INSIGHTS FROM THE WGRISK STATUS OF PRACTICE FOR LEVEL 3 PROBABILISTIC SAFETY ASSESSMENT SURVEY

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Introduction

- WGRISK is the Working Group on Risk Assessment under the Organisation for Economic Co-operation and Development (OECD) / Nuclear Energy Agency (NEA) / Committee on the Safety of Nuclear Installations (CSNI).
- WGRISK mandate is to support improved uses of probabilistic safety assessment (PSA) in risk-informed regulation and safety management.

Background

- Level 3 PSA is an assessment of the *offsite public* risks attributable to a spectrum of potential accident scenarios involving a nuclear installation.

- An increasing number of countries are pursuing development and application of Level 3 PSAs.

- Experience indicates there are many challenging issues that would benefit from increased information exchange and sharing of methods and practices.

Objectives

- Survey member and observer countries to determine current methodological practices in offsite radiological consequence analysis element of Level 3 PSA.
- Identify common challenges and notable practices.
- Summarize and document results.

Core Group Composition

Country	Organization
Canada	Canadian Nuclear Safety Commission (CNSC)
Hungary	Hungarian Academy of Sciences, Centre for Energy Research (MTA EK)
Japan	Japan Atomic Energy Agency (JAEA)
Korea	Korea Atomic Energy Research Institute (KAERI)
Netherlands	Nuclear Research and Consultancy Group (NRG)
United States (activity lead)	U.S. Nuclear Regulatory Commission (USNRC)

Coordination: Expanded Group

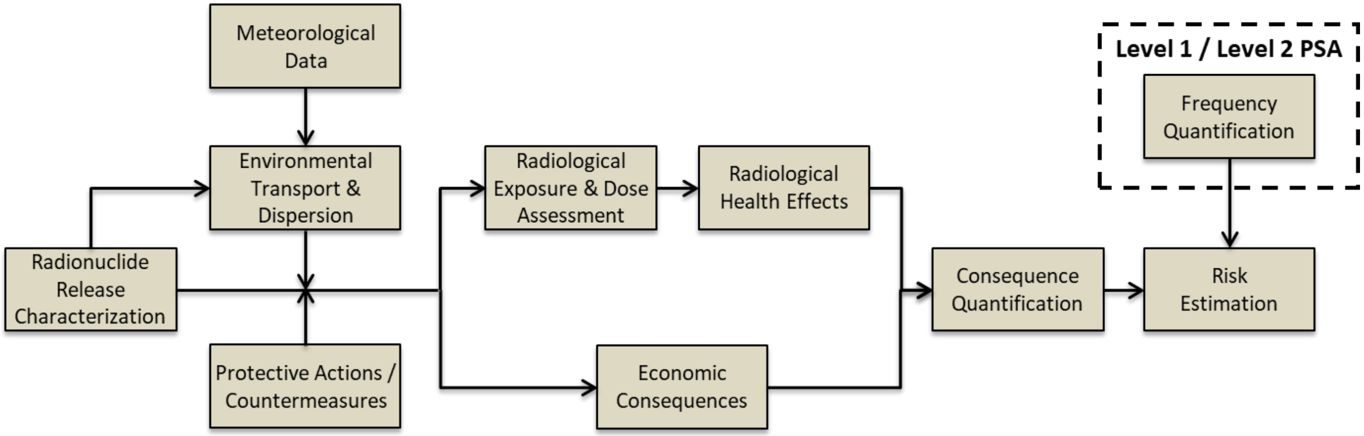
- Working Group on Analysis and Management of Accidents (WGAMA)
- Committee on Nuclear Regulatory Activities (CNRA)—Working Group on Public Communication (WGPC)
- Committee on Radiation Protection and Public Health (CRPPH)
- NEA Nuclear Development Division—Expert Group on Costs of Nuclear Accidents, Liability Issues and their Impact on Electricity Costs (EG-COSTNA)
- International Atomic Energy Agency (IAEA)

Survey Structure (1 of 2)

- Part 1: Respondent Information
  - Helps determine whether and how responses differ across different countries or types of organizations.
- Part 2: Application of Level 3 PSA
  - Obtains information about whether and how participants use or intend to use Level 3 PSA or other offsite radiological consequence analyses.
  - Provides important contextual information for understanding and evaluating responses to Part 3.

Survey Structure (2 of 2)

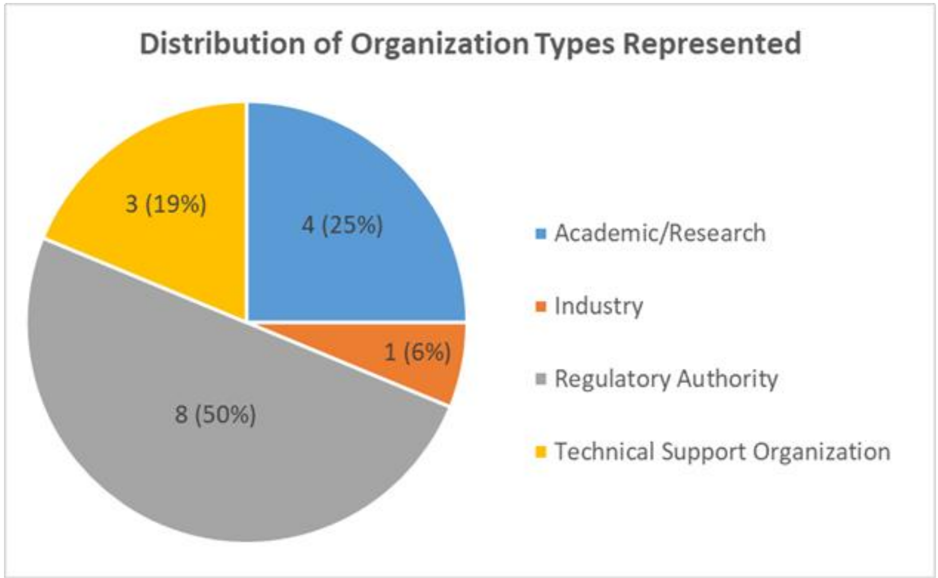
- Part 3: Level 3 PSA Modeling Issues and Technical Challenges
  - Elicits information about whether and how participants address specific modeling issues and other technical challenges in Level 3 PSA.
  - Survey items grouped by high-level technical element.



Respondent Information

- 10 survey responses
- Countries represented
  - Belgium
  - Canada
  - Finland
  - Hungary
  - Japan
  - Korea
  - Netherlands
  - Sweden
  - Switzerland
  - United States

Survey respondents represented a diverse set of organization types, with 50% representing regulatory authorities and the other 50% representing a mix of academic/research, industry, and technical support organizations.



Application of Level 3 PSA (1 of 2)

- 2 out of 10 countries represented require Level 3 PSA.
  - Korea and Netherlands.
  - Required for comparison to risk acceptance criteria, safety goals, or other quantitative objectives.
  - Emergency response protective actions are not credited.
- 7 out of 10 countries represented are currently performing, planning to perform, or considering Level 3 PSA.

Application of Level 3 PSA (2 of 2)

- Five broad types of Level 3 PSA applications:
  - Comparison to risk acceptance criteria, safety goals, or other quantitative objectives.
  - Evaluation of protective action effectiveness to inform emergency preparedness and response guidelines.
  - Inform development of severe accident management plans.
  - Environmental assessments.
  - Applied research.
- Deterministic analyses continue to provide primary analytical basis for:
  - Siting of nuclear installations.
  - Establishing emergency planning or protective action zones.

Level 3 PSA Scope Considerations

- Onsite worker population are typically excluded.
- Radiological releases to aqueous pathways are typically screened out.
  - Movement of radionuclides to accessible environment through aquatic pathways is expected to be slow relative to atmospheric transport.
  - Aqueous releases are considered easier to interdict.
- Economic models are generally used to estimate costs attributed to modeled protective actions.
  - Countries that require Level 3 PSA (Korea and Netherlands) do not consider economic consequences.

Modeling Practices (1 of 3)

- Level 2 PSA analysts typically work closely with Level 3 PSA analysts in radionuclide release characterization to:
  - Define radiological release categories or source term groups.
  - Select a representative accident sequence for each radiological release category to estimate source term input to consequence analysis.
  - Onsite severe accident mitigation actions are typically considered.
- Size of the modeled region and spatial intervals are typically application- and site-specific.
  - A larger number of spatial intervals with finer-resolution grid elements is typically used for the region close to the site.
  - The number of spatial intervals and grid resolution decreases as the distance from the site increases.

Modeling Practices (2 of 3)

- Most countries use site-specific information sources supplemented with generic information sources.
- For meteorological data:
  - Site-specific data with hourly observations for one year are typically used.
  - Code-specific weather binning and sampling strategies are typically used to account for temporal variability in offsite weather conditions.
- Protective action models typically do <u>***not***</u> account for:
  - Multiple population groups or cohorts with different protective action behaviors.
  - Probabilities of success or failure for modeled protective actions.

Modeling Practices (3 of 3)

- A range of early radiological health effects is typically estimated using deterministic models:
  - Early fatalities.
  - Acute radiation syndrome (radiation sickness).
  - Other early injuries arising from acute doses to various tissues or organs.
- Fatal and non-fatal cancers involving multiple organs generally represent the latent radiological health effects estimated using stochastic models.
  - Dose-response models based on the linear no-threshold (LNT) hypothesis are the default.
  - Most countries do not evaluate dose-response model uncertainty.

Presentation of Risk Results and Uncertainties

- Commonly used formats for presenting risk results
  - Weighted sum of mean consequences over all weather trials, weighted by mean radiological release category frequency.
  - Complementary cumulative distribution function (CCDF) curves that illustrate effect of temporal variability in offsite weather conditions over all modeled radiological release categories.
  - FN curves that illustrate societal risk as the frequency of N or more consequences (F) as a function of total number of consequences (N).
- Commonly used formats for presenting uncertainties
  - Empirical probability distributions (e.g., probability density function).
  - Box plots that illustrate locations of key summary statistics (e.g., mean, 50th percentile (median), 95th percentile, and 5th percentile).
  - Sets of CCDF curves.

Common Technical Challenges

- Perceived barriers to performing Level 3 PSA
  - Absence of a technical or legal framework to perform Level 3 PSA.
  - Large uncertainties in Level 3 PSA results, especially when combined with uncertainties propagated from Level 1 and Level 2 analyses.
  - Limited expected benefit in terms of potential safety enhancements.
  - Additional resources required.
- Limitations of available probabilistic consequence analysis (PCA) codes
  - PCA codes use relatively simple models of some phenomena (e.g., atmospheric transport and dispersion, terrain effects)
  - Cannot directly calculate risk metrics within PCA codes by combining radiological release category frequencies and associated consequences.

Recommendation for Future Activities

- Many typical practices or common technical challenges are driven by limitations or capabilities of available PCA codes.
- Underscores potential need for future studies to update previous benchmarking of PCA codes.
  - Nuclear Energy Agency. *International Comparison Study on Reactor Accident Consequence Modelling*. Paris, France: Organisation for Economic Co-operation and Development; 1984.
  - Nuclear Energy Agency, Commission of the European Communities. *Probabilistic Accident Consequence Assessment Codes Second International Comparison: Overview Report*. Paris, France: Organisation for Economic Co-operation and Development; 1994.
- Recommendation:
  - Consider performing a follow-on study to benchmark more recent versions of available PCA codes used for Level 3 PSA applications.

Result

- CSNI approved the corresponding report for publication in December 2017.
  - NEA/CSNI/R(2018)1 Status of Practice for Level 3 Probabilistic Safety Assessment

Bibliography

- Nuclear Energy Agency. *International Comparison Study on Reactor Accident Consequence Modelling*. Paris, France: Organisation for Economic Co-operation and Development; 1984.
- Nuclear Energy Agency, Commission of the European Communities. *Probabilistic Accident Consequence Assessment Codes Second International Comparison: Overview Report*. Paris, France: Organisation for Economic Co-operation and Development; 1994.
- Nuclear Energy Agency. *Status of Practice for Level 3 Probabilistic Safety Assessment*. Paris, France: Organisation for Economic Co-operation and Development; TBD.