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PSA Technology Reminders and Challenges Revealed by the Great East Japan Earthquake: 2016 Update

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Project Objective and Scope

- Identify potential lessons regarding PSA technology to support
  - NRC's Level 3 PSA project
  - future R&D planning
  - community dialog
- Literature review
  - reports and papers
  - informal discussions, site visit

"Technology"

- Methods (e.g., event tree/fault tree approach)
- Models (e.g., plant-specific model)
- Tools (e.g., PSA code)
- Data (e.g., operating experience)

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Potential Technology Challenges: 2013

Topic	*Issues*
PSA scope	Multiple units/sources, systems not normally analyzed (e.g., security systems), off-site organizations, post-accident risk
Feedback loops	Feedback from Level 3 to Level 1/Level 2 (e.g., venting delays due to delayed evacuation), multi-unit/source interactions
“Game over” modeling	Intentional conservatisms skewing risk results and insights, masking important scenarios, de-valuing mitigative activities
Long duration scenarios	Offsite resources, additional warnings and shocks, toll on operators, definition of safe and stable state
External hazards analysis	Beyond design basis events, multiple correlated hazards, multiple shocks, finite duration of elevated hazard, multiple damage mechanisms
Human reliability analysis (HRA)	Errors of commission, technical support center and external decision making, ex-control room actions, new/re-defined performance influencing factors, support of creative HRA methods applications
Uncertainty in phenomenological codes	Varying views and treatments of uncertainty (e.g., sensitivity cases, ensemble modeling, probabilistic/non-probabilistic methods) across technical disciplines
Searching vs. screening	Screening of beyond design basis hazards, biases (e.g., focusing on extreme events), systematic methods to search for failures

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This Presentation…

- Focus on implications for “advanced methods”

Advanced ≤ Possible

- See paper for full details on reminders and challenges

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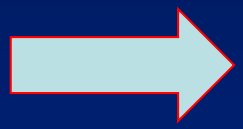
External Hazards

Topic

- Using PSA to ensure defense-in-depth
- Dealing with full hazard spectrum
- Treating correlated hazards



Advanced Methods Needed?

- Conceptually straightforward
- Data (e.g., penetration seal failures for flooding)?
- Need to treat dynamics?

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Human Reliability Analysis

Topic

- Decision making under severe accident conditions
- Ex-control room actions
- Teamwork

Advanced Methods Needed?

- Mechanistic treatment of many challenges, e.g.,
  - ✓ Choices among options
  - ✓ Communications
- Approximations?
  - ✓ Robotic follower
  - ✓ Individual cognition with communications
  - ✓ Social organization
- Approximate > None?

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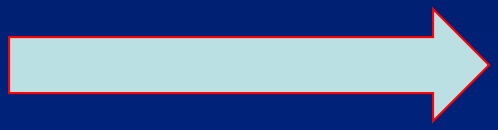
Level 2 PSA

Topic

- Long-duration scenarios
- Equipment survivability and I&C system-related impacts
- Environmental conditions and habitability



Advanced Methods Needed?

- Current technology
  - ✓ Temperature
  - ✓ Lighting
- Radiation?
  - ✓ Source number, strengths, and locations
  - ✓ Transport
  - ✓ Crew information, effect on planning
- Simplifications?

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Level 3 PSA

Topic

- Effect of offsite hazard on response
- Intentional venting
- Onsite contractors
- Aqueous pathway
- Training and resources
- Assessment endpoints

Advanced Methods Needed?

- Improved transport and dispersion?
  - ✓ Higher resolution
  - ✓ Broader coverage
- Human behavior (affecting costs)?
  - ✓ Psychological impacts
  - ✓ Social response

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Knowledge Management – Blayais

- 12/27/1999 – Storm during high tide in Gironde River estuary
- Overtopping of protective dyke
- Loss of
  - Offsite power (Units 2 and 4) – wind
  - Essential service water (Unit 1, Train A), low head safety injection and containment spray pumps (Units 1 and 2), site access – flooding
  - Site accessibility
- Papers in 2005 IAEA workshop following Indian Ocean tsunami
- Presentation at 2010 USNRC Regulatory Information Conference
- Little notice in PSA community

E. De Fraguier, "Lessons learned from 1999 Blayais flood: overview of EDF flood risk management plan," U.S. NRC Regulatory Information Conference, March 11, 2010.

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Conclusion and Closing Thoughts

Recognizing events at Fukushima Daiichi and other plants

- NRC continues to use PRA to support regulatory decision making
- Events reveal topics/issues where advanced PSA methods could be useful
- PSA R&D needs to focus on improvements supporting practical risk management.

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Additional Slides

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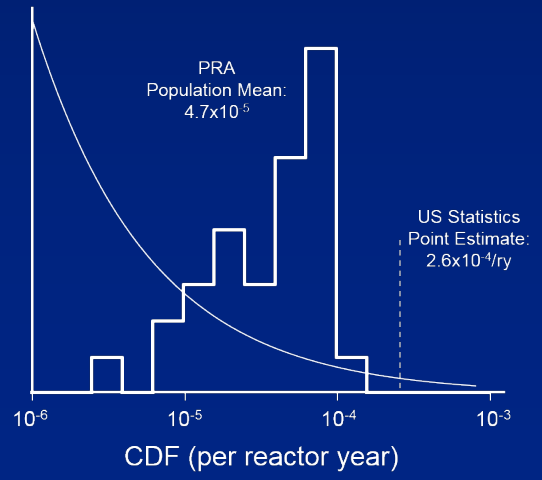
Post-Fukushima PRA Discussions

PRA Critiques

- PRAs did not predict observed scenario – "failure of imagination"
- Global statistics "prove" PRAs underestimate risk



NRC Perspectives

- PRAs
  - identify and quantify possibilities; do not "predict"
  - look beyond the design basis and past operational experience
  - provide framework to search for failure scenarios
- Global statistical estimates
  - assume exchangeability
  - neglect key information needed for regulatory decisionmaking
  - can spur examination of models

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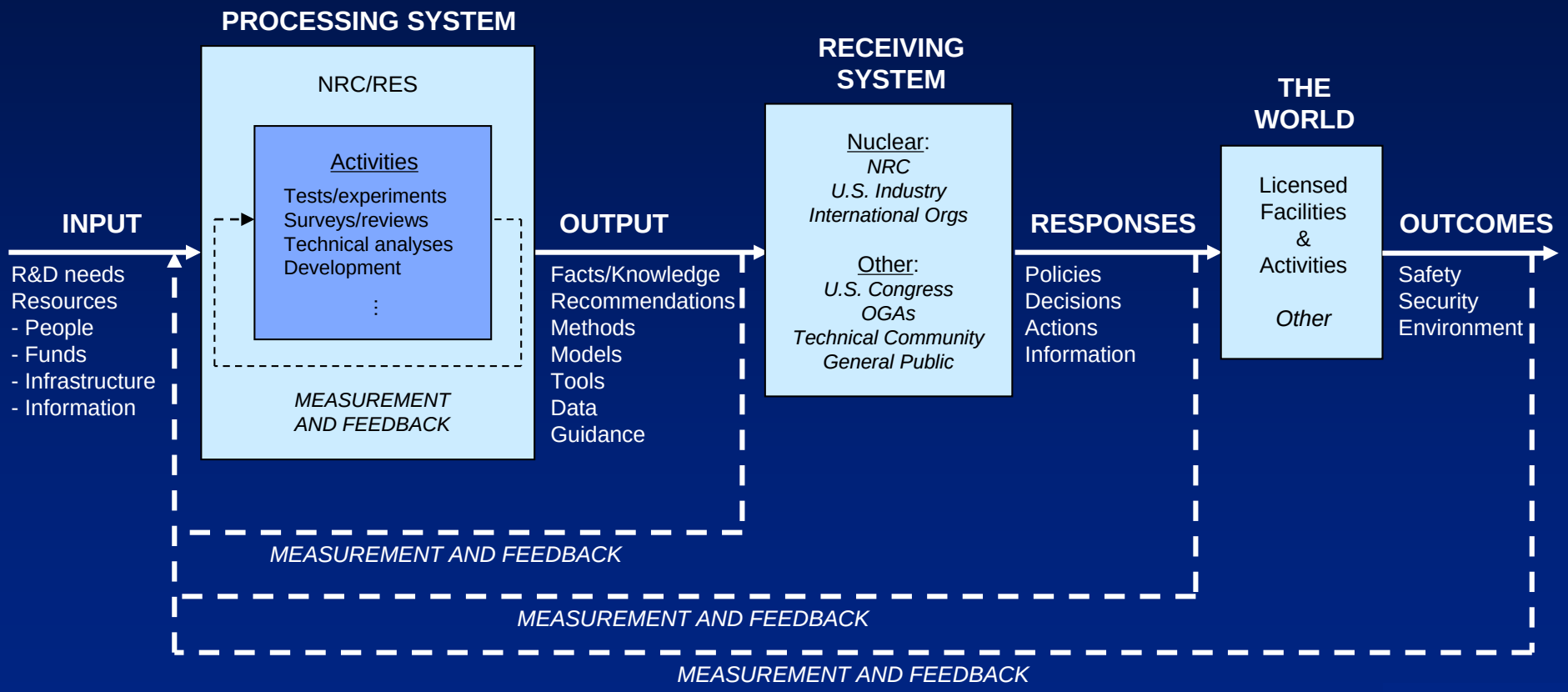
NRC R&D in the System



Adapted from National Research Council, "World-Class Research and Development Characteristics for an Army Research, Development and Engineering Organization," National Academy Press, Washington, DC, 1996, ISBN 0-309-05589-X.