Intelligent decision support for through-life nuclear asset management

Dr. Graeme West

Department of Electronic and Electrical Engineering

graeme.west@strath.ac.uk

Presentation Overview

Industrial Informatics: Overview of intelligent decision support

Reflection: Development & Deployment of Industrial Informatics

Future look: Opportunities for engagement

Challenges

- Continued and extended operations of reactors, plant & equipment that was constructed and commissioned over 40 years ago
- Key decisions on plant health & return to service reliant on limited but highly experienced individuals
- Assets complex and specialised (often one-off or limited numbers)
- Decisions lie on critical outage path
- Safety-critical environment – decisions require justification and explanation
- Instrumentation and control systems have been modernised, but associated analysis process lagging behind
- Digital technologies can provide significant benefits

Asset Management

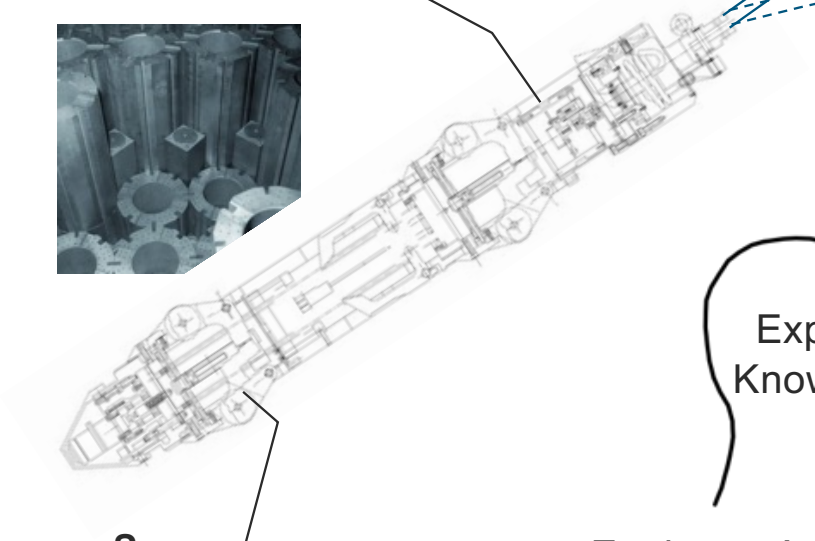
Historical Data

Deployment Platforms
Probes
Drones
Robotic Crawlers

Communications
Wireless

Data

Data Management System (Database)



Data Preprocessing
Transformation

Data Visualisation
Dashboards/graphs
Image maps
3D models, visual SfM
VR, AR
Data Fusion

Data Analytics
Anomaly Detection
Fault Classification
Diagnostics
Prognostics

Spatial

Temporal

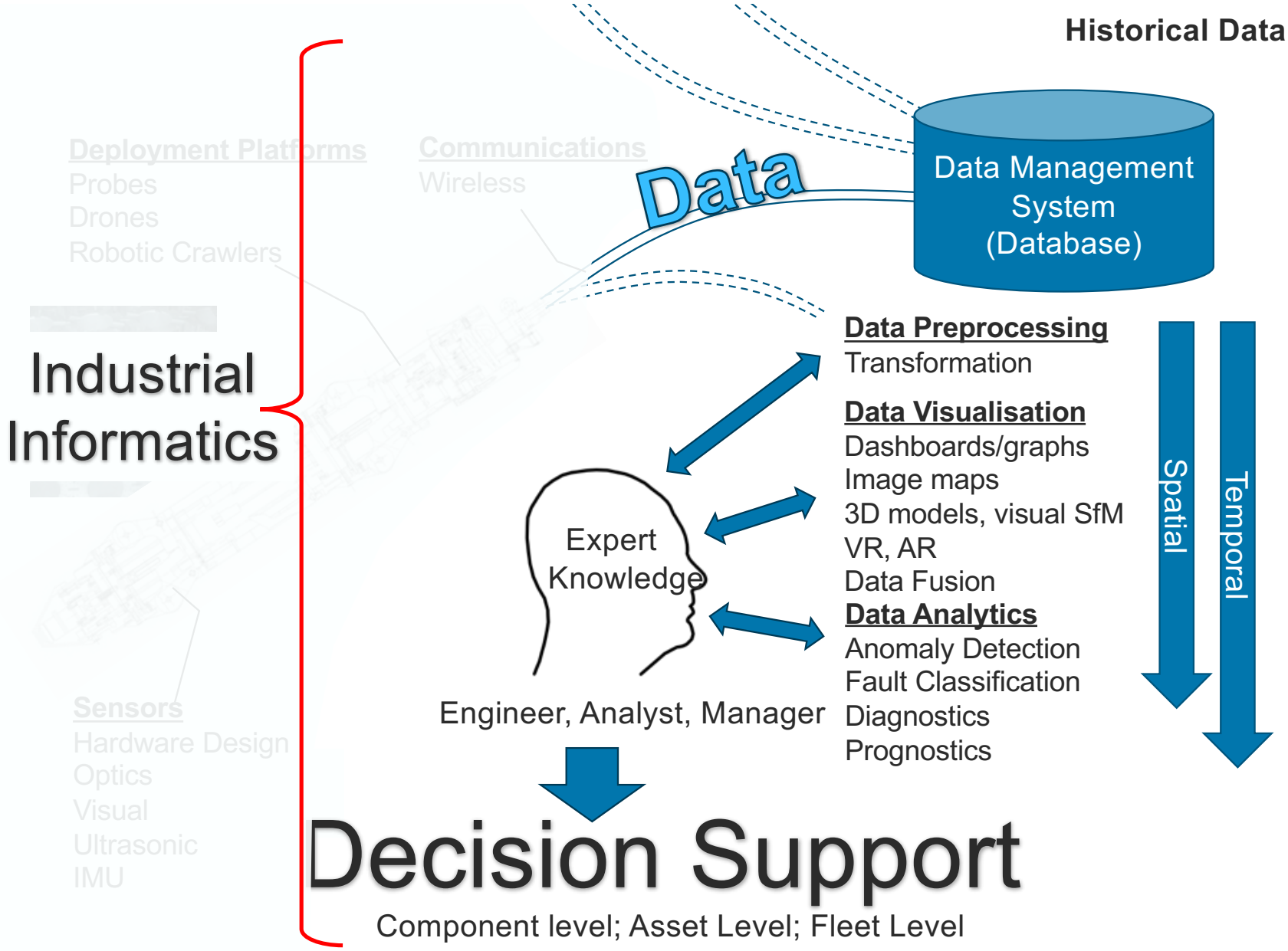
Expert Knowledge

Engineer, Analyst, Manager

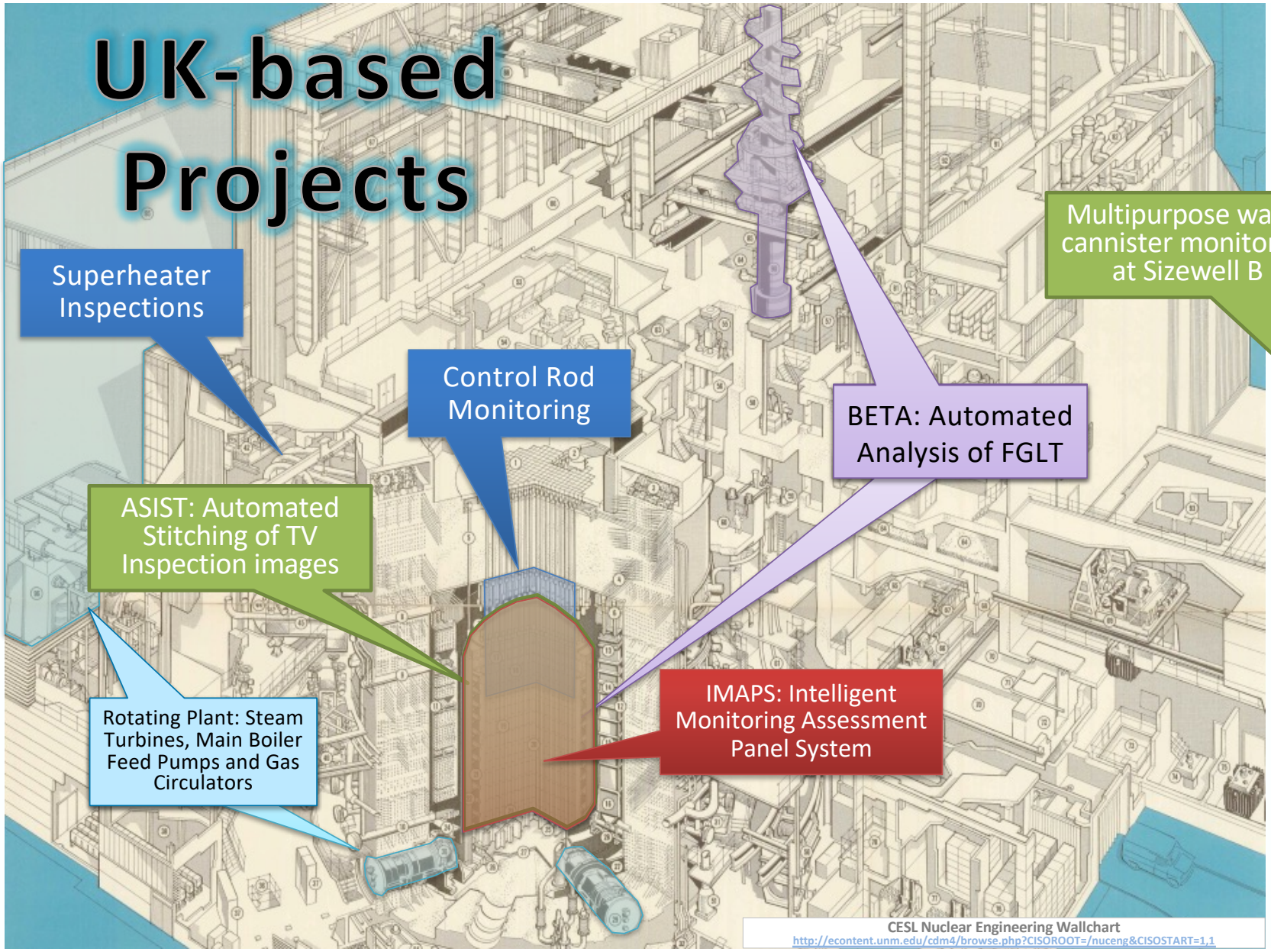
Sensors
Hardware Design
Optics
Visual
Ultrasonic
IMU

Decision Support

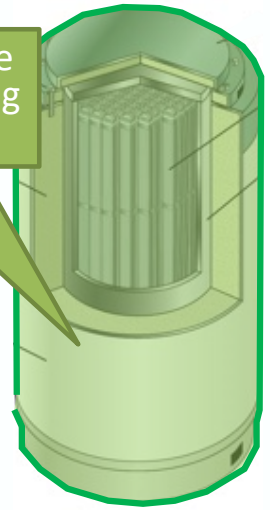
Component level; Asset Level; Fleet Level


Historical Data
Data
Data Management System (Database)
Deployment Platforms
Probes
Drones
Robotic Crawlers
Communications
Wireless
Industrial Informatics
Data Preprocessing
Transformation
Data Visualisation
Dashboards/graphs
Image maps
3D models, visual SfM
VR, AR
Data Fusion
Data Analytics
Anomaly Detection
Fault Classification
Diagnostics
Prognostics
Spatial
Temporal
Expert Knowledge
Engineer, Analyst, Manager
Sensors
Hardware Design
Optics
Visual
Ultrasonic
IMU
Decision Support
Component level; Asset Level; Fleet Level

UK-based Projects



University of Strathclyde Engineering

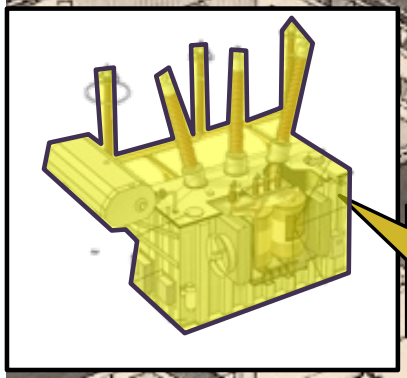


Knowledge Models for Waste Classification

Waste Storage Vault Monitoring at Sellafield

Higher Active Waste (HAW) package inspection at MAGNOX

Canada-based Projects



Transformer and Cable Condition Monitoring

Primary Heat Transport Pump Diagnostics

D_2O filter remaining useful life estimation

Fuelling Machine Diagnostics

Pressure Tube Flaw Sizing and Classification

Spacer Location and Repositioning Decision Support

Delayed Neutron Detector Data Trending and Failed Fuel Detection

Main Component Replacement Programme

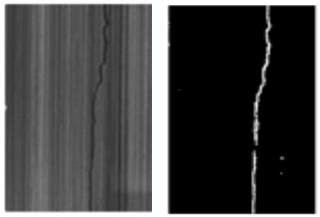
Calandria Bore Tubesheet Inspection

Knowledge Capture from Legacy Engineering Drawings

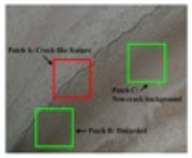
Common underpinning research

Visual Inspection

Pile cap hardware upgrade



Graphite crack detection



Superheater inspection

Sellafield Ltd

Vault monitoring

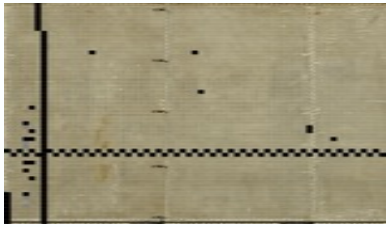
Contrast enhancement

Movement vectors

Defect detection

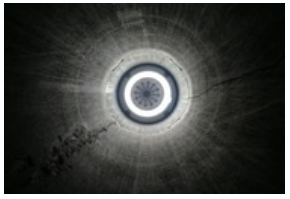
Image Stitching

AGR graphite inspection



Waste Cannister inspection

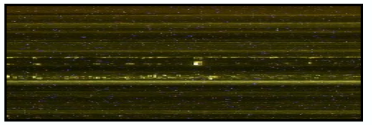
Fly's Eye Camera



Bruce Power

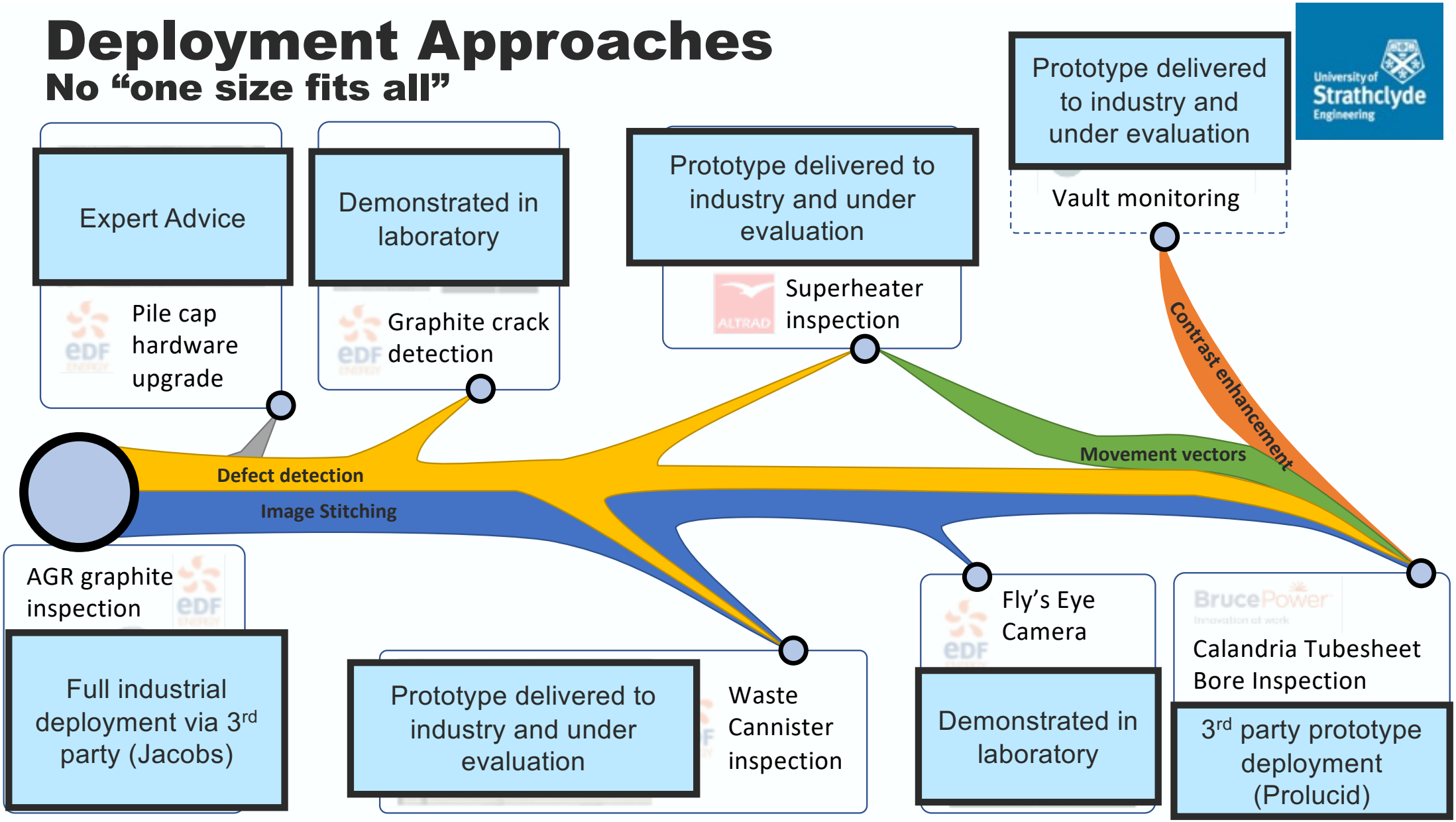
Innovation at work

Calandria Tubesheet Bore Inspection



Deployment Approaches

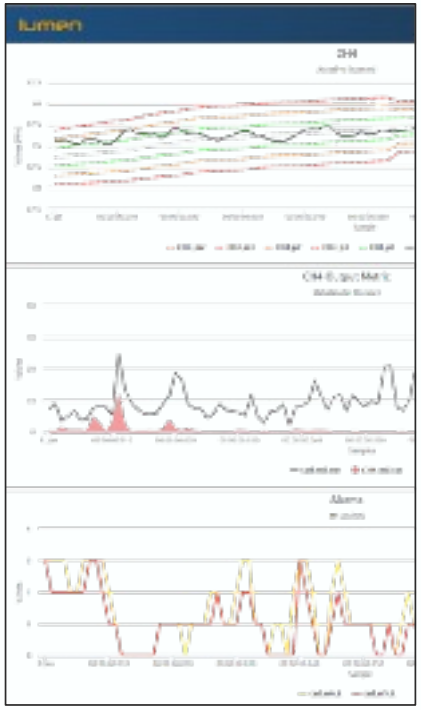
No “one size fits all”



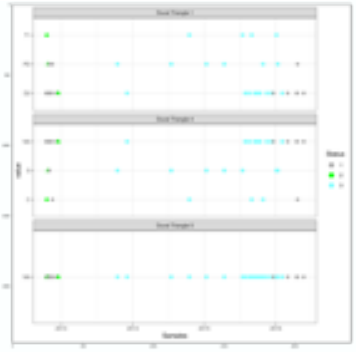
Deployment Approaches
Power Transformers

Deployed via Bellrock Technologies

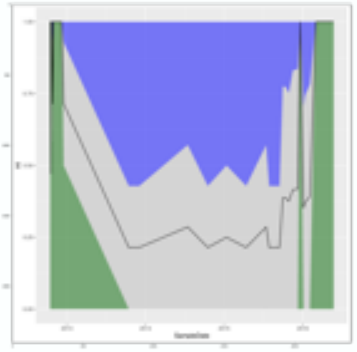
Deployed via Ad-Astra



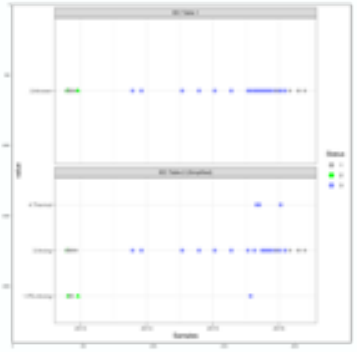
- Interpretable Expectations
- Traceable Metric
- Summarising Alarm Level



Duval Triangles 1-4-5

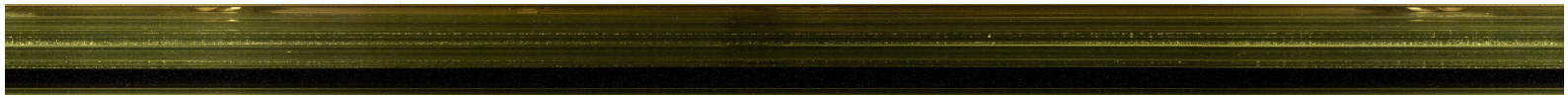


Health Index

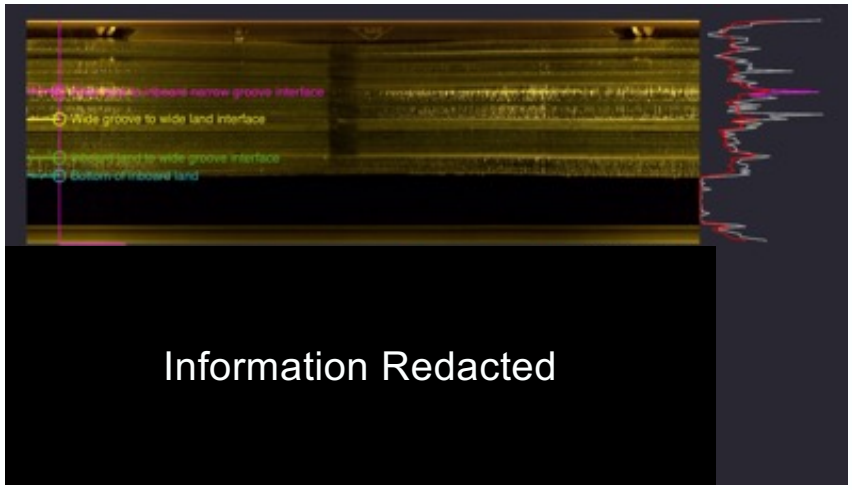


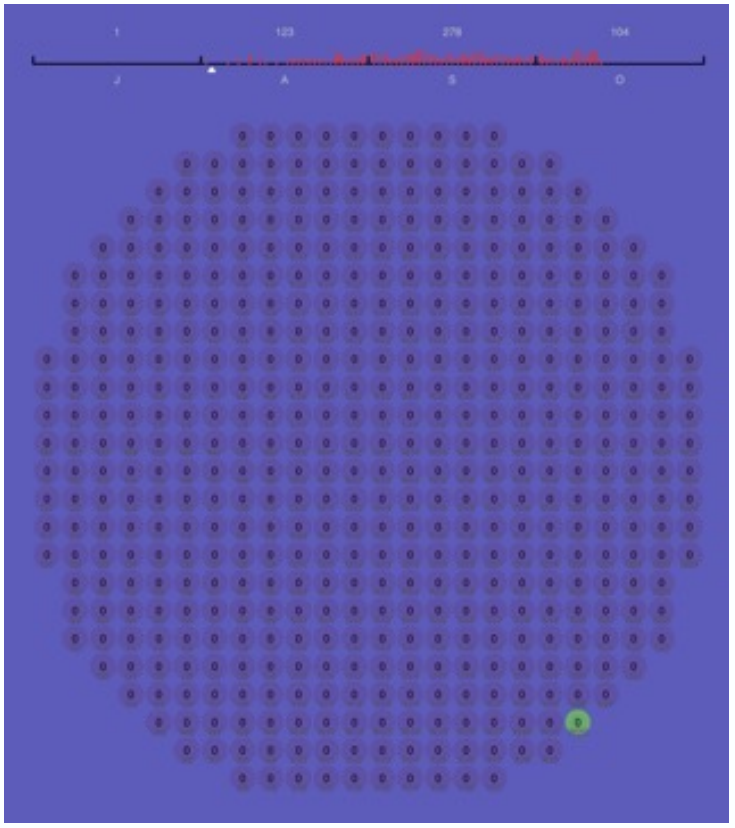
IEC Diagnostic

Accelerated Translation
Calandria Tubesheet Bore Inspection



- Re-use of existing software approaches
- Lab demonstrations within weeks
- Accelerated development with 3rd Party industry support (Prolucid)
- First version of software to be delivered in 6 months to Bruce Power



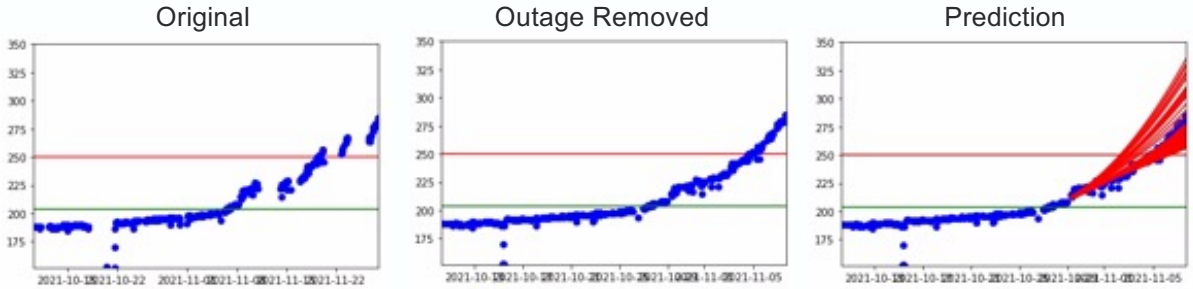


Common Platforms

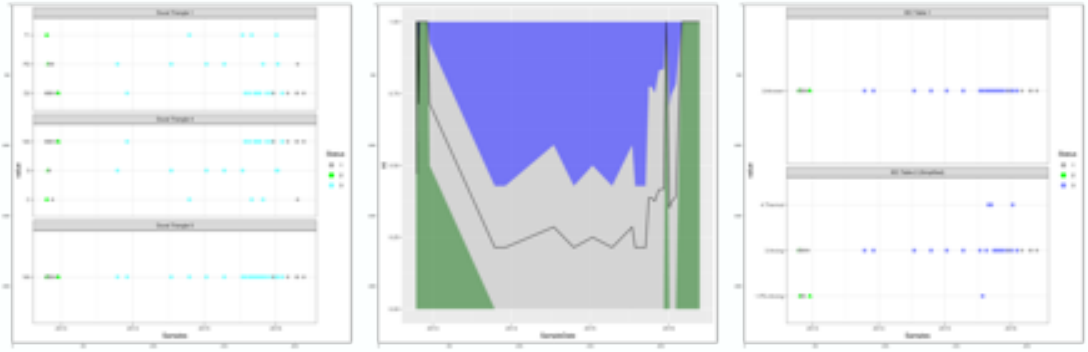
Remote deployment of algorithms for evaluation on desktop

- Secure connection
- Algorithms developed at Strathclyde
- Deployed via Ad-astra (Microsoft Azure)
- Sandbox environment with local upload of operational data

Deuterium Filter RUL Prediction

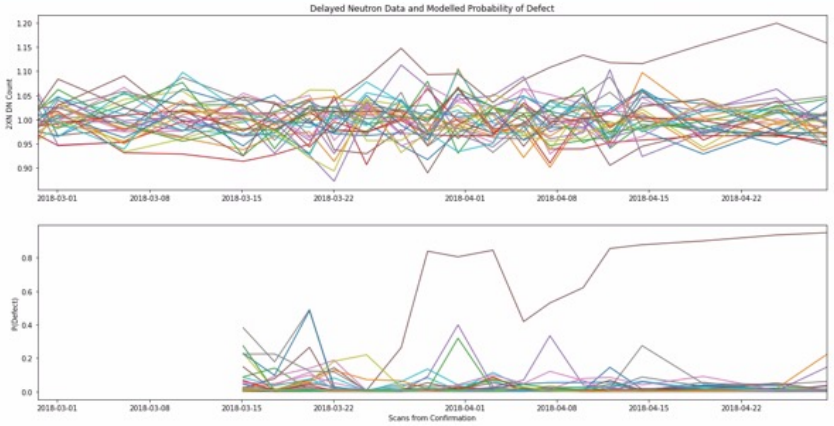


Dissolved Gas Analysis



Duval Triangles 1-4-5 | Health Index | IEC Diagnostic

Delayed Neutron (DN) Analysis



Future Direction

Decision Support: Regulatory acceptance of AI/ML

- Automating knowledge elicitation and knowledge validation
- Human in the loop; Legacy documentation
- Enhancing regulatory acceptance of automated tools

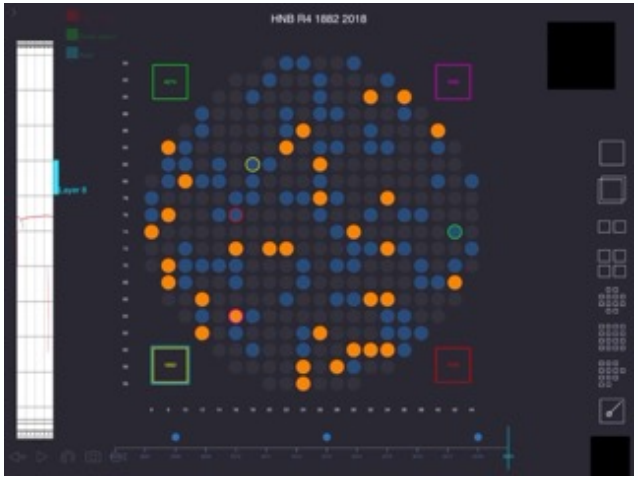
Intelligent Systems: Closing the physical and digital gap

- Moving human decision making into the digital world
- Capturing, representing and re-use human expertise
- Enhancing asset knowledge and uptime

Applications: Operating Infrastructure

Explainable & Regulatory Approved AI

Enhanced Digital Twins



Summary & Opportunities

- Large portfolio of projects
- Common underlying research threads
- Multiple routes to deployment – demonstrated and in use in industry

- Thank you – any questions?

THE PLACE OF USEFUL LEARNING

University of
Strathclyde
Engineering