Licensing Modernization Project (LMP)

First Working Meeting between NRC Staff and NEI

Regulatory Process Improvements for Advanced Reactor Designs

February 14, 2018 • USNRC Rockville MD

Agenda

- Discussion of Guidance Document (GD) Annotated Outline
- High level path to NRC endorsement of LMP guidance document
  - LMP vision
  - NRC vision
- Applicable NRC regulatory requirements
  - LMP insights
  - NRC insights
- LMP GD objectives for addressing those requirements
  - LMP insights
  - NRC suggestions
- Use of References
- Definitions
- NRC to suggest a content model to follow
  - Regulatory vs. Developer content

Discussion of Annotated Outline

- 1. Purpose
- 2. Background
- 3. Applicability and Scope
- 4. Process for Preparing Input for Application
  - 4.1 Overview
  - 4.2 Selection of LBE Event
  - 4.3 Safety Classification of SSC
  - 4.4 RIPB Defense in Depth

High Level Path to NRC Endorsement

The primary objectives of the LMP guidance document provide an means acceptable to the NRC of satisfying applicable regulations for non-light water reactors. NEI and industry will request NRC endorsement of the completed guidance document.

- RIPB LMP Guidance Document completed and approved as an NEI document by NEI management;
- NEI request for NRC endorsement via letter;
- Pending NRC approval, endorsement of RIPB LMP Guidance Document via appropriate regulatory vehicle.

Selected Regulatory Requirements

10 CFR Part 52 requires that the FSAR included in a license application must include the following content:

- 52.79(a)(1)(vi):· A description and safety assessment … . The assessment must contain an analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site under the radiological consequence evaluation factors …. In performing this assessment, an applicant shall assume a fission product release from the core into the containment assuming that the facility is operated at the ultimate power level contemplated.

- 52.79(a)(2):A description and analysis of the structures, systems, and components of the facility with emphasis upon performance requirements, …and the evaluations required to show that safety functions will be accomplished. It is expected that reactors will reflect … an extremely low probability for accidents that could result in the release of significant quantities of radioactive fission products.

- 52.79(a)(5): An analysis and evaluation of the design and performance of structures, systems, and components … provided for the prevention of accidents and the mitigation of the consequences of accidents.

Foundation of Regulatory Review

Similar requirements are reflected in the regulations associated with the Part 50 licensing path:

- 50.34 (a) for the PSAR
- 50.34(b) for the FSAR

These regulatory requirements center around the following underlying questions:

- What are the plant events and accidents that are associated with the design?
- How does the proposed design and its SSCs respond to those events?
- What are the margins provided by the facility's response, as it relates to radiological release limits and protecting public health and safety?

Challenge for Advanced non-LWRs

- The Standard Review Plan (NUREG-0800) for LWRs requires the applicant to propose AOOs and postulated accidents and includes examples applicable to LWRs only;

- Given the lack of a method for selecting LBEs, NUREG-0800 does not provide useful guidance for non-LWRs on this topic.
  - This creates significant uncertainty for reactor developers, future facility owner-operators, and the NRC staff.

- RIPB Guidance Document describes a set of acceptable processes for LBE selection, SSC classification, performance criteria and special treatment, and evaluation of DID.

LMP Guidance Document Objectives

The primary objectives of the LMP guidance document are to address this cross-cutting uncertainty by:

- Providing a technology-inclusive, risk-informed, and performance-based approach for selecting and evaluating licensing basis events, applying SSC safety classification, and evaluating DID adequacy for advanced non-LWRs
- Establishing this approach as an acceptable means for addressing and complying with the associated regulatory requirements, including those summarized above (50.34 or 52.79)
- Gaining formal NRC endorsement of this approach in a form that can be referenced and implemented by future applicants

Endorsement of this licensing approach also significantly reduces advanced reactor development uncertainty, since it establishes an approach that the designer can employ at an early stage to ensure effective risk management of challenges to the safety design process.

Use of References within GD

The RIPB LMP Guidance Document is based on a foundation of research and development stretching back decades to the present day. As an NRC endorsable document however, the GD is structured and written as a stand-alone document.

- No LMP white papers are incorporated by reference.
  - NRC Staff formal review and approval of LMP documents other than the GD is not intended.
  - External references provide history, context, detailed guidance for specific tasks, etc. and are not included for NRC endorsement.
- LMP seeks NRC feedback on this GD philosophy.

Definition of Key Terms

As has been previously noted, the RIPB LMP GD relies on decades of foundational work by the NRC Staff, national laboratories, and industry. In order to ensure understanding among readers of the RIPB LMP GD, the following is proposed:

- LMP and Staff identify a list of terms frequently used within the GD.
  - LMP and Staff propose terms at next working meeting for consolidation and discussion.
- End goal is to prepare an endorsable glossary of terms that have precise meaning within the GD.

Content Model Precedents

In seeking to provide an acceptable product to the NRC Staff, LMP requests NRC identify any NRC-endorsed documents that are particularly useful models for content and endorsement process steps.

- GD “licensing focus” vs. “design focus”.

ADDITIONAL BACKGROUND SLIDES

SSC Safety Classification

- 10 CFR 50.2: Safety-related structures, systems and components means those structures, systems and components that are relied upon to remain functional during and following design basis events to assure:
  - The integrity of the reactor coolant pressure boundary
  - The capability to shut down the reactor and maintain it in a safe shutdown condition; or
  - The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in § 50.34(a)(1) or § 100.11 of this chapter, as applicable.
- LMP approach for SSC safety classification based on keeping DBEs within F-C target and considers aspects of 10 CFR 50.69 safety significance categories with understanding that all LMP safety-related SSCs are regarded as risk-significant.
- QA requirements for safety-related SSC are consistent with 10 CFR 50, Appendix A.

Defense in Depth

- Defense in Depth is a general NRC philosophy, but regulatory guidance/process to determine defense in depth adequacy has not been developed
- LMP approach is consistent with historical philosophy and Commission policy
- NUREG/KM-0009, “Historical Review and Observations of Defense-in-Depth” was considered
- LMP approach considered related industry standards, including IAEA’s Safety Report Series No. 46, “Assessment of Defense in Depth for Nuclear Power Plants”

Draft B – 02/12/2018

- Includes….

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Advanced Reactor Guidance Documents

February 14, 2018

Bridge Number	Pass Code
(888) 793-9929	18396

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Advanced Reactor Program

- NRC Vision and Strategy: “Safely Achieving Effective and Efficient Non-LWR Mission Readiness” - December 2016
- Implementation Action Plans (IAPs)
- SECY-18-0011, “Advanced Reactor Program Status” - ML17334B217

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IAPs Strategy 3 Contributing Activities

1) Establish criteria, as necessary, to reach a safety, security, or environmental finding for non-LWR technologies
2) Determine appropriate licensing bases and accident sets for non-LWR technologies
3) Identify and resolve gaps in current regulatory framework associated with non-LWR reactors and the associated fuel cycle
4) *Develop a regulatory review "roadmap" reflecting design development lifecycle and appropriate interactions, including potential research and test reactor interactions*
5) *Update prototype reactor guidance*
6) Engage on technology- or design-specific licensing project plans and develop regulatory approaches commensurate with the risks posed by the technology
7) Support longer-term efforts to develop, as needed, a new non-LWR regulatory framework that is risk-informed and performance-based, and that feature staff review efforts commensurate with the demonstrated safety performance of the non-LWR NPP design being considered

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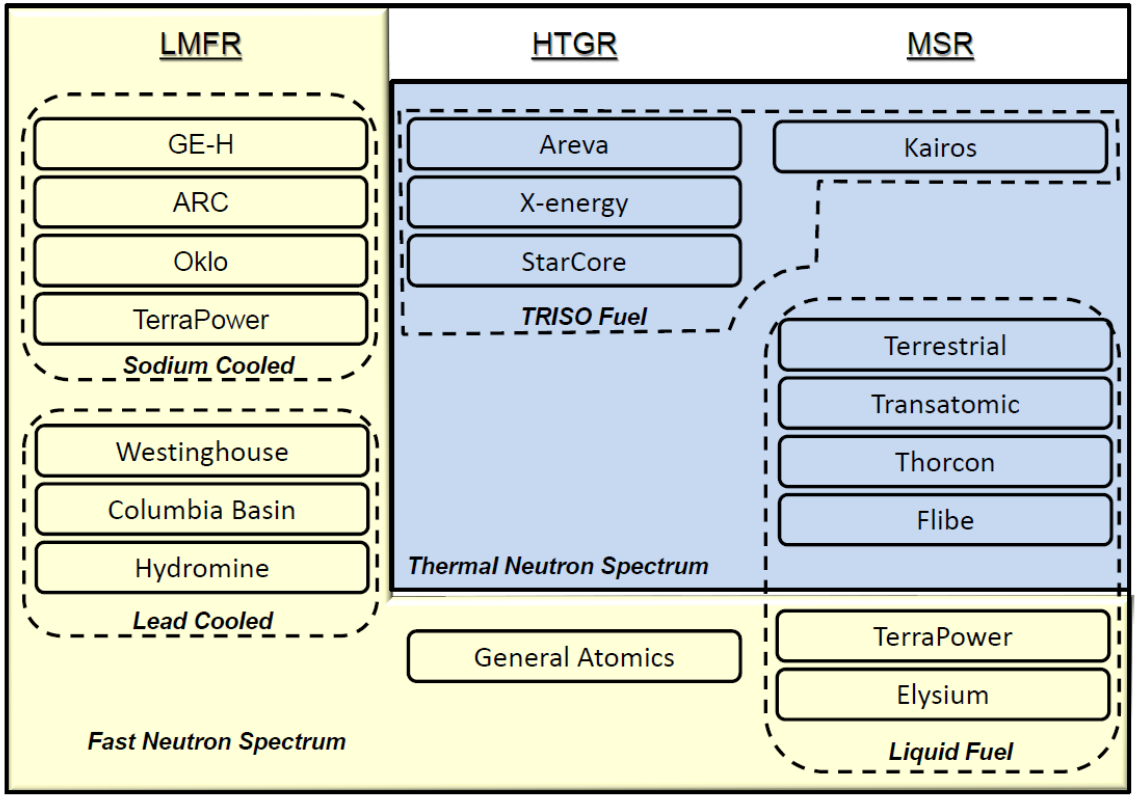
Advanced Reactor Landscape

- GOAL: As much as possible, develop technology-inclusive approaches



Technology working group (TWG) members

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All or selected topics to support critical decisions

- General Description of the Plant
- Site Characteristics
- Design of SSCs and Equipment
- Reactor
- Reactor Coolant and Connecting Systems
- Engineered Safety Features
- Instrumentation and Controls
- Electric Power
- Auxiliary Systems
- Steam and Power Conversion System
- Radioactive Waste Management
- Radiation Protection
- Conduct of Operations
- Verification Programs
- Transient and Accident Analyses
- Technical Specifications
- Quality Assurance and Reliability Assurance
- Human Factors Engineering
- Probabilistic Risk Assessment/Severe Accident Evaluation

RG 1.206
Chapters 1-19

- Emergency Planning
- Security
- Staffing
- Mitigating Strategies
- Aircraft Impact Assessment
- Environmental Report
- Financial
- Inspections, Tests, Analyses, and Acceptance Criteria
- Insurance
- Fuel Cycle
- Other (design or technology specific)

Other Parts of Applications & Possible Issues

Need for Discussions / Guidance on Format & Content ?

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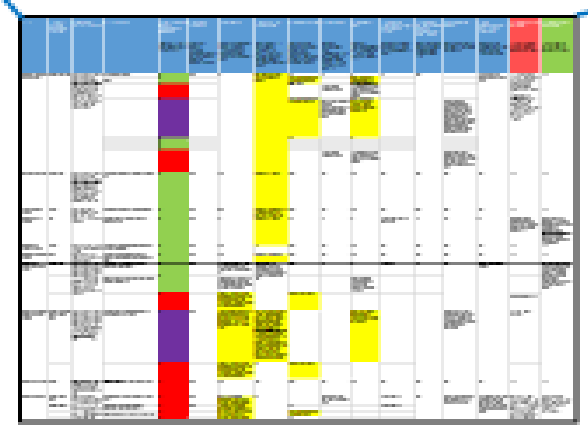
Format

Key Review Considerations

Safety-significance	Regulatory compliance	Novel design	Shared structures, systems, and components	Licensing approach

Safety margin	Defense-in-depth	Operational programs	Impact on safety functions	Additional risk insights	Other considerations

Review Tool



Output:

Scope and Depth of Review

- Provide supplemental approaches for implementation of NUREG-0800, Introduction - Part 2 and Design Specific Review Standard reviews
- Systematic thought process applicable to non-structure, system, or component and programmatic reviews

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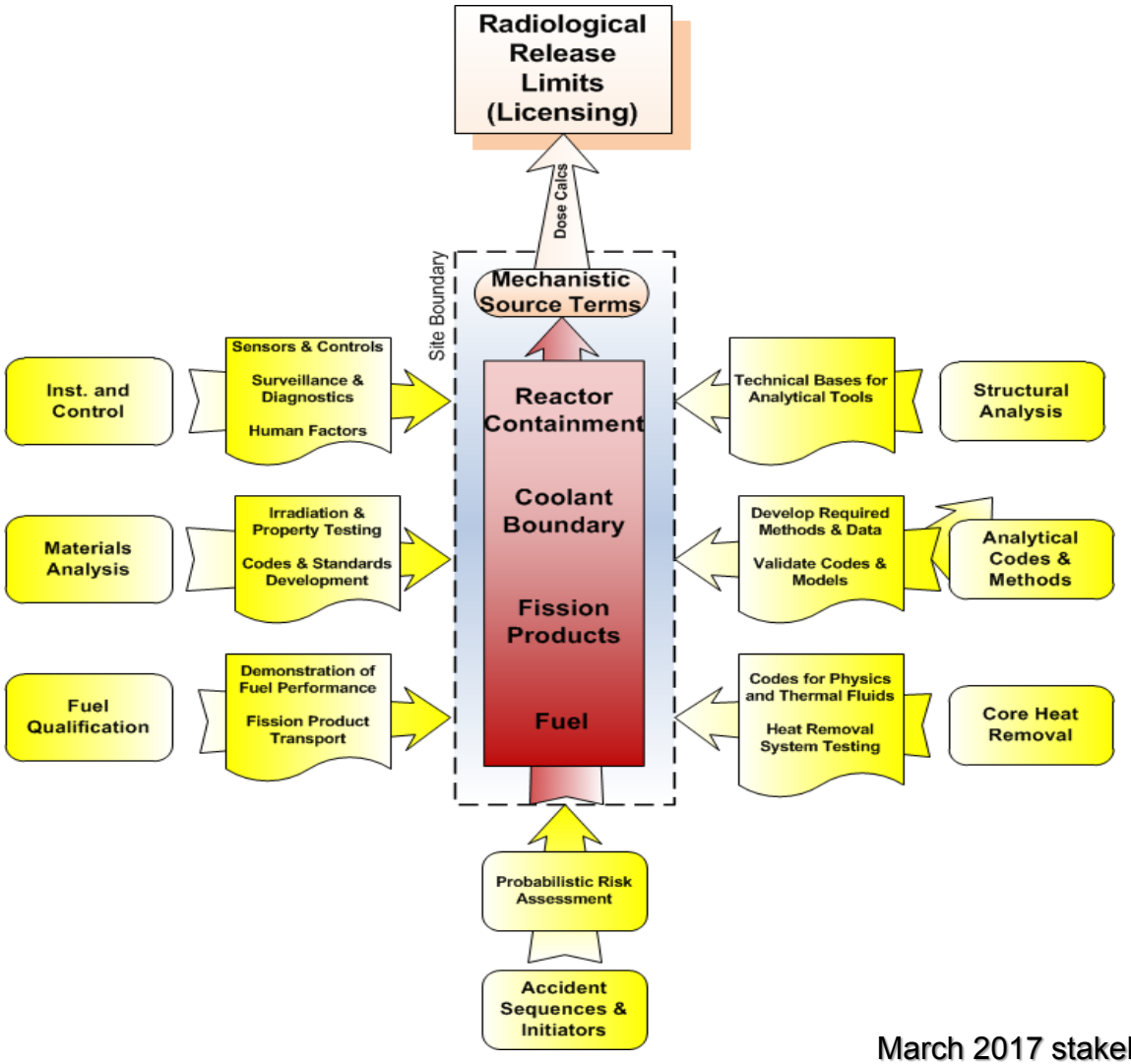
Key Inputs for Licensing (INL Figure)



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Staff Feedback
Licensing Basis Events (LBEs)

Framework

	Analysis Attributes/Documentation				How Analysis Supports Selected Regulatory Areas				
	Approach	Acceptance Criteria	Analysis QA Standard	Lic Basis Document	SSC Safety Class	Tech Spec	Procedures	Used for Siting (<25 rem)	Environ Reviews (SAMDA)
AOOs	Risk Assess (PRA)	SAFDL, SARRDL, Part 20	PRA Reg Guide (1.200*), 50.69, Realistic mean values	Chapters 15/19	Non-Safety systems with enhanced regulatory treatment (e.g. NSRST, RTNSS, 50.69, D-RAP, etc.)	50.36 criteria 1,2,3, or 4	Normal, Alarm, AOPs	No	No
DBEs		FPB (eg, SAFDL, SARRDL), F-C (PAG option)					EOP	Yes	
BDBEs		Safety Goal (PAG option)					Guidelines (eg.,SAMGs, FSGs)		Yes
Functional Containment Basis									
EP-basis		PAGs				No	EP		
DBAs	Deterministic	FPB, 50.34	Appendix B	Chapter 15	Safety Related	Yes	EOP	No	No
External Events	Probabilistic Hazards Analysis Role of "design basis external events (DBEE)"?	Facility protection requirements	PRA Reg Guide (1.200*), Realistic mean values	Chapters 2/3/19	Safety related for DBEEs?	Via equipment qualification Or 50.36 criteria 1,2,3, or 4	OPs, AdmPs, EDMGs	Yes	Yes

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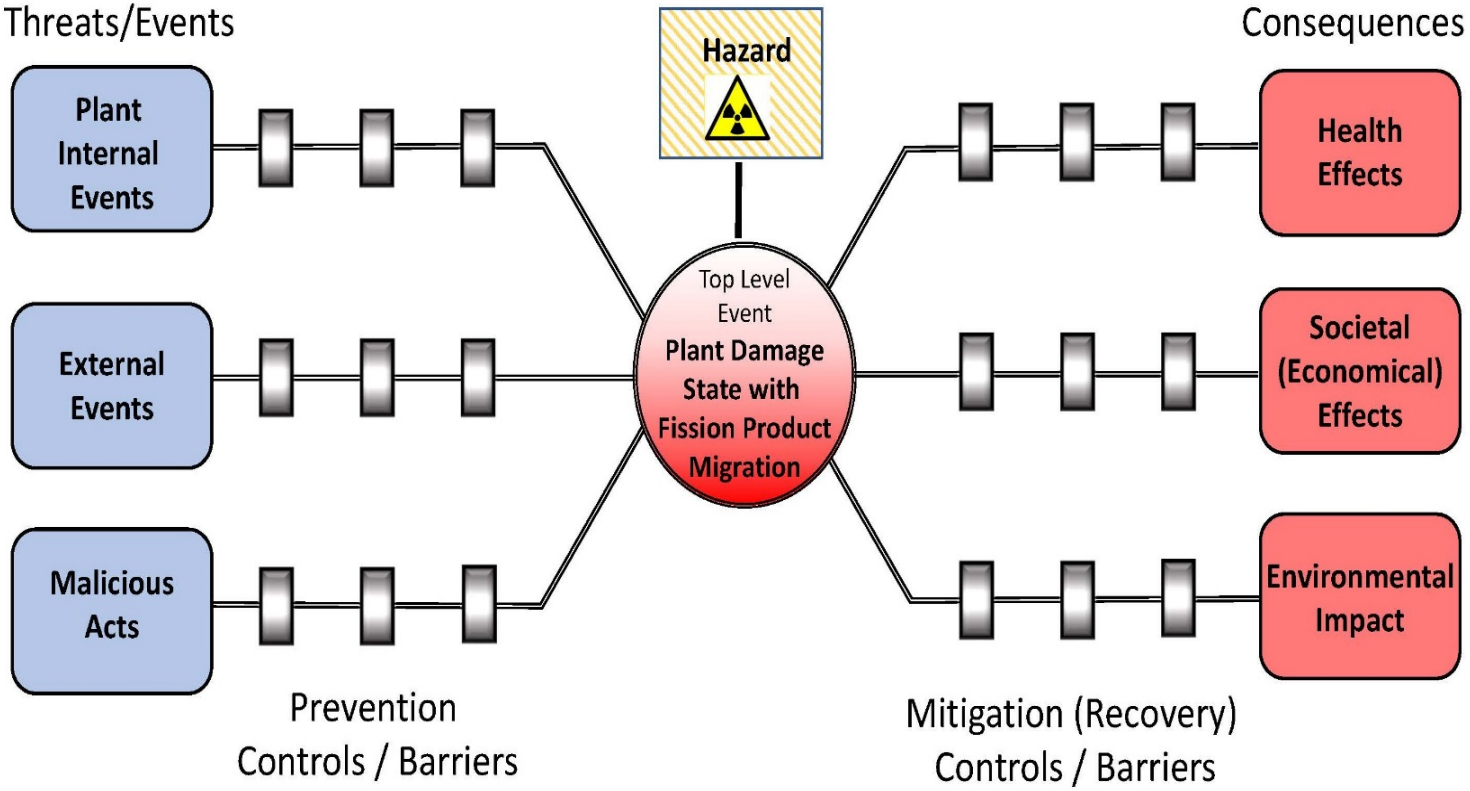
Integrating Activities



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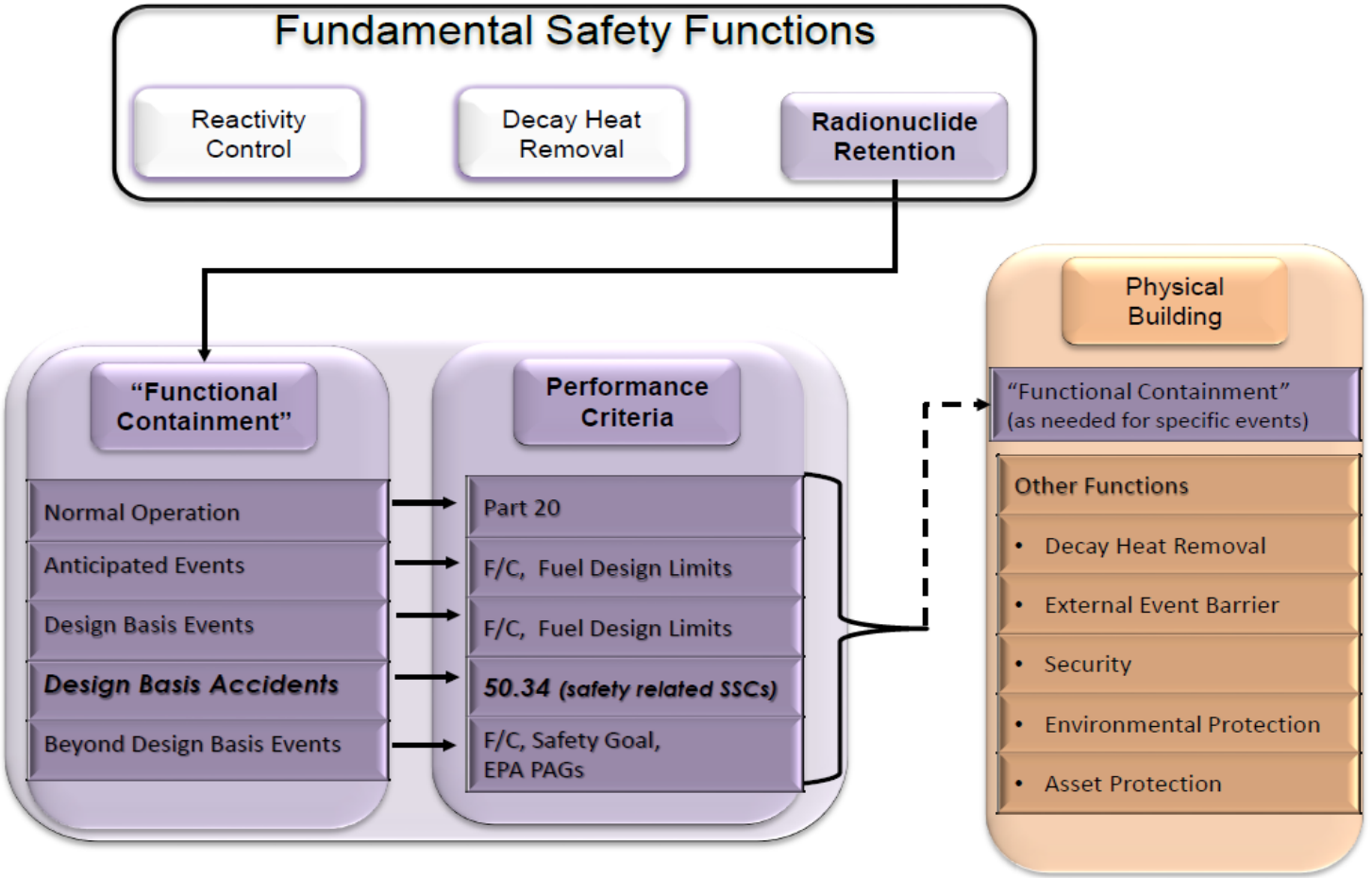
Methodology to Identify Performance Criteria



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Mechanistic Source Term

Mechanistic Source Terms White Paper *INL/EXT-10-17997*

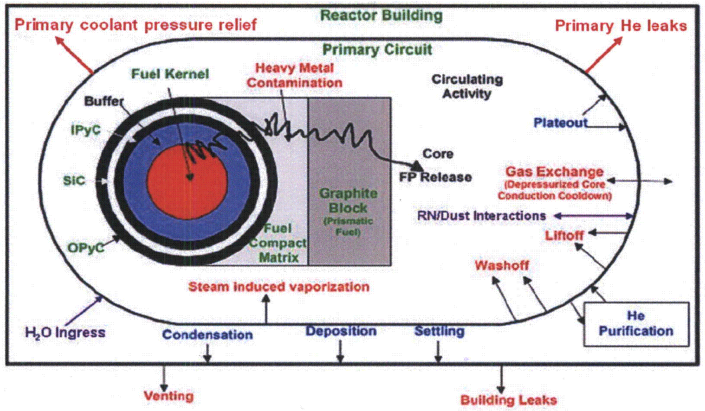

Figure 2-4. HTGR radionuclide retention system.

A Mechanistic Source Term Calculation for a Metal Fuel Sodium Fast Reactor

prepared by
David Grabaskas, Matthew Bucknor, James Jerden, Richard Denning (Consultant)

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Argonne National Laboratory
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Argonne, I

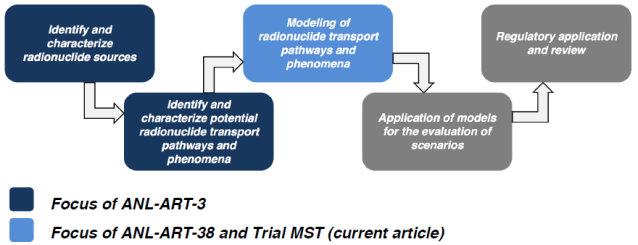

FIG. 1. MST Development Pathway and Project Reports

INL/EXT-16-40755
Revision 0

Department of Energy's
An Introduction to Current Practices at DOE

James O'Brien
DOE / HSS

Workshop on Risk Assessment and Safety Decision Making Under Uncertainty

September 2010

Implementing Guides and Standards

- Key Standards and Guides
  - DOE Standard 1027 – Facility Hazard Categorization
  - DOE Standards 3009 and 1189 – Safety Analysis Development
  - DOE Handbook 3010 – Airborne Release Fraction
  - DOE Guide 420.1-1 – Facility Safety Design
- Standards can be found at: https://www.directives.doe.gov/
- Guides can be found at: http://hss.doe.gov/nuclearsafety/ns/techstds/

NSR&D Program Fiscal Year 2015
Funded Research

Stochastic Modeling of Radioactive Material Releases Final Report

DBE dose consequence calculations traditionally use the "five-factor" formula:

$$ST = MAR \cdot DR \cdot ARF \cdot RF \cdot LPF \quad (1)$$

where ST is the source term (Bq), MAR is the total available material-at-risk (Bq), DR is the damage ratio (no units), ARF is the airborne release fraction (no units), RF is the respirable fraction (no units), and LPF is the leak path factor (no units).

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Guidance Document

- Applicable Regulatory Requirements
  - 10 CFR 50.34(a) (preliminary)
    - The safety features that are to be engineered into the facility …
    - The principal design criteria for the facility.
    - A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety…
    - An identification of those structures, systems, or components of the facility, if any, which require research and development to confirm the adequacy of their design…

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Guidance Document

- Applicable Regulatory Requirements
  - 10 CFR 50.34(b) (final)
    - A description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements ..
    - For nuclear reactors, such items as the reactor core, reactor coolant system, … shall be discussed insofar as they are pertinent.
    - A final analysis and evaluation of the design and performance of structures, systems, and components …
    - A description and evaluation of the results of the applicant's programs, including research and development, …
  - Similar content required in 10 CFR 52.47 (design certifications) and 10 CFR 52.79 (combined licenses)

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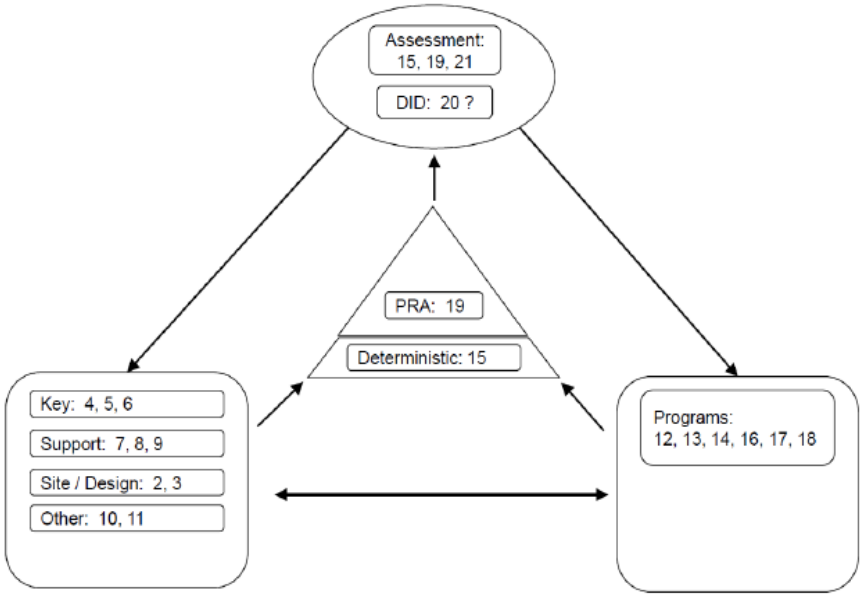
Comments/Questions
Defense in Depth White Paper

Much of the guidance and discussions relate to the design process. While important for the designer, the regulatory guidance document may need to focus more on the development of the licensing-related documentation. This will be a key point as the project moves toward developing the consolidated guidance document for NRC endorsement (i.e., is the NRC being asked to endorse a guidance document for designing or licensing an advanced reactor design?). See figure below for preliminary alignment of processes to support licensing documentation (in terms of FSAR chapters) – where assessments would not only support design process but also begin to define appropriate discussions (scope and level of detail) in safety analysis reports and other parts of applications.



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Related Examples

- RG 1.181, Content of UFSAR (NEI 98-03)
- RG 1.186, 50.2 Design Basis (NEI 97-04)
- RG 1.188, License Renewal Applications (NEI 95-10)
- RG 1.201, Categorizing SSCs (NEI 00-04)

- NUREG-0800 (SRP) Introduction – Part 2
  - *Enhanced Safety Focused Review*

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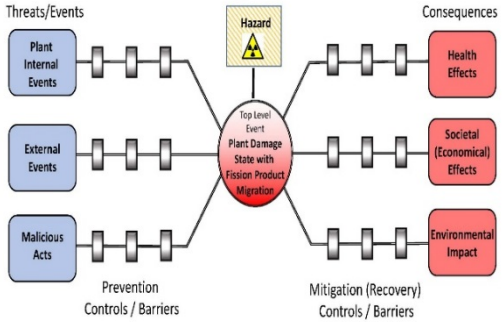
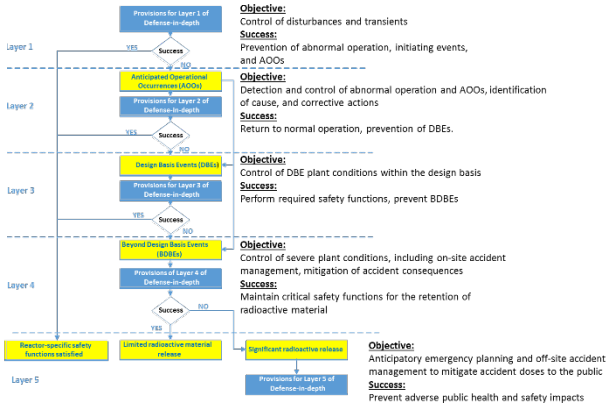
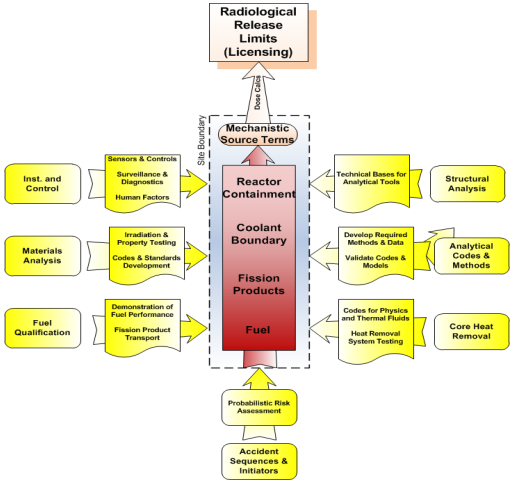
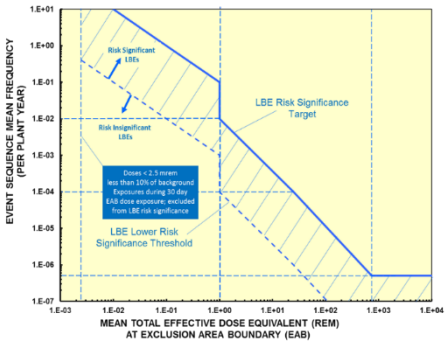
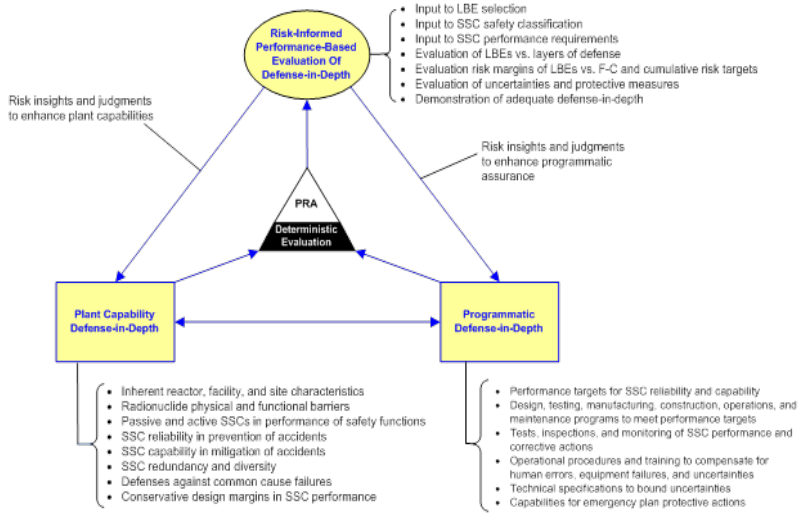
Some Assembly Required











Mechanistic Source Terms White Paper *INL/EXT-10-17997*

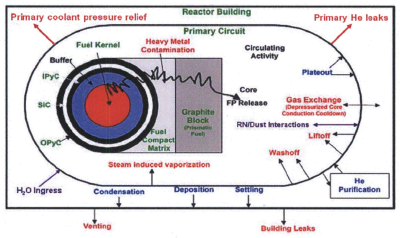


Figure 2-4. HTGR radionuclide retention system.

Discussion