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Robotics Safety Philosophy – Glovebox Operations

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Project Objectives

AWE is assessing the technical viability of using robotic manipulators within gloveboxes for radioactive material operations. In particular to assess the implications of using robotics to support the demonstration of the ALARP solution as well as the subsequent generation of the Safety Case.

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Operational Functions

“Glove Box operations (hands in gloves) is Grandparent thinking”

- **Unload material**
- **Process materials**
- **Reprocess materials**
- **Treat residues**
- **Load materials**

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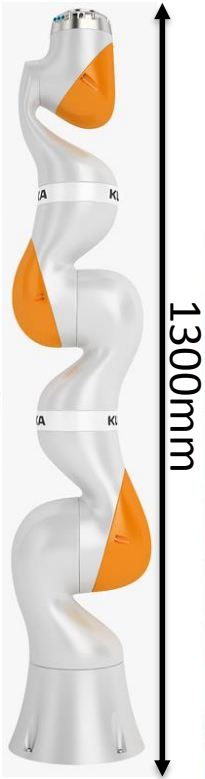
Technical Slides – co AWE/MTC Funded Project

- AWE and the Manufacturing Technology Centre (MTC) are developing a Haptic Controlled Remote Operations (HCRO) system to be used within a glovebox. No automation has currently been implemented in this system.
- The hardware being used is:
  - Programmable controller - Kuka Sunrise Controller
  - Manipulator arm - Kuka LBR iiwa 14 R820
    - *Weight 30kg*
    - *14kg payload*
    - *Maximum working reach 820mm*
    - *Force detection*
    - *7 degrees of freedom*
  - Vision system - RealSense D435 + IP cameras
  - Human interface - Omega.7 Haptic interface
    - Active force feedback
    - Active grasping
  - End effector - Schunk EGL-90 gripper and FT force/torque sensor



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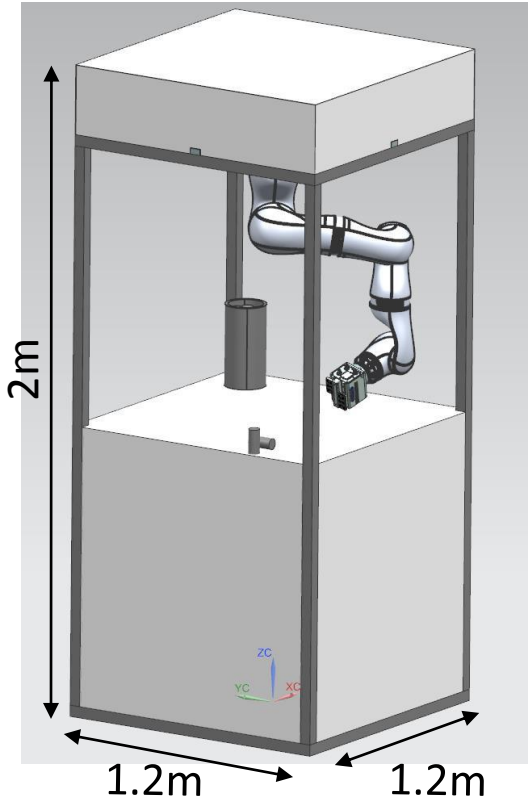
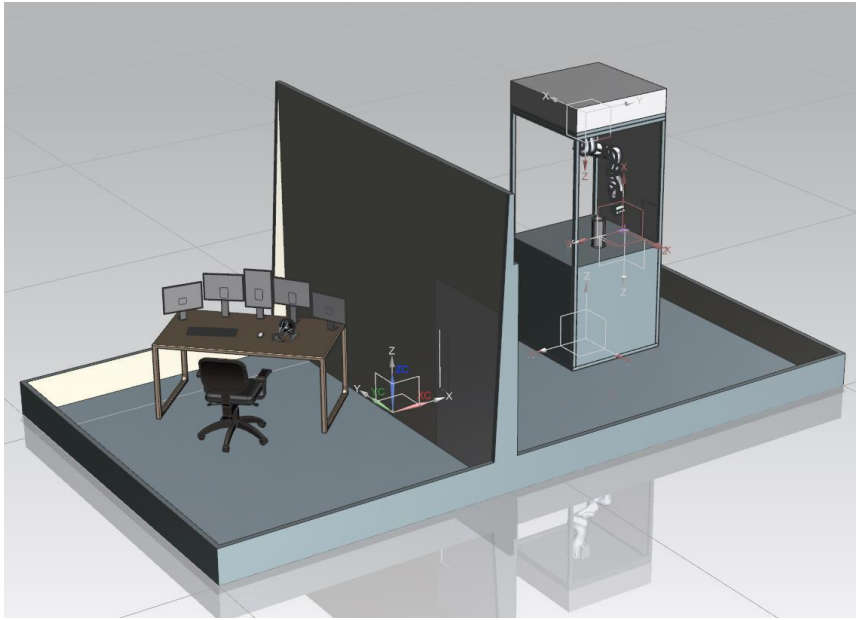
Technical Slides – MTC Work





Control Room (located anywhere)

Process Area (personnel removed from front-line)

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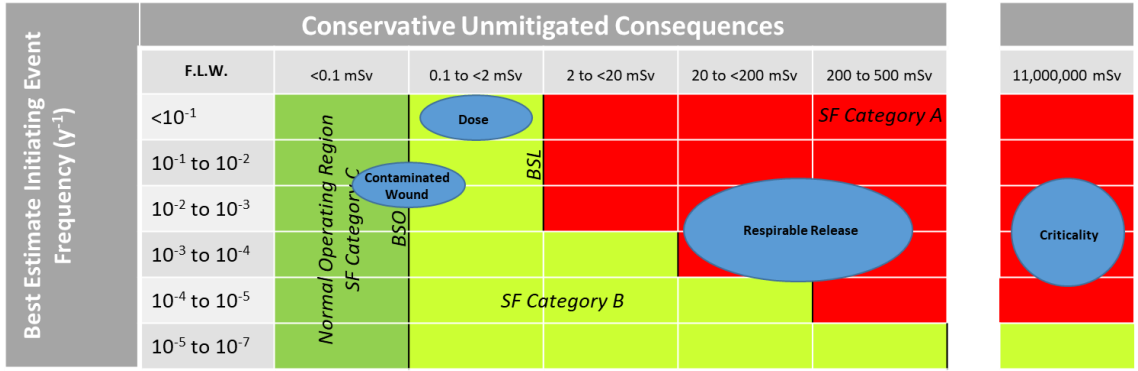
Key Hazards – Unmitigated Fault Consequences: Front Line Worker



Hazard	Dose (mSv)
Contaminated Wound	0.1 – 0.2
Dose	<1
Respirable Release	20 – 350 (18,800*)
Criticality	11,300,000

* Containment Explosion

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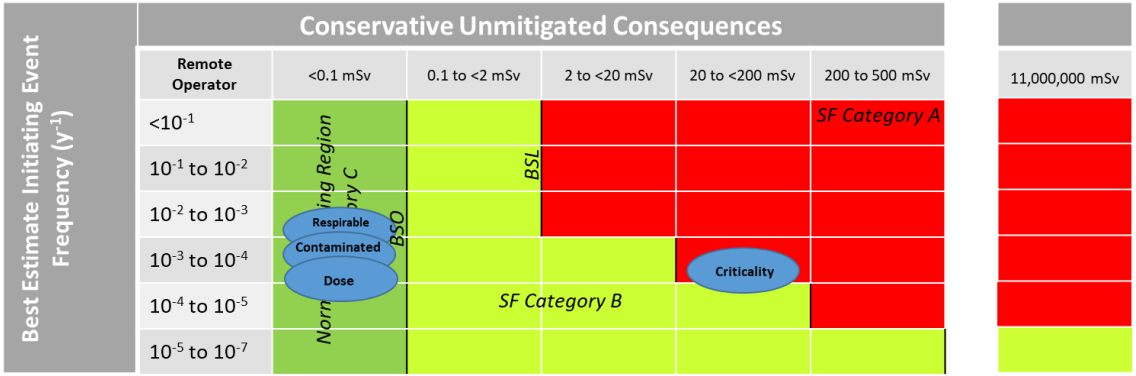
Key Hazards – Unmitigated Fault Consequences: Remote Operator during Operations



Hazard	Dose (mSv)
Contaminated Wound	N/A
Dose	N/A
Respirable Release	N/A (N/A)
Criticality	ca. 100

There is an opportunity that routine maintenance could also be completed remotely

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Safety Philosophy

"Remote operations means remote operations when working with significant quantities of fissile material"

Consequences

1. Remote operations only occur when access has been strictly controlled.
2. Will have a significant impact on set up and maintenance operations. This will need to be designed for.

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Potential Safety Controls

Safety Function	Potential Control Methods
Ensure process area is unoccupied during remote operations	• Interlocks • CACS • RFID • Operational room sensors • Procedural

Note: Safety systems within the robotic system will be defence in depth in the Safety Case.

- Hard stops - Mechanical limiting devices
- Non-mechanical stops
  - Joint sensors for force detection to stop on unexpected contact
  - Configuration controls – e.g. Arm movement speed, Power/force limiters, proximity switches
  - Software controlled joint restrictions
- Regular maintenance
- Trained operators

A key discriminator for robotic system technology down selection will be the anti-collision system deployed and the segregated control for process and safety circuitry.

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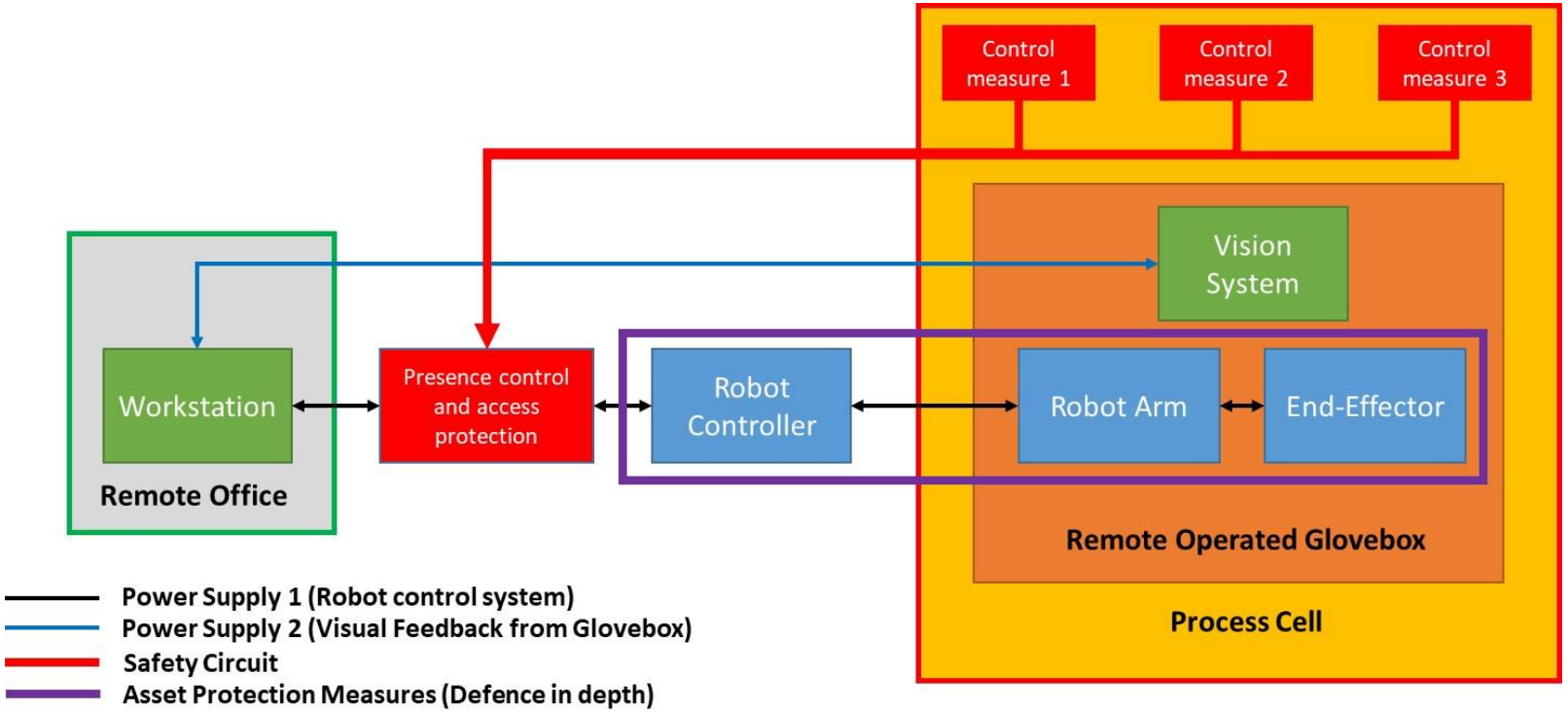
Summary - Control System Overview



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Future Work

- Establish demonstrator (August 2019)
- Safety Assessment
  - Detailed fault analysis assessment
  - Consider viability of fail safe
  - Human factors

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Summary

- AWE is undertaking technology development to establish ALARP solutions
- Robotics have real potential to remove personnel from the front line
- Clear agreement of what is required for the Safety Case and that what provides Defence in Depth is essential early in the development of the project
- Potential for other applications at AWE and the wider nuclear enterprise

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Questions?

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