Integrated Site Risk

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Outline

- Technical Tasks
- PRA Modeling Issues
- Site Information Review
- Multi-Unit Accident Sequence Delineation
- Integrated Risk Metrics
- Challenges

Technical Tasks

- Task 1: Technical approach
- Task 2: Multi-unit effects
- Task 3: Integrated Level 3 PRA model
- Task 4: Integrated uncertainty analysis

White Paper to Identify Issues

- Prepared by contractor
- Issues
  - Multiple concurrent accidents (reactors, spent fuel)
  - Integrated treatment of multiple hazards
  - Account for the impact of core damage or radiological releases occurring in one unit on others

PRA Modeling Issues

PRA Element and Associated Issues	Modeling Capabilities		
	Current Practice	Minor Revisions or Additions to Current Practice	Major Revisions or Additions to Current Practice
Plant Operating States	X		
Hazards and Initiating Events	X		
Accident Sequence Evaluation		X	
Success criteria	X		
Systems Analysis	X		
Data Analysis	X		
HRA			X
Dependency Analysis		X	

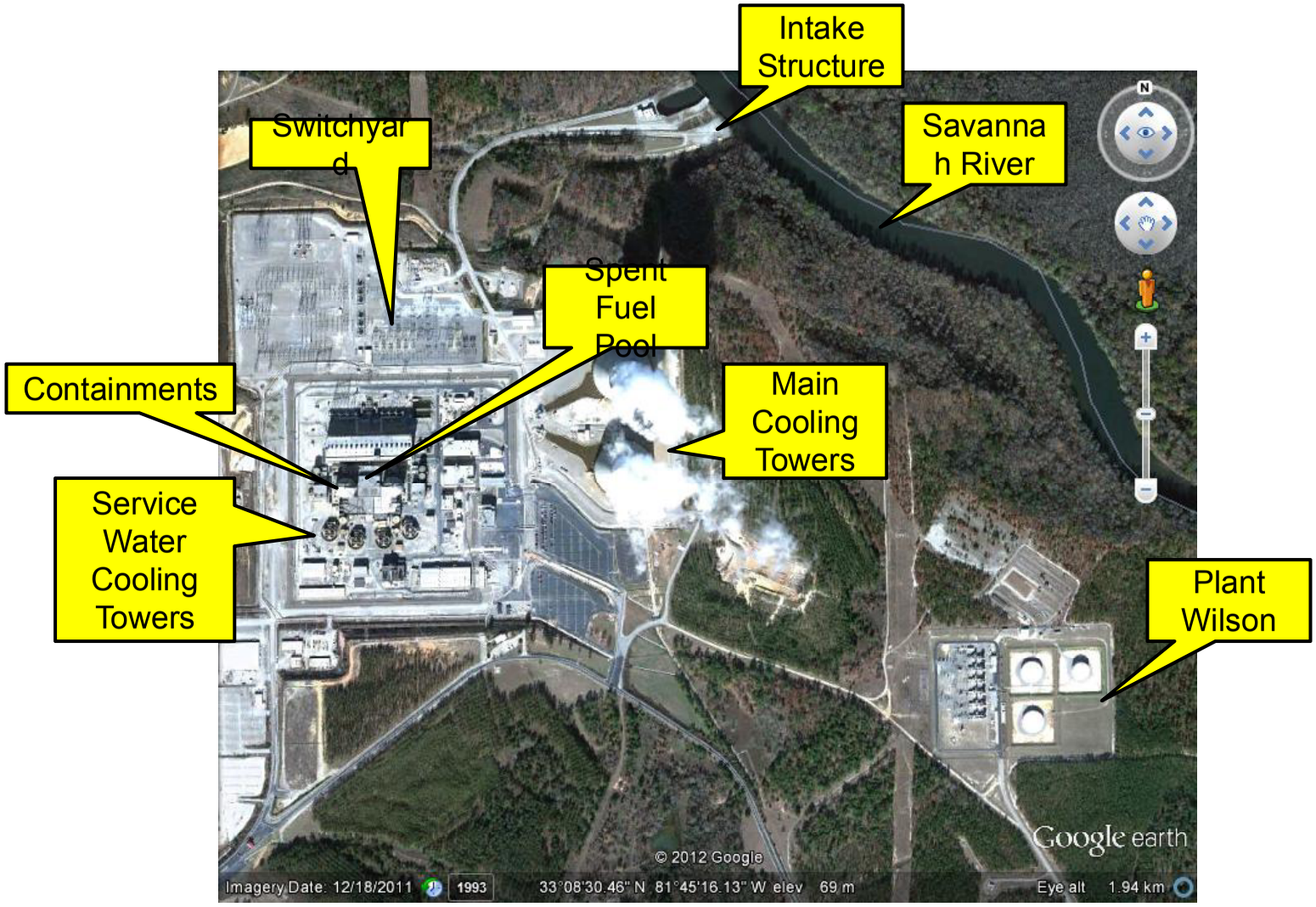
PRA Modeling Issues (Con't.)

PRA Element and Associated Issues	Modeling Capabilities		
	Current Practice	Minor Revisions or Additions to Current Practice	Major Revisions or Additions to Current Practice
Structural Analysis			X
Containment Performance Analysis	X		
Analysis of Severe Accidents and Radiological Releases		X	
Offsite Consequence Analysis		X	
Risk Quantification and Integration			X
Uncertainty Analysis	X		

Site Information Review

- What are we reviewing?
  - FSAR
  - SPAR internal events model
  - Information provided by licensee to support the project
- What are we looking for?
  - Shared systems
  - Systems that have cross-connects between the units
  - Common locations
  - Common-cause initiating events
  - Common-cause failures that need to be expanded to include both units
  - Recovery actions modeled in the PRA that credit the other unit

Site Layout


Intake Structure
Switchyard
Savannah River
Spent Fuel Pool
Containments
Main Cooling Towers
Service Water Cooling Towers
Plant Wilson
© 2012 Google
Google earth
Imagery Date: 12/18/2011
1993
33°08'30.46" N 81°45'16.13" W elev 69 m
Eye alt 1.94 km

Site Information Review Observations

- Systems that are typically included in a PRA model (electric power, service water, etc.) are not shared between units
- Plant Wilson can only supply power to one unit at a time
- Some common locations may be important for some internal hazards (floods, fires)
- Candidate multi-unit initiating events
  - Loss of grid
  - Consequential LOOP
  - Internal hazards (fires, floods)
  - External hazards (seismic, floods, high winds)

Delineation of Multi-Unit Accident Sequences

- Objective: Develop and quantify accident sequences that involve combinations of site radiological sources (reactors, SFP, dry casks)
- Challenges
  - Demonstrating completeness
  - Accounting for plant operating states (POSs)
  - Accounting for cross-unit dependencies (e.g., shared systems, CCFs, operator actions)
  - Achieving reasonable logic model solution times
  - Completing work within resource/schedule constraints

Multi-Unit Sequence Types

- Type I: common-cause initiators (CCIs)
  - Directly and simultaneously affects both units
  - Examples: seismic events, external floods, high winds
- Type II: consequential initiators
  - Second unit is automatically tripped (or required to trip) due to an evolving sequence in the first unit (i.e., a direct cause-and-effect relation exists between the two units)
  - Examples: consequential LOOPs, shared support systems, internal fires or internal floods that propagate from one unit into another
- Type III: manual shutdown
  - Operators may decide to shut down the second unit due to
    - Core-damage in the first unit
    - Release from the first unit
    - T/S requirements
    - Management decision or NRC order
- Type IV: coincidental initiators
  - Unrelated initiators that occur within a short timeframe
  - Example: SBO in one unit, followed by LOCA in the second unit

Multi-Unit Sequence Development

- In theory, multi-unit accident sequences may be formed by ANDing together two single-unit sequences
  - Brute-force approach may generate a very large number of multi-unit accident sequences
  - Qualitative screening: Some POS combinations may not be possible (e.g., simultaneous refueling in both reactors)
  - Quantitative screening: May use single-unit PRA results or auxiliary calculations to show that some theoretically possible multi-unit sequences have very low frequencies
- Need to develop an integrated logic model that includes all reactors, SFP, and dry casks
  - Adjust CCF group sizes
  - Account for shared systems and cross-connects (affects the modeling of recovery actions)
  - Account for dependent human failure events

Integrated Risk Metrics

- Identifying candidate risk metrics
  - Balance desire for completeness and usefulness against project schedule and resource constraints
- Candidate risk metrics
  - Total early fatality risk
  - Total latent cancer fatality risk
  - Individual early fatality risk (0-1 miles)
  - Individual latent cancer fatality risk (0-10 miles)
  - Population dose risk (0-50 miles)
  - Offsite economic cost risk (0-50 miles)
  - Individual early injury risk
  - Individual cancer incident risk
  - Land contamination
- Candidate risk surrogates
  - Core-damage frequency (CDF)
  - Large release frequency (LRF)
  - Large early release frequency (LERF)

Challenges

- Addressing PRA modeling issues
  - Delineation of multi-unit accident sequences
  - Human reliability analysis
  - Dependency analysis
  - Structural analysis
  - Analysis of severe accidents and radiological releases
  - Offsite consequences
  - Risk quantification and integration
- Managing expectations