Licensing Modernization Project
Basic Training in LMP Processes

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Meeting Purpose and Agenda

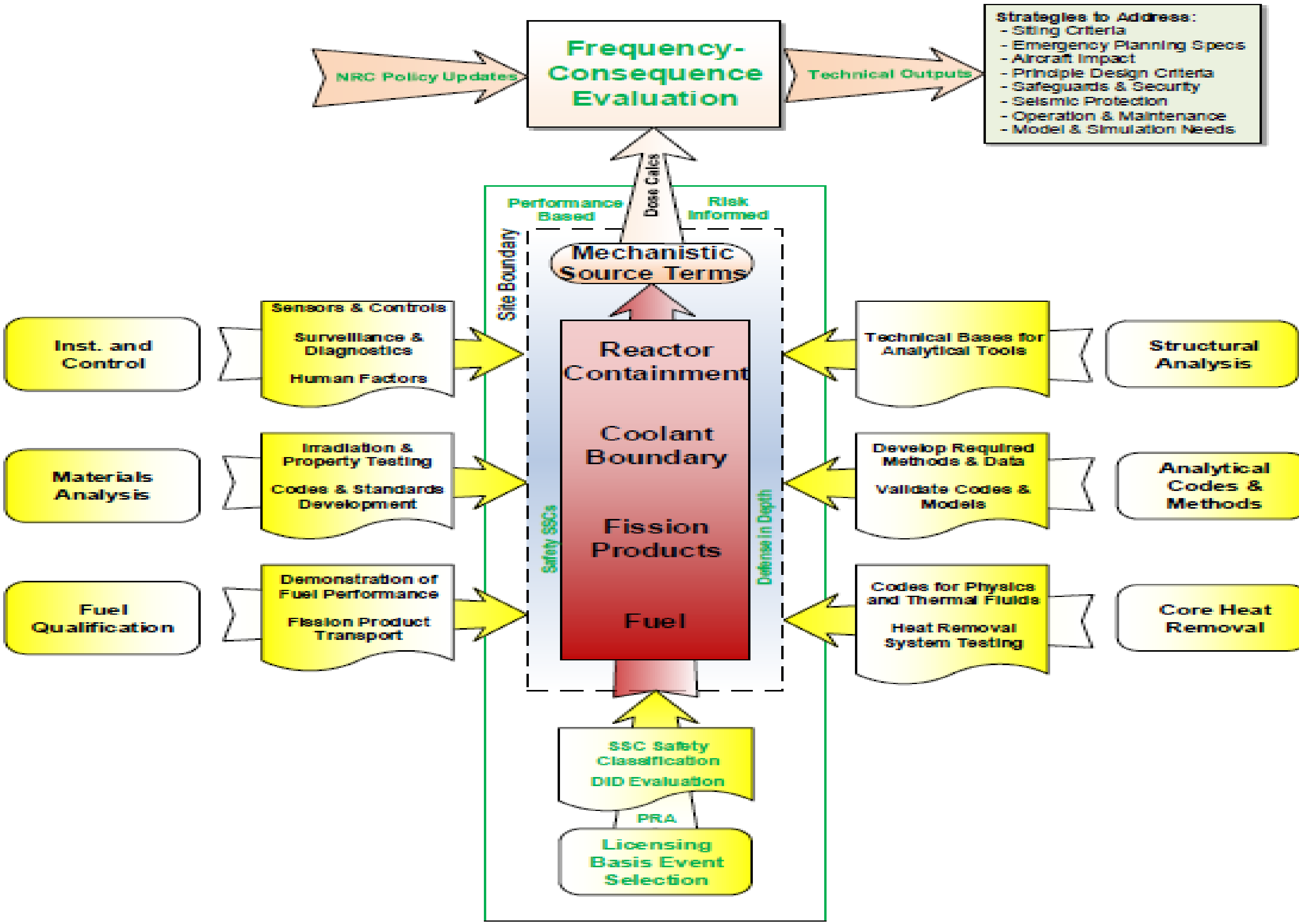
Purpose: To provide NRC staff with familiarization in implementing LMP technical* processes based on information in the LMP Guidance Document and supporting White Papers and MHTGR examples.

Discussion topics:

- Introduction to LMP by Amir Afzali
- LMP Technical* Processes by Karl Fleming / Ed Wallace
  - Selection and evaluation of licensing basis events
  - PRA development and technical adequacy
  - SSC safety classification and performance requirements
  - Evaluation of defense-in-depth adequacy

* This material does not get into open issues with regulatory interfaces that are being addressed in separate training sessions

LMP RIPB Framework



Quantitative Risk-Informed Decision Making

- LMP proposals present a formal and transparent risk-informed and performance-based process for making key design and licensing decisions
- A PRA for non-LWRs is an essential element of the proposed RIPB LMP framework.
- Very often, criticisms are focused on PRA without discussing the shortcomings of the traditional “deterministic” system.
- The proposed approach is risk informed and combining the best attributes of deterministic and risk systems. Performance-based outcomes are also an intrinsic part of the LMP approach
- PRA technical adequacy per ASME/ANS RA-S-1.4-2013, Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants, 2013.

The Key Consideration

- **SRP Chapter 15.0 statement:**

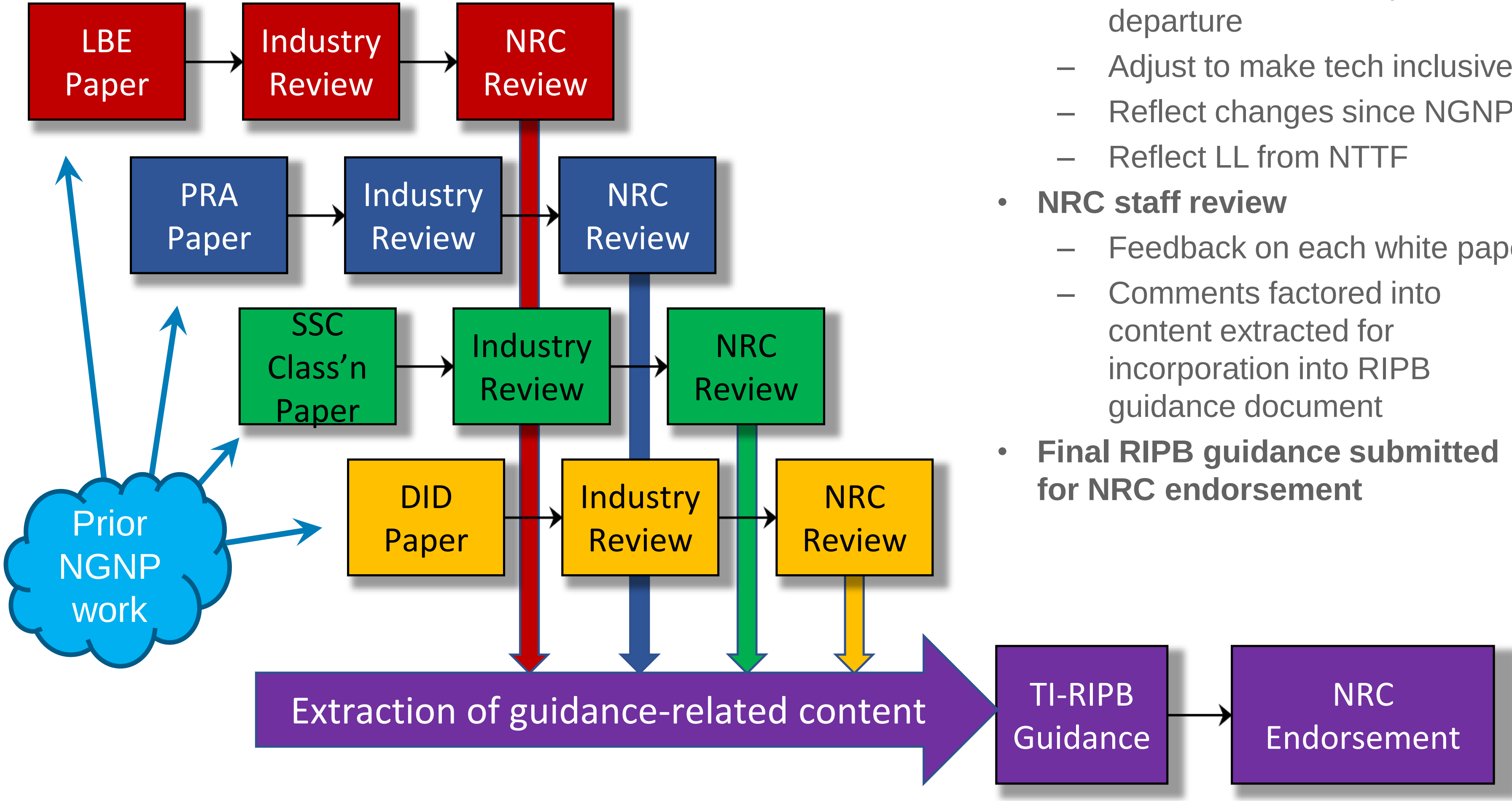
  *"If **the risk of an event** is defined as the product of **the event's frequency of occurrence and its consequences**, then the design of the plant should be such that all the AOOs and postulated accidents produce about the same level of risk (i.e., the risk is approximately constant across the spectrum of AOOs and postulated accidents). This is reflected in the **general design criteria (GDC)**, **which generally prohibit relatively frequent <u>events</u> (AOOs) from resulting in serious consequences, but allow the relatively <u>rare events</u> (postulated accidents) to produce more severe consequences**."*

- Conclusion: To meet this requirement LBE Selection has to be RIPB
- Options: Ad hoc RIPB Approach vs. Systematic RIPB Process

Comparison of Options for the LBE Selection Process

LBE Selection Options	Process	Tools used for identification and consequence analysis	Frequency estimate	Uncertainty Analysis	Technical Adequacy
Ad Hoc RIPB	Events are identified and analyzed based on Engineering Judgment; revised to reflect service experience	Ad hoc approach similar to FMEA; reproducible process to select LBEs for new reactors does not exist	Qualitative based engineering judgment	Not explicitly identified, addressed primarily using conservative assumptions based on engineering judgment.	No consensus standards as the LBE procedures do not exist; rests solely on regulatory review judgments.
Systematic RIPB	Incorporates approaches used in Ad hoc method in a systematic, reproducible PRA procedure.	FMEA, HAZOPs, MLD, PERT, PRA methods for systematic search for initiating events and defining accident sequences	Quantitative based on applicable service experience, engineering judgment and PRA data analysis methods	Explicitly identified and listed via structured PRA process,. Systematically analyzed and accounted for; defense-in-depth approach to capture uncertainties not well represented in PRA	ASME non-LWR PRA Standards, EPRI research, experience with HTGR and LMFR PRAs

Document Development Review Approach



NEI 18-04

- **Discrete topic papers**
  - Start with NGNP as point of departure
  - Adjust to make tech inclusive
  - Reflect changes since NGNP
  - Reflect LL from NTTF
- **NRC staff review**
  - Feedback on each white paper
  - Comments factored into content extracted for incorporation into RIPB guidance document
- **Final RIPB guidance submitted for NRC endorsement**

LMP seeks to define processes that are:

- Systematic and reproducible
- Sufficiently complete
- Available for timely input to design decisions
- Risk-informed and performance-based
- Reactor technology inclusive
- Consistent with applicable regulatory requirements

Selection and Evaluation Of LBEs

Licensing Basis Events (LBEs)

- LBEs are defined broadly to include all the events used to support the safety aspects of the design and to meet licensing requirements. They cover a comprehensive spectrum of events from normal operation to rare, off-normal events.
- Categories defined as Normal Operations (NO), Anticipated Operational Occurrences (AOO), Design Basis Events (DBE), Beyond Design Basis Events (BDBE) and Design Basis Accidents (DBA)
- LBE definitions and approach build on those developed in NGNP white papers
- LMP guidance document includes glossary to clarify differences in terminology with regulatory terms

LBE Categories

Anticipated Operational Occurrences (AOOs). Anticipated event sequences expected to occur one or more times during the life of a nuclear power plant, which may include one or more reactor modules. Event sequences with mean frequencies of 1×10-2/plant-year and greater are classified as AOOs. AOOs take into account the expected response of all SSCs within the plant, regardless of safety classification.

Design Basis Events (DBEs). Infrequent event sequences that are not expected to occur in the life of a nuclear power plant, which may include one or more reactor modules, but are less likely than an AOO. Event sequences with mean frequencies of 1×10-4/plant-year to 1×10-2/plant-year are classified as DBEs. DBEs take into account the expected response of all SSCs within the plant regardless of safety classification. The objective and scope of DBEs to form the design basis of the plant is the same as in the NRC definition.

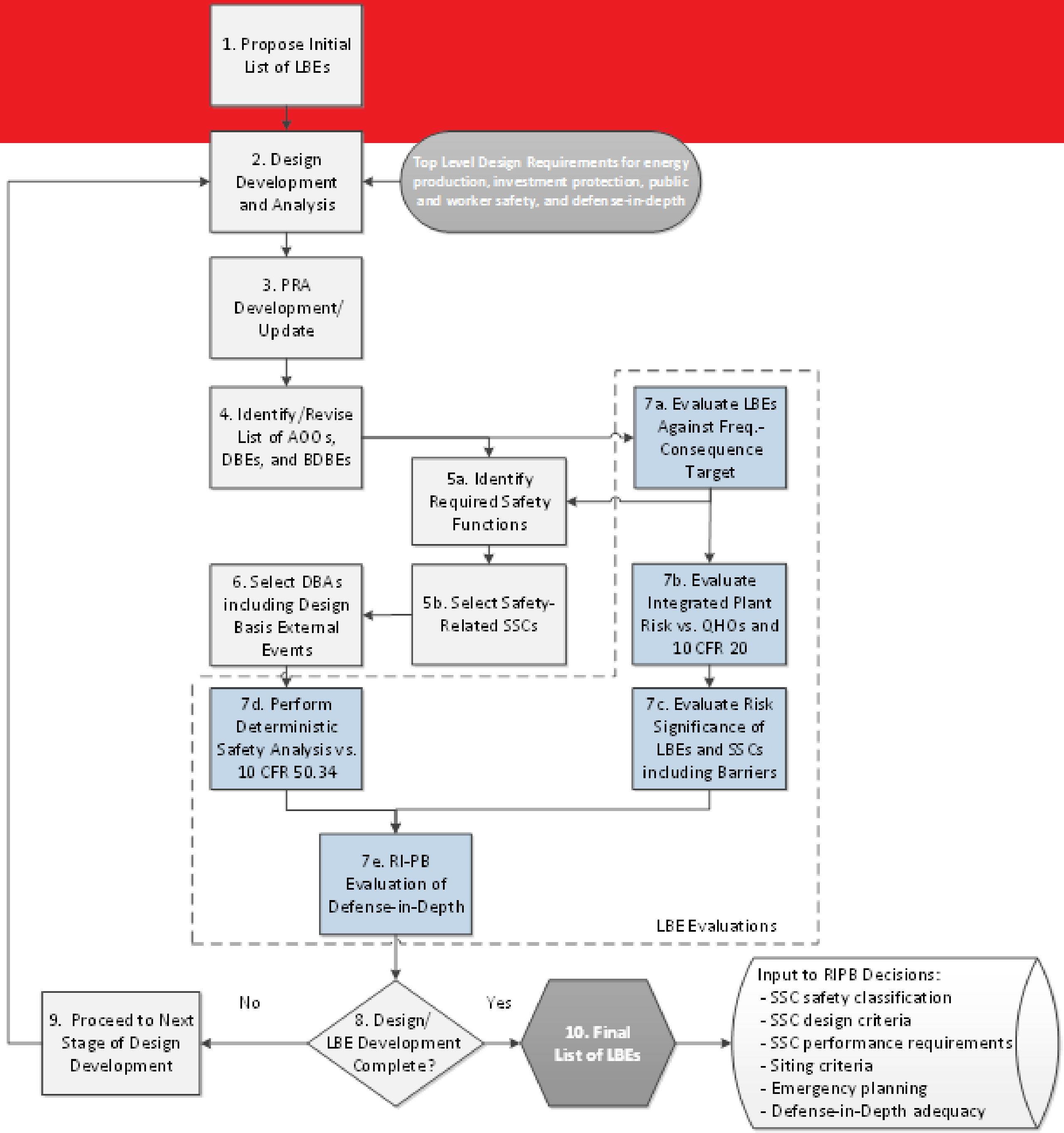
Beyond Design Basis Events (BDBEs). Rare event sequences that are not expected to occur in the life of a nuclear power plant, which may include one or more reactor modules, but are less likely than a DBE. Event sequences with mean frequencies of 5×10-7/plant-year to 1×10-4/plant -year are classified as BDBEs. BDBEs take into account the expected response of all SSCs within the plant regardless of safety classification.

Design Basis Accidents (DBAs). Postulated accidents that are used to set design criteria and performance objectives for the design and sizing of SSCs that are classified as safety-related. DBAs are derived from DBEs based on the capabilities and reliabilities of safety-related SSCs needed to mitigate and prevent accidents, respectively. DBAs are derived from the DBEs by prescriptively assuming that only SSCs classified as safety-related are available to mitigate postulated accident consequences to within the 10 CFR 50.34 dose limits.

Selection and Evaluation of LBEs

- AOOs, DBEs, and BDBEs are defined in terms of event sequence families from a reactor design-specific PRA
- AOOs, DBEs, and BDBEs are evaluated:
    - Individually for risk significance using a Frequency-Consequence (F-C) chart against a F-C Target
    - Collectively by comparing the total integrated risk against a set of cumulative risk targets
- DBEs and high consequence BDBEs are evaluated to define Required Safety Functions (RSFs) necessary to meet F-C Target
- Designer selects Safety Related SSCs to perform required safety functions among those available on all DBEs
- DBAs are derived from DBEs by assuming failure of all non-safety related SSCs and evaluated conservatively vs. 10CFR50.34

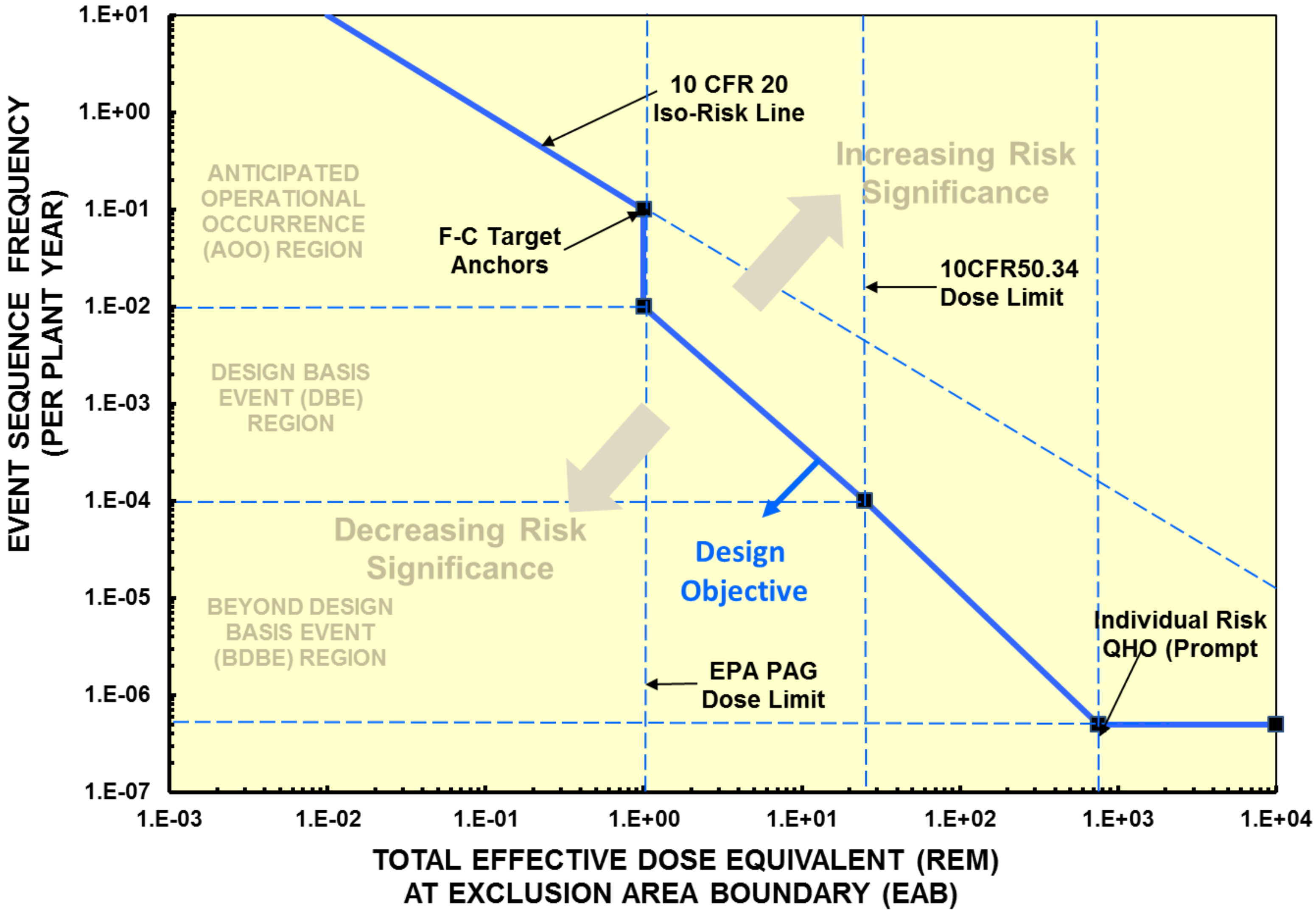
LBE Selection and Evaluation Process



Frequency-Consequence (F-C)Target

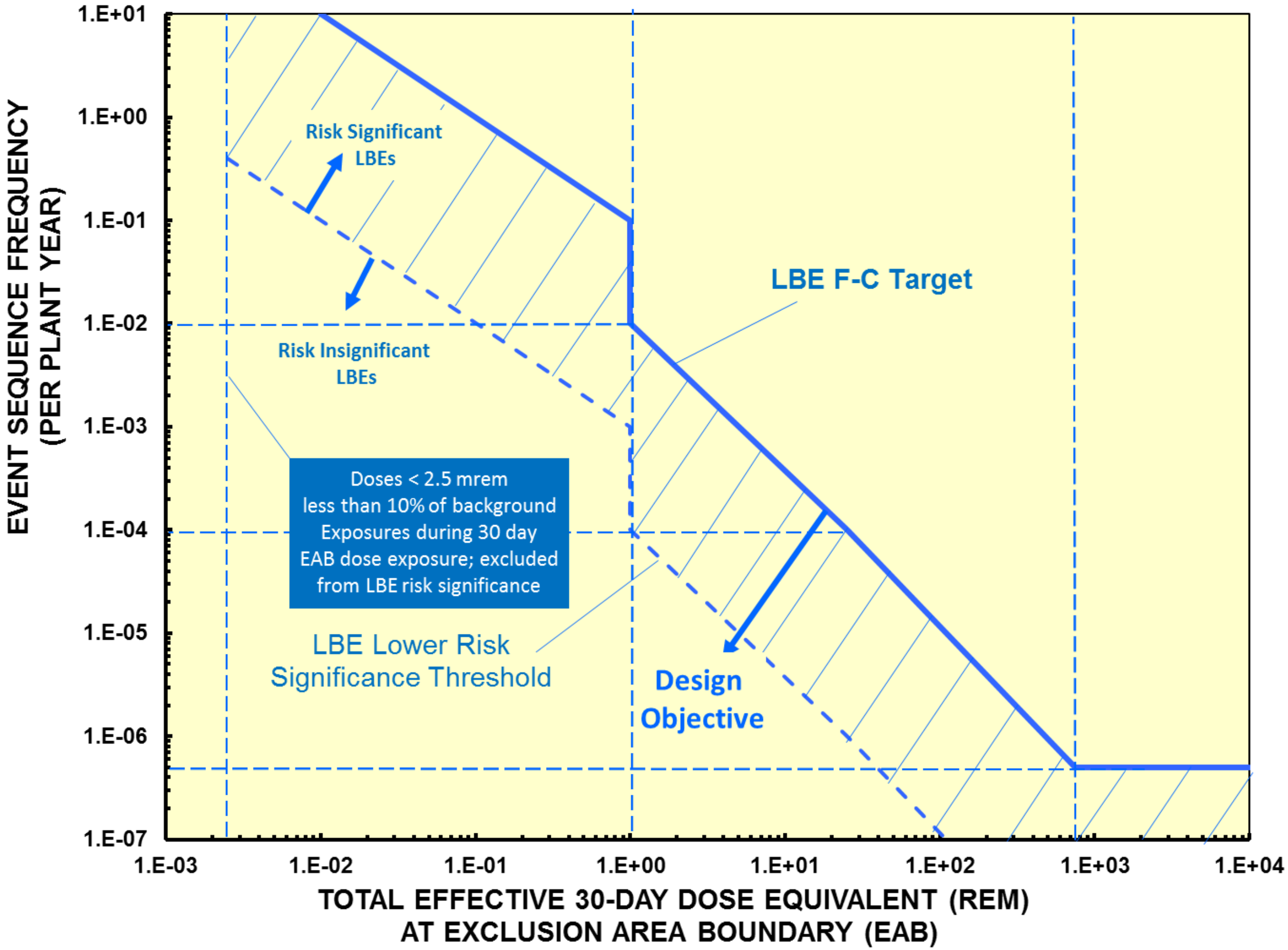
- Purpose is to evaluate risk significance of individual LBEs and to help define the RSFs
- Derived from the NGNP F-C Target and frequency bins for AOOs, DBEs, and BDBEs
  - Addressed staircase issue with previous F-C targets
- F-C Target anchor points based on:
  - 10 CFR 20 annual dose limits and iso-risk concept
  - Avoidance of offsite protective actions for lower frequency AOOs
  - 10 CFR 50.34 dose limits for lower frequency DBEs
  - Consequences based on 30day TEDE dose at EAB
  - EAB doses selected to assure meeting QHO for prompt fatality individual risk

F-C Target



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
EVENT SEQUENCE FREQUENCY (PER PLANT YEAR)
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

LBE Risk-Significance Criteria

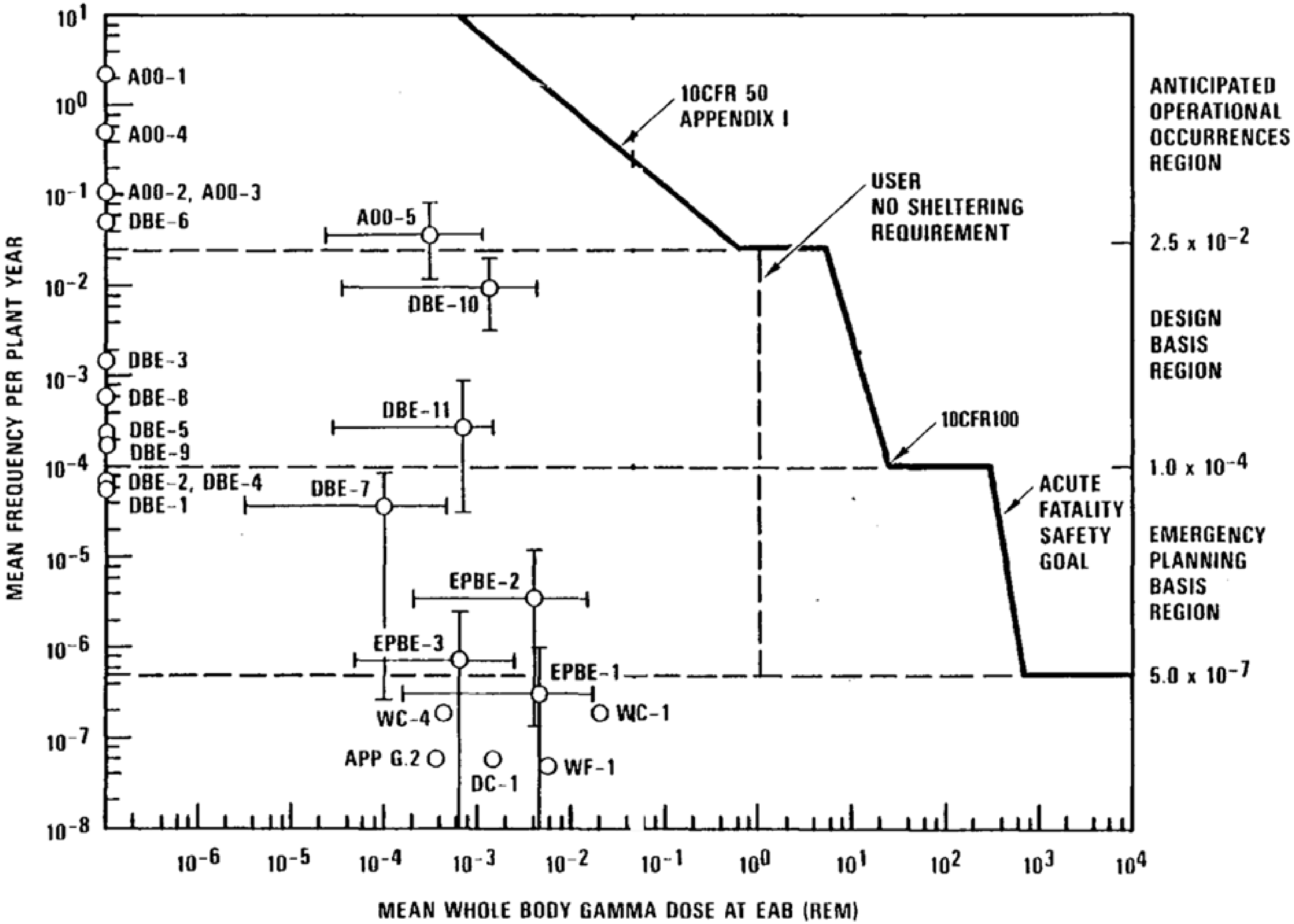


LBE Cumulative Risk Targets

- The total frequency of exceeding an offsite boundary dose of 100 mrem shall not exceed 1/plant-year to ensure that the annual exposure limits in 10 CFR 20 are not exceeded.
- The average individual risk of early fatality within the area 1 mile of the EAB shall not exceed $5x10^{-7}$/plant-year to ensure that the NRC Safety Goal Quantitative Health Objective (QHO) for early fatality risk is met
- The average individual risk of latent cancer fatalities within the area 10 miles of the EAB shall not exceed $2x10^{-6}$/plant-year to ensure that the NRC safety goal QHO for latent cancer fatality risk is met.

MHTGR LBE Examples

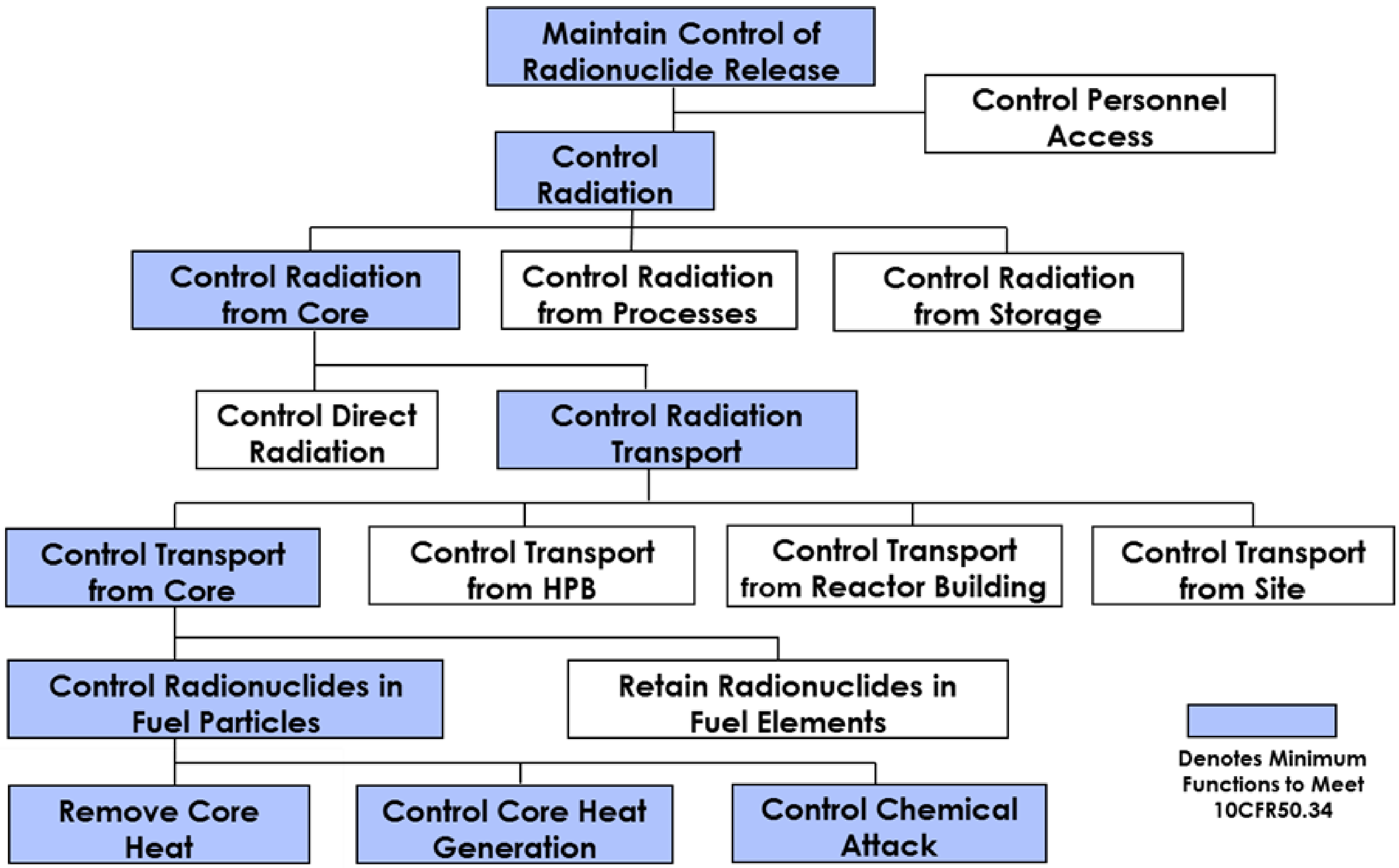
MHTGR Example with Early Version of F-C Chart



MHTGR DBEs

DBE-1	Loss of offsite power initiating event and SCS forced cooling, successful reactor trip, passive cooling via RCCS, intact HPB and no release involving a single reactor module.
DBE-2	Main Loop Transient with Control Rod Trip failure, successful reactor trip via RSS, forced cooling via SCS, intact HPB and no release involving a single reactor module.
DBE-3	Control Rod Withdrawal, with successful reactor trip, Main Loop forced cooling failure, forced cooling via SCS, intact HPB and no release involving a single reactor module.
DBE-4	Control Rod Withdrawal with successful reactor trip, loss of Main and SCS forced cooling via failures, passive cooling via RCCS, intact HPB and no release involving a single reactor module.
DBE-5	Seismic event with loss of offsite power, successful reactor trip, continued forced cooling via Main Loops or SCS, intact HPB and no release involving all four reactor modules.
DBE-6	Moderate SG leak with successful reactor trip, SG isolation and dump, forced cooling via SCS, intact HPB and no release involving a single reactor module.
DBE-7	Moderate SG leak with successful reactor trip, SG isolation and dump, failure of forced cooling via SCS, intact HPB and no release involving a single reactor module.
DBE-8	Moderate SG leak with moisture monitor failure, successful manual reactor trip, SG isolation and dump, forced cooling via SCS, intact HPB and no release involving a single reactor module.
DBE-9	Moderate SG leak with successful reactor trip and SG isolation, failure of SG dump, forced cooling via SCS, circulating activity release via open primary relief valve to reactor building involving a single reactor module.
DBE-10	Moderate HPB leak with successful reactor trip, continued forced cooling, release of circulating activity and lift-off of plateout to reactor building involving a single reactor module.
DBE-11	Small HPB leak with successful reactor trip, failure of forced cooling via Main and SCS Loops, passive cooling via RCCS, partial release of circulating activity and delayed fuel release to reactor building involving a single reactor module.

MHTGR Required Safety Functions



MHTGR Selection of Safety Related SSCs for Control Core Heat Removal Safety Function

Alternate Sets of SSCs	Design Basis Events									SSCs Classified as SR?
	DBE 1	DBE 2	DBE 3	DBE 4	DBE 5	DBE 6/7	DBE 8/9	DBE 10	DBE 11	
• Reactor • HTS • ECA	No	No	No	No	No	No	No	No	No	No
• Reactor • SCS • SCWS	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
• Reactor • RV • RCCS	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
• Reactor • RV • RB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

MHTGR DBAs 1 0f 3

<table>
<tr><th>DBE</th><th>Design Basis Events</th><th>DBA</th><th>Design Basis Accidents</th></tr>
<tr><td>DBE-1</td><td>Loss of offsite power initiating event and SCS forced cooling, successful reactor trip, passive cooling via RCCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 5x10^{-5}/plant-year or about 1x10^{-5}/reactor-year)</td><td>DBA-1</td><td>Loss of Main and SCS forced cooling, successful reactor trip, passive cooling via RCCS, intact HPB and no release involving a single reactor module (corresponds to PRA sequence family with frequency of 5x10^{-5}/plant-year or about 1x10^{-5}/reactor-year)</td></tr>
<tr><td>DBE-2</td><td>Main Loop Transient with Control Rod Trip failure, successful reactor trip via RSS, forced cooling via SCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 7x10^{-5}/plant-year or about 2x10^{-5}/reactor-year)</td><td>DBA-2</td><td>Loss of Main and SCS forced cooling with Control Rod Trip failure, successful reactor trip via RSS, passive cooling, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 7x10^{-5}/plant-year or about 2x10^{-5}/reactor-year)</td></tr>
<tr><td>DBE-3</td><td>Control Rod Withdrawal, with successful reactor trip, Main Loop forced cooling failure, forced cooling via SCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 2x10^{-3}/plant-year or about 5x10^{-4}/reactor-year)</td><td rowspan="2">DBA-3
DBA-4</td><td rowspan="2">Control Rod Withdrawal, with successful reactor trip, failure of forced cooling via Main loops and SCS, passive cooling via RCCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 7x10^{-5}/plant-year or about 2x10^{-5}/reactor-year)</td></tr>
<tr><td>DBE-4</td><td>Control Rod Withdrawal with successful reactor trip, loss of Main and SCS forced cooling via failures, passive cooling via RCCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 7x10^{-5}/plant-year or about 2x10^{-5}/reactor-year)</td></tr>
</table>

MHTGR DBAs 2 0f 3

<table>
<tr><td>DBE-5</td><td>Seismic event with loss of offsite power, successful reactor trip, continued forced cooling via Main ~~Loop~~s or SCS, intact HPB and no release involving all four reactor modules. (corresponds to PRA sequence family with frequency of 2x10^{-4}/plant-year or 2x10^{-4}/reactor-year)</td><td>DBA-5</td><td>Seismic event with loss of offsite power, successful reactor trip, failure of forced cooling via Main ~~Loops or~~ and SCS, passive cooling via RCCS, intact HPB and no release involving all four reactor modules. (corresponds to PRA sequence family with frequency of 6x10^{-8}/plant-year or ~6x10^{-8}/reactor-year)</td></tr>
<tr><td>DBE-6</td><td>Moderate SG leak with successful reactor trip, SG isolation and dump, forced cooling via SCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 5x10^{-2}/plant-year or about 1x10^{-2}/reactor-year)</td><td>DBA-6</td><td>Moderate SG leak with successful reactor trip and SG isolation, failure of SG dump, failure of forced cooling via SCS, passive cooling via RCCS, circulating activity and delayed fuel release via primary relief valve to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of 2x10-7/plant-year or 5x10^{-8}/reactor-year)</td></tr>
<tr><td>DBE-7</td><td>Moderate SG leak with successful reactor trip, SG isolation and dump, failure of forced cooling via SCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 4x10^{-5}/plant-year or 1x10^{-5}/reactor-year)</td><td rowspan="3">DBA-7
DBA-8
DBA-9</td><td rowspan="3">Moderate SG leak with successful reactor trip and SG isolation, failure of SG dump, failure of forced cooling via SCS, passive cooling via RCCS, circulating activity and delayed fuel release via primary relief valve to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of <10^{-8}/plant-year or <10^{-8}/reactor-year)</td></tr>
<tr><td>DBE-8</td><td>Moderate SG leak with moisture monitor failure, successful manual reactor trip, SG isolation and dump, forced cooling via SCS, intact HPB and no release involving a single reactor module. (corresponds to PRA sequence family with frequency of 4x10^{-5}/plant-year)</td></tr>
<tr><td>DBE-9</td><td>Moderate SG leak with successful reactor trip and SG isolation, failure of SG dump, forced cooling via SCS, circulating activity release via open primary relief valve to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of 2x10^{-4}/plant-year)</td></tr>
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MHTGR DBAs 3 0f 3

DBE	Design Basis Events	DBA	Design Basis Accidents
DBE-10	Moderate HPB leak with successful reactor trip, continued forced cooling, release of circulating activity and lift-off of plateout to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of $1x10^{-2}$/plant-year or about $3x10^{-3}$/reactor-year)	DBA-10	Moderate HPB leak with successful reactor trip, failure of forced cooling via Main loops and SCS, passive cooling via RCCS, release of circulating activity, delayed fuel release, and lift-off of plateout to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of $6x10^{-8}$/plant-year or about $1.5x10^{-8}$/reactor-year)
DBE-11	Small HPB leak with successful reactor trip, failure of forced cooling via Main and SCS Loops, passive cooling via RCCS, partial release of circulating activity and delayed fuel release to reactor building involving a single reactor module. (corresponds to PRA sequence family with frequency of $3x10^{-4}$/plant-year or about $8x10^{-5}$/reactor-year)	DBA-11	Small HPB leak with successful reactor trip, failure of forced cooling via Main and SCS, partial release of circulating activity and delayed fuel release to reactor building involving a single reactor-module. (corresponds to PRA sequence family with frequency of $<10^{-8}$/plant-year or $<10^{-8}$/reactor-year)

PRA Development

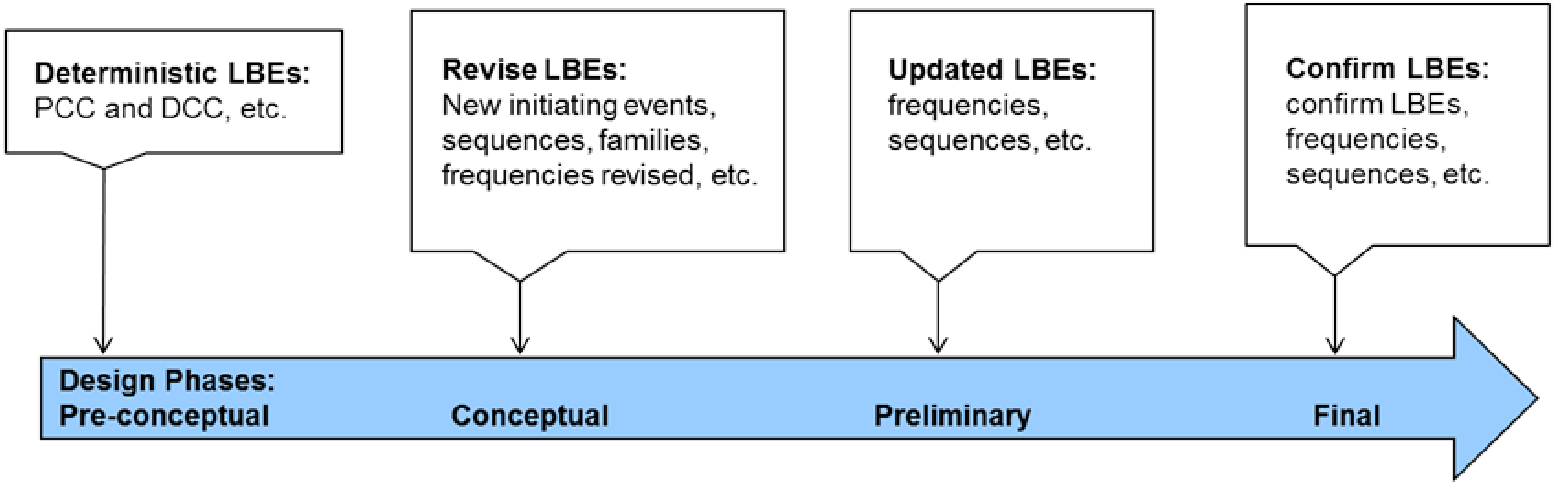
Uses of PRA inputs in LMP Framework

- Supporting and evaluating the development of the design
- Identifying the spectrum of LBEs to be considered
- Evaluating the risk significance of LBEs against F-C Target
- Performing an integrated risk assessment of advanced non-LWR plants that may be comprised of two or more reactor modules and associated non-core sources of radioactive material
- Safety classification of SSCs
- Development of performance criteria for the reliability and capability of SSCs in the prevention and mitigation of accidents
- Determining integrated plant performance margins compared to risk targets
- Exposing and evaluating sources of uncertainty in the identification of LBEs and in the estimation of their frequencies and consequences, and providing key input to the evaluation of the adequacy of DID
- Providing risk and performance-based insights into the evaluation of the design DID adequacy
- Supporting other risk-informed and performance-based (RIPB) decisions

PRA Development

- Although not required, early introduction of PRA into design process facilitates risk-informing design decisions
- Scope and level of detail consistent with scope and level of detail of design and site information and fit for purpose in RIPB decisions
- Depending on the stage of the design and design, PRA event-sequences include those hazards that have state of practice PRA methods and involve single and multiple reactor modules and include risk significant non-reactor sources
- Supporting non-LWR PRA standard specifically designed to support LMP PRA applications
- Limitations and uncertainties associated with PRA addressed in the evaluation of defense-in-depth adequacy and deterministic inputs to RIPB decisions

MHTGR Phased Development of PRA



LBE selection process inputs vary by design phase:

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

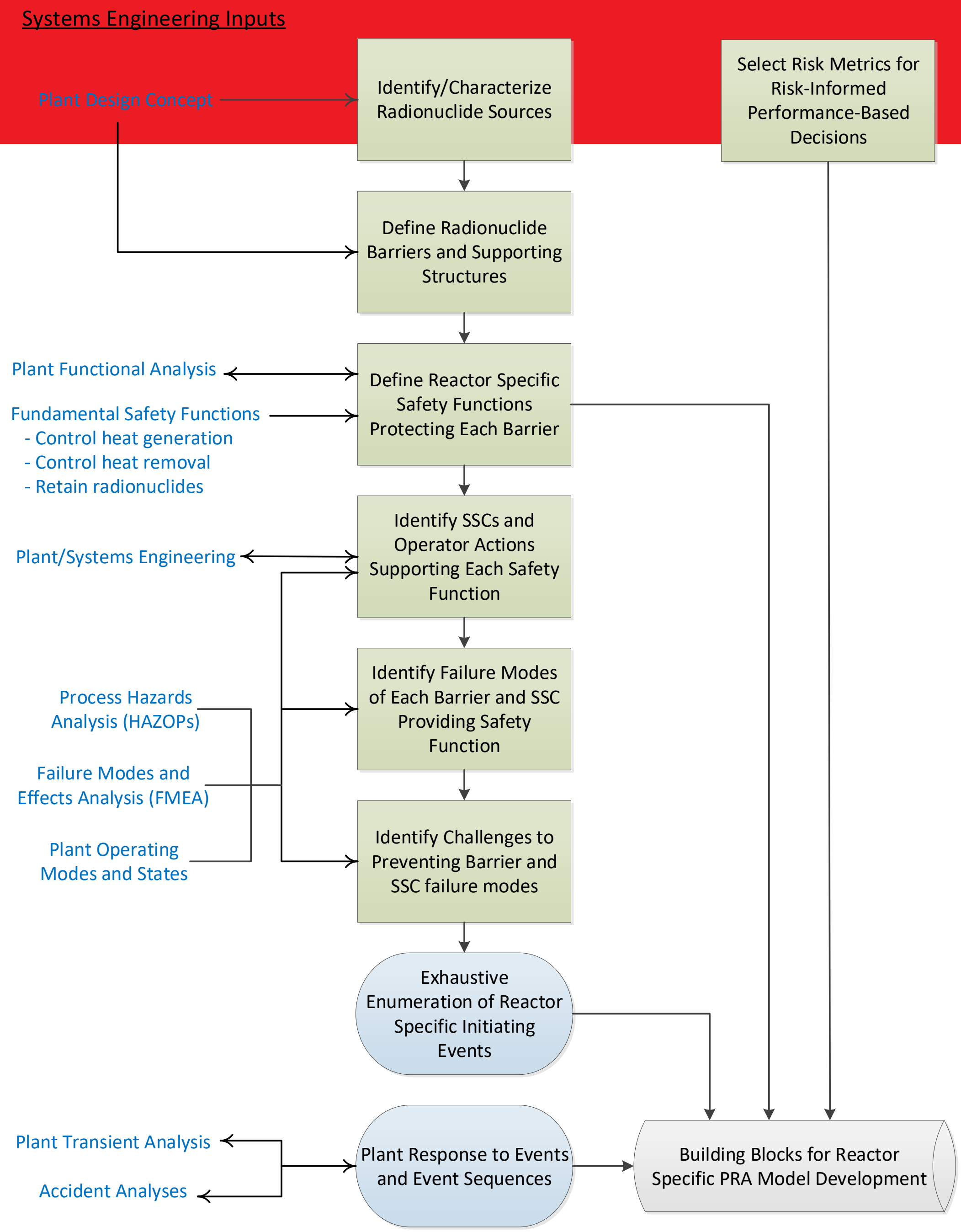
- Basic design*
- Initial analyses (FMEA, HAZOPs, etc)*
- Initiate PRA development†
- Design rqmts.*
- Expert reviews*

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

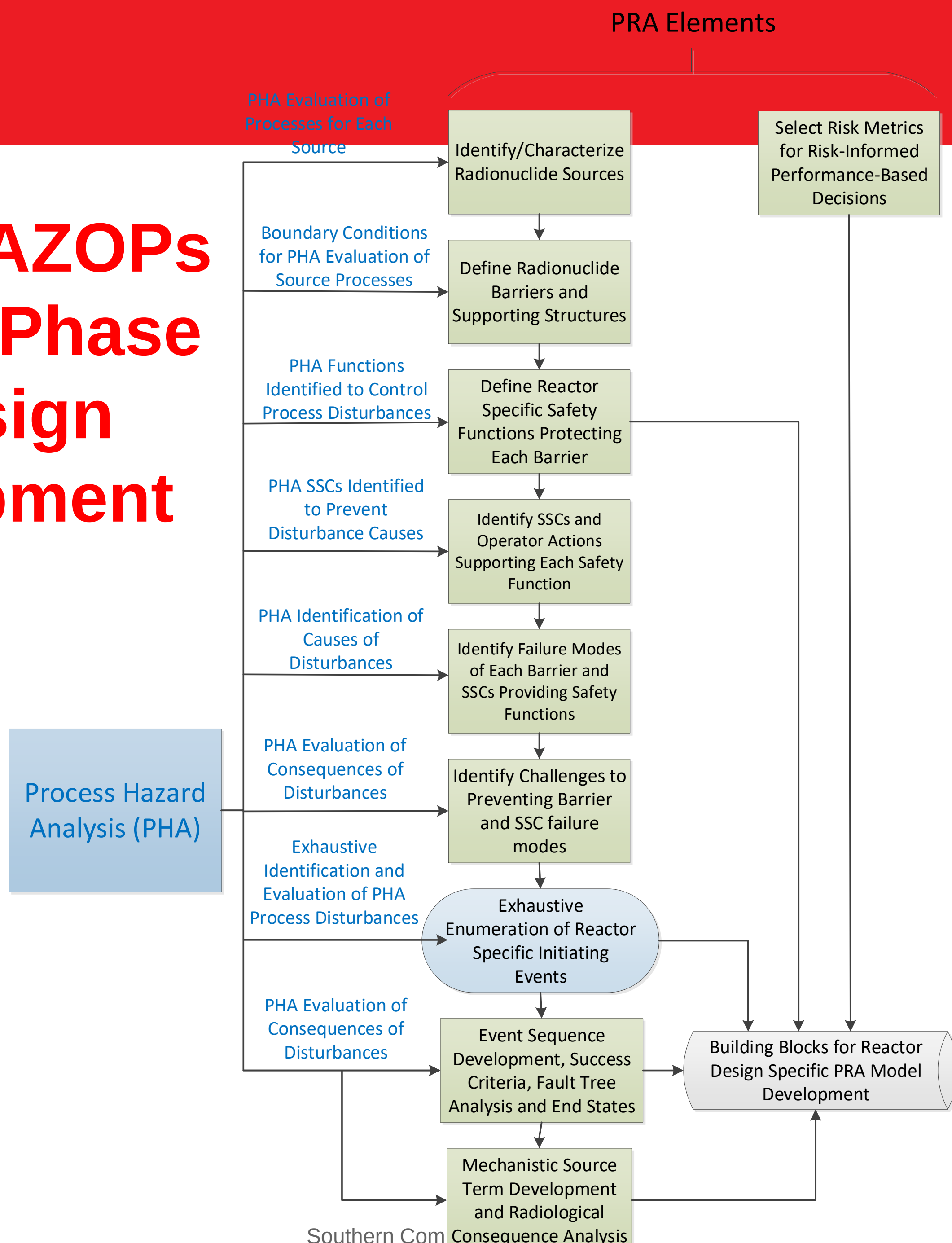
- Mature design
- Detailed FMEAs, etc.
- Complete PRA results
- Expanded PRA scope†
- Expert reviews
- Regulator feedback

* **Steps performed during MHTGR project through early preliminary design**
† PRA scope and level of detail expands as design matures

Typical PRA Development Interfaces



Use of HAZOPs at Early Phase of Design Development



Non-LWR PRA Standard

- ASME/ANS started the development of a non-LWR PRA standard in 2006 and produced a trial use standard ASME/ANS-Ra-S-1.4-2013
- Approximately 80% of the technical requirements are common to the LWR PRA standards; remaining 20% address:
  - Risk metrics appropriate for all advanced non-LWRs
  - PRAs on multi-module plants
  - PRAs that support event sequence frequencies and consequences
  - PRAs that are performed at early stages in design
- Trial use standard is currently being revised towards a ballot for an ANSI standard in 2019

PRA Pilots for the Non-LWR Standard

- GE-Hitachi PRISM reactor, a pool type liquid metal fast reactor.
- HTR-PM under construction in China, a pebble bed type HTGR. PRA performed to meet China regulatory requirements for construction permit and operating license
- Traveling Wave Reactor, a sodium-cooled fast reactor that is designed to utilize spent LWR fuel as a fuel source under development at Terrapower
- Argonne National Laboratory has participated in the development of the trial use standard; incorporated experience in supporting the design of another liquid metal fast reactor being developed in Korea; participated in the GE-PRISM PRA upgrade and has used the requirements in the standard for mechanistic source terms to guide the development of source term technology for SFRs.
- The trial use standard was sponsored in part by the PBMR project in South Africa and the DOE NGNP project and reflected the lessons learned from those PRA projects.
- Molten Chloride Fast Reactor, a homogeneous fuel molten salt reactor under development at Terrapower.
- X-Energy is using the standard to guide the development of a PRA for the Xe-100 pebble bed HTGR

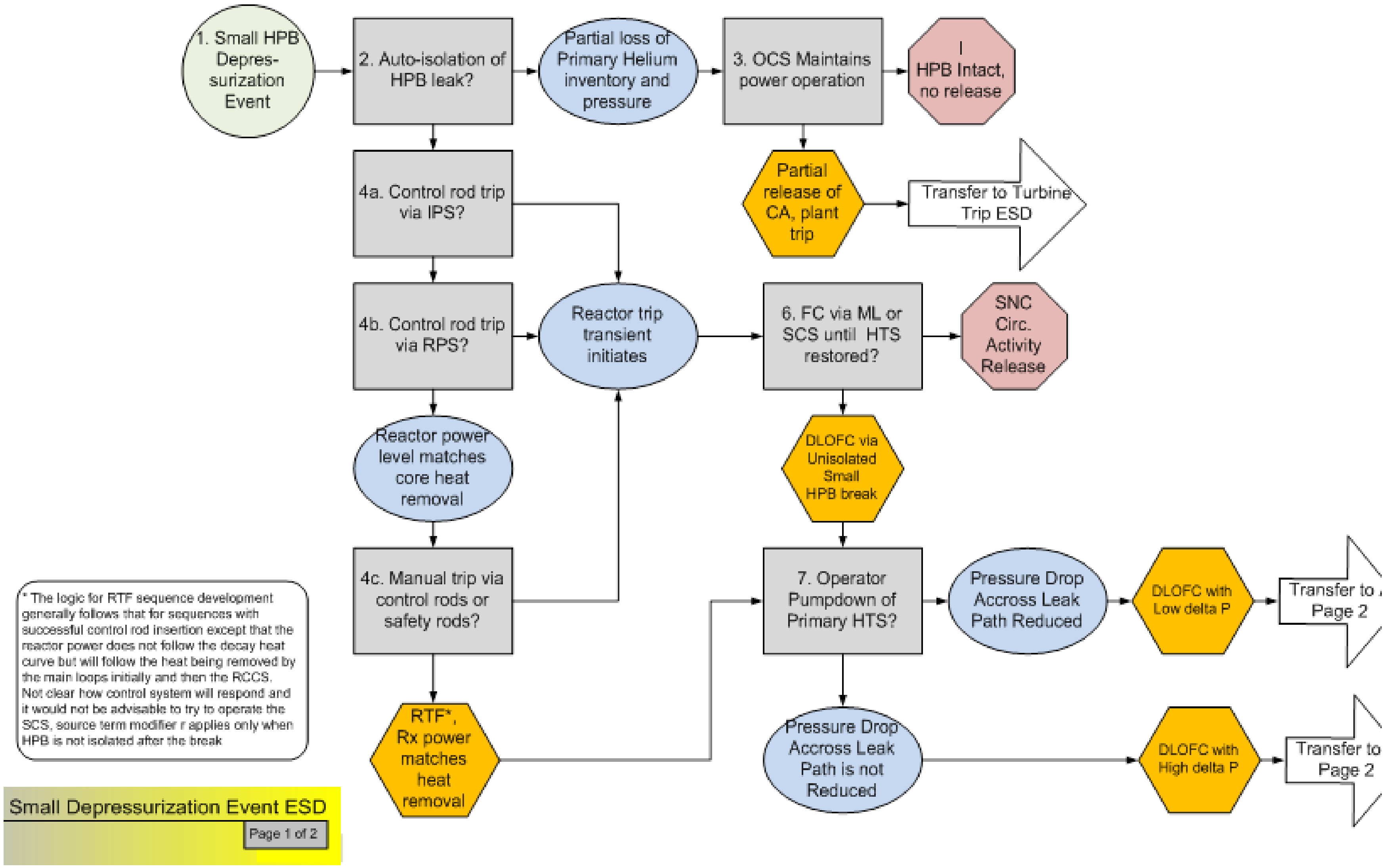
Comparison of PRA Standards

ASME/ANS-RA-S-1.4-2013[43]	Corresponding LWR PRA Standard
Plant Operating State Analysis (POS)	Similar to POS in ANS Low Power and Shutdown PRA standard[44] to support PRA models covering operating and shutdown modes
Initiating Event Analysis (IE)	Similar to IE in ASME/ANS-RA-Sb-2013[42] except that LWR IE categories are replaced by reactor technology neutral categories and both single unit and multi-unit initiators are included
Event Sequence Analysis (ES)	Similar to AS in ASME/ANS-RA-Sb-2013 except that event sequences are developed to user defined intermediate end states and release categories
Success Criteria Development (SC)	Similar to SC in ASME/ANS-RA-Sb-2013 except that safe stable end states are defined to prevent user defined end states rather than to prevent core damage and large early release
Systems Analysis (SY)	Similar to SY in ASME/ANS-RA-Sb-2013
Human Reliability Analysis (HR)	Similar to HR in ASME/ANS-RA-Sb-2013
Data Analysis (DA)	Similar to DA in ASME/ANS-RA-Sb-2013
Internal Flood PRA (FL)	Similar to FL in ASME/ANS-RA-Sb-2013
Internal Fire PRA (FI)	Similar to FI in ASME/ANS-RA-Sb-2013
Seismic PRA (S)	Similar to S in ASME/ANS-RA-Sb-2013
Other Hazards Screening Analysis (EXT)	Similar to EXT in ASME/ANS-RA-Sb-2013
High Winds PRA (W)	Similar to W in ASME/ANS-RA-Sb-2013
External Flooding PRA (XF)	Similar to XF in ASME/ANS-RA-Sb-2013
Other Hazards PRA (X)	Similar to X in ASME/ANS-RA-Sb-2013
Event Sequence Quantification (ESQ)	Similar to QU in ASME/ANS-RA-Sb-2013 except that the event sequences are mapped to user defined end states and release categories and cover anticipated events, and events within and beyond the design basis, and accidents involving single reactor units and multiple reactor units
Mechanistic Source Term Analysis (MS)	Similar to source term requirements in ANS Level 2 PRA standard[45] except that source terms cover both single unit and multiple reactor units
Radiological Consequence Analysis (RC)	Similar to the requirements in the ANS Level 3 PRA standard[75] except that there is an option to limit the scope to the performance of site boundary dose calculations rather than a full Level 3 analysis
Risk Integration (RI)	This PRA element is unique to the non-LWR PRA standard and includes requirements to combine the results of the ESQ and RC elements to affect an integrated risk assessment with options to combine the information in different ways. This includes requirements to establish the risk significant release categories which is then used in ESQ to decompose the risk significant accident sequences and basic events.

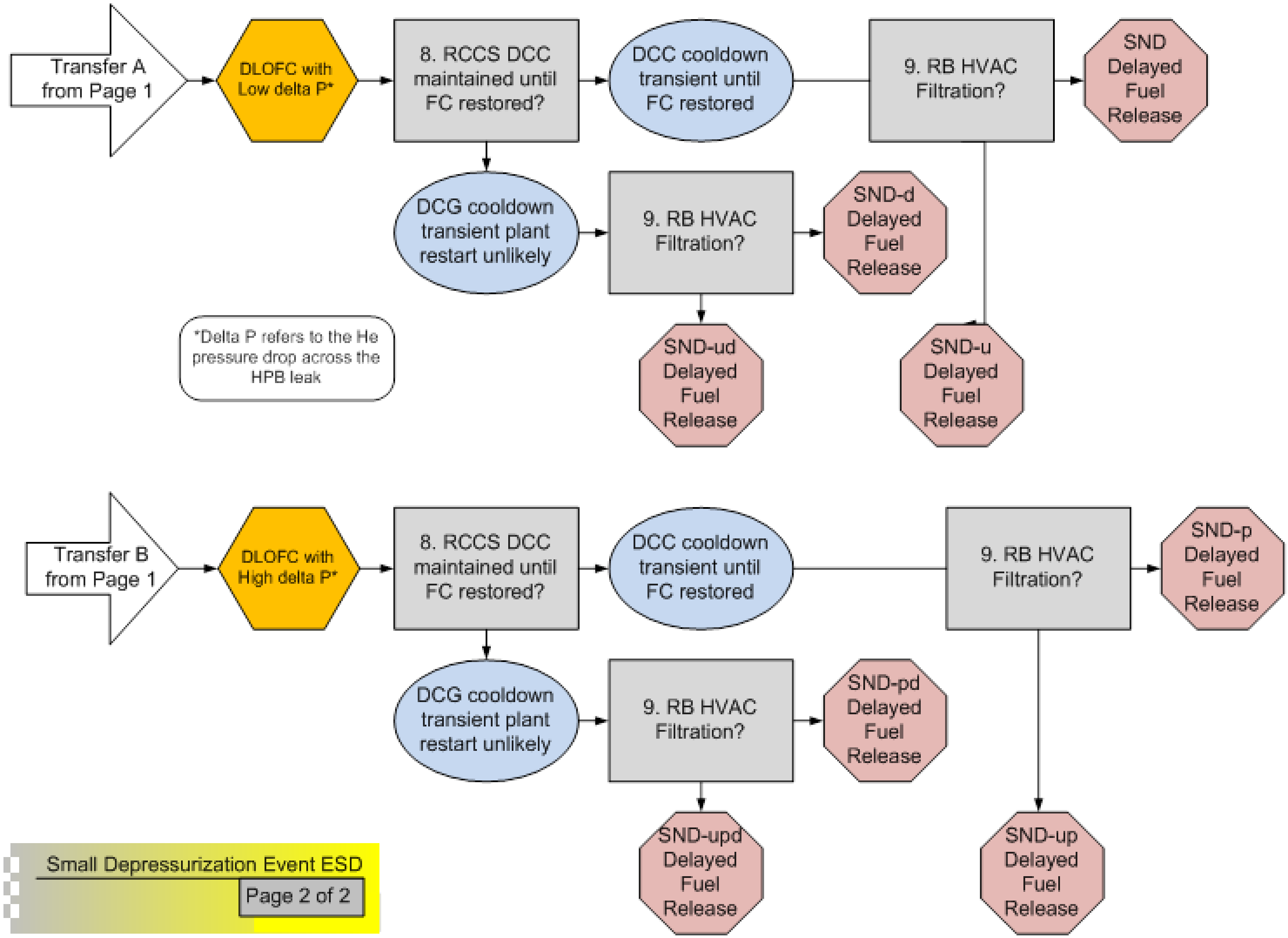
Pebble Bed HTGR PRA Examples

- Following examples from a PRA developed in early stage of design for a small pebble bed HTGR with 4 reactor modules, passive and inherent safety features and vented confinement similar to MHTGR
- Sufficient information available to select initiating events and develop event sequences but too early in design to develop mechanistic source terms; consequences qualitatively assessed.

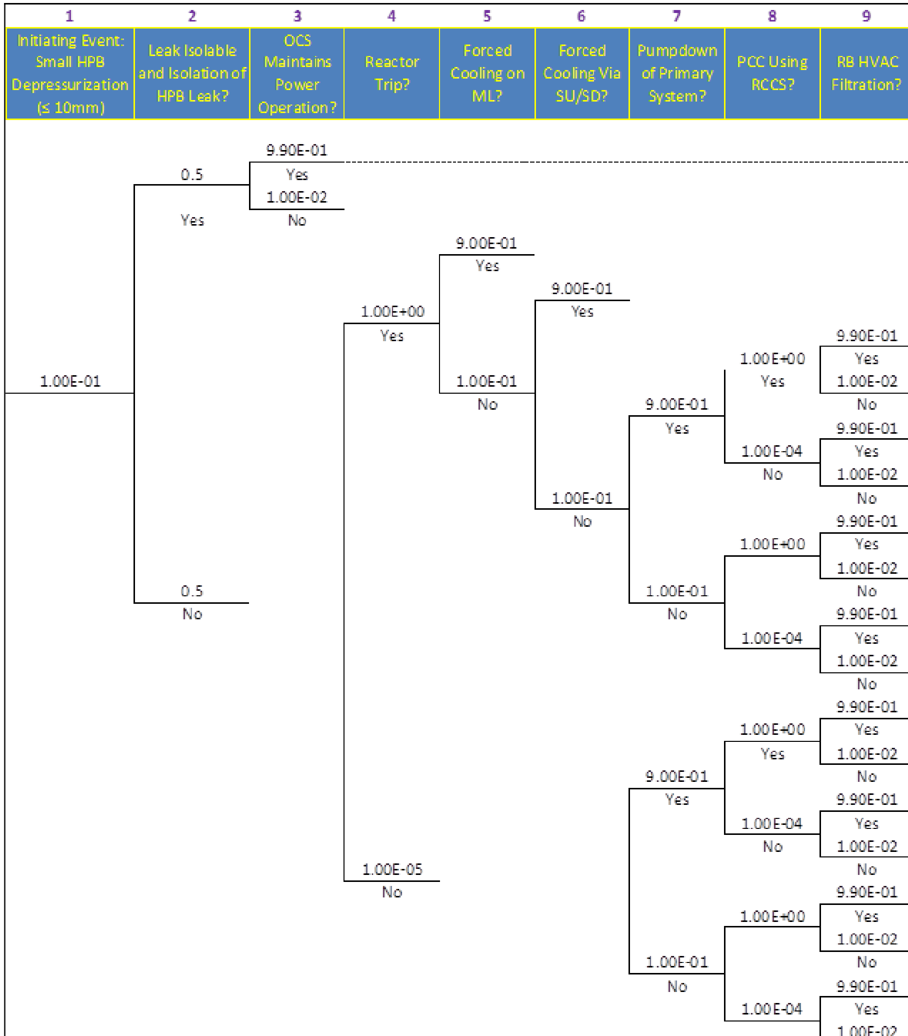
HTGR ESD for Slow Depresurization 1 of 2



HTGR ESD for Slow Depresurization 2 of 2



HTGR Slow Depressurization Event Tree



Sequence No.	Sequence Frequency (Plant-Year^{-1})	Number of Modules	Sequence End State*	LBE Category **
1	4.95E-02	1	I	AOO
2	5.00E-04	1	TT-IE	N/A
3	4.50E-02	1	SNC	AOO
4	4.50E-03	1	SNC	DBE
5	4.45E-04	1	SND	DBE
6	4.50E-06	1	SND-u	BDBE
7	4.45E-08	1	SND-d	BDBE
8	4.50E-10	1	SND-ud	BDBE
9	4.95E-05	1	SND-p	BDBE
10	5.00E-07	1	SND-pu	BDBE
11	4.95E-09	1	SND-pd	BDBE
12	5.00E-11	1	SND-pud	BDBE
13	4.45E-07	1	SND-r	BDBE
14	4.50E-09	1	SND-ur	BDBE
15	4.46E-11	1	SND-dr	BDBE
16	4.50E-13	1	SND-udr	BDBE
17	4.95E-08	1	SND-pr	BDBE
18	5.00E-10	1	SND-pur	BDBE
19	4.95E-12	1	SND-pdr	BDBE
20	5.00E-14	1	SND-pudr	BDBE

* See Figure 4-2 for Definition of End State Codes

**	
AOO	Anticipated Operational Occurrence, > 1E-2/Plant-Year
DBE	Design Basis Event, 1E-4 to 1E-2/Plant-Year
BDBE	Beyond Design Basis Event, 1E-8 to 1E-4/Plant-Year
BDBE	Beyond Design Basis Event, < 1E-8/Plant-Year

HTGR Event Sequence End State Codes

Helium Pressure Boudary Status

W	Description
I	Intact HPB
V	Release Path thru Primary Relief Valve into RB
S	Small HPB Break into RB
M	Medium HPB Break into RB
L	Large HPB Break into RB
Z	Multiple HPB Breaks into RB
X	Release Path thru SG Tube Break/dump lines into RB

Reactor Building Status

X	Description
{blank}	No release from intact HPB
N	No Challenge to RB pressure relief system
R	RB Pressure relief opens, re-closes (remains isolated)
O	RB Pressure relief opens; fails to re-close (fails to isolate)
F	Reactor building structural damage

Source Term Category

Y	Description
{blank}	No release from an intact HPB
C	Release of Circulating Activity only
P	Release of Circulating Activity Release and plateout
D	Delayed Fuel Release

Source Term Modifier (s)

z	Description
{blank}	No release from HPB or filtered release
a	Air Ingress into HPB
w	Water Ingress into HPB
r	Failure of active reactivity control function
p	High ΔP Across Release Path
d	Dry RCCS
u	Unfiltered release

W | X | Y | z

SSC Safety Classification And Performance Requirements

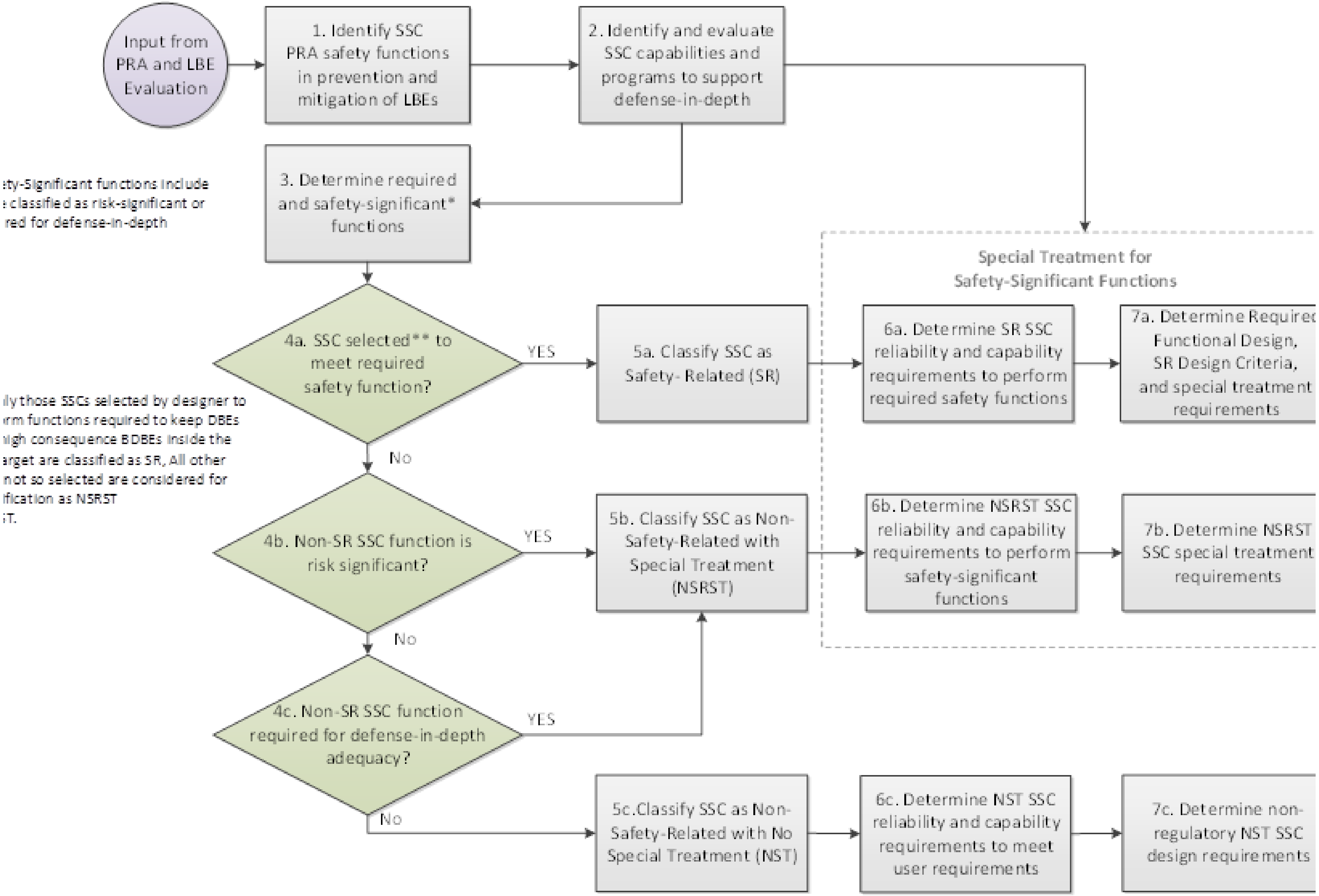
SSC Approach Highlights

- Retains three SSC safety classification categories in NGNP SSC white paper
- Proposes criteria for SSC risk significance based on absolute risk metrics (for consideration in next edition of non-LWR PRA Standard)
- Incorporates concepts from 10 CFR 50.69 and NEI-00-04 in the context of a “forward fit” process
- Includes SSC requirements to address single and multi-module event sequences
- Expands on guidance for deriving performance requirements beyond those in NGNP SSC white paper

LMP Proposed SSC Safety Categories

- **Safety-Related (SR):**
  - SSCs selected by the designer to perform required safety functions to mitigate the consequences of DBEs to within the F-C target, and to mitigate DBAs to meet the dose limits of 10 CFR 50.34 using conservative assumptions.
  - SSCs selected by the designer to perform required safety functions to prevent the frequency of BDBEs with consequences greater than 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C target.
- **Non-Safety-Related with Special Treatment (NSRST)**:
  - Non-safety related SSCs relied on to perform risk significant functions. Risk significant SSCs are those that perform functions that keep LBEs from exceeding the F-C target, or make significant contributions to the cumulative risk metrics selected for evaluating the total risk from all analyzed LBEs.
  - Non-safety related SSCs relied on to perform functions requiring special treatment for DID adequacy.
- **Non-Safety-Related with No Special Treatment (NST)**:
  - All other SSCs.

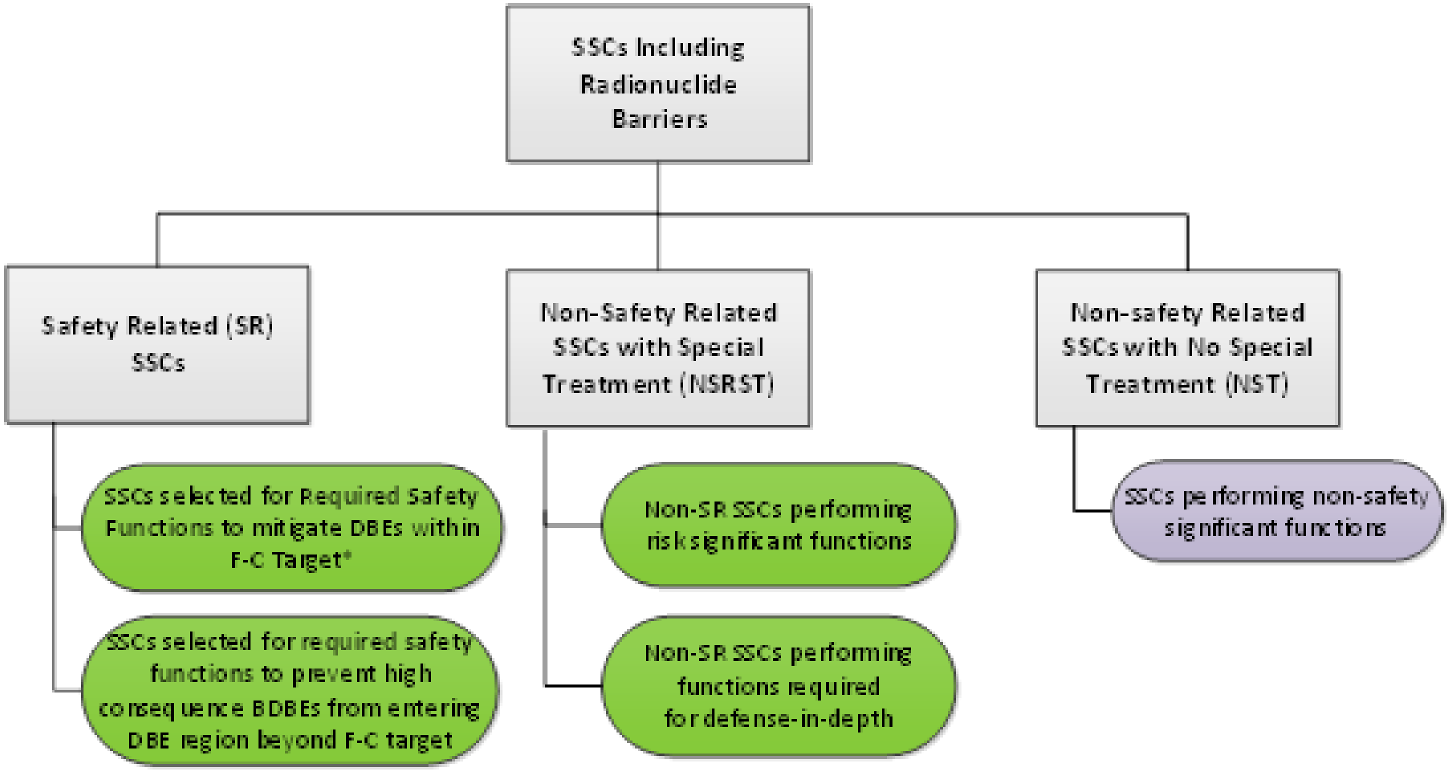
LMP SSC Safety Classification Approach



SSC Risk Significance

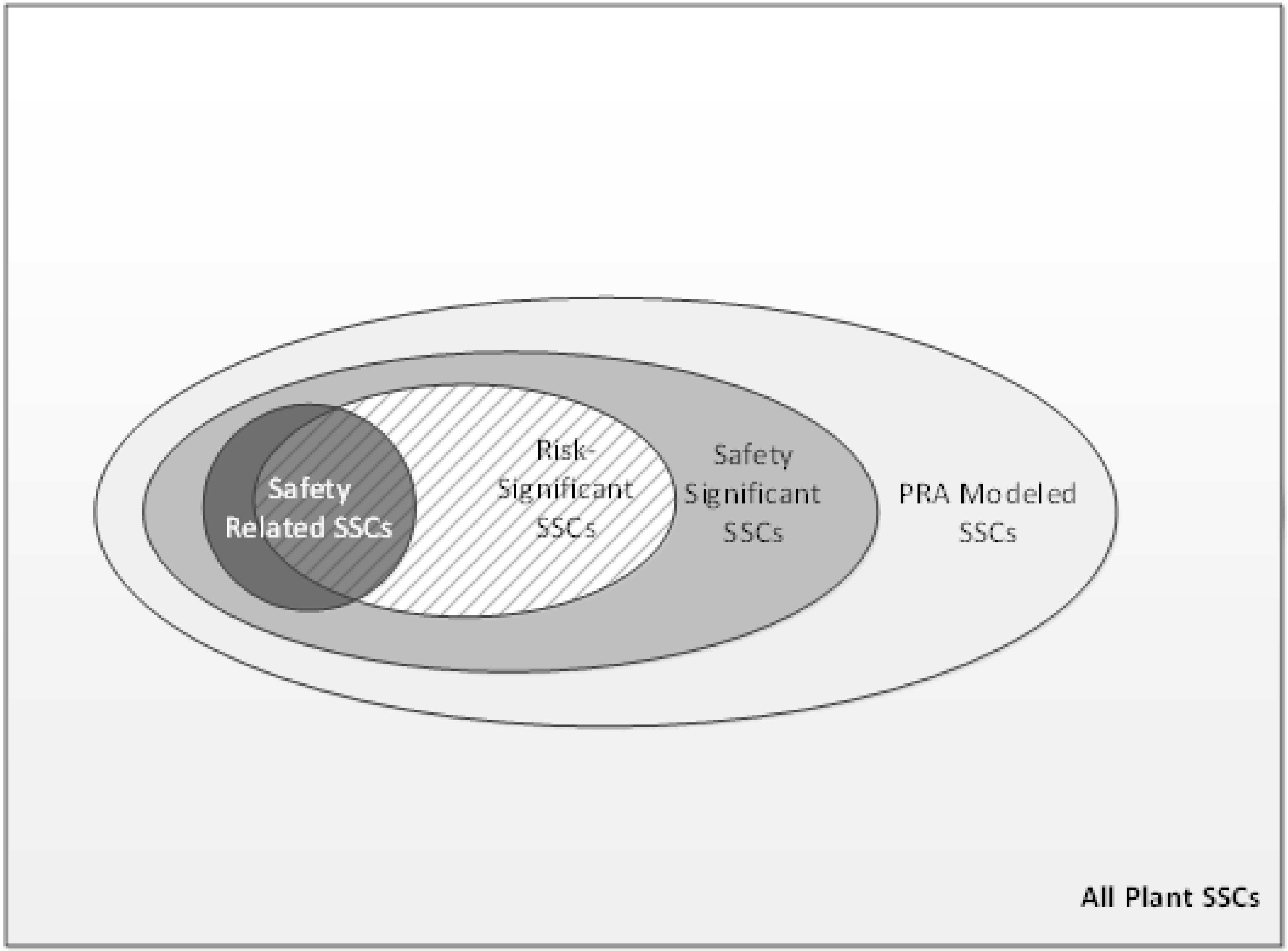
- **A prevention or mitigation function of the SSC is necessary to meet the design objective of keeping all LBEs within the F-C target.**
  - The LBE is considered within the F-C target when a point defined by the upper 95%-tile uncertainty of the LBE frequency and dose estimates are within the F-C target.
- **The SSC makes a significant contribution to one of the cumulative risk metrics used for evaluating the risk significance of LBEs.**
  - A significant contribution to each cumulative risk metric limit is satisfied when total frequency of all LBEs with failure of the SSC exceeds 1% of the cumulative risk metric limit. The cumulative risk metrics and limits include:
    - The total frequency of exceeding of a site boundary dose of 100 mrem <1/plant-year (10 CFR 20)
    - The average individual risk of early fatality within 1 mile of the Exclusion Area Boundary (EAB) < 5×10^{-7}/ plant-year (QHO)
    - The average individual risk of latent cancer fatalities within 10 miles of the EAB shall not exceed 2×10^{-6}/plant-year (QHO)

LMP SSC Safety Categories

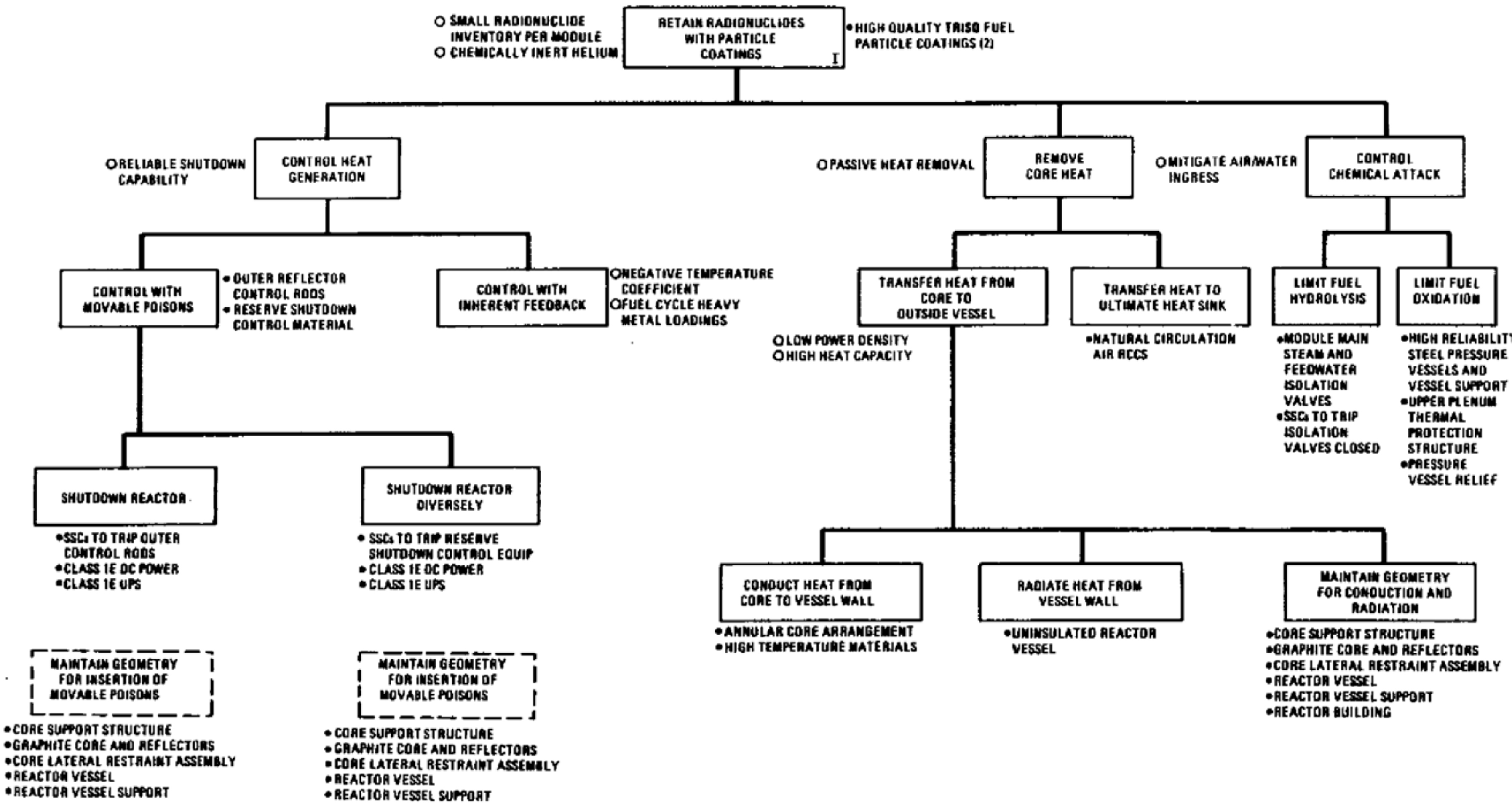


* SR SSCs are also relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions

SSC Category Relationships



MHTGR Safety Related SSCs



(1) ATTRIBUTES SELECTED ARE PRECEDED BY O, DESIGN SELECTIONS ARE PRECEDED BY ●

(2) REDUCE ALLOWABLE COATING DEFECTS DESIGNED TO MEET MORE RESTRICTIVE PAG LIMITS

MHTGR Required Functional Design Criteria 1 of 3

Required Safety Function	Functional Design Criteria
Retain Radionuclides in Fuel Particles	I: The reactor fuel shall be designed, fabricated, and operated in such a manner that minor radionuclide releases from the fuel to the primary coolant will not exceed acceptable values.
Control Chemical Attack	II: The vessel and other components that limit or prevent the ingress of air or water shall be designed, fabricated, and operated in such a manner that the amount of air or water reacting with the core will not exceed acceptable values.
Control Heat Generation	III: The reactor shall be designed, fabricated, and operated in such a manner that the inherent nuclear feedback characteristics will ensure that the reactor thermal power will not exceed acceptable values. Additionally, the reactivity control system(s) shall be designed, fabricated, and operated in such a manner that during insertion of reactivity, the reactor thermal power will not exceed acceptable values.
Control Heat Removal	IV: The intrinsic dimensions and power densities of the reactor core, internals, and vessel, and the passive cooling pathways from the core to the environment, shall be designed, fabricated, and operated in such a manner that the fuel temperatures will not exceed acceptable values.
Control with Movable Poisons	V: Two independent and diverse sets of movable poison equipment shall be provided in the design. Either set shall be capable of limiting the heat generation of the reactor to acceptable levels during off-normal conditions.
Shutdown Reactor	VI: The equipment needed to sense, command, and execute a trip of the control rods, along with any necessary electrical power, shall be designed, fabricated, and operated in such a manner that reactor core shutdown is assured during off-normal conditions.

MHTGR Required Functional Design Criteria 2 of 3

Required Safety Function	Functional Design Criteria
Shutdown Reactor Diversely	VII: The equipment needed to sense, command, and execute a trip of the reserve shutdown control equipment, along with any necessary electrical power, shall be designed, fabricated, operated, and maintained in such a manner that the shutdown of the reactor core is assured during off-normal conditions.
Maintain Geometry for Insertion of Movable Poisons	VIII: The design, fabrication, operation, and maintenance of the control rod guide tubes, the graphite core and reflectors, the core support structure, the core lateral restraint assemblies, the reactor vessel, and reactor vessel support shall be conducted in such a manner that their integrity is maintained during off normal conditions as well as provide the appropriate geometry that permits the insertion of the control rods into the outer reflector to effect reactor shutdown.
	IX: The design, fabrication, and operation of the reserve shutdown control equipment guide tubes, the graphite core and reflectors, the core support structure, the core lateral restraint assemblies, the reactor vessel, and reactor vessel support shall be conducted in such a manner that their integrity is maintained during off-normal conditions, as well as provide the appropriate geometry that permits the insertion of reserve shutdown control material to effect reactor shutdown.
Transfer Heat to Ultimate Heat Sink	X: A highly reliable, passive means of removing the heat generated in the reactor core and radiated from the reactor vessel wall shall be provided. The system shall remove heat at a rate which limits core and vessel temperatures to acceptable levels during a loss of forced circulation.
Limit Fuel Hydrolysis	XI: The steam, feedwater and other cooling systems shall include a reliable means to limit the amount of steam and water that can enter the reactor vessel to an acceptable level.

MHTGR Required Functional Design Criteria 3 of 3

Required Safety Function	Functional Design Criteria
Limit Fuel Oxidation	XII: The primary system/boundary shall be designed and fabricated to a level of quality that is sufficient to ensure high reliability of the primary system/boundary integrity needed to prevent air ingress during normal and off-normal conditions. The plant shall be designed, fabricated, operated, and maintained in a manner that ensures that the primary system boundary design limits are not exceeded.
Conduct Heat from Core to Vessel Wall	XIII: The reactor core shall be designed and configured in a manner that will ensure sufficient heat transfer by conduction, radiation, and convection to the reactor vessel wall to maintain fuel temperatures within acceptable limits following a loss of forced cooling. The materials which transfer the heat shall be chosen to withstand the elevated temperatures experienced during this passive mode of heat removal. This criterion shall be met with the primary coolant system both pressurized and depressurized.
Radiate Heat from Vessel Wall	XIV: The vessel shall be designed in a manner that will ensure that sufficient heat is radiated to the surroundings to maintain fuel and vessel temperatures within acceptable limits. This criterion shall be met with the primary coolant system in both a pressurized and depressurized condition.
Maintain Geometry for Conduction and Radiation	XV: The design, fabrication, operation, and maintenance of the core support structure, graphite core and reflectors, core lateral restraint assembly, reactor vessel, reactor vessel support, and reactor building shall be in such a manner that their integrity is maintained during off-normal conditions so as to provide a geometry conducive to removal of heat from the reactor core to the ultimate heat sink and maintain fuel temperatures within acceptable limits.

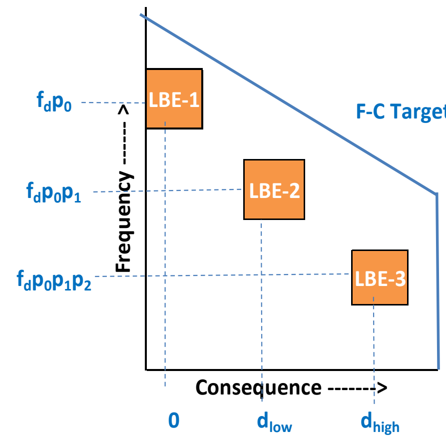
Derivation of Special Treatment Requirements

- SR SSCs
  - Required Functional Design Criteria (RFDC) derived from Required Safety Functions (RSFs)
  - Component level Safety Related Design Criteria (SRDC) developed from RSFs
- SR and NSRST SSCs
  - SSC reliability and capability performance targets
  - Focus on prevention and mitigation functions from LBEs
  - Integrated decision making process to derive specific special treatment requirements
  - Reflects concepts from 10 CFR 50.69 and NEI-00-04 from existing reactors from a "forward fit" perspective
  - Reflects Commission's expectations for risk-informed and performance based regulation from SRM to SECY 98-0144

Roles of SSC Capability and Reliability in Prevention and Mitigation of Accidents

Plant Distrubance	Plant features prevent Inititating event?	SSC_1 Prevents Fuel Damage?	SSC_2 Limits Release?	LBE	End State	Defense-in-Depth Layers Challenged [1]	Frequency	Dose
f_d	Yes			N/A	Disturbance controlled with no plant trip	Layer 1	f_d	0
	p_0 No	Yes		1	No fuel damage or release	Layer 2	$f_d p_0$	0
		p_1 No	Yes	2	Fuel damage w/ limited release	Layer 3	$f_d p_0 p_1$	d_{low}
			p_2 No	3	Fuel Damage w/ un-mitigated release	Layers 4 and 5	$f_d p_0 p_1 p_2$	d_{high}

[1] See Figure 2-4 for definition of defense-in-depth layers



SSC	LBEs	Function	SSC Performance Attribute for Special Treatment
Plant	N/A	Prevent initiating event	Reliability of plant features preventing initiating event
SSC_1	1	Mitigate initiating event	Capability to prevent fuel damage
	2	Prevent fuel damage	Reliability of mitigation function
	3	Help prevent large release	Reliability of mitigation function
SSC_2	2	Mitigate fuel damage	Capability to limit release from fuel damage
	3	Prevent unmitigated release	Reliability of mitigation function

SSC Classification Summary

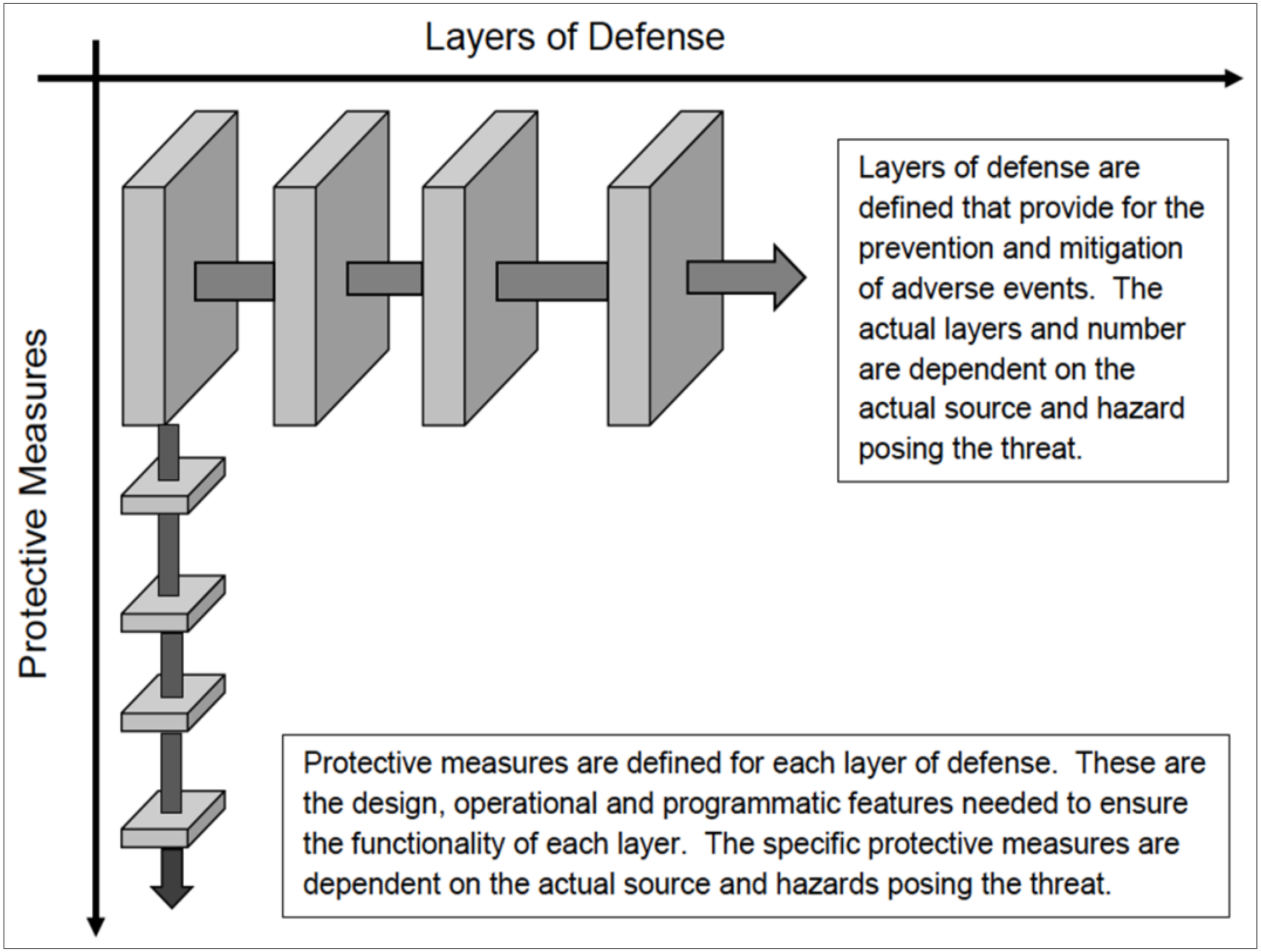
- LMP retains the NGNP SSC safety categories of SR, NSRST, and NST
- All safety significant SSCs classified as SR or NSRST
- Absolute risk metrics used for SSC and LBE risk significance
- SR SSCs are not necessarily risk significant
- NSRST SSCs include other risk significant SSCs and SSCs requiring some special treatment for DID adequacy
- Specific special treatment for capabilities and reliabilities in the prevention and mitigation of event sequences
- Special treatment defined via integrated decision panel using “forward fit” 10 CFR 50.69 process

Defense In Depth Adequacy Evaluation

DID Adequacy Approach

- Builds on NGNP DID approach also reflected in ANS-53.1
- Evaluation of DID adequacy is both risk-informed and performance-based.
- The “layers of defense” and attributes of the NRC and IAEA DID frameworks are more visibly represented.
- DID attributes for plant capability and programmatic DID have been enhanced for consistency with the measures defined in the LMP Guidance Document
- This process is used to evaluate each LBE and to identify the DID attributes that have been incorporated into the design to prevent and mitigate accident sequences and to ensure that they reflect adequate SSC reliability and capability.
- Those LBEs with the highest levels of risk significance are given greater attention in the evaluation process.
- The practicality of compensatory actions for DID purposes are considered in the context of the individual LBE risk significance and in a cumulative manner across all LBEs

DID Concept from NUREG/KM-0009



Defense In Depth Adequacy Basic Objectives

Risk-Informed Evaluation of DID

This element provides a systematic, holistic, integrated, and transparent process for examining the DID adequacy achieved by the combination of plant capability and programmatic elements. This evaluation is performed by a risk-informed integrated decision-making (RIDM) process to assess and establish whether DID is sufficient to enable consideration of different alternatives for achieving commensurate safety levels at reduced burdens. The outcome of the RIDM process also establishes a DID baseline for managing risk throughout the plant lifecycle.

How is Approach Risk-Informed and Performance-Based?

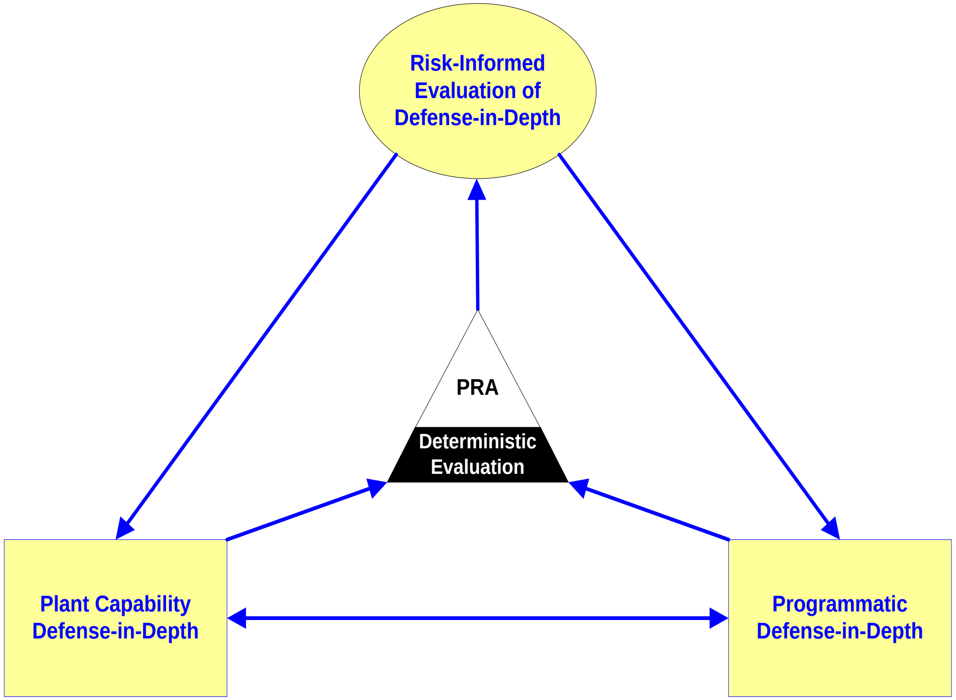
- Use of quantifiable and absolute risk metrics to evaluate plant, LBE, and SSC risk significance
  - F-C Target
  - Cumulative Risk Targets
  - Capability to quantify risk vs. risk targets
  - Tracking of performance against risk targets through design and operational phases
- Development of SSC performance requirements
  - tied to the reliability and capability of SSCs to prevent and mitigate LBEs derived from risk-significance evaluation and evaluation of defense-in-depth adequacy
  - Selection of special treatment requirements for SR SSCs to provide assurance of defense-in-depth adequacy
  - Expectation to monitor SSC performance against requirements
- Performance-based requirements anchored to maintain risk margins and assurance of defense-in-depth adequacy

Defense In Depth Adequacy Basic Structure

Plant Capability DID

Plant Functional Capability DID—This capability is introduced through systems and features designed to prevent occurrence of undesired LBEs or mitigate the consequences of such events.

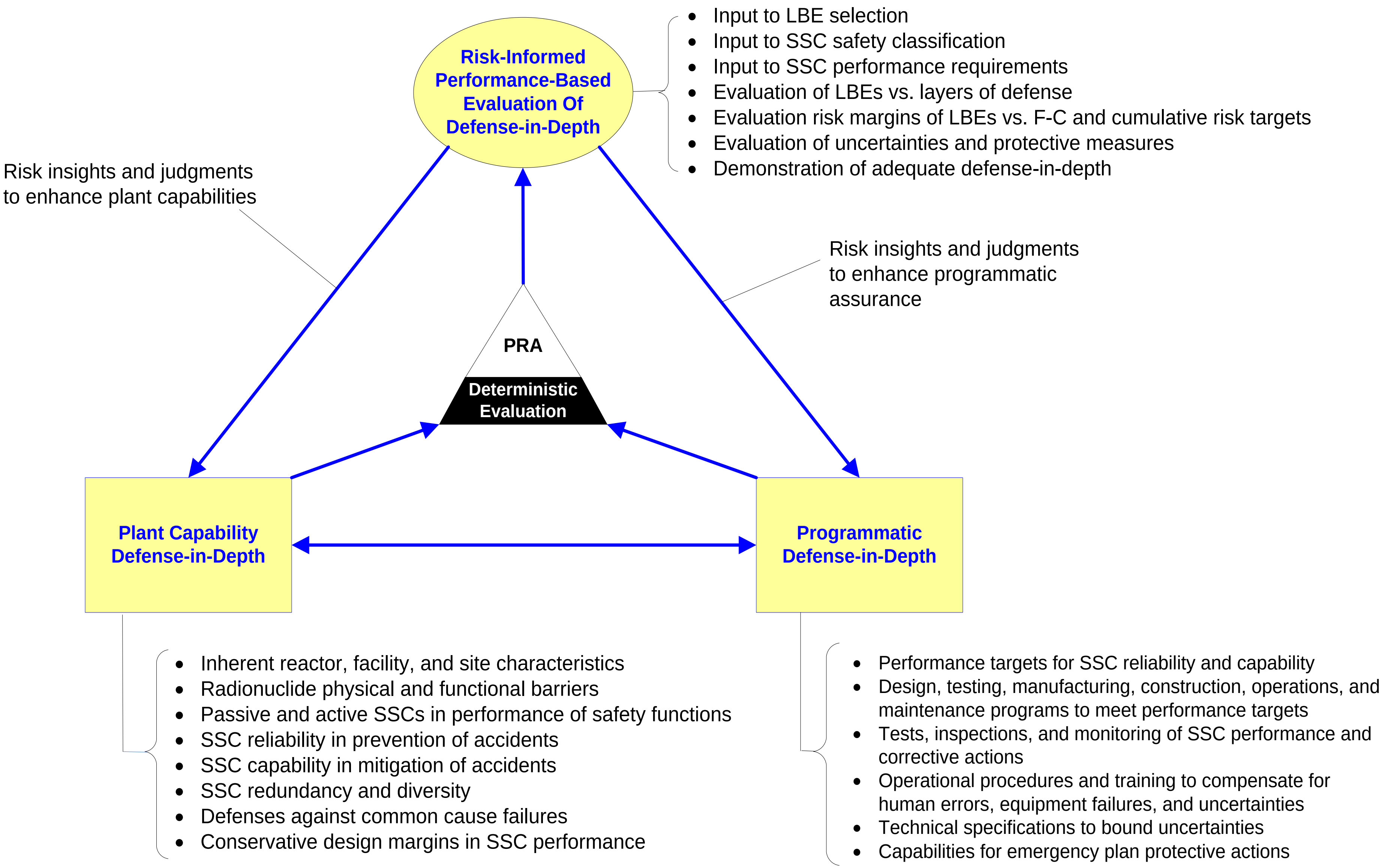
Plant Physical Capability DID—This capability is introduced through SSC robustness and physical barriers to limit the consequences of a hazard.



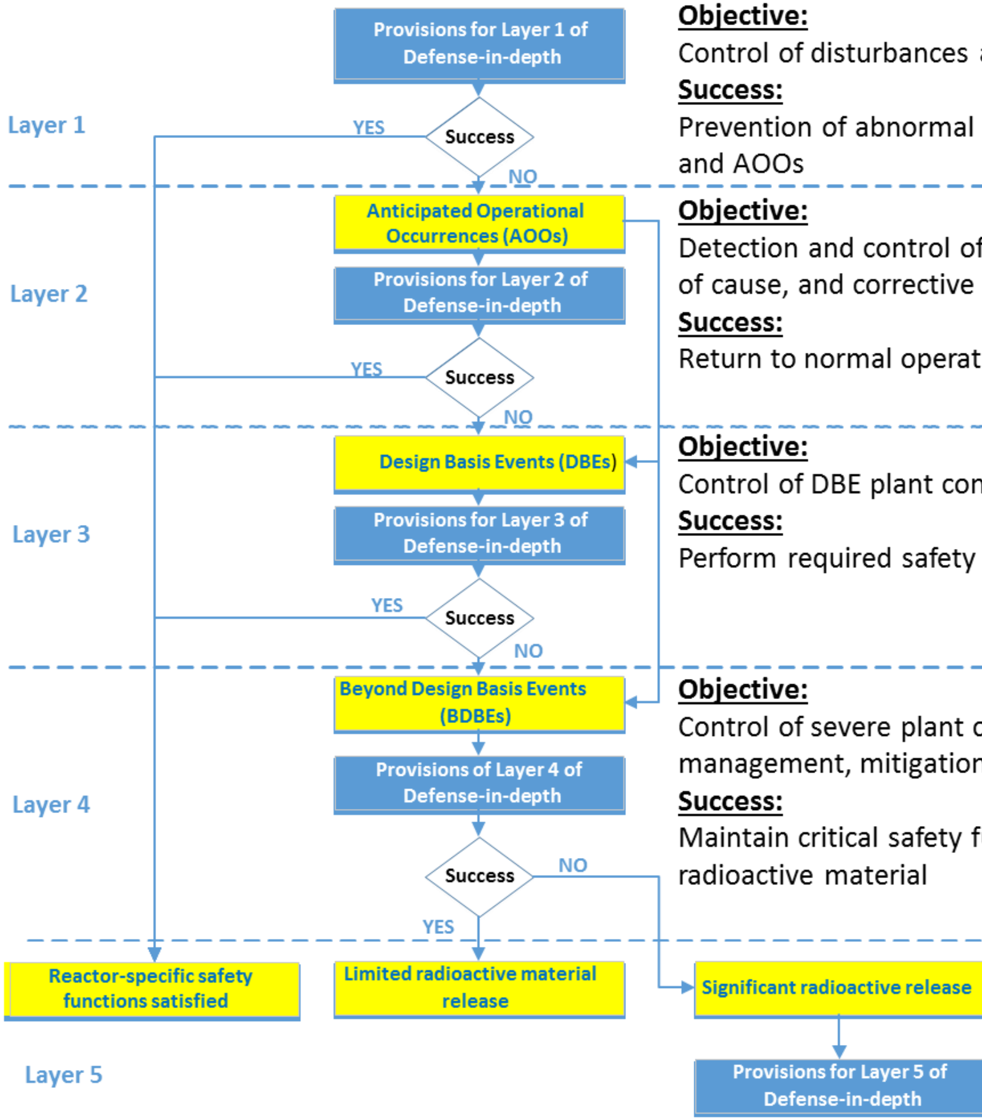
Programmatic DID

Programmatic DID is used to address uncertainties when evaluating plant capability DID and is used where programmatic protective strategies are defined. It is used to incorporate special treatment during design, manufacturing, constructing, operating, maintaining, testing, and inspecting of the plant and the associated processes to ensure there is reasonable assurance that the predicted performance can be achieved throughout the lifetime of the plant. The use of performance-based measures, where practical, to monitor plant parameters and equipment performance that have a direct connection to risk management and equipment and human reliability are considered essential.

DID Adequacy Framework



Layers of Defense Adapted from IAEA



Objective:
Control of disturbances and transients
Success:
Prevention of abnormal operation, initiating events, and AOOs

Objective:
Detection and control of abnormal operation and AOOs, identification of cause, and corrective actions
Success:
Return to normal operation, prevention of DBEs.

Objective:
Control of DBE plant conditions within the design basis
Success:
Perform required safety functions, prevent BDBEs

Objective:
Control of severe plant conditions, including on-site accident management, mitigation of accident consequences
Success:
Maintain critical safety functions for the retention of radioactive material

Objective:
Anticipatory emergency planning and off-site accident management to mitigate accident doses to the public
Success:
Prevent adverse public health and safety impacts

Plant Capability Defense-In-Depth Attributes

Attribute	Evaluation Focus
Initiating Event and Event Sequence Completeness	PRA Documentation of Initiating Event Selection and Event Sequence Modeling
	Insights from reactor operating experience, system engineering evaluations, expert judgment
Layers of Defense	Multiple Layers of Defense
	Extent of Layer Functional Independence
	Functional Barriers
	Physical Barriers
Functional Reliability	Inherent Reactor Features that contribute to performing safety functions
	Passive and Active SSCs performing safety functions
	Redundant Functional Capabilities
	Diverse Functional Capabilities
Prevention and Mitigation Balance	SSCs performing prevention functions
	SSCs performing mitigation functions
	No Single Layer /Feature Exclusively Relied Upon

Programmatic DID Attributes

Attribute	Evaluation Focus
Quality / Reliability	Performance targets for SSC reliability and capability
	Design, manufacturing, construction, O&M features, or special treatment sufficient to meet performance targets
Compensation for Uncertainties	Compensation for human errors
	Compensation for mechanical errors
	Compensation for unknowns (performance variability)
	Compensation for unknowns (knowledge uncertainty)
Off-Site Response	Emergency response capability

RIPB Decision-Making Attributes

Attribute	Evaluation Focus
Use of Risk Triplet Beyond PRA	What can go wrong?
	How likely is it?
	What are the consequences?
Knowledge Level	Plant Simulation and Modeling of LBEs
	State of Knowledge
	Margin to PB Targets and Limits
Uncertainty Management	Magnitude and Sources of Uncertainties
Action Refinement	Implementation Practicality and Effectiveness
	Cost/Risk/Benefit Considerations

Guidelines for Establishing Adequacy of Plant Capability Defense-in-Depth

Layer[a]	Layer Guideline		Overall Guidelines	
	Quantitative	Qualitative	Quantitative	Qualitative
1) Prevent off-normal operation and AOOs	Maintain frequency of plant transients within designed cycles; meet owner requirements for plant reliability and availability[b]		Meet F-C Target for all LBEs and cumulative risk metric targets with sufficient[d] margins	No single design or operational feature,[c] no matter how robust, is exclusively relied upon to satisfy the five layers of defense
2) Control abnormal operation, detect failures, and prevent DBEs	Maintain frequency of all DBEs $< 10^{-2}$/ plant-year	Minimize frequency of challenges to safety-related SSCs		
3) Control DBEs within the analyzed design basis conditions and prevent BDBEs	Maintain frequency of all BDBEs $< 10^{-4}$/ plant-year	No single design or operational feature[c] relied upon to meet quantitative objective for all DBEs		
4) Control severe plant conditions, mitigate consequences of BDBEs	Maintain individual risks from all LBEs < QHOs with sufficient[d] margins	No single barrier[c] or plant feature relied upon to limit releases in achieving quantitative objectives for all BDBEs		
5) Deploy adequate offsite protective actions and prevent adverse impact on public health and safety				

Notes:

[a] The plant design and operational features and protective strategies employed to support each layer should be functionally independent

[b] Non-regulatory owner requirements for plant reliability and availability and design targets for transient cycles should limit the frequency of initiating events and transients and thereby contribute to the protective strategies for this layer of DID. Quantitative and qualitative targets for these parameters are design specific.

[c] This criterion implies no excessive reliance on programmatic activities or human actions and that at least two independent means are provided to meet this objective.

[d] The level of margins between the LBE risks and the QHOs provides objective evidence of the plant capabilities for DID. Sufficiency will be decided by the IDP.

DID Evaluation Baseline Summary Concept

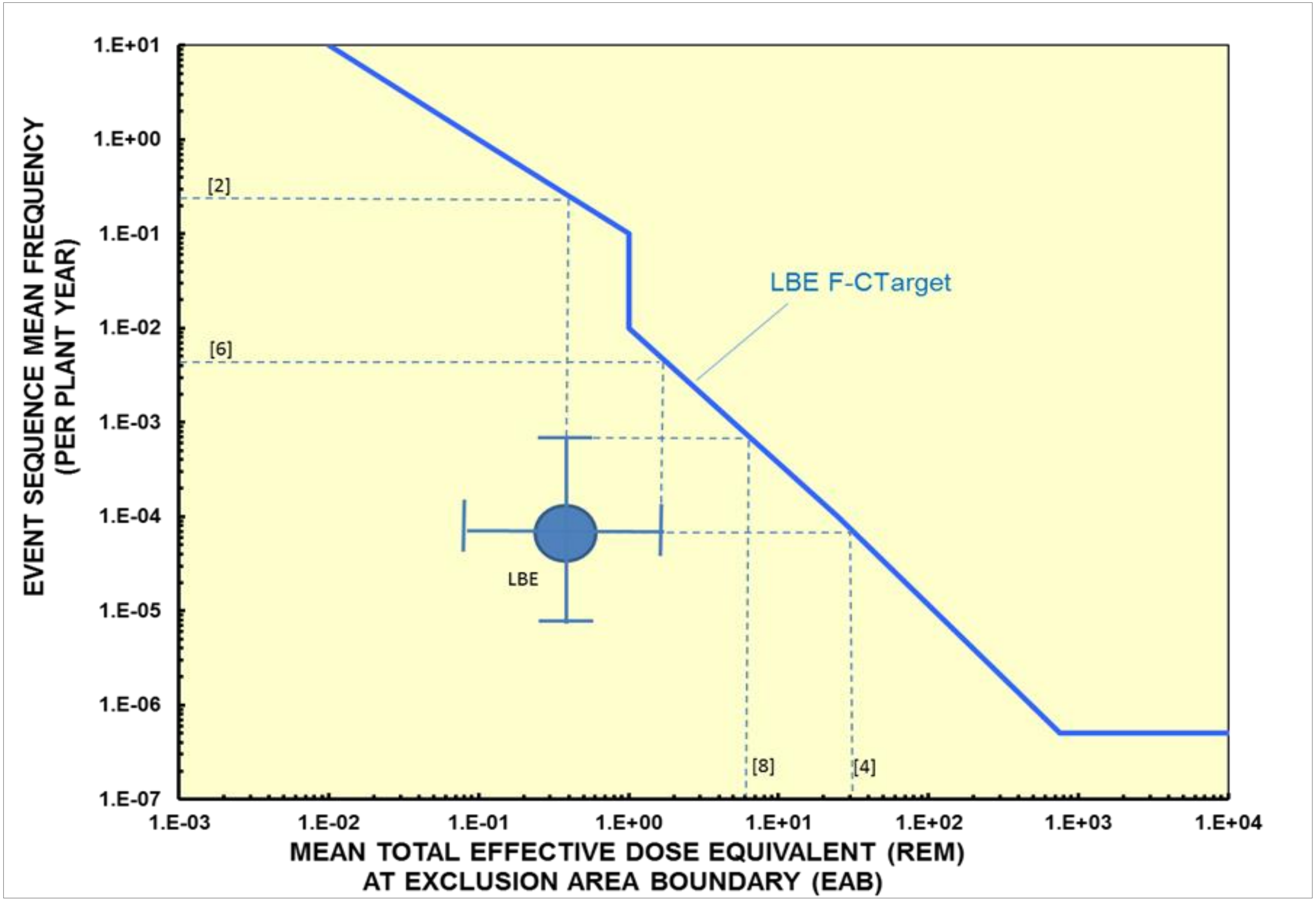
Qualitative Evaluation of Plant Capability DID

LBE IE Series Name	Functional			Physical	
	Margin Adequacy	Multiple Protective Measures	Prevention and Mitigation Balance	Functional Reliability	No Single Feature Relied Upon
Normal Operation	√		√	√	
AOOs	√		√	√	
DBEs	√	√	√	√	√
BDBEs	√	√	√	√	√
DBAs	√	√	√	√	√

Evaluation Summary – Qualitative Evaluation of Programmatic DID

LBE IE Series Name	Quality/Reliability: Design, Manufacturing, Construction, O&M	Compensation for Uncertainties			Emergency Response Capability
		Human Errors	Mechanical Failures	Unknowns	
Normal Operation	√	√	√	√	
AOOs	√	√	√	√	
DBEs	√	√	√	√	√
BDBEs	√	√	√	√	√
DBAs	√	√	√	√	√

Evaluating Margins Against F-C Target



Example Risk Margins for MHTGR

LBE Category	Limiting LBE[a]			F-C Target			
	Name	Mean Freq. /plant-yr.	Mean Dose (Rem)	Freq. at LBE Dose/plant-yr. [b]	Mean Frequency Margin[c]	Dose at LBE Freq. (Rem) [d]	Dose Margin[e]
AOO	AOO-5	4.00E-02	2.50E-04	4.00E+02	1.00E+04	1.00E+00	4.00E+03
DBE	DBE-10	1.00E-02	2.00E-03	6.00E+01	6.00E+03	1.00E+00	5.00E+02
BDBE	BDBE-2	3.00E-06	4.00E-03	2.50E+01	8.30E+06	2.50E+02	6.00E+04

Notes:

[a] The Limiting LBE is the LBE with the highest risk significance in the LBE category

[b] Frequency value measured at the LBE mean Dose level from the F-C target, See [2] in **Error! Reference source not found.**

[c] Ratio of the frequency in note [b] to the LBE mean frequency, mean frequency margin

[d] Dose value measured at the LBE mean frequency from the F-C target, See [4] in **Error! Reference source not found.**

[e] Ratio of the Dose in Note [d] to the LBE mean dose, Mean Dose Margin

LBE Category	Limiting LBE[a]			F-C Target			
	LBE Name	95th Percentile Freq./plant-yr.	95th Percentile Dose (Rem)	Freq. at LBE Dose/plant-yr. [b]	95th Percentile Frequency Margin[c]	Dose at LBE Freq.(Rem)[d]	95th Percentile Dose Margin[e]
AOO	AOO-5	8.00E-02	1.10E-03	9.00E+01	1.13E+03	1.00E+00	9.09E+02
DBE	DBE-10	2.00E-02	6.00E-03	2.00E+01	1.00E+03	1.00E+00	1.67E+02
BDBE	BDBE-2	1.00E-05	1.50E-02	8.00E+00	8.00E+05	1.00E+02	6.67E+03

Notes:

[a] Limiting LBE is LBE with highest risk significance in LBE Category

[b] Frequency value measured at the LBE 95th percentile Dose level from the F-C target, See [6] in **Error! Reference source not found.**

[c] Ratio of the frequency in note [2] to the LBE 95th percentile frequency, 95th percentile Frequency Margin

[d] Dose value measured at the LBE 95th percentile frequency from the F-C target, See [8] in **Error! Reference source not found.**

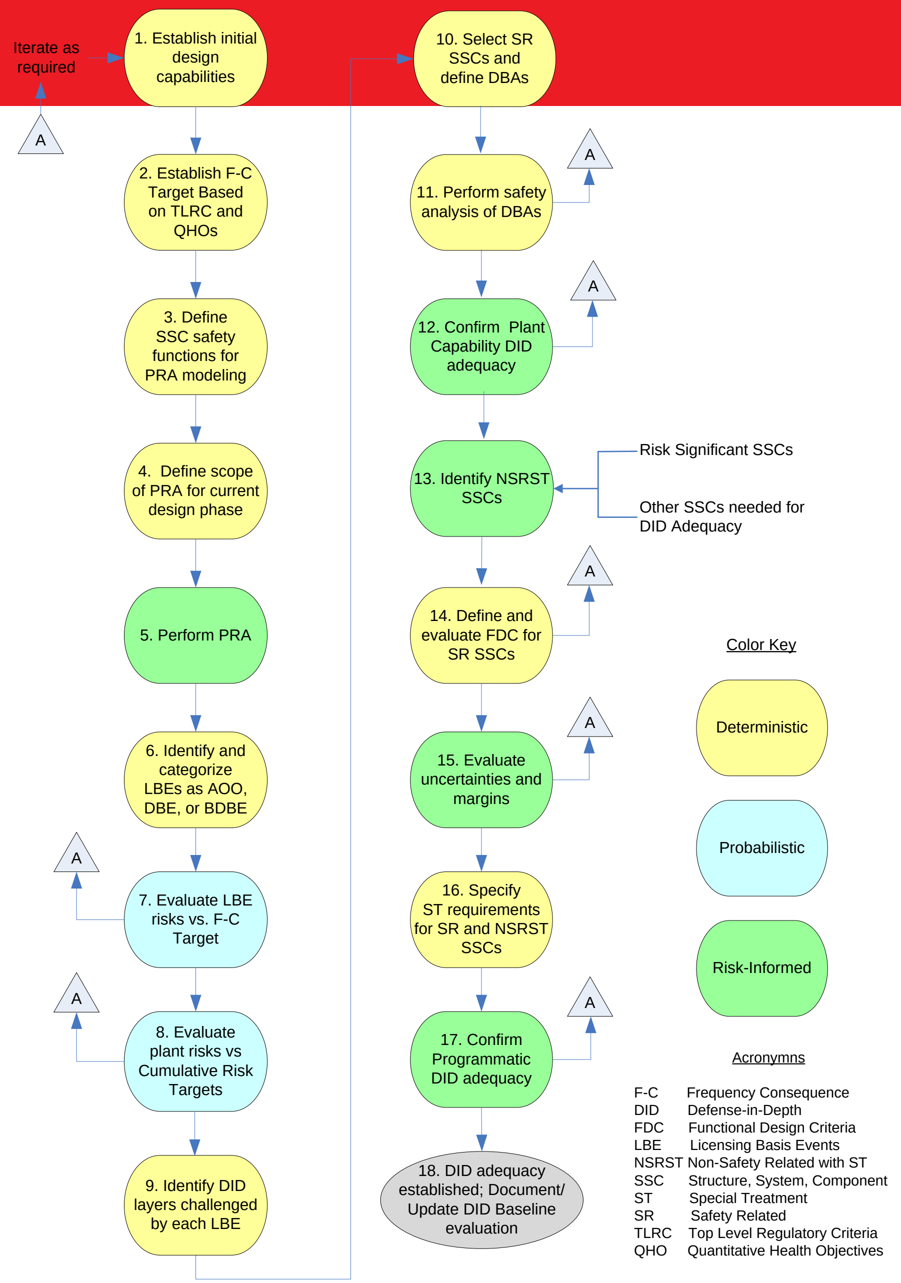
[e] Ratio of the Dose in note [d] to the LBE 95th percentile dose, 95th percentile Dose Margin

DID Adequacy Evaluation Process

- DID Baseline Evaluation documented by Integrated Decision Panel (IPD) and updated during each design/licensing phase
- Defense-in-depth is deemed by IDP as adequate when:
  - Plant capability DID is deemed to be adequate.
  - Plant capability DID guidelines in Table 5-2 are satisfied.
  - Review of LBEs is completed with satisfactory results.
  - Programmatic DID is deemed to be adequate.
  - Performance targets for SSC reliability and capability are established.
  - Sources of uncertainty in selection and evaluation of LBE risks are identified.
  - Special treatment for all SR and NSRST SSCs is sufficient.

Integrated Process for Incorporation and Evaluation of DID

- Tasks are not necessarily sequential
- Tasks can begin early in the conceptual design process and mature with the design evolution
- All of the attributes included in the DID adequacy evaluation are completed when the design baseline for the license application is submitted
- Programmatic confirmation of performance and sustained DID continues for life of the plant.



References

- LMP Guidance Document (NEI 18-04) Revision N
- Glossary rev A
- LMP White Papers on:
  - LBE Selection and Evaluation
  - PRA Development
  - SSC Safety Classification and Performance Requirements
  - Evaluation of Defense-in-Depth Adequacy

Glossary

- SSC Function Terms
  - Fundamental Safety Function (FSF)
  - PRA Safety Function (PSF)
  - Prevention Function
  - Mitigation Function
  - Required Safety Function (RSF)
  - Required Functional Design Criteria (RFDC)
  - Safety Related Design Criteria (SRDC)
- Licensing Basis Event Terms
  - Licensing Basis Event (LBE)
  - Anticipated Operational Occurrence (AOO)
  - Design Basis Event (DBE)
  - Beyond Design Basis Event (BDBE)
  - Design Basis Accident (DBA)
  - Frequency-Consequence Target (F-C Target)
  - Risk Significant LBE

Glossary 2 of 3

- Plant Design and SSC Terms
  - Design Basis External Hazard Level (DBEHL)
  - Plant
  - Multi-module Plant
  - Safety Related (SR) SSC
  - Non-Safety Related SSC with Special Treatment (NSRST) SSC
  - Non-Safety Related SSC with No Special Treatment (NST) SSC
  - Risk Significant SSC
  - Safety Significant SSC
  - Safety Design Approach
- RIPB Regulation Terms
  - Defense-in-Depth
  - Layers of Defense
  - Performance-Based Decision Making
  - Risk-Informed Decision Making

Glossary 3 of 3

- PRA Terms
  - Initiating Event
  - Event Sequence
  - Event Sequence Family
  - End State
  - PRA Technical Adequacy
  - Plant Operating State
  - Mechanistic Source Term

From: Afzali, Amir
To: Reckley, William
Cc: Shirley, Barry J.
Subject: [External_Sender] LMP Training Material
Date: Tuesday, December 03, 2019 8:43:27 AM
Attachments: Basic Training in LMP Processes Rev 0.pdf

Greetings,
Please find one of the latest LMP training decks that we have used to train some of the LMP's stakeholders. Please let me know if you prefer the PowerPoint version of this presentation.
Best regards,
Amir

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