U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Advanced Reactors Instrumentation and Controls (I&C) Licensing Workshop

USNRC Headquarters
Rockville, Maryland 20850

March 14, 2024

Agenda

- Background
- Introduction
- Topics
  - Path forward for non-LWRs to address the Commission's expanded policy in SRM-SECY-22-0076 on digital I&C common cause failures (CCFs): Dinesh Taneja, NRC
  - Classification of a diverse backup system under NEI 18-04 addressing digital I&C CCFs: Ian Jung, NRC
  - Advanced Reactor Codes and Standards – Dr. Richard Wood, IEEE Representative
  - LMP Impacts to Post-Accident Monitoring – Ted Quinn and Wesley Steh, X-Energy
  - LMP Non-Safety-Related with Special Treatment Considerations – Alan Campbell, NEI
- Discussion of the next workshop
- Summary and conclusion

Background

- The U.S. Nuclear Regulatory Commission (NRC) is sponsoring public workshops on the instrumentation and controls (I&C) licensing for advanced reactors to discuss topics selected by the NRC staff and the industry stakeholders.
  - The NRC and the industry began discussions in 2022 to provide a forum for exchanging information.
  - Previous workshops were held on February 23, March 16, and April 4, 2023. Workshop meeting summaries are available on newly added webpage to the NRC advanced reactor rulemaking and guidance website dedicated to I&C
    - https://www.nrc.gov/reactors/new-reactors/advanced/modernizing/rulemaking-and-guidance/digital-instrumentation-and-control.html
- The workshops are part of the agency's efforts to make the safety reviews of advanced reactor licensing applications safety-focused, risk-informed, and performance-based.

Background

- The NRC has developed a risk-informed and performance-based licensing framework.
  - Regulatory Guide (RG) 1.233, endorsing NEI 18-04, issued in 2020.
  - Often called the Licensing Modernization Project (LMP)
  - Guidance under Advanced Reactor Content of Application Project (ARCAP) and Technology-Inclusive Content of Application Project (TICAP)
    - Interim Staff Guidance documents and RG 1.253 endorsing NEI 21-07 to be issued
- Design Review Guide (DRG) was issued in 2021 (ML21011A140) for I&C reviews by the NRC staff and is aligned with the LMP.
- Pre-application engagements are underway with a variety of prospective advanced reactor applicants regarding I&C.
  - Pre-application readiness assessments for X-energy and Natrium recently conducted
  - Feedback provided on white papers
  - Pre-application public meetings held

SRM-SECY-22-0076

- The Commission approved the staff's recommendation to expand the existing policy for digital I&C CCFs to allow the use of risk-informed approaches to demonstrate the appropriate level of defense-in-depth, subject to the edits provided
- The Commission directed the staff to clarify in the implementing guidance that the new policy is independent of the licensing pathway selected by the reactor licensees and applicants
- The Commission directed the staff to complete the final implementing guidance within a year from the date of the SRM (May 24, 2024)

NRC's Policy to Address Digital I&C CCFs in SRM-SECY-93-087

SRM-SECY-93-087 – "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," identifies four points to address digital I&C CCFs:

Point 1 requires a defense-in-depth and diversity (D3) assessment to demonstrate that CCFs have adequately been addressed.

Point 2 requires the D3 assessment analyze each postulated CCF for each event evaluated in the accident analysis using best estimate methods to demonstrate adequate diversity.

Point 3 requires a diverse means of actuation (manual or automatic) if a CCF could disable a safety function.

Point 4 requires diverse main control room displays and manual controls for actuation of critical safety functions.

Source: https://www.nrc.gov/docs/ML0037/ML003708056.pdf

NRC's Expanded Policy to Address Digital I&C CCFs

SRM-SECY-22-0076 – "Expansion of Current Policy on Potential CCF in Digital I&C Systems," identifies four points to address digital I&C CCFs:

- **Point 1:** The applicant must assess the defense in depth and diversity of the facility incorporating the proposed digital I&C system to demonstrate that vulnerabilities to digital CCFs have been adequately identified and addressed. The defense-in-depth and diversity assessment must be commensurate with the risk significance of the proposed digital I&C system.
- **Point 2:** In performing the defense-in-depth and diversity assessment, the applicant must analyze each postulated CCF using either best-estimate methods or a risk-informed approach or both. When using best-estimate methods, the applicant must demonstrate adequate defense in depth and diversity within the facility's design for each event evaluated in the accident analysis section of the safety analysis report.

  When using a risk-informed approach, the applicant must include an evaluation of the approach against the Commission's policy and guidance, including any applicable regulations, for risk-informed decision-making. The NRC staff will review applications that use risk-informed approaches for consistency with established NRC policy and guidance on risk-informed decision-making (e.g., Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," RG 1.233, "Guidance for a Technology-inclusive, Risk-informed, and Performance-based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors).

NRC's Expanded Policy to Address Digital I&C CCFs

- **Point 3:** The defense-in-depth and diversity assessment must demonstrate that a postulated CCF can be reasonably prevented or mitigated or is not risk significant. The applicant must demonstrate the adequacy of any design techniques, prevention measures, or mitigation measures, other than diversity, that are credited in the assessment. The level of technical justification demonstrating the adequacy of these techniques or measures, other than diversity, to address potential CCFs must be commensurate with the risk significance of each postulated CCF.

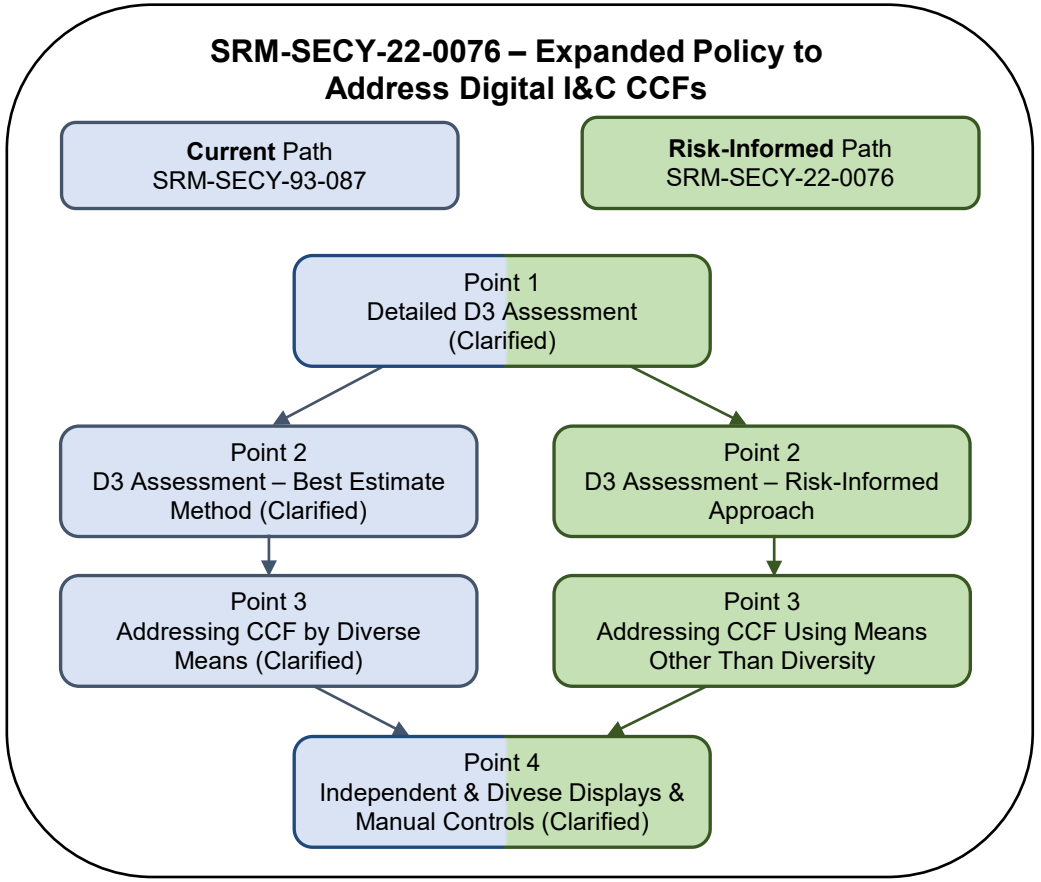
  A diverse means that performs either the same function or a different function is acceptable to address a postulated CCF, provided that the assessment includes a documented basis showing that the diverse means is unlikely to be subject to the same CCF. The diverse means may be performed by a system that is not safety-related if the system is of sufficient quality to reliably perform the necessary function under the associated event conditions. Either automatic or manual actuation within an acceptable timeframe is an acceptable means of diverse actuation.

  If a postulated CCF is risk significant and the assessment does not demonstrate the adequacy of other design techniques, prevention measures, or mitigation measures, then a diverse means must be provided.

- **Point 4:** Main control room displays and controls that are independent and diverse from the proposed digital I&C system (i.e., unlikely to be subject to the same CCF) must be provided for manual, system-level actuation of risk-informed critical safety functions and monitoring of parameters that support the safety functions. These main control room displays and controls may be used to address point 3, above. The applicant may alternatively propose a different approach to this point in the policy if the plant design has a commensurate level of safety.

Overview Diagram

The Current Path allows for the use of best estimate analysis and diverse means to address a potential Digital I&C CCF.



The Risk-Informed Path allows for the use of risk-informed approaches and other design techniques or measures other than diversity to address a potential Digital I&C CCF.

SRM-SECY-22-0076 and non-LWRs

- In SECY-23-0092, the NRC staff communicated to the Commission the following approach for addressing the expanded CCF policy for non-LWRs:
  - The NRC staff is using the guidance in the Design Review Guide (DRG) and RG 1.233
  - RG 1.233 is risk-informed and includes guidance on the adequacy of defense-in-depth
  - The DRG is aligned with RG 1.233; together with the SRM, they provide reasonable guidance for addressing DI&C CCFs
  - The NRC staff is using pre-application engagements to discuss use of the expanded policy with non-LWR applicants to address any questions or concerns
  - The NRC staff will communicate the Commission's policy to stakeholders during advanced reactor I&C public workshops

SECY-23-0092

In SECY-23-0092, “Annual Update on Activities to Modernize the U.S. Nuclear Regulatory Commission’s Digital Instrumentation and Controls Regulatory Infrastructure and License Amendment Requests,” the NRC staff informed the Commission of plans for updating implementing guidance addressing new policy for non-LWR DI&C reviews, in parts:

- *While the language used in the DRG does not clearly connect to the revisions of the four points in SRM-SECY-22-0076, the language does not preclude the reviewers from considering alternative approaches. Therefore, the NRC staff will use pre-application engagement to discuss use of the expanded policy with interested applicants to address any questions or concerns. The NRC staff plans to revise the DRG, and possibly RG 1.233, in the future. The revision will address the **differences in language** discussed above and reflect any **additional clarifications or improvements** based on lessons learned by the NRC staff and prospective applicants, input received from the stakeholders during the ongoing advanced reactor I&C public workshops, and other interactions.*

- The NRC staff also recognizes differences in definitions as well, such as, “critical safety function” in point 4 vs the definition of Required Safety Function in the LMP framework.

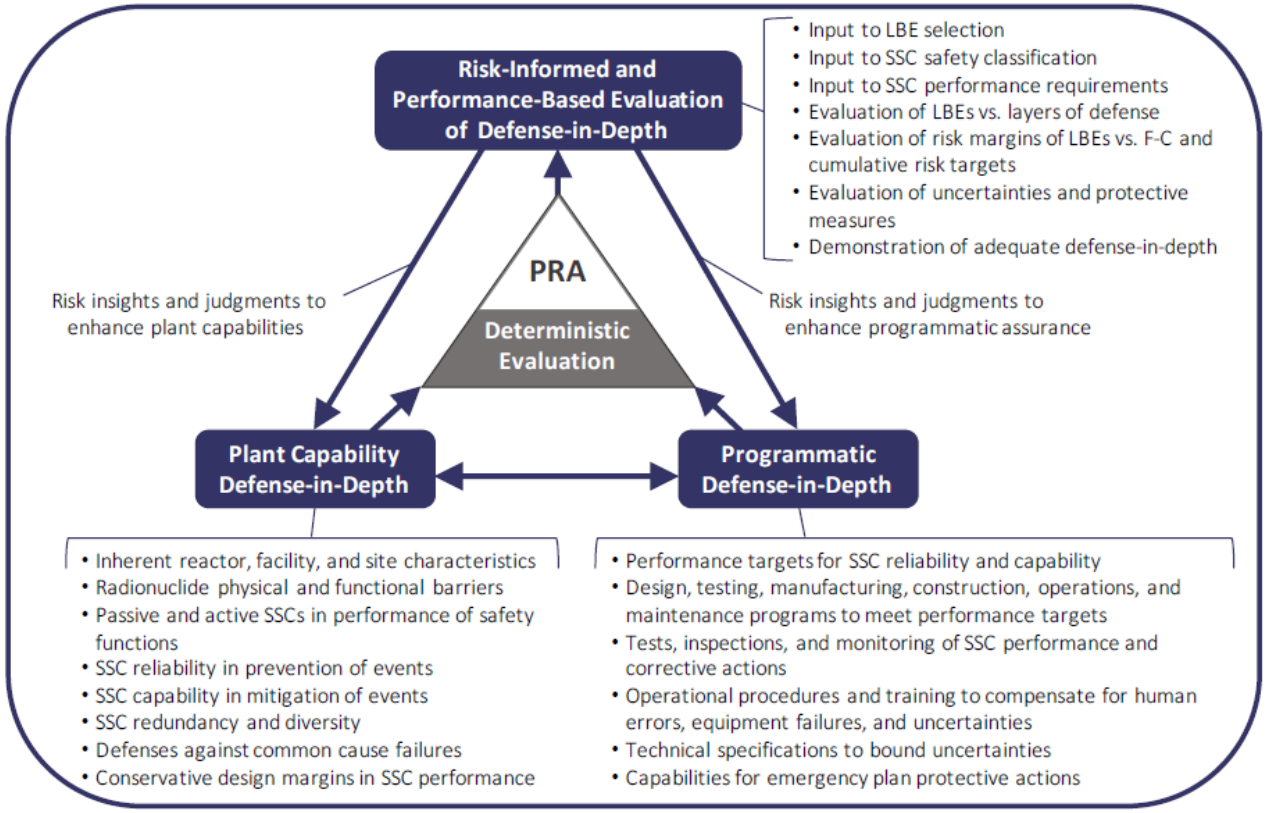


Figure 5-2. Framework for Establishing DID Adequacy

SRM-SECY-22-0076 and Non-LWR Guidance Differences

- Diversity is only an element of the adequacy of DID.

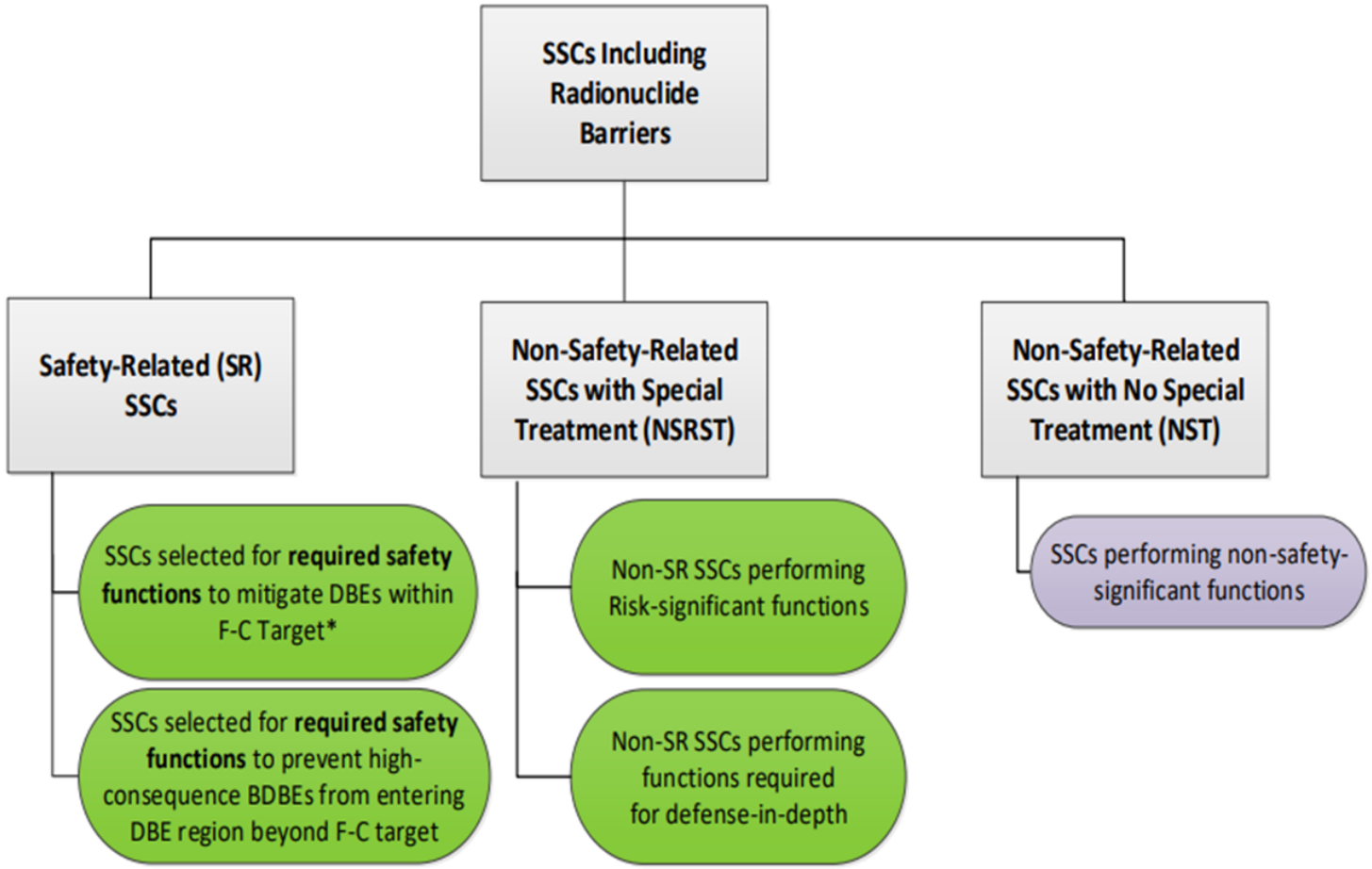
- RG 1.233 establishes the adequacy of DID via an integrated decision-making process that considers various elements of plant capability DID, programmatic DID, and risk insights and judgments.

Key Messages: SRM-SECY-22-0076 and non-LWRs

- The expanded policy provides a risk-informed option and is applicable to non-LWRs.
- Non-LWR designs are expected to meet the policy.
- The NRC staff uses RG 1.233 and the DRG, already risk-informed, to address the expanded policy.
- The NRC staff will work with near-term applicants via pre-application engagements.
- The NRC staff will discuss it with stakeholders (e.g., workshops).
- The NRC staff will revise the guidance (e.g., the DRG) based on lessons and feedback in the future.
- The industry stakeholders should identify any gaps related to the expanded CCF policy in DRG or RG 1.233.

Classification of a diverse backup system under the LMP addressing digital I&C CCFs

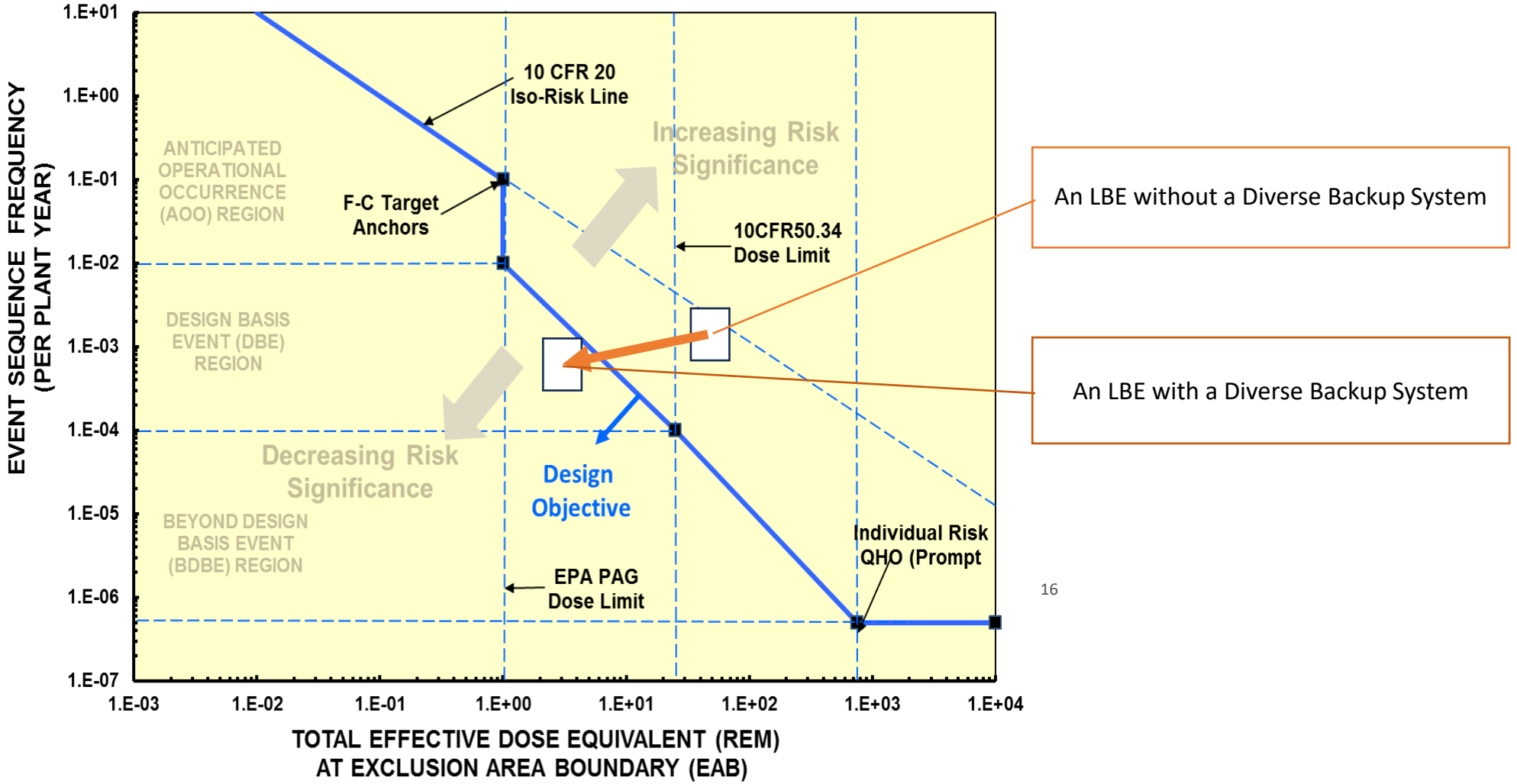
- The industry indicated there was a scenario that the LMP classification criterion directs a diverse backup system to be Safety-Related.
- Under the LMP, the classification of SSCs is determined as follows:



Safety-Related SSCs under the LMP

- Definition
  - SSCs selected by the designer from the SSCs that are available to perform the RSFs to mitigate the consequences of DBEs to within the LBE F-C Target, and to mitigate DBAs that only rely on the SR SSCs to meet the dose limits of 10 CFR 50.34 using conservative assumptions
  - SSCs selected by the designer and relied on to perform RSFs to prevent the frequency of BDBE with consequences greater than the 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C Target
- Scenarios may be possible for which the backup system would meet the Safety-Related SSC definition. For example,
  - Example 1: Both the primary system and the diverse backup system are needed to perform the RSFs to mitigate the consequences of DBEs to within the F-C Target.
  - Example 2: The diverse backup system is relied to perform RSFs to prevent the frequency of BDBE with consequences greater than the 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C Target.

Example 1


EVENT SEQUENCE FREQUENCY (PER PLANT YEAR)
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
TOTAL EFFECTIVE DOSE EQUIVALENT (REM) AT EXCLUSION AREA BOUNDARY (EAB)
10 CFR 20 Iso-Risk Line
ANTICIPATED OPERATIONAL OCCURRENCE (AOO) REGION
F-C Target Anchors
Increasing Risk Significance
10CFR50.34 Dose Limit
DESIGN BASIS EVENT (DBE) REGION
Decreasing Risk Significance
Design Objective
BEYOND DESIGN BASIS EVENT (BDBE) REGION
EPA PAG Dose Limit
Individual Risk QHO (Prompt
An LBE without a Diverse Backup System
An LBE with a Diverse Backup System

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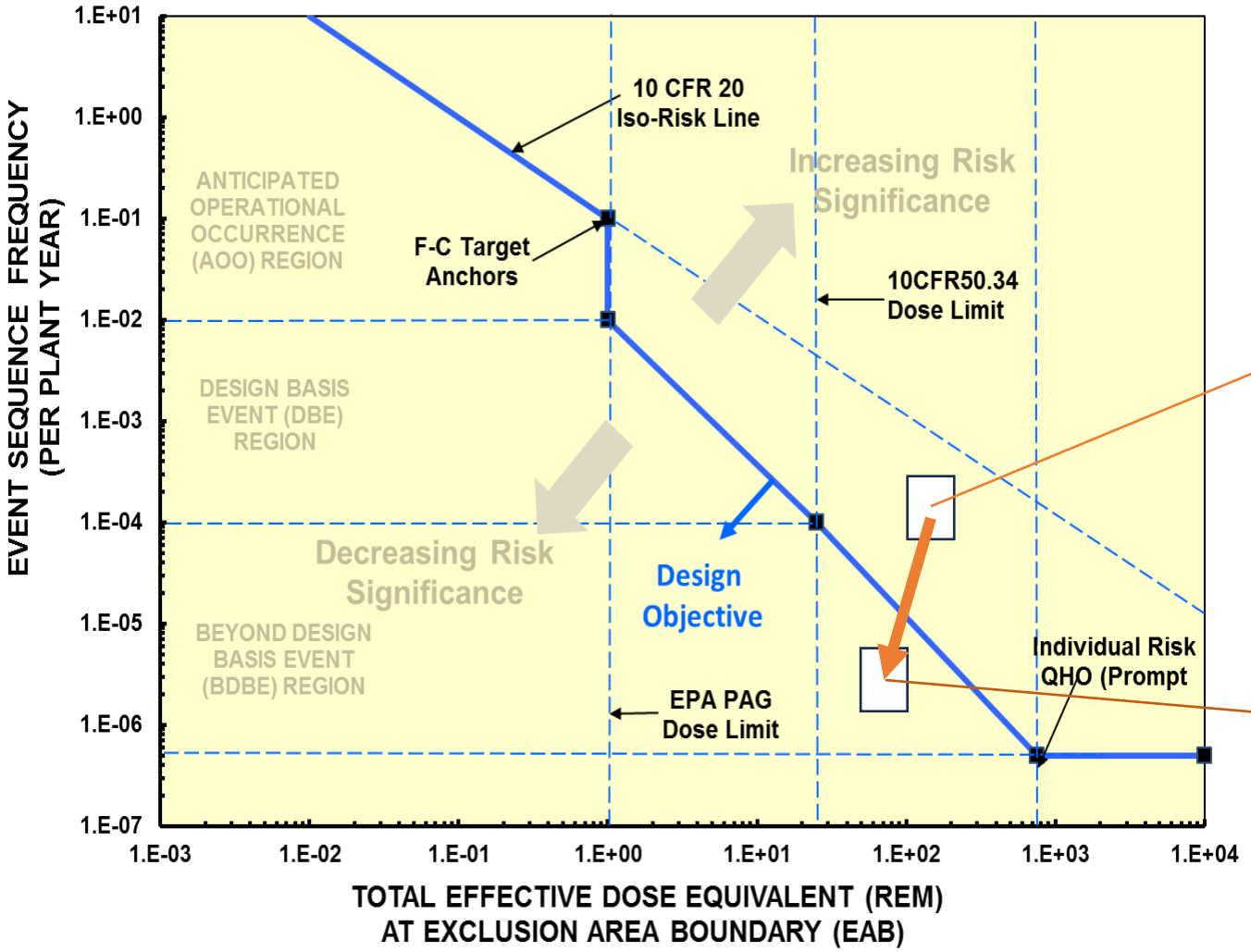
Example 2



An LBE without a Diverse Backup System

An LBE with a Diverse Backup System

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Perspectives

- The scenarios depend on specific designs and the possibilities are not unique to I&C. The scenarios are not likely but theoretically possible.
- For the diverse backup system:
  - The LMP process in RG 1.233, approved by the Commission in SRM-SECY-19-0117, is regulatory guidance, not a regulatory requirement.
  - SRM-SECY-22-0076 is applicable to advanced reactors including non-LWRs. Point 3 of the SRM-SECY-22-0076 states:

    "A diverse means that performs either the same function or a different function is acceptable to address a postulated CCF, provided that the assessment includes a documented basis showing that the diverse means is unlikely to be subject to the same CCF. The diverse means may be performed by a system that is not safety-related if the system is of sufficient quality to reliably perform the necessary function under the associated event conditions. Either automatic or manual actuation within an acceptable timeframe is an acceptable means of diverse actuation."
  - Therefore, the diverse backup system can be either Safety-Related or Non-Safety-Related with Special Treatment (NSRST) under the LMP.
  - Sufficient capability and reliability of the system, i.e., special treatment, is essential.
  - The iterative, systematic process of the LMP promotes improvements in design and operation of the plant using insights from various elements including deterministic and probabilistic risk analyses and integrated DID adequacy evaluation.
  - The NRC staff can work with prospective applicants on the issue.
- The NRC staff also understands that the industry is interested in continued discussion on the subject of 'special treatment of NSRST I&C equipment' and 'reliability analysis of I&C equipment'.

Questions

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