Risk-Informed Decision Making in Regulatory Oversight

Gerry Frappier, P. Eng.
Director General, Power Reactor Regulation
Canadian Nuclear Safety Commission

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Presentation Outline

- **Legislative Framework**
  - Risk-Informed Focus
  - Performance Based Requirements (REGDOC 2.5.2)
- **Risk-Informed Decision Making**
  - Deterministic Analysis
  - Probabilistic Safety Assessment
- **Incorporating Risk Insights**
  - Long Term Operation
  - Beyond Design Basis Accident
  - Compliance Verification Program
- **Concluding Remarks**

The Canadian Nuclear Safety Commission

- Established in May 2000, under the ***Nuclear Safety and Control Act***
- Replaced the Atomic Energy Control Board (AECB) under the 1946 ***Atomic Energy Control Act***

Marking 70 years of nuclear safety in 2016

Legislative Framework – The Act

Nuclear Safety and Control Act

- **§9. Objects of the Commission**

  Prevent unreasonable risk to the environment and to the health and safety of persons

- **§24 (4). Conditions for Licence issuance**

  No licence shall be issued, renewed, amended or replaced unless, in the opinion of the Commission, the applicant

  a) is qualified…; and

  b) will **make adequate provision** for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

Legislative Framework – Regulatory Document

Regulatory Document REGDOC 2.5.2 *Design of Reactor Facilities: NPP*

- **Qualitative Safety Goals**
  - Individual member of the public bear **no significant additional risk to life and health**
  - Societal risk to life and health shall **not significantly add to other societal risks**
- **Quantitative Safety Goals**

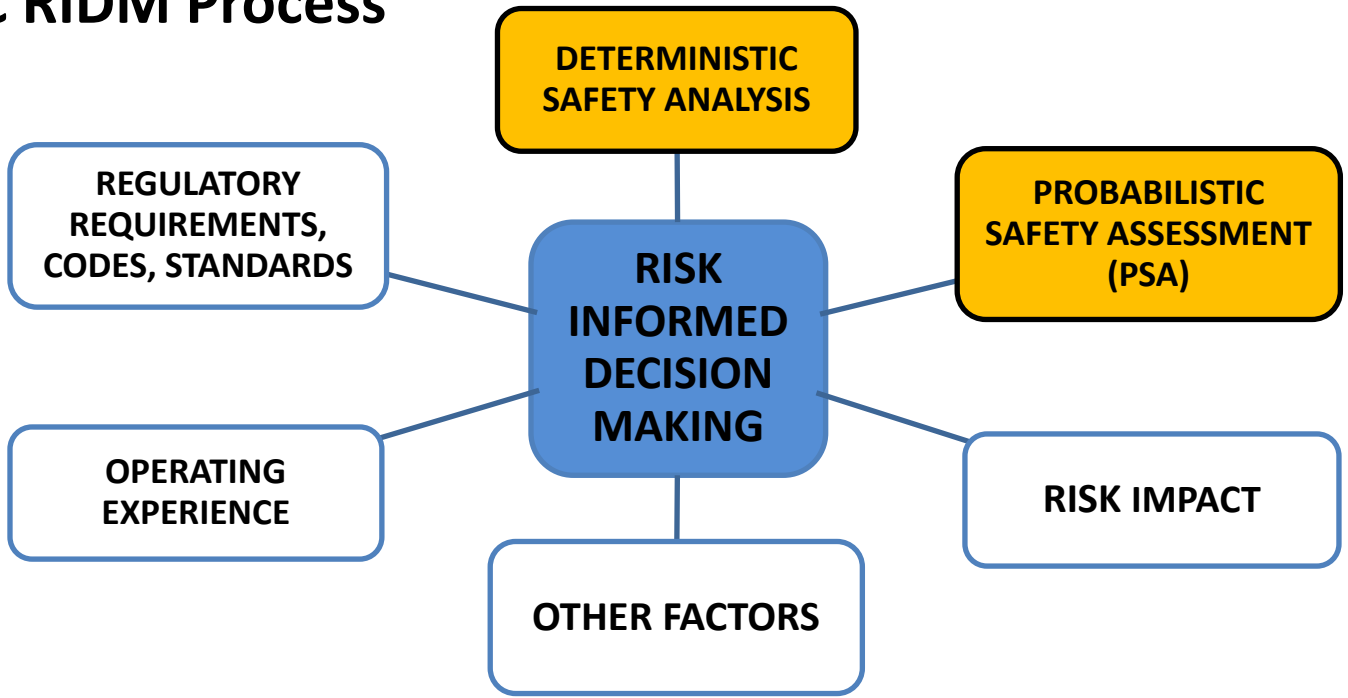
  Frequency of all event sequences that can lead to:
  - Large release that would trigger long term relocation (< 1 in 10^{-6} per reactor year)
  - Small release that would trigger temporary evacuation (< 1 in 10^{-5} per reactor)
  - Severe core damage as reactor defence-in-depth principle (1 in 10^{-5} per reactor)

Risk-Based vs. Risk-Informed

- Risk-Based
  - implies that final decision criteria are based solely on absolute risk values
- Risk-Informed
  - implies that decisions are based on risk insights along with deterministic, licensing basis and other information

Risk-Informed Decision Making (RIDM)

CNSC RIDM Process



RIDM – Deterministic Safety Analysis (DSA)

- DSA objectives
  - Adequacy of design
  - **Dose acceptance criteria** met for Abnormal Operating Occurrences (AOO) and Design Basis Accidents (DBA)
  - Approximate conditions associated with beyond-design-basis events (for example, energy discharge in containment, fission products transport)
- DSA scope
  - Set of **selected bounding events** considered individually to assess potential consequences of initiating events
    - likelihood of selected bounding events not included

RIDM – Probabilistic Safety Assessment (PSA)

- PSA objectives
  - Support safety case/safety goals
  - Complement deterministic safety analysis
    - provide **numerical quantification of risk** associated
    - identify dominant risk contributors
  - Evaluate and optimize reactor design
    - identify the design basis challenges to physical barriers
    - balance strategies for accident prevention and mitigation
    - identify practical safety improvements

RIDM – PSA Regulatory Requirements

- CNSC requires full scope **Level 1 and Level 2 PSA**
- Revisions made to PSA regulatory document to address Fukushima Task Force recommendations to include:
  - irradiated fuel bay (spent fuel pools) analysis
  - multi-unit station impacts
  - site specific external events and potential combinations

RIDM – PSA Safety Goals

- Operating NPPs in Canada meet or exceed applicable safety goals
  - Actioned Fukushima related improvements to reduce risk further
- Ongoing work to extend application of safety goals to the whole-site (spent fuel pools, waste facilities, etc.)

PSA safety goals are amongst the many tools used in making regulatory decisions

Risk Insights – Long Term Operation/Life Extension

- Periodic Safety Review (PSR) comprehensive self-assessment carried are out by licensees
  - A systematic, comprehensive and balanced approach for identifying safety enhancements
    - enables determination of **reasonable and practical modifications** that should be made to enhance safety of the facility to a level **approaching that of modern plants**
- Integrated Aging Management Program (IAMP)
  - **IAEA**: Ageing Management, Long Term Operation, *International Generic Ageing Lessons Learned (I-GALL)*
  - Regulating requirements for all NPPs to implement IAMP as per REGDOC 2.6.3

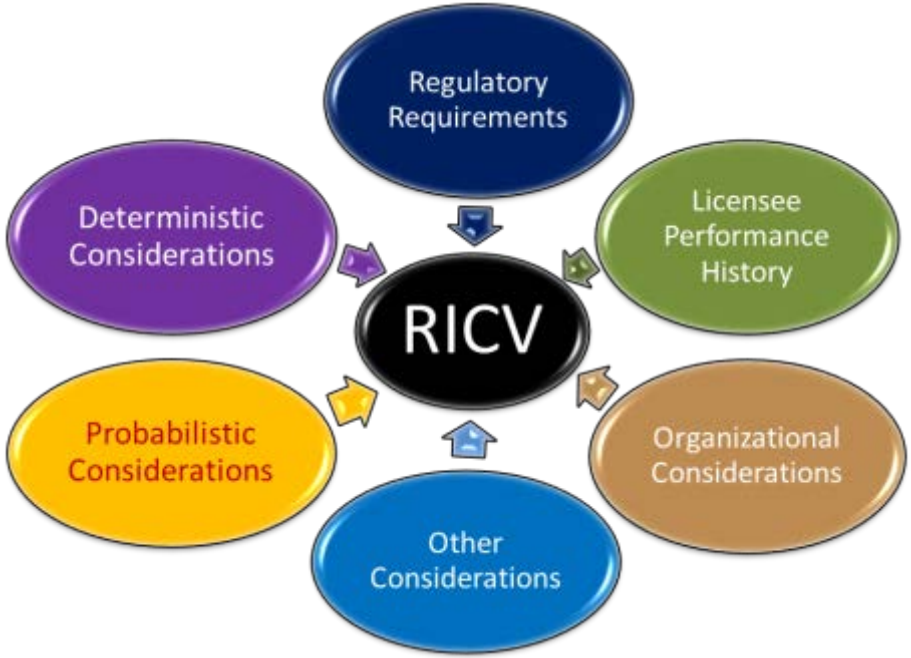
Risk arguments used to bring plants inline with modern standards

Risk Insights – Beyond Design Basis Accidents (BDBA)

- Probabilistic Safety Assessment (PSA) is main tool for assessing BDBA
  - Containment integrity assessed using Level 2 PSA
  - Severe Accident Management Guides (SAMG) and training enhanced based on PSA results
  - SAM equipment developed to support timely response to BDBA
  - Design extension conditions
    - Complementary design features, such as containment filtered venting systems
    - Fixed or portable equipment located onsite or offsite, such as mobile pumps or electric power generators

Risk Insights – Compliance Verification Plan

Consideration used to determine risk-informed compliance verification (RICV)



Risk Insights – Compliance/Inspections

Risk-Informed Inspections

- Risk insights from PSAs used **to support CNSC inspections and other compliance verifications**
  - Development of Risk Handbook to provide additional **quantitative risk information** to CNSC inspection process
- Focus on activities with highest potential impact on safety
  - System/component failures and human errors identified as dominant contributors to:
    - Reactor core damage frequency (Level 1 PSA)
    - Radioactive releases to the environment (Level 2 PSA)
  - Impact on programs assessment
    - *Management Systems* extend to all safety and control areas

Risk Insights – Reliability/Maintenance Programs

- Risk-Informed Operation
  - Request for extending allowed outage time of a System Structure or Component (SSC)
  - Configuration management and time at risk for SSC taken out of service
  - Operational events assessment
- Changes to the Licensing Basis
  - Changes in Operating Policies and Procedures (OP&Ps)
  - Changes in test/maintenance interval
- Input of Operating Experience – domestically and internationally

Risk Insights – Compliance/Pressure Boundary Components

- Application of PSA to aging of pressure boundary components
  - Evaluation of risk of pressure tube failures due to aging related degradations
    - demonstration of pressure-tube leak before break behaviour (PLBB)
    - assessment of pressure tube to calandria tube (PT-CT) contact
  - Use of risk-informed to accept frequency of guillotine break of large diameter nuclear piping is low

Concluding Remarks

- CNSC accepted regulatory decision making process is in a risk-informed context, based on probabilistic methodologies
  - Currently granted on a case-by-case basis, considering
    - Appropriateness of proposed acceptance criteria
    - Conservatism in underlying models and assumptions
    - Quantification of uncertainties
    - Validation and verification
    - Quality requirements
- CNSC requires a Level 1 and Level 2 PSA to provide fundamental understanding of the risk, vulnerabilities of nuclear power plants

Thank You!

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