# Post-Accident Remediation Critical Lessons

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# Connecting the Dots

TMI-2, Fukushima Daichi, Sellafield:

- Very different events, in terms of consequences, hazards, remediation technologies

**but…**

- Important points of commonality in remediation strategies and lessons learned

# TMI-2 Challenges

- Single plant Accident
- Inaccessible Reactor Building (RB)
  - Uncertain condition/reliability of systems
  - Flooded RB basement, ~600,000 Cs-137 Ci
  - Hi rad, hi contamination
- Core melt
  - Entire core damaged, ~1/3 melted
  - Uncertainty of location/condition of damaged fuel
  - Fuel retrieval, handling and disposition
- Waste management
  - Processing and disposal of contaminated water

# Fukushima Daiichi Challenges

- Six unit site, four units severely engaged
- Extreme site and facility accessibility issues
  - Three reactor buildings destroyed by hydrogen explosions
  - Fuel pool overheating / damage
  - Prohibitively high radiation / contamination levels
  - Extensive tsunami damage, debris
- Three essentially full core melts
  - Uncertainty of location / condition of damaged fuel
- Waste Management
  - High and continually increasing volumes of contaminated cooling water
  - Congested, seaside site demanding environmental protection

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# Sellafield Challenges

- Legacy storage of large quantities of nuclear and other potentially high hazard material
- Storage facilities (ponds and silos)
  - Aging (50+ years), deteriorating structures of uncertain design
  - Must maintain integrity through retrievals duration, decades in some cases
- Uncertain quantities, character and condition of stored materials
  - Imprecise, incomplete records
  - Uncertain physical and chemical changes over time in storage
  - Limited accessibility for characterization
- Waste management
  - Large quantities, all classifications, full range of conditions post-retrieval
  - Congested site poses significant logistics challenges

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# Common Lessons

- There are compelling lessons relating to the TMI-2 and Fukushima events and their emergency responses
  - — But not the subject of this presentation
- Remediation Lessons
  - — Among many, six selected for discussion today

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# Public Trust

- **Lesson 1**: Public trust is an essential component of a successful remediation project

  The full set of stakeholder - public, regulators, government, media – is an interactive and influential force.

- **Corollary**: When your world turns brown, it is too late to begin to establish public trust

- Principles:
  - — Public acceptance is based on **trust** and is central to long term nuclear viability
  - — It's personal: Focus is on people, not technology

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# Time at Risk

- **Lesson 2**: For hazard remediation, the prime objective is accelerated risk reduction
- **Corollary** to Lesson 2: Remediation work is often somewhere in the murky middle between house-on-fire and business-as-usual; we must find a way to apply proper level of urgency to the work.
- **Another corollary** to Lesson 2: In remediation work, safer is sometimes the enemy of safe enough
- With deteriorating or unknown conditions:
  - Time at risk will likely outweigh remediation activity risks
  - That calls for aggressive action to identify and overcome obstacles, streamline approaches, establish sensible safety bases, etc.

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# End States, End States, End States

- **Lesson 3**: Begin – and proceed – with the end in mind
- TMI-2 Example**:** Year 1 Wheel spinning
- It is necessary to define, secure applicable approvals), and communicate:
  - Plant/site ultimate end state

    **and**

  - Interim states/milestones to achieve that ultimate condition
- **Key point** on end states:
  - the appropriate target state for risk reduction may be very different than that for other decom objectives

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# End States (continued)

- End State definition must be:
  - In depth, covering all plant spaces, systems, components
  - Based on need, not opportunity (i.e., linked to such factors as public and worker safety, downstream access requirements, etc.)
  - Quantitative and realistically achievable
- Prioritized, sequenced interim end states form the basis of project schedule and cost (and not the other way around).

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# Characterization

- **Lesson 4:** What you **don't** know is more likely to drive the program than what you **do** know.
- **Corollary:** Hard fact trumps theory – every time
- TMI-2 **Example:** TMI-2 de-fueling approach
- Key points:
  - Characterization is the bedrock of technical decision making, planning and engineering
  - Where it is most difficult, it's usually most important
  - It's never perfect – key is to get <u>enough</u> information to proceed
  - It's an iterative, ongoing process – think military 'recon'
  - Follow-on task is data management: compiling, organizing and disseminating technical data.

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# Flexible, Adaptable Methods

- **Lesson 5:** In the land of surprises, flexibility and adaptability carry the day
- TMI-2 Example: Remote-manual defueling system and tools
- Sellafield Example: More and more, we are moving away from rigid specialty designs to adaptions of flexible, off-the-shelf ones.
- Key points:
  - This is a key to technical/programmatic risk management
  - Adapting proven technology beats invention
  - Avoid unnecessary complexity (the ‘KISS’ principle)

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# Protecting Workers

- **Lesson 6:** Radiological recovery work challenges worker safety, every day
- TMI-2 Example: In-containment work
- Key Challenge is the composite effect of radiological and industrial hazards:
  - High Radiation (and related stay time constraints)
  - Issues re: congestion / accessibility / visibility / heights / enclosed space / etc.
  - High surface and airborne contamination (and required protective clothing)

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# Decommissioning Mentality

- At Sellafield, "Decommissioning Mentality" has emerged as a term that capture and articulates these lessons – nos. 2-5, in particular:
- It connotes:
  - Unblinking focus on accelerated risk reduction – ***SAFER SOONER*** – to drive down time at risk
  - Risk-based prioritization and interim state / end state selections
  - Eyes-open treatment of unknown, combined with maximum practical characterization
  - Use of flexible, adaptable, OTS technologies
  - Early retrievals – confront the practical obstacles as early in the program as practical

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# In Summary

- TMI-2, Fukushima and Sellafield (and other remediation programs worldwide) are different in most respects
- Over time, there have been vast improvements in technology, tools, preparedness, etc.
- BUT, much was learned and needs to be remembered and applied

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# Questions?