Key Insights from Nuclear Power Risk-Informed Assessments

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CENTER FOR RISK AND RELIABILITY

UMD Center for Risk and Reliability in a Nutshell

- An umbrella organization for risk and reliability research and education at the A.J. Clark School of Engineering.
- Conducts a wide range of research in reliability and risk of systems, structures and processes
  - Reliability prediction and testing
  - Probabilistic risk assessment
  - Probabilistic physics of failure
  - Human reliability analysis
  - Machine learning for health monitoring and prognostics

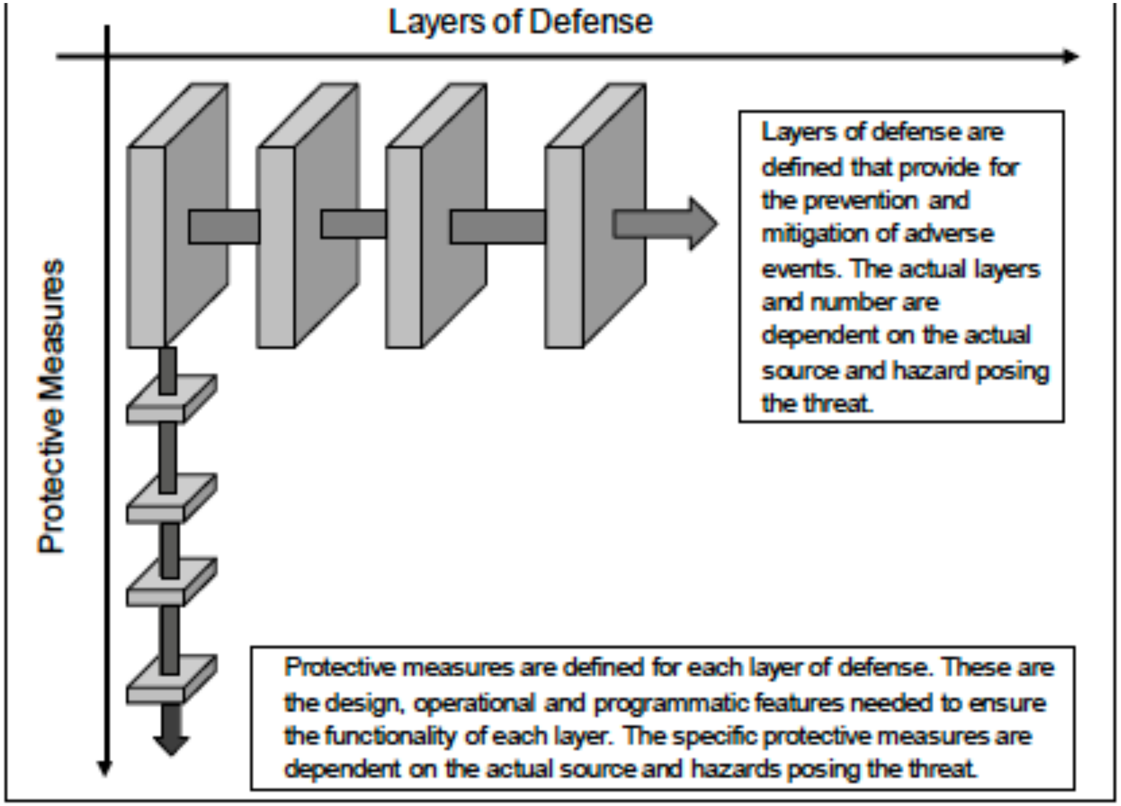
- Applications to nuclear power plants, Hydrogen energy, infrastructure, manufacturing, space missions, consumer products & devices, information systems, and defense

Origin of Nuclear Safety and Bridge Safety

- U.S. Atomic Energy Act of 1946 rested atomic technology and military applications with Government
- U.S. Atomic Act of 1954 ended the government's monopoly and allowed peaceful uses provided that: " . . . a *reasonable assurance* exists that such uses would not result in undue risks to the health and safety of the public"
- Department of Transportation Act of 1966: created the DOT, including the Federal Highway Administration (FHWA) that among other things *oversees the safety of public bridges*…
- Federal-Aid Highway Act of 1968: mandated FHWA to develop National Bridge Inspection Standards (NBIS) that mandates regular inspections of bridges to *ensure their safety and structural integrity*.

Defense-in-Depth (DiD): A Safety Design Principle in Nuclear Power Plants

DiD evolved into design and operating requirements to overcome lack of precise knowledge



Elements of DiD:

1. Multiple active & passive redundant and diverse barriers to rule out single failures
2. Use of large design margins to overcome lack of precise knowledge of accidents
3. Application of quality assurance & operation within defined safe design limits
4. Continuous testing, inspections, and maintenance to preserve original design margins

NEI, Modernization of Technical Requirements, Draft 9/2018

Defense-in-Depth (Cont.)

Acceptance criteria needed to measure adequacy of DiD

- Withstand a fixed set of accident scenarios *judged* by experts as most significant adverse events or the so-called "Design Basis Accidents (DBAs)"
- Assumed a plant that could handle the DBAs, it will handle any other accident scenario
- Reasonable assurance was interpreted as conformance to the body of regulations based on DiD.
- Acceptances criteria measured deterministically with conservative methods, tools and bounds

Emergence of Probabilistic Risk Assessment (PRA)

- In the mid-1960s, concerns over containment integrity paved the way for use of PRA to address limitations of the DBAs
- PRA was to model more realistic accident scenarios
- PRA was meant to answer:
    1) What can go wrong (scenarios)?
    2) How likely is it?
    3) What are its consequences?
- The landmark WASH-1400 study commissioned by the AEC (later NRC) in 1972-1975, developed the concept and assess operating nuclear plant safety

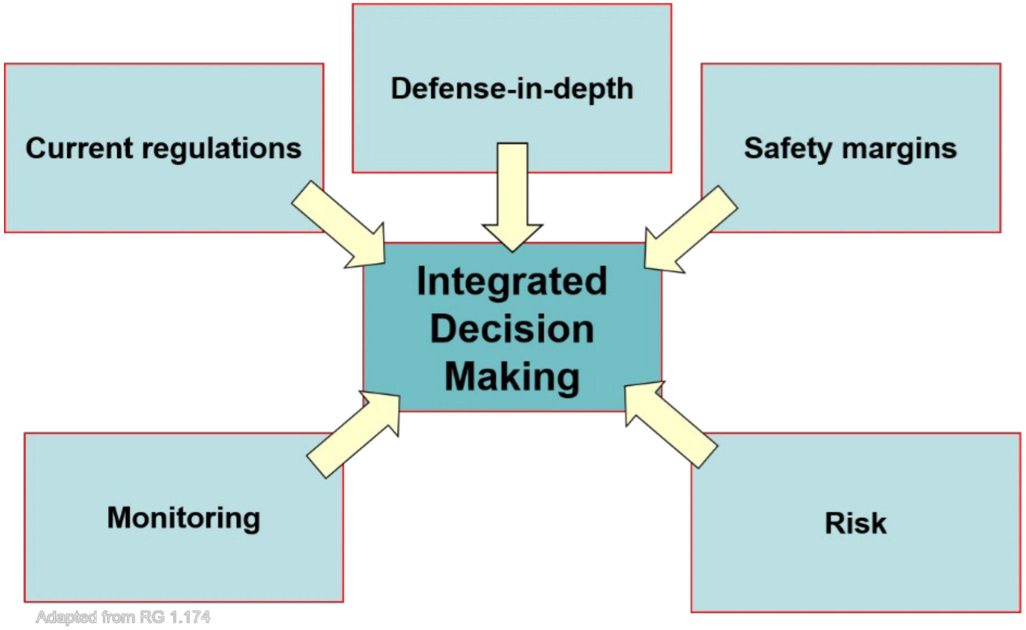
Pre- & Post-WASH-1400

- Pre PRA:
  - Protect against large loss of coolant
  - Core damage is unlikely < 10^{-8} per year
  - Consequences are disastrous

- Post PRA:
  - Small loss of coolant and transients are more important
  - Core damage is more likely than believed ~5×10^{-5}
  - Consequences are significantly smaller
  - Support systems and human reliability are very important

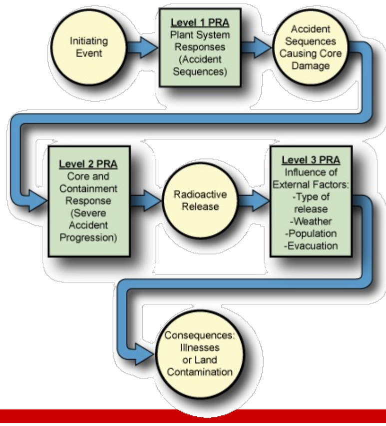
Risk-Informed Regulation

- NRC developed a set of qualitative safety goals and qualitative (probabilistic) safety objectives
- NRC developed a PRA Policy Statement and reformed its safety regulation to “risk-informed”



An Example of Risk Informed Regulation: Reactor Oversight Process (ROP)

- ROP a top-down regulatory framework to assess the licensees
- Inspectors rely on PRA results to characterize their inspection findings
- ROP provides the plant owners and regulators with a common framework to communicate safety and security
- ROP provides a systematic, predictable, actionable, and consistent approach to monitoring critical equipment

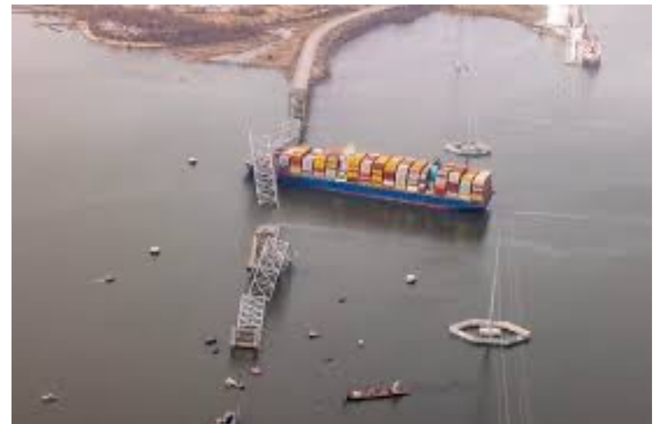


Why a Risk-Informed Approach to Bridge Safety?

Worldwide, between 1960 and 2015 ships or barges caused *35 major bridge collapses that killed 342 people*, half occurred in the US.

From: 2018 report from the World Association for Waterborne Transport Infrastructure

- Automating Everything
- Integrating Human-Vehicles &Vessels-Systems-Bridge
- Collecting 24/7 Risk Information and Online Data
- Learning from Incidents and Accidents
- Establishing risk acceptance (how much risk is tolerable or how "safe is safe enough"



Courtesy of the The Epoch Times

Tasos Katopodis/Getty Images

Conclusions

- There is room for more Dynamic PRA for risk-informed bridge "system of system"

- Technological Advancements: Adopting new technologies, like advanced sensors and monitoring systems, can improve risk information and predictive maintenance.

- Risk-Informed Approaches: Can incorporate all uncertainties into the design, operation, inspection, and regulation of next-generation bridges.

- Innovation and Safety: Risk-informed methods foster innovation, better design, adequate safety features, and sound policy.