Benefits of Risk-Informed Decision-Making in U.S. Nuclear Power Plants

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2024 NRRC Workshop on Risk-Informed Decision-Making: Benefits and Obstacles

NUCLEAR ENERGY INSTITUTE

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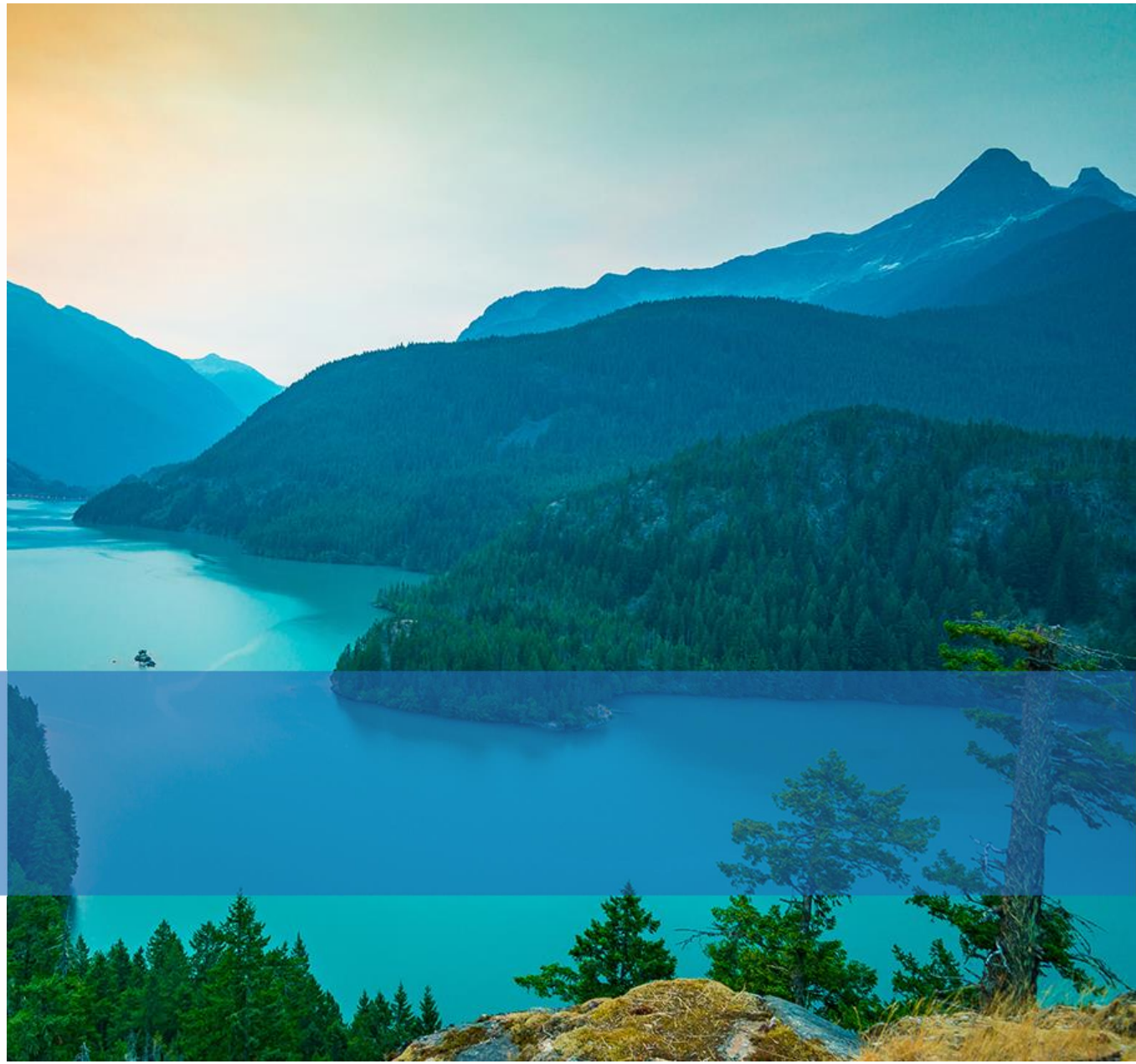


U.S. Nuclear Safety

- U.S. Nuclear Regulatory Commission (NRC) is a strong, independent nuclear regulator
- Safety and security are shared goals of NRC and industry
- U.S. utilities have the primary responsibility for safety of their nuclear power plants
  - This is fundamental to the NRC's regulatory system
  - Decisions at U.S. plants are predicated on making the right choice for safety and security

Contrasting Approaches to Safety

Deterministic Safety

Purpose:

- Define necessary design and operational requirements

Objectives:

- Clear delineation of compliance limits at a level that can be implemented and inspected
- Conservative approach to uncertainties

Probabilistic Safety

Purpose:

- Measure the residual risk beyond the deterministic requirements

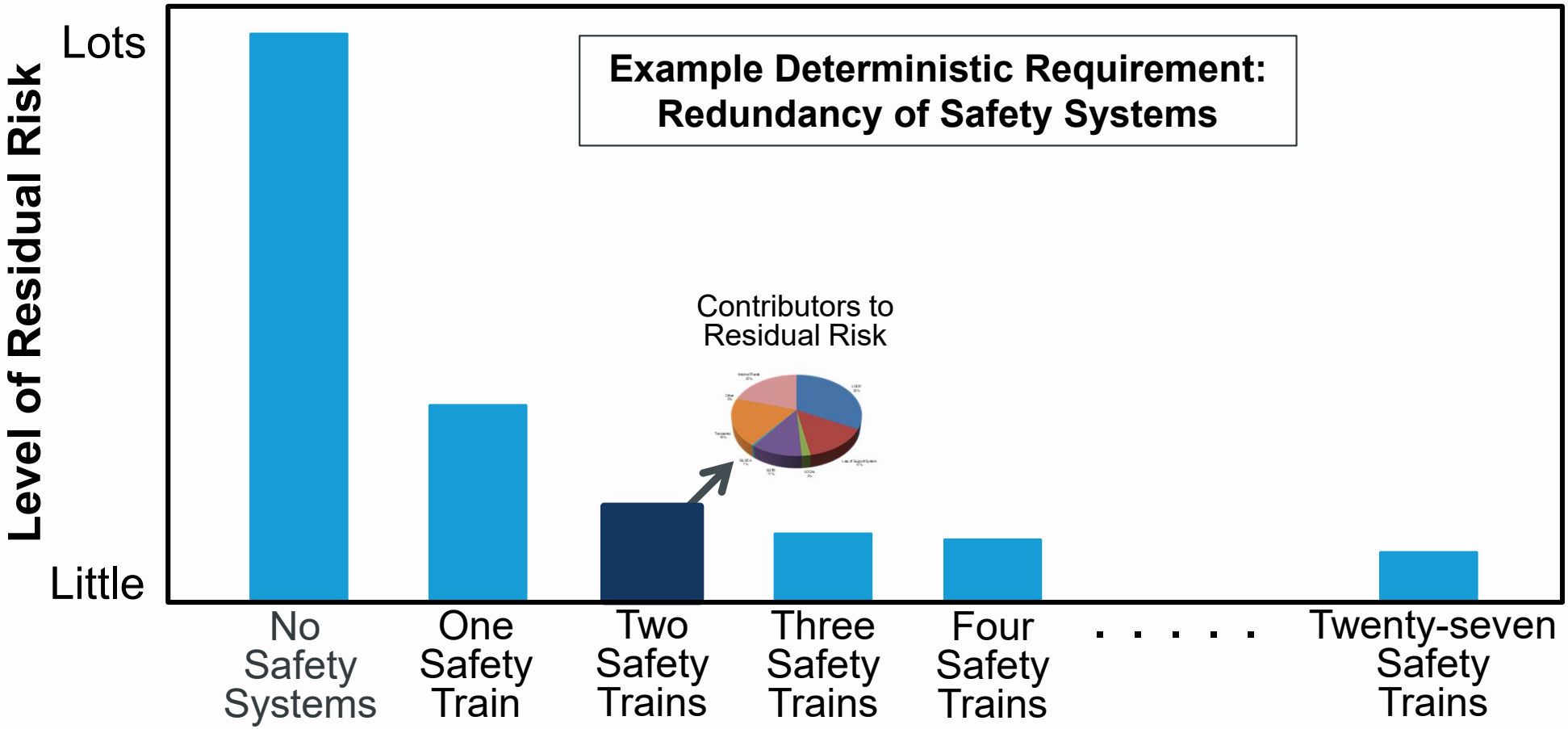
Objectives:

- Integrated view of plant design and operation
- Realistic approach with consideration of uncertainties

Safety vs. Risk

- U.S. Regulations, based on deterministic requirements, provide an important foundation for assuring the safety of nuclear power plants
- Risk Analysis provides a tool to assess the risk that remains even when regulations are followed
    - Residual risk is never zero
- Risk Analysis provides an estimate of the residual risks (aka level of safety) associated with the deterministic requirements
- Risk Analysis can also assess the risk increment of changes to requirements and/or non-compliances

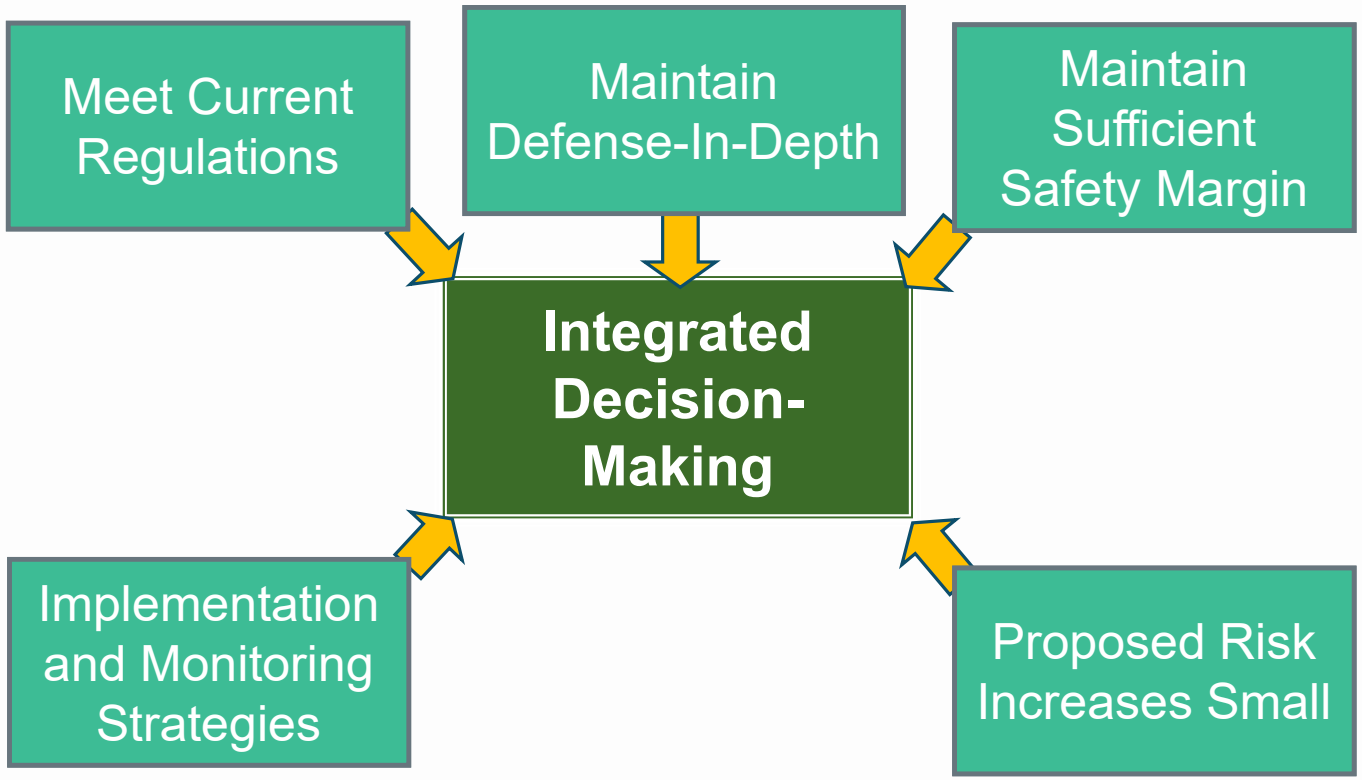
Conceptual Relationship Between Safety & Risk



Deterministic Approach to Safety

- Deterministic regulation contains inherently subjective judgments on what is adequate, e.g., assumption of single worst active failure
  - If deterministic requirements were more restrictive, the residual risk would likely be lower (e.g., if one assumed worst two active failures)
  - If deterministic requirements were less restrictive, then the residual risk would be HIGHER and this would show up in the Risk Analysis.
- Sometimes these subjective judgments:
  - Support low residual risk,
  - Miss important risks (e.g., backfit for Station Blackout),
  - Overly constrain design and operations for minor or negligible residual risks (e.g., DEGB LOCA)

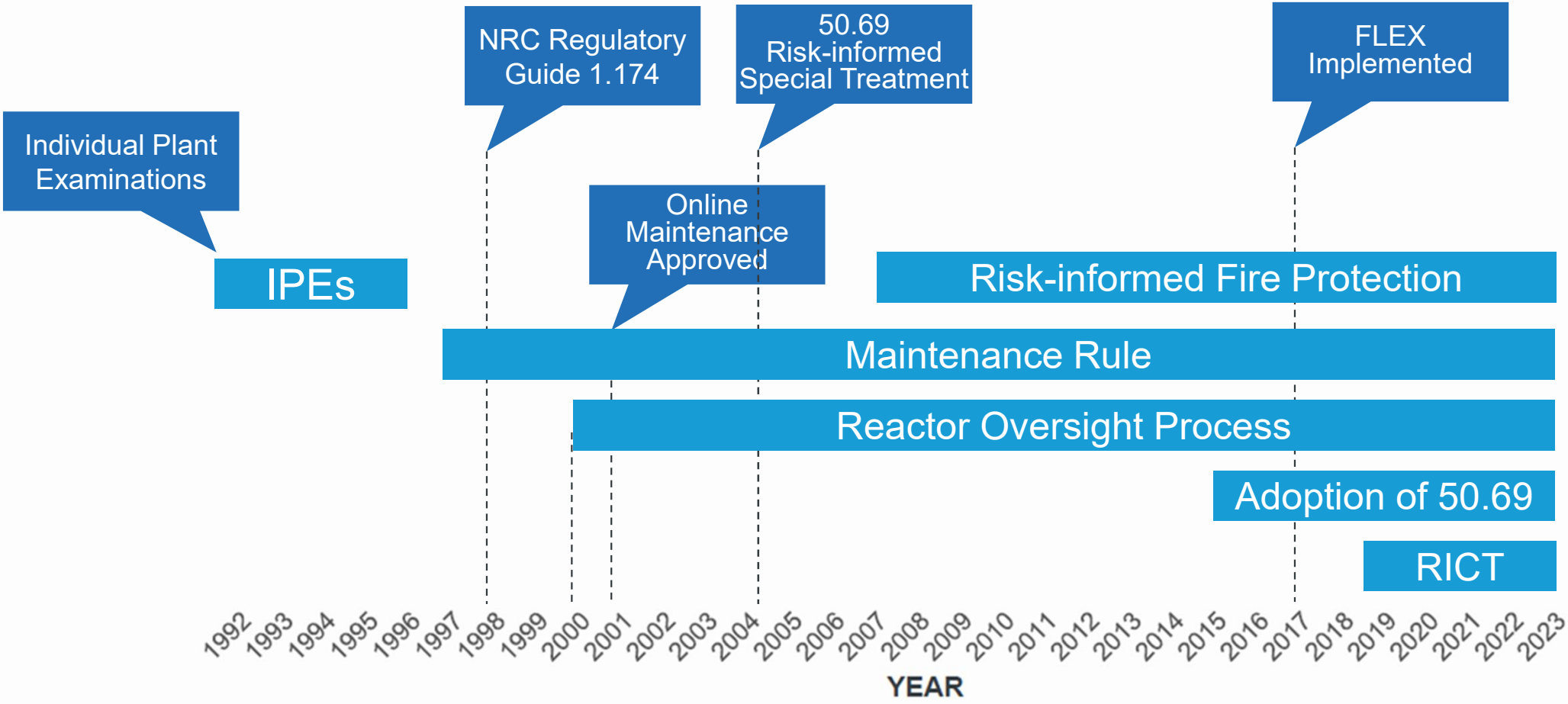
Risk-Informed Decision-making (RG 1.174)



Why Risk-Informing Improves Safety

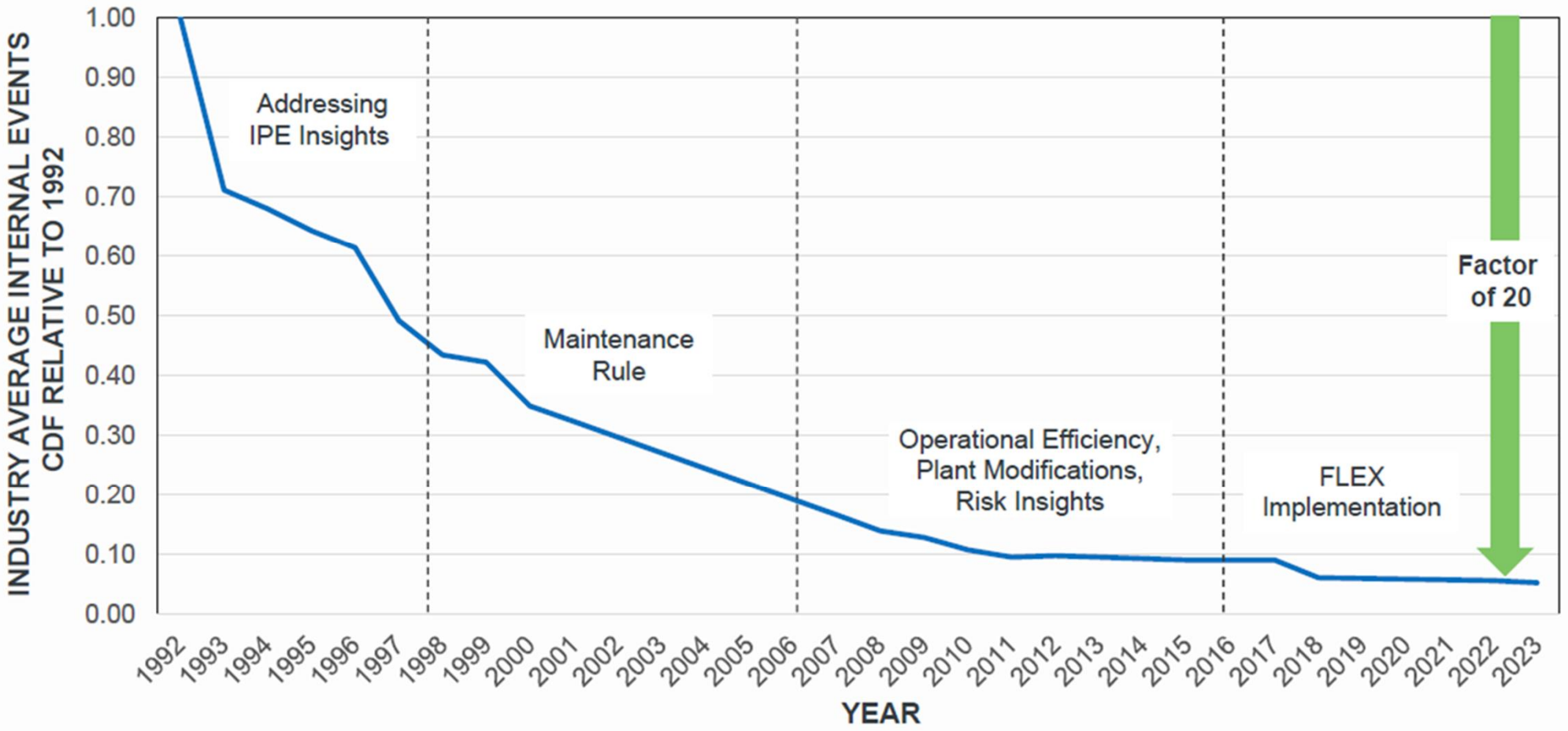
- Focus on the safety significant issues:
  - Allows allocation of resources in the manner that most effectively improves safety
  - Incentivizes licensee focus on issues important to safety
  - Reduces resources applied to issues of low importance
  - Stimulates a net improvement in safety
- Must account for limitations in risk analysis models (e.g., PRA)
  - PRA is a tool that must be used appropriately
  - PRA is neither omnipotent, nor omniscient
    - Neither is a deterministic approach

U.S. Implementation of Risk-informed Programs



Source: EPRI based on multiple Sources including IPE submittals and ROP data for Mitigating System Performance Index

U.S. Industry Internal Events CDF Trend



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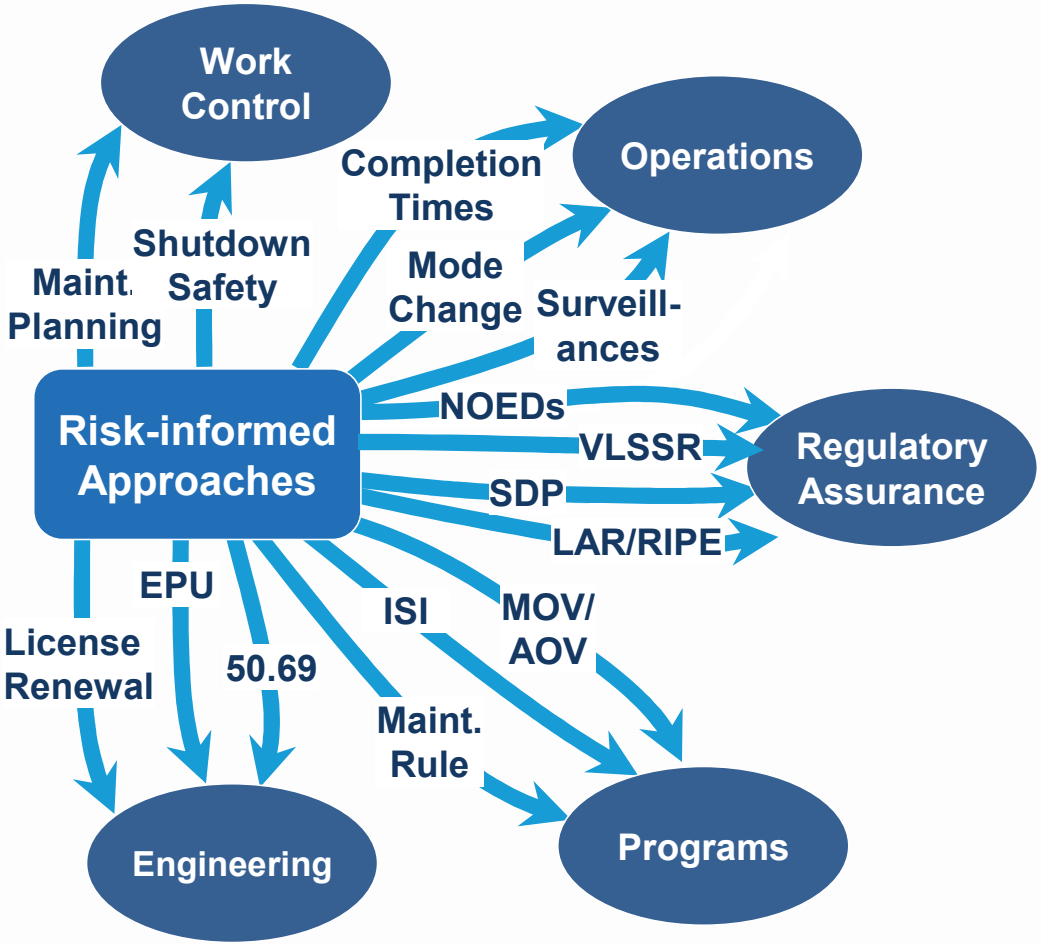
Today, PRA is Part of the Plant Safety Fabric



U.S. Plants use risk information every day

NEI 20-04, *The Nexus Between Safety and Operational Performance in the US Nuclear Industry*

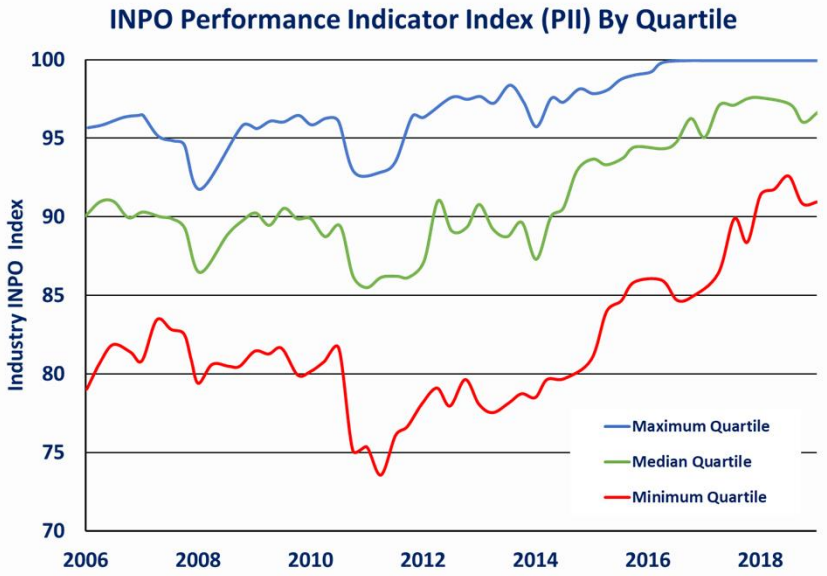
- Foundational document aggregating objective data from multiple sources (e.g., WANO/INPO, ROP, EIA, BLS)
- Three key messsages:
  1. U.S. Industry Performance at All Time High
  2. Industry Performance Level Improves Safety
  3. Risk-Informed Focus Improves Safety

https://www.nei.org/resources/reports-briefs/performance-safety

Industry Performance

Three main messages:

1. **U.S. Industry Performance at All Time Highs**
   - Compendium of performance data from multiple sources
2. Industry Performance Level Improves Safety
   - Demonstrates nexus between operational performance and improved safety
3. Risk-Informed Focus Improves Safety
   - Shows value of risk-informed approaches to improved safety and operational focus

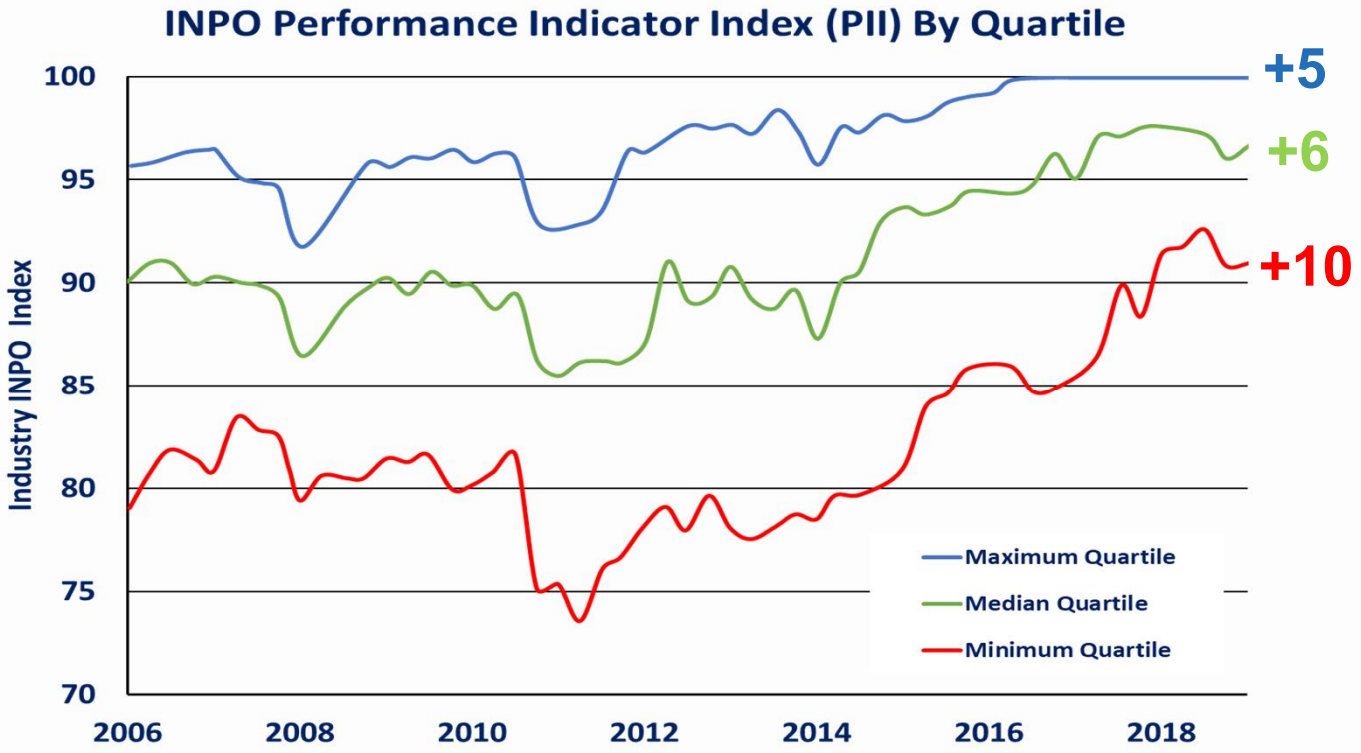


Example: INPO Performance Indicator Index

INPO PII

Covers a broad expanse of performance

- Reactor
- Safety systems
- Occupational safety
- Chemistry
- Radiation exposure



One of more than 35 Performance Trends

- From multiple sources
- All showing the strong performance of the US Nuclear Industry

Performance-Safety Nexus

Three main messages:

1. U.S. Industry Performance at All Time Highs
   - Compendium of performance data from multiple sources
2. **Industry Performance Level Improves Safety**
   - **Demonstrates nexus between operational performance and improved safety**
3. Risk-Informed Focus Improves Safety
   - Shows value of risk-informed approaches to improved safety and operational focus

Performance and Safety are Linked

There is a clear Nexus between operational performance and improved safety

Industry performance improvements have enhanced nuclear safety and plant reliability and reduced risk

The same actions, programs and processes that drive improved operational performance also enhance safety

Risk-informing Improves Safety

Three main messages:

1. U.S. Industry Performance at All Time Highs
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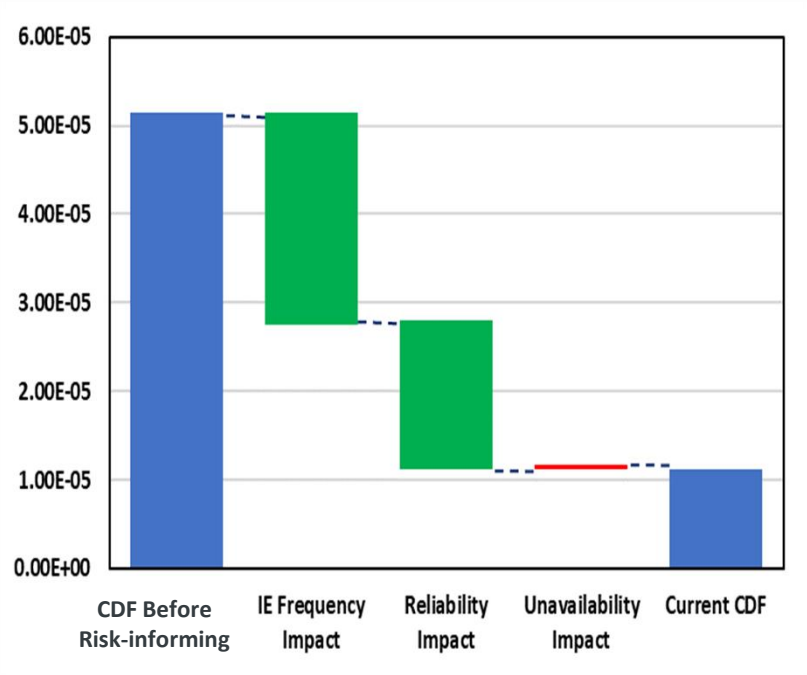
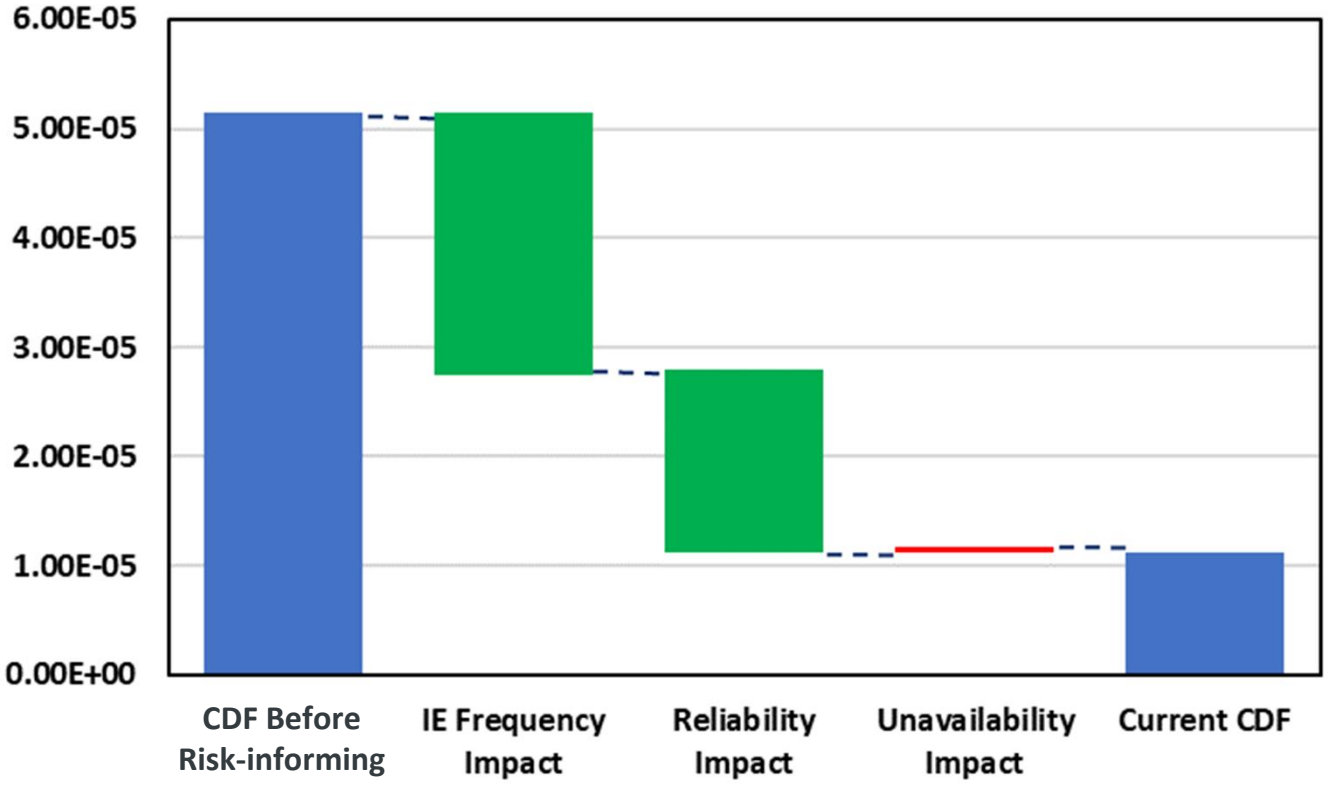


Performance Ties to CDF

CDF Before Risk-informing

Average of 5 current NRC SPAR models with NRC data for components and Initiating Event (IE) frequencies prior to RI initiatives



Current CDF

Average of 5 current SPAR models and current data for components and Initiating Event (IE) frequencies

Why Risk-informing Works

- Focusing on the safety significant issues:
  - Allows allocation of resources improve safety
  - Incentivizes licensee focus on issues important to safety
  - Reduces resources applied to issues of low importance
  - Stimulates a net improvement safety
- Must account for limitations in risk analysis models (e.g., PRA)
- Focus should not be entirely on high-risk areas
- Will not be applicable in all functional areas (e.g., Security)

Challenges

- Clear risk metrics aligned with Safety Goals
- Technically adequate PRA models (scope, level of detail)
- Consensus methods for realistically treating key contributors (e.g., human reliability, fire modeling, etc.)
- Processes for maintaining realism but understanding the impacts of key uncertainties

Summary

- U.S. has been on a risk-informed journey for decades
- The nexus between performance and safety is clear
- Many tangible safety benefits from risk-informed programs (factor of 20 improvement in safety)
- Challenges exist but can be overcome

Risk-informed Approaches Improve Safety

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Acronyms

AOV – Air Operated Valve
BLS – U.S. Bureau of Labor Statistics
CDF – Core Damage Frequency
CPRR – Containment Protection and Release Reduction
DBT – Design Basis Threat
DEGB – Double Ended Guillotine Break
EIA – U.S. Energy Information Administration
EPU – Extended Power Uprate
IPE – Individual Plant Examination
INPO – Institute of Nuclear Power Operations
ISI – In-service Inspection
LAR – License Amendment Request
LERF – Large Early Release Frequency
MOV – Motor Operated Valve
NOED – Notice of Enforcement Discretion
QHO – Quantitative Health Objectives
RII – Risk-Informed Initiative
ROP – Reactor Oversight Process
SBO – Station Blackout
SDP – Significance Determination Process
SOARCA – State-of-the-Art Consequence Analysis
SPAR – Standardized Plant Analysis Risk
WANO – World Association of Nuclear Operators

