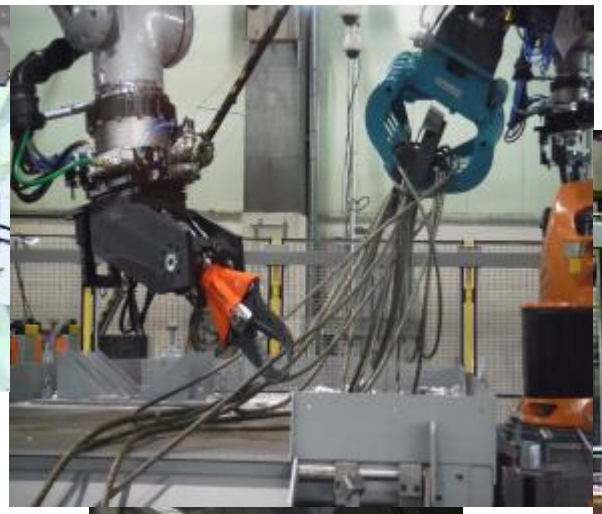
- A very high degree of dexterity & control, both in manual tele-operation & automated modes.
- A high waste consolidation & packing efficiency and enables packing of light weight waste into new cans.



BEP Robot:
Control and Tooling

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- Automated programmed sequences have reduced operator workload and stress especially for routine operations, housekeeping, waste/liquor management and tool change

BEP Robot: Tooling

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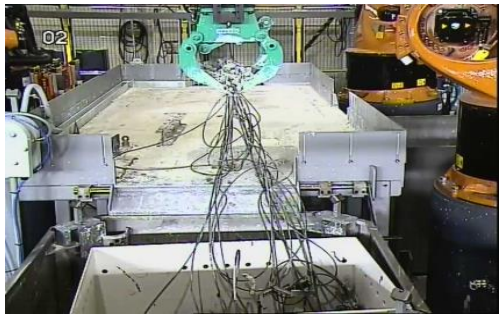

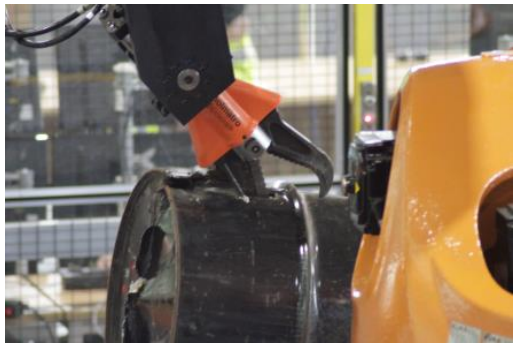

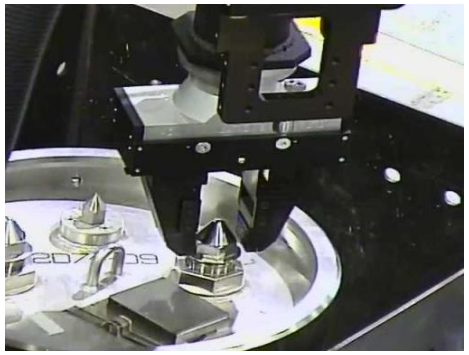

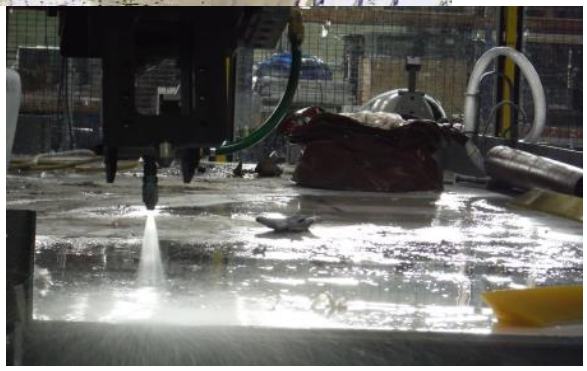

BEP Robot Future Project Work

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- Current test rig will be modified to be a complete inactive demonstrator of the BEP cell.
- Trials to investigate remote installation/removal and failure recovery equipment.
- Completion of radiation and environmental tolerance assessments.
- Nuclearisation modifications on the robot implemented
- Continued trials to investigate robot reliability, redundancy, human factors, waste identification and inventory etc.

EU Horizon 2020 RoMaNS:
Robotic Manipulation for Nuclear Sort and Segregation

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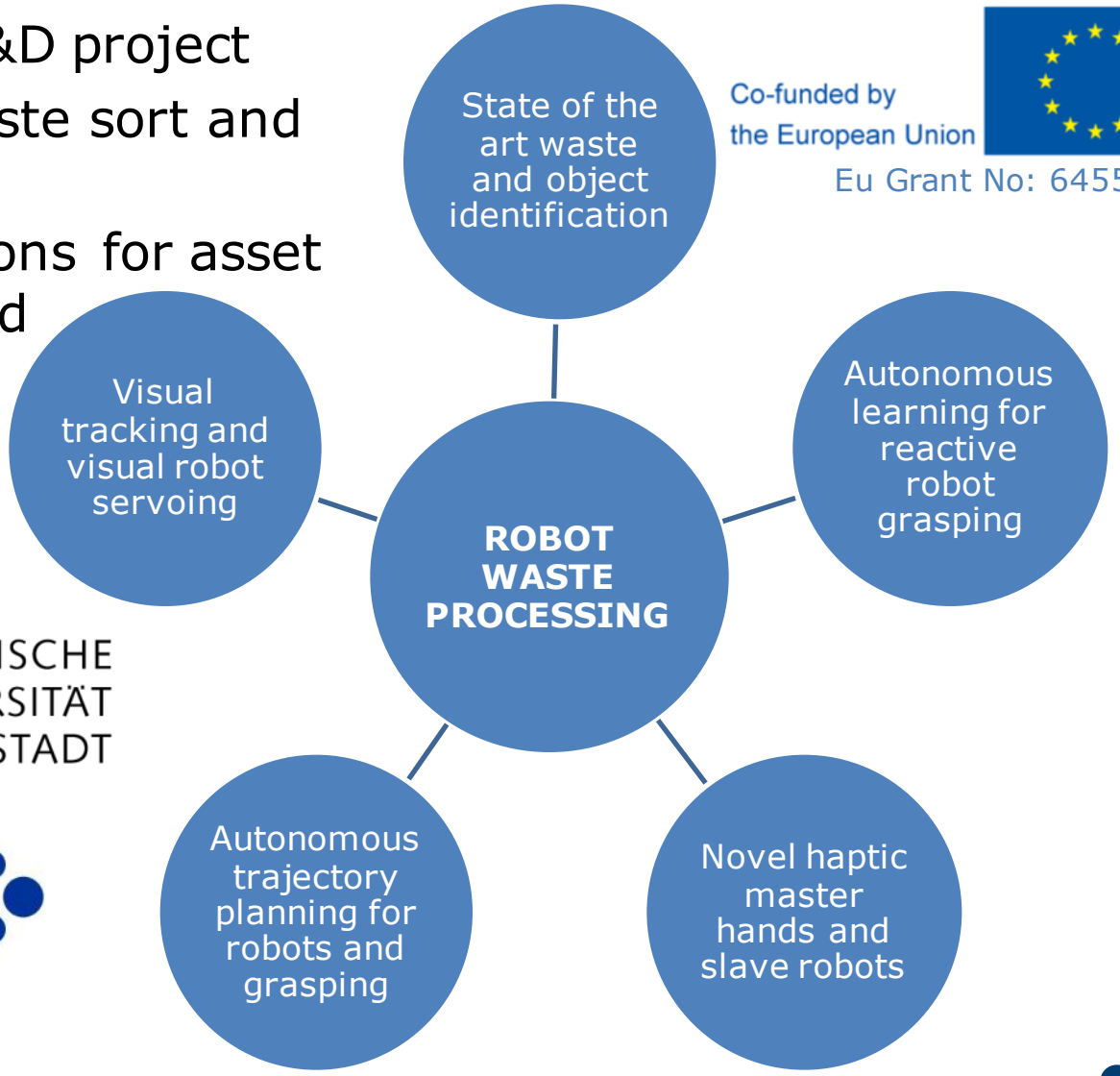
- €6.4 million 3 year R&D project
- Applied to nuclear waste sort and segregate processes
- Cross-sector applications for asset care, maintenance and decommissioning



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TECHNISCHE UNIVERSITÄT DARMSTADT

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Robot Laser Cutting

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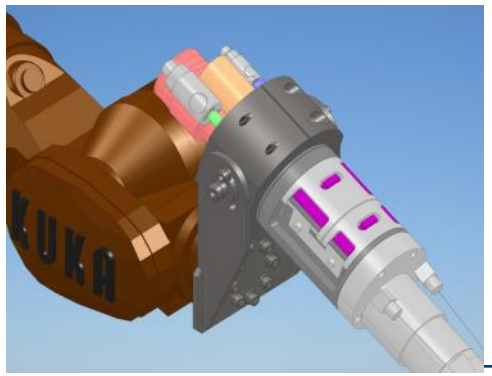
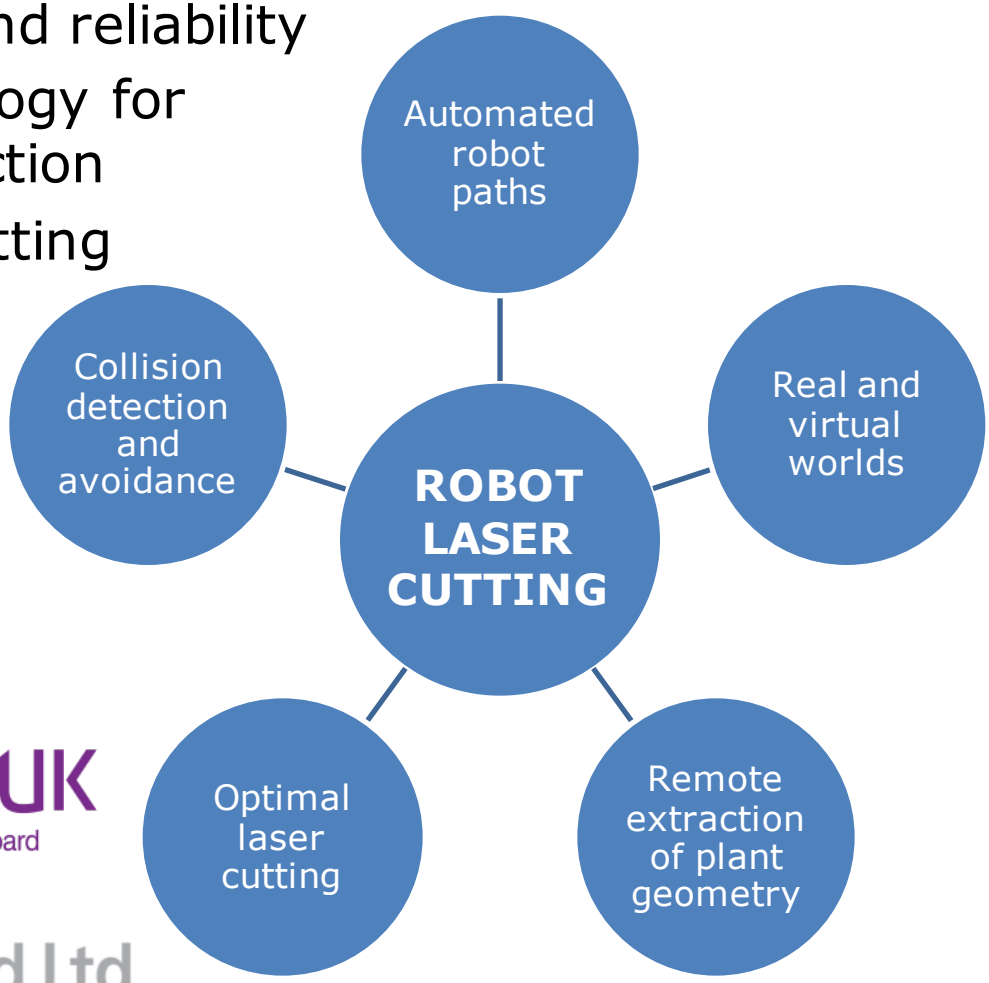
- Deploy industrial robot and laser at Sellafield
- Increase throughput, safety and reliability
- Proven and innovative technology for robot paths and collision detection
- Applied to welding, plasma cutting
- Easy operator interfaces





OCRobotics

Laser Optical Engineering Ltd

Department of Energy & Climate Change

ULO Optics

TWI

NDA Nuclear Decommissioning Authority

Innovate UK Technology Strategy Board

Sellafield Ltd

Summary

- Robots have been chosen as the technology to deliver the SL risk reduction programme for the next 50 year.
- Box Encapsulation Plant will be commissioned in 2018 with installed robots.
- Robot trials will continue for the next 5 years supporting:
  - Nuclearisation of the robots
  - Continuous Training and education platform for employees
  - Hot spares for operational robots
  - Inactive test rig supporting active operations
  - Testing for future robot and tooling development.

- Research is undertaken in parallel to delivery of the BEP Robot project thereby minimising schedule and scope creep

BEP Robot Project: Any questions?

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Thanks to:

Sellafield Ltd

NUCLEAR TECHNOLOGIES

NSG legacy management

KUKA