Multi-Module PRA Issues

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Critical Questions

• What is the definition of multi-module CDF?
• What are the categories of multi-module dependencies that should be considered in the PRA?
• What methods are useful to account for the dependencies in the PRA logic?
• Should we develop a single multi-module PRA model or a single-module PRA expanded for use to multi-module risk?
• Are there particular quantification considerations related to the multi-module logic PRA model?
Examples of Multi-Module CDF Definitions

• CDF as the frequency of an event (per year) involving the union of mutually exclusive sets of core damage events.

• CDF as as the frequency of events (per year) involving one OR more core damage occurrences (the so-called site CDF)

• Should significance of the effect of a core damage be formally accounted for in the CDF value? (i.e., one core damage event in a 150 MW(th) is equivalent to one core damage in a 3000 MW(th) reactor?)

• Does the NRC’s CDF guideline of 1.0E-4 /r-yr used as a surrogate for the cancer fatality QHO applies to a single unit or a plant site?
Categories of Dependent Events?

Other categorization? For example does the traditional “Cause” and “Coupling Factor” categorization used in common cause failure analyses applicable across modules?

From: SUSANNE SCHROER, MS THESIS, “AN EVENT CLASSIFICATION SCHEMA FOR CONSIDERING SITE RISK IN A MULTI-UNIT NUCLEAR POWER PLANT PROBABILISTIC RISK ASSESSMENT”, University of Maryland 2012.
Methods to Account for Dependencies

• Many models exist, more work needed to know their applicability.

• Schrorer’s model classification show applicability to LER events involving multi-unit events:
  – **Combination** (usually good for hard couplings-share components, shared initiating events)
  – **Parametric** (common cause failures across modules good for soft couplings)
  – **Causal-Based** (Dynamic spatial and intra-module causal human and hardware dependencies)
One Multi-Module PRA?

- Complexities of linking PRA modules of a single module into multi-module. One may take advantage of the symmetric properties of modules.
- Extending one-module PRA accident scenarios by including union of mutually exclusive scenarios involving all possible module-to-module dependencies.
- Decision of what do in this question also depends on the choice of definition of Core Damage event and CDF.
Summary

• Far more work and research would be needed to address the issues.
• Dynamic PRA concepts would be useful in identifying not so obvious dependencies.
• Dependencies in the Severe Accident regime need research.
• Definition of core damage and other risk measures need better definition for applications to multi-module SMRs