Severe Accident Analysis and Management Strategies

with particular emphasis on non-reactor facilities

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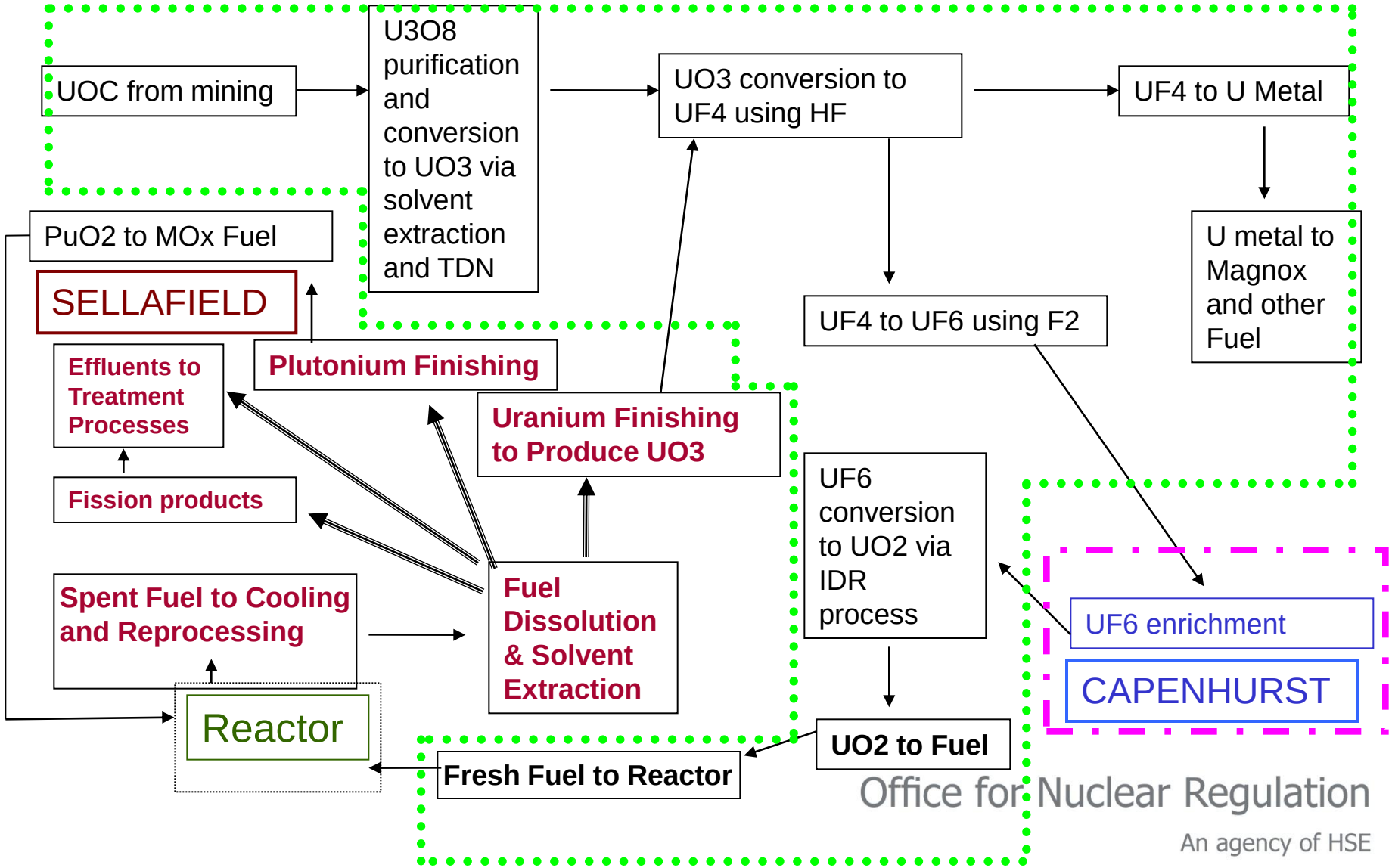
Overview

- Brief overview of non-reactor facilities in the UK
- The UK regulatory regime: Risk assessment→ Fault analysis→ Severe Accidents Analysis
- Focus of severe accident analysis and out-put of the analysis
- A methodology proposed for SAA
- Examples
- Conclusion

The Civil Nuclear Fuel Cycle in the UK on a Slide !



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Other non-generating Industry Sectors

- Defence Sector (jointly regulated with the Ministry of Defence Regulator
  - Weapons programme
  - Propulsion programme
- Defuling/ decommissioning reactor

Risk Assessment

UK Law:

HSWA 1974, sections 2(1) and 3(1) impose duties upon employers to consider risks (to workers and others) arising from their operations. Legal precedent gives interpretation of the law (case law).

…*A material risk simply means that the risk must not be trivial or fanciful*.”;

"[The HSWA sections] are not limited, in the risks to which they apply, to risks which are obvious. They impose, in effect, a duty on employers to think deliberately about things which are not obvious.

Licence Conditions

ONR’s Safety Assessment Principles

- Guidance provided to inspectors on risk assessment in Safety Assessment Principles (SAPs)
- Assessment of risks arising from nuclear facilities
  - Normal operation
  - Fault condition

Three Pillars of Fault Analysis

- DBAA- Design Basis Accident Analysis:

  Providing a robust demonstration of the fault tolerance of the engineering design and the effectiveness of safety measures …FA10

- PSA- Probabilistic Safety Assessment

  helps ensure the safe operation of the site and its facilities e.g. investigation of significant abnormal occurrences, developing and changing operating procedures and associated training…FA12

- SAA- Severe Accident Analysis

Radiation Emergency

Radiation (Emergency Preparedness and Public Information) Regulations 2001.

"Any event (other than a pre-existing situation) which is likely to result in any member of the public being exposed to ionising radiation arising from that event in excess of any of the doses set out in Schedule 1, any health protection measure to be taken during the 24 hours immediately following the event shall be disregarded. Schedule 1 specifies an effective dose of 5 mSv over a period of one year immediately following the radiation emergency."

What is a Severe Accident?

IAEA NS-G-2.15:

*A Beyond Design Basis Accident comprises accident conditions more severe than a design basis accident, and may **or may not** involve core degradation, such accidents are termed severe accidents.*

ONR's SAPs para. 543 ***(Guidance for ONR inspectors)***

' fault sequences beyond design basis that have the potential to lead to a severe accident … FA16'

Severe accidents are those faults that have the potential to lead **EITHER** *to consequences exceeding the highest radiological doses (>100 mSv to Public, >500 mSv to Workers)* **OR** *unintended relocation of radioactive material within the facility which places demand on the integrity of the remaining physical barriers.*

TECHNOLOGY NEUTRAL

Output of the Analysis: Safety Enhancement

WENRA, Harmonization of Reactor Safety

Principle: *Consideration shall be given … to selection of severe accidents, to determine those sequences for which reasonable practicable preventive or mitigatory measures can be identified (accident vulnerability study); combination of* ***engineering judgement*** *and* ***probabilistic methods*** *can be used and evaluations be made on a* ***best estimate basis***

(a) Instrumentation and hardware provisions

(b) Emergency operating procedures for management of severe accidents

- Equipment
- Instructions
- Training

Safety Enhancement

SAPs:

Using best estimate approach analysis should determine:

(a) Magnitude and characteristics of consequences

(b) Consider cliff edge effects

TO

With Support from PSA of the facility

1- Identify reasonably practicable preventive or mitigating measures for BDBA

2- Provide a basis for emergency plans and severe accident management strategies

Safety Enhancement Cont.

- Facility's accident management strategy
  - Development of a strategy for maintenance and examination of equipment required for emergencies
  - Development of strategies across the plant for specific fault groups such as loss of containment
  - Development of relevant training for personnel involved in responding to a severe accidents/emergency.

- Assisting in identification of vulnerable plant areas/systems
- For multi-facility sites, development of a strategy for dealing with external hazards at a site (rather than facility) level
- For multi-facility sites, development of a strategy for dealing with domino effect where an incident in one facility/area may have an impact on others
- For multi-facility sites, development of a strategy for prioritising the response across the site

Summary: SAA

- Applicable to design and operation phases of the plant
- Measures identified do not need to follow conservative engineering practice
- The analysis informs identification of additional equipment and instructions that cover beyond design basis scenarios and identifies training needs for plant personnel involved in responding to such events

A Methodology

- Identification of critical safety functions from the safety case/ other sources of technical data
  - Containment
  - Cooling
  - Criticality
  - Shielding
  - Control
- Identify candidate fault scenarios

A Methodology (2)

- Three types of scenarios that should be addressed by SAA
  - Low frequency/ high consequence event beyond design basis
  - Design basis events where safety provisions have assumed to have failed
  - Scenarios omitted from the safety case (including security initiators)
- Identify AND implement control measures in support of the safety functions discussed

Relevant examples

- Real Example: TOMSK 7

- Generic Scenarios with the potential to lead to SAs

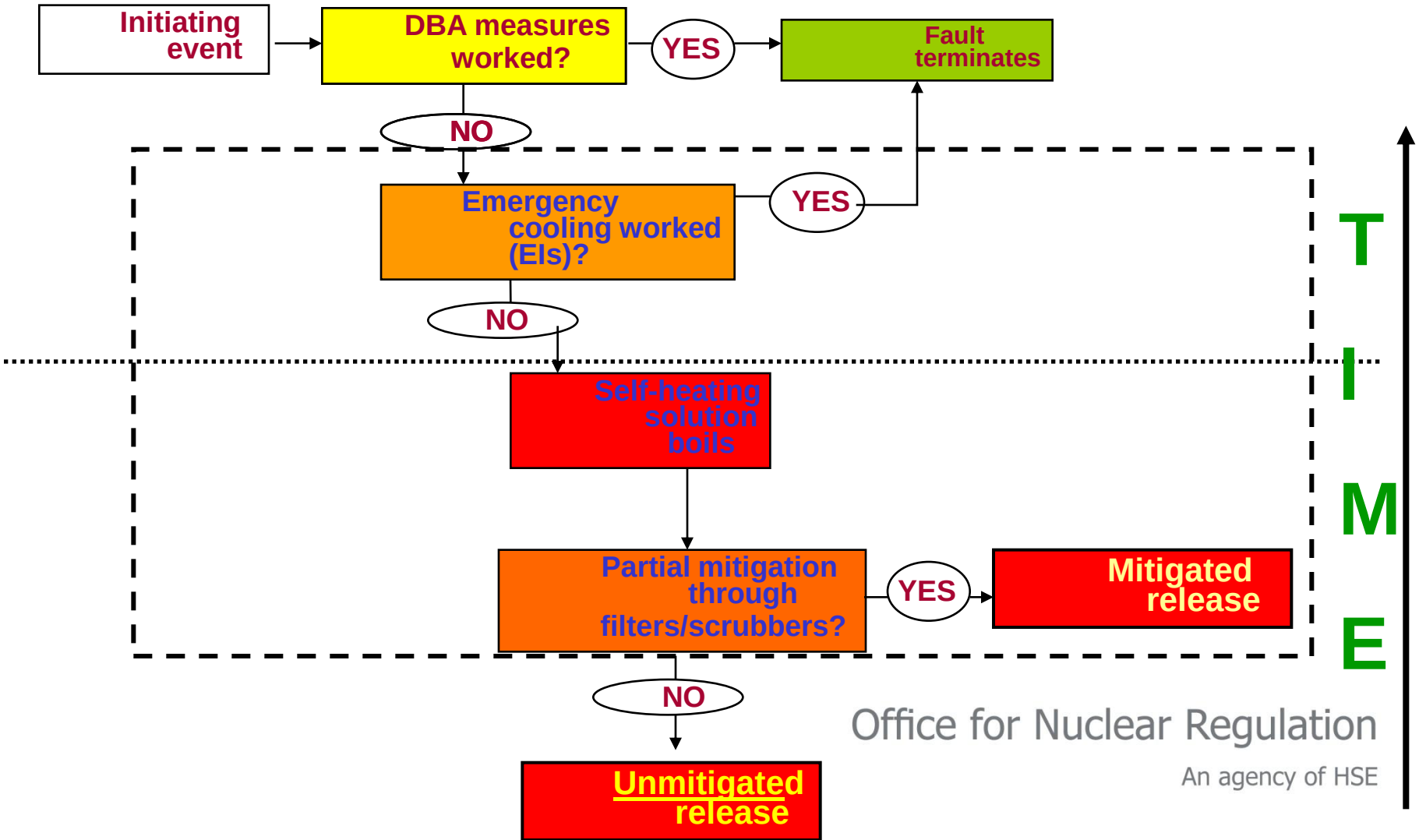
Real Example: TOMSK 7 incident

- **Accident occurred in a chemical reprocessing facility in a closed town of TOMSK 7 in Siberia**
- **Explosion of a vessel containing U and Pu solution followed by a fire caused by short circuited electrical system**
- **The explosion was so violent that it led to collapse of the walls on two floors of the building and spread contamination over 120 km^2**

"I will not call this a catastrophe because I know it's not a catastrophe... It is practically an accident without danger, but an accident all the same."

"You simply cannot compare it to Chernobyl. About 80 million curies of radioactivity were released at Chernobyl. Here we do not have a single curie so it is 80 million times less"!!!

Example : Loss of Cooling



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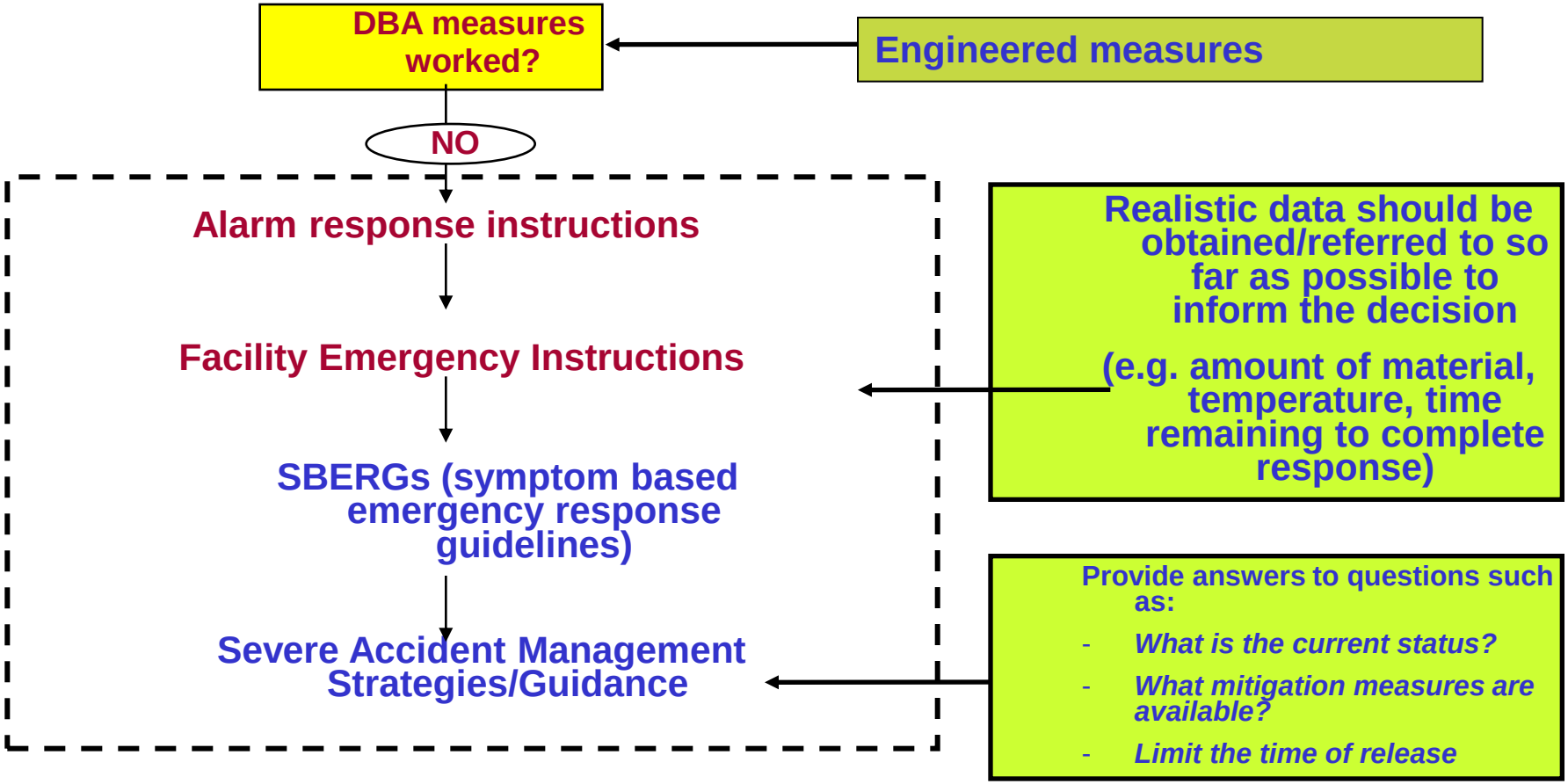
Layers of emergency instructions



Domino effects

Faults in services, nuclear or non-nuclear facilities on site that may escalate to lead to a site-wide nuclear event or potentially a severe accident

- Utilities on site
- Other non-nuclear chemical facilities on site
- External hazards

Site-wide emergencies, response and prioritisation

- Challenges in UK multi-facility sites: range of operations, close proximity of plants, range of emergency response needed

Example- Loss of Power: Loss of ventilation to facilities that require chronic hydrogen management, loss of cooling to storage facilities, loss of non-nuclear strategic facilities (data centres etc)

Priorities: varying accident progression timelines, prioritisation of deployment of emergency equipment and response personnel

Conclusion

- The principles used in SAA which inform Severe Accident Management Strategies in Nuclear Power Plants is equally applicable to non-NPP facilities

Therefore

- Consideration should be given to analysis of severe accidents as part of facility risk assessment to inform SAMS
- The examples provided aimed to discuss potential scenarios; they are not a comprehensive list and not a prescription on how analysis should be done

Thank you for your attention

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