

# **NRC Safety Research Programs: The Strategic Vision for PRA and Human Performance Research**

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# Overview

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- Research Framework
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# Office of Nuclear Regulatory Research

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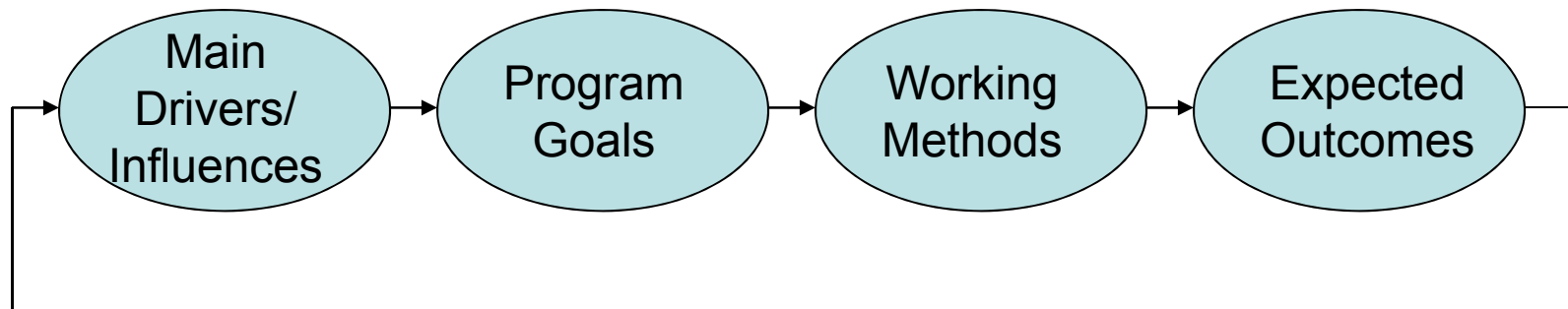
# NRC/RES Role

- RES ≡ Office of Nuclear Regulatory Research
- RES's primary role is to conduct independent confirmatory research:
  - Research that will produce results that the NRC can use to independently confirm or dispute safety claims made by applicants or licensees.
  - Research that confirms or dismisses suspected safety issues.
- Principles
  - The primary burden for demonstrating safety lies with applicants and licensees.
  - Regulatory offices (e.g., NRR, NRO) have the primary role in making safety determinations about plants.
  - Industry has lead responsibility to:
    - Improve methods or techniques helping themselves
    - Solve industry safety issues

# NRC/RES/DRA Mission

- Key Areas:
  - PRA-based methodologies, models, and analysis techniques, as well as other risk assessment techniques
  - Guidance and regulatory tools for implementation of the Safety Goal Policy and PRA Policy Statements
  - Human factors and HRA
  - Fire safety
  - Operating experience (system studies, PIs, trends, ASP) and data systems
  - Generic issues
- Recent activity: Strategic Planning Initiative
  - Help articulate DRA core values
  - Support development of vision to guide upcoming decisions

# Regulatory Research Framework



- SRMs
- User Needs
- TARs
- LTRP
- Agency Mandates
- Emergent Needs (e.g., 9/11)
- Influences
- ACRS recommendations
- Work/views from other international/external
- Operational experience
- Exploratory work
- Planning initiatives

- Issue resolution
- Application support
- Mission support

- Contracts
- Staff work
- International agreements
- MOUs
- Professional societies
- Internal collaboration

- Analysis insights and results
- Technology
  - Methods
  - Models
  - Tools
  - Data
  - Guidance
- Recommendations

# Looking Ahead

## Planning Activities

- NRC Strategic Plan update
- RPP
- Long-Term Research Plan
- Multi-year PRA improvement plan (potential)
- NNGP roadmap
- DRA Strategic Planning Initiative
- Informal (e.g., counterparts meetings)

## Potentially Significant Trends

- Aging plants
- New plants
  - Evolutionary
  - Advanced
- New technologies
  - Regulated systems and processes
    - Digital I&C (including advanced HSI)
    - Passive safety systems
    - New NPP uses and designs
    - New fuel cycles
  - Analytical
    - Computational power
    - Methods
- Continuing agency efforts to improve efficiency and effectiveness
  - Risk-informed initiatives in licensing, regulation, oversight, activity prioritization
    - Increased comfort level with RIDM (especially at Regions)
  - Integrated, risk-informed approaches to technical issues
    - Multiple disciplines
    - Consolidation and integration of research results
  - Development: PRA models, methods, tools, data, guidance and standards
- Continuing industry efforts to reduce costs and improve performance
  - Reduction of trips and other performance indicators
  - Extending operations (power uprates, increased burnup)
  - New management strategies (staff reduction, use of contractors)
  - Risk-informed applications (e.g., fire, Tech Specs, special treatment)
  - New approaches to safety management (including safety culture)
- Changing nuclear industry infrastructure
  - Changing vendors (plant and support) and suppliers
  - Changing workforce (size, experience, culture)
- Changing environment
  - Physical environment (global warming)
  - Increasing demands for electric power
  - Aging critical infrastructure
  - Changing threats

# Goals and Main Drivers – Current PRA Research Activities

- Support the Reactor Oversight and Operating Experience Programs
  - User Needs
  - Agency Mandate
- Remove obstacles to implementation of risk-informed regulation
  - User Needs
  - Commission direction
- Expand PRA infrastructure to encompass new reactor concepts and designs
  - User Needs
  - Commission direction
  - Industry trends
- Support continuous advancement in PRA state-of-the-art and state-of-practice
  - RES Long-Term Research Plan
  - Commission direction
  - ACRS recommendations



# Potential Path Forward: PRA at NRC

	Today/Very Near Term	Near Term ( $\Delta$ )	Long Term ( $\Delta$ )
Methods	<ul style="list-style-type: none"> <li>Event Tree/Fault Tree framework</li> <li>Updated internal fire, NUREG/CR-2300 external events</li> <li>Offline phenomenological calcs (e.g., success criteria, accident progression)</li> <li>Parametric CCF</li> <li>Bayesian estimation</li> <li>Parameter uncertainty propagation, qualitative model uncertainty, limited sensitivity calculations</li> </ul>	<ul style="list-style-type: none"> <li>Extension to new topics (e.g., software failures, design errors)</li> <li>Updated external events (e.g., seismic, external flooding)</li> <li>Consensus methods for selected topics (e.g., HRA, expert elicitation)</li> <li>Probabilistic networks to treat influences</li> <li>Improved integration of phenomenology (e.g., physics of failure for CCF, aging; accident progression for Level 2, HTGRs)</li> <li>Improved uncertainty and sensitivity analysis methods</li> <li>Improved risk representation/communication methods (targeted at decision makers)</li> </ul>	<ul style="list-style-type: none"> <li>Improved treatment of phenomenology (full integration of other engineering disciplines, e.g., xLPR; dynamic PRA for selected scenarios)</li> <li>Treatment of outstanding topics (e.g., errors of commission)</li> <li>Information-technology related methods to better facilitate review and use of PRA (e.g., searching and inferencing methods)</li> </ul>
General Models	<ul style="list-style-type: none"> <li>SPAR L1 internal events, at-power models representing all operating plants</li> <li>SPAR models for other applications (e.g., LPSD, ext. events, LERF)</li> <li>Consensus models for specific topics (e.g., support system initiators)</li> </ul>	<ul style="list-style-type: none"> <li>Maintain and improve agency SPAR models to address new and evolving program needs (e.g., NFPA 805, external events, digital I&amp;C)</li> </ul>	<ul style="list-style-type: none"> <li>Comprehensive (all levels, all modes, all initiators, all sources), state-of-the-art models for selected sites</li> </ul>
Tools	<ul style="list-style-type: none"> <li>SAPHIRE</li> <li>RASP Handbook</li> <li>Simulation codes (e.g., MELCOR)</li> <li>General purpose calculational software (e.g., spreadsheets)</li> </ul>	<ul style="list-style-type: none"> <li>Software to implement improved methods (see above)</li> <li>Software to facilitate use of existing analytical and numerical methods (e.g., convolution, simulation, estimation, hypothesis testing)</li> <li>Standardized model representations to support reviewers</li> </ul>	<ul style="list-style-type: none"> <li>Software to implement improved methods and associated models (see above)</li> <li>Standardized presentation of risk assessment results and bases supporting multi-disciplinary, collaborative decision making</li> </ul>
Data	<ul style="list-style-type: none"> <li>Operational experience (NRC, industry, international)</li> <li>Special topic event databases (e.g., CCF, HERA, FEDB)</li> <li>Generic estimates (e.g., initiating event frequencies)</li> <li>Topic-specific (e.g., Halden experiments, data for phenomenological parameters)</li> </ul>	<ul style="list-style-type: none"> <li>Empirical data to support improved methods and associated models (e.g., expanded HRA data set)</li> <li>Benchmark exercise results (various topics)</li> </ul>	<ul style="list-style-type: none"> <li>Empirical data to support improved methods and associated models (see above)</li> </ul>

# Goals and Main Drivers – Current HF/HRA Research Activities

**Mission: Support oversight, licensing, and rulemaking programs by providing safety perspectives on the impacts of HP on regulated activities**

- Drivers
  - User Needs
  - Commission direction
  - Industry trends
  - ACRS recommendations
  - RES Long-Term Research Plan
  - Issue identification from research activities
  
- Goals
  - Ensure HF/HRA methods and guidance have sound, up-to-date technical bases
  - Expand HF/HRA infrastructure for new applications (anticipated changes in industry)
  - Improve HF/HRA methods to reduce uncertainty - promote state-of-the-art
  - Maintain infrastructure of expertise, facilities, capabilities, and data

## Potential Path Forward: HF/HRA at NRC

	Today/Very Near Term	Near Term ( $\Delta$ )	Long Term ( $\Delta$ )
<b>Methods</b>	<ul style="list-style-type: none"> <li>Multiple HRA methods</li> <li>Standard methods (e.g., experimental design, survey design, field observations, statistical analysis)</li> <li>HFE methods</li> </ul>	<ul style="list-style-type: none"> <li>Consensus methods for HRA</li> <li>Methods to test/validate HF models</li> <li>Methods for evaluating new systems (e.g., modernized control rooms), advanced plant designs (e.g., multimodular reactors), and advanced concepts of operation (e.g., remote operation)</li> </ul>	<ul style="list-style-type: none"> <li>Treatment of outstanding HRA issues (e.g., errors of commission, organizational influences)</li> </ul>
<b>Models</b>	<ul style="list-style-type: none"> <li>General models (e.g., information processing modeling framework, task models)</li> </ul>	<ul style="list-style-type: none"> <li>Dynamic crew simulation models (demonstration)</li> <li>Topic-specific models (e.g., fatigue, workload, situation awareness, organizational factors and safety culture)</li> </ul>	<ul style="list-style-type: none"> <li>Dynamic crew simulation models (application)</li> </ul>
<b>Tools</b>	<ul style="list-style-type: none"> <li>NUREG-0700/0711</li> <li>Task simulation software (e.g., MicroSAINT)</li> <li>Experimental facilities (e.g., Halden Man-Machine Laboratory)</li> </ul>	<ul style="list-style-type: none"> <li>Expanded experimental simulation capabilities (small- and medium-scale)</li> <li>Computer aids for performing HRA</li> <li>Computer aids for HF licensing reviews</li> </ul>	<ul style="list-style-type: none"> <li>Expanded experimental simulation capabilities (large-scale, US and international)</li> <li>Software for dynamic crew simulation</li> <li>Assessment tools for HF licensing reviews and inspection</li> </ul>
<b>“Data”</b>	<ul style="list-style-type: none"> <li>HRA database (HERA)</li> <li>Research literature</li> </ul>	<ul style="list-style-type: none"> <li>Expanded HRA data set to support improved HRA</li> <li>Information knowledge base for HF reviews</li> </ul>	<ul style="list-style-type: none"> <li>Integrated information base addressing HF and HRA, including data from actual operations, training simulators, and experiments</li> </ul>

# Our Challenges as a Research Organization

- How to balance long-term and short-term needs and desirable improvements
- How to best support the agency in making risk-informed decision making and thinking a more intrinsic aspect of the agency's environment

# Concluding Remarks

- NRC Safety Research Program has a broad range of PRA and HF activities
  - Current in user office areas of interest
  - Leadership role in select areas
- Major improvements require sustained support
  - Solution approaches may be technically complex and require empirical data
  - Deployment may require cultural shifts
  - Current working methods and recent initiatives are aimed at developing this support
- Need to continuously incorporate peer review feedback into process

# Discussion – Potential Topics

- Improving our understanding of risk
  - Tough and other remaining issues
  - New technologies and systems
  - New applications and arenas
- Improving our PRA toolbox
  - Accessibility of established models and methods
  - Use of new analytical/information technologies