BARRNON
CHANGING ENVIRONMENTS

BLISSS

Autonomous sort & segregation by robotics

BLISSS started with this brief –

‘Develop an integrated, autonomous toolkit which sorts and segregates radioactive waste generated from nuclear decommissioning activities into optimised containers.’

The benefits sought:

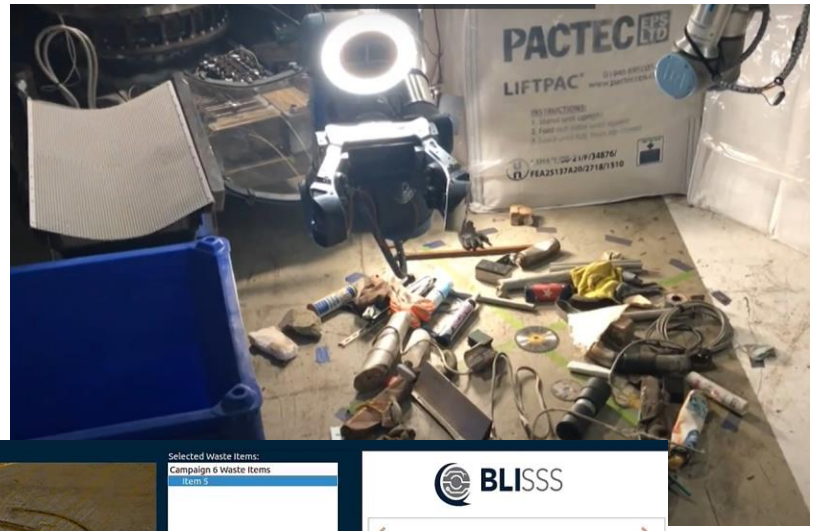
- reduce waste by prioritising recycling over its disposal
- significantly reduce sorting and segregation processes carried out by humans
- increase productivity
- be scalable and transferable

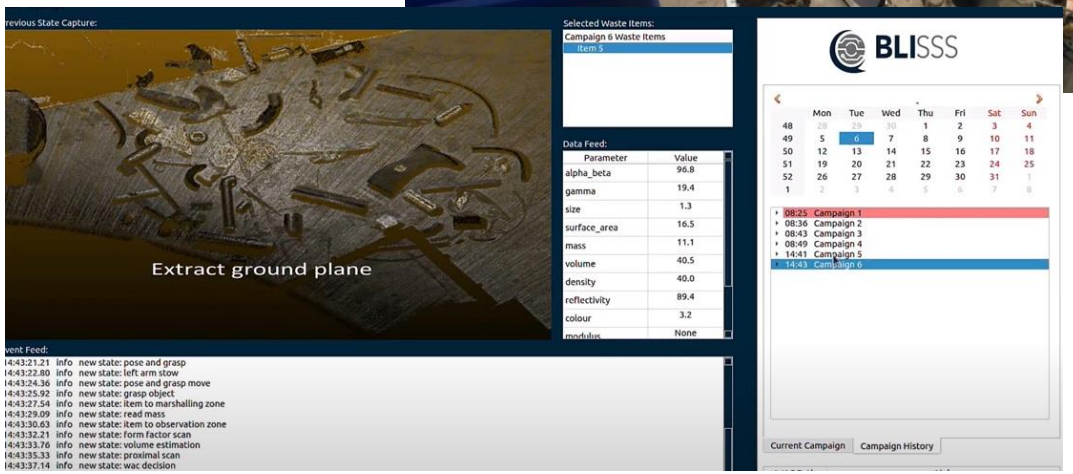
The solution:

Barrnon **L**imited **I**ntegrated **S**ort & **S**egregation **S**ystem

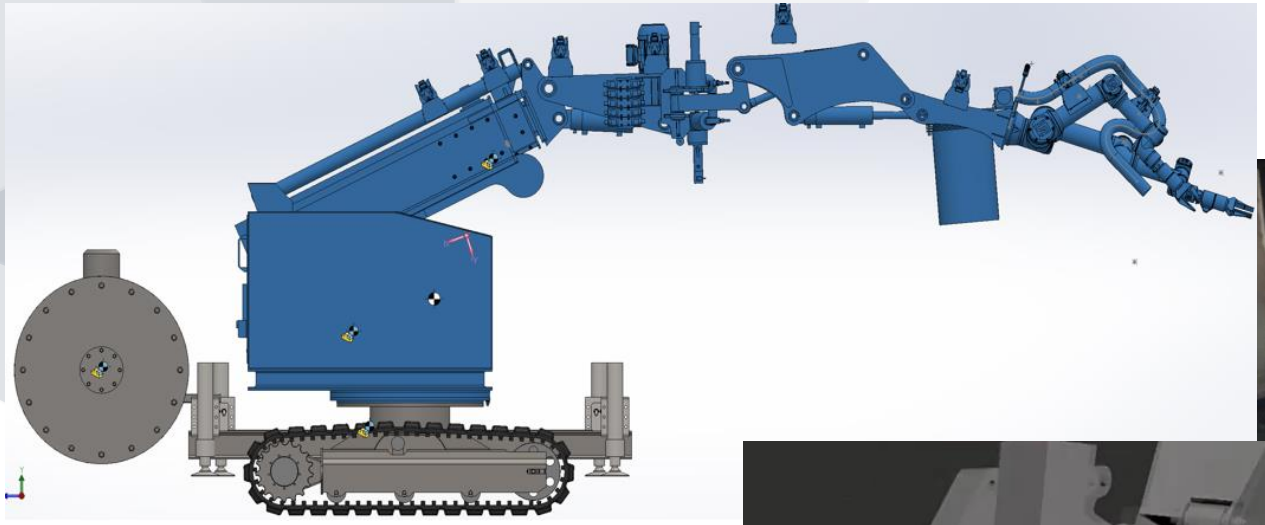
- BLISSS emulates human beings biomimetically by using many forms of perception and intelligence to achieve tasks

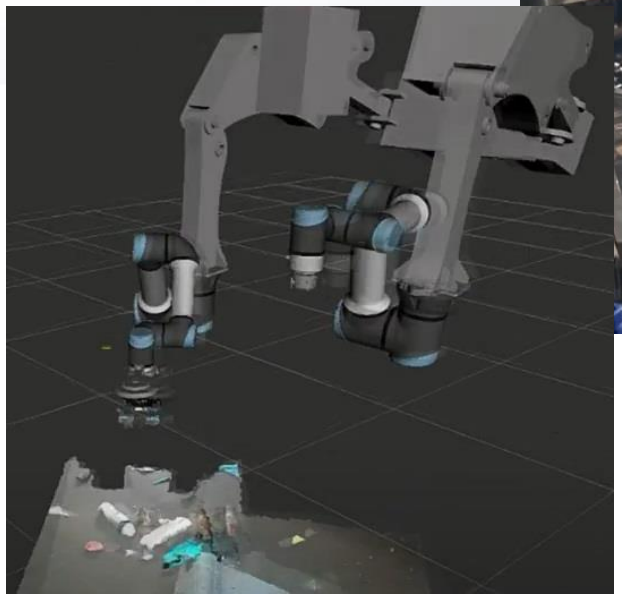
- BLISSS goes far beyond human beings as it is robotic, robust and powerful, not disrupted by ambient radiation and capable of operating 24/7





BLISSS is -





Robust highly capable robotics

allied to advanced sensing and AI

The BLISSS sort & segregate process has **5 discrete phases of operation**:

1. Autonomous access & environment capture

2. Objet recognition & location

3. Prioritisation & object collection

4. Data capture & WAC Decision Tree

5. Object delivery & Reporting

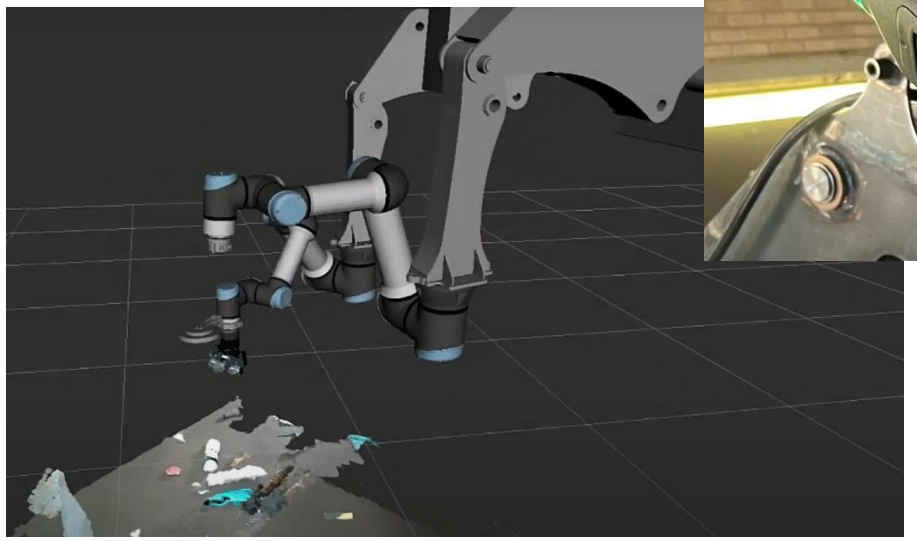
All processes are overseen by an independent Supervisory System

Phase 1: Autonomous access & environment capture

The BLISSS ROV enters a decommissioning cell then creates its own 3D model of the operating environment.

This is achieved using a Lidar scan linked to a model of the robotic system, a URDF (Unified Description Robotic Format).

Once the global coordinates are obtained from the 3D point cloud the URDF is accurately positioned in relation to the environment. Thereafter, all movements are planned and executed within these global coordinates.



Simulation in Rviz of the robot system and the debris pile

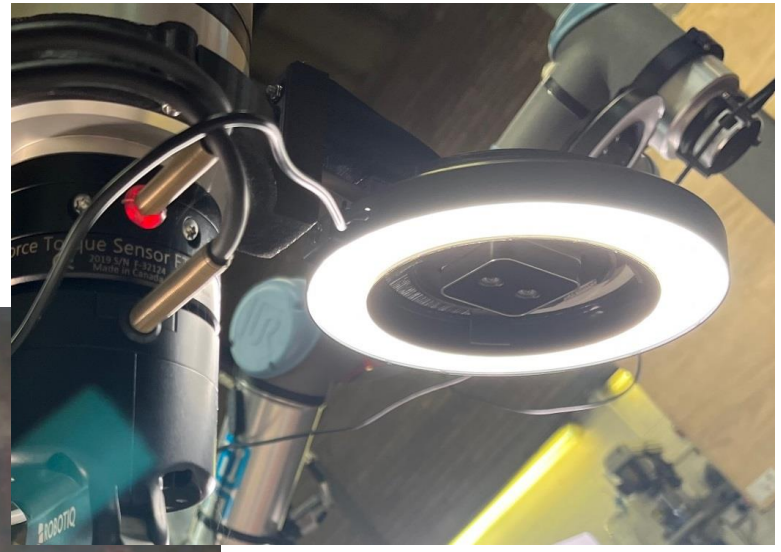
Leica Lidar scanner mounted in an optimised position on the robot system

Phase 2:
Object recognition & location

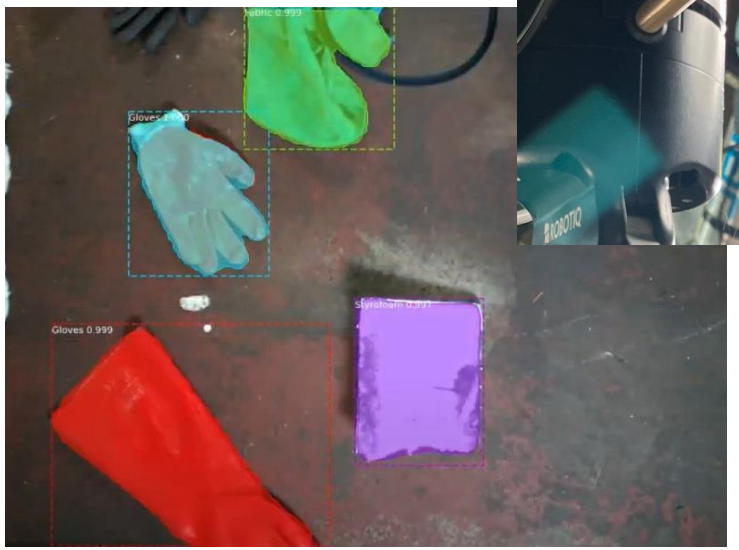
The debris items are located and recognised by a depth camera mounted on a robotic arm. The depth camera is deployed to perform a raster scan.

Data from the scan are put through a system of analytics which compares what is observed with multiple 1000s of instances of previously scanned objects. This process of reinforcement learning is akin to how human beings learn to recognise objects.

The provisionally recognised objects are then put into a distribution table to establish where they are located.



Scanner mounted on arm



Object identification

Phase 3: Prioritisation & object collection

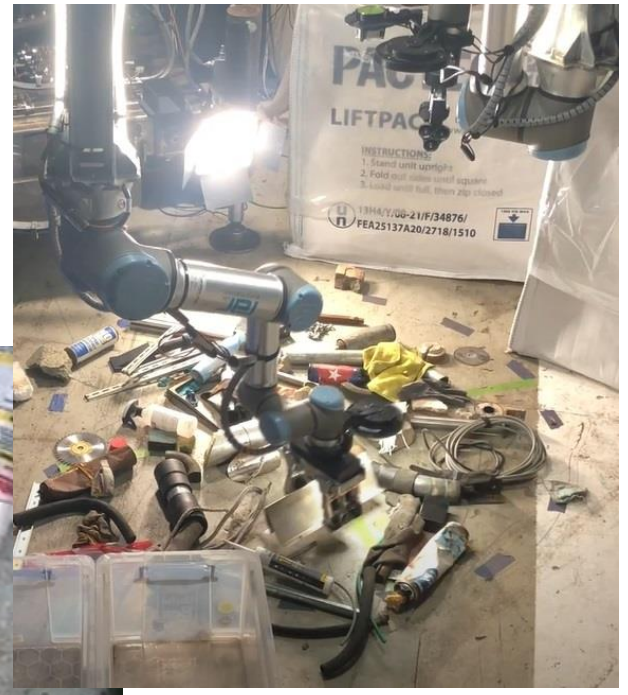
Depending on the criteria selected – largest object, object highest on pile etc. – the order of collection of objects is decided by the system.

The next step is pose & grasp estimation: here the system calculates the optimal route to move the gripper to the selected object, and how to pick it up.

All moves are simulated and verified by the independent Safety Supervisory System. If a potential error is identified, the Supervisory System can intervene and call in a remote operator using VR.

The object is collected if the move has been approved.

Camera view of gripper action



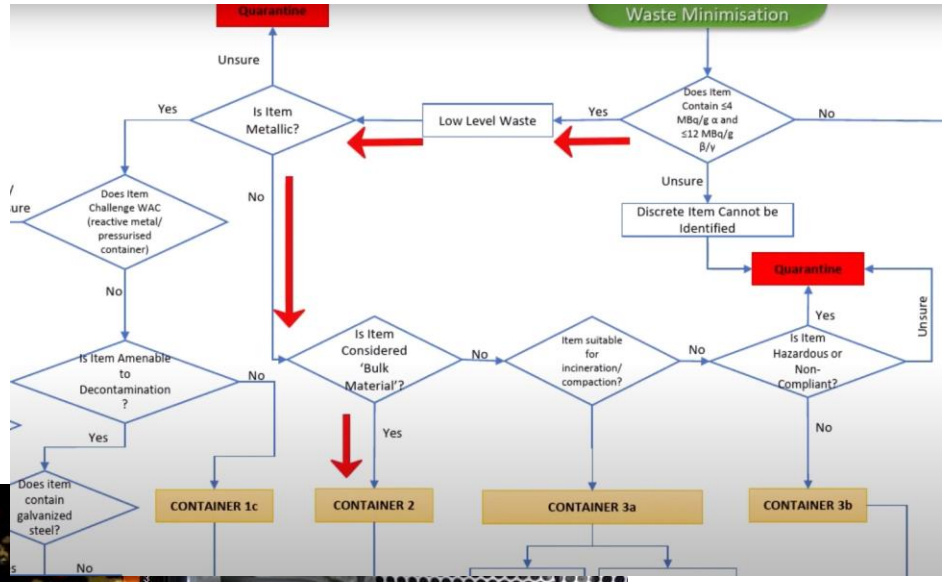
Collection of object from debris zone

Phase 4:
Data capture &
WAC Decision Tree

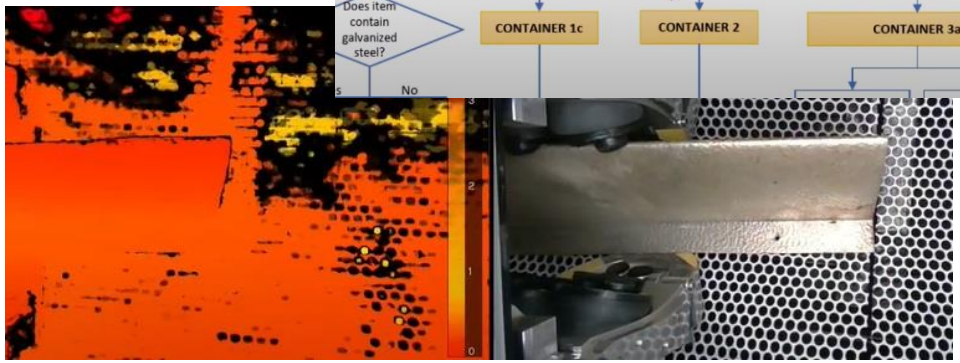
The reliable identification of an object depends on the number of data sets and the quality of the analytics. BLISSS collects multiple orthogonal data sets to corroborate or challenge the initial identification.

Data include mass, volume, ferromagnetic and radiation signatures.

The data are thereafter put through a Decision Tree which uses rules obtained from the industry standard Waste Acceptance Criteria (WAC) and Certificate of Acceptance. Any decision can be challenged by the Safety Supervisory System.



WAC Decision Tree



Item delivered to weighing scale

Phase 5: Object delivery & Reporting

The waste disposal decision is now implemented, but only after the path-planning has been verified by the Safety Supervisory System. Any potential collision must be avoided.

The object is delivered to the appropriate waste route container and packing is optimised by the system to ensure efficient and safe use of the containers.

BLISSS issues a Report in the Sellafield format plus an independent evidence trail demonstrating how the object recognition was arrived at, and how the WAC decision was made.

OFFICIAL (When Completed)

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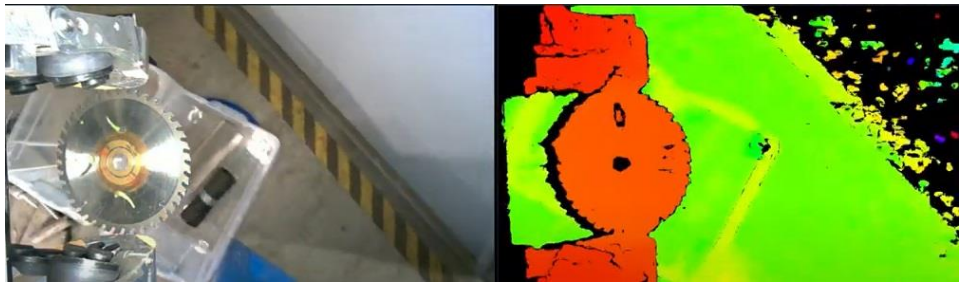
Monitored By:	Date Monitored:
Ratemeter Type:	M00
Probe Type:	M00
Radiation Inst Type:	M00

Notes:
Complete **all** monitoring columns
- Give **Gross** readings taken ***prior to wrapping.***
- **Items** identified with any loose contamination **MUST** be securely wrapped in PVC and sealed.
- **External** surfaces of **all** packages must be free from non fixed (loose) contamination.

Item ID	Item Description *Give an accurate Item Description so that the waste can be identified from this description – the word "waste" is not adequate. Include all material types that make up the item on separate lines.*	Fixed Contamination (cps) α Bgd	α Peak	α Avg	β Bgd	β Peak	β Avg	Loose Contamination (cps) α Bgd	α Loose	β Bgd	β Loose	Radiation (μSv/h) γ Peak¹ Avg²	βγ Peak¹ Avg²	Hazardous (Y / N) If yes state what hazardous properties*	W.E.E.E (Y / N) If yes state number of items*
	Surface Area (m²) / Weight (kg) / Thickness (mm)													Yes / No	Yes / No
	Surface Area (m²) / Weight (kg) / Thickness (mm)													Yes / No	Yes / No

Sellafield form with data entries made by BLISSS

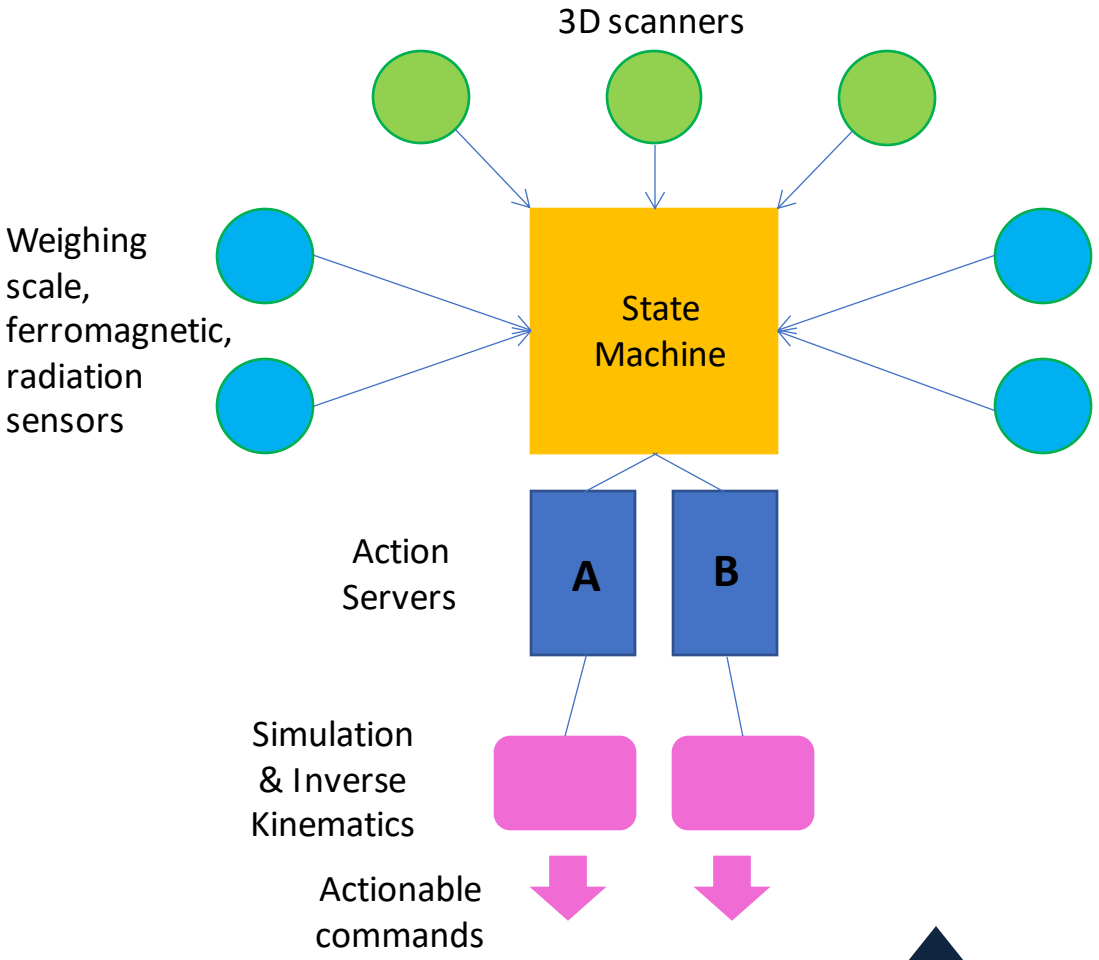


Object delivered to designated waste route container

How BLISSS works

A highly schematised version of how the BLISSS sensing and intelligence works:

3D scanners provide data that enable the system to build a model of itself in the environment. The State Machine manages all events and makes next-step decisions based on the outcome from previous events. Orthogonal data sets are processed. Based on the outcomes at each step, the State Machine activates the Action Servers, **A** and **B**. **A** generates commands for the mechatronics to enact and **B** generates commands for the sensors and data-processing capability. Commands issued to the mechatronics are converted into inverse kinematics format and simulated before being issued to the mechatronic system. All these functionalities recur in multiple loops.



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