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Probabilistic Risk Assessment Research Activities

December 8, 2011

Presented at a meeting of the Pressurized Water Reactor Owners' Group Risk Subcommittee

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Outline

- Background on PRA Research
- Overview of Key Research Projects
- Emerging Focus Areas
- Recent Publications

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Overall PRA Research Goals

- Support the reactor oversight and operating experience programs
- Using risk-informed approaches to improve the effectiveness and efficiency of regulation
- Expand PRA infrastructure to encompass new and advanced reactor concepts and designs
- Support continuous advancement in PRA state-of-the-art and state-of-practice

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Operating Experience

- Accident Sequence Program
  - Purpose is to identify accident precursors and to factor operating experience insights into the regulatory process.
  - Input to NRC performance measures reported in the annual performance and accountability report to Congress and Industry Trends Program
  - Determination of safety significance of events and regulatory issues
  - Program has been screening and analyzing events since 1979
- RES Data Collection, Analysis, and Trending Programs
  - Data sources are integrated into collections and databases
  - Analysis feeds the Industry Trends and other programs, as well as quantification of SPAR models

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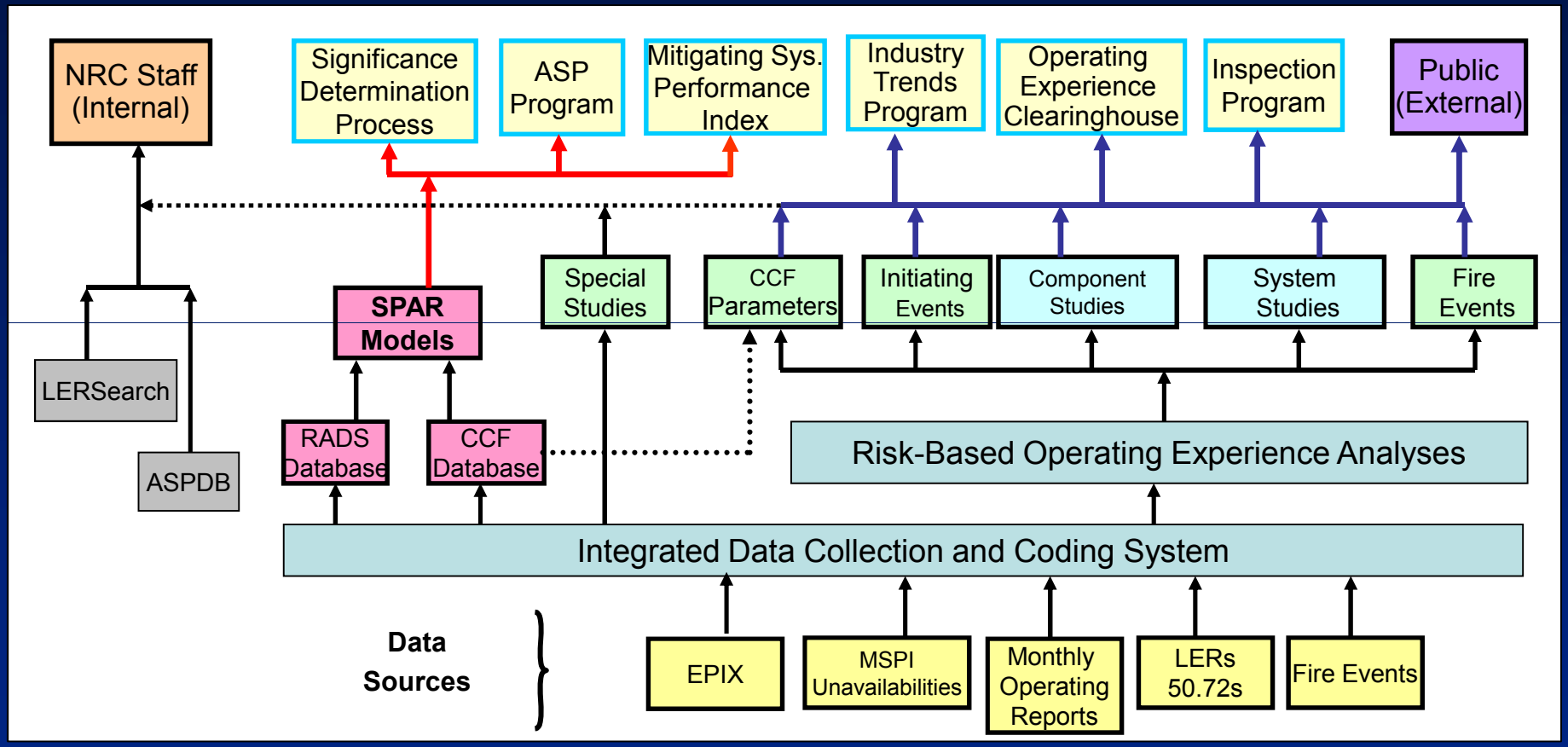
RES Data Collection, Analysis, and Trending Programs



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Reactor Oversight Support – SPAR and SAPHIRE

- Standardized Plant Analysis Risk (SPAR) Model Development and Maintenance
  - 78 Level 1 Internal Event Models for Operating Plants
  - Some models have Other Hazards Models, Shutdown Template Models, and/or Level 2 Internal Event Feasibility Models
  - 3 “New Reactor” Models (AP1000, ABWR, US-APWR)
  - Licensees can request their own SPAR model
  - ➢ Point of contact: Peter Appignani, peter.appignani@nrc.com, 301-251-7608
- SAPHIRE Version 8 (PRA Analysis Computer Code)
  - Anticipating increased inspector use for Phase 2 SDP
  - Enhanced integrated modeling features
  - Improving analysis time
  - SAPHIRE is provided for the purpose of accessing the SPAR models
  - ➢ Point of contact: Jeffery Wood, jeffery.wood@nrc.gov, 301-251-7588

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SPAR – Focus Areas in the Coming Year

- Other hazard and NFPA-805 fire models
- Support system initiating events
- Integrated capabilities model
  - 1 SPAR model with all modes/hazards/levels that SPAR currently covers
- Confirmatory success criteria analysis
  - 4-loop Westinghouse plant
- Resolution of ASME Peer Review Findings and Observations
- “New reactor” model upgrades:
  - Shutdown templates for ABWR
  - US EPR model

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PRA Methods, Models, and Tools

- Common-Cause Failure Analysis in Event and Condition Assessment
  - Draft NUREG-XXXX, "Common Cause Failure Analysis in Event and Condition Assessment," out for public comment
  - See FRNs dated 11/2/11 and 11/15/11; document in ADAMS at ML111890290
  - Public comments due by January 31, 2012
  - Future research needs are being identified and suggestions are being requested

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PRA Methods, Models, and Tools

- Human Reliability Analysis

  Working with external stakeholders on:

  – SRM M061020: Propose either a single model for the agency to use or guidance on which model(s) should to be used in specific circumstances

    - "Hybrid" model user guide and technical basis report under development
    - Next ACRS Subcommittee Meeting – December 14th AM
    - Reports for public release – early 2012

  – Fire HRA: NUREG-1921 – Spring 2012

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Standards and Regulatory Guidance

- Supporting consensus PRA Standards development, including improving existing standards and developing supporting guidance
  - PRA Glossary
  - NUREG-1855 revision
  - Clarify “defense-in-depth” to ensure consistent implementation (SRM SECY 11-0014)
  - Involvement with Level 1/LERF activities
  - Involvement on other standards under development
    - LWR, non-LWR, LPSD, Level 2, and Level 3

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Fire Research

- Fire PRA and HRA
  - NFPA-805 Support
    - NRC/EPRI Training (2 classes/year)
  - NUREG-1921, “Fire HRA” – to be released in Spring 2012
- Fire Modeling
- Fire and Electrical Systems Circuit Analysis
  - DESIREE-FIRE wrapping up
  - Electrical Circuit Phenomena PIRT in progress
- Fire Testing
  - Spent fuel shipping cask testing
  - CHRISTI-FIRE ongoing

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External Flooding Research

- Flooding, Storm Surge, and Precipitation
  - NUREG/CR "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants" - issued in November
  - NUREG/CR "Estimation of Very-Low Probability Hurricane Storm Surges for Design and Licensing of Nuclear Power Plants in Coastal Areas" in internal review process
  - NUREG/CR "Updates to Probable Maximum Precipitation Estimates for NC/SC Pilot Region" in internal review process
  - Update to RG-1.59 "Design Basis Floods for Nuclear Power Plants" (draft for public comment expected this Spring)
  - Updates to Probable Maximum Precipitation Estimates for Orographic Regions in the Tennessee River Valley and Parts of Georgia, Alabama, and Virginia (research project with USBR expected to start this Spring)
- New research underway on climate variability contribution to flooding risks
  - Data and Methodology for Probabilistic Precipitation Modeling (research project with Oak Ridge National Labs)
  - Frequency analysis methods for hydrologic extremes
  - Continuous simulation approaches for flood risk assessment
  - Integration of flood hazards into NPP risk models

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Generic Issues Update

- GI-199 , "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants"
  - Draft Generic Letter Issued – comments due by December 15th
  - Public Meetings held in 2008, 2010, and 2011
- Proposed GI-XXX, "Flooding of NPP Sites Following Upstream Dam Failures" under review
  - If declared a GI, will proceed to Safety/Risk Assessment
  - Public Meeting (Date TBD)
- Two new proposed Generic Issues being assessed
  - Effect of Downstream Dam Failure on NRC Licensed Facilities
  - Dispersal of Fuel Particles During a Loss of Coolant Accident

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Emerging Focus Areas

- Working with NSIR to investigate risk-informed Emergency Action Levels - NUREG under development
- Spent Fuel Pool Limited-Scope Consequence Study – providing probabilistic and boundary condition support
- Continued work in Dynamic Event Tree Level 1 and Level 2 PRA
- Evaluate options for more holistic risk-informed, performance-based regulatory approach (February 11, 2011 Tasking Memo)

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Emerging Focus Areas – Level 3 PRA

- SECY-11-0089 (July 7th) and SRM (September 21st), "Options for Proceeding with Future Level 3 Probabilistic Risk Assessment (PRA) Activities"
- All modes, all hazards, all levels, all sources PRA, including multi-unit effects
- 4 year schedule
- Site selection underway – public meeting held on November 10th
  - Target for selecting a site – December 2011
- Plan due to the Commission in March 2012

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Emerging Focus Areas – Level 3 PRA (2)
Preliminary Site Selection Criteria

- *High Priority:*
  - Multi-unit site
  - Licensee participation
- *Medium Priority:*
  - Scope and type of licensee PRA
  - Information availability
    - Electric cable raceway database
    - Seismic fragilities
    - PRA success criteria analyses
    - SAMA analysis
    - Consolidated source of design and licensing basis documentation
    - MELCOR input deck
  - Geographic Location
    - External hazard profile
    - Nearby population (avoid isolated sites)
    - Agricultural land use
    - 50-mile radius within US borders
  - SOARCA plant
  - Shared systems between units
- *Low Priority:*
  - Plant design type
  - ISFSI

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Fukushima Task Force Update - Documents

- SECY-11-0093 (July 12th) and SRM (August 19th), "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan"
- SECY-11-0117 (August 26th) and SRM (October 19th) "Proposed Charter for the Longer-Term Review of Lessons Learned from the March 11, 2011, Japanese Earthquake and Tsunami"
- SECY-11-0124 (September 9th) and SRM (October 18th), "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report" – *a.k.a. "the 21 day paper"*
- SECY-11-0137, October 3rd, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned" – *a.k.a. "the 45 day paper"*
- ACRS letters dated October 13th, "Initial ACRS Review of: (1) the NRC Near-Term Task Force Report on Fukushima and (2) Staff's Recommended Actions to be Taken Without Delay" & November 8th, "ACRS Review of Staff's Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned (SECY-11-0137)"

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Fukushima Task Force Update – Current activities

- Staff is working on the implementation of the actions in SECY-11-0124 (the NTTF Tier 1 recommendations with slight modification)
  - Each individual implementation effort (Rulemakings, Orders, 50.54(f) letters) calls for external stakeholder involvement
- Commission deliberating on SECY-11-0137 – a.k.a. "the 45 day paper"
- An additional SECY is under development to:
  - Address Tier 3 recommendations,
  - Incorporate feedback from the Commission, ACRS, and other stakeholders
  - Incorporate any additional insights that arise

For more information, and access to the above documents, see http://www.nrc.gov/japan/japan-info.html

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Relevant Recently-Issued Technical Reports

- NUREG-1022, Revision 3, "Event Report Guidelines 10 CFR 50.72 and 50.73," Draft report for comment – comments due by 12/12/2011
- NUREG-1953, "Confirmatory Thermal-Hydraulic Analysis to Support Specific Success Criteria in the Standardized Plant Analysis Risk Models—Surry and Peach Bottom," September 2011
- NUREG/CP-0195, "Proceedings of the Workshop on Engineered Barrier Performance Related to Low-Level Radioactive Waste, Decommissioning, and Uranium Mill Tailings Facilities," August 2011
- NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants," imminent publication
- NUREG/CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants," imminent publication
- NUREG/CR-7039, "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) Version 8: Technical Reference," June 2011
- NUREG/CR-7046, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," November 2011

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Relevant Publications Since August (cont)

- Regulatory Guides (RGs) and Draft Guides (DGs)
  - RG 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” October 2011
  - DG-1278, proposed Revision 3 to RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants “ (comment period closed)
- Generic Communications
  - Draft NRC Generic Letter, “Seismic Risk Evaluations for Operating Reactors,” comment period closes on 12/15/2011

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Acronym List

- ABWR – Advanced Boiling Water Reactor
- ACRS – Advisory Committee on Reactor Safeguards
- ADAMS – Agencywide Document Access and Management System
- ASME – American Society of Mechanical Engineers
- ASP – Accident Sequence Precursor
- ASPDB – Accident Sequence Precursor Data Base
- CCF – Common Cause Failure
- CHRISTI-FIRE - Cable Heat Release, Ignition, and Spread in Tray Installations During Fire
- DESIREE-FIRE - Direct Current Electrical Shorting in Response to Exposure Fire
- DG – Draft [Regulatory] Guide
- EPIX - Equipment Performance and Information Exchange
- EPRI – Electric Power Research Institute
- GI – Generic Issue
- HRA – Human Reliability Analysis
- ISFSI – Independent Spent Fuel Storage Installation
- JCNRM – Joint Committee on Nuclear Risk Management
- LER – Licensee Event Report
- LERF – Large Early Release Frequency
- LPSD – Low Power and Shutdown
- LWR – Light-water Reactor
- MSPI – Mitigating System Performance Index
- NC – North Carolina
- NFPA – National Fire Protection Association
- NPP – Nuclear Power Plant
- NRC – US Nuclear Regulatory Commission
- NSIR – NRC Office of Nuclear Security & Incident Response
- NTTF – Near Term Task Force
- PIRT – Phenomena Identification & Ranking Table
- PRA – Probabilistic Risk Analysis
- RADS - Reliability and Availability Database System
- RASP – Risk Assessment Standardization Project
- RG – Regulatory Guide
- ROP – Reactor Oversight Process
- SAMA – Severe Accident Mitigation Alternative
- SAPHIRE - Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
- SC – South Carolina
- SDP – Significance Determination Process
- SECY – a.k.a., Commission Paper
- SOARCA – State-of-the-Art Reactor Consequence Analyses Project
- SPAR – Standardized Plant Analysis Risk
- SRM – Staff Requirements Memorandum
- USBR – US Bureau of Reclamation