Public Workshop on Common Cause Failure in the Significance Determination Process and Accident Sequence Precursor Program

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Outline

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- Background Summary
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  - Basic Parameter Model
  - Recent Communications
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- Common Challenges in SDP.
- Meeting Organization and Future Discussions

Agenda

- Introductions
- NRC presentation(s)
- NEI and industry presentations
- Public presentation(s)
- Future meetings

Purpose and Goals

- Purpose
  - A discussion of topics relevant to modeling and accounting for Common Cause Failure (CCF) primarily in the SDP and ASP*.
- Goals
  - To start an open dialog between stakeholders on issues impacting evaluation of CCF in the SDP and ASP.
  - Presentation of possible solutions by external stakeholders on some of the issues encountered in assessing CCF for NRC staff to consider.
    - Solutions need to have a sound technical basis, be defensible, and be consistent.
  - Not to make immediate decisions today but, have enough information to consider future actions.
  - Discuss plans for future engagement.

* Including NOED and reactive inspection assessments.

Topics to Cover

- Basic modeling of CCF.
- How failures are adjusted by NRC in the Significance Determination Process (SDP) and Accident Sequence Precursor (ASP) program.
- Explore development of other methodologies to maintain a risk-informed framework to realistically include CCF.
- Integration of quantitative and qualitative CCF factors.
- Root cause determination in evaluation of CCF.
- Applicable time interval.
- CCF and passive component failures
- Plant performance regarding attributes that impact CCF.
- Treating CCF as a component of a sensitivity analysis.
- Consideration of historical data.
- Crediting to plants that proactively manage the risk of CCF.
- Should intersystem dependencies be considered in models.
- Other topics, if time permits.

Criteria for CCF Events

- Two or more individual components fail or are degraded, including failures during demand, in-service testing, or deficiencies that would have resulted in a failure if a demand signal had been received.
- Components fail within a selected period of time such that success of the PRA mission would be uncertain.
- Component failures result from a single shared cause and coupling mechanism.
- A component failure occurs within the established component boundary.

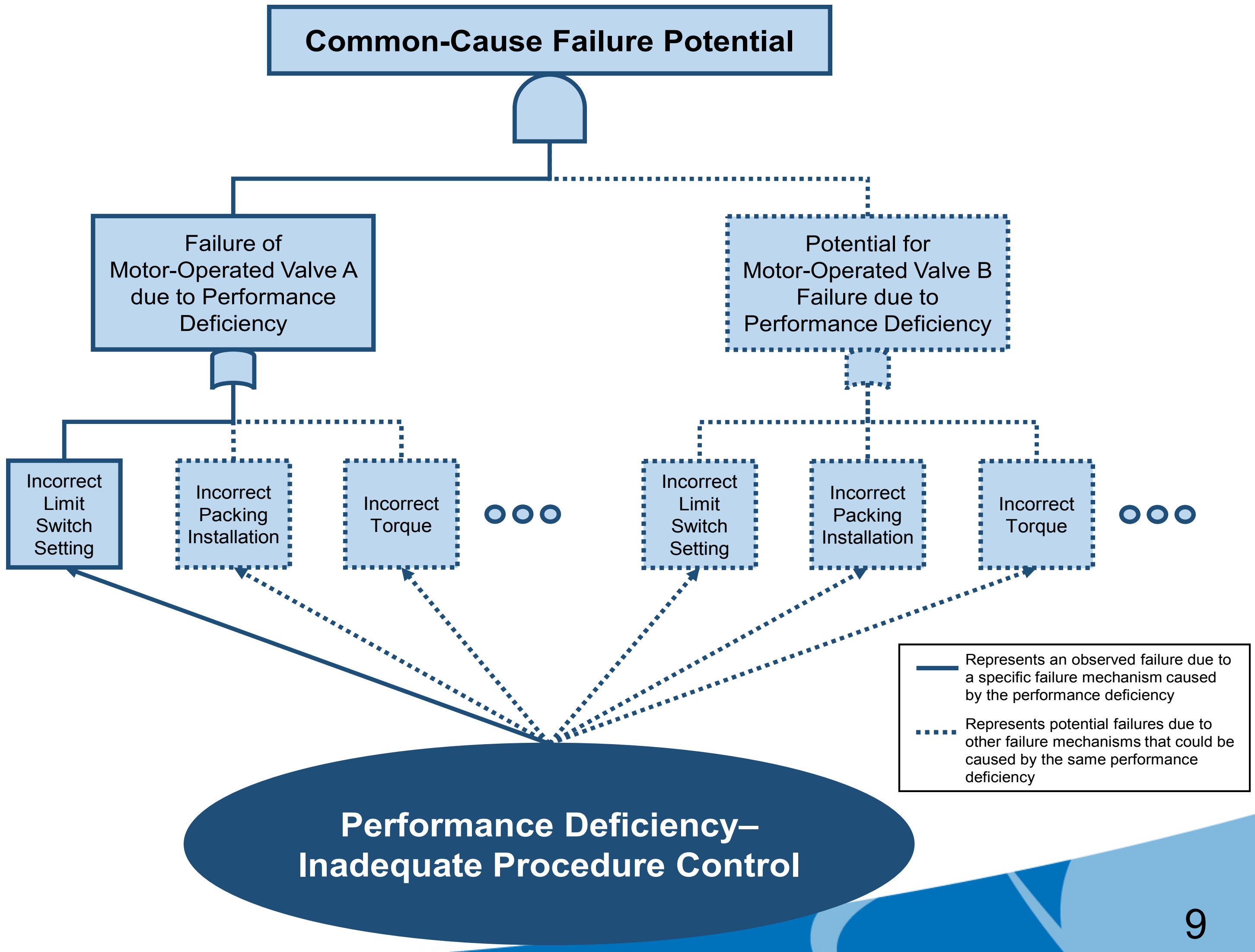
SDP Experience

- Finding results have a high sensitivity to several factors. Most dominant are:
  - CCF contributions to ΔCDF.
  - Human failure events.
  - Recoveries.
- Various licensees have had differences in application of CCF in failure models over the years.

Background Summary

- CCF is part of the basic PRA/PSA models for both licensees and NRC.
- Currently CCF is accounted for in SPAR models:
  - Intra-system interactions between trains of SSCs.
  - CCF events are modeled at the higher component level.
- Methodologies:
  - Most use basic parameter models such as:
    - Alpha.
    - Multiple Greek Letter (MGL).
    - Beta.
  - NRC uses the alpha methodology:
    - Conditional probability method.
    - Alpha factors are event based and easier to estimate from observed data.
    - Take uncertainty into account.
  - These methodologies produce acceptable results.
- Areas of Difference
  - Adjusting CCF given the failure of one or more components in a common cause component grouping (CCCG).

Illustration of NRC's Approach to Common Cause Potential



Staggered Test Basic Parameter Model

$$Q_k^{(m)} = \frac{1}{\binom{m-1}{k-1}} \alpha_k Q_t$$

$Q^{(m)}_k$ = probability of a CCBE involving k specific components in a common cause component group of size m, ($1 \leq k \leq m$).

Q_t = total failure frequency of each component due to all independent and common cause events.

α_k = fraction of the total frequency of failure events that occur in the system and involve the failure of k components due to a common cause.

Recent Communications

- Exelon letter to the NRR Office Director in January 2017.
  - “Rely on Fact-Based Common Cause Failure (CCF) Treatment: The RASP Handbook guidance should be enhanced to allow the as-found conditions and extent of condition to factor into the determination of CCF multipliers.”
  - “When determining the risk significance of equipment failure, it is important to question the potential for CCF. The current RASP Handbook guidance represents a bounding quantitative application of common cause factors, and often controls the risk significance of the performance deficiency. In some cases where the failure mechanism/extent of condition cannot be known, simplified approaches are warranted. “
  - “In situations where the failure mechanism is known and the extent of condition can be clearly assessed, it would be more appropriate to use the actual as-found condition to assess significance. The RASP Handbook essentially uses a "guilty until proven innocent beyond a reasonable doubt“ philosophy with no consideration of how to modify such a significant risk penalty if found innocent.”
- Public meeting on May 2, 2017.
  - Industry representatives advocated graded approach.
    - First introduced an approach during March 2017 Oyster Creek regulatory conference on failure of Electromatic Relief Valve (EMRV).

RASP Guidance Ground Rules

- ***Ground Rule 1.*** The performance deficiency (PD) that resulted in a failure in the CCCG has the potential for CCF of other components in the same CCCG.
- ***Ground Rule 2.*** The potential for CCF given an observed PD that resulted in a failure in the CCCG is the conditional CCF probability.
- ***Ground Rule 3.*** Crediting observed defenses against CCF (i.e., successes) may be considered qualitatively outside the risk analysis.

RASP Guidance

- ***Evaluate the PD.*** Generally, a PD that resulted in a failure of one component has the potential to fail other components in the CCCG within the system's mission time (see Ground Rule 1). Consider the PD in the broader context of CCF dependency and not in the context of the observed piece-part failure or failure mechanism. If a PD has yet to be defined in a MD 8.3 assessment, then assume that a PD exists.

CCF Treatment Cases

- Case 1– Observed failure with loss of function of one component in the CCCG.
- Case 2– Observed failures with loss of function of two or more components in the CCCG.
- Case 3– Observed failure with loss of function of one component in the CCCG—component not in SPAR model.
- Case 4– Observed degradation in one or more components in CCCG without observed failure.
- Case 5– Observed unavailability of a component in CCCG due to testing or planned maintenance.
- Case 6– Observed loss of function of components in CCCG caused by the state of other components not in the CCCG.
- Case 7– Observed loss of function of one or more components in CCCG as a result of environmental stress caused by failure or degradation of other components outside affected CCCG.
- Case 8– No observed failure or degradation in the affected CCCG.
- **See RASP Manual Guidance in Table 5-1.**

Use of SPAR Models in SAPHIRE

- SAPHIRE automatically re-calculates the CCF probability with failure of the impacted SSC.
- Latest version 8.1.5. easier to use and trace database of alpha factors and configuration.

Common Challenges in SDP

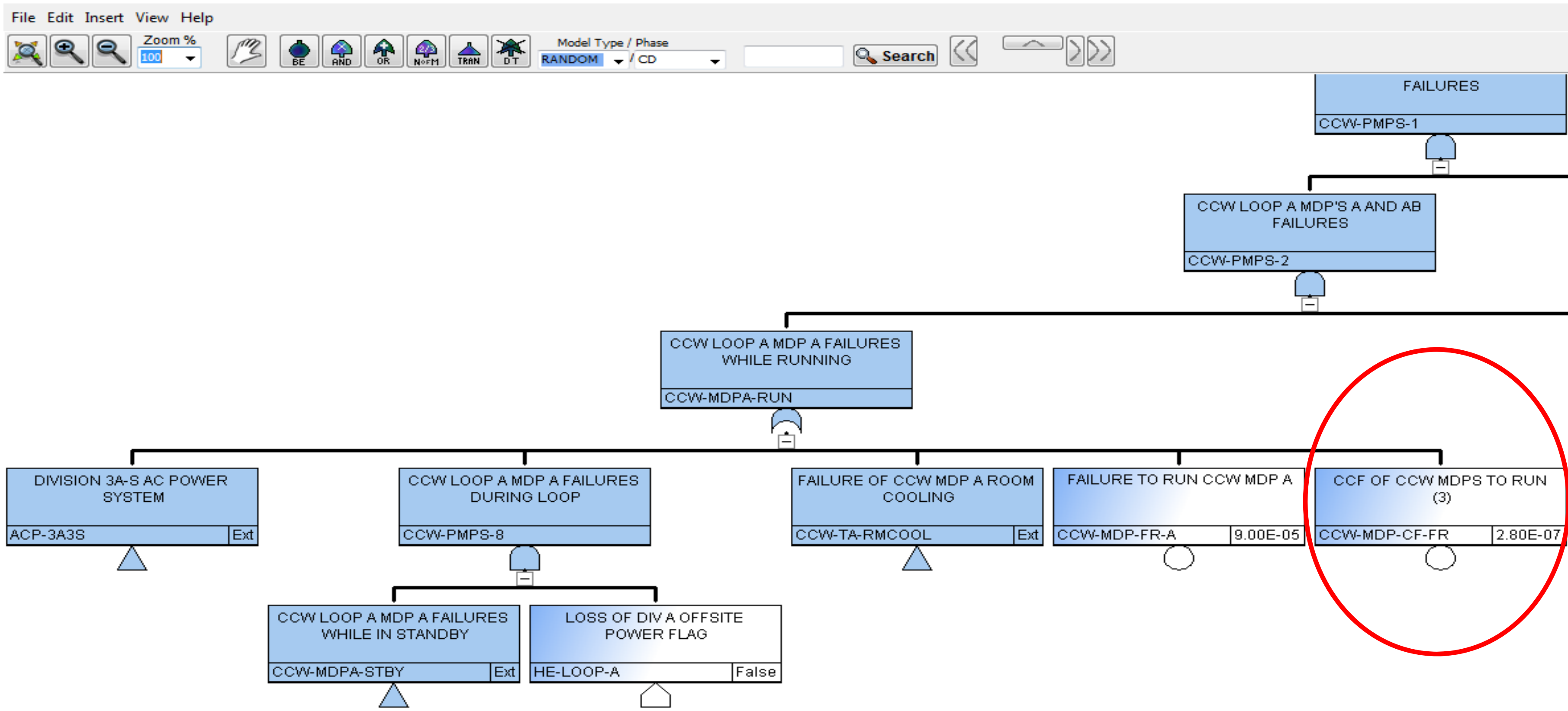
- Characterizing the contribution of CCF to a performance deficiency given the high-level nature of modeling.
- Should extent-of-condition testing of redundant SSCs be sufficient to eliminate or substantially reduce CCF contributing from a performance deficiency?
- How can the impact of higher organizational deficiencies be factored?
- How should timing limitations be adjusted?

Meeting Organization and Future Discussions

- Develop a “parking lot” list of proposed issues for further consideration.
- Discussion of each item with pros/cons, solutions, and recommendations for later meetings or communication.
- Plan for future venues to discuss “parking lot” issues.

Back-up Slides

Example CCW MDP FTR



CCW MDP FTR CCF Data

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Independent Failure Events

ID	Name	Failure Type	Value
A	CCW-MDP-FR-A	Nominal	9.00E-5
B	CCW-MDP-FR-AB	Nominal	9.00E-5
C	CCW-MDP-FR-B	Nominal	9.00E-5

Factors

Parameter	Name	Value
Alpha 1	ZA-MDP-FR-CCW-03A01	9.84E-1
Alpha 2	ZA-MDP-FR-CCW-03A02	1.26E-2
Alpha 3	ZA-MDP-FR-CCW-03A03	3.11E-3

Probability: 2.80E-7

Summary

2.8005E-07 total failure value.
4 permutations.
3 inputs out of 3 possible must fail - All independent only groups are not counted.

Nominal Q Values

Factors
[1] - 9.8400E-01, [2] - 1.2600E-02, [3] - 3.1100E-03
Events CCW-MDP-FR-A, CCW-MDP-FR-AB, CCW-MDP-FR-B
Qt = 9.0000E-05, 9.0000E-05, 9.0000E-05
Q1 = 8.8560E-05, 8.8560E-05, 8.8560E-05
Q2 = 5.6700E-07, 5.6700E-07, 5.6700E-07
Q3 = 2.7990E-07, 2.7990E-07, 2.7990E-07

CCF Terms

1 * Q3 +
3 * Q1 * Q2

CCF Sub-elements

Element #	Terms	Nominal Value
# 1	CCW-MDP-FR-B, CCW-MDP-CF-FR-AB	5.0214E-11
# 2	CCW-MDP-FR-AB, CCW-MDP-CF-FR-AC	5.0214E-11
# 3	CCW-MDP-FR-A, CCW-MDP-CF-FR-BC	5.0214E-11
# 4	CCW-MDP-CF-FR-ABC	2.7990E-07

Sav

Adjusting CCF for CCW MDP A FTR

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Summary of Conditional Event Changes

Event	Description	Cond Type	Cond Value	Nominal Type	Nominal Value
CCW-MDP-FR-A	FAILURE TO RUN CCW MDP A	T	True	3	9.00E-5
CCW-MDP-CF-FR	CCF OF CCW MDPS TO RUN (3)	R	3.11E-3	R	2.80E-7

Implied Event Changes as per RASP Guidance

Event	Description	Cond Type	Cond Value	Nominal Type	Nominal Value
CCW-MDP-FS-A	FAILURE OF COMPONENT COOLING WATER SYSTEM MDP A	F	False	1	1.09E-3
CCW-MDP-TM-A	CCW MDP A UNAVAILABLE DUE TO TEST AND MAINTENANCE	T	True	1	4.56E-3
CCW-MDP-CF-FS	CCF OF CCW MDPS TO START (3)	R	0.00E+0	R	2.38E-6