Idaho National Laboratory

MODULE P

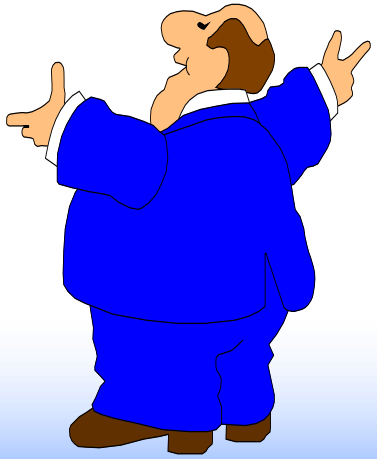
PLANT-SPECIFIC, RISK-INFORMED APPLICATIONS

Introduction to Risk-Informed Regulation

- **Purpose: Students will be introduced to the NRC PRA Policy Statement, Risk-Informed and Performance-Based Plan (RPP), concepts of risk-informed regulation, potential PRA applications, the principal steps in making risk-informed regulatory decisions, including the acceptance guidance contained in the Standard Review Plans (SRP).**
- **Objectives:**
  - **Understand the NRC PRA Policy Statement**
  - **Understand Risk-Informed and Performance-Based Plan**
  - **Understand general concepts of risk-informed regulation**
  - **List potential PRA applications**
  - **List the major elements of the decision logic used to review submittals containing changes to the current licensing basis and the role of the new Regulatory Guides and SRPs in this process, including the numerical decision criteria related to CDF and LERF**

PRA Policy Statement (1995)

- **General Objectives**
  - **Improve regulatory decision making and, therefore, safety**
  - **Make more efficient use of Staff resources**
  - **Reduce unnecessary regulatory burden on industry**



PRA Policy Statement

- **Use of PRA technology should be increased in all Regulatory matters to the extent supported by state-of-the-art in PRA methods and data and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy**
- **PRA and associated analyses should be used in Regulatory matters, where practical within the bounds of state-of-the-art, to reduce unnecessary conservatism associated with current Regulatory requirements, Regulatory guides, License commitments, and staff practices. Where appropriate, PRA should be used to support the proposal for additional Regulatory requirements in accordance with 10 CFR 50.109 (Backfit Rule). The existing rules and regulations shall be complied with unless these rules and regulations are revised.**

PRA Policy Statement

- **PRA evaluations in support of Regulatory decisions should be as realistic as practicable and appropriate supporting data should be publicly available for review.**
- **The Commission's safety goals for nuclear power plants and subsidiary numerical objectives are to be used with appropriate consideration of uncertainties in making regulatory judgments on the need for proposing and backfitting new generic requirements on nuclear power plant licensees.**

PRA Implementation Plan - Overall Objectives and Scope

- Agency-wide plan to implement PRA Policy Statement
- Included on-going and new PRA-related activities
  - e.g., maintenance rule, IPE program, generic safety issues
- Provided mechanisms for monitoring programs and management oversight
  - Defined, scheduled, and assigned responsibilities for staff activities needed to accomplish goals of PRA Policy Statement
- Encompassed activities in NRR, RES, former AEOD, and NMSS
- Informed Commission of staff progress via quarterly updates and briefings
- Replaced with Risk-Informed Regulation Implementation Plan (RIRIP) and reporting semi-annual (March 15, 2000)

Risk-Informed and Performance-Based Plan - Overall Objectives and Scope

- Name changed from (RIRIP) to the Risk-Informed and Performance-Based Plan (RPP) (April 26, 2007)
  - Older plan focused on risk-informed initiatives
- Goal is to achieve holistic, risk-informed and performance-based regulatory structure
- Will include publicly accessible database of activities
- Identify criteria for the selection and prioritization of practices and policies to be risk-informed and guidelines for implementation
- Identify major pieces of work associated with these efforts and related major milestones, including plans for communicating information to stakeholders
- Commission informed of staff progress via annual updates and briefings (changed from semi-annual to annual October 27, 2009)

Risk-Informed Regulation

- **Insights derived from probabilistic risk assessments are used in combination with traditional engineering analyses to focus licensee and regulatory attention on issues commensurate with their importance to safety.**
- **Various approaches are used in the resulting regulations:**
  - **Prescriptive (e.g., design feature, program elements)**
  - **Performance-oriented (e.g., maintenance rule, Performance Indicators)**
  - **Risk-oriented (e.g., R.G. 1.174)**

NRC Applications of PRA

- **Monitoring reactor operations**
  - **Maintenance Rule**
  - **Mitigating System Performance Index (MSPI)**
- **Value impact analysis for potential changes to licensed reactor design and operations (backfits)**
- **Efforts to Risk-Inform 10 CFR 50**

Applications of PRA

- Licensing advanced reactor designs
- Reactor operations
  - Evaluation of changes to licensing basis
    - General guidance - R.G. 1.174
    - IST - R.G. 1.175
    - ISI - R.G. 1.178
    - Graded QA - R.G. 1.176
    - Tech. Specs. - R.G. 1.177
  - Inspections
    - Prioritization and planning of inspections
    - Evaluation of inspection findings
    - Evaluation of licensee use of PRA

Applications of PRA

- **Resource allocation**
  - **Regulatory requirements (e.g., NEI initiative)**
  - **Research (e.g., generic issue prioritization)**
  - **Regulatory analyses (e.g., generic issue resolution)**
- **Reactor design**
  - **Identify weaknesses in design**
    - **Risk-significant SSCs**
    - **Risk-significant accident scenarios**
    - **Risk-significant human actions**

Applications of PRA

- Standardized Plant Analysis Risk (SPAR) Models
- Events analysis and risk significance
  - Accident Sequence Precursors (ASP)
  - Significance Determination Process (SDP)
  - Management Directive 8.3
- Risk Monitors
- Non-reactor issues
  - Licensing high-level waste repository
  - Sealed sources
  - Spent fuel storage
  - Others

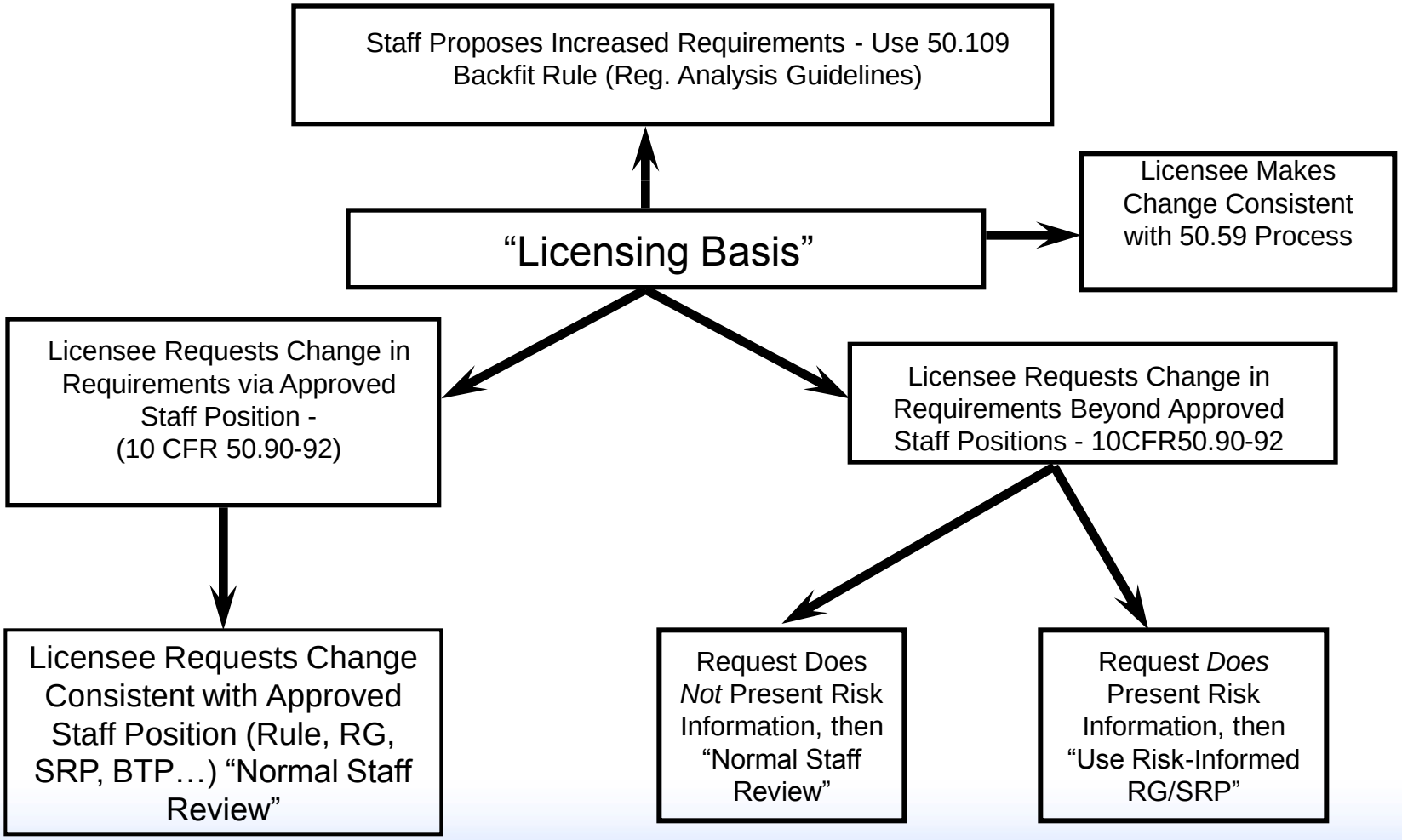
Factors Leading to Increased Use of PRA

- Recommendations of groups who reviewed TMI-2 accident
  - Increased use by NRC
- Challenger disaster
  - Increased use by NASA; relied largely on FMEAs before Challenger
- Chernobyl accident
  - Increased use for DOE reactors
- Drell report to U.S. Congress
  - Increased use for risk assessments of nuclear weapons systems
- Economic pressures
- Increased understanding and acceptance of methods
- Increasing availability of cheap, powerful computers

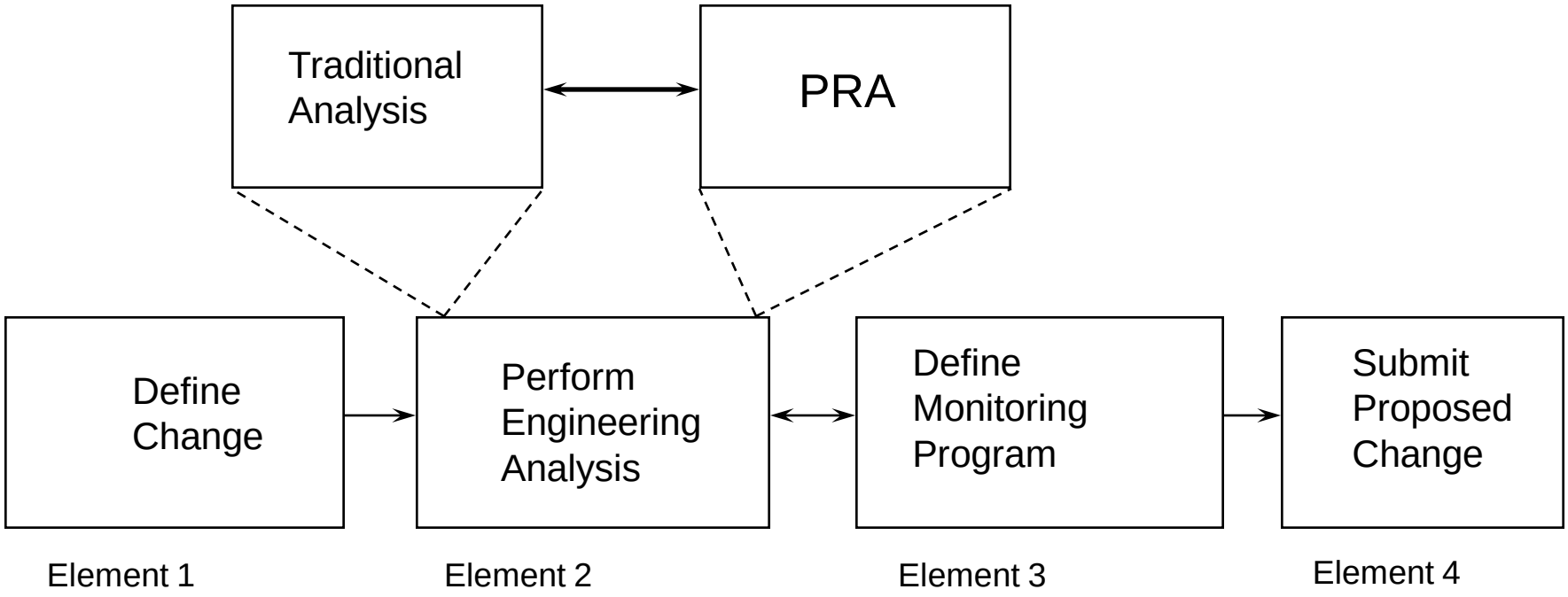
Risk-Informed Regulatory Guides and SRPs

Regulatory Guide	Standard Review Plan
• R. G. 1.174 - General guidance to licensees	• SRP Chapter 19 - General guidance to staff
• R.G.-1.175 - Application-specific guidance on in-service testing	• SRP Section 3.9.7 - Application-specific guidance on IST
• R.G. – 1.176 - Application-specific guidance on graded quality assurance	• Inspection guidance - under development Draft DG-1064
• R.G. – 1.177 - Application-specific guidance on technical specifications	• SRP Section 16.1 - Application-specific guidance on technical specifications
• R.G. – 1.178 - Application-specific guidance on in-service inspection	• SRP Section 3.9.8 - Application-specific guidance on ISI
• R.G. – 1.200 – An approach for determining technical adequacy of PRA results for risk-informed activities	• SRP Chapter 19.1 – Determining the technical adequacy of PRA results for risk-informed activities

Decision Logic for Submittal Reviews



Principal Elements of Risk-Informed Plant-Specific Decision Making



Principles of Risk-Informed Regulation

- The proposed change meets current regulations unless it is explicitly related to a requested exemption or rule change
- The proposed change is consistent with the defense-in-depth philosophy
- The proposed change maintains sufficient safety margins
- Proposed increases in core damage frequency and risk are small and are consistent with the intent of the Commission's Safety Goal Policy Statement
- The impact of the proposed change should be monitored using performance measurement strategies

Expectations from Risk-Informed Regulation (from RG-1.174)

- **All safety impacts of the proposed change are evaluated in an integrated manner as part of an overall risk management approach in which the licensee is using risk analysis to improve operational and engineering decisions broadly by identifying and taking advantage of opportunities for reducing risk, and not just to eliminate requirements the licensee sees as undesirable. For those cases where risk increases are proposed, the benefits should be described and should clearly outweigh the proposed risk increases. The approach used to identify changes in requirements should be used to identify areas where requirements should be increased, as well as where they could be reduced.**

Expectations from Risk-Informed Regulation

- **Acceptability of proposed changes should be evaluated by the licensee in an integrated fashion that ensures that all principles are met**
- **The use of core damage frequency (CDF) and large early release frequency (LERF) as bases for probabilistic risk assessment acceptance guidelines is an acceptable approach. Use of the Commission's Safety Goal Quantitative Health Objectives (QHOs) for this purpose is acceptable in principle and licensees may propose their use; however, in practice, implementing such an approach would require careful attention to the methods and assumptions used in the analysis, and treatment of uncertainties.**

Expectations from Risk-Informed Regulation

- **Increases in estimated CDF and LERF resulting from proposed changes will be limited to small increments and the cumulative effect of such changes should be tracked**
- **The scope and quality of the engineering analyses (including traditional and probabilistic analyses) conducted to justify the proposed change should be appropriate for the nature and scope of the change and should be based on the as-built and as-operated and maintained plant, including reflection of operating experience at the plant**
- **Appropriate consideration of uncertainty is given in analyses and interpretation of findings**
- **A program of monitoring, feedback, and corrective action should be used to address significant uncertainties**

Expectations from Risk-Informed Regulation

- **The plant-specific PRA supporting licensee proposals has been subjected to quality controls such as an independent peer review or certification**
  - **Note: Owner's groups have been conducting PRA reviews**
- **Data, methods, and assessment criteria used to support regulatory decision-making must be scrutable and available for public review**

Acceptance Guidelines

- **Defense-in-depth is maintained**
  - **A reasonable balance among prevention of core damage, prevention of containment failure, and consequence mitigation is preserved**
  - **Over-reliance on programmatic activities to compensate for weaknesses in plant design is avoided**
  - **System redundancy, independence, and diversity are preserved commensurate with the expected frequency and consequences of challenges to the system (e.g., no risk outliers)**
  - **Defenses against potential common-cause failures are preserved and the potential for introduction of new common-cause failure mechanisms is assessed**

Acceptance Guidelines

- **Defense-in-depth is maintained**
  - **Independence of barriers is not degraded**
  - **Defenses against human errors are preserved**
  - **The intent of the General Design Criteria in 10 CFR 50, App. A, are maintained**
- **Sufficient safety margins are maintained**
  - **Codes and standards or alternatives approved for use by the NRC are met**
  - **Safety analysis acceptance criteria in the licensing basis (e.g., FSAR, supporting analyses) are met, or proposed revisions provide sufficient margin to account for analysis and data uncertainty**

Acceptance Guidelines

- **Risk guidelines on following slides are met**
  - **Risk guidelines are intended for comparison with full-scope PRA results**
    - **Internal events (full power, low-power/shutdown)**
    - **External events (seismic, fire, etc.)**
    - **Use of less than full scope PRA may be acceptable in certain circumstances**

Mean Core Damage Frequency Acceptance Guidelines (RG 1.174)

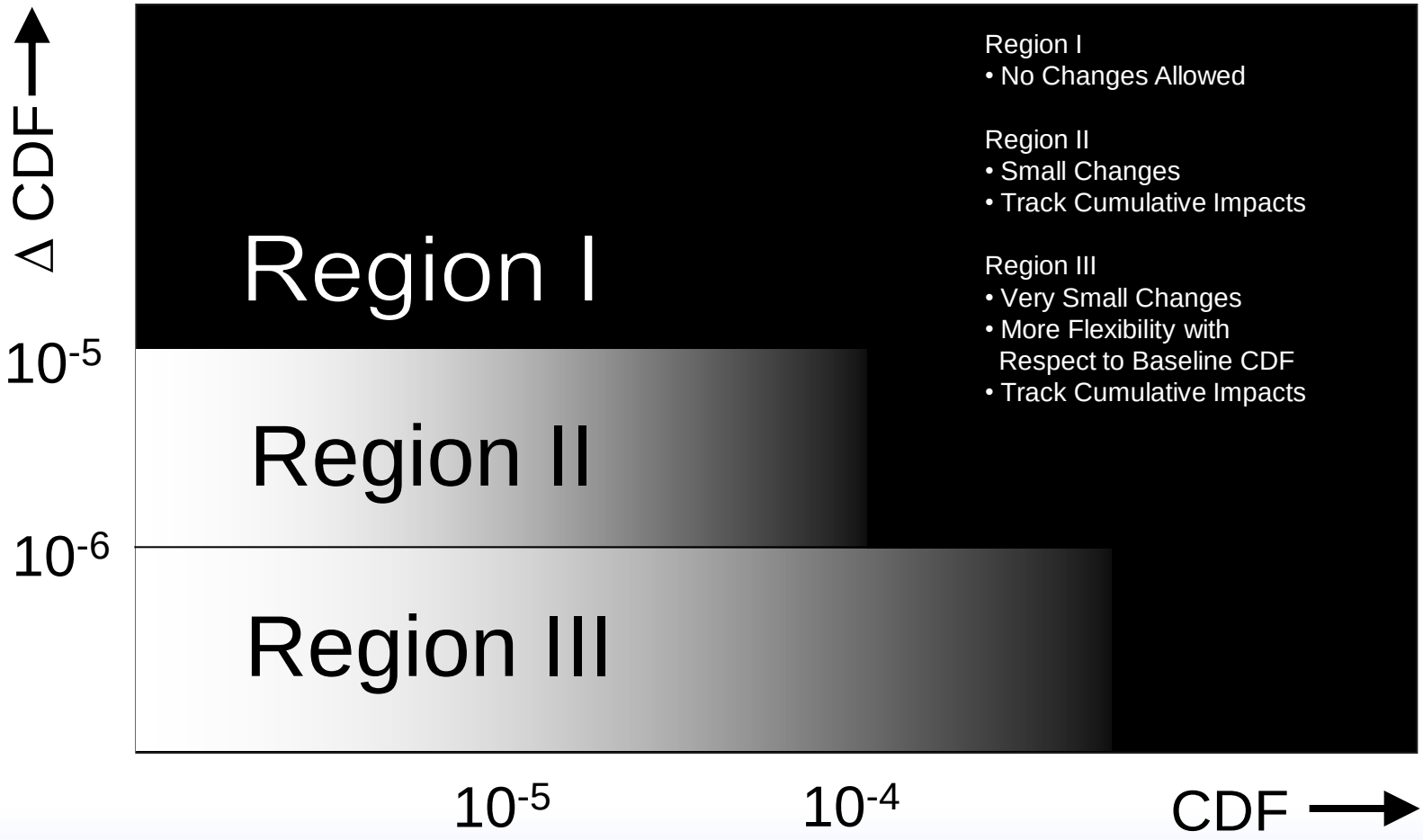


Figure 3. Acceptance Guidelines for Core Damage Frequency (CDF)

Mean Large Early Release Frequency Acceptance Guidelines (RG 1.174)

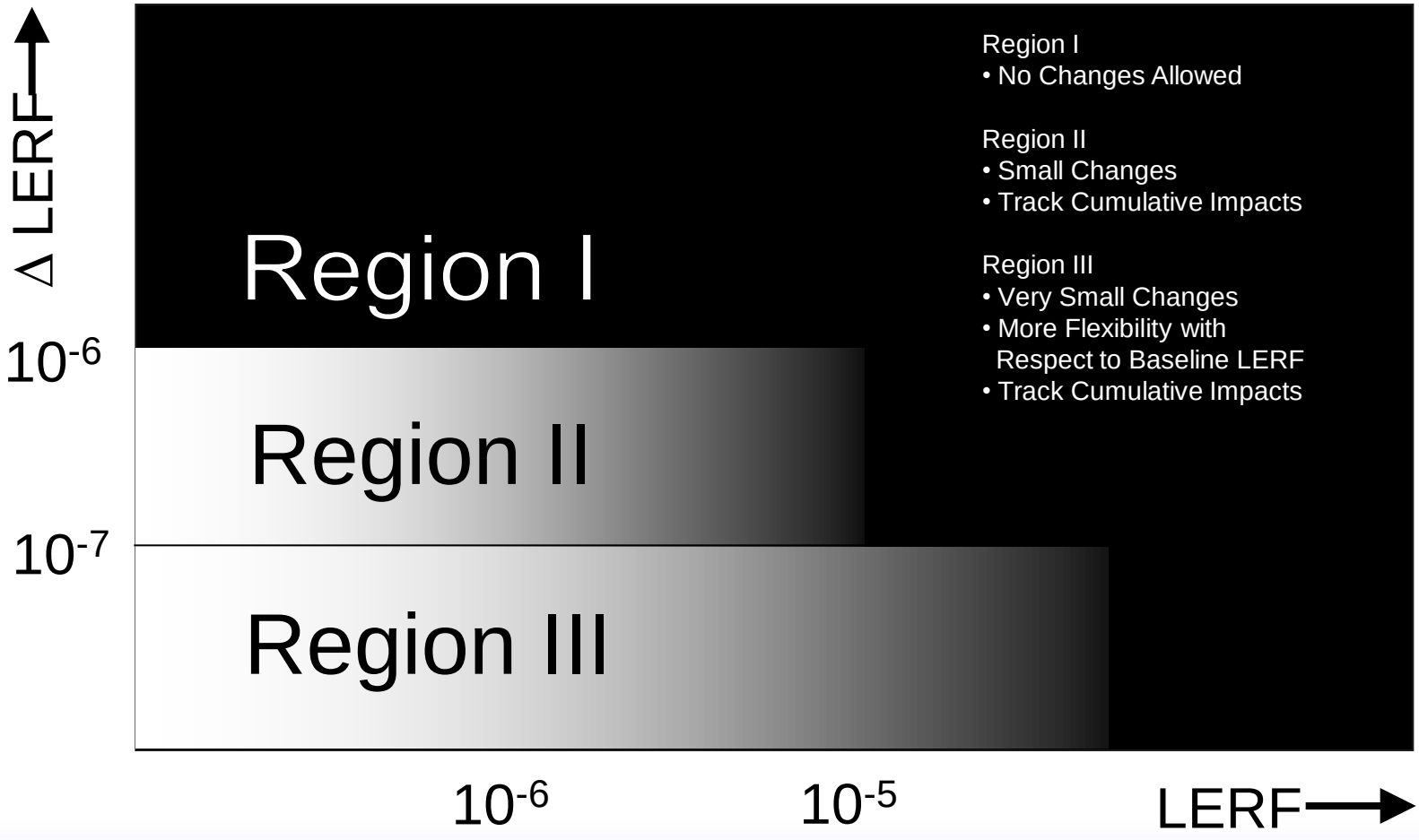


Figure 4. Acceptance Guidelines for Large Early Release Frequency (LERF)

Increased Management Attention

- **Application is given increased NRC management attention when the calculated values of the changes in the risk metrics, and their baseline values when appropriate, approach the guidelines. The issues addressed by management will include**
  - **Cumulative impact of previous changes and trend in CDF and LERF (licensee's risk management approach)**
  - **Impact of proposed change on operations complexity, burden on operating staff, and overall safety practices**
  - **Benefit of the change with respect to its risk increase**
  - **Level 3 PRA information, if available**

Consideration of Uncertainties

- Use mean values (not median) of CDF and LERF used for comparison with guidelines
- Identify important sources of uncertainty
  - Parameter
  - Modeling
  - Completeness
- Perform sensitivity calculations on parameter and modeling uncertainties
- Perform quantitative or qualitative analysis on completeness uncertainties
- Results of sensitivity studies should generally meet guidelines
- Region III - no need to calculate uncertainty on baseline CDF/LERF

Combined Change Requests

- Several changes can be combined in one submittal
- Will be reviewed against acceptance guidelines
  - Individually with respect to defense in depth
  - Cumulatively
- Combined changes should be related. For example
  - Be associated with same system, function, or activity
  - Changes reviewed individually against risk criteria if not closely related
- Combined changes should not trade many small risk decreases for a large risk increase (i.e., create a new significant contributor to risk)

Key Issues in PRA Quality

- **Ensure that, within scope, PRA analysis is complete and has appropriate level of detail**
  - **Consideration of relevant initiating events, plant systems, and operator actions**
  - **Analysis reflects plant-specific operating experience, design features, and accident response**
  - **All calculations are documented**
- **PRA methodology and associated input**
  - **Influence of models, input data, and assumptions on results and conclusions**
- **Licensee review and QA process**
  - **Peer review**
    - **Nuclear Energy Institute, "Probabilistic Risk Assessment Peer Review Process Guidance," NEI-00-02, Revision A3, March 20, 2000.**
  - **Certification**
  - **Standards**
    - **American Society of Mechanical Engineers, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, Addenda to ASME/ANS RA-S-2008," ASME/ANS RA-Sa-2009, February 2, 2009.**
    - **American Nuclear Society, "American National Standard External-Events PRA Methodology," ANSI/ANS-58.21-2007**
  - **Regulatory Guides**
    - **Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," March 2009.**

NRC Staff and Management Responsibilities

- Ensure that licensing submittals are identified and processed in accordance with risk-informed guidance
- Identify current requirements that could be significantly enhanced with a risk-informed and/or performance-based approach
- Ensure objectives of risk-informed regulation are met
  - Enhanced safety decisions
  - Efficient use of NRC resources
  - Reduced unnecessary regulatory burden on industry
- Ensure adequate staff training on use of risk-informed guidance and underlying PRA technical disciplines
- Maintain current levels of safety