White Paper for Addressing Common Cause Failure (CCF)
Impact within the Significance Determination Process (SDP)

Background

The quantitative impact of reflecting potential common cause associated with a performance deficiency in a multi-train system, as outlined in the Risk Assessment Standardization Project (RASP) Handbook, can greatly influence the final outcome of an SDP finding where CCF is a driver. The goal of this effort is not to focus on the mathematical foundation used to quantify the impact of CCF associated with the preliminary SDP significance but, rather, to provide a framework for consideration of qualitative aspects that can be credited during the enforcement process.. The intent is to reinforce a risk-informed framework in which CCF is still appropriately considered, but that includes a more robust consideration of both quantitative and qualitative aspects, therefore minimizing resource expenditure of both NRC and utilities in attempting to achieve numerical refinements that are beyond the state of practice in CCF for SDP event and condition assessment.

The basic ground rules in the treatment of CCF for event and condition assessment outlined in Section 5.2 of the RASP Handbook provide guidance to assist analysts in a consistent approach in SDPs. Specifically, Ground Rule 3 allows the crediting of strong defenses against CCF to be considered qualitatively outside the quantitative risk analysis in the SDP process by the Significance and Enforcement Review Panel (SERP). Specific programmatic utility actions to defend against or limit common cause coupling factors (a characteristic of a group of components that identifies them as susceptible to the same causal mechanisms of failure) can reduce the occurrence of CCF. The impact of these actions or defenses is difficult to reflect quantitatively and may not be fully captured by the CCF databases with respect to a specific performance deficiency. However, a qualitative assessment may be applied if utility actions to defend against CCF were in place to reduce the likelihood of the remaining components in a common cause component group (CCCG) from a similar failure mechanism.

Illustrating the Impact of Common Cause Failure using Sensitivities

Section 5 of the RASP handbook provides guidance for the treatment of CCF dependencies among components in a CCCG given an observed failure, and/or unavailability due to test or maintenance of one or more components in the CCCG. The quantitative adjustment to the baseline CCF basic event probability of the CCCG using the Standardized Plant Analysis Risk (SPAR) model to reflect the failure(s) that were observed is automatically calculated using embedded calculations in the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) software. In addition, quantitative credit of defenses against CCF is not part of the scope of the Handbook due to the inability to quantitative apportion the CCF data to specific coupling factors such as environment, maintenance, design, etc. Although this may be the case, the current analytical approach used within the context of the RASP handbook is essentially binary, in that, either a conditional CCF probability is automatically applied, or an allowable deviation from the ground rules justifies not propagating the conditional CCF. Since there are known potential conservatisms in this approach, the over-reliance on strict

quantification does not provide flexibility nor clarity on the impact the quantitative CCF can have on the SDP evaluation to both the utility staff and NRC decision-makers

The proposed process for considering the overall impact of CCF would still include the quantification of the results that include the conditional CCF as a first step. This result would be considered the entry result that would be coupled with additional considerations given an observed deficiency that resulted in a single failure in the CCCG. A second step would involve considering qualitative aspects and how they may impact the spectrum of results given the thresholds in safety significance established for SDPs (Green-White or White-Yellow or Yellow-Red). Illustrating this spectrum and considering how the possible qualitative aspects that are applicable to a specific case may impact the quantitative results can both help communicate the CCF impact in a more clear and understandable way, and provide a framework for a color change decision to be made, if justified, as stated in Ground Rule 3.

It is proposed that an additional paragraph be added to the end of Section 5.3 in the RASP handbook to help outline this added consideration when characterizing the CCF impact. The details regarding how to select the values of CCF used would be contingent on the difference between the quantitative conditional CCF results and the SDP threshold, along with the consideration of qualitative factors as stipulated by Ground Rule 3.

Crediting Observed Defenses Qualitatively

The current quantitative CCF evaluation process does not account for specific or deliberate actions taken by a utility that reflect an understanding of the implications of common cause for similar components in redundant trains. In other words, the current quantitative approach is the same irrespective of the actions, or lack thereof, to defend against some contributors to common cause due to limitations in the data and quantitative approaches. Formulating a representative set of accepted industry defensive practices, reflected as a qualitative factor within the framework of Ground Rule 3 in the RASP Handbook, will not only add perspective to the evaluation of significance of a performance deficiency, but will promote increased recognition and use of common cause defenses by utilities, thereby proactively promoting good practices.

NUREG/CR-6268, R1, “Common-Cause Failure Database and Analysis System: Event Data Collection, Classification, and Coding” defines extrinsic dependency as those conditions where the dependency or coupling is not inherent or intended in the functional characteristics of the system. The source and mechanism of such dependencies are often external to the system, such as environmental or human interaction dependencies. A typical classification scheme used in the analysis of operational data and in evaluating specific defenses against multiple failures is partitioned into 5 coupling factor classes of quality, design, maintenance, operation, and environmental. The focus of this effort is on coupling factors or mechanisms associated with the extrinsic dependencies of maintenance or operation that create the potential for multiple components to be affected by the same cause.

The maintenance based coupling factors propagate a failure mechanism from identical maintenance program characteristics among several components. The categories of maintenance based coupling involve maintenance/test/calibration activities on multiple components being performed simultaneously or sequentially, propagation of errors through procedural errors and operator interpretation of procedural steps, or the same team/individual being responsible for maintaining multiple similar systems or components.

Similarly, the operation based coupling factors propagate a failure mechanism from identical operational characteristics among several components. The categories of operation based coupling involve cases when operation of all identical components is governed by the same operating procedures, or result if the same operator (team of operators) is assigned to operate all trains of a system,

A defense strategy against proximate causes can include design control, use of qualified equipment, testing and preventive maintenance programs, procedure review, personnel training, quality control, redundancy, diversity, and barriers. When a defense strategy is developed using protection against a proximate cause as a basis, the number of individual failures may decrease, as well as, result in a reduction in the CCF coupling factors.

If a defense strategy is developed using protection against a coupling factor as a basis, the relationship between the failures is eliminated and common cause reduced. The proximate cause codes used in the determination of potential common cause failure data analysis in the above referenced NUREG/CR can be used to identify defensive strategies to help illustrate the relationship between deliberate utility actions and consideration of a qualitative adjustment factor.

Human error resulting in an unintentional or undesired action, wrong procedure followed, failure to follow a procedure, inadequate training, inadequate procedure are all proximate causes considered in the development of CCF data are associated with maintenance and operational coupling factors. Demonstration of actions taken to reduce or eliminate these potential contributors can be used to assess the qualitative impact on the quantitative result.

The use of qualitative factors associated with the “varying strength of defenses” against common cause is aligned with a concept employed in NUREG/CR-6268, R1, specifically section 7.3.1. The strength of defense is characterized using the terms, “Complete”, “Superior”, “Moderate”, and “Weak”. The coupling factor for each is represented by a qualitative factor that could be applied for a given characterization of defense strength. Table 7-2 can serve as the framework in assessing the defenses or actions employed by a utility in the context of a specific performance deficiency by applying a qualitative factor that best represents the actions taken. The strength of the defense determines the qualitative factor used to inform the quantitative result during SERP deliberation. For example, a set of defenses addressing the coupling factors exhibited by a utility could be considered “Complete” using the above framework. If so, the qualitative factor applied would be such that only the nominal or baseline CCF factor would be used. The converse would be that a “Weak” characterization of employed defenses

would result in the full use of the quantitative conditional CCF used in the existing process. A "Superior" or "Moderate" characterization would clearly fall within the range defined by "Complete" and "Weak".

Varied terminology may be used in characterizing the type of defensive actions, but in general, the defensive actions can be applied to reduce or prevent the maintenance and operation coupling factors listed above. A limited sampling of human performance tools and verification practices include alternate verification to validate expected response or action, concurrent verification used in confirming correct components were manipulated or worked, identification of error precursors and barriers (physical or procedural) employed to defend against errors, independent verification, 2 minute drill at the job site, pre-job briefs, application of technical human performance tools that reflect a cognitive level of understanding of the factors influencing the task at hand. Defenses on a programmatic level that may be employed involve management or supervisory oversight, use of additional or outside subject matter experts, the use of mockups or simulations prior to work, peer or supplemental review in the field, challenge meetings/calls prior to action being taken, discussion or application of human performance fundamentals, or staggered maintenance on redundant components.

Discussion of the defensive actions can also provide an improved understanding of the performance deficiency in terms of the influence of organizational factors as compared to singular or isolated errors associated with equipment.

It is proposed that additional text be added to the discussion of Ground Rule 3 in Section 5 of the RASP handbook to reflect the matrix or graded approach in considering qualitative factors using the above approach. The additional framework would help both the SERP deliberations as well as utilities better view the application of common cause with respect to the defenses employed. A common or general characterization of defenses can be developed to relate the actions to application of the qualitative factors.

Conclusion

The industry believes that enhancements in the use of qualitative factors along with CCF quantification for event/condition assessment within the existing framework of the RASP Handbook can improve the characterization of performance deficiencies when common cause is identified as a significant contributor to the preliminary as well as final significance determination. It will also highlight proactive defensive actions that can be taken to minimize the impact from common cause whether a performance deficiency is under consideration or not (but that can be justifiably credited during an SDP to properly provide context on the impact of the current quantitative approach). The effective use of such an approach, could minimize resource expenditure during SDP assessments (given the state of practice in numerical CCF estimation) by focusing on risk-informed aspects rather quantitative refinements that may not provide additional clarity for robust decision making.

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