# MU-PRA Metrics and Safety Goals Implication

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### **Multi-Unit CDF Metrics**

- Three Possible MU-CDF Definitions:
  - CDF of one unit including <u>consideration of all states</u> of the other units (*marginal CDF Definition*)\*
  - Frequency of at least one or more core damages (total Site CDF Definition)
  - *CDF for multiple core damages (concurrent CDF Definition)*

\* Single unit PRAs include scenarios exclusive to one unit, assuming others will be unaffected



#### COPYRIGHT © 2017, M. Modarres Multi-Unit CDF Metrics (Cont.)



A multi-unit PRA (MUPRA) analysis for any of the proposed CDF metric requires assessment of the inter- and intra-unit dependencies



### MU Risk Implications on Safety Geats Modarres Quantitative Health Objectives (QHOs)

- NRC qualitative safety goals and QHOs still applicable to multi-unit sites.
  - Prompt fatality goal remains more restrictive than the latent cancer fatality goal in multi-unit releases
- Multi-unit risk should be below the QHOs for both prompt and latent fatalities
- For multi-unit releases, surrogates for QHOs (CDF, LRF and LERF) for site risk should be assessed and compared to goals
  - Would limits of 10<sup>-4</sup>, 10<sup>-6</sup>, and 10<sup>-5</sup> for these surrogates remain the same?



#### COPYRIGHT © 2017, M. Modarres Surrogate Multi-Unit LRF and LERF Metrics

- Three Options for Measuring LRF (surrogate for prompt fatality goal--NRC has not defined LRF yet)
  - Frequency of rapid, unmitigated release of airborne fission products that would result in at least one early fatality from the sites (NUREG/CR-6094 suggests a stationary individual one mile from plant)
  - 2. Frequency of site-level absolute or relative quantities of radionuclides released (absolute expressed in terms of activity released, relative in terms of the percent of available inventory—usually of I-131 or Cs-137)
  - 3. Frequency of pre-set site-level plant states: physical condition of systems, states of pressure boundaries and radionuclide barriers at the time release begins
  - The prompt fatality in the safety goals applies to an average individual living in the region between the site boundary and 1 mile beyond.
  - The latent cancer fatality in the safety goals applies to an average individual living in the region between the site boundary and 10 miles beyond.

### Surrogate Multi-Unit LRF and ERF 2017, M. Modarres Metrics (Cont.)

- LERF (proposed by EPRI and adopted in RG 1.174 as the surrogate for prompt fatality goal)
  - U.S. NRC's definition: "the frequency of of significant, unmitigated releases in a time frame prior to effective evacuation of the close-in population such that there is a potential for early health effects." The use of system states to define magnitudes of release has been discussed in NUREG/CR-6596 for calculating LERF.
  - Note that the Commission rejected the recommendation to use LERF (10<sup>-5</sup>/year) in place of LRF (10<sup>-6</sup>/year) in the Safety Goal Policy statement.

LRF appears to be a more appropriate surrogate for sequences involving multi-unit site-specific

#### Conclusions

- Multi-unit accidents are important contributors to site risks
- Site-level CDF and LRF as surrogates to latent cancer and prompt fatality QHOs need better definition in MUPRA
- Contribution from multi-unit accident scenarios reduce margin to QHO.
- Seismic event hazard dependency research a possible path to developing dependencies in unit response and fragilities
- Societal and disruption risks quantitatively monetized would be a critical addition to the QHOs



## Questions?

