Full-Scope Site Level 3 PRA

Advisory Committee on Reactor Safeguards
Reliability and PRA Subcommittee

July 22, 2013
(Open Session)

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Outline

- Open Session
  - Integrated site risk
  - Human reliability analysis
- Closed Session
  - Level 1, at-power, internal events model conversion
  - Acceptance review and initial results
  - Path forward

Site Level 3 PRA Project Integrated Site Risk Assessment (ISRA) (TAAP Section 17)

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Agenda

- Integrated Site Risk Assessment (ISRA) Technical Analysis Approach
- Current Status of Work
- Risk Metrics

ISRA Technical Approach

- The single-source PRA models will not be directly integrated (linked together) to form the multi-source PRA models; rather, they provide the “raw material” used to develop the simplified ISRA PRA models.
- A highly iterative effort
- Important to maintain functional and logical consistency:
  - Frequent and substantive Task Leader meetings
  - One-on-one meetings with other Task Leaders
  - Documentation of modeling issues as specified in Section 18 (Quality Assurance), and prompt resolution of these issues
  - Comparison of results to the single-source PRA results as the ISRA is progressively developed

ISRA Technical Approach Involves

- Developing insights from individual single source models to focus attention on risk-significant multi-source accidents; e.g.,
  - RCP seal LOCAs (loss of coolant accidents) tend to be risk significant in PWR PRA models, often involving a loss-of-offsite power. Because loss-of-offsite power sequences can often affect both units at once, these sequences may be a driving risk factor for dual-unit core damage.
- Developing criteria and assumptions to help simplify ISRA model; e.g.,
  - Screening on the likelihood of the specific site configuration, the partial multi-source sequence frequency, or the partial multi-source sequence risk.

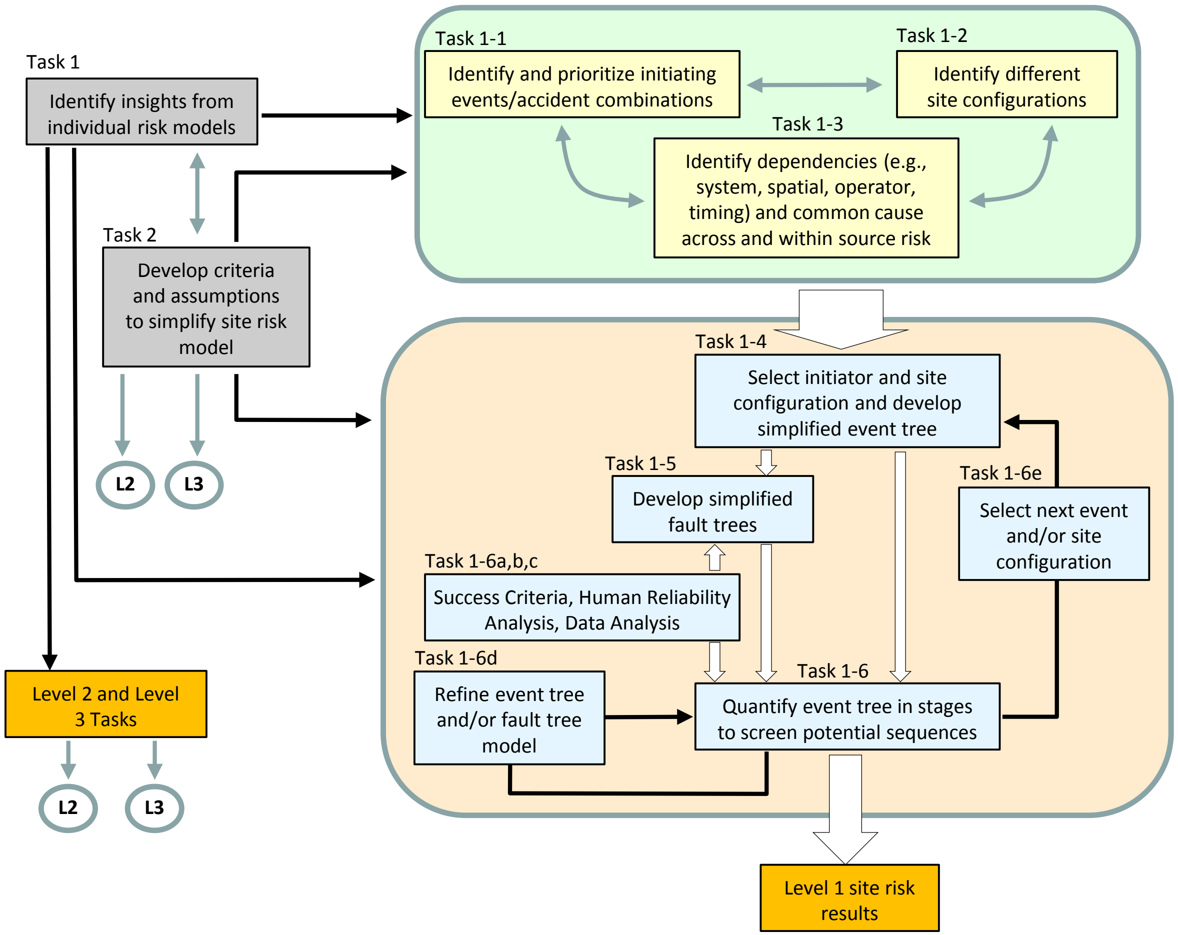
ISRA Technical Approach Involves (cont'd)

- Identifying and prioritizing; e.g.,
  - Initiating events and accident sequences
  - Plant damage states
  - Radiological release states
- Identifying dependencies within and across risk sources; e.g.,
  - Single-source initiators may cause multi-unit accidents due to cross-unit dependencies such as shared support systems, spatial interactions (e.g., flood propagation pathways), common-cause failures, or operator actions
  - Common-cause initiators that simultaneously challenge all of the units at a multi-unit site (e.g., earthquakes, external floods, severe weather)

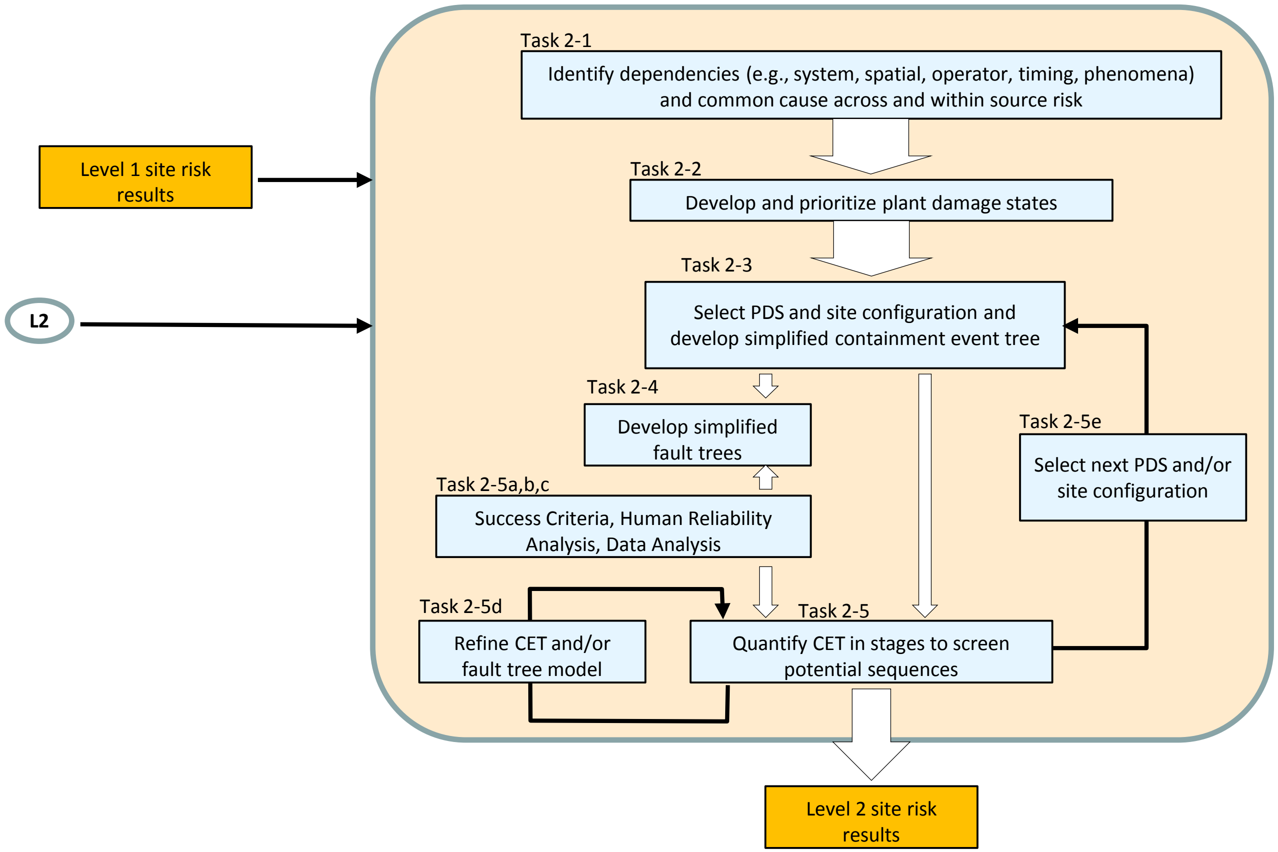
ISRA Technical Approach Involves (cont'd)

- Developing simplified model based on prioritization and dependency analysis
- Quantifying model in stages to determine if screening criteria are met
  - Use screening criteria developed in earlier task
  - Revise and refine the simplified model

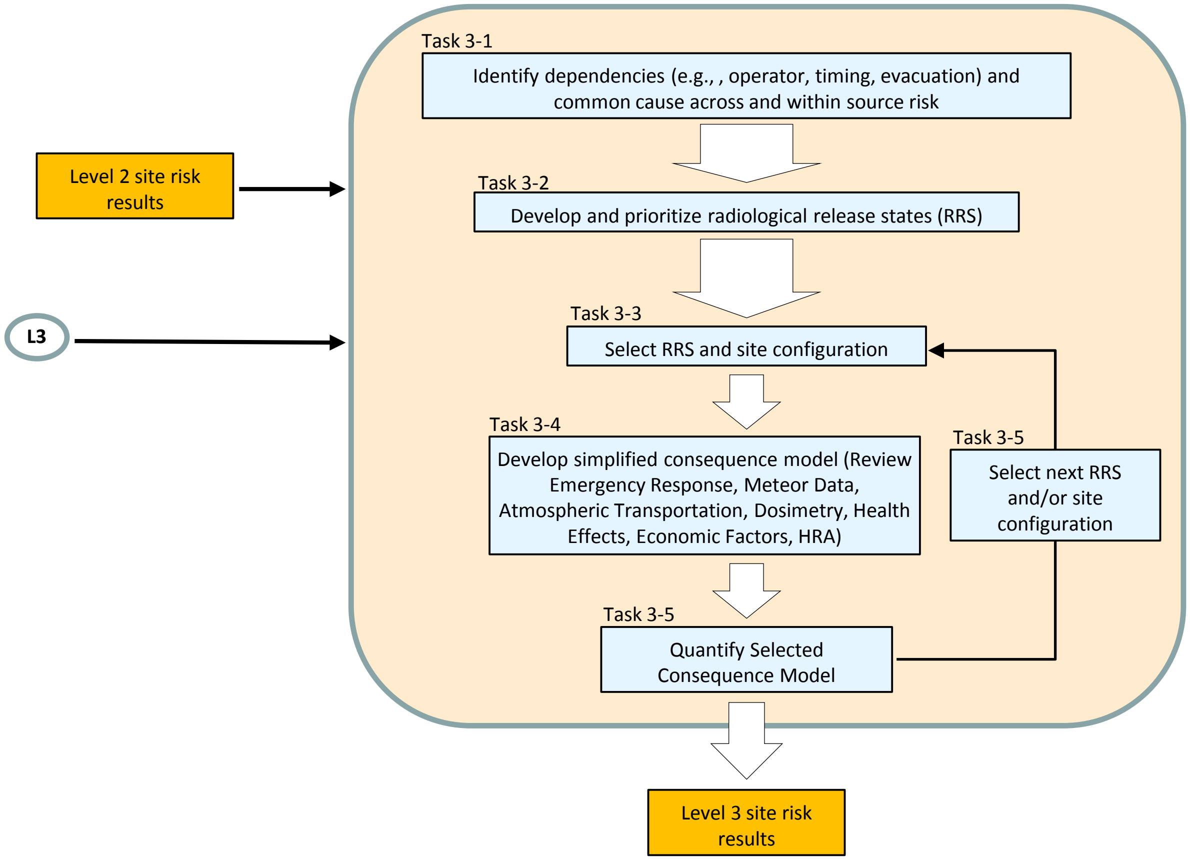
Integrated Site Risk Analysis Flowchart (Level 1)



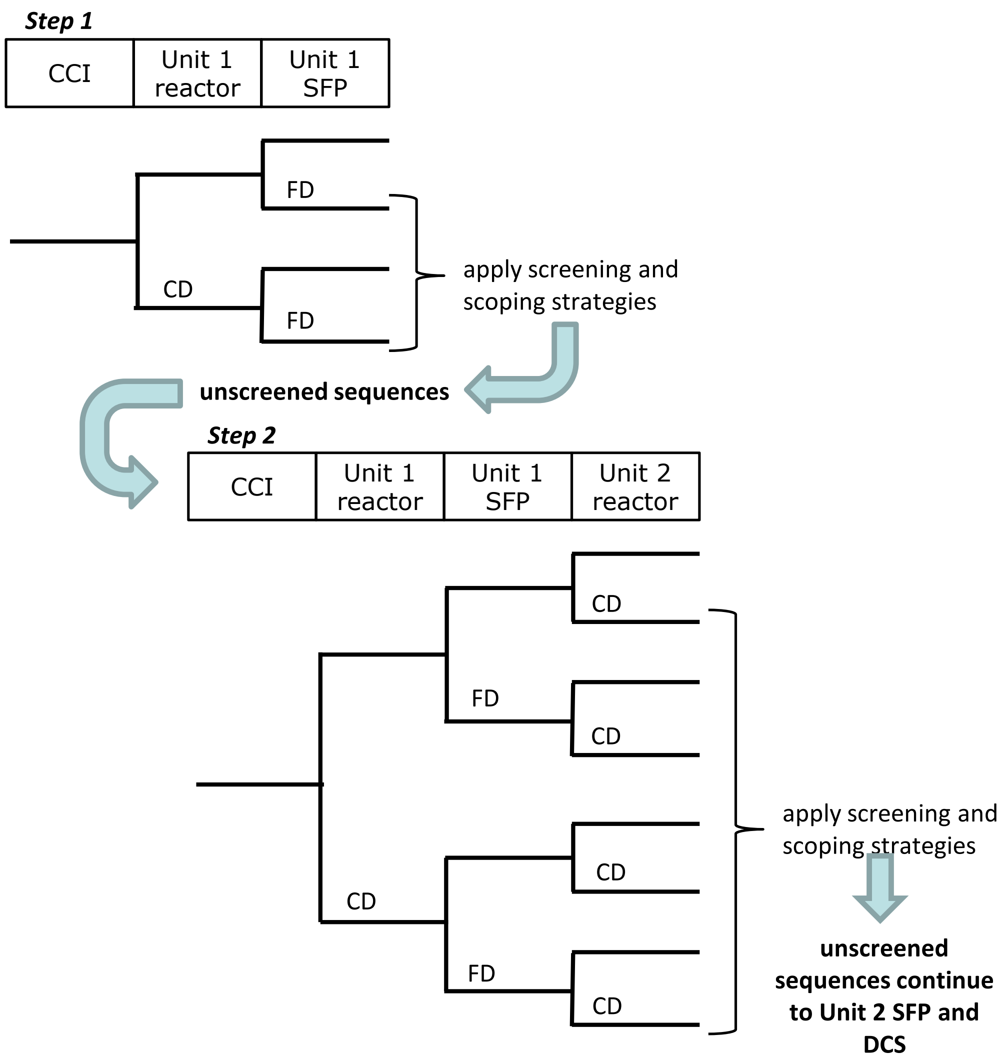
Integrated Site Risk Analysis Flowchart (Level 2)



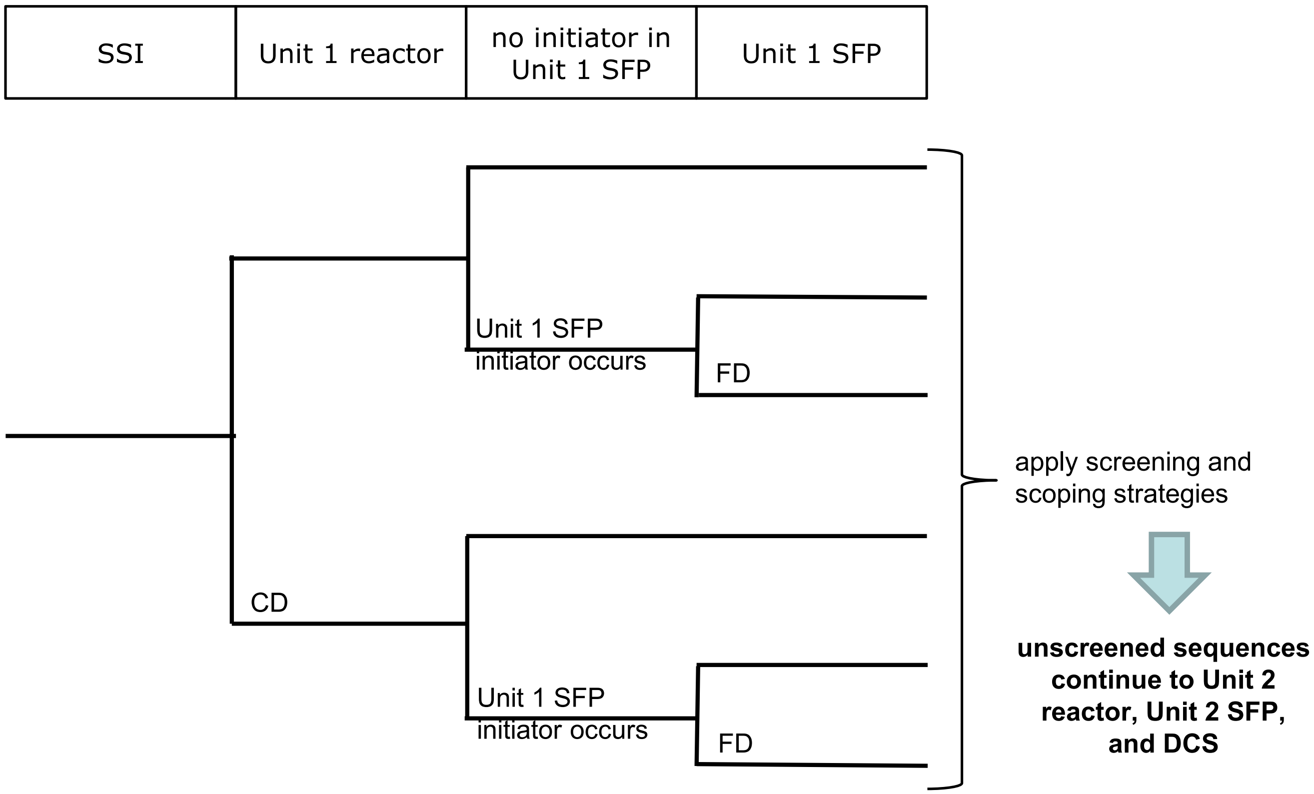
Integrated Site Risk Analysis Flowchart (Level 3)



Common-Cause Initiator Modeling



Single-Source Initiator Modeling



Work Performed to Date

- Completed dependency matrices for reactor PRA model
- Conducted SAPHIRE experiment to assess quantification capability
- Developing table of single-source sequences for the reactor, at-power, internal hazards

Insights on Source Dependencies

- A dependency matrix is being created that shows what systems can be cross-linked between the five major radiological sources (i.e., the two reactors, two spent fuel pools and the dry cask storage).
- Some examples of these dependencies are:
  - A potential cross-connection between the diesel generators of the two units
    - This cross connection is modeled, but turned off by default.
  - The two SFPs are usually connected hydraulically and with a large common air space.

Example of Insights from Single-Source PRA

- A table of sequences is being created that lists the following information for each sequence:
  - Sequence Source
  - Source Operating State
  - Initiator
  - Sequence Point Estimate
  - Cut Set Count
  - Logic
  - Common Cause Initiator or Single Source Initiator
  - Multiple Operator Actions
  - CCF potential across sources

- With all of this information, can begin to understand how the different sources at the site affect each other, and begin to pull out the independent pieces of the model

Candidate Risk Metrics

	QHO	Reported in NUREG-1150	Regulatory Analysis
Total early fatality risk		X	
Total latent cancer fatality risk		X	
Individual early fatality risk (0-1 miles)	X	X	
Individual latent cancer fatality risk (0-10 miles)	X	X	
Population dose risk (person-rem/y)		X	X
Offsite economic cost risk			X

Candidate Risk Metrics (cont'd)

- Other potential risk metrics
  - Cancer incident risk
  - Early injury risk
  - Land contamination risk
  - Multi-source risk surrogates
  - Others?
- Challenges and considerations
  - Use of LNT and/or threshold models
  - Distance truncation
  - Duration truncations
  - Others?

Human Reliability Analysis

July 22, 2013

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HRA Approach for At-Power, Internal Events Level 1 PRA

- Original plan (as described in TAAP):
  - Uses utility's analysis and results for NRC's HRA, to extent consistent with NRC's needs
  - Involves spot-check reviews of Vogtle's HRA documentation and calculation files
  - Involves reviews of Vogtle's peer review results for HRA
  - Assumes limited re-work of Vogtle's qualitative and quantitative HRA for NRC's purposes
- Initial reviews of Vogtle's documentation and peer review led to more work than originally planned
- Review findings identified questions regarding, for example, how methods were applied, basis for selection of methods
  - Currently addressing with SNC

HRA Approach for At-Power, Internal Events Level 1 PRA (cont'd)

- Additional work has included:
  - More detailed review of pre-initiator HFEs and associated human error probabilities
  - Verification of appropriate post-initiator HFEs (comparing PRA basic event files with other HRA documentation)
  - Review and simple re-casting of Vogtle's timing analysis
  - Limited comparisons with SPAR model HFEs and associated HEPs
  - Identification of time-critical operator actions (and associated HFEs)
  - Identification of risk important HFEs (using importance measures)
  - Review of Vogtle's inputs and analysis using EPRI HRA Calculator for time-critical and/or risk important HFEs
  - Re-calculation of HEPs for time-critical and/or risk important HFEs
  - Re-work of HRA dependency analysis and uncertainty analysis
  - Internal reviews of all re-analysis (still on-going)

HRA Self-Assessment for At-Power, Internal Events Level 1 PRA

- HRA self-assessment was based on:
  - NRC's HRA, for example,
    - NRC's re-casting of Vogtle's timing analysis
    - NRC's re-calculations of HEPs for several HEPs
    - Vogtle's HRA for remaining HFEs
  - Use of same software tool and process used for self-assessment of other PRA elements
  - Vogtle's HRA documentation
  - Vogtle's PRA peer review
- HRA self-assessment for internal flooding – not yet completed
  - No post-flood HFEs modeled in Vogtle's converted internal flooding scenarios

HRA Approach for Level 2 PRA

- Overall:
  - Maintain internal consistency of HEPs through reviews, sanity checks, and so forth
  - Especially for risk-important scenarios, maintain a continuous "narrative" of the path to failure
  - Recognize important differences between Level 1 and Level 2 with respect to influencing factors
- Vogtle-specific information is crucial, e.g.,
  - Collection and review of plant information (e.g., SAMGs, emergency drill critiques)
  - Plant site visit (June 18 – 20)
  - Discussion and interpretation of plant information (in collaboration with other L3PRA leads)

HRA Approach for Level 2 PRA (cont'd)

- For the HRA Technical Analysis Approach Plan (TAAP):
  - Original process steps still apply
- To assist in communicating the differences between HRA for Level 2 and more traditional HRA:
  - Expansion of TAAP specifically for HRA supporting Level 2 PRA has been drafted
  - Expansion addresses each process step in the HRA TAAP (e.g., definition and interpretation of HRA/PRA issue, qualitative analysis, quantification), focusing on how HRA for Level 2 will be different from how it is traditionally performed

HRA Approach for Level 2 PRA (cont'd)

- Examples of discussion in expanded HRA TAAP:
  - Differing from Level 1 HRA, qualitative analysis will need to focus on SAMGs and EDMGs, the TSC and field operators, availability and usefulness of cues
  - HFEs in Level 2 do not map well to our traditional definitions of success and failure
  - In quantification, the <u>execution</u> of actions may be addressed using existing methods with some expansion to address relevant PSFs (especially, environmental factors); many differences between Level 1 and Level 2 with respect to decision-making which will require a correspondingly different approach

HRA Approach for Integrated Site Risk

- For multiple source accident, issues being identified needing resolution; for example:
  - How are priorities established?
  - Is the accident tracked? How is the accident followed in trying to understand what has occurred and why, and how to arrest the accident?
  - Who is orchestrating the team response to the accident? Who is making the ultimate decisions and how are they communicated?
  - How many decision makers are there? Is there one for each source (e.g., Unit 1 versus Unit 2 versus spent fuel pool versus dry cask storage)? How is it coordinated?
  - What is the protocol if challenged with multiple accidents? That is, both reactors, and spent fuel pool and dry cask storage? How are multiple accidents handled? Will there be a priority, for example, attempt to save one unit and not the other?
  - Are decisions made in light of what may occur, how is this determined?
  - Are the operators trained on the occurrence of multiple accidents? What does the training involve?
- Some initial answers were obtained from Vogtle plant site visit

Summary of Vogtle Plant Site Visit

- Overall goals:
  - Gain general confirmation of operator behavior for at-power, internal events Level 1
  - Gather initial information relevant to HRA in support of Level 2 PRA and integrated risk model
- Walk-downs and activities observed:
  - Simulator exercise
  - Several recommended plant locations and equipment associated with EDMGs, especially related to SBO events
  - Main control room
  - Technical Support Center (TSC)

Summary of Vogtle Plant Site Visit (cont'd)

- Interviews (some staff with multiple roles):
  - Simulator trainers
  - Various SROs, especially on topics related to:
    - Training (specific types of scenarios and procedures)
    - Plant history and drills on "challenging scenarios"
    - Back-up strategies for electrical connections
    - August 2012 Emergency Planning drill (where SAMGs were implemented)
  - System operator, especially on topics related to:
    - EDMG training
    - Combined training with licensed operators (i.e., "mini E-drills")
    - Staffing
  - SAMG developer
  - EMDG developer
  - SAMG "players":
    - Emergency director
    - SAMG Evaluator/Operations
  - NRC resident inspector

Backup Slide: HRA TAAP: Key Assumptions & Limitations

- Procedures & other formal guidance that support operator actions addressed in the PRA exist & are currently being used & trained upon
- Action locations, equipment, control panels and so forth exist, are currently being used & trained upon
- Licensee's PRA(s) will form the basis for the NRC analysis, provided that it:
  - Is adequate for needs of NRC's Level 3 HRA/PRA effort with respect to scope & objectives
  - Meets the ASME/ANS PRA Standard requirements
  - Has a peer review
  - Requires no adjustment to success criteria or timing information relevant to HRA
  - Addresses key & relevant performance influencing factors
  - Has used HRA methods & approaches suitable for the application
  - Has included an HRA that was performed using HRA methods & approaches as they are intended to be used
  - Requires little or no re-work of HRA qualitative or quantitative analysis for post-initiator HFEs
  - Requires no re-work for pre-initiator HFEs