

# ***Qualitative PRA Insights from Operational Events***

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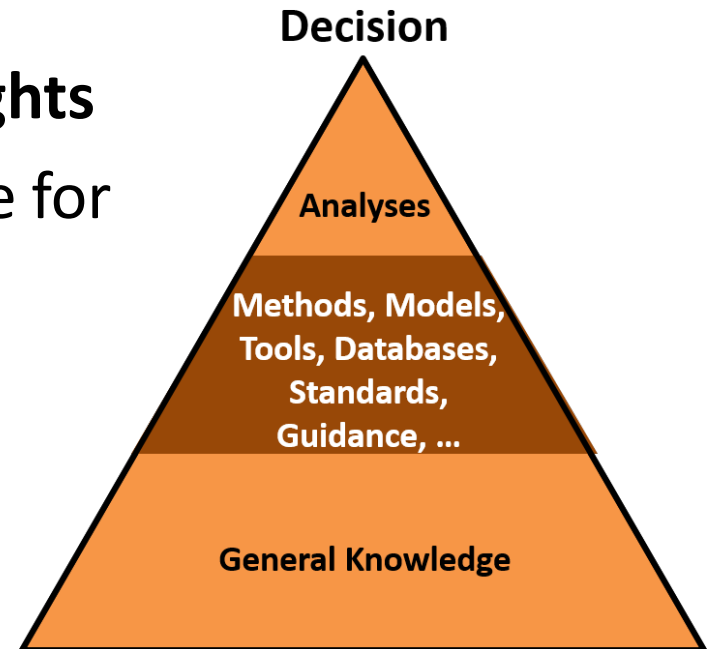
# Background

- PRA ethos: *search* for potential scenarios
- Empirical evidence: helps stimulate and temper imagination
- Example: fire incident reviews (NUREG/CR-6738)
- Hypothesis: analogous reviews of other incidents could be valuable to
  - PRA developers and analysts
  - Broader NRC efforts to increase/improve use of risk information

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# Project Objectives and Scope

- Objectives
  - **Identify PRA technology\*** insights
  - Provide educational experience for RIDM support
  - Identify lessons for intelligent search tool development
- Scope
  - Exploratory, qualitative study
  - Limited number of incidents



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\* “Technology” = Methods, models, tools, data

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# Approach

- General
  - Team: varied PRA experience levels and areas of interest
  - Informal event selection, considering
    - Safety challenge indications (e.g., INES level, CCDP, LOOP, LOUHS)
    - Information availability
    - Personal interest
  - Review structure
    - Chronological
    - Hazard, fragility, plant response
- Principal data sources
  - Public (e.g., LERs, papers, technical reports)
  - IAEA Incident Reporting System

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# Incidents Reviewed

## External Floods\*

- Hinkley Point, 1981
- Dresden, 1982
- Blayais, 1999
- Cruas, 2009
- St. Lucie 2014

## Storms\*

- Turkey Point, 1992
- Maanshan, 2001
- Browns Ferry, 2011
- Pilgrim, 2013
- LaSalle, 2013

\*Categories are not exclusive.

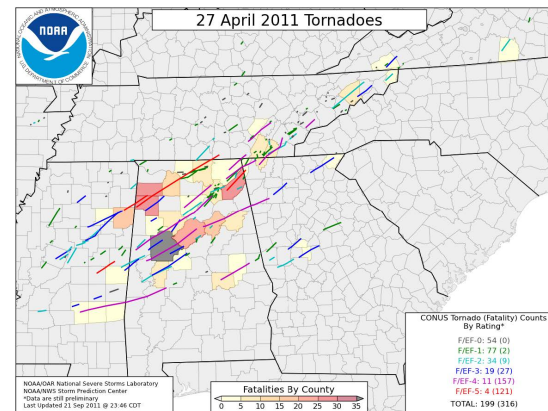
# Observations: PRA Technology

## Confirmatory

- Multiple hazards
- Asymmetrical multi-unit impacts
- Less-than-extreme hazards
- Hazard persistence
- Failure of mitigation SSCs
- Failure of implicitly considered SSCs
- Warning times and precautionary measures
- HRA and emergency response complexities

## Less-Discussed

- Multiple shocks
- Scenario dynamics
- Geographical extent and potential for multi-site impacts



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# Observations: Knowledge Management and Engineering

- Educational benefits
  - Improved understanding of specific events and mechanisms
  - Improved understanding of external hazards PRA modeling challenges
  - Potential precursors to Fukushima Dai-ichi
- Challenges for intelligent search tools
  - Limitations with current event significance measures
  - Limitations with analytics-based approaches
  - Database concerns (e.g., errors, multiple sources, evolution over time, volatility)
  - Need for multidisciplinary interpretation and analysis

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# Concluding Remarks

- Limited scope, exploratory study achieved project objectives
- “Old” events can still provide useful lessons; release of restricted access information:
  - would facilitate dissemination
  - might improve data quality
- Conservative PRA analysis assumptions can “bound” many observed complexities but
  - might mask important risk contributors
  - might not motivate useful risk management activities (e.g., preparation for asymmetrical impacts)
- Follow-on activities (additional PRA-oriented incident reviews, event catalogs) are underway



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# BACKUP SLIDES

# Example: Chronological Review

Date/Time	Event or Step Description
August 17	Turkey Point staff began tracking Tropical Storm Andrew in the control room.
August 21	Plant staff began implementing the Emergency Plan Implementing Procedure (EPIP), including moving equipment inside, tying down equipment, and preparing for storm surge. Equipment was moved from the Unit 3 diesel fuel oil tank, which did not have missile protection.
August 23	An Unusual Event was declared due to hurricane warning issued by the National Hurricane Center.
1800	Units 3 began shutting down. Turkey Point operators estimated that it would take 8 hours to complete an orderly shutdown and wanted to stagger the shutdown on each unit by 2 hours. There was concern over the main turbines and balance of plant supporting equipment being located on an open air deck (risking personnel if they needed to be outside). Unit 3 reached Mode 3 at 1940 and Mode 4 at 0213 on Aug 24 <sup>th</sup> .
2000	Unit 4 began shutting down. Both units were kept in Mode 4, rather than Mode 5, to retain steam-driven auxiliary feedwater pumps as an option for removing decay heat. Unit 4 reached Mode 3 at 2245 and Mode 4 at 0405 on Aug. 24 <sup>th</sup> .
August 24 0400	Hurricane Andrew passed directly over Turkey Point, with sustained winds of 145 mph and gusts of at least 175 mph. Spurious alarms received for the spent fuel pool low level and instrument air pressure low.
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# Example: PRA-Oriented Review

Category	Sub-Category	Summary
Hazard	Conditions	Exceptionally strong storm (985 hPa; 180-200 km/h); high tide, storm surge, wind-driven waves at site.
	Protection	Dikes (5.7 m) insufficient height and inadequate shape, upgrade suggested by earlier study not done. Also problems with detection and warning systems.
	Onsite Impact	...
Fragility	Safe Shutdown SSCs Exposed	...
	Safe Shutdown SSCs Affected	...
	Barrier SSCs Affected	...
Response	Functions Lost	...
	Safe Shutdown Path	...
	Recovery	...
	Operator Actions	...
	Other Incident Management	...
	Offsite Impact	...
Long-Term	Post-Event Changes (Plant)	...
	Post-Event Changes (Fleet)	...

# Knowledge Management Challenge

