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L3PRA: Updating NRC's Level 3 PRA Insights and Capabilities

A. Kuritzky, N. Siu, K. Coyne, D. Hudson, and M. Stutzke

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

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Outline

- Background (context for study)
- Project Overview
- Key Challenges
- Concluding Remarks

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PRA Policy Statement (1995)

"The use of PRA technology should be increased in all regulatory matters to the extent supported by the state-of-the-art in PRA methods and data and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy…"

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U.S. Risk-Informed Regulation: Notable Activities and Events

Policy Statements — Safety Goal; PRA

Rules & Programs — ATWS; SBO; MR (a)(4); ROP; FP; SSC; PTS

Reg Guides — RG 1.174; RG 1.200

Standards — NFPA 805; ASME PRA

TMI — *Chernobyl* — *Fukushima*

1980 — 1990 — 2000 — 2010

NUREG-2150

WASH-1400

NUREG-1150
NUREG/CR-4832, 5305
NUREG/CR-6143 , 6144

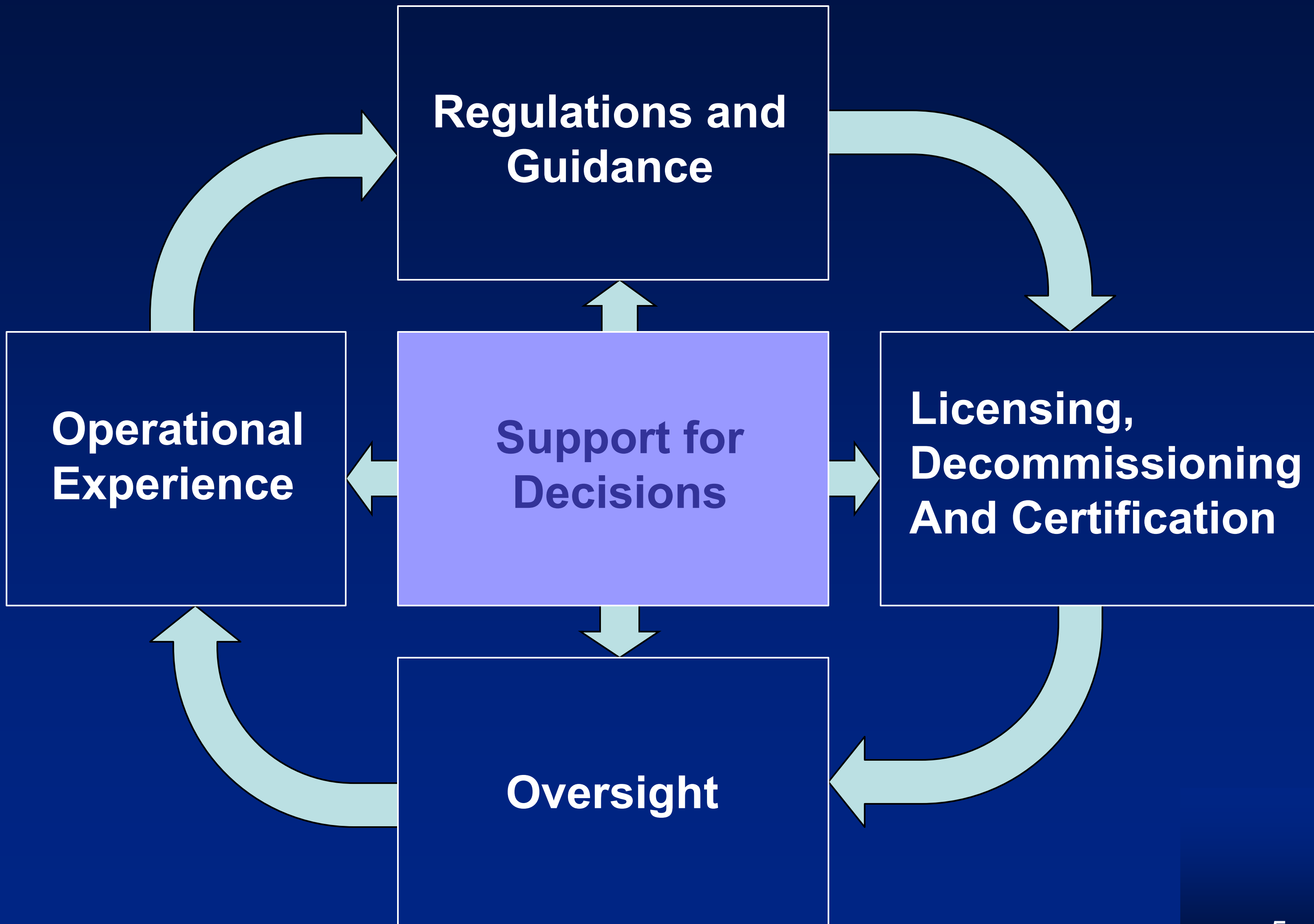
SPAR Models

Early Industry Studies
(Zion, Indian Point, Limerick, …)

IPEs / IPEEEs

Licensee Models
(e.g., SAMDA analyses)

Use of Risk Information: Activities



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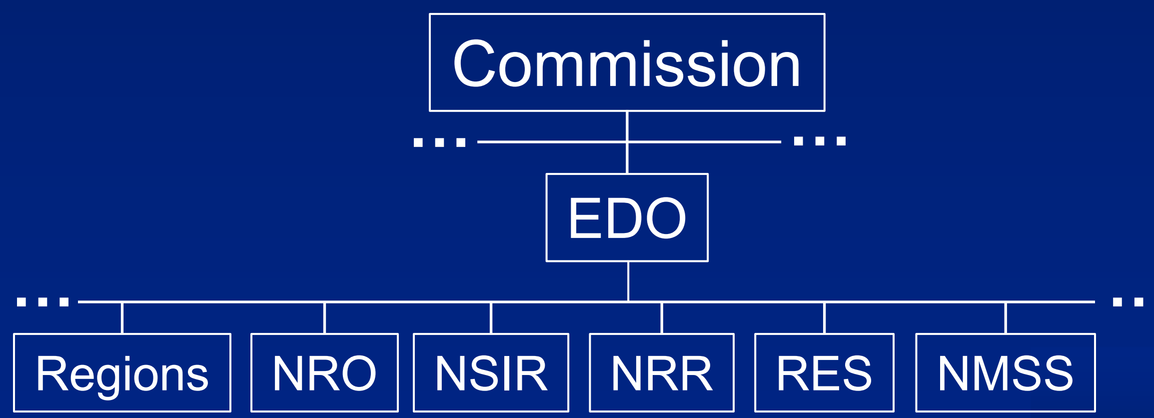
Producers and Users of Risk Information: Organizations

- Multiple Offices
- Numerous staff
  - Analysts
  - Users
- Contractors



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Potential Uses of Level 3 PSA

- Confirm acceptability of NRC's current use of PSA in risk-informed regulatory decision making
- Verify or revise regulatory requirements and guidance (e.g., those based on NUREG-1150)
- Support specific risk-informed regulatory applications
- Develop and pilot PSA technology, standards, and guidance
- Prioritize generic safety issues and nuclear safety research
- Develop in-house PSA technical capability and support knowledge management
- Support future risk-informed licensing of new designs

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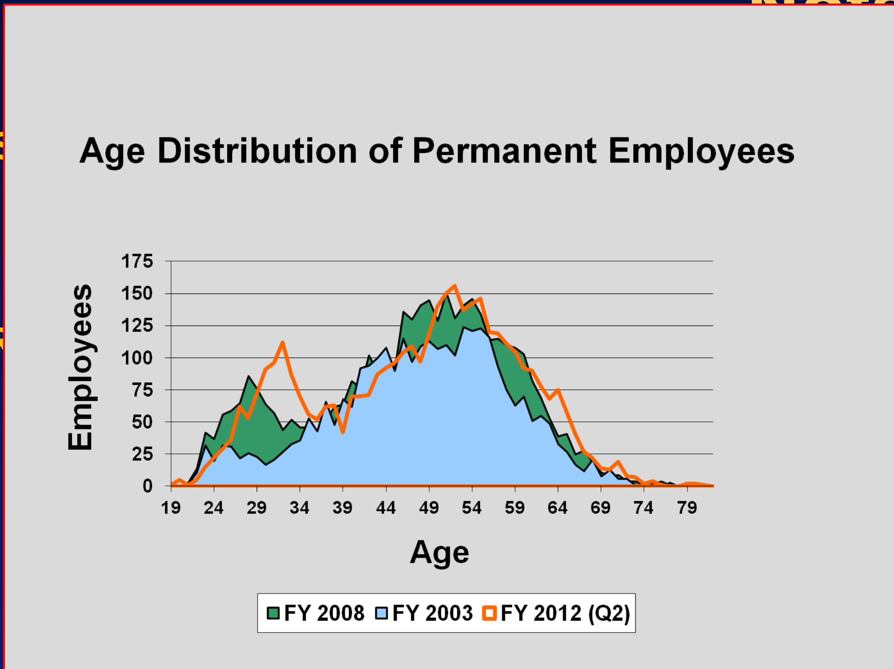
U.S. Risk-Informed Regulation: Notable Activities and Events



PRA

MR (a)(4)
ROP
RG 1.174

FP
SSC

PTS
RG 1.200

NFPA 805
ASME PRA

Fukushima

1980 1990 2000 2010

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Project Objectives

- Develop a Level 3 PRA generally based on current state of practice that
  - reflects technical advances since the last NRC-sponsored Level 3 PRAs
  - addresses scope considerations not previously considered
- Extract new insights to enhance regulatory decisionmaking and to help focus limited agency resources on issues most directly related to the agency’s mission
- Enhance PRA staff capability and expertise and improve documentation practices
- Demonstrate technical feasibility and evaluate the realistic cost of developing new Level 3 PRAs

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Project Scope

- All major site radiological sources (all reactor cores, spent fuel pools, and dry storage casks).
- All internal and external hazards, and all modes of plant operation. Excludes initiating events involving malevolent acts.
- Incorporates improvements in PRA technology as well as changes in plant operational performance and safety since completion of NUREG-1150
- Excludes some aspects for which no risk model or analytical method has been established (e.g., software failure and aging)
- Single multi-unit site (not likely to provide insights applicable to all sites and all technical issues).

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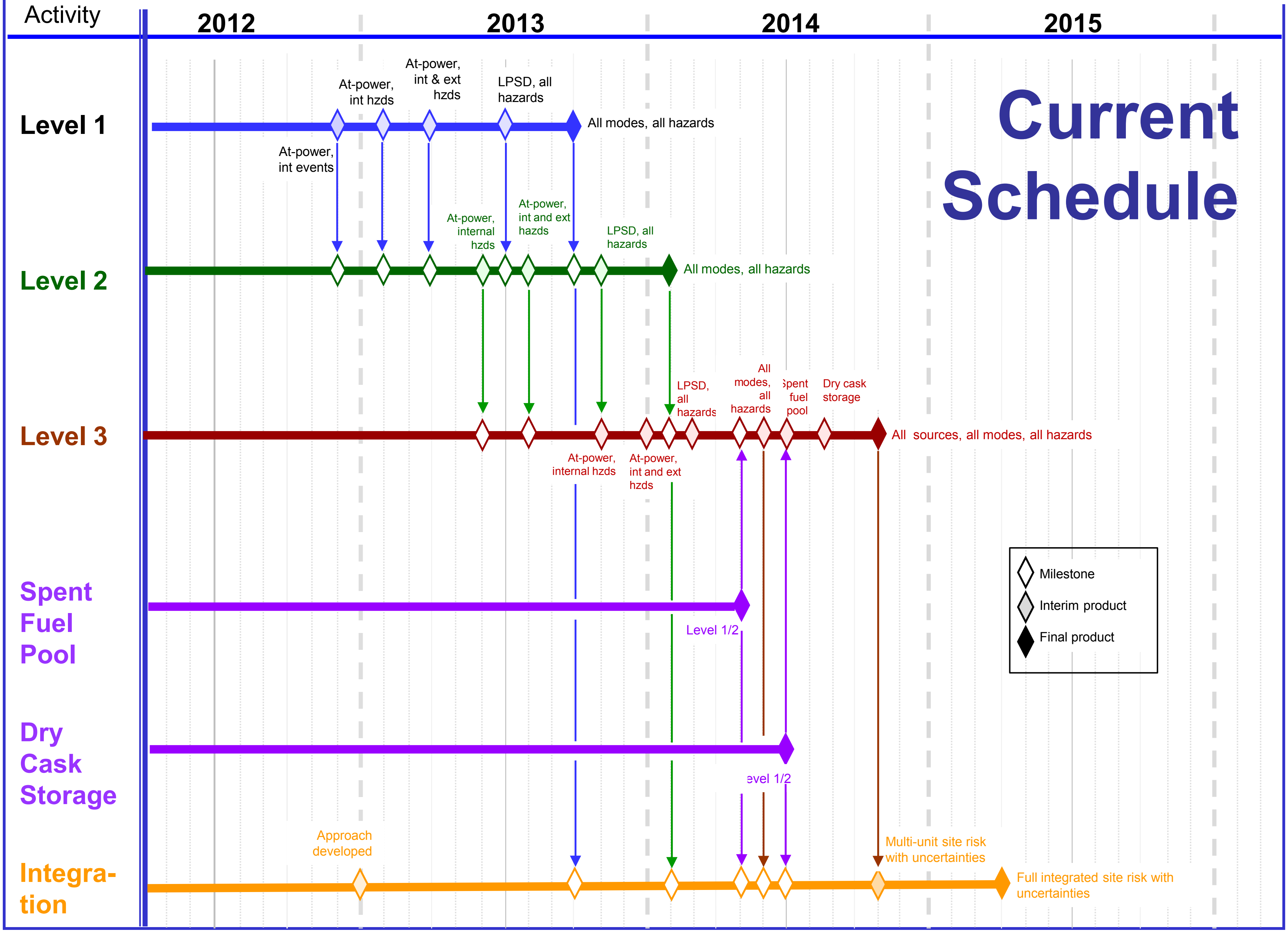
Technical Approach Philosophy

- Generally based on the ***current state of practice***.
- Will consider:
  1) ASME and ANS PRA standards
  2) Results of earlier scoping study (documented in SECY-11-0089)
  3) Interactions with NRC experts
  4) Input from internal Technical Advisory Group (TAG)
- ***Documentation completeness*** (transparency) is a priority
  – Technical bases, assumptions, decisions, etc.
  – Hyper-linking
- ***Peer Reviewed***

Other Considerations

- Proposed tools and models
  - SAPHIRE 8
  - MELCOR
  - MACCS2
  - SPAR
  - Licensee model (at-power internal events, floods, fires; seismic underway)
- Risk metrics
  - Public health effects and offsite economic costs
  - Core damage frequency and large early release frequency
- Communication plan
- Documentation will likely be multi-tiered
  - Top tier (NUREG report, technical approach document) will be publicly available
  - Lower tier (interim deliverables) will likely contain proprietary information


Current Schedule
Activity
2012
2013
2014
2015
Level 1
Level 2
Level 3
Spent Fuel Pool
Dry Cask Storage
Integration
At-power, int hzds
At-power, int & ext hzds
LPSD, all hazards
All modes, all hazards
At-power, int events
At-power, internal hzds
At-power, int and ext hzds
LPSD, all hazards
All modes, all hazards
LPSD, all hazards
All modes, all hazards
Spent fuel pool
Dry cask storage
All sources, all modes, all hazards
At-power, internal hzds
At-power, int and ext hzds
Level 1/2
evel 1/2
Approach developed
Multi-unit site risk with uncertainties
Full integrated site risk with uncertainties
Milestone
Interim product
Final product

Project Organization

- Multi-disciplinary team of senior, mid-career, and junior staff with experience in PRA and supporting technical areas
  - Program Manager: Alan Kuritzky
  - Technical Advisers: Marty Stutzke, Mary Drouin
  - Project Coordinator: Anders Gilbertson
  - TAG Chair: Nathan Siu
- Predominantly staff from Office of Nuclear Regulatory Research
- Limited support from other NRC offices
- Commercial and DOE laboratory contractor support to supplement project team

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Technical Challenges

Internal events	Internal floods	Internal fires	Seismic and other external hazards	Low power and shutdown	Severe accident progression	Consequence analysis
Initiating event analysis [Y]	Identification and screening analysis [G]	Screening analysis [G]	Screening/ bounding analysis [G]	Initiating event analysis [G]	Plant damage state analysis [G]	Source term binning [G]
Accident sequence analysis [Y]	Plant response analysis [G]	Plant response analysis [Y]	Plant response analysis [G]	Accident sequence analysis [G]	Accident progression and source term analysis [Y]	Modeling of emergency preparedness response and development of MACCS2 input deck [G]
Success criteria analysis [G]				Success criteria analysis [G]		
Systems analysis [G]				Systems analysis [G]		
Data analysis [Y]	Flood frequency analysis [G]	Fire initiation analysis [G]	Event frequency analysis* [O]	Data analysis [O]		
		Fire damage analysis [G]	Fragility analysis [O]			
Human reliability analysis [G]	Human reliability analysis [O]	Human reliability analysis [G]	Human reliability analysis [O]	Human reliability analysis [O]	Human reliability analysis [O]	Human reliability analysis [O]
Quantification [G]	Quantification [G]	Quantification [G]	Quantification [G]	Quantification [G]	Quantification [G]	Consequence calculation [G]
						Risk integration [R]
Uncertainty analysis [G]	Uncertainty analysis [G]	Uncertainty analysis [G]	Uncertainty analysis [G]	Uncertainty analysis [G]	Uncertainty analysis [O]	Uncertainty analysis [O]

Spent fuel pool [O]

- Initiating event analysis
- Accident sequence analysis
- Success criteria analysis
- Systems analysis
- Data analysis
- Human reliability analysis
- Quantification
- Uncertainty analysis

Dry cask storage [O]

- Initiating event analysis
- Accident sequence analysis
- Success criteria analysis
- Systems analysis
- Data analysis
- Human reliability analysis
- Quantification
- Uncertainty analysis

Site risk [R]

- Initiating event analysis
- Equipment and operator dependency analysis
- Model integration
- Risk metrics
- Uncertainty analysis

*Event frequency analysis is categorized as "Orange" for external flooding, only. For seismic and other "non-flooding" external hazards, this element is characterized as "Green."

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Key Technical Challenges (Red)

Red = new method development needed

- Site Risk
  - Initiating event analyses
  - Equipment and operator dependency analyses
  - Model integration
  - Risk metrics
  - Uncertainty analysis
- Consequence analysis: risk integration

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Key Technical Challenges (Orange)

Orange = existing methods not yet developed and/or demonstrated but adaptable (or substantial effort may be required to implement)

- HRA (internal floods, external events, low power/shutdown, severe accident progression, consequence analysis)
- External flooding (hazard analysis)
- External events (fragility analysis)
- LPSD data analysis
- Uncertainty analysis (severe accident progression, consequence analysis)
- Spent fuel pools and dry cask storage

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Key Technical Challenges (Yellow)

Yellow = methods exist, limited effort needed to improve or select consensus approach

- Internal events (support system initiating event modeling, common-cause failure modeling)
- Internal fires (plant response analysis)
- Severe accident progression (accident progression and source term analysis)

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Concluding Remarks

- Currently in detailed planning stage
  - Technical plan under development
  - SECY on potential regulatory uses under development
- Need to take advantage of previous work (including international work)
  - State-of-Practice Methods
  - Insights

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BACKUP

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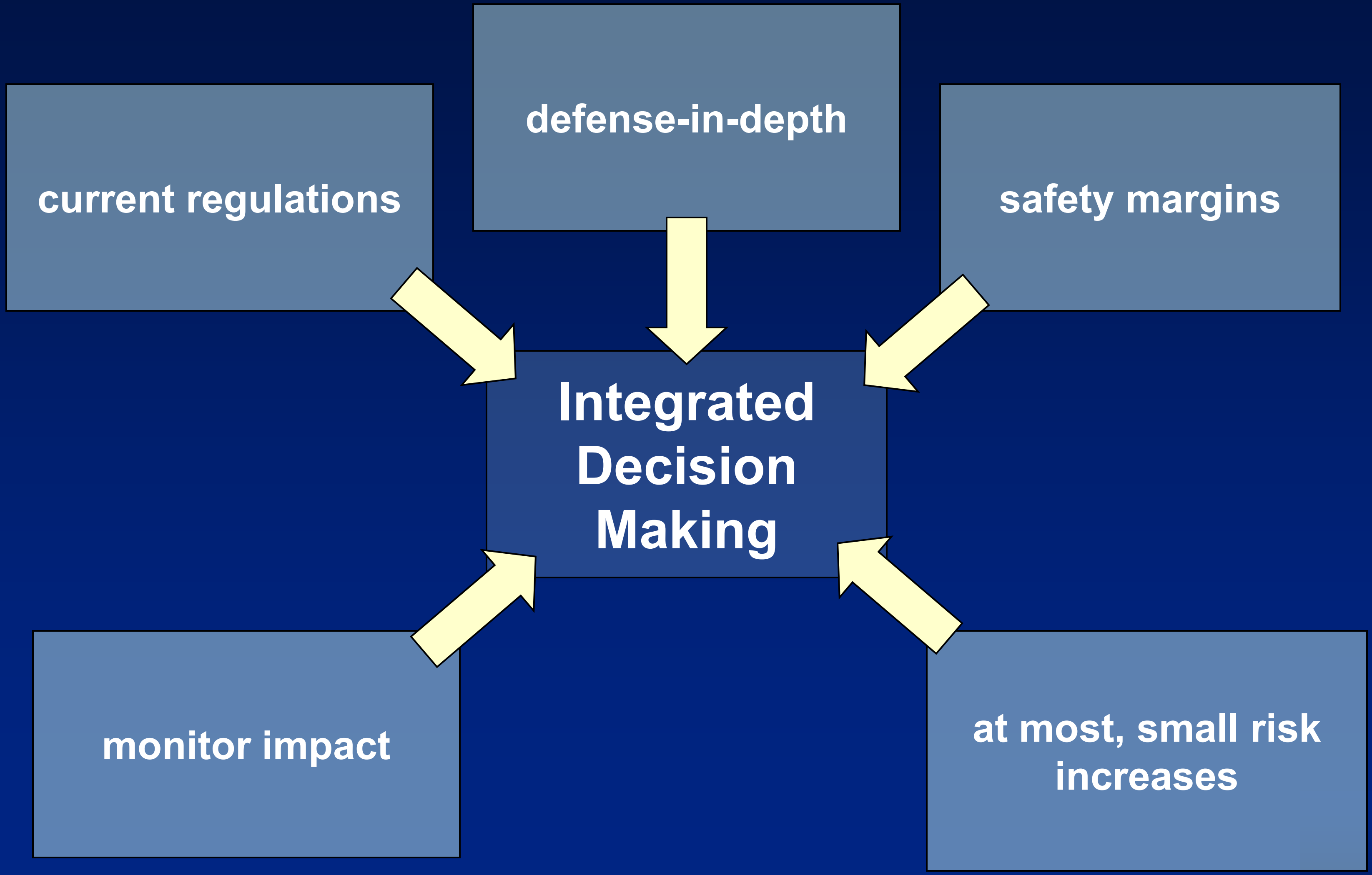

Overall PRA Research Goals

- 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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Ongoing/Planned Activities (examples)

- SPAR models
- CCF for event assessment
- PRA standards
- Fire PRA (HRA, spurious operations)
- Digital I&C PRA
- HRA (common method for NRC, empirical studies)
- External events (e.g., seismically-induced fires and floods)
- Expert elicitation
- Spent fuel pool scoping study
- Advanced studies
  - Dynamic PRA
  - Advanced knowledge engineering