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PSA R&D Activities and Planning

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NRC History with PSA R&D

- Pioneering efforts
  - WASH-1400/Lewis report
  - NUREG-1150
  - RMIEP (LaSalle, NUREG/CR-4832)
- Later focus on applications and standardization
- Current R&D attention on “tough issues” with potentially strong dependencies
  - Human reliability analysis (HRA)
  - Fire
  - Digital systems

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Changing Environment

- Increased use of risk information (integration of risk into everyday activities)
  - New and possibly more detailed applications
  - New systems and technologies
  - Increased demands for realism
  - Increased involvement of other technical disciplines
  - Need for transparency to multiple stakeholders
- Increased capabilities
  - Computation
  - Phenomenological understanding
- Changing workforce
- Changing physical environment

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Other PSA Challenges

- Empirical data to support
  - Identification of possibilities
  - Limiting possibilities
  - Model quantification (especially dependencies)
  - Model and method validation
- PSA gaps (e.g., errors of commission)

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Example Activities* (1)

Technical Area	Topic Area	Example Activity
Reactors	Level 1 internal events at power	Development and maintenance: standardized event tree/fault tree models for all U.S. plants**
	Level 2	Development: standardized Level 2 models**
	Level 3	Development: improved consequence analysis code
	Low power and shutdown (LPSD)	Development: standardized LPSD models**
	Operational data	Analysis: industry trends
	Event analysis	Analysis: accident precursor significance
	Generic safety issues (GSI)	Analysis: issue significance
	Performance indicators and thresholds	Support: implementation of new performance index
	New reactors (evolutionary)	Analysis: HRA needs for new reactors
	Advanced reactors	Analysis: HRA needs for advanced reactors
	Research and test reactors	
Non-Reactor Facilities and Activities	Geologic repositories	
	High-level waste (HLW)	Analysis: qualitative HRA for high-level waste
	Low-level waste/decommissioning	Development: performance assessment models/tools
	Fuel cycle facilities	Analysis: mixed oxide fuel fabrication facility
	Transportation	
	Sources	Development and implementation: HRA-informed training

*FY-2008
**Part of standardized plant analysis risk model (SPAR) program

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Example Activities* (2)

Technical Area	Topic Area	Example Activity
Special Topics	HRA	Analysis: performance of HRA methods against simulator data; Development: human events database
	Ageing	
	Passive components	
	Passive systems	
	Digital systems	Analysis: PSA methods for digital systems
	CCF	Support: international CCF database
	Design and construction	
	Fire	Support: risk-informed fire protection rule implementation; Development: HRA for fire PRA
	Seismic	Development: standardized external events models**
	Other external events	Support: international review of methods
	Security-related events	Support: rulemaking for new reactors
	EP&R	
General Systems Analysis Methods and Tools	PRA tools	Maintenance: PSA software (SAPHIRE)
	Uncertainty and sensitivity analysis methods and tools	Development: guidance for treatment of uncertainties
	Advanced computational methods	
	Advanced modeling methods (e.g., simulation)	Review: dynamic PSA methods
	Elicitation methods	
Implementation and Application	PRA quality (e.g., guidance, standards)	Development: PSA standards
	Risk-informed regulation infrastructure	Development: risk-informed and performance-based technology-neutral framework for new reactors
	Risk-informed regulation applications	Support: steam generator tube rupture resolution
	Risk perception and communication	

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Human Reliability Analysis

- International Empirical HRA Study
- HRA Model Use in Decision-Making
- Human Event Repository and Analysis System
- Assessment of U.S. Crew Performance?

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Digital Instrumentation & Controls

- Traditional Methods
  - NUREG/CR-6962, “Traditional Probabilistic Risk Assessment Methods for Digital Systems” (Oct. 2008)
  - Draft NUREG/CR, “Modeling a Digital Feedwater Control System Using Traditional PRA Methods” (Fall 2009)
- Dynamic Methods
  - NUREG/CR-6901, “Current State of Reliability Modeling Methodologies for Digital Systems and Their Acceptance Criteria for Nuclear Power Plant Assessments” (Feb. 2006)
  - NUREG/CR-6942, “Dynamic Reliability Modeling of Digital Instrumentation and Control Systems for Nuclear Reactor Probabilistic Risk Assessments” (Oct. 2007)
  - NUREG/CR-6985, “A Benchmark Implementation of Two Dynamic Methodologies for the Reliability Modeling of Digital Instrumentation and Control Systems” (Feb. 2009)
- Probabilistic Modeling of Software Failures
- OECD/WGRisk Digital I&C Reliability

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Fire Modeling and PSA

- Support for 50.48(c)/NFPA-805 Implementation
- Fire Modeling Users Guide for NPPs
- Cable Flame Spread & Heat Release Rate Testing
- NRC/EPRI Fire PSA Training Course
- HRA for Post-Fire Human Actions
- DC Circuit Spurious Actuation Testing
- Fire Events Database

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Advanced PSA Methods

Enable the more accurate and/or efficient solution of existing problems

- Advanced sensitivity analysis methods
  - Evaluating multivariate problems (e.g., fire, passive systems reliability)
  - Integrated, simulation-based approach to the treatment of key phenomena
- Uncertainty analysis
- Advanced modeling techniques for Level 2/3 PSA
- Dynamic PSA

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PSA R&D Plan: Development Approach

- Information gathering
  - Conferences, workshops, etc.
  - Contracted reviews (SNL, BNL)
  - Other R&D plans (NRC, industry, international)
  - Stakeholder feedback (ACRS, ACNW&M, RMT, SPI, user needs…)
- Initial gap analysis
  - Uncertainties
  - Decision support needs
  - Feasibility of improvements
- Develop input (with basis) to support budget process
- Finalize initial plan

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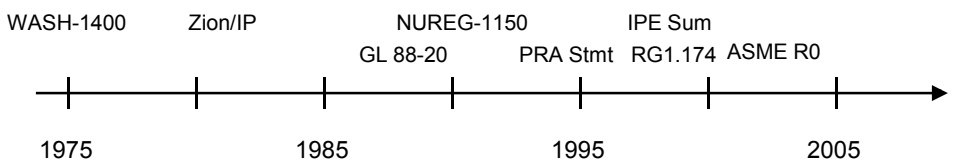
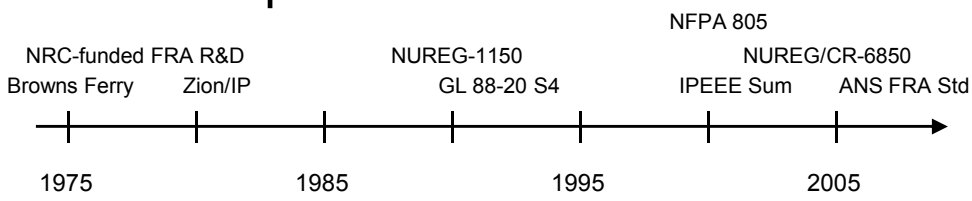
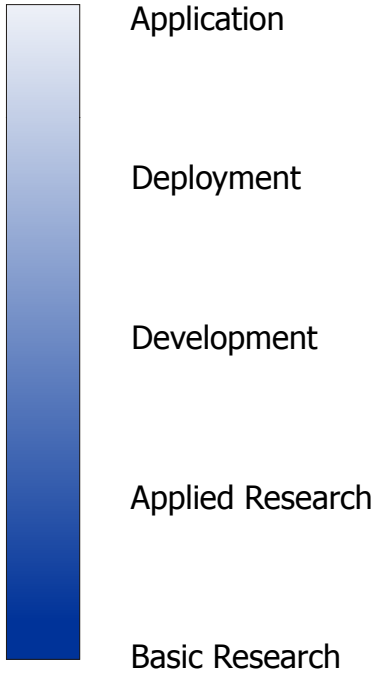
Observations

- Wide range of activities
- Potentially long time to maturity and implementation
  - PRA Example 1: WASH-1400



  - PRA Example 2: Fire





- Often has side benefits
  - Unforeseen uses
  - Training/development