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Protecting People and the Environment

Standardized Plant Analysis Risk (SPAR) Models - Success Criteria

Donald Helton
US NRC
301-415-1545
Donald.Helton@nrc.gov

Robert Buell
Idaho National Labs
208-526-9400
Robert.Buell@inl.gov

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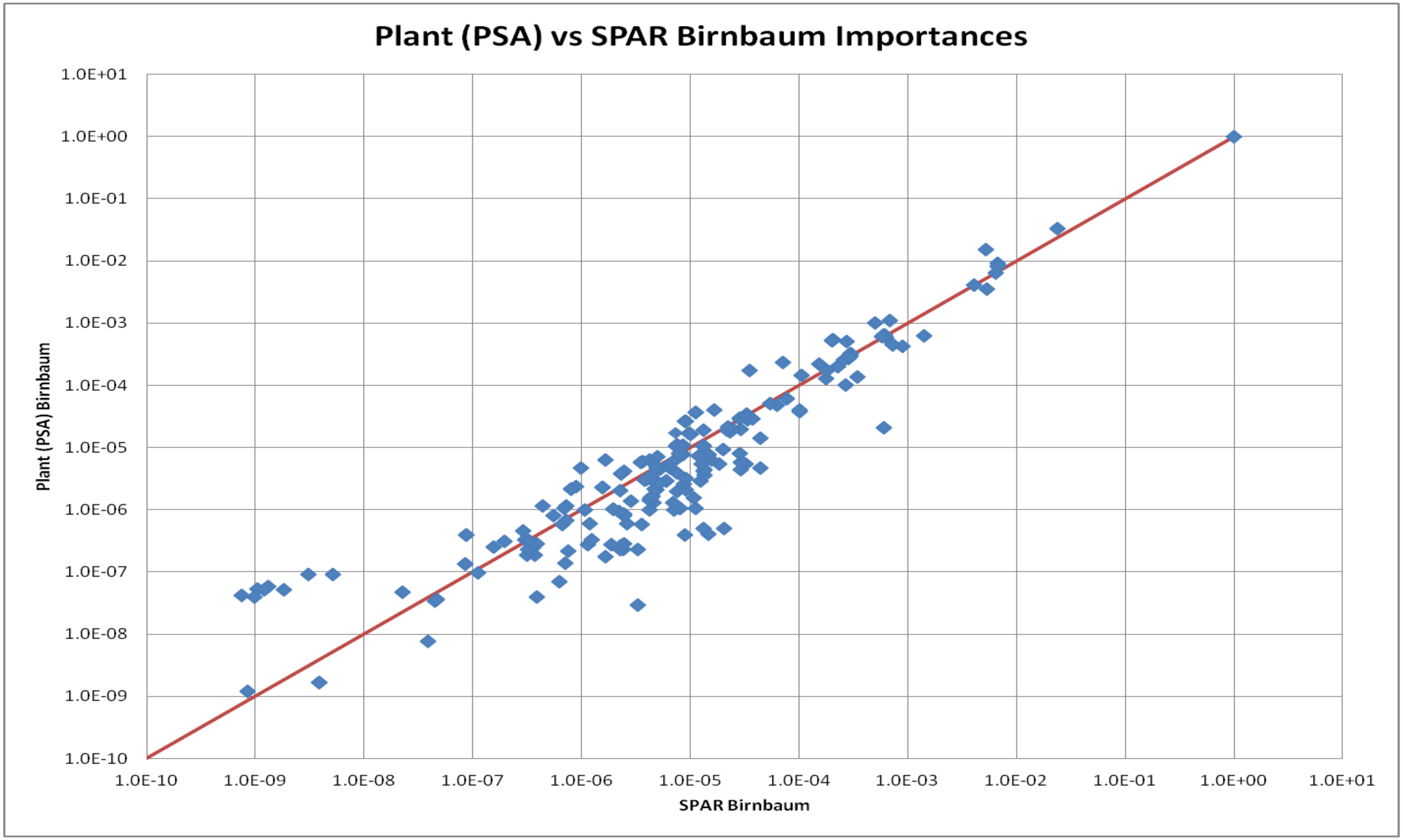
SPAR Success Criteria Background

- Success criteria:
  - The minimum combination of systems and components needed to carry out safety functions given an initiating event [NUREG-2122]
  - High-level and supporting requirements defined in the consensus PRA Standard
- Licensee probabilistic risk assessment (PRA) and SPAR success criteria developed and refined based on numerous sources:
  - Design-basis accident analysis
  - Individual plant examination (IPE) program
  - NRC studies and vendor topical reports
  - Mitigating Systems Performance Indicator (MSPI) implementation
  - Dedicated plant-specific thermal-hydraulic (TH) analyses

SPAR Success Criteria Benchmarking

- Benchmarking is a process used to identify differences between SPAR models and the licensee models
  - Knowledge of these differences leads to enhancements of the SPAR models
    - Prioritizes and focuses plant specific TH analyses
      - Provides basis for changing success criteria as well as confirms existing criteria
    - Identifies additional equipment/systems that may be potentially credited
    - Identifies subtle dependencies that may not be readily apparent
    - Etc
- During routine baseline model updates, licensees are requested to provide cutsets and model documentation
  - Cutsets are used to do cross-comparisons to the SPAR model to identify success criteria differences
  - Model documentation is used to assess the basis for success criteria prior to adopting changes
  - **Licensees providing PRA results and documentation is a key aspect of this process**

SPAR Success Criteria Benchmarking (2)



SPAR Success Criteria Benchmarking (3)

- Significant SPAR/PSA differences that are evident through the benchmarking process
  - Termination of SPAR SBO scenarios at battery depletion
    - Reduces credit for B.5.b/FLEX equipment
    - Reduces credit for time associated with boiloff
  - Support System Initiating Event (SSIE) frequencies
    - SPAR frequencies are typically higher than analogous PSA frequencies
    - Primary difference is due to CCF application in the fault trees
  - SPAR application of recovery to failed diesel generators
  - SPAR application of convolution correction factors
  - 24 hour maximum for AC power recovery
  - PSA SLOCA success path without recirculation requirement

SPAR Success Criteria Confirmatory MELCOR Analysis

- Investigations of issues felt to be important for substantiating SPAR modeling assumptions related to success criteria and sequence timing:
  - NUREG-1953 (2011) – Surry and Peach Bottom
  - NUREG/CR-7177 (2014) – End-State Modeling Issues Investigation
  - NUREG-XXXX (est. 2015) – Byron (Unit 1)
- Plant-specific modeling using the NRC's MELCOR accident analysis code
  - Results are extended to other plants in the same design class, where appropriate
- These reports have benefited from licensee fact checking (all), a public comment period (1953 & 7177), and Advisory Committee on Reactor Safeguards (ACRS) quality review (1953)
- Results are used for both baseline model changes and to support SDP/ASP

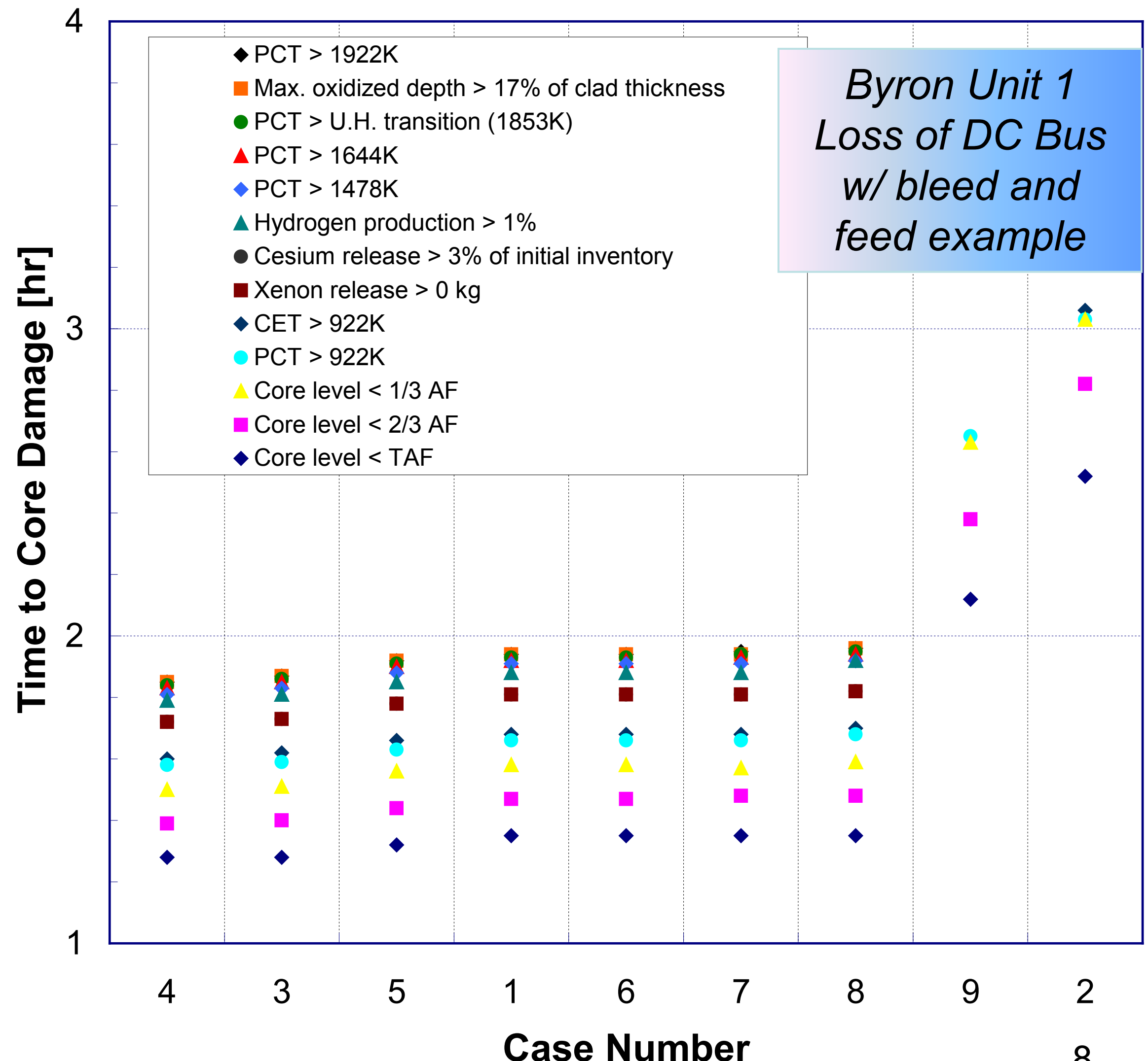
Example: Figure-of-merit variability (NUREG/CR-7177)

- 4 scenarios, with 8 to 20 variations for each
  - Results were analyzed to determine the degree of variability for key figures of merit (e.g., time of switchover to recirculation, time of core damage), and which modeling assumptions drove this variability
- Modeling assumptions found to have a significant effect, e.g.:
  - Within-bin variations in break size; break location
  - number of ruptured steam generator tubes
  - reactor power level at the time of trip
  - time of battery depletion
  - behavior of turbine-driven systems after battery depletion
  - stochastic failure in the open or partially open position of relief valves

Event	Byron LoDC Bus 111	…
First opening of the pressurizer PORV or SRV	0.13 – 0.33 [1a]	…
Number of pressurizer or vessel PORV or SRV cycles at time of core damage (or end of run) [2]	1 – 49 [1a]	…
Pressurizer first goes water-solid	0.42 [2a]	…
…	…	…

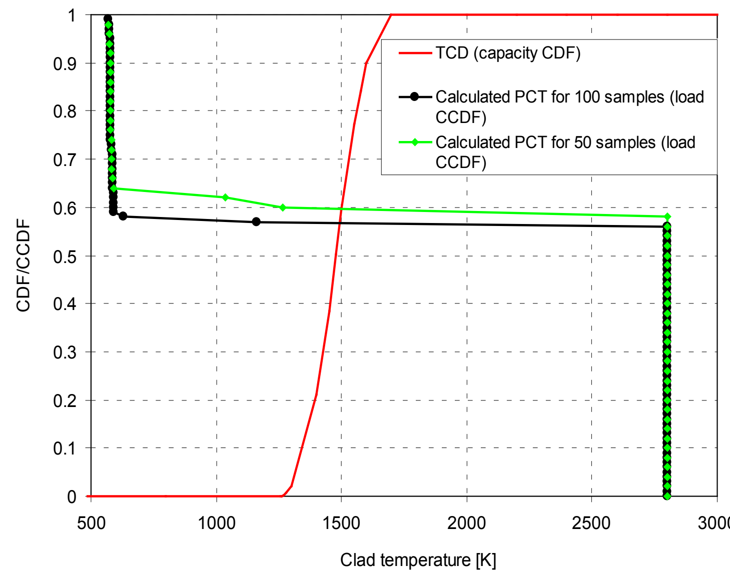
Example: Core damage surrogate variability (NUREG/CR-7177)

- At-power reactor accidents:
  - 2200F (1478K) peak node cladding temperature (PCT) found to be appropriately realistic for confirmatory MELCOR applications
- Reactor accidents during shutdown:
  - A combination is recommended:
    - Water level at 1/3 fuel height
    - 2200F (1478K) PCT
    - Cesium release > 3%



MAAP4/MELCOR LoMFW Comparison (NUREG/CR-7177)

- Electric Power Research Institute (EPRI) TR-1023032 documented a loss of main feedwater scenario with primary-side bleed and feed uncertainty analysis using the Modular Accident Analysis Program (MAAP) version 4.0.6
- NRC replicated a portion of that study, using MELCOR 1.8.6, for:
  - 1 safety injection (SI) train, 1 power-operated relief valve (PORV), and operators trip reactor coolant pumps
  - 1 SI train, 2 PORVs, operators trip RCPs
  - Also demonstrated sensitivity to sample size



- For this situation, good agreement was demonstrated between the two codes

Study	Configur-ation	>TCD	> 1,800 ° F (1255 K)	> 2,200 ° F (1,478 K)	> 2,600 ° F (1,700 K)
NRC-MELCOR Study	1	57	57	57	**57**
	2	15	15	15	**15**
EPRI-MAAP Study	1	61	63	61	**60**
	2	**22**	**26**	**22**	**19**

Going Forward - General

- NRC plans to continue both the benchmarking activities and the confirmatory success criteria analysis activities
- Licensees are encouraged to continue providing information for model updates, and to volunteer to provide design/operation information for confirmatory activities
- Members of the public are encouraged to express interest in receiving future information on the confirmatory activities
- In addition, general modeling issues related to success criteria are being deliberated on, including:
  - Implementation of the PRA Standard’s safe and stable end-state requirements
  - Handling of the largest reactor coolant pump seal LOCAs (binning as medium versus small LOCA)
  - Degree of inclusion of LOCA break ranges (particularly for medium break LOCA) in success criteria determinations