



State-of-the-Art Reactor Consequence Analyses (SOAR CA)

October 25, 2006

**United States Nuclear Regulatory
Commission**



AGENDA

- **Objectives**
- **Method**
- **Potential Uses**
- **Motivation**
- **Schedule**
- **Details**
- **Conclusion**
- **Public questions and comments**



OBJECTIVES

- **Realistic evaluation of severe accident progression, radiological releases and offsite consequences**
 - **Provide a more accurate assessment of potential offsite consequences**
- **Focus on a spectrum of scenarios most likely to contribute to release and subsequent offsite consequences, using a risk-informed approach**



METHOD

- **Use realistic, detailed integral modeling of plant systems, radionuclide transport and deposition, and release pathways (i.e., PRA, MELCOR, MACCS etc.)**
- **Use updated emergency preparedness modeling assumptions**
- **Account for plant improvements, including insights from newer, more realistic NRC evaluations**
- **Account for use of mitigation strategies for the delay or prevention of core damage, and further reduction in offsite consequences**



POTENTIAL USES

- **Safety-related decision making**
- **Emergency preparedness and emergency response**
- **Regulatory analysis guidelines**
- **Communication with the public, DHS**
- **Insights for future regulatory and research activities**



MOTIVATION

- **Improved PRA modeling**
- **Improved plant performance**
- **Added plant design features (e.g., alternative AC power for SBO)**
- **Better understanding of physical phenomena of severe accidents**
- **MELCOR integrated severe accident analysis code**
- **Computing speed**
- **More realistic assessment of radiological source term and potential consequences**



SCHEDULE

- **Three-year project**
 - **1st year: Westinghouse 4-loop large dry, GE Mark I, and GE Mark III plants**
 - **2nd year: GE Mark II, Ice Condenser, and other Westinghouse plants**
 - **3rd year: B&W and CE plants**
- **Six plants selected as lead plants on the basis of providing a mixture of offsite populations**
 - **Westinghouse 4-loop large dry**
 - **Diablo Canyon, Salem, Seabrook**
 - **GE Mark I**
 - **Duane Arnold, Fermi, Peach Bottom**



TECHNICAL CONSIDERATIONS

- **Select scenarios**
- **Identify and quantify likelihood of operator actions (e.g., EOPs)**
- **Estimate accident progression and fission product release to environment using MELCOR**
 - Design-specific (e.g., Mark I)
 - Realistic containment performance modeling
- **Estimate offsite radiological consequences using MACCS**
 - **Site-specific**
 - Emergency response modeling
 - Population densities
 - Weather



INFORMATION NEEDS

- **Detailed reactor plant data for each reactor class (e.g., Mark I)**
 - **Develop/confirm the MELCOR model for accident progression and fission product release**
- **Site-specific information to calculate offsite consequences**
 - **Emergency response modeling information**
 - **Hourly meteorological information**



INFORMATION NEEDS (cont.)

- **Human Reliability Analysis**
 - **Plant-specific information (e.g., relevant procedures and how procedures are implemented)**
 - **Plant site visits may be needed**
 - **Plant variability information**
 - **Has an Owner's Group report regarding the variation between plants on how procedures been written?**

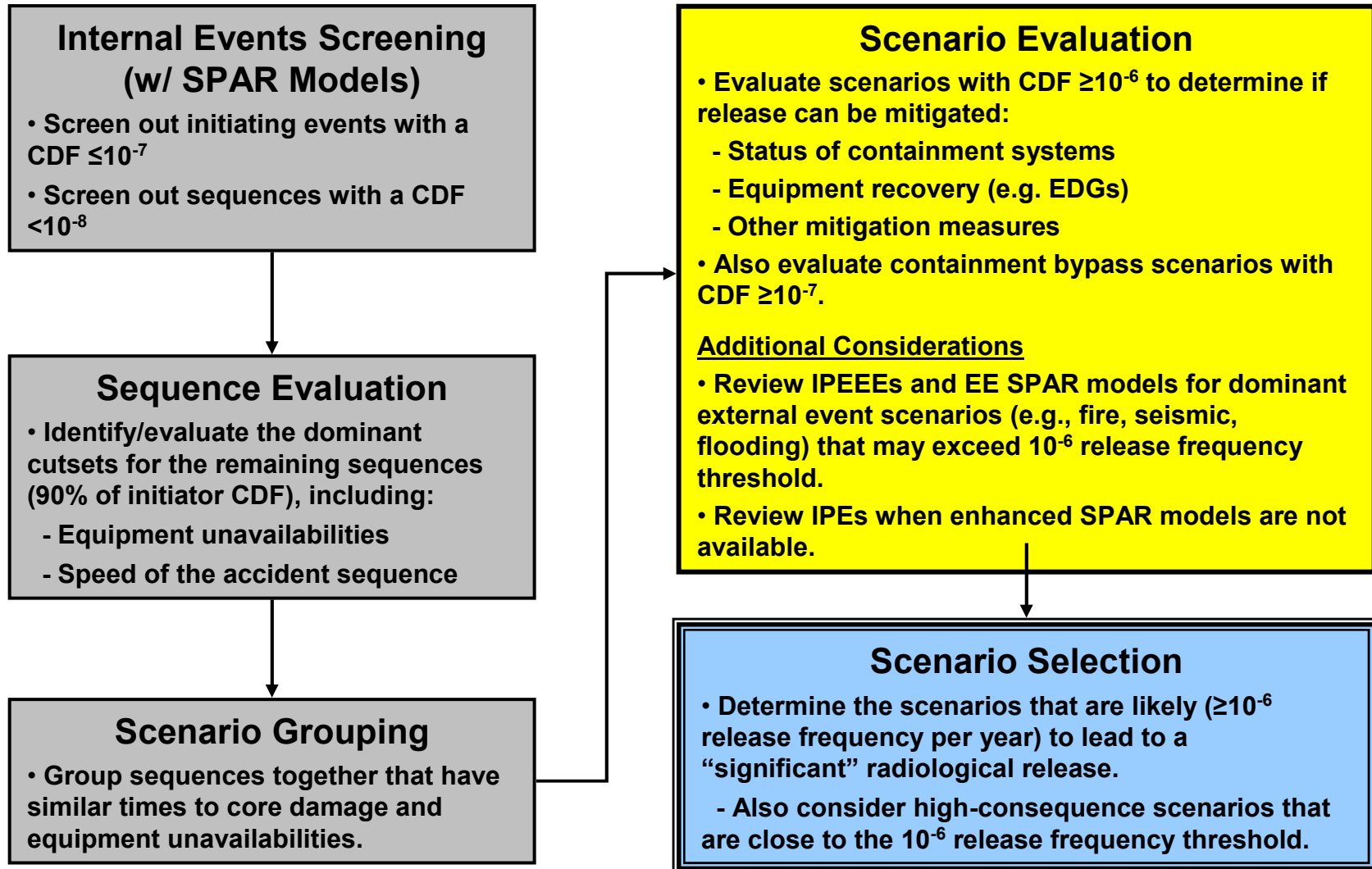


ACCIDENT SCENARIO SELECTION

- **Focus on dominant accident scenarios**
 - Focus should be on accident scenarios with a $\geq 10^{-6}$ (i.e., one in one million) per year release frequency
 - Where possible, also consider high-consequence scenarios with somewhat lower frequencies (e.g., ISLOCA)
 - Lower the release frequency screening threshold by an order of magnitude for bypass scenarios
- **Account for plant improvements which have been incorporated, but not credited in current PRAs**
- **Complete the preliminary offsite consequence calculations for two (or three) groups of plants within the first year**
 - Start with six lead plants
 - The results for all plants will be finalized and released in a final report issued in 2009



SCENARIO SELECTION PROCESS





SCENARIO SCREENING APPROACH

- **Approach focuses on selecting scenarios for plant/containment groups (i.e., MELCOR groups)**
 - The SPAR models for each plant within the group undergoes the internal events screening
 - Identify general scenarios that exceeded the 10^{-6} threshold (based on CDF)
 - Not all scenarios will exceed the 10^{-6} threshold (based on CDF) for all the plants within the group
- **A defined case for each general scenario is developed for input into MELCOR calculations**
 - Sensitivity studies will be performed to address important scenario variations
- **Reviewed IPEEEs and EE SPAR models (if available)**
 - Determine external event contribution to internal event scenarios
 - Identify unique external event scenarios that are close to or exceed the 10^{-6} threshold



BWR MARK I SCENARIOS

- **Three preliminary internal event scenarios have been identified:**
 - Transients with RCIC/HPCI unavailabilities and failures of RCS depressurization
 - SBO with failure to recover power prior to battery depletion
 - Transients with RHR/SW unavailabilities and containment venting/late injection failures that lead to unavailability of SPC/SDC and containment failure
- **Dominant external event scenarios tend to be functionally (i.e., system response) equivalent to one or more of the selected internal event scenarios**
- **No LOCA (including ISLOCA) scenarios have exceeded the screening threshold**
 - Most Mark I BWRs have LOCA CDFs one to two orders of magnitude below the 10^{-6} threshold
- **ATWS CDFs are lower than the 10^{-6} threshold (based on CDF)**
- **Selected scenarios may later screen out if strong mitigation credit is applicable**
 - Plant improvements, SAMGs may result in lowering of frequency
- **Important to realistically capture the timing of events**



WESTINGHOUSE 4-LOOP/LARGE DRY PWR SCENARIOS

- **Five preliminary internal event scenarios have been identified:**
 - Transients with AFW unavailabilities and failures to bleed and feed
 - SBO with failure to recover power either prior to battery depletion or prior to core uncover in case of RCP seal LOCA
 - Loss of service water or component cooling water with failure of RCP seals
 - Interfacing systems LOCA from RHR system
 - Steam generator tube rupture
- **All other LOCA scenarios screen out either due to low CDFs or strong post-core damage and/or release mitigation credit**
- **A few ATWS CDFs exceed the 10^{-6} threshold (based on CDF), however this is due to modeling simplifications currently be corrected by INL**
- **Dominant external event scenarios tend to be functionally (i.e., system response) equivalent to one or more of the selected internal event scenarios**
- **Scenarios with very long times to core damage (>24 hours) could be screened out due to the large amount of time available for mitigation**



ADDITIONAL TECHNICAL ISSUES

- **Evaluation of Mitigation Measures**
 - Data collection and evaluation of plant enhancements
 - HRA credit for operator actions
- **Scenario Selection Output**
 - Quantitative scenario calculations
 - Release frequency estimations uncertainties



QUESTIONS?