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**

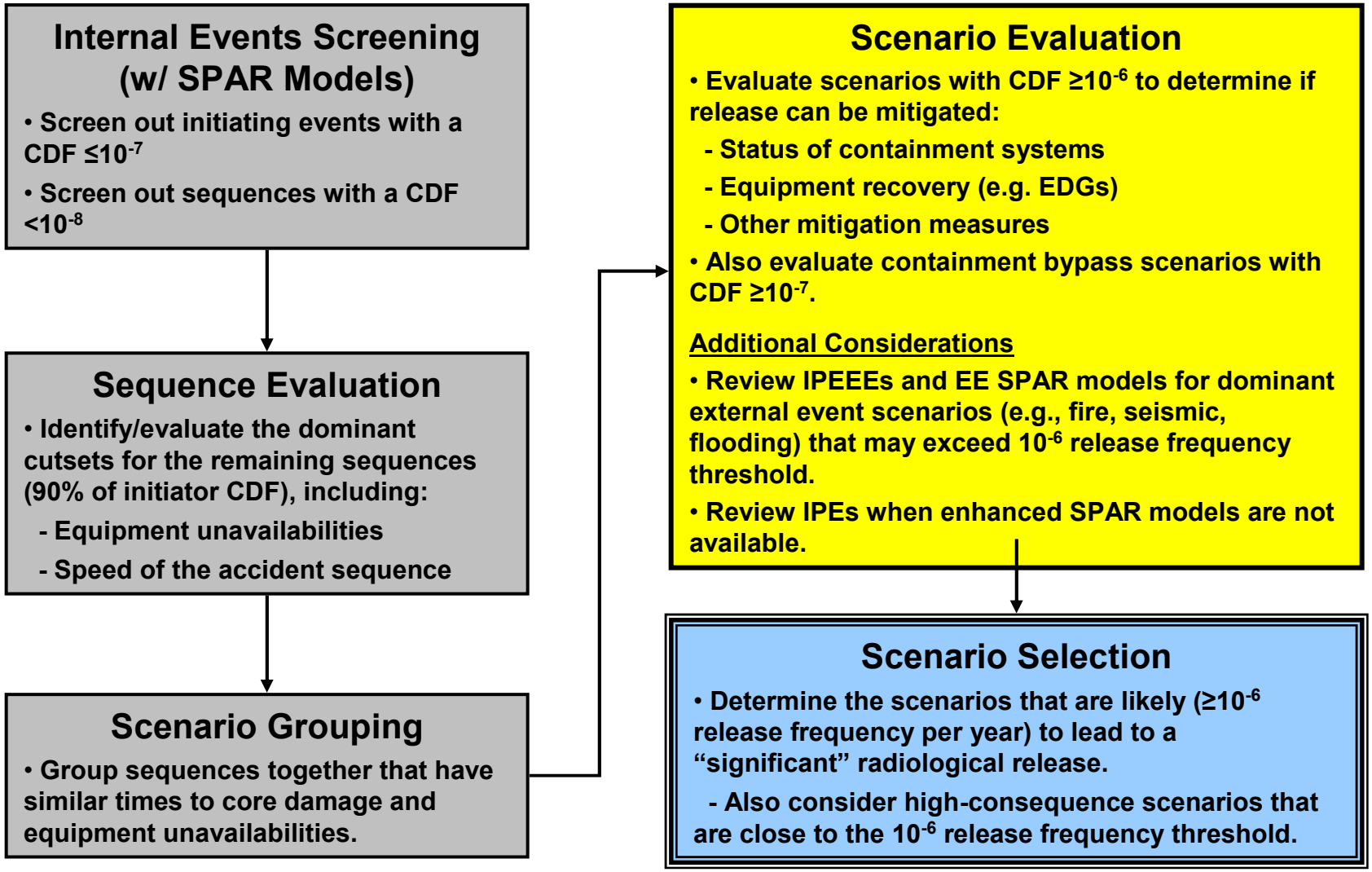
INFORMATION NEEDS (cont.)

- **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 ≥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 uncovery 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?