ENHANCED GUIDANCE ON INTEGRATED RISK-INFORMED DECISION-MAKING

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Presentation Outline

- Brief discussion on the risk-informed decision-making (RIDM) concept
- Relationship to risk aggregation aspects and past efforts
- Challenges in RIDM and potential path forward

The RIDM Concept

- Part of decision-making for as long as risk has been an input (explicit/implicit)
- Not just a quantitative risk framework (e.g., probabilistic risk assessment, PRA)
- Defined in multiple ways, depending on application and context. For nuclear:
- Overarching definitions for nuclear applications, e.g.:

Risk-Informed Approach: "A 'risk-informed' approach to regulatory decision-making represents a philosophy whereby risk insights are considered together with other factors to establish requirements that better focus licensee and regulatory attention on design and operational issues commensurate with their importance to health and safety **[NRC SECY-98-144, 1998]**

Integrated Risk Informed Decision-Making (IRIDM) is a systematic process aimed at the integration of the major considerations influencing nuclear power plant safety. The main goal of IRIDM is to ensure that any decision affecting nuclear safety is optimized without unduly limiting the conduct of operation of the nuclear power plant. It underpins nuclear safety decisions and ensures consistency with the safety goals of the Member State. **[IAEA INSAG-25]**

The RIDM Process (continued)

- At its core, RIDM is an approach of making decisions with risk characterized using to a varying level of formality and detail (i.e., risk inputs may be more than just risk results)
- Should not be treated as substituting “deterministic” judgment
- RIDM framework needs to be stable, otherwise it will could lead to a “patchwork” of risk-informed decision-making approaches and requirements
- Like any other decision-making process, needs to consider multiple aspects
  - What is the purpose/impact of the decision under consideration?
  - Who will be making the decision/who are the stakeholders?
  - What are the sources of information that can impact the decision?
  - What is the level of confidence of the sources of information used for the decision?
  - How can different/disparate sources of information be weighed in the decision?
  - How can the decision be documented in an efficient, robust manner?

The RIDM Process & Risk Aggregation

- Recent EPRI efforts focused on moving beyond simple arithmetic summations into a more broadly informed understanding of the aggregated risk, i.e., RIDM (!)
- Risk aggregation must be dealt with within an appropriate RIDM process
- Past and current EPRI activities regarding risk aggregation:
  - EPRI (2005) *"Aggregation of Quantitative Risk Assessment Results"* 1010068 (publicly available)
  - EPRI (2015) *"An Approach to Risk Aggregation for Risk-Informed Decision-Making"* (RIDM) 3002003116 (publicly available)
  - Pressurized Water Reactors Owners Group (PWROG) completed a pilot of high level framework contained in this EPRI report
    - Further guidance and enhancements on a logical process for assessing realism and principles of RIDM is needed (e.g., defense-in-depth)
    - Need of expansion of the RIDM framework and principles beyond risk-informed licensing application guidance

EPRI Report (2015) - Challenges in risk aggregating/RIDM

- Properly supported RIDM decisions require an understanding of:
  - Differing levels of maturity of the risk analyses
  - Approximations made to facilitate the construction of the PRA models
  - Nature and magnitude of uncertainties associated with the analyses

- Provided a simple, direct definition:

> *Risk aggregation is the process of combining all relevant information on the risk from the various contributors to provide an overall characterization of risk for use in risk-informed decision-making.*

- Focused on use of specific risk metrics commonly quantified by PRAs (e.g., core damage frequency, large release frequency, changes in frequency/probability, consequences)

- Assumes a RIDM framework is in place (!):
  - Policy on the use of risk assessment for decision-making
  - Quantitative results from the PRA are compared against a benchmark value
  - Minimum level of maturity and application of quantitative risk assessment tools

EPRI Report (2015) - Types of Applications & Implications on Risk Aggregation

Type of risk-informed application to be informed by PRA needs to be considered, e.g.:

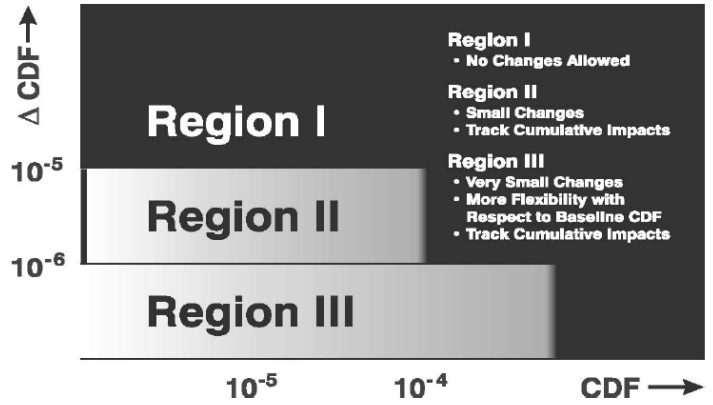
- Demonstrating that a safety goal has been met
- Providing input for steps taken in meeting specific regulations
- Assessing the risk significance of changes to the plant's licensing basis
- Demonstrating or assessing the robustness of a design
- Comparing design alternatives
- Optimizing maintenance strategies including evaluating configuration risk and determining protection and return to service priorities to minimize risk
- Assessing the robustness of a plant against newly recognized challenges (e.g., extreme external hazard events), and exploring options for dealing with these new challenges
- Assessing the risk significance of operational events
- Assessing the risk significance of inspection findings

EPRI Report (2015) - Types of Applications & Implications on Risk Aggregation

Metric	Example Application(s)	Challenges	Ramifications
Total Risk (CDF/LERF/LRF)	Comparison to Safety Goal(s) or Subsidiary Objectives Comparison to RG 1.174 Quantitative Guidelines	Conservative methods	Overstatement of total risk
		Intentionally conservative characterizations	Typically only implemented for minor contributors or in cases where margin is very large
		Immature methods	Uncertain characterization of state of knowledge Often overstates risk
		Uncertainties due to rare environmental events	Mean value may not be meaningful measure
		Modeling uncertainties	Requires sensitivity studies
		Quantified uncertainties (parameter)	Only essential for computing mean Uncertainty bands typically not used in comparison with criteria
		Scope of model (completeness)	Risk from omitted contributors understated
		Cliff-edge effects	May not be captured in mean values

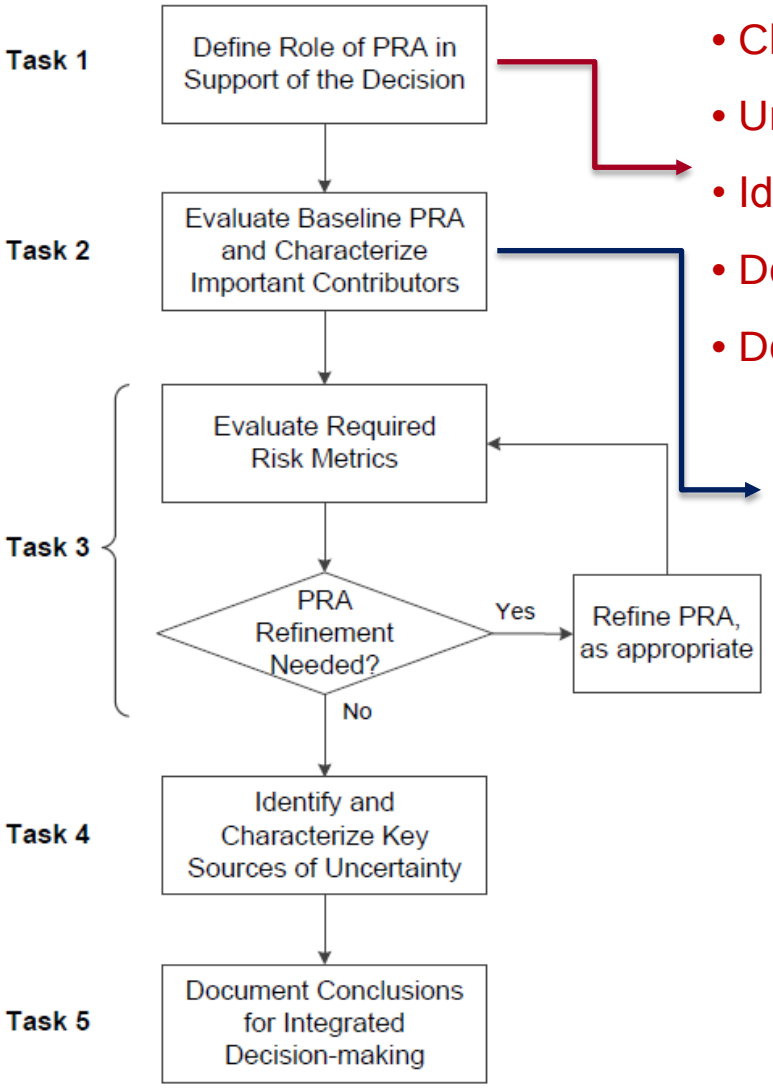
Individual challenges need to be, understood within the context of the application

Effect of individual challenges may not be intuitive, e.g., conservative assumptions could lead to non-conservative decision-making



E.g. NRC's Regulatory Guide 1.174 acceptance guidelines for CDF for plant licensing bases changes

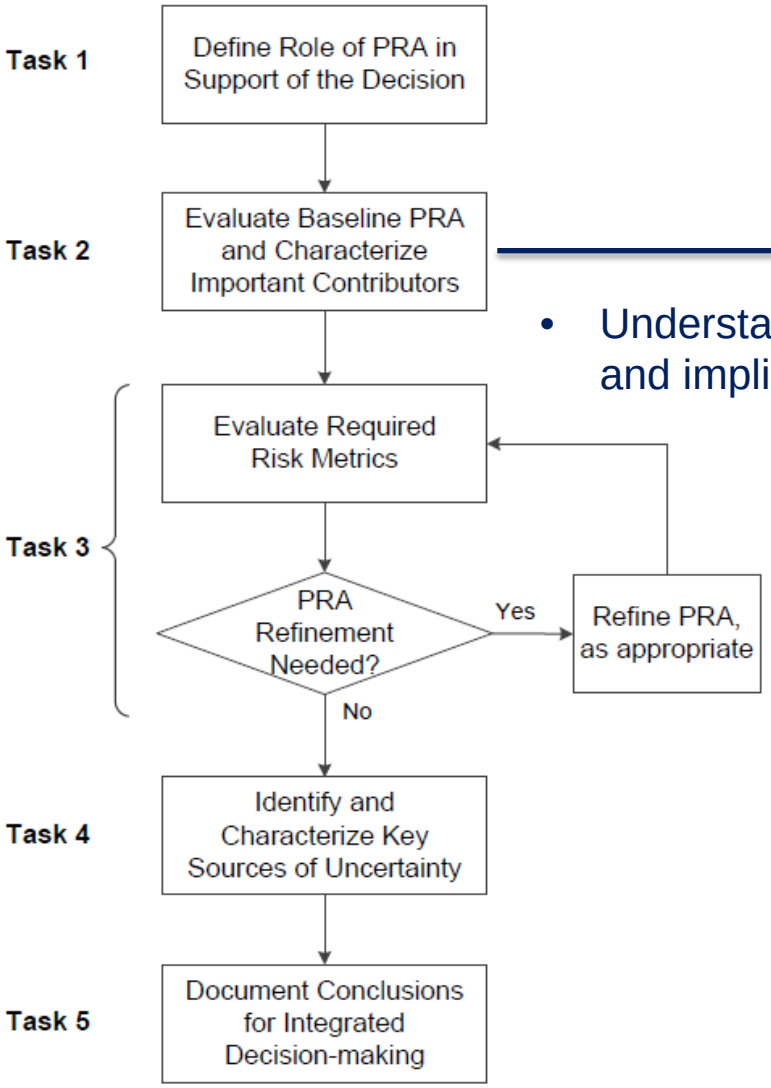
EPRI Report (2015) – Proposed Approach & Framework



- Clearly define purpose of decision and role that the PRA will play in that decision
- Understand the acceptance guidelines or decision criteria
- Identify the metrics (CDF, ΔCDF, importance measures, etc.) for comparison
- Define the scope of the PRA required to assess the risk implications
- Define cause-effect relationship that will be used to model the impact on the plant risk

- Understand what is in the baseline PRA (main step for any application)
- Decomposition of results to identify important hazard events, as needed
- Consideration of cliff-edge effects, as needed

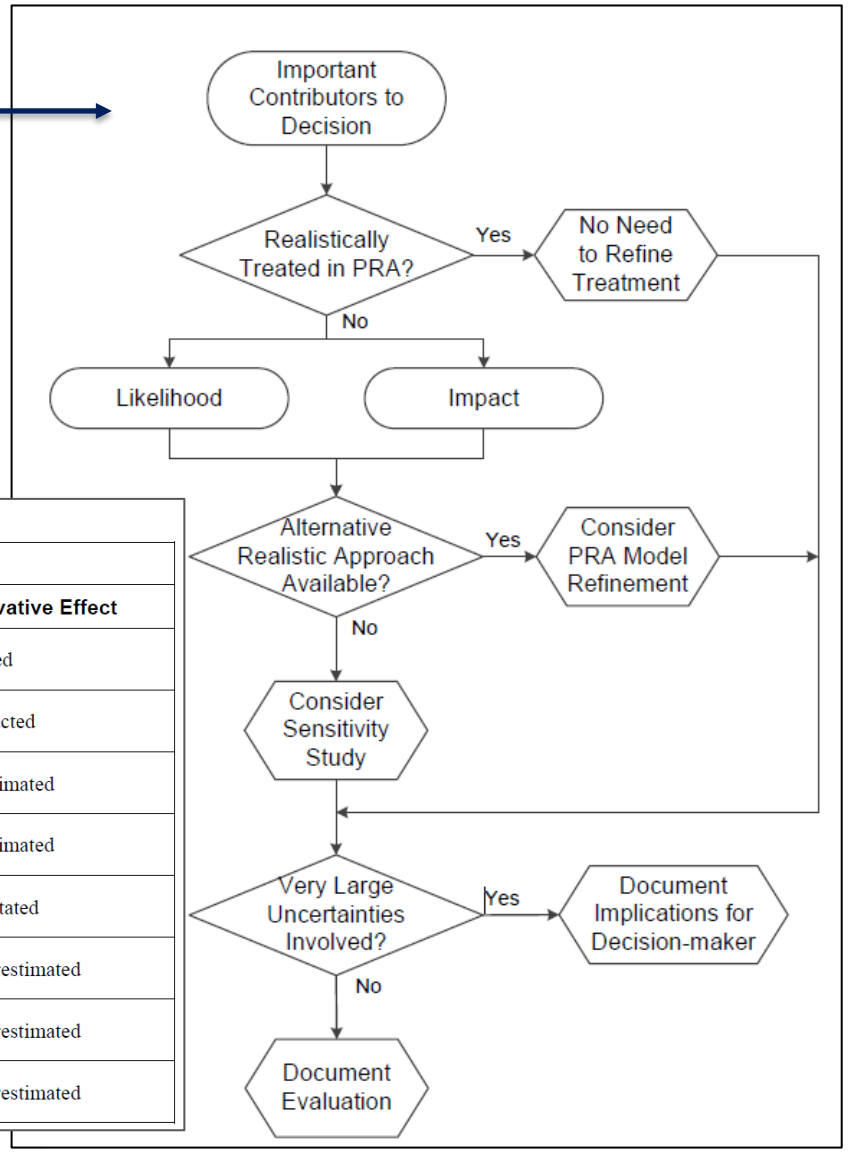
EPRI Report (2015) – Proposed Approach & Framework



- Understand and document important contributors and implications of modeling realism

Implications of Conservative Treatments

Type of Risk Metric	Contributor	Nature of Conservatism	
		Conservative Likelihood	Conservative Effect
Risk Level	Directly Impacted Contributor	Overstated	Overstated
	Other Realistic Contributors	Not impacted	Not impacted
ΔRisk or Integral Risk	Directly Impacted Contributor	Overstated	Underestimated
	Other Realistic Contributors	Not impacted	Underestimated
FV Importance	Directly Impacted Contributor	• Overstated	• Overstated
	Other Realistic Contributors	• Underestimated	• Underestimated
RAW Importance	Directly Impacted Contributor	• Underestimated	• Underestimated
	Other Realistic Contributors	• Underestimated	• Underestimated



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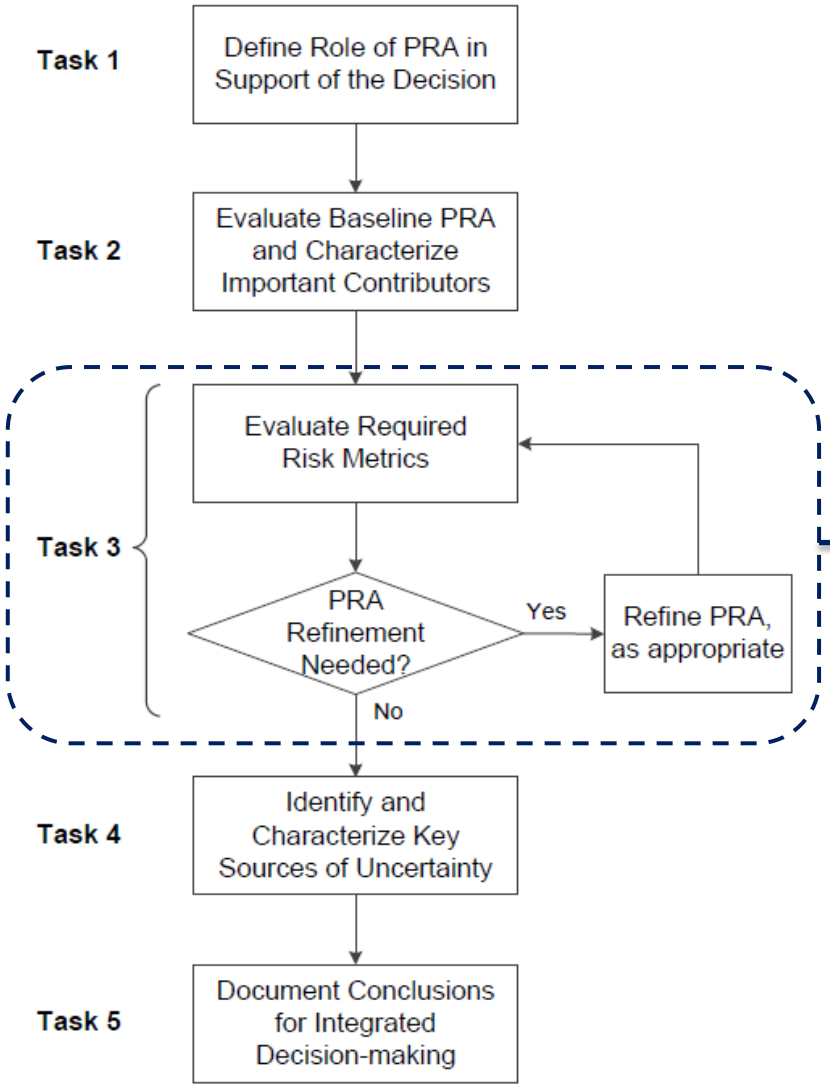
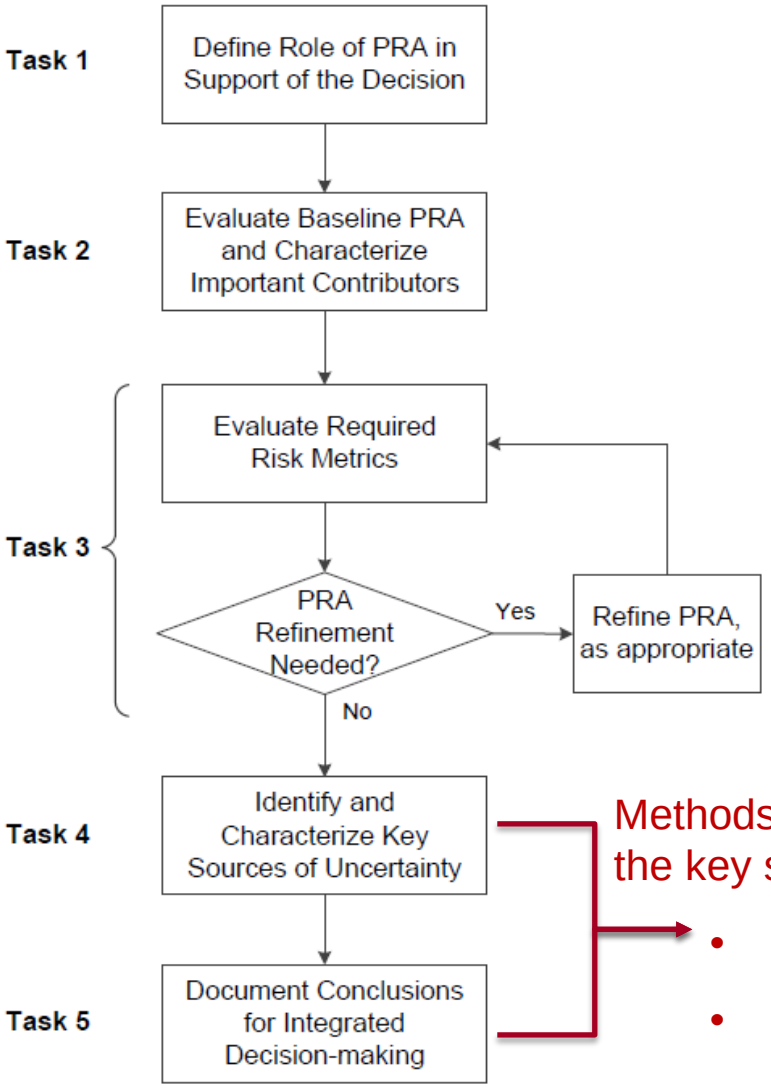


Consider application-specific needs for refinement:

1. The evaluated mean value is <u>less than</u> the quantitative guidelines;
2. The evaluated mean value is <u>greater than</u> the acceptance guideline; and
3. The decision is <u>indeterminate</u>, e.g., conservatisms are known to exist, but the current methods do not support the case for meeting the acceptance guidelines. [Large Uncertainties]

EPRI Report (2015) – Proposed Approach & Framework



Methods for identification and characterization of the key sources of uncertainty, e.g.,

- US NRC's NUREG-1855
- EPRI 1016737
- EPRI 1026511

EPRI Report (2015) – Proposed Approach & Framework

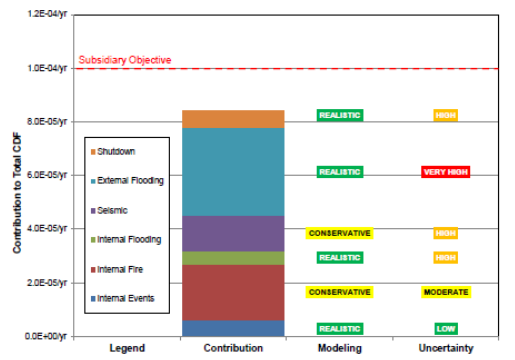
Integrated RIDM approach to be highlighted and communicated visually, for example, a rubric template was proposed:

- Present information to a decision-maker in support of a truly integrated decision
- Summarize level information to be provided to the decision-maker
- Provide information on the risk contributors that are important to the decision
- Provide perspective on the other elements of the integrated decision-making process, e.g., defense-in-depth, safety margins, and performance monitoring
- Information supporting these conclusions will be available and decision-makers can delve deeper into details

Purpose

Characterize the overall risk from plant operations with respect to the subsidiary safety of objective of CDF<$1x10^{-4}$/yr.

Risk Information



Parametric Uncertainty
- Mean values represented in results
- External Flood mean values highly uncertain

Modeling Uncertainty
- External flooding initiating event frequencies highly uncertain
- Fire PRA methods result in a substantial overstatement of fire CDF.

Completeness Uncertainty
- All relevant site hazards and operating modes considered except:
  - High winds – design basis shown to protect to 1E-7/yr

Overall Risk Characterization
- Computed total CDF less than subsidiary objective
- Very large uncertainties for external flood results could challenge subsidiary objective
- Non-realistic fire PRA methods are not likely to compensate for external flooding uncertainties

Defense-in-Depth Characterization

- No DID vulnerabilities identified. All fire scenarios confirmed to have at least one success path.
- Mitigating strategies capabilities to mitigate external flooding not included in PRA model

Safety Margin Characterization

- Limited available margin to address beyond design basis floods leads to potential external flooding scenarios

Performance Monitoring

- Annual average CDF monitoring performed as part of Maintenance Rule
- Routine PRA updates scheduled for every 4 years

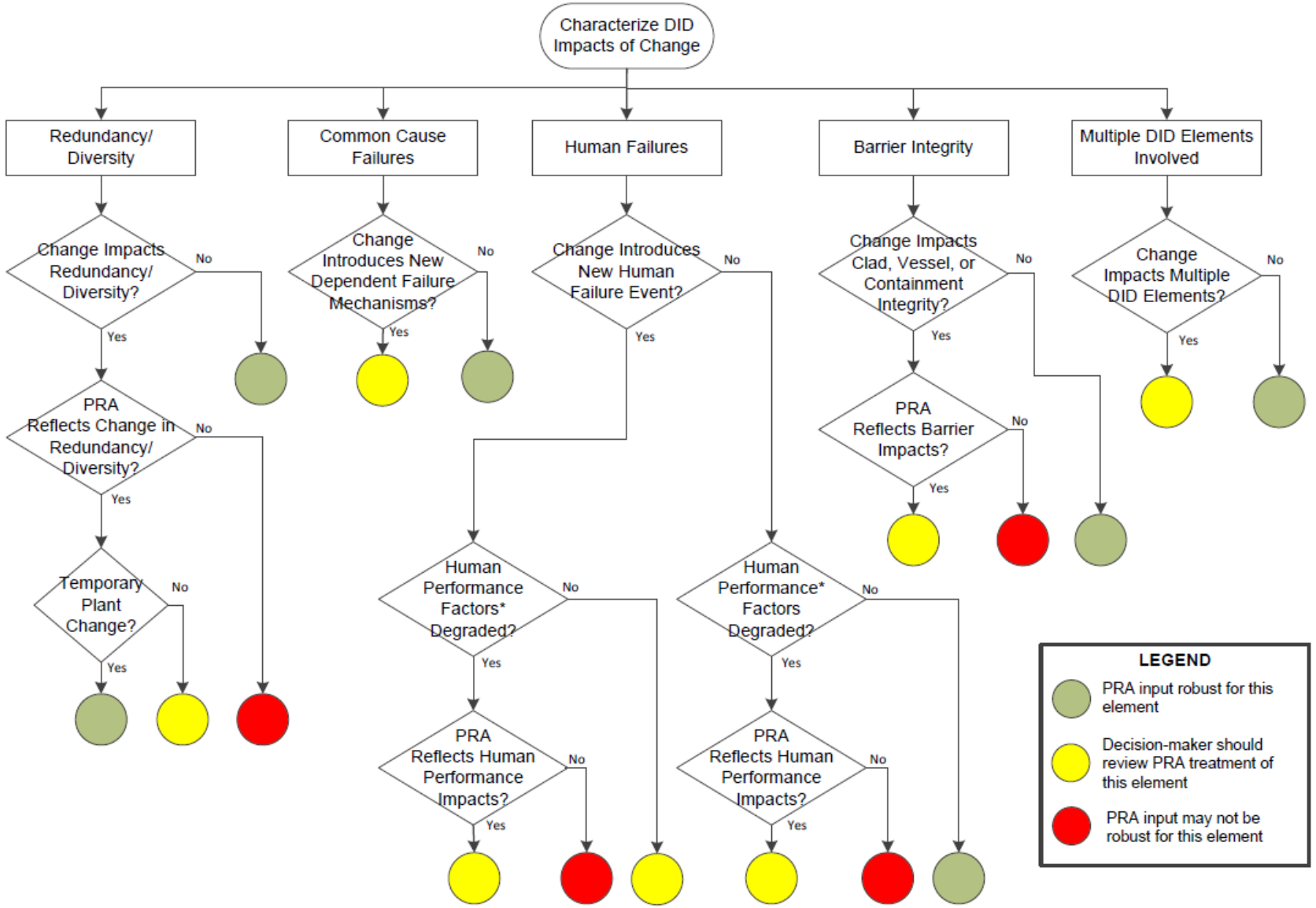
Integrated Decision-making Inputs

Risk	Defense-in-Depth	Safety Margins	Performance Monitoring
External Flood Uncertainties	*Confirmed*	*Limited for External Flooding*	*Annual Average CDF Monitoring*

Conclusion:
- Although the computed total CDF meets subsidiary objective with some margin, the external flooding risks are sufficiently uncertain that they do not provide confidence in the computed mean value.
- Capabilities of mitigating strategies lowers external flood risk and effectively increases safety margin
- Performance monitoring not effective for low frequency flood scenarios that drive plant risk

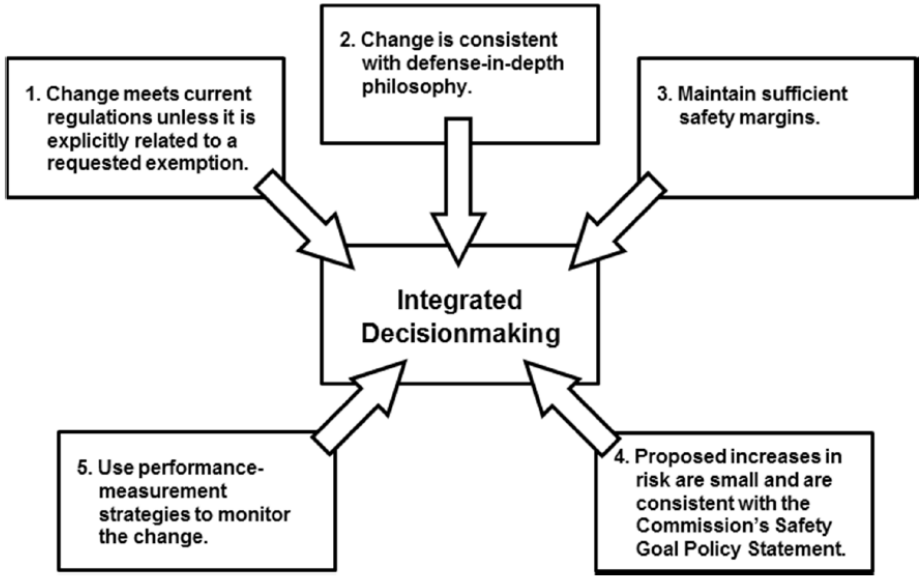
EPRI Report (2015) – Proposed Approach & Framework

- Proposed process for evaluating defense-in-depth applications (as well as other RIDM principles)



Expanding/Enhancing the RIDM principles

- General principles of Regulatory Guide 1.174 are still valid, however:
  - How do we balance individual principles (e.g., quantification versus DID)?
  - Are specific principles well-understood, uniformly applied (e.g., SM)?
  - Should an individual principle override all other principles (e.g., DID)?
  - Do these principles apply to all RIDM applications (e.g., Reactor Oversight Process)?
- How can we use these principles to better support nuclear safety decisions in a cost effective manner via PRA?
- How do we augment/enhance guidance on these principles beyond RG1.174?
- What other RIDM processes and/or existing documents can be leveraged?



On-going EPRI Efforts – Guidance on IRIDM

- Guidance on Integrated Risk Informed Decision Making (IRIDM)
  - Appropriately considering the overarching principles of risk-informed decision-making
  - Integrating the different elements in decision-making
  - Broadening the scope of the guidance beyond licensing bases changes
  - Presenting IRIDM information to decision-makers
  - Addressing the input from the PWROG pilots
  - Expanding the relevance of the guidance and its use for an international audience

- Why focus on RIDM now?
  - RIDM has been applied for 20+ years domestically and internationally
  - Despite successes, evolving PRA technology/regulation have led to consistency issues
  - RIDM was always supposed to be integrated, but we may have deviated from it
  - It's time to integrate risk insights as well as non-risk information better = IRIDM

Path Forward on Risk Aggregation & RIDM

- Risk aggregation is not a new or unique issue, it is a core aspect of RIDM
- Main challenges of risk aggregation are not necessarily technical; they speak to the need for a clear, well-supported decision-making framework
- Clear language is still needed when discussing/communicating risk aggregation and RIDM in general; especially with respect to the meaning of “risk-informing”
- EPRI report on RIDM will focus on decision-making with regards to risk-informed applications in a general framework (with examples on implementation)
  - A better approach to risk aggregation should be an outcome of an enhanced/improved RIDM

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