UK Atomic Energy Authority

Functional Safety and Artificial Intelligence

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RACE

Official

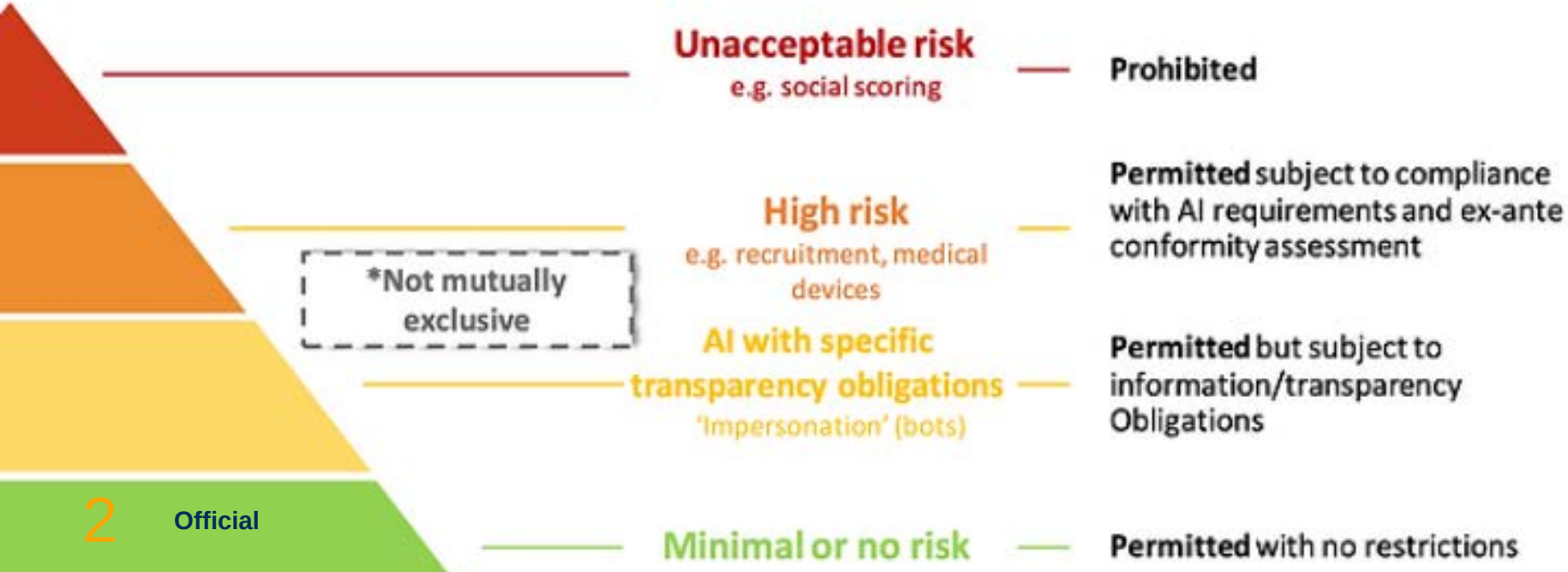
Regulation

UK AI Regulation Bill

- AI Authority
- AI Responsible Officers
- Regulatory Sandboxes
- Records Transparency

EU AI Act

- Within a four-tier system any use of AI in Safety Components or in Critical Infrastructure is to be considered High Risk.
- For High-Risk systems developers must:
  - Ensure data quality
  - Systems capability assessment and limitations
  - Design to allow for effective Human Oversight



Standards

- ISO/IEC TR 5469 (22440): Artificial intelligence — Functional Safety and AI Systems.
  - Extends IEC 61508 – defines terminology and considerations but not rules to achieve integrity levels.

- VDE-AR-E 2842-61: Development and Trustworthiness of Autonomous Cognitive Systems
  - Extends IEC 61508 – addresses trustworthiness as an expansion of the safety concept to incorporate elements such as ethics

- UL4600: Standard for Safety for the Evaluation of Autonomous Products
  - Focused on Autonomous Vehicles and compatible with IEC 26262 and ISO/PAS 21448.

Figure 2: Aspects of Trustworthiness

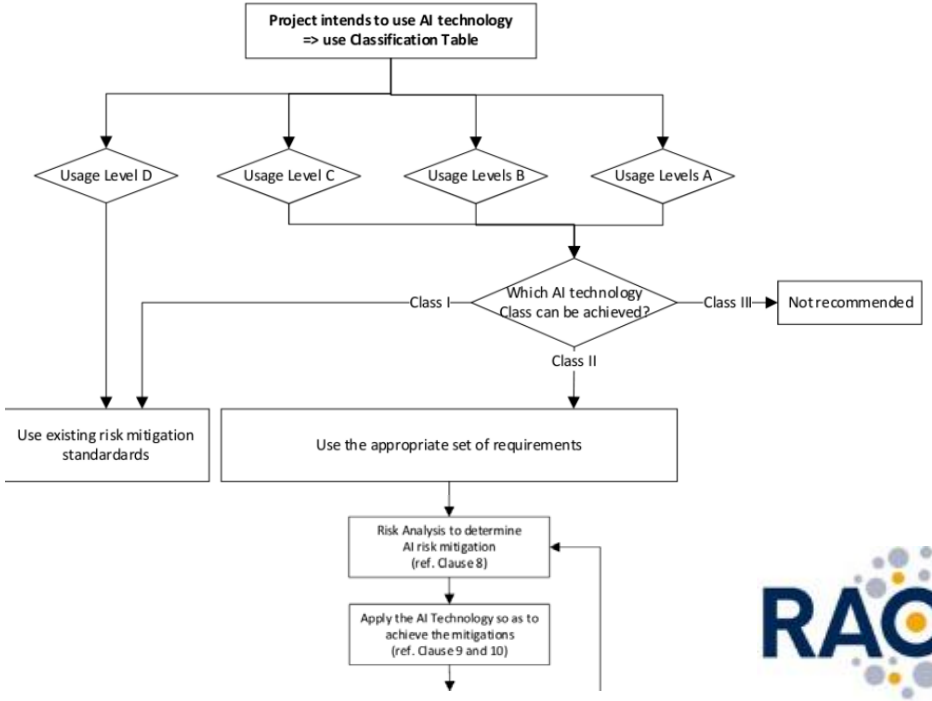
Classification and Evaluation

- Technology Class – The degree to which the AI technology can be developed and reviewed under existing Functional Safety Standards and frameworks.
- Usage Level – Whether the AI technology is used within:
  - Operation or Development
  - Primary Function or Diagnostics or Indirect impact (such as demand rate)

Advanced Technology Class and Usage Level should not be Combined!

- Maximising Explainability and Transparency
  - Network Visualisation and Inspection
  - Input Masking

- Environmental Complexity
  - Appropriate Requirements and Reward Function



Nuclear Decommissioning – Use for AI

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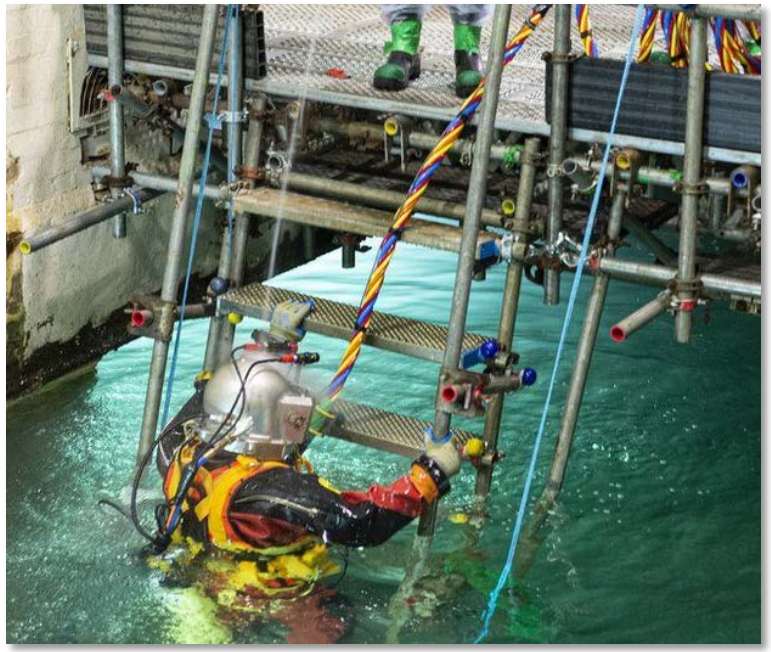

Decommissioning with human operators will always put human operators at risk

Lots of protective equipment, high supervision, highly procedural, slow

Difficult tasks to automate, complex environments,

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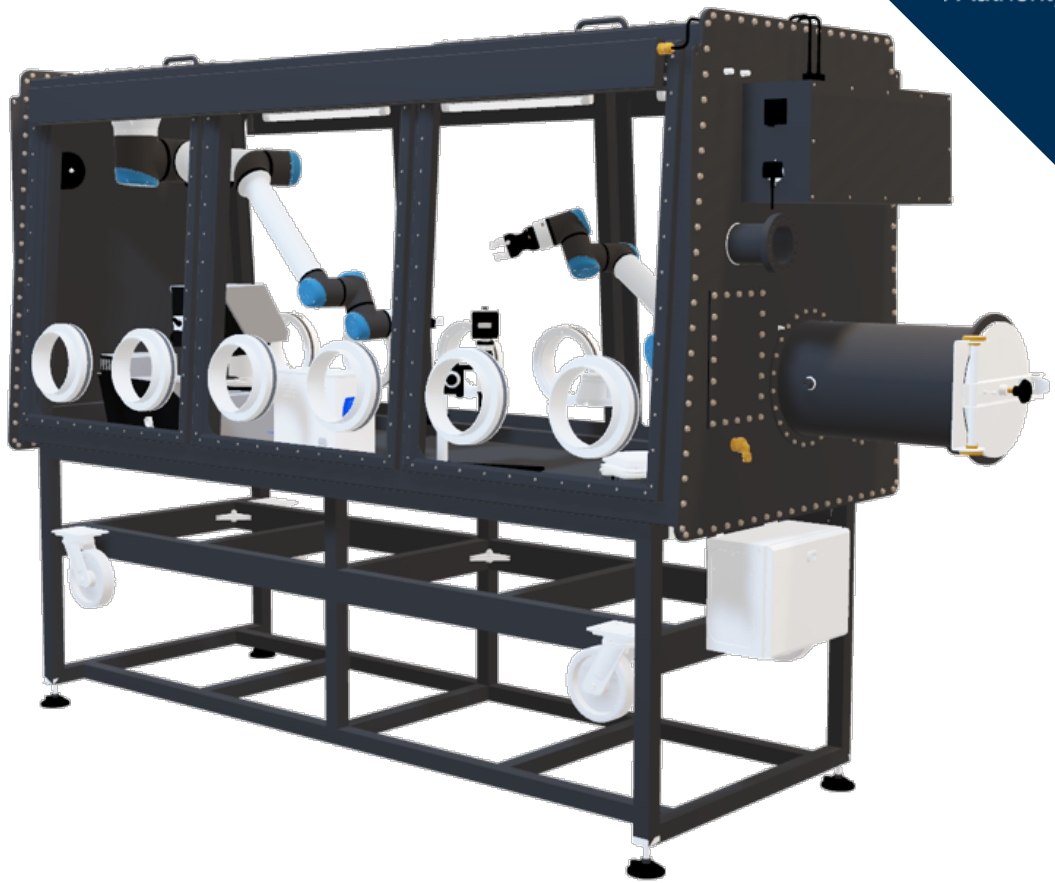
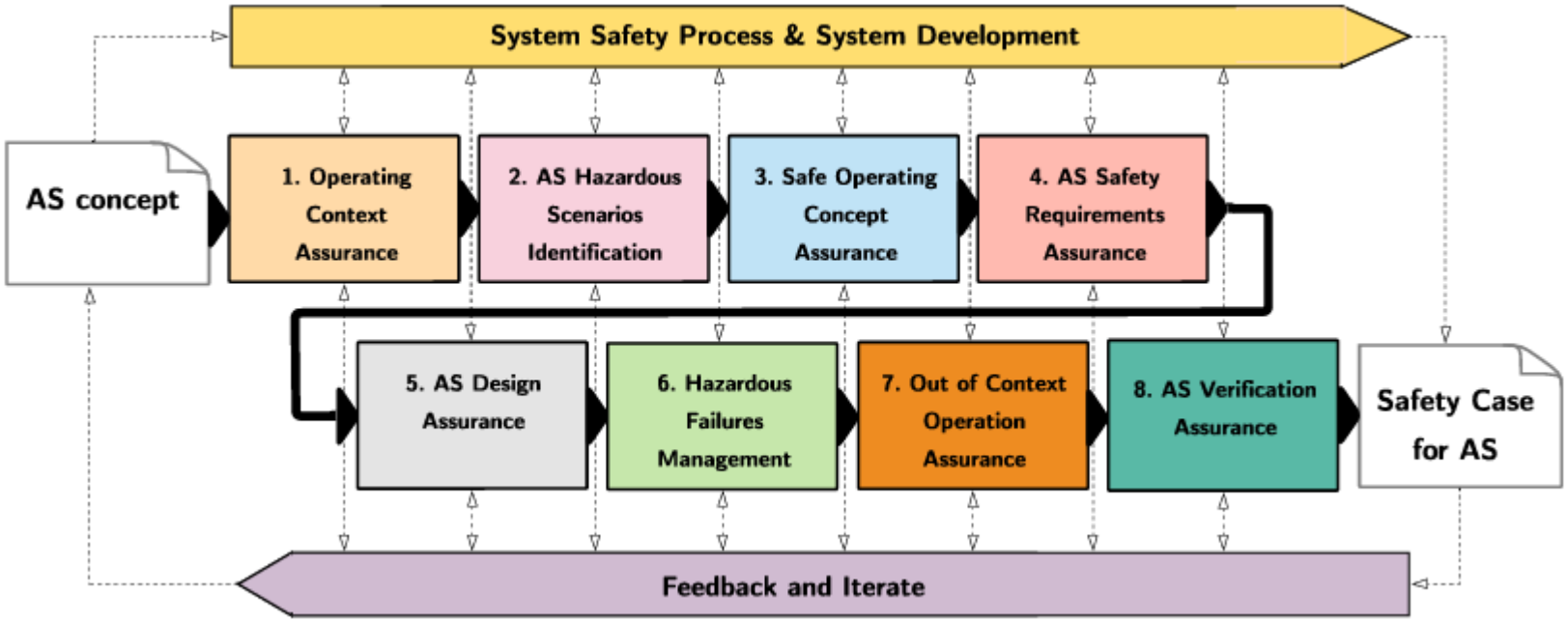
RAICo Glovebox

First of a kind Autonomous Glovebox
Safety Case Development

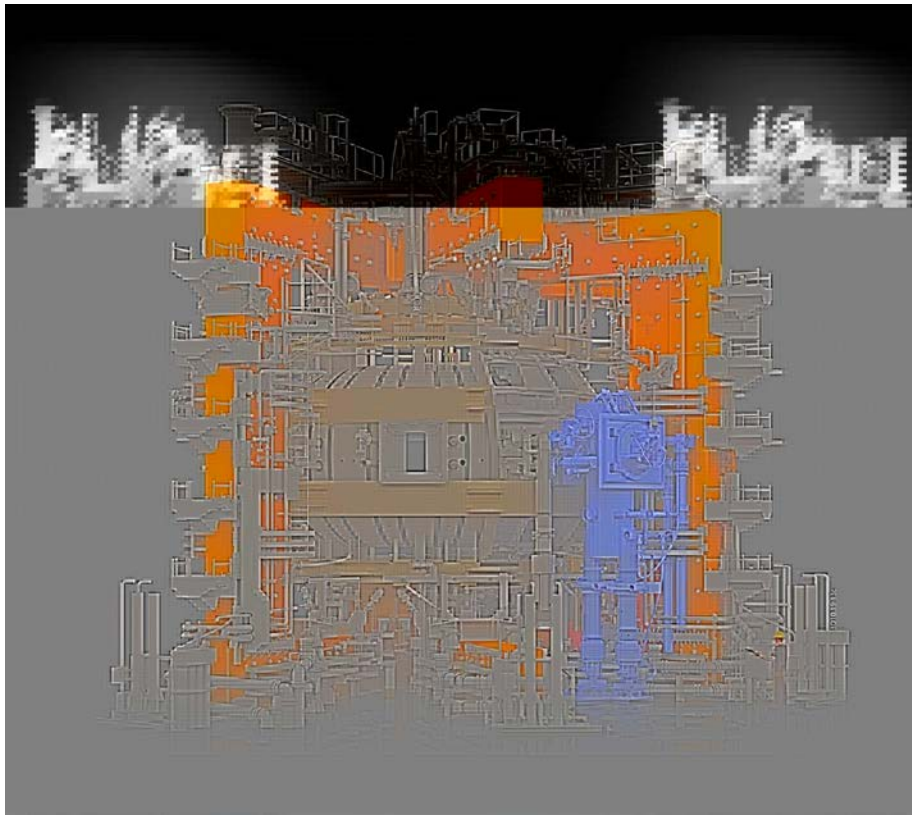


SACE

- Guidance on the Safety Assurance of Autonomous Systems in Complex Environments (SACE) by the Assuring Autonomy International Programme (AAIP) at the University of York.
- A safety framework utilising systems engineering principles to plan and carry out an AI safety case for complex systems.



Use case for AI in fusion



Fusion Tokamak

- Future global fusion opportunity
- Proven, but fusion at-scale inevitably requires enhanced use of technology
- Challenges involve:
  - Sense and control
  - Disruption mitigations
  - Big Data
  - Radiation (short-lived)
  - Complex System-of-Systems

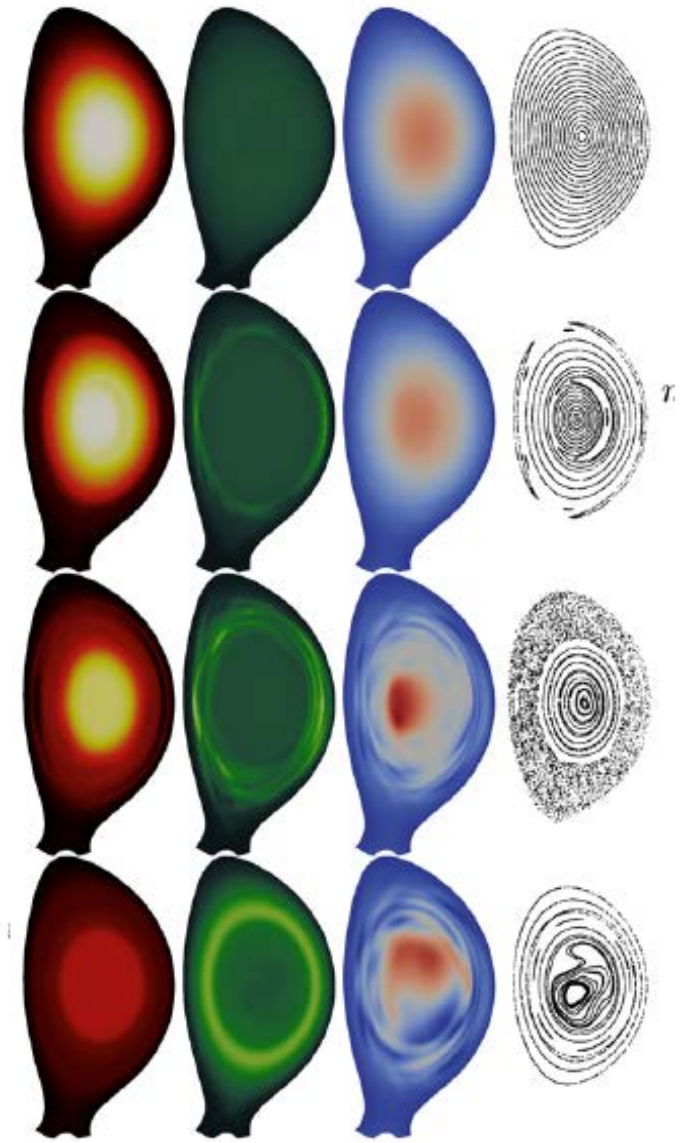
Plasma Instabilities As A Hazard

- Plasma instabilities threaten the viability of fusion reactors due to significant:
  - Reactor vessel damage
  - Damage to supporting systems and utilities particularly divertors
  - Plasma Loss
  - Some risk to humans but lower than Fission applications.
- Difficult problem for safety problem and control as instabilities grow rapidly and chaotically from microscopic turbulence.

AI Addressing Plasma Instabilities

- We have used Neural Networks to form surrogate models for the partial differential equations which predict plasma behaviour.

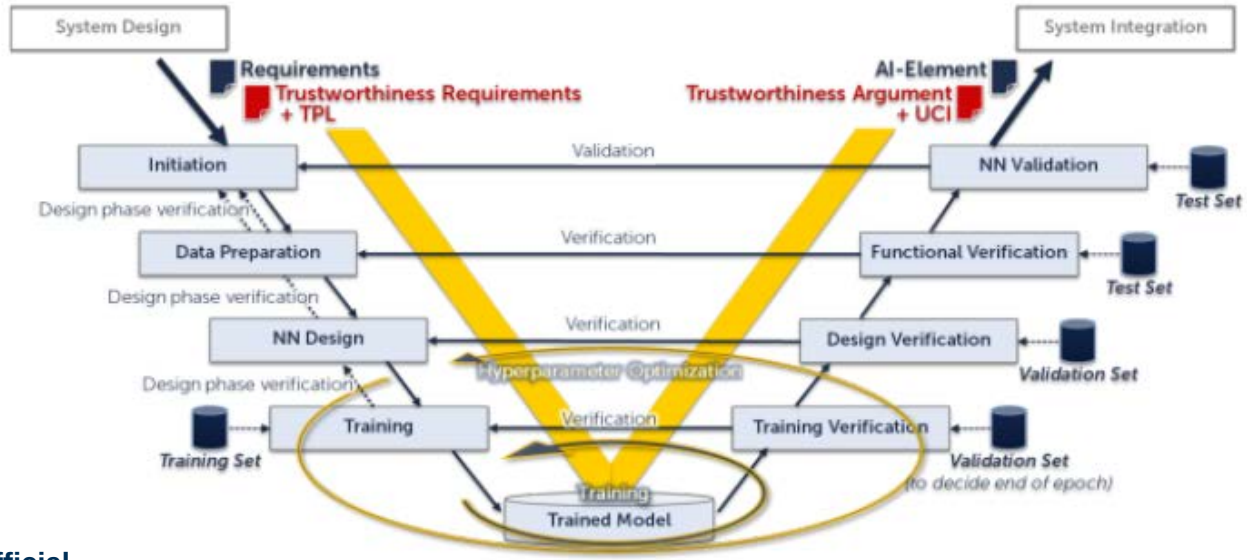
- Gaussian processes give Uncertainty Quantification for model accuracy and the action results.



Design

- Use of Supervising Functions
- Uncertainty related failures as a third failure type connected to forseeable misbehaviour
  - Uncertainty Confidence Indicators

type of failure	measures	HW measures	SW measures	AI measures
systematic	qualitative requirements	systematic capability	systematic capability	systematic capability
random	quantitative requirements	λ, SFF, DC, target values	-- / --	-- / --
uncertainty-related	structured approach	-- / --	-- / --	Uncertainty confidence indicator (UCI)



- Structured Approach
  - AI Blueprints & Design Patterns

Future of Plasma Control and Safety

- Virtual and Physical Testing (Shattered Pellet Injection)

Any Questions?

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13:25	Slot A-7: ***Functional Safety and Artificial Intelligence (AI)*** Chris Hume – UKAEA RACE Jon Wiggins – ABD Solutions	Slot B-7: ***CASS 61511 Workshop*** Andrew Derbyshire – ERM Deepti Chauhan – Sensia
14:00	Slot A-8: ***Black Box Testing for Functional Safety*** Dr. Silke Kuball – EDF Energy	
14:35	Slot A-9: ***Machinery Functional Safety with IEC 62061 and ISO 13849*** Paul Reeve – SILMETRIC	Slot B-9: ***Functional Safety Tool Qualification*** Hassan El Sayed – UL Solutions