Challenges in Risk-Informed Approach to Safer Fuel Debris Retrieval

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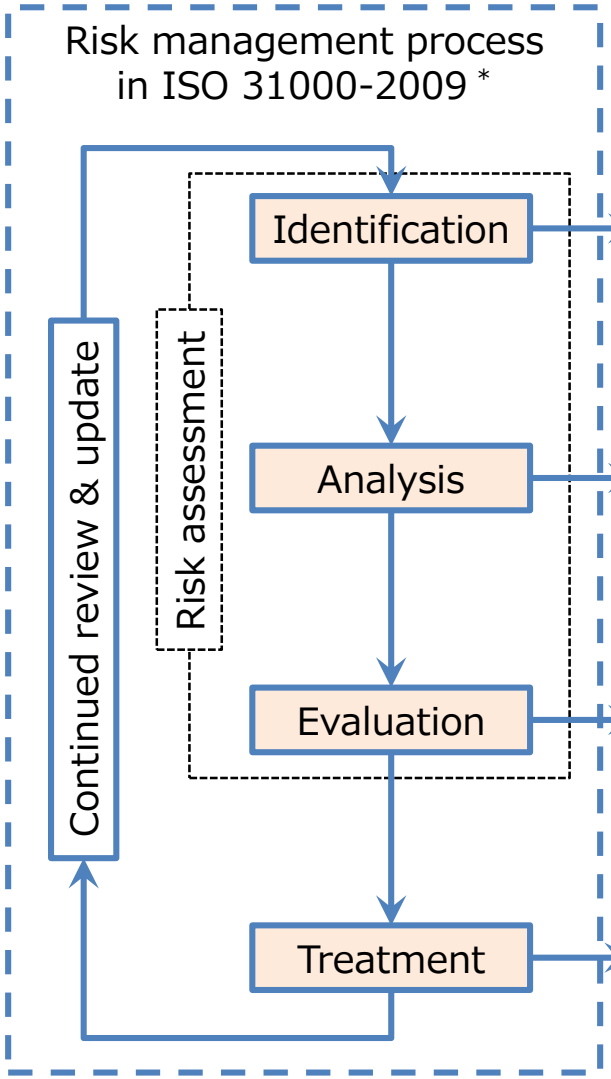
Safer Fuel Debris Retrieval

- NDF's fundamental policy for decommissioning of Fukushima Daiich NPS (1F)
  - To reduce continuously and promptly the radiological risks that resulted from the accident
- Safety is of highest priority among five guiding principles
  - Safe, proven, efficient, timely, field-oriented

- Risk-informed approach to safer fuel debris retrieval
  - Risks posed by fuel debris
    - Existing baseline risk
      - Radioactive release originated from initiating events
    - Additional risk during retrieval
      - Changes in facilities & fuel debris characteristics
      - Events caused by operation
  - Use of risk management process to understand risks & to reduce level of risks

Risk Management Process



* Referenced in "For understanding of risk assessment"
Atomic Energy Society of Japan

Risk sources: fuel debris, initiating events
Events: loss of safety functions for
criticality, cooling & confinement
Consequence: uncontrolled airborne & waterborne release

Analysis of consequence & likelihood of occurrence
- Semi-quantitative expert judgment
- Quantitative method adapted from PRA

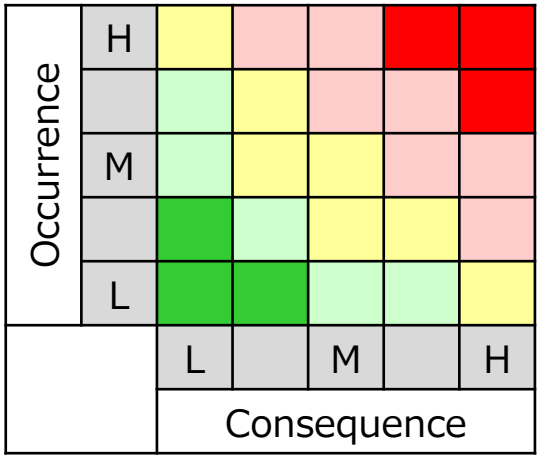
Comparison of level of risk with criteria (or goals)
- Setting safety goals
- Consideration of 1F reality

Reduction of level of risk
- Prevention, mitigation & their combination
- Practicably achievable measures

Risk Analysis by Expert Judgment

- Semi-quantitative analysis of consequence & likelihood of occurrence (collaboration with U.S. PNNL)
  - Based on judgment by experts who experienced TMI-2 or Hanford decommissioning
- Risk identification
  - Potential events based on assumed facilities & operation
- Risk analysis & evaluation
  - Five categories for consequence & likelihood of occurrence
    - Effective dose rate estimated by assuming fuel debris characteristics & release paths
  - Five categories for level of risk
- Risk treatment
  - Prevention & mitigation measures

Group of events
Airborne release
Heavy load drop
Waterborne release
Criticality
Hydrogen combustion

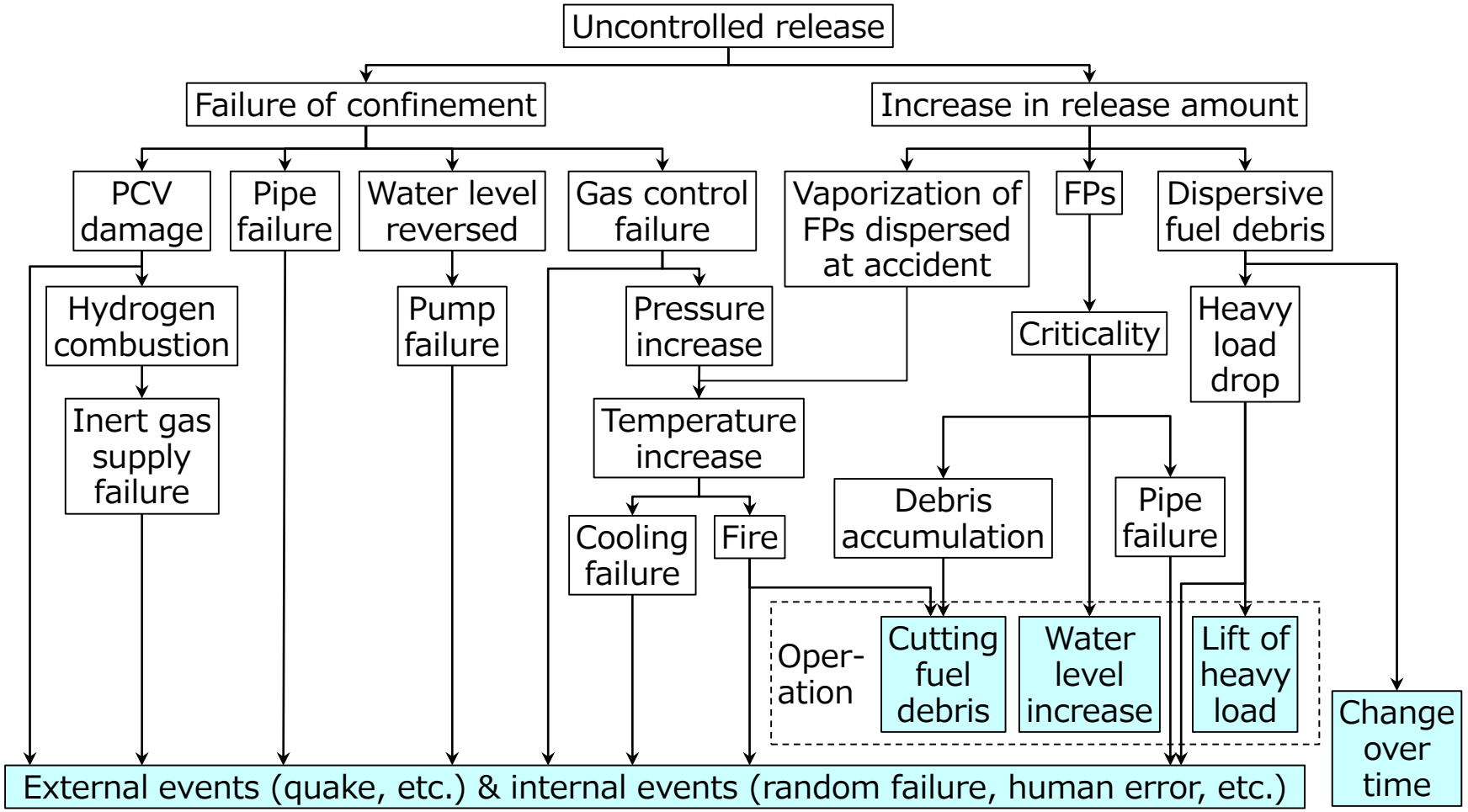


Quantitative Risk Analysis Adapted from PRA

- Events
  - Events identified by experts & loss of safety functions
- Analysis method
  - Event trees & fault trees
- Frequencies & probabilities
  - Hazard curves for quake & tsunami
  - Fragility & random failure from database
  - Human error
  - Natural phenomena by expert judgment
- Source Term = MAR x DR x LPF x ARF x RF
  - MAR (Material-At-Risk)
    - Fuel debris, FPs, contaminated water
  - DR (Damage Ratio) & LPF (Leak Path Factor)
    - Expert judgment
  - ARF (Airborne Release Fraction) & RF (Respirable Fraction)
    - Database

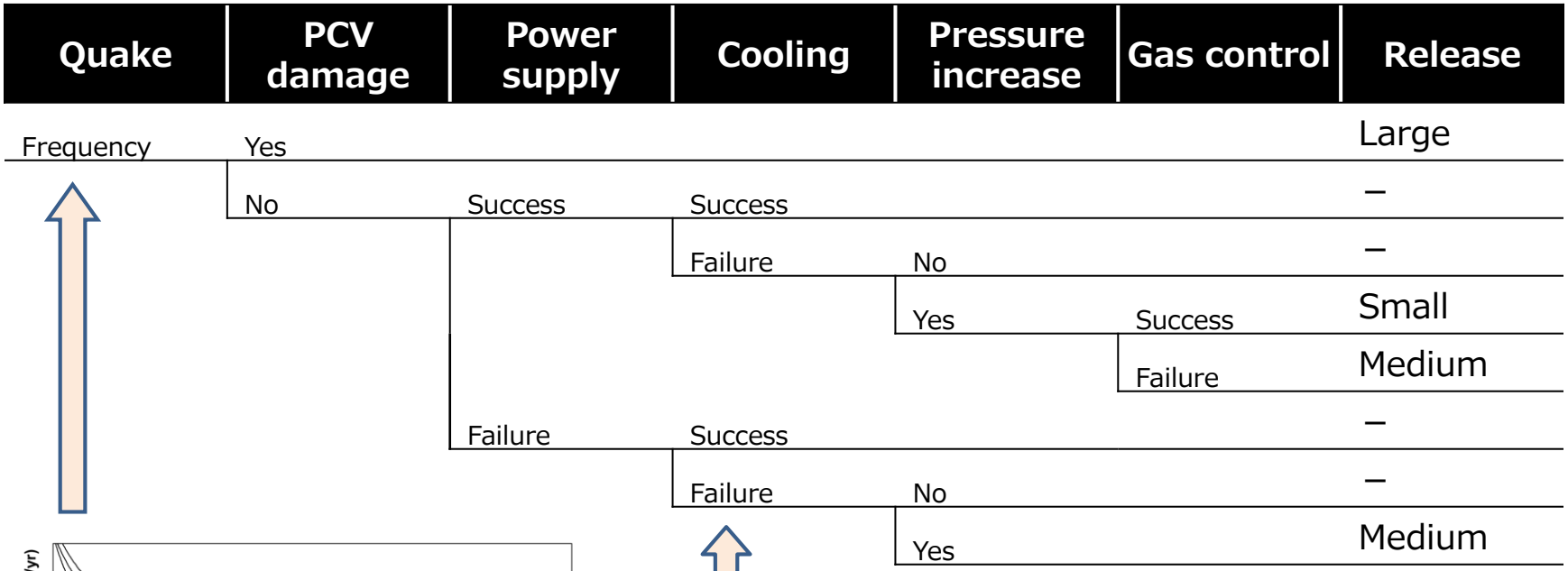
Example probability by expert judgment	
Certain	1.0
Likely	0.9
Indeterminate	0.5
Unlikely	0.1
Highly Unlikely	0.001
Impossible	0.0

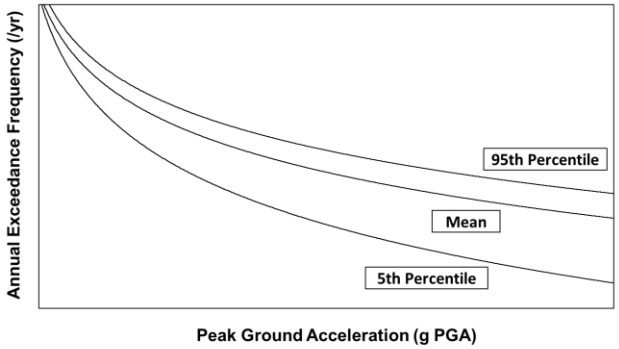
Preliminary Event Diagram



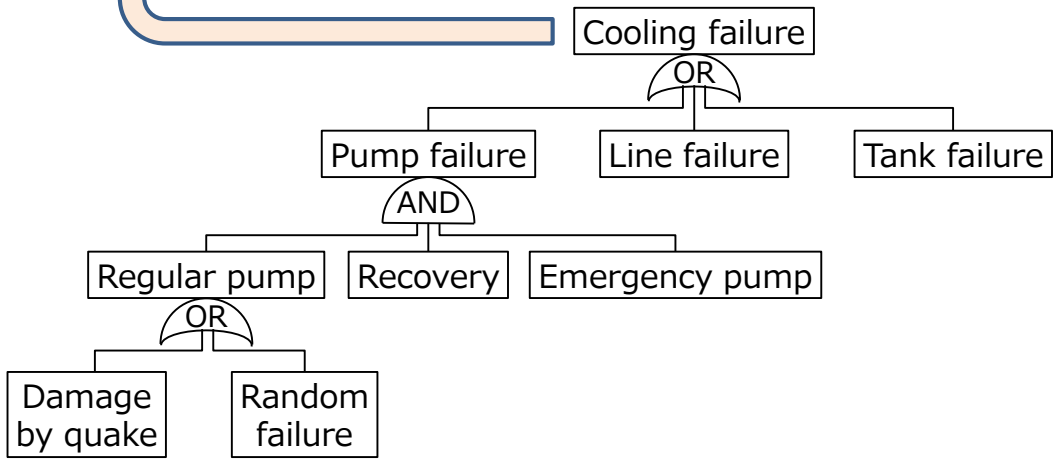
Core of risk management → continued information collection & update

Example of Event Tree & Fault Tree

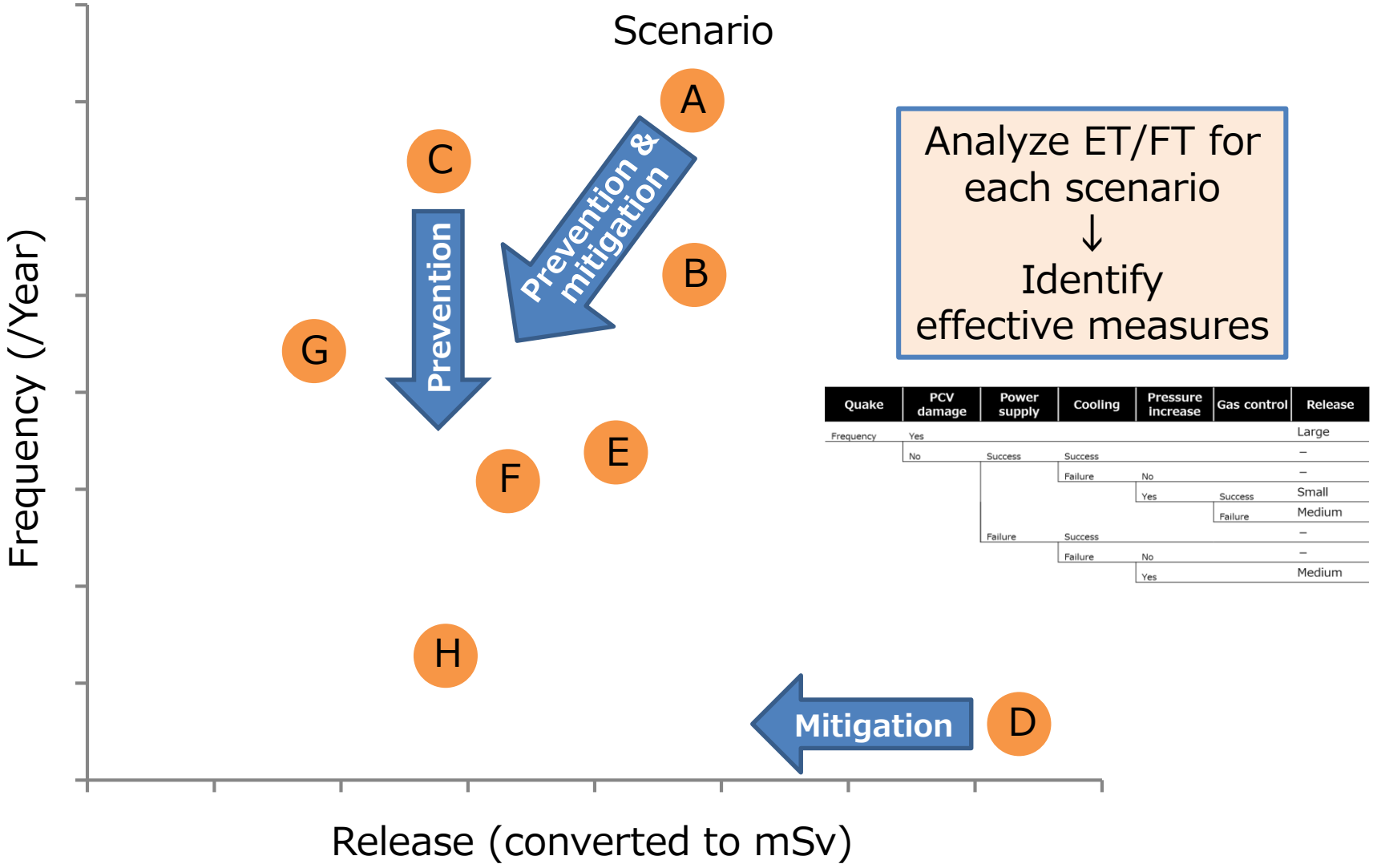




Example of hazard curve



Example of Results & Risk Treatment



Safety Goals

- 1F reality important for goal setting & their impacts
  - Uncertainty → conservative safety measures & extended preparation/operation period
    - Extension of time at risk posed by fuel debris
  - Contamination → operation under high dose environment (implementation, maintenance, etc.)
    - Increase in occupational exposure

- Example of goal setting & safety evaluation
  - Goal setting
    - Reduce level of risk during retrieval as low as reasonably practicable
    - Consider time at risk posed by fuel debris & occupational exposure
  - Safety evaluation
    - Practical definition of representative agent

Concluding Remarks

- Risk-informed safe & prompt fuel debris retrieval
  - Expert knowledge collected
  - Quantitative risk analysis method developed & applied
- Lessons learned from preliminary study
  - Benefits of risk-informed approach
    - Understanding of existing risk & risk during retrieval
    - Prioritization of risk treatment
    - Development of risk reduction measures
  - Challenges in method
    - Challenges: probabilities for natural phenomena & release scenarios
    - Short term solution by expert judgment & mid-to-long term solution by R&Ds
  - Continued review & update are critical
    - Progress in facility design & operation planning
    - New information regarding fuel debris characteristics