Presentations for February 2, 2017 Public Meeting
on Advanced Reactor Regulatory Reviews

1) NRC Staff Presentation

2) Department of Energy Update

3) Nuclear Infrastructure Council Presentation

4) Nuclear Innovation Alliance Presentation on “Major Portions” of a Standard Design Approval

5) Nuclear Energy Institute Presentation – Licensing Technical Requirements Modernization Project (Licensing Basis Event Selection)

6) NRC Backup Slides used during discussion

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Public Meeting on Advanced, Non-light water Reactor Regulatory Reviews

Office of New Reactors

February 2, 2017

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Public Meeting

- Telephone Bridge

  (888) 570-6344

  Passcode: 3222936
- Opportunities for public comments and questions at designated times
- Please mute phones

  *6 – Self Mute/Unmute

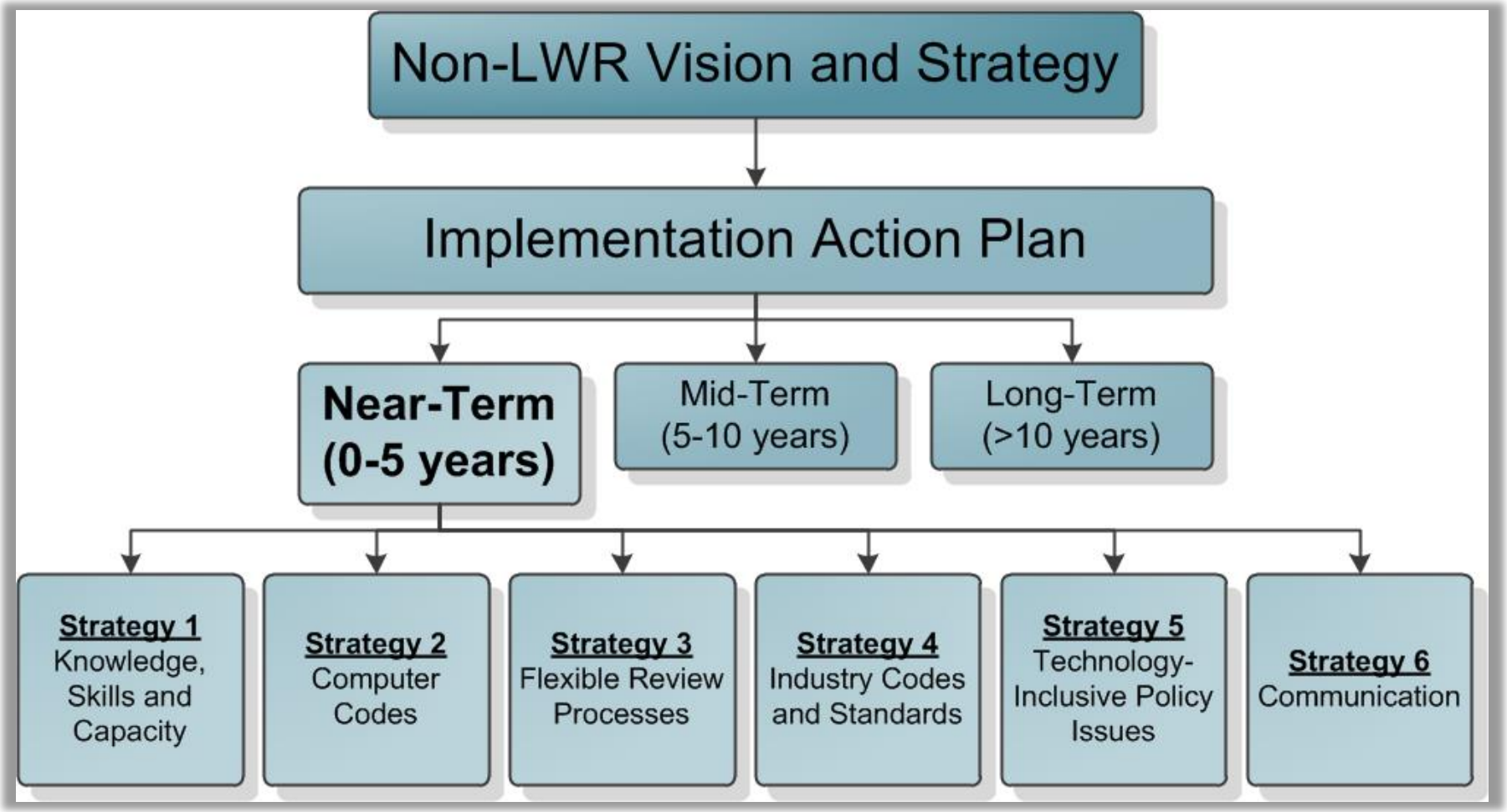
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Agenda

- Morning
  - Discussions
    - Vision & Strategies
    - Implementation Action Plans
    - Policy Issues
  - DOE Update
  - Nuclear Infrastructure Council
  - Nuclear Innovation Alliance
  - Agenda Items & Plans for Future Meetings
- Afternoon
  - Nuclear Energy Institute
  - Utility-Led Licensing Modernization Project

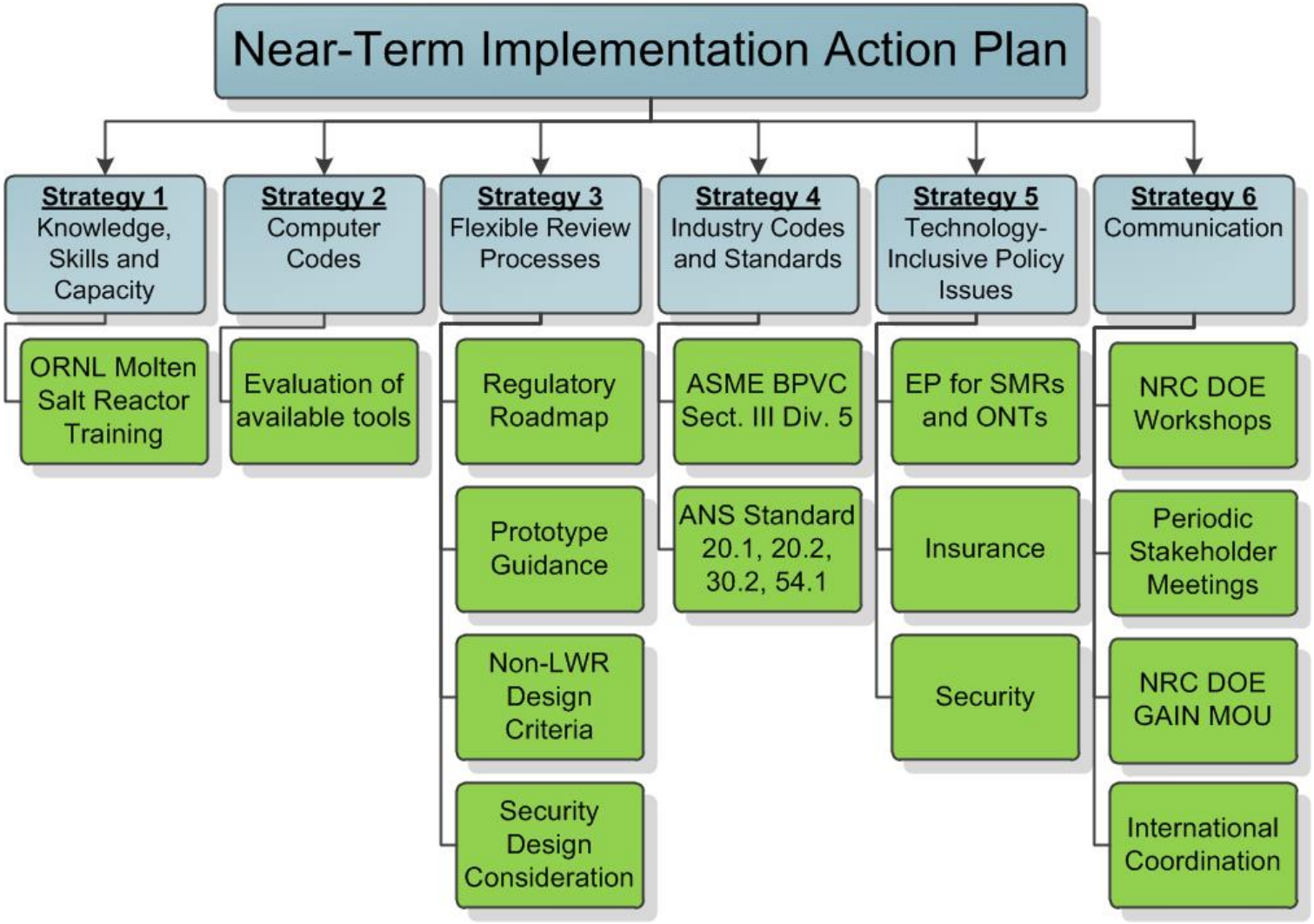
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Vision and Strategies
(Discussion)



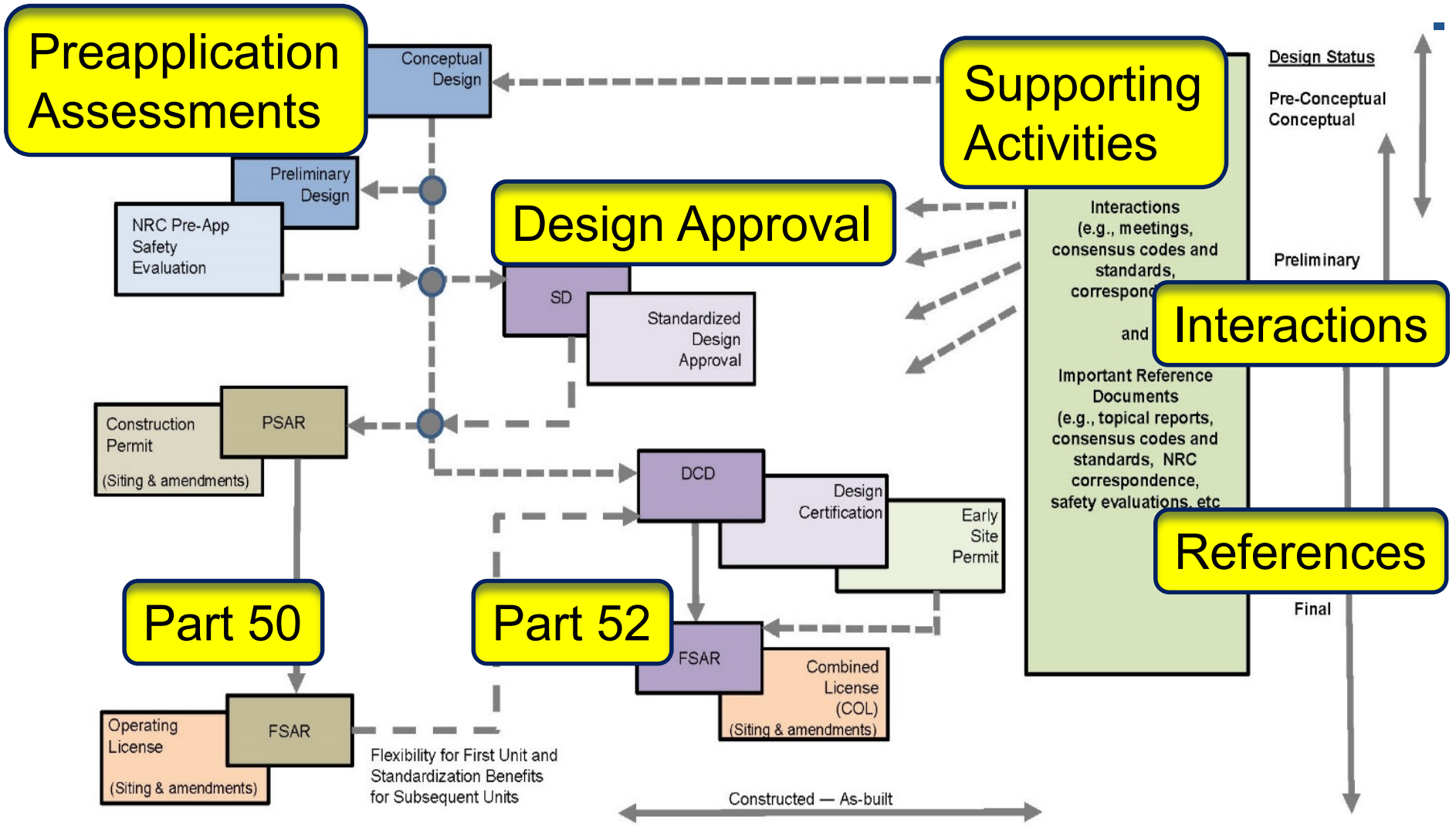
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Implementation Action Plans
(Discussion)



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Flexible Approaches



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Preliminary (preapplication) Design Assessments

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 ?

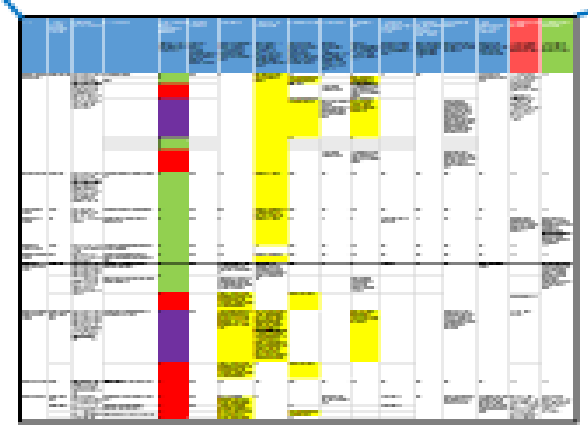
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Enhanced Safety Focused Review for SMRs

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

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Policy Issues – Future Topics ?

License for Prototype Reactors	Drafting white paper
License Structure for Multi-Module Facilities	SECY-11-0079
Appropriate Source Term, Dose Calculations, and Siting	SECY-16-0012
Offsite Emergency Planning (EP) Requirements	SECY-15-0077 Drafting Regulatory Basis
Annual Fees	Final Rule (May 2016)
Insurance and Liability	Evaluating for periodic report to Congress on Price-Anderson Act
Manufacturing License Requirements	Interest ?
Use of Probabilistic Risk Assessment in the Licensing Process	SRP Revisions (safety focused review)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Policy Issues – Future Topics ?

Key Component and System Design Issues	Design Specific
Operator Staffing for Small or Multi-Module Facilities	SECY-11-0098 (flexibility w/ existing guidance)
Operational Programs for Small or Multi-Module Facilities	SECY-11-0112 (flexibility w/ existing guidance)
Installation of Reactor Modules During Operation of Multi-Module Facilities	SECY-11-0112 (existing guidance)
Industrial Facilities Using Nuclear-Generated Process Heat	SECY-11-0112 (assess as necessary)
Decommissioning Funding Assurance	SECY-11-0181 (Site-specific exemptions)
Implementation of Defense-In-Depth (DiD) Philosophy for Advanced Reactors	SECY-15-0168 (part of licensing framework)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Policy Issues – Future Topics ?

Security and Safeguards Requirements for SMRs	NEI White Paper
Aircraft Impact Assessments	Issue ?
Licensing Basis Event Selection	Ongoing discussions
Fuel qualification, materials qualification	Issues vary by technology
Fuel cycle facilities, enrichments	
?	
?	

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Priorities for work and future meetings

Ongoing Topics

- Rulemaking for Emergency Preparedness for Small Modular and Other New Technologies
- Advanced Reactor Design Criteria
- Licensing Technical Requirements Modernization Project
- Physical Security Requirements for Advanced Reactor Technologies
- NRC periodic assessment of insurance and liability requirements
- NRC Implementation Action Plans
  (roadmap document, preapplication assessments, prototypes)
- DOE activities
- Design-specific preapplication interactions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Priorities for work and future meetings

Discussion

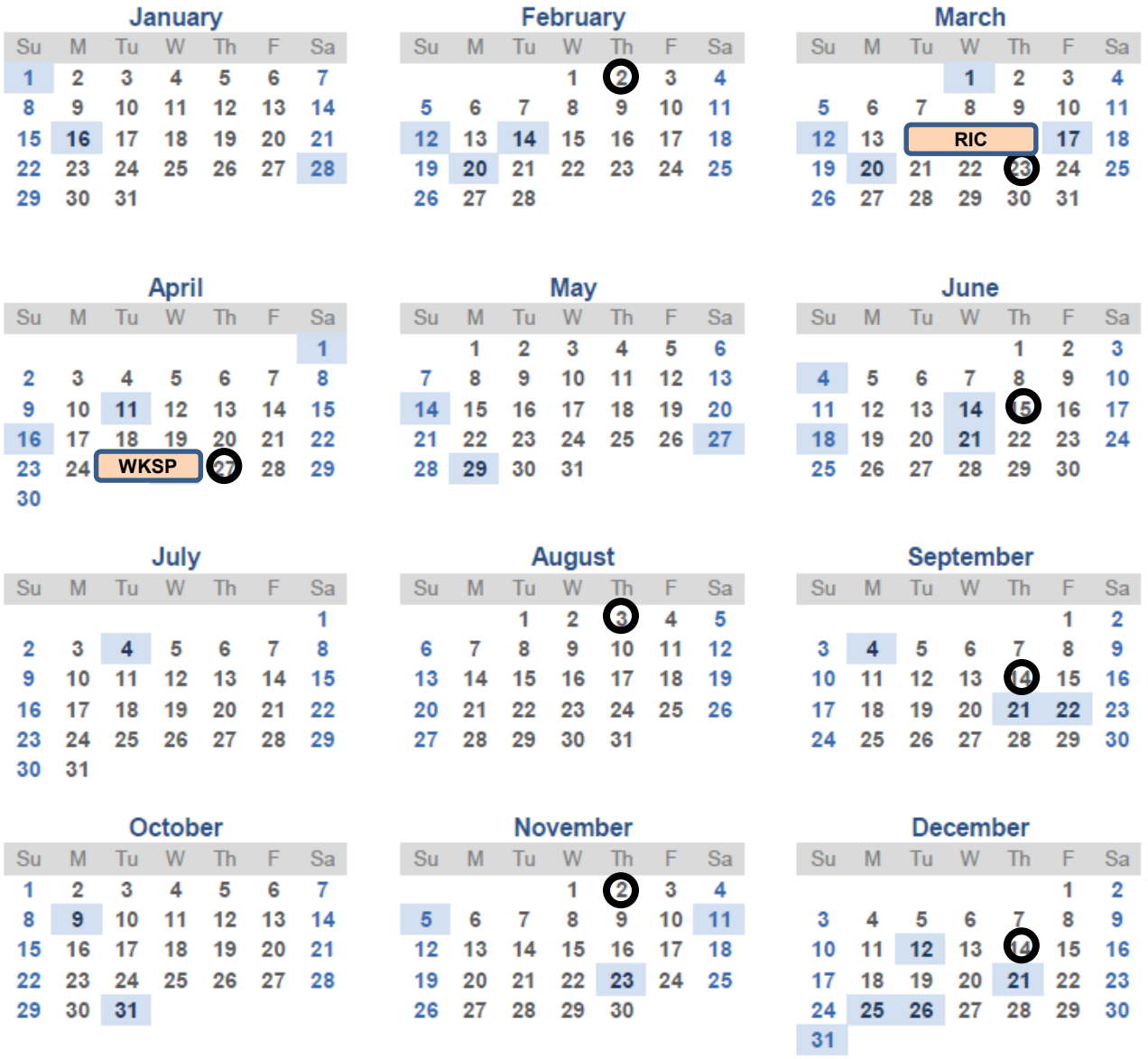
- What are we missing ?
- What is the most important ?
- What are we able to discuss at next meeting ?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

DOE Update

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

2017



Tentative Meetings

February 2, 2017
March 23, 2017 <change?>
April 27, 2017
June 15, 2017
August 3, 2017
September 14, 2017
November 2, 2017
December 14, 2017

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Regulatory Process Improvements for Advanced Reactor Designs

DOE Update

Office of Nuclear Energy

U.S. Department of Energy

February 2, 2017

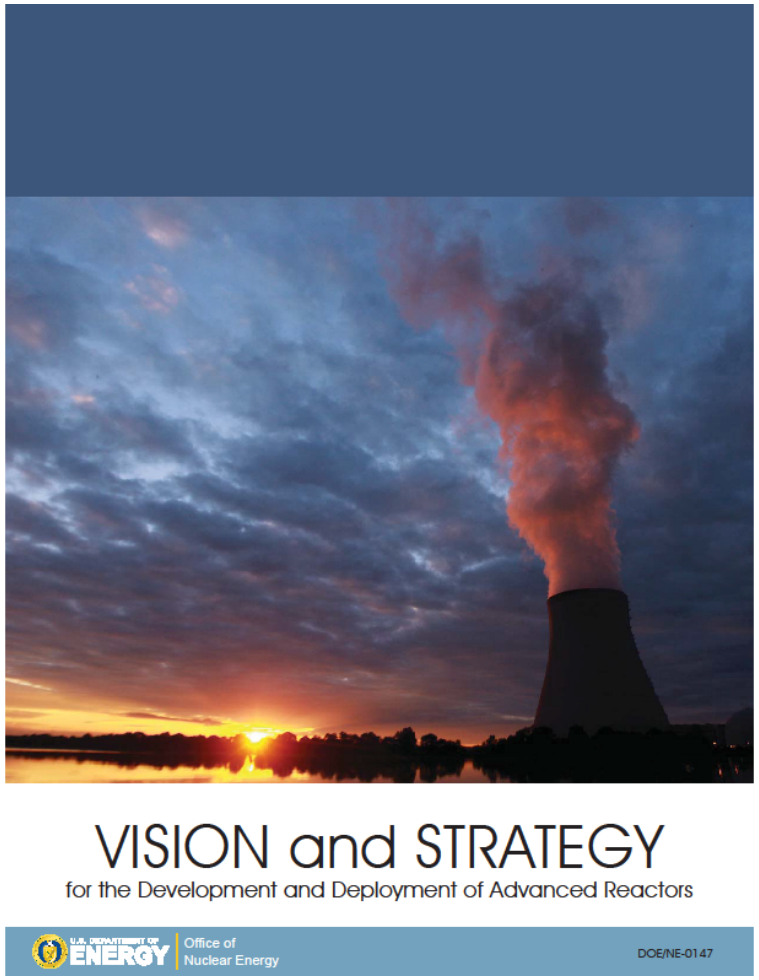
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

DOE Vision and Strategy

DOE recently issued its "VISION and STRATEGY for the Development and Deployment of Advanced Reactors"

https://energy.gov/ne/downloads/vision-and-strategy-development-and-deployment-advanced-reactors

- Aligned with NRC's Implementation Action Plan (IAP)
- Incorporates feedback from industry's review of May, 2016 draft
- Includes a near term focus on an NRC regulatory framework being established for advanced non-LWRs



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Regulatory Framework

Three key parts of the regulatory framework:

- **Research, Development and Analytical Tools**
  - Technical Readiness
  - NRC IAP Strategies 1 & 2
- **Address Policy Issues & Establish Licensing Technical Requirements**
  - Regulatory Readiness
  - NRC IAP Strategies 3, 4 & 5
- **Establish staged/phased review processes**
  - Regulatory Readiness
  - IAP Strategy 3

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Industry-Informed Research & Analytical Tools Development

- **GAIN Initiative - Industry Workshops**
  - Resulted in formation of 3 industry technology working groups being coordinated in conjunction with NEI
    - Fast Reactor
    - High Temperature Gas Reactor
    - Molten Salt Reactor
- **GAIN-EPRI Modeling & Simulation workshop (Jan. 24-25)**
  - Share DOE national lab M&S capabilities with advanced reactor developer community
  - Increase coordination, collaboration, and access to the national laboratory complex
- **Close coordination with industry stakeholders and DOE national laboratories is key**
  - Future workshop item: NRC discuss guidance and restrictions on shared development and use of analytical tools

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Establishing Licensing Technical Requirements

- **DOE-NRC joint initiative addressing adaptation of the LWR-based General Design Criteria (10 CFR 50 App. A)**
  - DOE adaptation proposal based on industry and national lab inputs
  - NRC effort nearing completion – draft NRC Regulatory Guide
- **Supporting the utility-led Licensing Technical Requirements Modernization Project**
- **Advanced Reactor Concepts awards for further technology and technical requirements development**
  - Southern team: Fluoride High Temperature Reactor - molten salt technology
  - X-energy team: HTGR technology

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Establishing Licensing Technical Requirements (cont.)

- **DOE pilot study - lack of consensus standards needed to support advanced reactor licensing**
  - Obtain a list of all standards used in the regulatory process
  - Select a few standards for an in-depth review (SFR pilot)
  - Estimate timelines for completion based on pilot sample set

- **Engagement in establishing international design criteria**
  - GIF Risk and Safety Working Group – SFR safety design criteria development
  - IAEA – Modular HTGR safety design criteria development

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Staged Regulatory Review Options

- **DOE engaged in options development through industry groups**
  - Nuclear Innovation Alliance (NIA)
  - Nuclear Energy Institute (NEI)
  - Nuclear Infrastructure Council (NIC)

- **DOE prepared to provide insights from its staged Critical Decision process for major projects**
  - Summarized in Strategy 3 of NRC's IAP

Regulatory Improvements in Advanced Reactor Designs

USNRC Meeting On Advanced Reactors Licensing

Jeffrey S. Merrifield: Chairman Advanced Reactors Task Force

U.S. Nuclear Infrastructure Council

February 2, 2017

Overview

- NIC commends the staff of the U.S. Nuclear Regulatory Commission (NRC) for organizing this meeting
- We appreciate the continuing opportunity to share our views on these important issues
- NIC serves as a leading advocate for Advanced Reactor technologies
- We appreciate the progress the NRC staff has made on this regulatory process
- NIC's comments today will focus on the December 2016 Vision and Strategy document and our related thoughts about the NRC Advanced Reactor licensing process

NRC Vision and Strategy

- On page 1 of the Executive Summary, the staff states that the NRC recognizes that "non-LWR vendors may wish to commence pre-application activities or submit applications for review in the near-term, in advance of DOE's deployment goal."
- NIC believes it is positive that the NRC is not tying itself to the DOE deployment goal
- However, the comment goes on to state that "(I)n those cases, the NRC will work with vendors on design-specific licensing project plans and the NRC *may* accelerate specific readiness activities as needed"
- NIC believes that the NRC should substitute the word "will" for "may"
- If the Agency needs additional resources to conduct these reviews, it should quantify those needs and request them from Congress. NIC continues to support off-the-fee-base funding for these activities
- It is the obligation of the NRC to conduct licensing reviews on applications that come before it, and it must follow a transparent and timely process to achieve that goal

NRC Vision and Strategy (2)

- On page 7, the document discusses the use of computer models and analytical resources and indicates that “the emphasis in the staff’s approach is to leverage, to the maximum extent practical, collaboration and cooperation…with the goal of establishing a set of tools and data that are commonly understood and accepted” NIC supports this approach
- In discussing policies on page 7, the staff emphasizes the need to identify policy decisions appropriate to govern the acceptability of non-LWR designs and recognizes several of these as well as some which may apply to both LWR and non-LWR designs
- NIC supports the need to readily identify these policy issues and will be convening a meeting of its Advanced Reactors Technology Owners Group next week in Chicago to discuss this issue
- It is NIC’s goal to provide a prioritized roadmap to the NRC of those policy issues that the Technology Owners Group believe are most critical to the Advanced Reactor Community
- While NIC appreciates the opportunity to discuss these issues at a staff level, it is interested in the engagement of the Commissioners in this dialog and hopes this will be a topic of focus at the RIC coming up next month

NRC Vision and Strategy (3)

- On page 9, NIC appreciates the change in the document recognizing the role that NIC plays in representing the Advanced Reactor community
- However, also on page 9, NIC continues to be concerned regarding the language discussing the prioritization of review and the NRC identification of which “particular technologies are more likely to become ready for the agency’s regulatory reviews”
- NIC continues to believe that the role of the Agency is to establish a set of risk informed performance based licensing requirements that are to the extent practicable, technology neutral and provide a framework for various Advanced Reactor technologies to move forward
- NIC is concerned with this language because it leaves the impression that the Agency may attempt to make a qualitative judgement about various reactor vendors. NIC’s view is that as long as the applicant meets the NRC requirements and pays the applicable fees, it should have the opportunity to have its design reviewed in a timely fashion
- If the NRC needs additional resources to review these designs, the Commission should seek the appropriate funding from Congress and the Trump Administration to cover these tasks

United States NIC Nuclear Infrastructure Council

Timing Issues

- NIC notes that the revised Vision and Strategy paper eliminated the mid and long term strategies that had been included in the first version of this document
- NIC as well as its industry counterparts raised concerns about the extended timelines included in the previous version which we believed were not reflective of the current reality of Advanced Reactor development
- While NIC supports the NRC stepping back from extended timelines, the fact remains that the issue does not go away
- In the Fall of 2019, at least one NIC member is intending to submit its licensing application to the Agency and several developers will begin pre-licensing activities later this year
- The Agency continues to insist that it is ready, today, to accept an application for and Advanced Reactor. While NIC appreciates this aspiration, it remains concerned about the timing and effectiveness of these reviews
- NIC firmly believes that the Agency must continue to accelerate the identification, funding and retention of the resources necessary to allow these designs to be reviewed in an effective, efficient and timely manner. NIC remains supportive of off-fee-base funding to achieve this goal

United States NIC Nuclear Infrastructure Council

Pre-Licensing Review

- NIC is encouraged by the continuing bi-partisan support in the House and Senate for the pre-licensing of Advanced Reactor designs similar to what is done in Canada
- While we do not yet know where President Trump and Secretary-Designate Perry stand on this specific matter, we do expect them to be supportive of Advanced Reactor deployment
- NIC continues to believe that a pre-licensing design review process similar to that in Canada is appropriate and that some developers would welcome a design review process that is phased in a manner appropriate to the financial abilities of the individual developers
- We believe it is positive that the staff has indicated that it will consider developing new guidance for a conceptual design assessment and staged regulatory review
- For innovative technology developers, it is critical that early indications regarding the viability of their designs be provided to guide future investment decisions
- We continue to look forward to working with the staff to achieve this important policy outcome

United States Nuclear Infrastructure Council

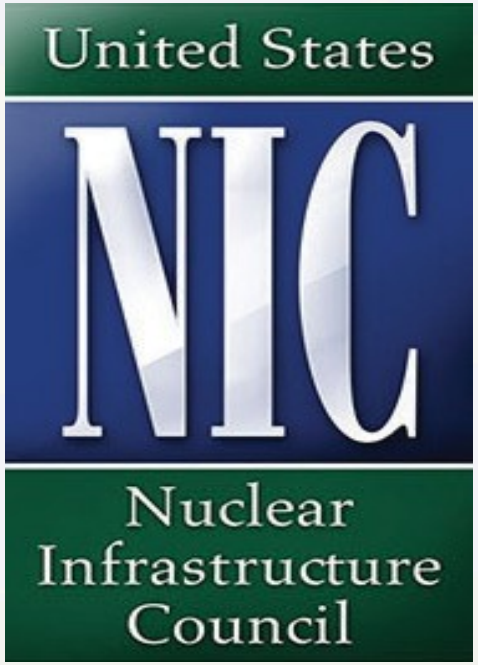
Moving Forward

- NIC remains concerned about funding issues associated with Advanced Reactors and continues to support fee relief – off-the-fee-base – to allow more detailed discussions between technology developers and the NRC before fees begin to be imposed
- NIC would welcome the Commission taking a more active role in supporting a change in this specific fee requirement
- We look forward to continuing to work with the Agency to identify ways to enable the deployment of Advanced Reactors through a timely, risk-informed, performance-based licensing process consistent providing adequate protection to the public
- While the Vision and Strategy document provides a clearer roadmap for how the Agency will license Advanced Reactors, it is virtually silent on the critical issues associated with the need for higher-assay LEU fuel sources
- NIC believes a more integrated plan should outline areas of emphasis for the Office of NMSS in the licensing of these Advanced technologies

United States NIC Nuclear Infrastructure Council

Closing

- NIC appreciates the opportunity to participate in this meeting and looks forward to our continuing involvement in these discussions
- Next week, on February 8-9, NIC will be hosting the 2017 Advanced Reactors Technical Summit IV & Technology Trailblazers Showcase at Argonne National Laboratory
- We appreciate the longstanding support of the NRC staff and Commission for this Summit and we look forward to all of you attending this important event. We would note that Commissioner Burns will be a featured speaker
- While NIC supports these working level meetings, it believes we are approaching a time when a direct discussion with the Commission is warranted and we look forward to identifying an opportunity for this conversation to occur



For more information visit www.usnic.org

U.S. Nuclear Infrastructure Council
1317 F Street, NW – Suite 350 – Washington, DC 20004
(202) 332-8155

About the USNIC

- Leading business consortium advocate for increased U.S. nuclear use and global deployment of U.S. nuclear technologies and services
- Represents 100 member companies encompassing wide representation of the nuclear energy supply chain and key movers
- Member of the Civil Nuclear Trade Advisory Committee
- Strongly supports Gen 3+ reactors, small modular reactors and advanced reactors moving in parallel paths
- Organizer of the 2017 Advanced Reactors Technical Summit IV & Technology Trailblazers Showcase on February 8-9 at Argonne National Laboratory

Update on "Major Portions" Project (Standard Design Approval)

NRC Meeting on Regulatory Process Improvements for Advanced Reactor Designs

February 2, 2017

Background

- 10 CFR Part 52, Subpart E allows an applicant to seek standard design approval for either an entire plant or "major portions" thereof
- NIA supporting NRC in clarifying the meaning of "major portions" to make SDA process useful for advanced reactor developers
- Drafting products for review, revision, etc., with input from industry representatives (and NEI/ARWG) for delivery to the NRC for their initial review

NUCLEAR INNOVATION ALLIANCE

Schedule/Milestones

- **Step 1 (Mar 2017) provides summary white paper describing SDA process at high level in support of NRC strategy/roadmap documents *(in review)***

- **Step 2 (proposed ~Apr 2017): expands into more detail to provide additional guidance for use in LPP/REP**

- **Step 3 (proposed - TBD): expands into ISG or other NRC guidance, including detailed discussion of boundary conditions and integration with Southern-led regulatory framework initiative**

NUCLEAR INNOVATION ALLIANCE

Step 1 Report Topics

- Purpose/benefit of SDA
- Scope
- Criteria for selection of “Major Portions”
- Context within “staged licensing”
- Regulatory basis & precedent
- Practicality
- Risks and mitigation
- Regulatory analogs

NUCLEAR INNOVATION ALLIANCE

Thank you

Feedback & Questions

Please feel welcome to send additional input at any time to Ashley Finan (afinan@catf.us).

NUCLEAR INNOVATION ALLIANCE

Licensing Technical Requirements Modernization Project (LTRMP)

Licensing Basis Event Selection Progress Report

Karl Fleming

Regulatory Process Improvements for Advanced Reactor Designs

February 2017 • USNRC Rockville MD

Discussion Topics

- LBE selection objectives
- LBE development approach
- Observations from review of LBE regulatory bases
- Expectations for LBE product scope and content

LBE Product Objectives

- Provide a technology inclusive, risk-informed, and performance-based approach for selecting licensing basis events for advanced non-LWRs
- Provide a proposal for a formal NRC endorsement in a form that can be referenced and implemented by license applicants
- Provide an approach
  - that can be applied to known advanced non-LWRs including HTGRs, liquid metal cooled reactors, molten salt reactors and employing multi-reactor module designs
  - that is capable of identifying unique reactor design specific events
  - that complements a risk-informed performance-based design process
  - that the designer can employ at an early stage to ensure effective risk management of challenges to the safety design approach
  - that avoids costly backfits during late stages of licensing

LBE Development Approach

- Use NGNP LBE WP as a starting point
  - Revise outcome objectives for alignment with LTRMP objectives
  - Consider interfaces with other LTRMP deliverables
- Revise/update regulatory basis to reflect
  - Review of bases for TLRC frequency vs. dose criteria (NGNP, earlier precedents)
  - Feedback from NRC staff and ACRS reviews of NGNP LBE approach
  - More recent documents relevant to RI-PB decision making
    - NUREG-1860, NUREG-2150, NTTF report, RG/SRP updates, NRC Advanced Rx Vision/Strategy
  - Yucca Mountain Pre-Closure Safety Analysis lessons learned
  - Review of United Kingdom Safety Assessment Principles (SAPs)

LBE Development Approach (cont'd)

- Restructure approach to make it technology inclusive
  - Consider enhancements to TLRC
  - Clarify that LBEs lead to and include deterministically derived DBAs
  - Technology inclusive "front end"
  - Consider NUREG-1860 insights
  - Retain and supplement MHTGR examples
  - Add GE-PRISM examples

LBE Selection Attributes

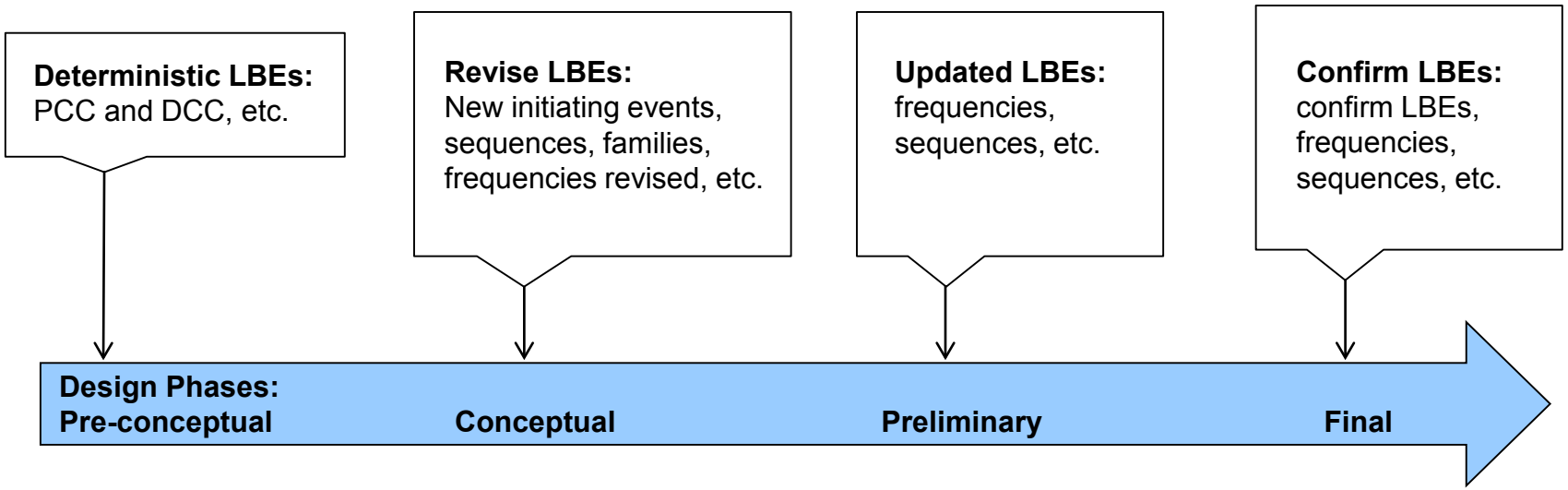
- Systematic and reproducible
- Reasonably complete set of LBEs
- Timely input to design decisions
- Risk-informed and performance-based
- Reactor technology inclusive
  - Capable of identifying reactor specific safety issues
  - Applicability to wide range of non-LWR concepts
  - Uniform level of safety
- Capable of meeting applicable regulatory requirements

Definition and Categorization of LBEs

- LBEs include all the events selected to develop the design bases and licensing requirements.
- LBEs cover comprehensive spectrum of events from normal operation to rare, off-normal events; identified using deterministic and probabilistic inputs. There are four categories of LBEs:
  - **Anticipated Operational Occurrences (AOOs**) encompass planned and anticipated events. Their frequencies and consequences are analyzed realistically.
  - **Design Basis Events (DBEs**) encompass unplanned off-normal events not expected in the plant's lifetime, but which might occur in the lifetime of a fleet of plants. Their frequencies and consequences are analyzed realistically.
  - **Beyond Design Basis Events (BDBEs**) are rare off-normal events of lower frequency than DBEs. BDBEs are evaluated to ensure that they do not pose an unacceptable residual risk to the public. Their frequencies and consequences are analyzed realistically.
  - **Design Basis Accidents (DBAs)** are deterministically selected for Chapter 15, "Accident Analyses," of the license application and are prescriptively derived from the DBEs. Their consequences are analyzed conservatively.

Event Selection Timeline

LBE evolution by design phase:



LBE selection process inputs vary by design phase:

- Initial design concept*
- Prior HTGR experience and PRAs*
- Expert insights*

- Basic design*
- Initial analyses (FMEA, HAZOPs, etc.)*
- Initiate PRA development†
- Design rqmts.*
- Expert reviews*

- Updated design*
- Detailed FMEAs, etc.*
- Preliminary PRA results†
- Expert reviews*
- Regulator interaction*

- Mature design
- Detailed FMEAs, etc.
- Complete PRA results
- Expanded PRA scope†
- Expert reviews
- Regulator feedback

* **Steps performed during MHTGR project through early preliminary design**

† **PRA scope and level of detail expands as design matures**

Concept for PRA Input to LBEs

- PRA introduced at early stage of design; scope and level of detail of PRA increases as design matures; design – PRA – LBE selection iterative process
- PRA event sequences developed sufficiently to define mechanistic source terms and to determine offsite radiological consequences (similar to LWR Level 3 PRA)
- LBEs defined as event sequence families grouped by similarity of initiating event, plant response, number of reactor modules affected, and mechanistic source terms
- Event sequence families categorized by mean frequency range:
  - AOOs: frequencies > 10^{-2}/multi-module plant year
  - DBEs: frequencies between 10^{-4} to 10^{-2}/multi-module plant year
  - BDBEs: frequencies < 10^{-4}/multi-module plant year
- DBAs: deterministically selected from DBEs and high consequence BDBEs to meet 10CFR50.34 dose criteria using conservative assumptions relying only on safety related SSCs to perform required safety functions

Concept for PRA Input to LBEs (cont'd)

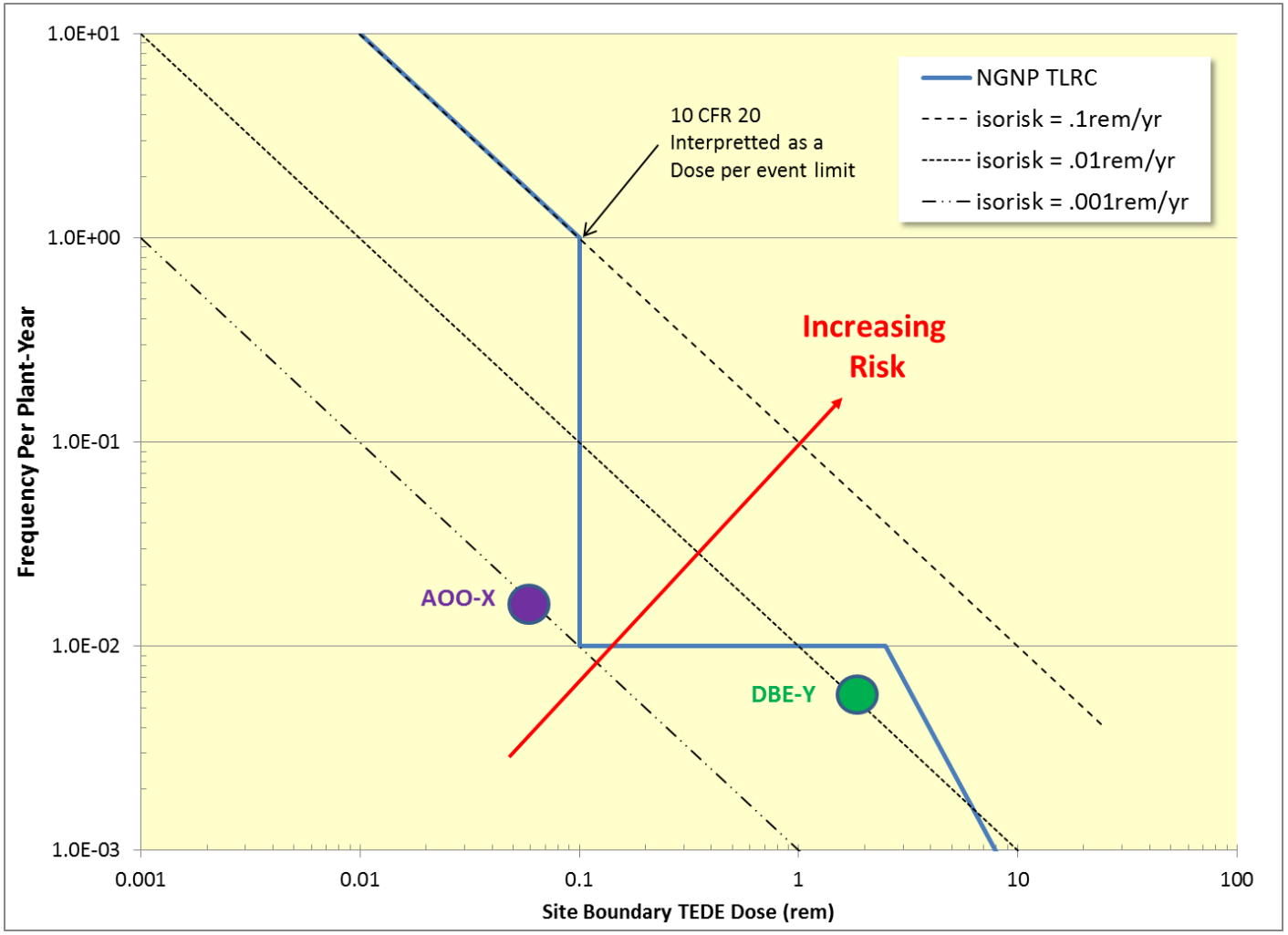
- LBE frequencies and dose consequences compared to TLRC criteria and EPA PAG dose limits
- Event sequences are used in an integrated multi-module plant evaluation to confirm that QHOs are met
- DBEs and high consequence BDBEs evaluated using prescriptive rules to select DBAs for conservative safety analyses in Ch. 15
- PRA information is used to identify and quantify uncertainties, evaluate radionuclide barriers, and capabilities of SSCs in the prevention and mitigation of accidents as part of a risk-informed evaluation of defense-in-depth; risk-insights provided to strengthen plant capabilities and programs for defense-in-depth

Key Observations from Regulatory Review 1 of 3

- Some interpretations of regulatory requirements reflected in TLRC frequency-dose criteria are under review
  - How to interpret 10 CFR 20 annual dose limits for individual events?
  - How to address SRP Chapter 15.0 statement?

    "If the risk of an event is defined as the product of the event's frequency of occurrence and its consequences, then the design of the plant should be such that all the AOOs and postulated accidents produce about the same level of risk (i.e., the risk is approximately constant across the spectrum of AOOs and postulated accidents). This is reflected in the general design criteria (GDC), which generally prohibit relatively frequent events (AOOs) from resulting in serious consequences, but allow the relatively rare events (postulated accidents) to produce more severe consequences."
  - Some practical issues identified with "Staircase" discontinuities
  - How to best address uncertainties in LBE frequencies and doses?
- Some enhancements to the frequency vs. dose criteria are being considered to reflect revised interpretations

Staircase Discontinuity Issue



Key Observations from Regulatory Review 2 of 3

- Interesting comparisons between NGNP WPs and NUREG-1860
  - Both present a risk-informed process for selecting LBEs in advanced non-LWRs
  - Both derive frequency vs. dose criteria from NRC regulations
  - Both identify a role for PRA together with deterministic inputs to support a risk-informed evaluation of defense-in-depth
  - Both provide useful guidance for developing a PRA for Advanced non-LWRs
  - Both provide/refer to criteria for ensuring technical adequacy of PRA
  - NGNP uses a risk informed process to define SSCs as “safety related” whereas NUREG-1860 skips this step and goes directly from PRA risk significance to special treatment requirements
  - Although NGNP WPs and NUREG-1860 have many differences in the details when viewed from 100,000 ft. the respective approaches are viewed as complementary.
  - Both provide useful guidance for the LTRMP approach to LBE selection and PRA

Key Observations from Regulatory Review 3 of 3

- Regulatory review expanded to include United Kingdom Safety Assessment Principles (SAPs)
  - SAPs are reactor technology inclusive and used for gas-cooled reactors, LWRs, and several ALWRs
  - SAPs roughly correspond to a combination of GDCs, SRP, and Safety Goal Policy
  - SAPs require PRAs as part of a Fault Analysis for a Generic Design Assessment GDA (Similar to DCA) and for operating license
  - SAPs include numerical risk targets (frequency vs. consequence criteria) at several levels
    - Facility level (single reactor unit) targets for GDA reviews
    - Site level for operating licenses: includes consideration of multi-reactor accidents
    - Different limits for onsite workers, other onsite people, and offsite
  - Two sets of frequency vs. consequence criteria
    - Basic Safety Limits – not to exceed limits for regulatory acceptance
    - Basic Safety Objectives – more strict limits to be met using ALARP principle

LBE Product Scope and Contents

- NGNP LBE WP serves as Starting Point
- Revised outcome objectives; LTRMP product interfaces
- Expanded regulatory review as noted in previous slides
- Possible revisions to interpretations for frequency vs. dose criteria
- Clarification that selection of deterministic DBAs are part of and the ultimate outcome of the LBE selection process
- Some details of how SSC safety classification helps define the deterministic DBAs
- More guidance on the role of multi-module and multi-source in the PRA and LBE selection process
- More examples using MHTGR and GE-PRISM

QUESTIONS?

BACKUP SLIDES

Resources

- Principal co-author of NGNP PRA white paper
- GE-Hitachi support for GE-PRISM examples
- Technical lead for Yucca Mountain Pre-Closure PRA
- UCLA Garrick Institute review of NGNP white papers on PRA, LBE, and DID
- LTRMP project team reviews and regulatory interfaces

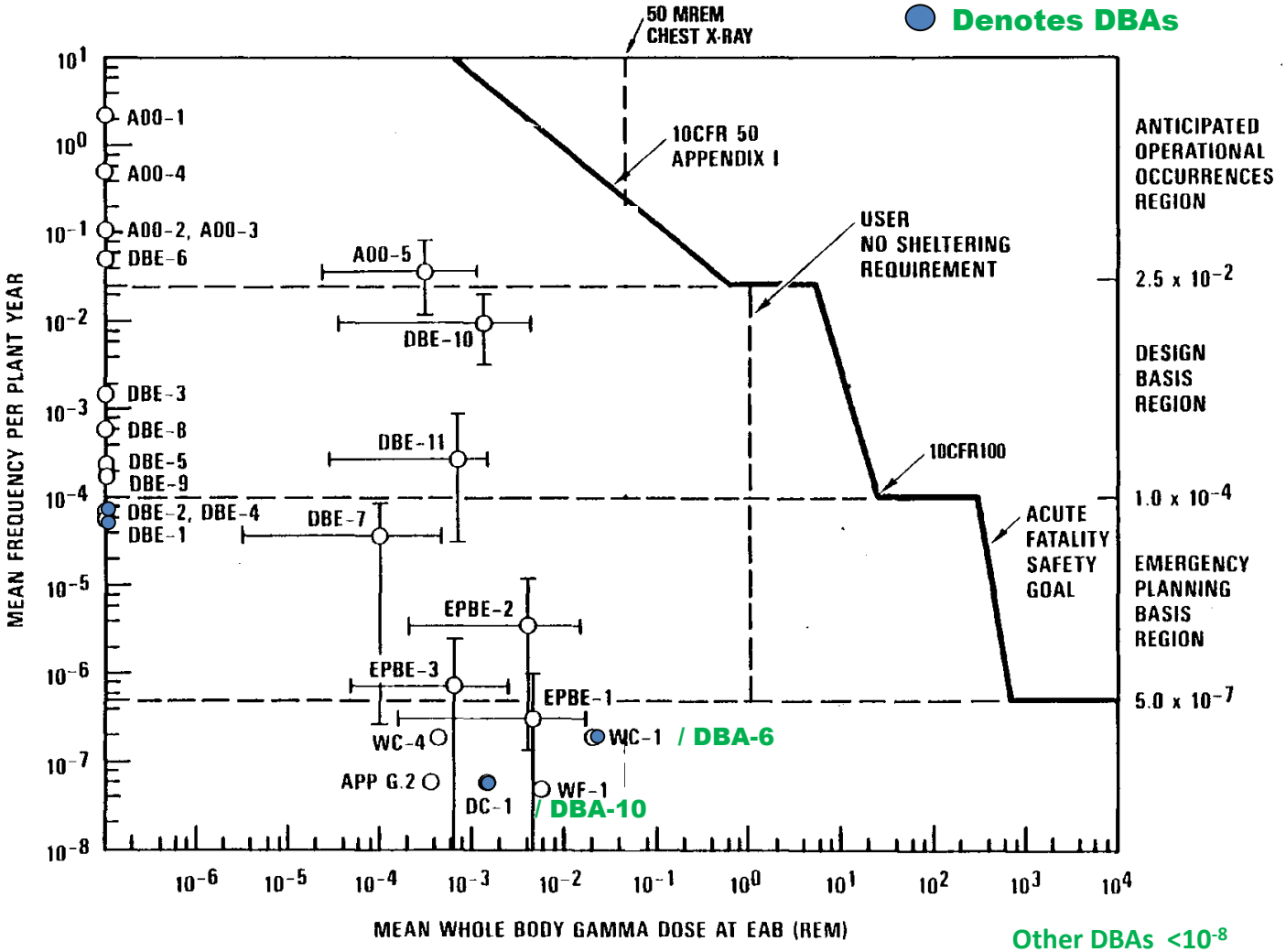
UK SAP Numerical Risk Targets

No.	Applicable State or Event	Applicable to	Facility or Site Based	Basic Safety Objective (BSO)	Basic Safety Limit (BSL)	Applicable Event Frequency or Consequence
3	Normal Operation	Any person off site	Site	0.02mSv/year	1mSv/year	Annual limits
4	Design Basis Accidents	Any person on site	Facility	< 0.1mSv/event	20mSv/event	> 10^{-3}/year
					200mSv/event	10^{-3} to 10^{-4}/year
					500mSv/event	10^{-4} to 10^{-5}/year
		Any person off site		< 0.01mSv/event	1mSv/event	> 10^{-3}/year
					10mSv/event	10^{-3} to 10^{-4}/year
					100mSv/event	10^{-4} to 10^{-5}/year
5	All accidents	Any person on site	Site	< 10^{-6}/year	< 10^{-4}/year	fatality
6	All accidents	Any Person on site	Facility	< 10^{-3}/year	< 10^{-1}/year	2-20mSv
				< 10^{-4}/year	< 10^{-2}/year	20-200mSv
				< 10^{-5}/year	< 10^{-3}/year	200-2000mSv
				< 10^{-6}/year	< 10^{-4}/year	> 2,000mSv
7	All accidents	Any person off site	Site	< 10^{-6}/year	< 10^{-4}/year	fatality
8	All accidents	Any Person off site	Facility	< 10^{-2}/year	< 1/year	0.1-1mSv
				< 10^{-3}/year	< 10^{-1}/year	1-10mSv
				< 10^{-4}/year	< 10^{-2}/year	10-100mSv
				< 10^{-5}/year	< 10^{-3}/year	100-1,000mSv
				< 10^{-6}/year	< 10^{-4}/year	> 1,000mSv
9	All accidents	All persons on and off site	Site	< 10^{-7}/year	< 10^{-5}/year	≥ 100 early or latent fatalities

Backup Slides used to support discussions during the public meeting of 2/2/2017

From NEI Slide (12/15/16 Meeting)
ADAMS Acc. No. ML16355A250

Example MHTGR LBEs, DBAs on F-C Plot (circa 1987)



Toshiba 4S
Acceptance Criteria for Licensing Basis Events

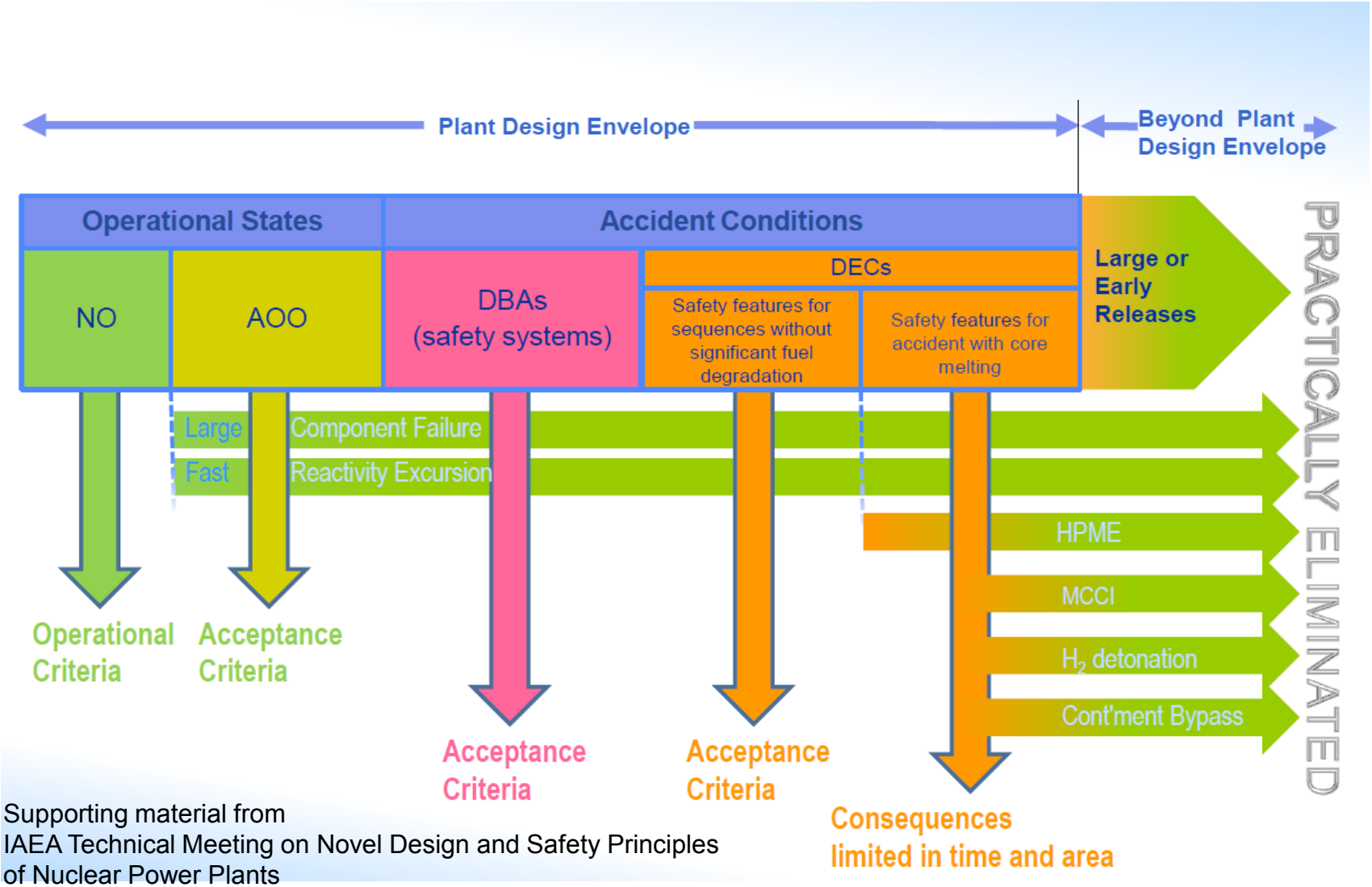
Table 1-1
Safety Criteria and Analysis Requirements

Event	Region	No Fuel Melting	Fuel Cladding Integrity	Core Coolable Geometry	Primary Coolant Boundary Integrity	Containment Integrity	Radiation Dose at EAB and LPZ	Analysis Requirements
DBE	AOO	✓	✓	*	✓ ASME SL[1] "B," "C"	*	*	Conservative
	DBA	-	✓	✓*	✓ ASME SL "D"	✓	*	Conservative
Beyond DBE	ATWS	-	✓	✓*	✓ ASME SL "D"	✓	✓*	Best estimate plus uncertainties

Notes:
✓ Explicit safety criterion is defined.
* Meeting the safety criterion is expected if the previous criterion is met.
† SL = Service Level

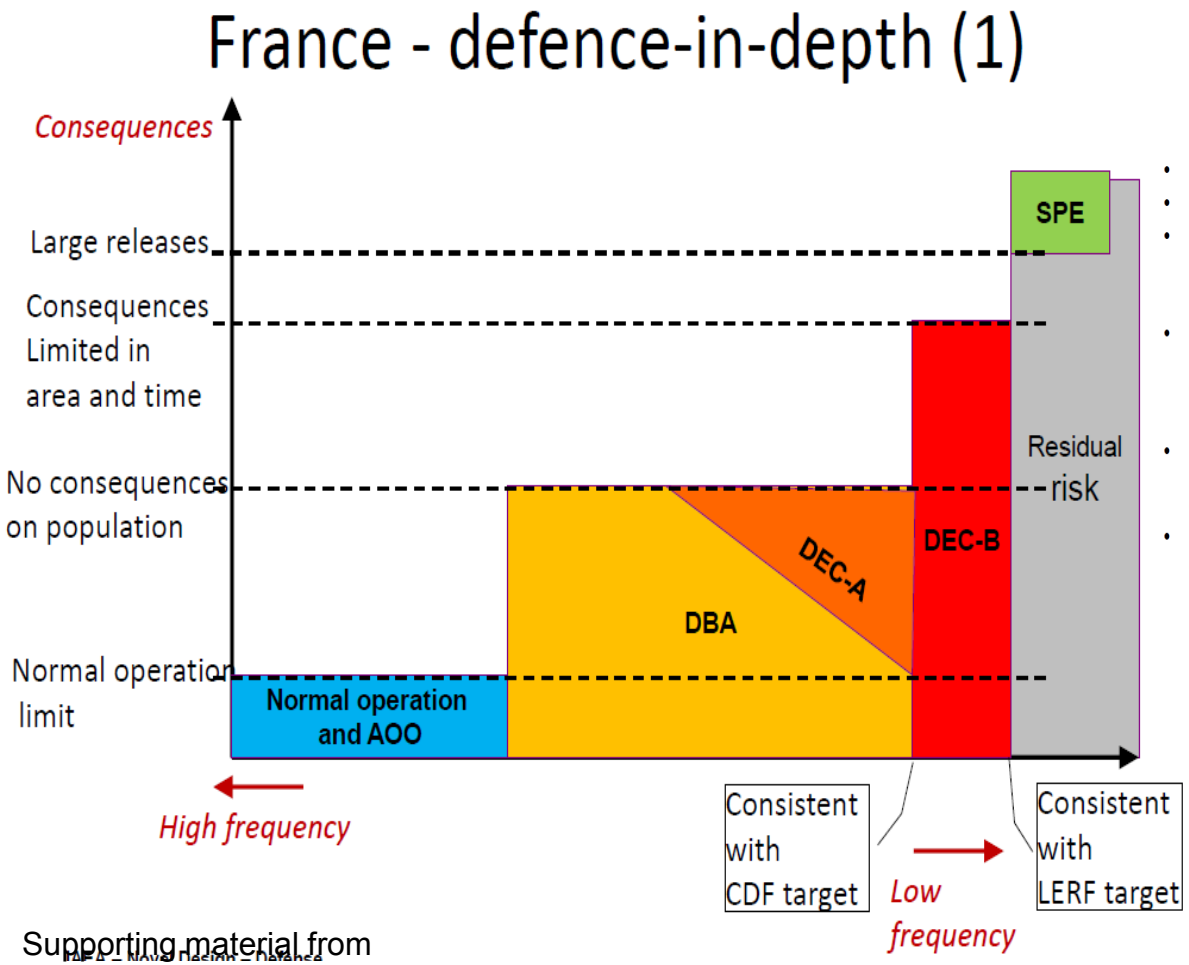
From "4S Safety Analysis" submitted by Toshiba Corporation, July 28, 2009
ADAMS Accession No. ML092170507

IAEA (TECDOC 1791)



Supporting material from
IAEA Technical Meeting on Novel Design and Safety Principles of Nuclear Power Plants
(https://nucleus.iaea.org/sites/gsan/act/noveldesignsafety)

Example from IAEA Mtg



- Regions AOO, DBA, DEC-A & DEC-B, Residual risk identified
- Large release category not defined (not in regulations)
- IAEA - discussion
  - SPE - location above residual release line
  - proportion of DEC-A outside DBA region
- IAEA discussion - even if claim practical elimination - always potential for residual risk - need to differentiate between practical elimination & residual risk
  - group - further clarity on terms & definitions beneficial
- Important for clarity on DBA, DEC-A & DEC-B regions / cut offs - indicate point where it is not necessary to implement additional design improvements.
- Practical elimination should be considered as a concept rather than a requirement - needs to be demonstrated through design

Supporting material from
IAEA Technical Meeting on Novel Design and Safety Principles of Nuclear Power Plants
(https://nucleus.iaea.org/sites/gsan/act/noveldesignsafety)