Joint European Torus DTE2 Safety Case

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8th June 2022

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EUROfusion

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053.
The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Overview

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Introduction to the JET DTE2 Campaign and UKAEA Safety Cases

JET DTE2 Campaign

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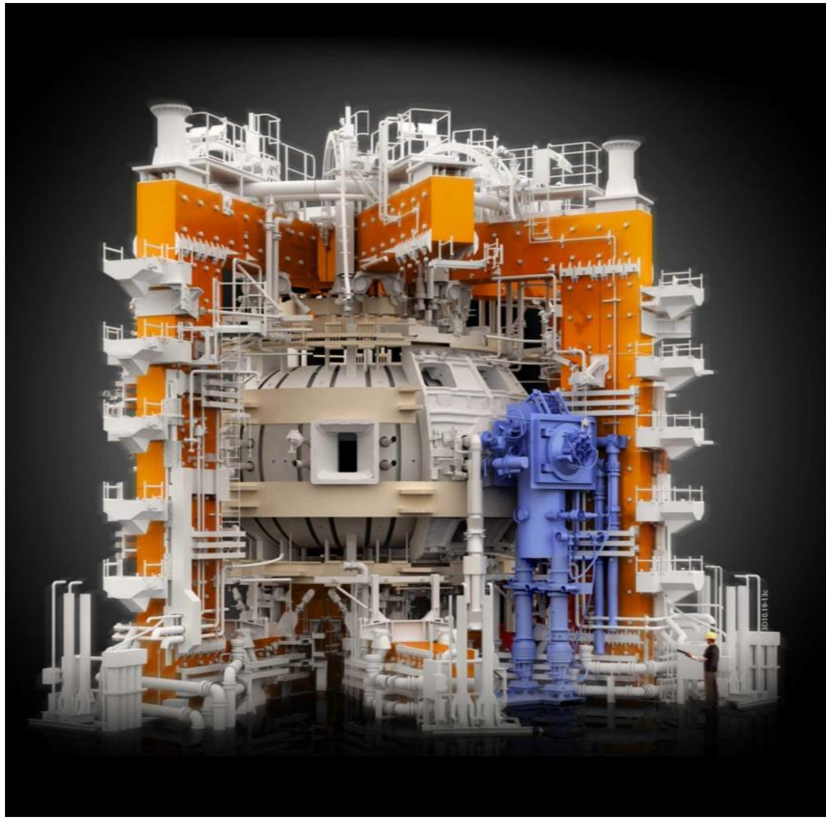
- JET was established with a long-term objective to create safe and environmentally sound prototype fusion reactors.
- JET is particularly suitable for investigating configurations and conditions relevant to ITER and is unique in having tritium injection capability. Without further D-T experiments in JET, it could mean a gap of 30 years between JET's previous D-T experiments and the start of D-T operation in ITER.

1991 Preliminary Tritium Experiment → 1997 DTE1 → 2003 Trace Tritium Experiments → 2021 DTE2 → ITER DT



JET DTE2 Safety Case Challenges

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- Last safety case for tritium issued in 2001
- Changes to methodology to meet modern standards
- Demonstrating aging safety systems will meet their safety function
- Major changes to JET from D-D to D-T operations:
  - Shielding
  - PSACS
  - Tritium Injection Modules

A Safety Case is the suite of documents that presents the safety argument, determines the operating envelope, principal outcomes and outputs from the safety assessments and confirms whether the risks are tolerable and as low as is reasonably practicable (ALARP)

UKAEA Safety Cases

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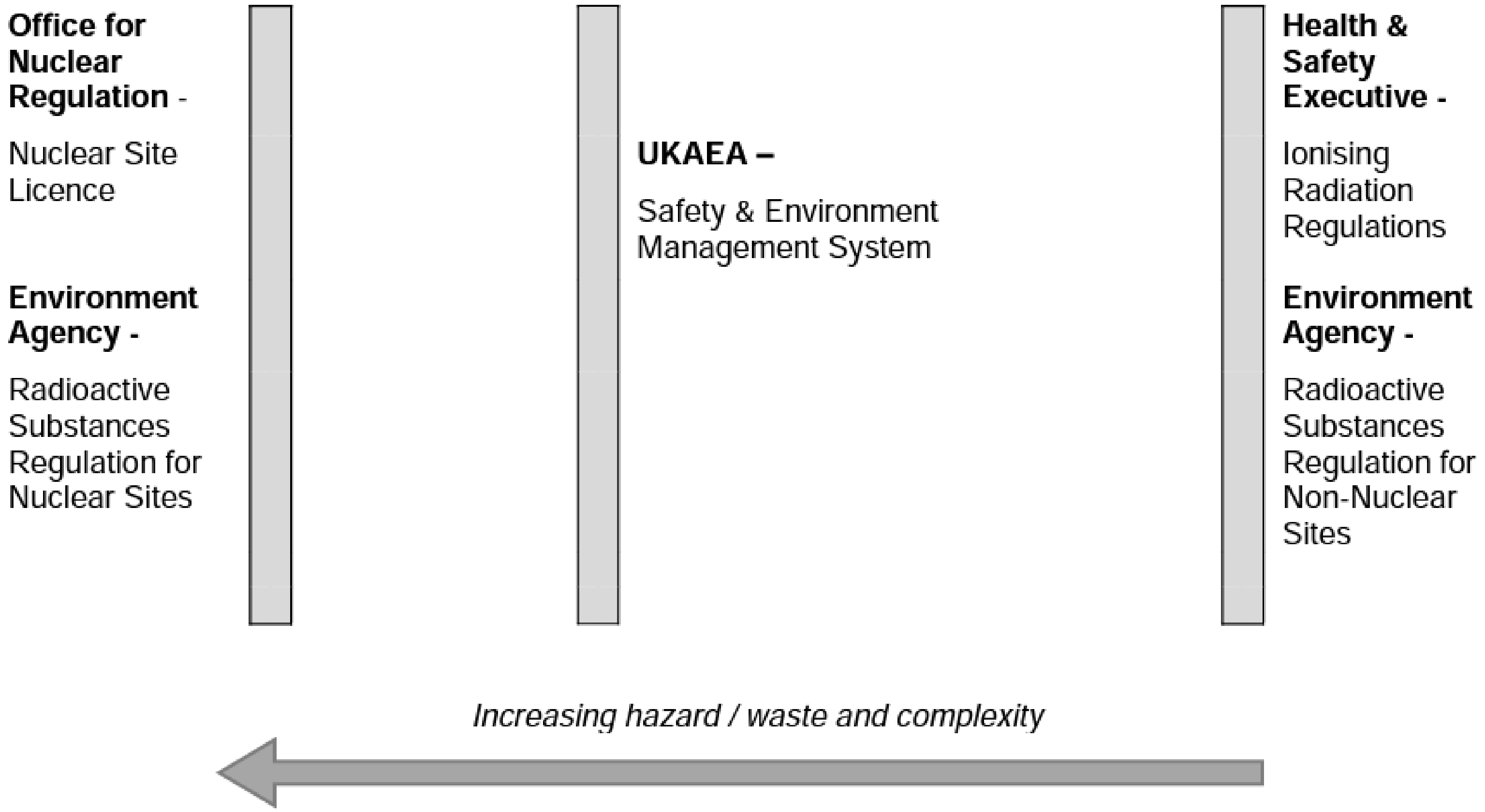
- UKAEA currently produces safety cases for circa 20 facilities
- UKAEA Culham is not a Nuclear Licensed Site, but we meet the spirit of ONR Guidance.
- UKAEA produces safety cases against its safety management procedures and standards. A ‘proportionate’ approach to ONR regulation.
- Safety Cases assess both radiological and non-radiological hazards of a high hazard nature.



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Safety Case Approach to the JET DTE2 Campaign

Approach and Methodology

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Utilises the ONR's Numerical Targets and Legal Limit when considering radiological hazards and the effective dose a person can receive in a calendar year:

- Employees working with ionising radiation:
- BSL(LL): 20 mSv
- BSO: 1 mSv

- Other employees on the site:
- BSL: 2 mSv
- BSO: 0.1 mSv

Any Person Offsite:
BSL(LL): 1 mSv
BSO: 0.02 mSv

Contents of the JET DTE2 Safety Case

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- **Introduction** – scope, facility rating
- **Plant Description** – processes & operations, hazardous material inventories
- **Operational History** – modifications, incidents, recorded doses, discharges
- **Safety Analysis** – Hazard Identification, Risk Analysis (DBA, PRA and Identification of Safety Controls)
- **Safety Management** – safety management procedures, emergency arrangements
- **Safety Argument** – demonstrate that risks have been reduced "As Low As Reasonably Practicable" (ALARP), safe operating envelope

Radiological Hazards from JET

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- External radiation – neutrons, gamma-rays
  - during pulse
  - activated materials (metals, tokamak dust)
- Internal radiation – airborne tritium
  - inside & outside buildings

Industrial Hazards from JET

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- Non-ionising radiation – lasers, radio frequency, magnetic & electric fields
- Fire / flammable gases – hydrogen
- Electrical – high voltage
- Hazardous substances – beryllium, galden
- Cryogens – liquid nitrogen, liquid helium
- Pressure systems – gas bottles
- Asphyxiants – nitrogen (fire suppression system)
- Dropped loads – cranes
- Working at height – platforms

Design Basis Assessment (DBA)

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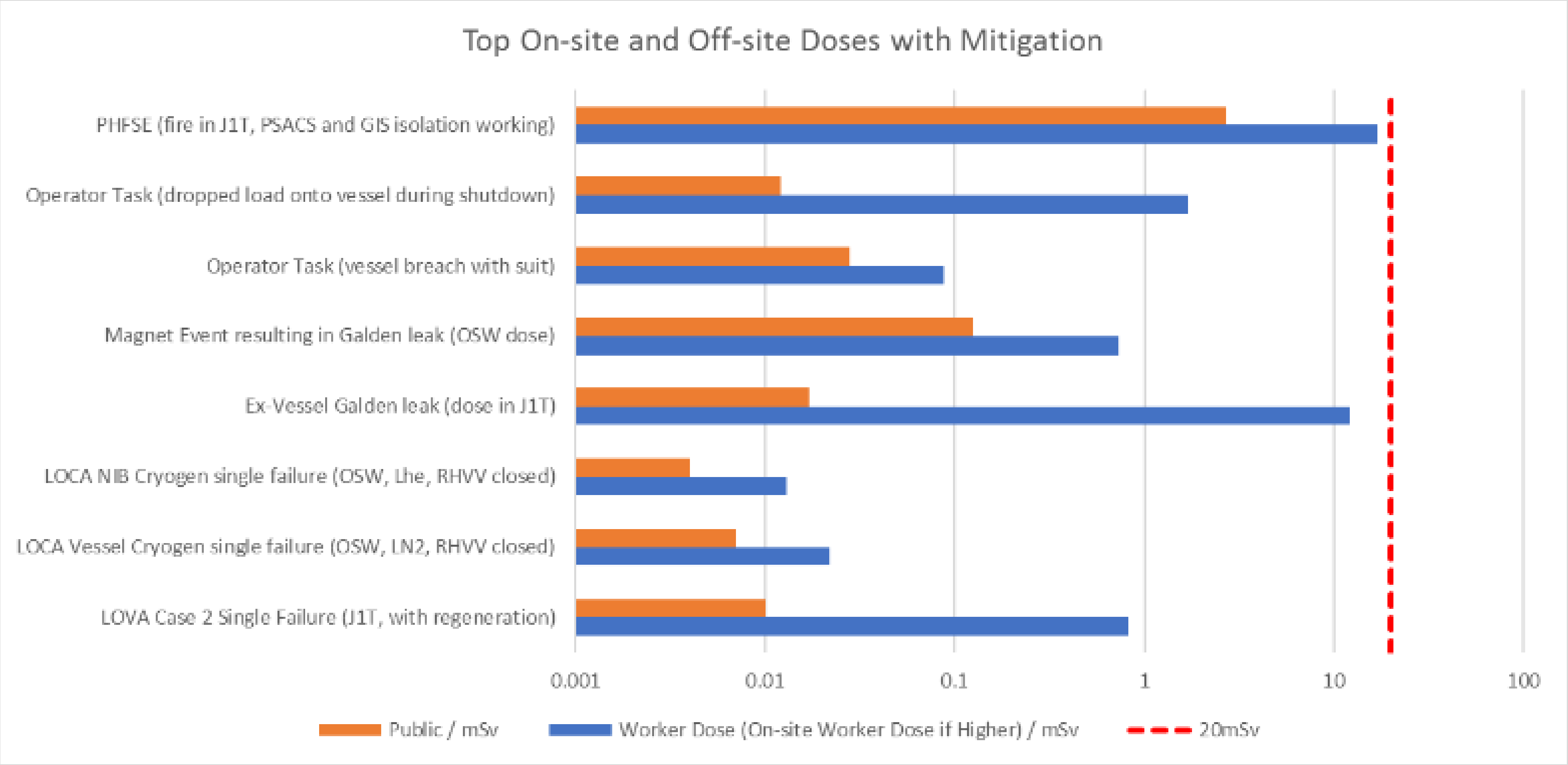
- Demonstrate fault tolerance of the plant and the provision of sufficient safety measures to prevent or mitigate accidents

- Assessment of <u>unmitigated</u> consequence (workers and public):
    - Identify design basis initiating faults
    - Initiating event frequency
    - Examine the fault sequences
    - Identification of safety controls – engineered systems & administrative measures

Top On-site and Off-site Doses with Mitigation



Probabilistic Risk Assessment (PRA)

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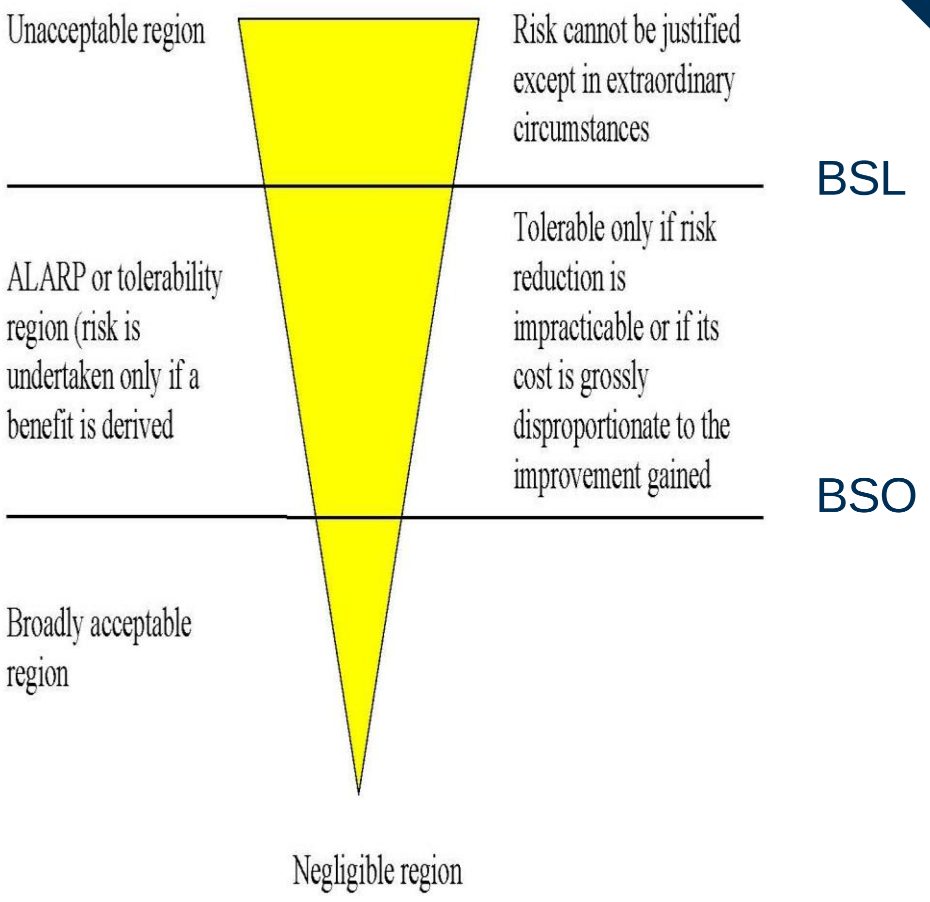
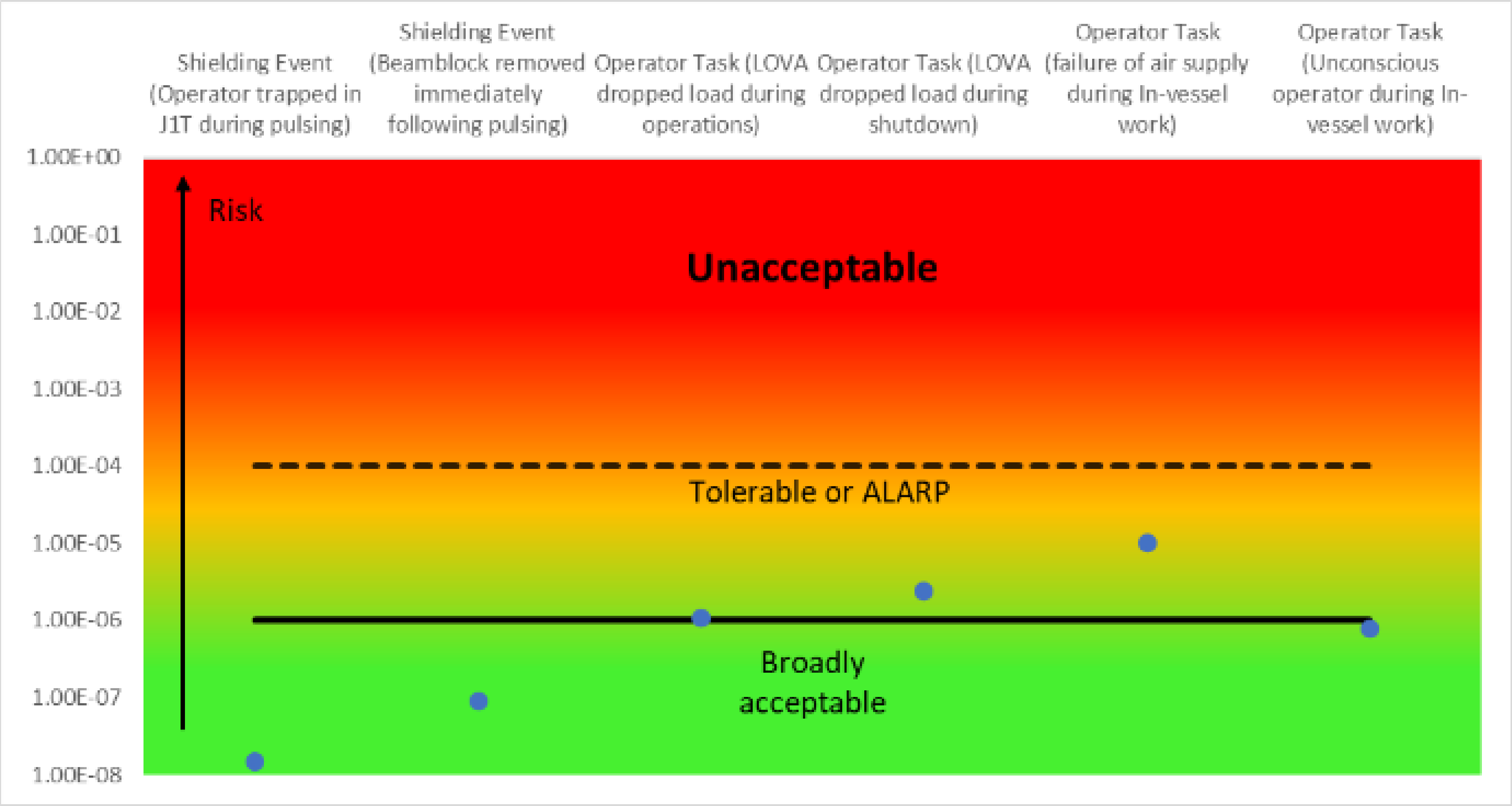
- Assesses risk to operators, others on site and members of the public

- Assessment of:
  - Mitigated dose
  - Takes account of the controls in place

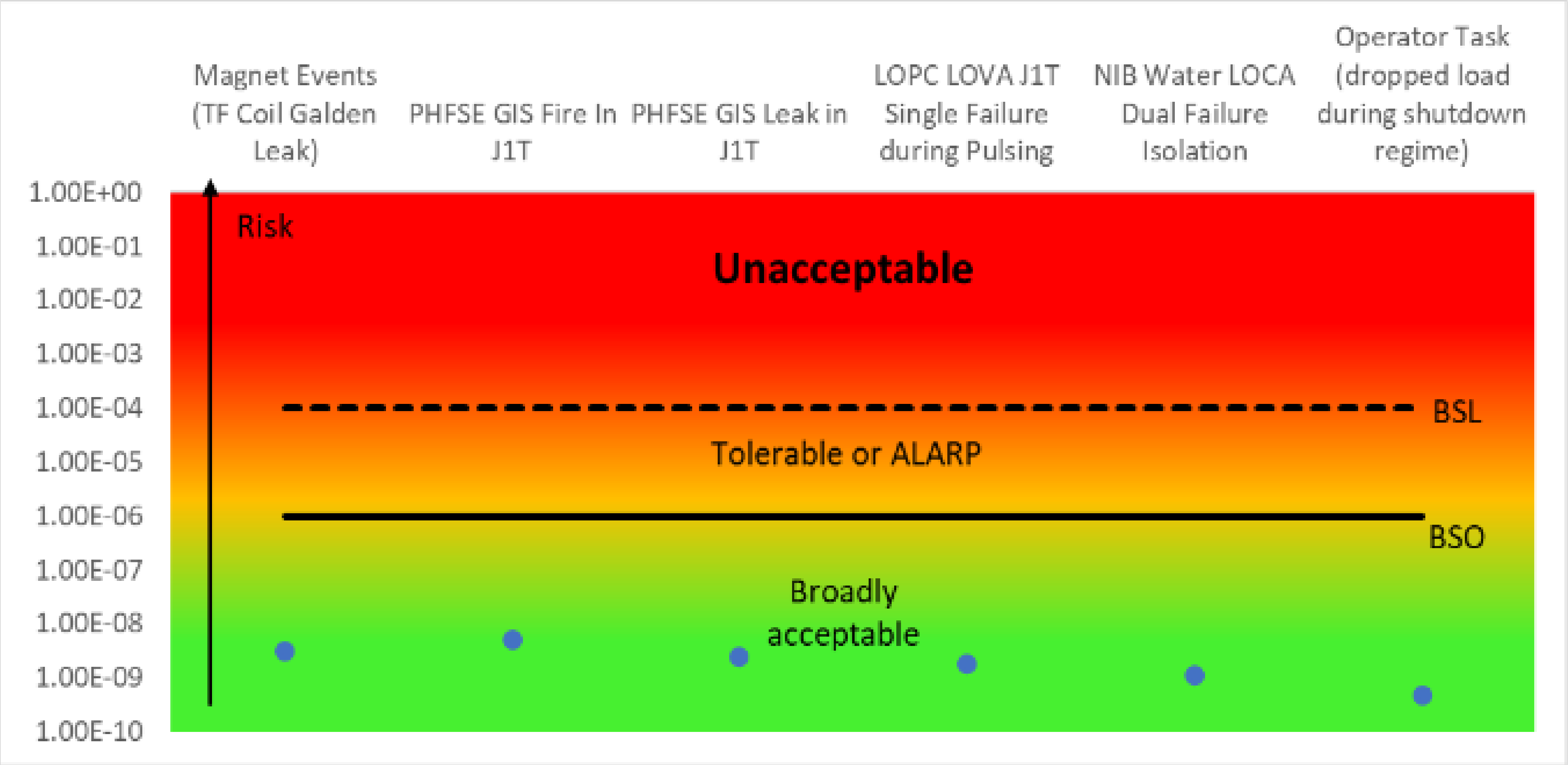
- Compare against Targets (SAPs) to demonstrate that risks are tolerable and ALARP
  - Basic Safety Level (BSL)
  - Basic Safety Objective (BSO)



Top Operator Risks



Risks to Members of the Public



(K)SRE & (K)SMR

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Safety Related Equipment (SRE)

- Key SRE – provide engineered control to reduce dose < 20mSv
- SRE – other engineered controls

- Fitness for Purpose – engineering substantiation to demonstrate the controls can perform their required safety function with sufficient reliability

Safety Management Requirement (SMR)

- Key SMR - provide procedural control to reduce dose < 20mSv
- SMR - other procedural controls

- Human Factors Review – assessment of tasks and generic arrangements (e.g. training, procedures, safety culture)

Identification of Safety Measures – JET Design Controls

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- **Shielding** – bulk radiological shield around Torus hall, (inc. shielding doors & beams)
- **Containment** – Torus vessel
- **Ventilation** – maintain negative pressure gradient within Torus Hall
- **Exhaust Detritiation System (EDS)** – removes tritiated gases before discharge to atmosphere
- **Radiological Protection Instrumentation**
- **Personnel Safety and Access Control System (PSACS) -** pulse cannot be initiated until all shield doors & beams closed
- **Radiological Protection Instrumentation**

Identification of Safety Measures – JET Operational Controls

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- **Search** - operational areas prior to lock up for pulsing
- **Regenerate cryopanels** - prior to access to torus hall
- **Evacuation procedures** - eg. LOVA alarm
- **Neutron budget** – to limit the extent of activation of components (1.7E21 neutrons)
- **Inventory Limits** – to limit the potential doses (max 15g tritium in Torus)

Conclusion and Look Ahead

Conclusion

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Building a robust and compliant safety case is essential to the safe management of projects and the individuals who work on them.

Although JET is not classed as a nuclear licenced facility, a similar rigorous approach to the fission industry is adopted. However, UKAEA have adopted a proportionate approach.

Use best practice and experience from the wider industry, together with guidance from the ONR, HSE, IAEA and other organisations and regulators to develop a safety case.

Look Ahead

- Produce a JET decommissioning safety case strategy
- Develop UKAEA new build safety case procedures for fusion power plants such as STEP
- Engage with the international community on the topic of safety cases
- UK Regulatory position to be confirmed

Any Questions?

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