

# From Waste Chaos to Compliance: A Robotic AI System Achieving Real-World Remediation End States



## About Us

- Research & Development
- Founded in 2008
- Privately Owned
- Headquarters in the United Kingdom
- Offices in Japan, United States and South Korea





# Sort & Segregation of Nuclear Waste

## Automation of Nuclear Waste Sorting

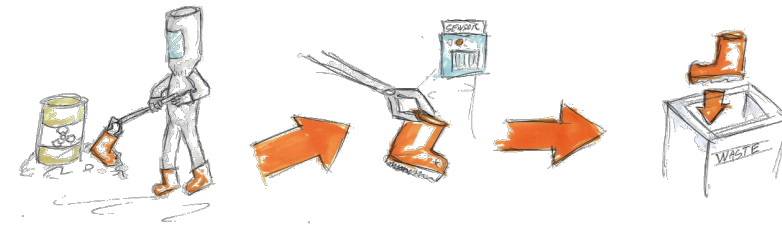
Utilises advanced computer vision, ML and robotic technology

## Identifies Waste

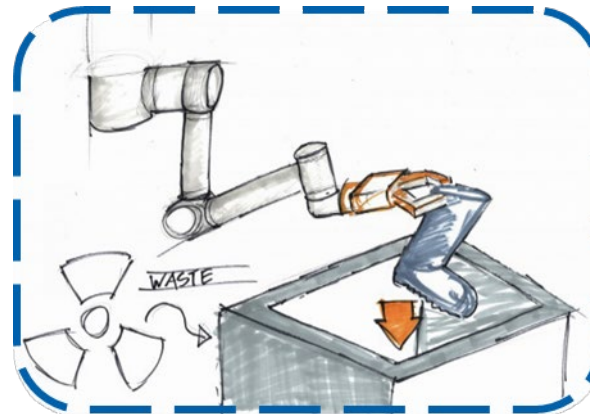
Identifies and sorts debris based on size, material and shape

## Agnostic Platform

Utilised by any robotic platform



Humans assess and sort contaminated into the appropriate stream for disposal.



A robot can mimic human activity via machine learning and allocate the waste to the appropriate stream.



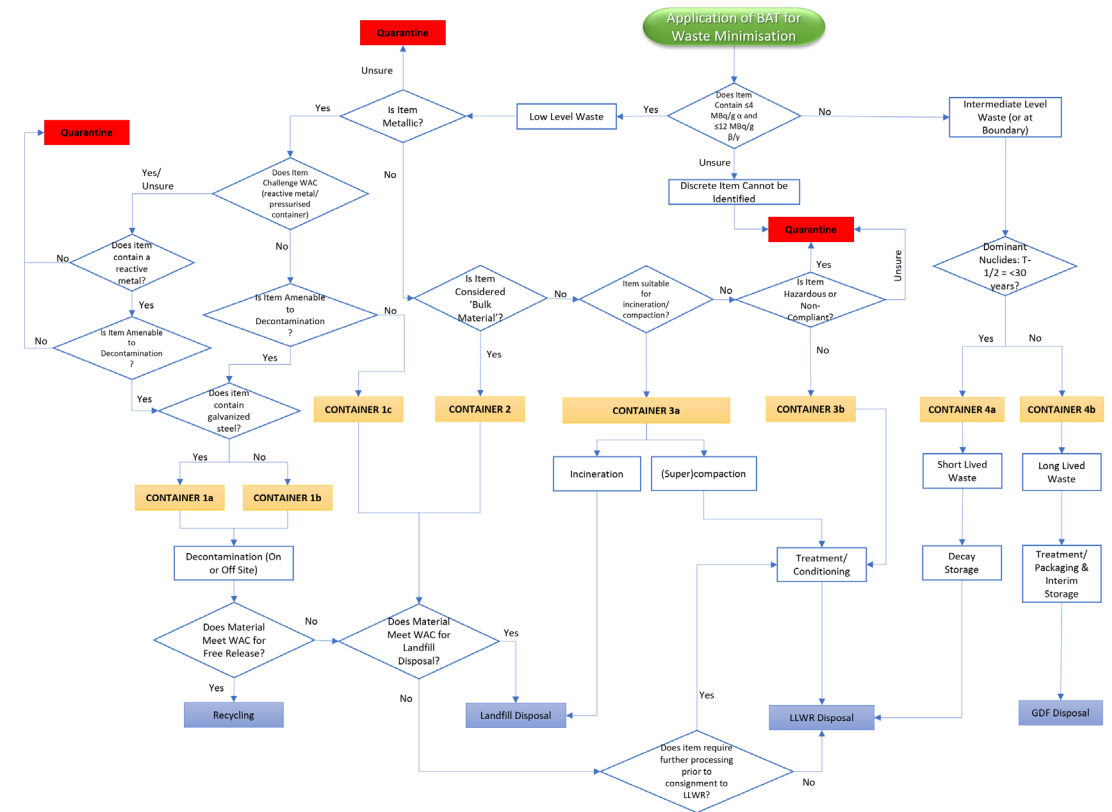
# Waste Stream Compliance

## BAT – Best Available Technique

- Utilise the best practical methods currently available.
- That are technically and economically feasible.
- And that minimised the generation of waste or its hazardous properties.

## Relevance to UK and EU Nuclear Regulation.

- Operators are required to demonstrate the application of BAT when managing radioactive or hazardous waste.



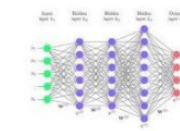
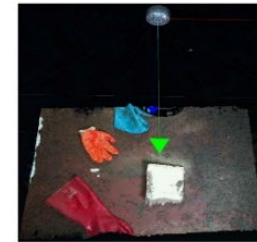


# Material Identification

- Initial identification via Machine Learning (deep-learning computer vision).
- Orthogonal datasets for mass and paramagnetic materials.
- Laser ablation techniques
- Hyperspectral imaging techniques

## Material identification

### Initial Recognition



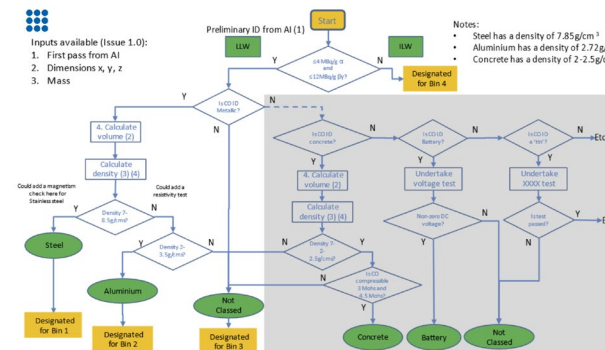
Deep learning recognition



### Orthogonal Data

✓ now

✓ future



- ✓ density
- ✓ ferro-magnetism
- ✓ voltage test
- ✓ compressable
- ✓ laser-induced breakdown spectroscopy (LIBS)



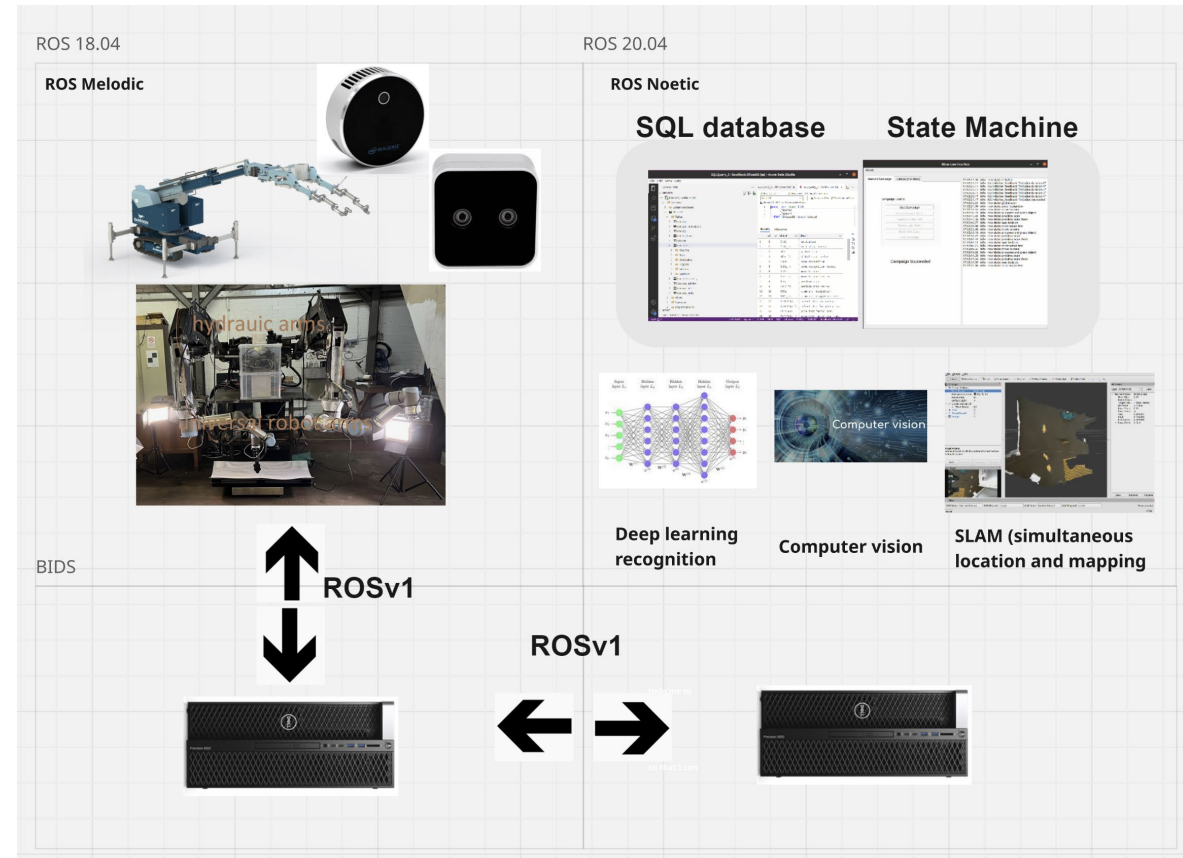
# System Architecture

## Device side (ROS Melodic):

- Interfaces to hydraulic arms/universal robots, RGB-D cameras, and other sensors provide real-time motion control.

## Perception (ROS Noetic):

- Deep-learning recognition for object/material ID.
- Computer vision for pose detection.
- SLAM for workspace mapping and localisation.
- State machine coordinates tasks, exceptions, and recovery sequences.
- SQL database logs images, features, decisions, and traceability metadata.





# Waste Item Process

- Example of waste classification
- Each stage of the identification
- Laser ablation tec
- Hyperspectral imaging techniques

The screenshot displays the 'Bliss User Interface' with three main sections:

- Campaign Control:** A panel with buttons for 'Start Campaign', 'Cancel Current State', 'Pause at State End', 'Repeat Last State', 'Start Next State', and 'End Campaign'. Below these is a large green button labeled 'proximal scan check'.
- Log:** A central text area showing a sequence of system messages with timestamps and state changes, such as 'new state: initialise', 'AS: initialise\_feedback: "initialise duration 0"', 'new state: global scan', 'new state: zone recognition', 'new state: pile pose and grasp object', 'new state: proximal scan', and 'new state: proximal scan check'.
- Waste Items:** A panel on the right showing 'Item 4' and a table of parameters.

Parameter	Value
alpha_beta	5.5
gamma	26.8
size	46.1
surface_area	77.8
mass	3.2
volume	31.7
density	65.1
reflectivity	3.4
colour	6.8
modulus	None

Below the table, there are fields for 'WAC Path' and 'Link'.

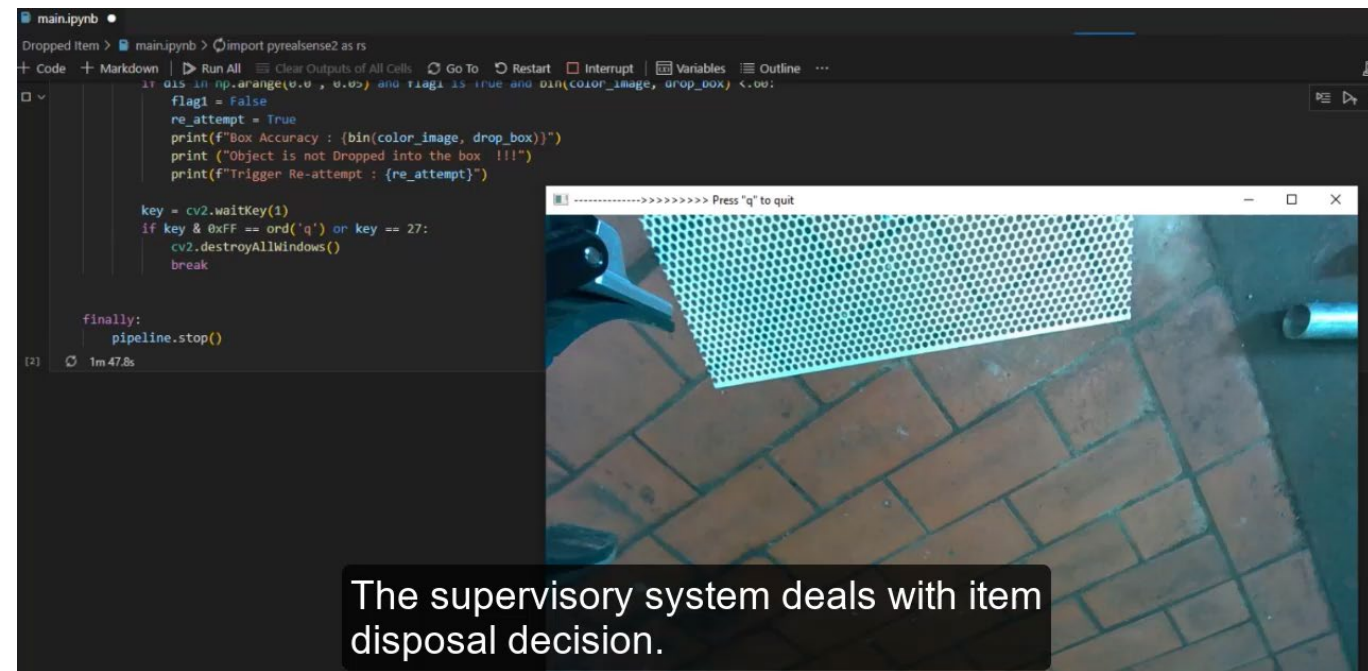
The WAC decision tree uses data gleaned from several sensors.





# Waste Allocation

- Follows the WAC Decision Tree
- Classifies: material, radiological Identification (iso ID) & object ID (shoe/tool/parts, etc)
- Routes to correct assignment
- Packing
- An image of the item placed in the correct bin is in the SQL database.







# Auto Allocation of Nuclear Waste: Summary

- **Problem:** Manual waste sorting is variable, slow, and dose-intensive with limited traceability.
- **Principle:** Decisions are grounded in BAT—best practical, technically & economically feasible methods that minimise waste and hazard.
- **Solution:** Automated sort & segregation using computer vision + ML + robotics, aligned to site WAC/BAT rules with quarantine for uncertainty.
- **Material ID:** Fast DL recognition, then orthogonal tests (density, magnetism, voltage, compressibility; roadmap: LIBS, hyperspectral) to raise confidence and auditability.
- **Value:** Lower dose (ALARP), higher throughput, fewer mis-sorts, increased recycling/decontamination, strong compliance evidence.

