

Key Observations and Challenges

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External Influence

- ❑ Regulatory agencies are, by their nature, conservative.

- ❑ Major changes usually require an external intervention.
 - Senator Pastore's letter to the U.S. Atomic Energy Commission (1971)
 - *"The members suggested that a comprehensive assessment of the safety aspects of nuclear reactors be made with the intent of setting down for the industry **and public** a clear-cut summary of what the facts are in this matter."*
 - *Outcome: The Reactor Safety Study (1974)*
 - NRC Chairman Jackson
 - Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions on Plant Specific Changes to the Licensing Basis." (1997)



The Reactor Safety Study

❑ Major findings:

- Dominant contributors: Small LOCAs and Transients (not large LOCAs)
- CDF higher than earlier believed (best estimate: 5×10^{-5} , once every 20,000 years; upper bound: 3×10^{-4} per reactor year, once every 3,333 years)
- Consequences significantly smaller

❑ Support systems and operator actions are very important

- The auxiliary feedwater system was not a safety-grade system at the time
- Research programs were initiated worldwide

❑ Conclusion: The traditional “deterministic” system is incomplete



Industry: Zion & Indian Point PRAs

- ❑ Explicit adoption of Bayesian methods
- ❑ Fires and earthquakes shown to be significant contributors to risk
- ❑ Rigorous containment response analysis
- ❑ Atmospheric dispersion methods
- ❑ PRAs should be plant-specific
 - Simple plant improvements were identified
- ❑ Success in hearings avoiding costly plant modifications



Early Challenges

Cultural issues

- Nuclear and mechanical engineers not trained in probability and statistics
- “Abandoning” the traditional “deterministic” approaches to regulations difficult to accept
- There is nothing “deterministic” about traditional approaches
- They deal with uncertainties using subjective bounding analyses

Training courses established

IPE and IPEEE programs established



Regulatory Activities

- ❑ Until 1997, the NRC issued regulatory requirements (e.g., SBO and ATWS) based on PRA findings
- ❑ No relief from regulations was granted, even though the PRAs were showing that several requirements did not contribute to safety and were costly
- ❑ This changed with the issuance of the 1995 PRA Policy Statement and RG 1.174 in 1997



The 1995 Policy Statement

- ❑ *The use of PRA should be increased **to the extent supported by the state of the art and data** and in a manner that complements the defense-in-depth philosophy.*
- ❑ *PRA and associated analyses (e.g., sensitivity studies, uncertainty analyses, and importance measures) should be used in regulatory matters, where practical within the bounds of the state-of-the-art, to **reduce unnecessary conservatisms** associated with current regulatory requirements, regulatory guides, license commitments, and staff practices.*
- ❑ *PRA evaluations in support of regulatory decisions should be as **realistic** as practicable.*



Removing Unnecessary Regulatory Burden

- ❑ RG 1.174 creates risk-informed decision making (RIDM)
 - Defense in depth and safety margins are combined with risk insights subjectively

- ❑ Risk-Informed (RI) initiatives are voluntary
 - The utilities decide whether to adopt them using cost-benefit tradeoffs

- ❑ The activities after 1997 create the wrong impression among some people that risk-informing the regulations is a means for weakening the regulations



Safety Goals (1986)

- ❑ PRAs raised the question “How Safe is Safe enough?”
- ❑ The NRC believed that establishing the safety goals would **enhance public understanding** of regulatory criteria and public confidence in nuclear power safety.
- ❑ They are goals, not criteria.
 - Safety goals are to be used as a reference point in ascertaining the need for safety enhancements (Backfit Rule).
 - Safety goals (CDF and LERF) are used as the basis for risk-informed changes to the licensing basis (RG 1.174).



PRA Quality

- ❑ PRAs quantify judgments explicitly. Traditional methods do not.
- ❑ The quality of PRAs is often questioned while that of “deterministic” judgments is not.
- ❑ Many traditional “deterministic” judgments have been shown to be incomplete.
 - Not appreciating the significance of human errors and support systems
 - Underestimating the significance of external events
 - Not appreciating the significance of station blackout
 - Underestimating the risk significance of low-power operations



PRA Standards

- ❑ ASME and ANS have formed a Joint Committee on Nuclear Risk Management (JCNRM) to develop and maintain PRA standards.
- ❑ “ASME/ANS RA-S–2008,” Revised in 2013, is currently maintained by the JCNRM.
- ❑ It includes a Level 1 CDF and LERF PRA standard for internal events at-power and standards for external hazards and internal fires at-power for LWRs.
- ❑ The standard defines “what” must be done, not “how”.
- ❑ To reduce the need for regulatory PRA technical review, NEI developed a peer review process.



Risk-Informed Initiatives

- ❑ Regulatory Guide 1.174 defines basic principles.
- ❑ It establishes the “Integrated Decision-Making Process.”
- ❑ A subjective integration of the defense-in-depth and safety-margins philosophy with risk changes.
- ❑ The risk-informed approach permitted small risk increases, which was a significant cultural challenge.
- ❑ The RI initiatives are voluntary; the utilities weigh costs and benefits in their decisions.



A Detailed Picture (INSAG 25)

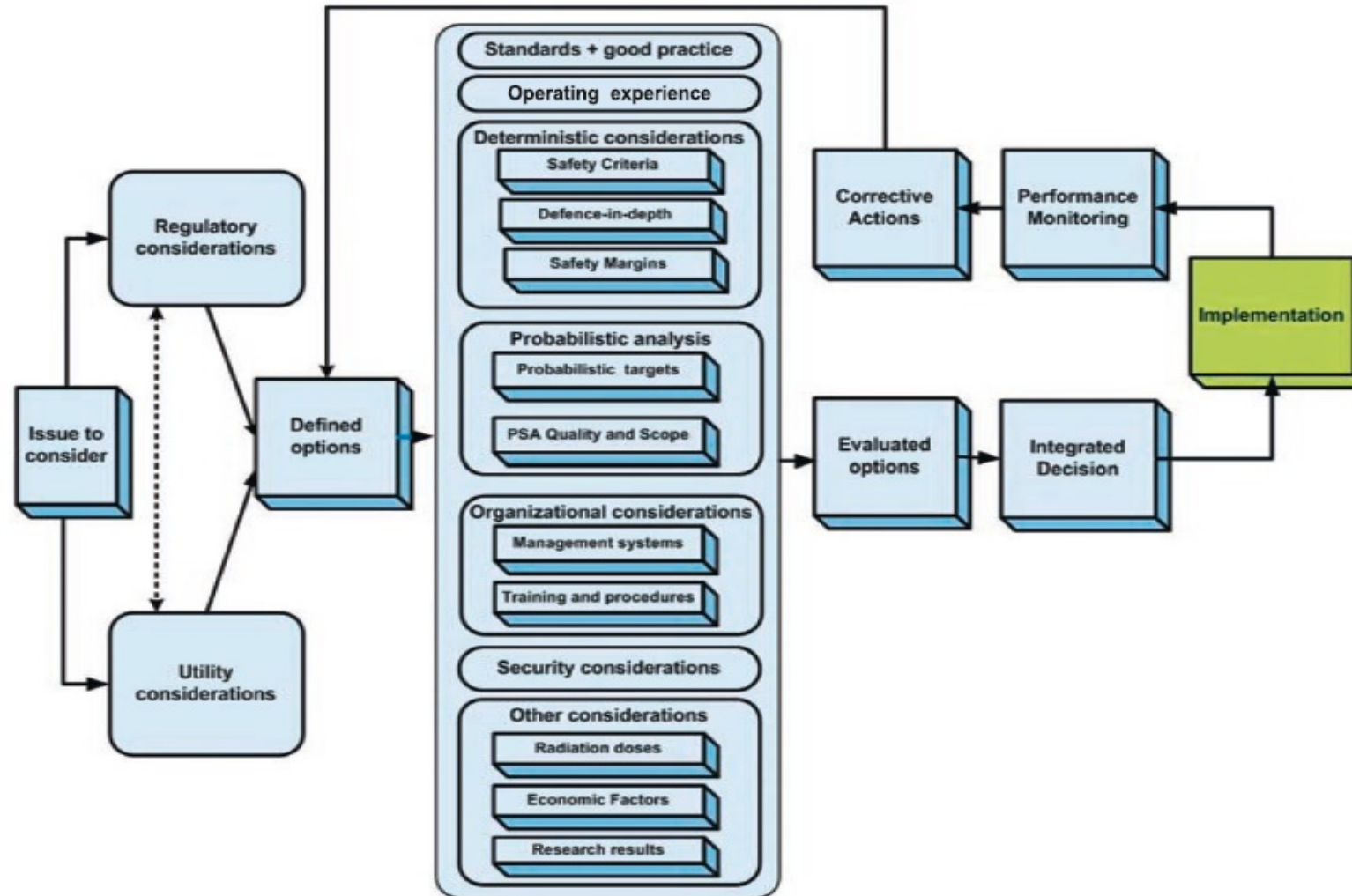
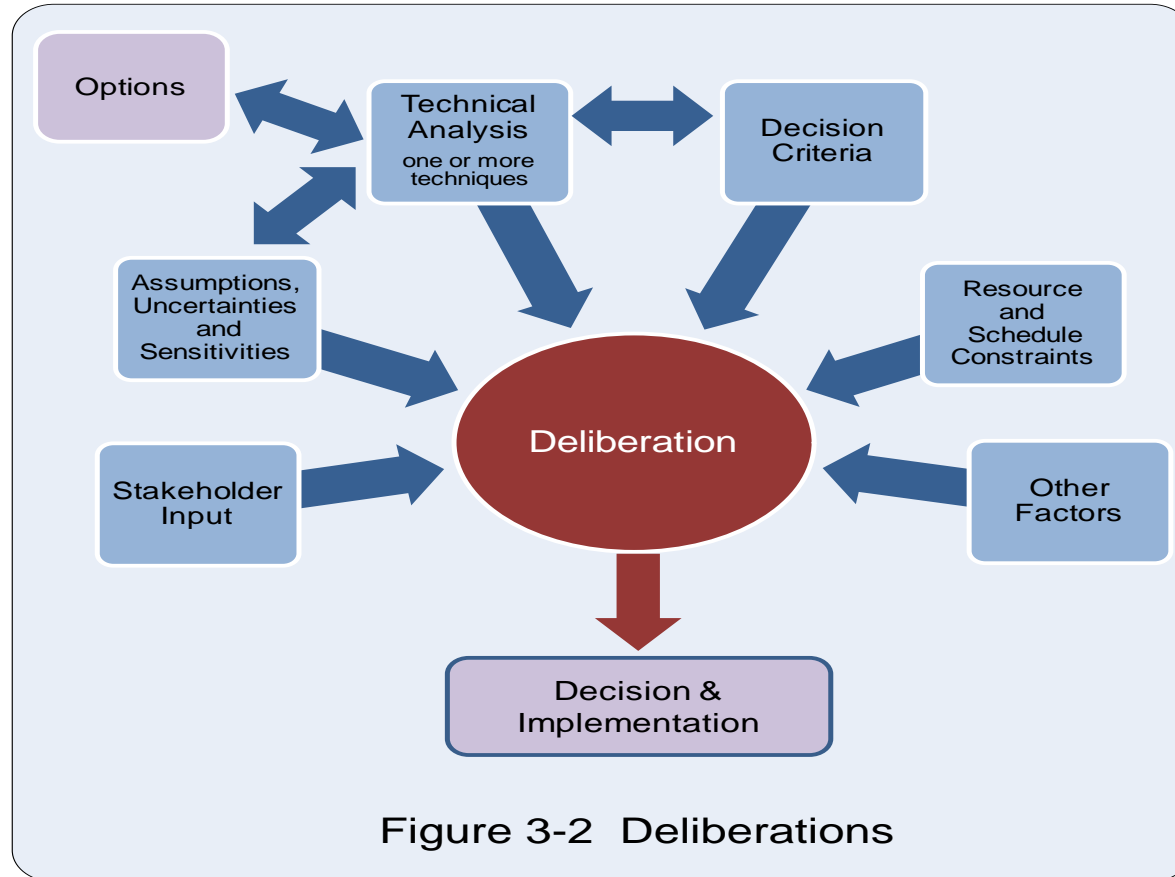


FIG. 1. Key elements of the integrated risk informed decision making process.

A Broader View of Decision Making



From NUREG-2150

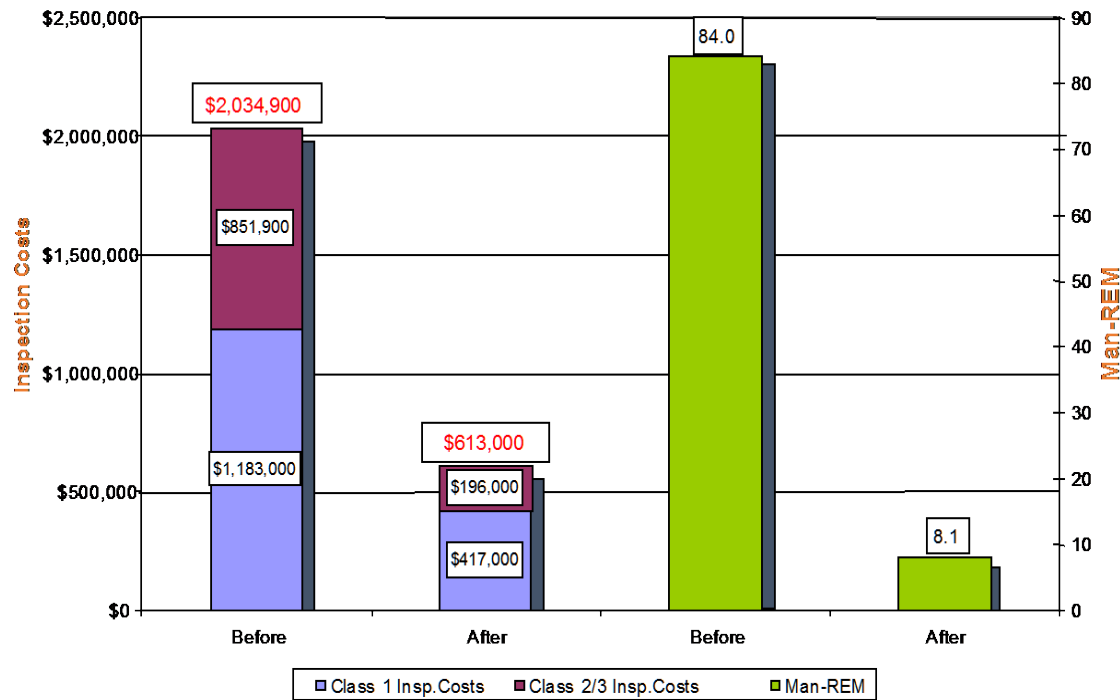


Objective Assessment of Plant Performance: The ROP Action Matrix

		Licensee Response Column	Regulatory Response Column	Degraded Cornerstone Column	Multiple Repetitive Degraded Cornerstone Column	Unacceptable Performance Column
Results		All assessment inputs (performance Indicators (PI) and inspection findings) Green; cornerstone objectives fully met	One or two White inputs (in different cornerstones) in a strategic performance area; Cornerstone objectives fully met	One degraded cornerstone (2 White inputs or 1 Yellow input) or any 3 White inputs in a strategic performance area; cornerstone objectives met with minimal reduction in safety margin	Repetitive degraded cornerstone, multiple degraded cornerstones, multiple Yellow inputs, or 1 Red input ¹ ; cornerstone objectives met with longstanding issues or significant reduction in safety margin	Overall unacceptable performance; plants not permitted to operate within this band, unacceptable margin to safety
	Response	Regulatory Conference	Routine Senior Resident Inspector (SRI) interaction	Branch Chief (BC) or Division Director (DD) meet with Licensee	DD or Regional Administrator (RA) meet with Licensee	EDO (or Commission) meet with Senior Licensee Management
Response	Licensee Action	Licensee Corrective Action	Licensee corrective action with NRC oversight	Licensee self assessment with NRC oversight	Licensee performance improvement plan with NRC oversight	
	NRC Inspection	Risk-informed baseline inspection program	Baseline and supplemental inspection 95001	Baseline and supplemental inspection 95002	Baseline and supplemental inspection 95003	
	Regulatory Actions	None	Document response to degrading area in assessment letter	Document response to degrading condition in assessment letter	10 CFR 2.204 DFI 10 CFR 50.54(f) letter CAL/Order	Order to modify, suspend, or revoke licensed activities
Communications	Assessment Report	BC or DD review / sign assessment report (w/ inspection plan)	DD review / sign assessment report (w/ inspection plan)	RA review / sign assessment report (w/ inspection plan)	RA review / sign assessment report (w/ inspection plan) Commission informed	
	Public Assessment Meeting	SRI or BC meet with Licensee	BC or DD meet with Licensee	RA discuss performance with Licensee	EDO (or Commission) discuss performance with Senior Licensee Management	Commission meeting with Senior Licensee Management
		Increasing Safety Significance →				

¹ It is expected in a few limited situations that an inspection finding of this significance will be identified that is not indicative of overall licensee performance. The staff will consider treating these inspection findings as exceptions for the purpose of determining appropriate actions.

A Success: RI-Inservice Inspection (RI-ISI)



V. Dimitrijevic, Short Course: Risk-Informed Operational Risk Management, Massachusetts Institute of Technology, 2008.



Limited Success: Risk-Informed Graded Quality Assurance (RI-GQA) or Rule 10 CFR 50.69

- Licensees have only slowly embraced risk significance categorization due to the substantial initial investment.
- A categorization in and of itself does not provide benefits.
- The benefits are realized when a procedure or program is changed to recognize the categorization.
- The RI-GQA process could be applied to the many thousands of pieces of equipment in a plant.
- All of the associated special treatment requirements for each component would be identified, including the basis for their requirement.
- This required extensive resources.



RI-GQA or Rule 10 CFR 50.69

- The IDP (Integrated Decision-Making Panel) is a representative, multi-disciplinary committee of experienced experts that approves the final categorization.
- NRC personnel raised concerns about relaxing special treatment requirements.
- These concerns were in part technical, relating to potential decreases in equipment performance.
- They were also part philosophical, as the resources saved by the licensee may not necessarily be re-invested in safety.
- Estimates of the potential cost savings were rather uncertain.



Licensee Decision on RI-GQA

- ❑ Licensees have been reluctant to pursue RI-GQA (with the exception of South Texas Project).
- ❑ The additional analysis of equipment and related record keeping appeared substantial with uncertain cost savings.
- ❑ These challenges are now being revisited as part of the new industry effort on “Delivering the Nuclear Promise.”
- ❑ There are non-regulatory applications for the risk significance categorization such as prioritization of station activities, and selection criteria for audits and inspections.



A Failure: Risk-Informed In-Service Testing

- ❑ In the early days, consensus standards committees that included ASME developed conservative standards to define testing requirements, frequencies, and scope.
- ❑ PRAs provide a more realistic assessment of the safety importance of plant equipment, important equipment failure modes, and the safety implications of operational decisions such as testing frequency and system testing configurations.
- ❑ Licensees had to develop new testing procedures with alternate testing approaches based on component risk significance levels.
- ❑ They also had to develop extensive information collection systems to catalog equipment potentially involved in the RI-IST program.



Risk-Informed In-Service Testing

- ❑ Some NRC individuals involved with the existing IST programs raised concerns that the RI-IST programs could lead to safety-related equipment degradation, even though the risk-informed approach indicated more optimal approaches could be available.
- ❑ Although both the NRC and ASME have implemented programs that could be used by licensees to implement RI-IST, neither has attracted much attention.
- ❑ It appears that the initial costs of regulatory approval and implementation outweigh the perceived long-term benefits, especially, in consideration of the more limited reductions in equipment testing



An Industry Initiative

- ❑ On December 9, 2003, STP's Unit 2, Diesel Generator (DG) #22 had a catastrophic failure that resulted in significant damage. Repair time was initially estimated to be 120 days.
- ❑ On December 30, STP was granted a one-time extension of the Allowed Outage Time (AOT) to 113 days in order to make repairs. As part of the approval, STP would develop a planned risk profile showing the changes in risk levels (both CDF and LERF) over the extended AOT.
- ❑ The risk management approaches taken were successful: STP units continued to provide power, and the regulator gained new insights on the DG failure. Importantly, the use of PRA provided robust means to manage allowed outage times.



Concluding Remarks

- ❑ Significant changes to the regulations are usually the result of external pressure.
- ❑ PRA and traditional methods are complementary.
- ❑ The major obstacles to RIDM are cultural.
 - Discomfort with probabilities
 - Familiarity with traditional methods creates reluctance to change.
- ❑ Risk-informed initiatives are voluntary
 - The utilities weigh costs and benefits
 - Great successes: ROP and RI-ISI
 - Failure: RI-IST

