Status of SPAR Models

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February 22, 2007

Topics

- SPAR Model Status
- Cut-Set Level Reviews
- Reasons for Disparity between SPAR Model and Licensee PRA
- Technical Issues
- How to Obtain Your SPAR Model

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SPAR Model Status

- Internal Events
  - Currently 72 models for 103 plants
  - 41 models have had cut-set level reviews completed (version 3.31, Enhanced SPAR models)
  - 20 models will be revised to version 3.31, Enhanced SPAR models in 2007
  - 11 MSPI Pilot plants with abridged cut-set level reviews will be re-evaluated in 2008
  - 12 version 3.31, Enhanced SPAR models to be re-evaluated in 2008 due to licensee PRA model changes during implementation of MSPI
  - Developing Browns Ferry 1 model for anticipated startup in May 2007
  - Developing single unit SPAR models for 4 multi-unit sites (4 additional SPAR models) in 2008
    - **Results in 77 version 3.31 Enhanced SPAR models for 104 plants in 2008.**
- There are also programs to develop external events, low power/shutdown models and large early release frequency models.

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SPAR Cut Set Level Reviews

- Purpose of the reviews:
  - More accurately model plant operation and configuration.
  - Identify the significant differences between PRA and SPAR logic.
- The main steps in the review process:
  - Obtain a deep cut of the licensee's cut sets.
  - Load licensee's cut sets into SAPHIRE.
  - Map ~150 of the most important events in the licensee PRA to analogous SPAR events.
  - Incorporate key licensee probabilities into SPAR model (via temporary change set).
  - Load SPAR and PRA importance reports into comparison spreadsheet
  - Identify the outliers and make the corrections allowed by SPAR policy and precedent.

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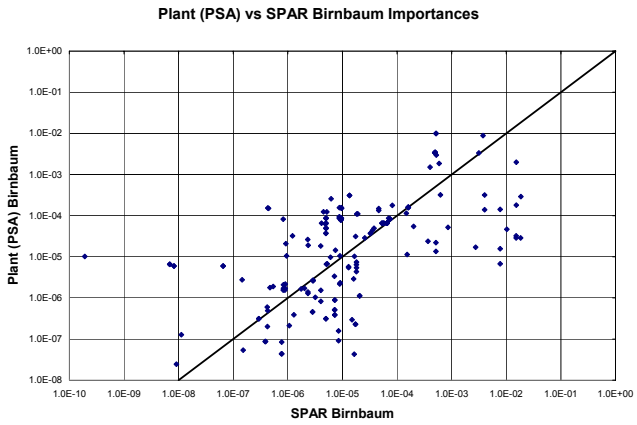
Plant X Prior to Cut Set Level Review



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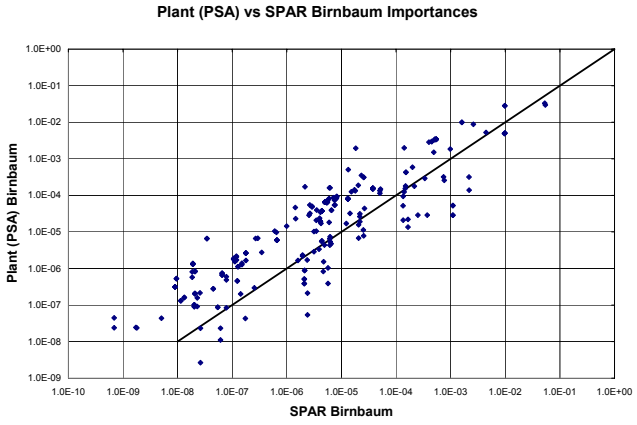
Plant X After Cut Set Level Review



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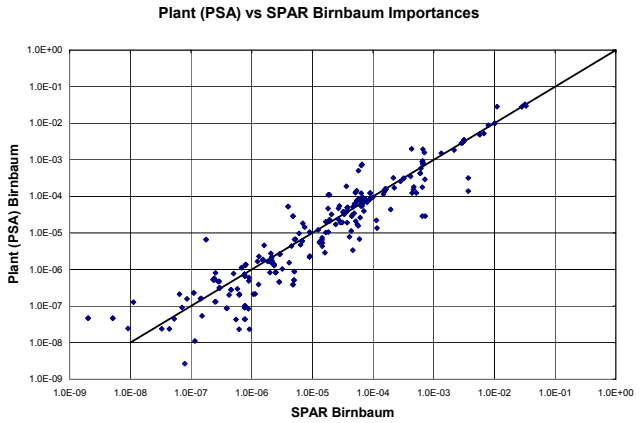
Plant X After Cut Set Level Review with Key PRA Data



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Cut Set Level Review Summary

- In the preceding figures outlying points have a story.
- The dominant contributors to differences between PRA and SPAR results involve:
  - CCF of the diesel generators.
  - DC bus failures.
  - PRA has much lower AC power recovery failure probabilities than SPAR model.
  - PRA credits feed and bleed with one PORV.
  - AFW pump volute CCF.
  - Etc.

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Reasons for Disparity between SPAR Model and Licensee PRA - Example 1

- **SPAR core damage frequency greater than 1E-4/yr**
- The CDF calculated by the SPAR model is 1.9E-4/yr. The SPAR model results are dominated by two related cut sets. These cut sets are single element cut sets of the form IE-LOSWS * RCS-MDP-LK-BP2 and IE-LOCCW * RCS-MDP-LK-BP2. The SPAR events in these cut sets are:
  - IE-LOCCW (4E-03) LOSS OF COMPONENT COOLING WATER INITIATING EVENT
  - IE-LOSWS (4E-03) LOSS OF SERVICE WATER INITIATING EVENT
  - RCS-MDP-LK-BP2 (2E-01) RCP SEAL STAGE 2 INTEGRITY (BINDING/POPPING OPEN) FAILS

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Example 1 - continued

These two cut sets alone yield a SPAR CDF contribution of 1.6E-4/yr which is in excess of 80% of the overall SPAR model CDF. In contrast, the PRA calculates an overall CDF of approximately 1.5E-6/yr for loss of CCW and 3E-6/yr for a loss of SWS. The primary reason for the differences in these results is the disparity in initiating event frequencies. The PRA initiating event frequencies are approximately two orders of magnitude lower than the analogous SPAR model initiating event frequencies.

The SPAR model incorporates initiating event frequencies of 4E-4/yr for each of these initiators. These frequencies are based on industry data of zero failures in 1269.4 years of reactor operation. The PRA calculates these initiating event frequencies using fault trees. The PRA calculates a loss of CCW initiating event frequency of approximately 6E-6/yr and calculates a loss of SWS frequency of approximately 1E-5.

These differences in initiating event frequencies are exacerbated by the large conditional core damage probabilities (CCDP) associated with these events. A loss of CCW or SWS fails normal RCP seal cooling. Loss of CCW fails the barrier coolers directly and indirectly fails seal injection by eliminating cooling to the charging pumps. Loss of SWS fails CCW by failing heat removal from the CCW heat exchangers. Given a failure of seal cooling, both models also incorporate a similar failure probability for RCP seals (~2E-1) and both models yield similar conditional core damage probabilities.

Alternate cooling to the charging pump(s) is available from the fire water system; however, neither the PRA nor the SPAR model takes credit for this action in time (~13 min) to preclude RCP seal failure.

In summary, the large SPAR CDF result is driven by a combination of LOSWS/LOCCW initiating event frequency and the inherent large CCDPs associated with these events. If the PRA frequencies for the two initiators in question are inserted into the SPAR model, the CDF drops to approximately 1.9E-5/yr.

REASON: ***<u>Method of Support System Initiator Modeling and IE Frequency for LOSWS/LOCCW</u>***

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Reasons for Disparity between SPAR Model and Licensee PRA - Example 2

•**Difference between initiator specific CCDPs greater than factor of 10**

•The small loss of coolant accident (SLOCA) initiator is found both in the SPAR model and the PRA and has a CCDP difference in excess of a factor of 10. The SLOCA initiator CCDP is approximately 2.6E-3 in SPAR and 6.9E-5 in the PRA. This is a factor of 38 difference. The primary reason for this difference is that the SPAR model requires sump recirculation for successful termination of this initiator while the PRA does not. The PRA credits depressurization of the primary with reducing the leak flow (and energy deposition to the containment) to such a level that recirculation is not required. If this action fails, sump recirculation is credited for containment heat removal and long term inventory control. It should be noted that this is one of the thermal-hydraulic issues previously identified as having significant impact on model results. As a reference point, the SPAR model matches the SDP notebook logic for this issue as well as the SLOCA logic in the Daily Events Manual.

REASON: Inconsistent requirements for containment sump recirculation during small loss-of-coolant events

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Technical Issues That Influence Risk Results

1. Standard methodology and implementation of initiating event fault trees for cooling water support systems (i.e., ESW & CCW) and instrument air systems.
2. Standard approach for recovery from station blackout after battery depletion (LOOP/SBO).
   - Convolution for LOOP
   - Conditional LOOP logic in SPAR models
3. Standard approach for injection following containment failure (BWR).

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Technical Issues continued

4. HRA dependencies and recovery modeling issues.

5. Initiating Event Frequencies

6. Success criteria inconsistencies
   - TH analysis
     - Extensive thermal-hydraulic analysis to determine ”bounding” success criteria and timing for SPAR models
   - Other

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Technical Issues continued

7. Common Cause Failure modeling/methods

8. Containment sump and pool plugging, GSI-191.

9. Standard requirements for containment sump recirculation during small loss-of-coolant and very small loss-of-coolant events.

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Approach to Address Outstanding Technical Issues

- NRC desires to work with industry to resolve outstanding technical issues.

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Suggested Approach to Address Technical Issues

- Develop detailed guidance for models and parameter estimates for the technical issue that can result in significant variations in results
- Implement “detailed guidance” consistent with High Level Requirements and Supporting Requirements of ASME RA-Sb-2005, Addenda To ASME RA-S-2002

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Suggested Approach to Address Technical Issues (continued)

- Less significant issues can be addressed thru ASME standard alone and case by case.
- Manage exceptions, emerging issues as they occur considering significance
- Recognize role of SPAR to provide confirmation of overall CDF and dominant contributors

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How to Obtain Your Plants' SPAR Model

- **At the present time, SPAR models will only be provided to the Licensee.**
- **Send an email requesting your SPAR model to:**
  - Pete Appignani
  - SPAR Model Level 1 Development Project Manager
  - US NRC, Office of Nuclear Regulatory Research
  - Email: pla@nrc.gov
  - Phone: (301) 415-6857
- **Include the following information:**
  - Name
  - Title
  - Company
  - Mailing Address
  - Phone number
  - Email Address
- **The SPAR models will be provided only for your organization's use and are not to be distributed further without the written consent of the Nuclear Regulatory Commission.**
- **SPAR models are not available to the general public.**

You will need the latest version of SAPHIRE to use the SPAR model. To obtain SAPHIRE, fill out, sign and return the non-disclosure agreement. The non-disclosure agreement can be obtained at http://www.nrccodes.com/. A copy of the agreement will also be provided on the CD-ROM containing the SPAR model(s). The code is provided for no fee, although no technical assistance is provided. Technical assistance can be obtained from the NRC contractor responsible for code distribution, the Idaho National Laboratory, by joining the SAPHIRE Users Group. If you have any questions about obtaining SAPHIRE please contact Dan O'Neal, SAPHIRE Project Manager at (301) 415-4146 or dma@nrc.gov

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