# Incorporation of FLEX Strategies and Equipment into SPAR Models

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# Objectives

- Provide information about the recent NRC/RES work on incorporating FLEX strategies and equipment into SPAR models
  - Recent work
  - Anticipated next stage
- Provide some observations from the work done for the PWR pilot

# Recent Work

- NRR asked RES to prepare a Model Makers Guideline (MMG) for incorporating FLEX strategies and equipment (FLEX-S&E) into SPAR models.
- In preparation for this task, RES has incorporated FLEX-S&E) into an existing SPAR-AHZ model for a PWR, as a pilot project.
- Draft Model, its report, and current comments on the report exist and are available for NRC staff use.
  - Note that SPAR models are not publicly available.

# Recent Work (2)

- The pilot PWR model includes FLEX usage in all hazard categories, as allowed and prescribed by the plant procedure for Total Loss of All AC Power.
- The hazard categories include (during power operation)
  - Internal events
  - Internal flooding
  - Internal fires
  - Seismic events
  - Wind-related events
- External flooding events were screened out for this site; otherwise they also would have been included.

# Anticipated Next Stage

- More NRC review is expected.
- RES is looking for a “volunteer” BWR to use as the next pilot SPAR-AHZ or SPAR model.
- The complete set of FLEX documentation is used to make the pilot models. This documentation includes
  - FSGs,
  - instructions for field actions,
  - plant procedures that refer to FSGs and field actions,
  - High level FLEX program description document(s).

# Anticipated Next Stage (2)

- Upon completion of the BWR pilot, an MMG document is to be created to standardize and coordinate further model making by NRC and INL PRA analysts.
- It is highly desirable that the models created benefit from the actual plant procedures referring to FLEX documentation. This requires INL/RES access to such documents. This is considered to be in the same spirit as the one that lead to verification of SPAR models.
- It is recognized that avoiding cookie-cutter modeling by using actual plant procedures would make the task costlier and time consuming.
- Exact nature and scope of this next stage work is yet to be determined

# Selected Observations from the Pilot Work

1. Seismic fragility of FLEX building during seismic events
2. Effect of ELAP declaration on AC power recovery distributions
3. Event tree "termination criteria" – safe and stable end state
4. ET core damage success criteria for some FSGs – boron injection
5. Timing of ELAP declaration – effect on SBO sequences
6. Treatment of early TDP failure in SBO – time window for FLEX pump
7. Impact of FLEX equipment on CDF.

# Seismic fragility of FLEX building during seismic events

- Plant documentation states that the FLEX building(s) were designed to meet SSE level seismic event.
- Seismic fragility parameters of the FLEX building(s) are not available.
- Seismic PRA shows that seismic events with high pga values contribute the most to SPRA CDF
- Moreover, these contributions involve SBO sequences.
- Seismic failure of FLEX buildings during  high intensity earthquakes would limit or eliminate use of FLEX equipment.

# Effect of ELAP declaration on AC power recovery distributions

- Once ELAP is declared, and is committed to
  - Available personnel will be preferentially directed to perform the FLEX related tasks;
  - There will be “deep” shedding of “unessential” buses.
- These factors are expected to affect unfavorably the AC power recovery distributions modeled in the PRA -  especially the onsite AC (EDGs).
  - If small-small LOCA is discovered after ELAP, AC power recovery may be necessary;
  - If some phase 1 and some FSG actions fail, AC power recovery may be necessary.

# Event tree “termination criteria” safe and stable end state

- Phase 3 evolution of an accident, if AC power is not recovered in 72 hours, is not modeled.
  - Due to limitations of a reliable quantification of a PRA model for this phase.
- Safe-and-stable end state is defined as recovery of AC power within 72 hours (phases 1 and 2 with onsite equipment only).
- After these 2 phases of PRA modeling become mature and generally acceptable, possible further modeling into phase 3 may be looked into.
- Presently, sufficient challenges for a quantitative CDF estimate for phases 1 and 2 exist before extending the models to phase 3.

# ET core damage success criteria for some FSGs – boron injection

- Consider some of the FSGs designed for later implementation in the accident timeline (such as boron injection):
  - Whether those actions are necessary in avoiding core damage or not need to be defined (event sequence success criteria).
    - If all FSGs are implemented successfully and timely, but boron injection FSG fails, will that sequence lead to core damage?
- The minimum accident sequence criteria in event trees to avoid core damage may need to be defined with best estimate and supportable assumptions for a few of the late FSG actions.
- [On the other hand, success criteria for some other late FSGs, such as refilling of CSTs, can be easily defined.]

# Timing of ELAP declaration – effect on SBO sequences

- ELAP declaration criteria is based on situation assessment – judgement
  - Not solely on plant parameters, alarms, etc.
- Premature declaration – may reduce success probability for small-small LOCAs accident sequences
- Late or no declaration when needed – may reduce success probability for transient accident sequences.
- Attempts to rigorously model and analyze the effects of the above “failures” may make the model too complicated and create difficulties in assignment of probabilities, with limited benefit.
- Simplified models may be “good enough” to capture the risk

# Treatment of early TDP failure in SBO time window for FLEX pump

- If TDP fails early in a SBO sequence (say 0-1 hour into it), getting the FLEX SG pump to run is unlikely.
- If TDP fails late in a SBO sequence (say 6-8 hours or later) it is very likely that FLEX SG pump setup will be successful.
- The time period in between poses interesting modeling opportunities, if warranted by the quantitative benefit obtainable.
- [Failure of the RCS heat removal by AFW TDP during a SBO event is modeled by the AFW-B fault tree, which lumps failures throughout the 24-hour mission time. Failure of AFW-B is modeled to require recovery of AC power in 1 hour; otherwise core damage is postulated. Almost 50% of the TDP failures occur after 8 hours into the sequence (failure to run in the time period of 8 to 24 hours). If the 1-hour recovery modeling in the SBO ET results in unduly high CDF values for currently modeled AFW-B failure sequences, they can be reassessed by using basic event probability information in the AFW-B fault tree cut sets.]

# Impact of FLEX equipment on CDF

- Impact of FLEX strategies and equipment measured as a reduction in CDF is largest when accident sequences that are candidates for ELAP are considered.
- This impact decreases as one focuses on different sets of accident sequences, in the following order:
  - SBO sequences candidates for ELAP
  - SBO sequences
  - LOOP sequences
  - Plant CDF.
- The impact also changes from one hazard category to another.
- Thus the “benefit” of FLEX appears less as one considers total plant CDF versus SBO-ELAP candidate sequences, which are the intended targets of FLEX.

# Conclusions

- If a plant incorporates FLEX strategies into its procedures (EOPs, AOPs, etc.), its PRA model is expected to include them, since PRAs are supposed to represent the as-built and as-operated plant.
- Even with limited data, it is possible to make credible models that are useful, and expand them as needed (with equipment failure probabilities, HEPs, etc.)