# SPAR Peer Review and Follow-up

**James K Knudsen**

**Idaho National Laboratory**

July 15, 2015

# OVERVIEW

- Background of Peer Review
- Peer Review: Strengths and Limitations
- Peer Review: Findings and Observations
- SPAR Team: Address how to handle F&Os
- SPAR Model Updates: Incorporate important F&Os

# Background of Peer Review

- Peer Review was Performed:
  - Provide for an independent review of the model by industry experts
  - Although confirmatory, the SPAR models still need to exhibit a minimum level of “quality”
    - ensure the SPAR models are of sufficient quality for performing SDP Phase 3, ASP and MD 8.3 event assessments of operational events
  - Provide insights on how the developed SPAR models would meet the standard
  - There were no requirements to have this review other than to obtain a pedigree on how the SPAR models are developed and gain insights on strengths and weaknesses

# Background of Peer Review

- Peer Review was performed with Industry PRA Experts and NRC PRA experts:
  - Results from review were independent and consistent with industry peer reviews
  - Provided industry detail information about SPAR models, modeling approach, level of detail, assumptions, etc.
  - Supported by Owners Group
  - Team Leaders:
    - PWR review – Barry Sloane, Erin Engineering
    - BWR review – Ed Burns, Erin Engineering

# Background of Peer Review

- A typical Boiling Water Reactor SPAR model was peer reviewed in August, 2009
  - A single BWR model was chosen for the review
  - All of the BWR models are developed based on a standardized set of assumptions, logic model level of detail, documentation
  - Information from this review can be incorporated into other BWRs

- A typical Pressurized Water Reactor SPAR model was peer reviewed in October, 2009
  - Again, a single PWR model was chosen for review, etc.

# Background of Peer Review

- The Peer Review was performed according to:
  - NEI 05-04 Guidance “Process for Performing Follow-on PRA Peer Reviews Using ASME PRA Standard”
  - American Society of Mechanical Engineers (ASME) Standard for Probabilistic Risk Assessment for Nuclear Power Plant applications; ASME RA-S-2002, ASME RA-Sa-2003, ASME RA-Sb-2005, ASME RA-Sc-2007, and
  - Regulatory Guide 1.200, Rev. 1

- Peer Review designed to assess technical quality and adequacy

- PRA configuration control requirements were also evaluated
  - NEI 05-04 guidance was used for this review and is based on PRA maintenance and update

# Background of Peer Review

- Technical Elements the SPAR models were reviewed against:
  - Initiating Events Analysis (IE)
  - Accident Sequence Analysis (AS)
  - Success Criteria (SC)
  - System Analysis (SY)
  - Human Reliability Analysis (HR)
  - Data Analysis (DA)
  - Quantification (QU) and
  - PRA maintenance and update (MU) [NEI 05-04]
- Internal Flooding and large early release factors (LERF) are not developed for the SPAR Models and therefore, these were not evaluated

# Background of Peer Review

- High level requirements (HLRs) are set for each technical element, which set the minimum requirement for the PRA to be technically acceptable
- Supporting requirements (SRs) are developed for each HLRs and are the metric used in the technical review
- The SRs were used to assess the ASME Standard Capability Category for the SPAR models
  - The overall review process in not designed to give a single Capability Category for the PRA as a whole
  - The PRA is assessed to assign a Capability Category to each SR
  - The objective for the SPAR model peer review was to have the models evaluated against Capability Category I

# Peer Review: Results of Review

- The overall results were consistent between the PWR and BWR SPAR models, i.e., similar F&Os; strengths and limitations
  - 331 individual ASME PRA SRs (98 related to internal flooding, 7 deleted; leaving 226
    - 11 SRs were judged not applicable for the PWR review and 10 for the BWR due to the level of review and generic aspect of SPAR models
- From the review, greater that 58% of the SRs met or exceeded Capability Category I for the PWR model
  - 42% of the SRs met all three Capability Categories (I, II and III)
- For the BWR model review, greater than 64% of the SRs met or exceeded Capability Category I
  - 47% of the SRs reviewed against the SPAR model met all three Capability Categories (I, II and III)

# Peer Review: Results of Review

- A majority of SRs that didn't meet at least Capability Category I were related to plant specific information; i.e.,
  - Plant specific initiating event frequencies
  - Plant specific data
  - System notebooks not developed as part of the models
  - Ability to maintain as-built, as-operated PRA model
  - SPAR model HRA

# Peer Review: Results of Review

- The number of findings or observations:
  - The BWR model had 200 Findings and Suggestions (142 were F&Os and 58 were Suggestions)
    - The F&O identified were evenly distributed for each technical element (about the same number of F&Os for each technical, except the HRA technical element had slightly more)
    - The Suggestions provided from the review were similar as the F&Os; about an equal amount across the technical elements
  - Example of F&O:
    - IE data driven from NUREGs, a systematic evaluation of each system to determine potential initiating was not performed
    - Unavailability terms not identified for every train nor documentation on why certain trains unavailability were not modeled

# Peer Review: Results of Review

- The number of findings or observations:
  - The PWR model had 101 Findings and Suggestions (76 were F&Os and 25 were Suggestions)
    - The F&O identified were evenly distributed for each technical element (about the same number of F&Os for each technical, except the HRA technical element had slightly more)
    - The Suggestions provided from the review were similar as the F&Os; about an equal amount across the technical elements

# Peer Review: Strengths and Limitations

- Identified Strengths of SPAR models from the Peer Review
  - INL SPAR model team is very knowledgeable and experienced along with significant “corporate” knowledge and expertise to develop, maintain, and use the SPAR models
  - Generic SPAR model structure is robust and well developed
  - SPAR model fault trees are streamlined with appropriate level of detail for the model’s intended users
  - SPAR model structure and SAPHIRE computer software are at the state of the technology
  - SPAR model is an efficient method to offer qualitative and quantitative insights for applications, SDP evaluations, inspections, event assessments, and model evaluations
  - Large number of generic initiating events that are addressed within the SPAR model

# Peer Review: Strengths and Limitations

- Identified Strengths of SPAR models from the Peer Review (cont)
  - System fault tree analysis is at an appropriate level to support the goals of the SPAR model application
  - Generic data and common cause applications are well performed and technically sound
  - Use MELCOR calculations directly to assess success criteria has been established (completed for Westinghouse 3-LOOP and Westinghouse 4-LOOP being reviewed)
  - INL has demonstrated the ability to incorporate plant changes or data updates into the model within very short times

# Peer Review: Strengths and Limitations

- Identified Limitations and Potential Enhancements of SPAR models from the ASME Standard Peer Review Limitations:

- Identified Limitations:
  - Plant specific IE frequencies and data (SPAR models generic data)
  - Plant specific notebooks are not developed and no plant specific calculations to determine success criteria
  - SPAR model HRA calculations are limited
  - Based on how/when plant information is provided to the SPAR modelers, it is hard to keep the SPAR model current to the as-built, as-operated
  - Internal Flooding element not investigated
  - LERF risk metric not included in SPAR and not part of Review

# Peer Review: Strengths and Limitations

- Potential Enhancements:
  - Information Gathering
    - Transfer of information from utilities to INL is not required; therefore, the SPAR model may not always be current to reflect recent changes to plant operation/configuration
  - Modeling Differences
    - Plant specific data (component and IE)
    - Different CCF groups (e.g., inter system)
    - AC power recovery after battery depletion
    - Use of convolution from LOOP/EDG assessment
    - Dependent HEP treatment
    - Pre-initiator HFE identification and treatment
    - Quantification of HRA

# Peer Review: Strengths and Limitations

- Potential Enhancements (cont):
  - Documentation
    - The SPAR model level of documentation generated the most F&Os when performing the review
    - There is a significant difference between the level of the SPAR documentation versus the ASME PRA Standard
    - The SPAR model documentation had no procedure or requirement on level of detail and scope when it was developed
    - The documentation relies heavily on expertise and corporate knowledge
    - Quantification documentation (convergence truncation, discussion of dominant sequences, etc.)
    - The level of detail added needs to balance with the ability to make sure the documentation stays in step with model updates

# Peer Review: Findings and Observations

- PWR Generic Findings
  - No T/H calculations to help define sequences and time progression
  - Transfer of RPS failure through ATWS tree
  - Development of HRA and HFE dependency use in SPAR (along with documentation)
  - SPAR model quality assurance program
  - System success criteria (what is modeled versus what is documented
- BWR Generic Findings
  - Transfer of RPS failure through ATWS tree
  - Recirculation pump seal failures – SBO modeling
  - AC power recovery given SBO and no RPV injection (less than 1 hour) [also after battery depletion]
  - Handling LOOP/SBO cut sets containing FTR of diesel generators and offsite power recovery

# SPAR Team: Address how to handle F&Os

- Documented the Peer Review results
- Ranked the Findings and Observations provided from the Peer Review
  - The rankings were placed into three different SPAR model impact categories (high, moderately, least)
  - The rankings provided a road map on prioritization of modifications and updates necessary
  - Part of the ranking also considered generic issues (i.e., those that can be addressed across all SPAR models)
    - A lot of comments were plant specific
- Provided suggestions to NRC on how to address and incorporate findings into all SPAR models based on prioritization

# SPAR Model Updates: Incorporate important F&Os

- SPAR Model Updates based on Peer Review F&Os
  - Model documentation changes - reformatted to match ASME standard, added more detailed results section (convergence, dominant sequences, dominant components
    - (SPAR models were originally not tasked to develop detailed documentation and therefore, only high level documentation was developed)
  - Added support system initiating event fault trees to all SPAR models for fluid systems (service water, component cooling)
  - Added convolution correction factors to all LOOP/SBO sequences given diesel generator fails to run and offsite power recovery
  - Transferred to ATWS tree given RPS failure given SLOCA, IORV, etc.

# SPAR Model Updates: Incorporate important F&Os

- SPAR Model Updates based on Peer Review F&Os (cont)
  - T/H calculations performed to help define success criteria (PWR - feed and bleed and LOCA injection; BWR - SBO timing
  - Enhance the quality assurance process prior to posting models
    - Feedback mechanism through SAPHIRE web site for formal tracking