Performance Assessment - Status of Art and Practice

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Performance (Safety) Assessment Process has a long history of successful use around the world

Relatively good agreement about fundamental process, technical approaches continually evolving

Essential blend of regulatory and science and engineering

Managing uncertainties associated with complex systems over long time frames is primary challenge
Growing Use of Performance Assessment

- PA traditionally focused on disposal
- More challenging D&D, Remediation, Tank Closure, NEPA, etc. assessments becoming PA-like
  - Need to take credit for more features
- EM Senior Management has recognized potential risks associated with inconsistency
Contents

- Perspective
- Existing Guidance and Common Principles
- Trends, Technical Advances and Challenges
Perspective - Concept of “Safety Case”

- IAEA, Nuclear Energy Agency and others
- Reflects use of performance assessment as only one part of a package used to support decisions
  - “The purpose of computing is insight, not numbers” – Richard Hamming
- Uncertainties can be managed in many different ways in addition to modeling
Example International Activities

- New IAEA project, PRISM, to address development of a safety case for near surface disposal facilities
  - Follow-on to NSARS, ISAM and ASAM
  - Lead for development of task for management of uncertainties
- European Commission Project named PAMINA
  - Sensitivity analysis
  - Management of uncertainties
Perspective – Dose Limits

100,000 mrem – Dose leading to ~5% chance of Fatal Cancer (UNSCEAR)
10,000 mrem/yr – IAEA mandatory intervention
5,000 mrem/yr – Worker dose standard
1,000 mrem/yr – IAEA reference level for intervention for cleanup situations
360 mrem/yr – US Average dose all sources (NCRP)
100 mrem/yr – All sources limit (IAEA practices, DOE)
25 mrem/yr – NRC and DOE LLW
15 mrem/yr – EPA Radiation (40 CFR 191)
10 mrem/yr – Air (atmospheric) (40 CFR 61)
4 mrem/yr – Drinking Water (40 CFR 141)
1 mrem/yr – IAEA Exemption/Clearance

Note: Air crew average (300 mrem/yr)
From UNSCEAR (2000)

Typical Annual Sources of Public Exposure

Graphics from NCRP Report No. 93

One Transcontinental round trip flight - 5 mRem

Total Effective Dose Equivalent = 30 mRem

Graphics from NCRP Report No. 93
Examples Performance Assessment Guidance

- International Atomic Energy Agency
  - Requirements and Guides, Technical Reports
- U.S. Department of Energy
  - DOE Manual 435.1-1 and Associated Guides
- U.S. Nuclear Regulatory Commission
  - NRC Staff Recommendations
- National Council on Radiation Protection and Measurements
  - Scientific Committee Report
- Others
Examples of Common Principles

- PA is a tool to support decision-making
- Detailed approaches need to be site- and decision-specific, but general agreement on basic principles:
  - Multi-Disciplinary
  - Complexity – Need for tension between simplicity and realism
  - Iterative and Graded Approach
  - Sensitivity Analysis
  - Role of the Source Term
Multi-Disciplinary

PA
How Much Complexity is Appropriate?

- Occam’s Razor (Principle of Parsimony) – “Pluralitas non est ponenda sine necessitas”
  
  Use method involving less detail and assumptions that arrives at same conclusions

- Einstein – “Everything should be made as simple as possible, but not simpler”

  Need to address key processes (which processes are key??), Don’t let over-conservatism change decisions

- Seeking cost-effectiveness and defensibility directed at specific decision to be made
## Iterative, Graded Approach

<table>
<thead>
<tr>
<th>Modeling Detail</th>
<th>D&amp;D, Remediation</th>
<th>PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening (simplified, “bulletproof”)</td>
<td>Typical</td>
<td>Typical</td>
</tr>
<tr>
<td>Assessment (compliance, detail as needed)</td>
<td>Occasional</td>
<td>Typical</td>
</tr>
<tr>
<td>Process-specific (input for compliance model)</td>
<td>Rarely</td>
<td>Typical</td>
</tr>
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</table>

Start simple, add complexity as needed for specific aspects of the problem.
Sensitivity “Importance” Analysis

- Focus attention on parameters and processes of greatest interest for decision
- NCRP Committee adopted the term “Importance Analysis”
- Guide reviewers and also identify areas for additional work
Role of Source Term

- Drives the PA Process
- Contaminant-Specific
  - Concentration averaging
  - Chemical/physical form
- Facility-Specific
  - Dimensions, barriers
  - Barrier degradation
- Site-Specific

Material Composition

- container lifetime?
- resins?
- concrete?
- enhanced mobility?
- activated metal?
- solubility?
- gaseous release?
Trends and Advances

- Emphasis on Consistency
  - Technical Forums, PA Community of Practice
- Regulatory Review at End → Scoping at Beginning and throughout PA process
- Deterministic → Probabilistic → Hybrid
  - Integrating Platforms
  - Abstraction/Upscaling
  - Distributions
- Compliance Monitoring → Performance Monitoring
- Technical Approaches
Consistency Issues

- Expansion of activities involving PAs has resulted in involvement of multiple regulators and DOE organizations
  - Preferred approaches, scenarios, etc.
- PAs and PA-like analyses distributed among different contractors and DOE Offices at a DOE Site, and within individual contractors
- Can be legitimate differences in waste forms, barriers, and geohydrology
- Need for awareness of activities at a site and complex-wide level
### Example DOE-EM Activities to Improve Consistency

<table>
<thead>
<tr>
<th>Administrative</th>
<th>Technical</th>
</tr>
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<tbody>
<tr>
<td>Consistency Requirements added to LFRG Review Criteria (identify/explain differences)</td>
<td>Probabilistic Sensitivity and Uncertainty Analysis Forum</td>
</tr>
<tr>
<td>Support for Scoping with Regulators</td>
<td>Forum on Development of Input Distributions</td>
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<tr>
<td>Proposal for updates to DOE Order 435.1 and associated manuals and guides</td>
<td>Forum on Monitoring Activities</td>
</tr>
<tr>
<td>Increasing technical staff involvement in LFRG PA reviews (peer review and sharing of approaches)</td>
<td>EM-11 and EM-23 cooperation on In-Situ Decommissioning</td>
</tr>
<tr>
<td>Supporting development of assessment consistency teams at Sites</td>
<td>EM-11 and EM-21 cooperation on Cementitious Barriers CRADA</td>
</tr>
</tbody>
</table>

PA Community of Practice and PA Assistance Teams discussed in a separate presentation.
Scoping

- Change in paradigm from regulatory review upon completion of assessment
- Open discussions with regulators at beginning of PA process
- Formal, documented approach
- Work to resolve technical issues
- Present and discuss approaches, conceptual models, scenarios, etc.
- Discuss relationship with other assessment activities
Deterministic -> Probabilistic -> Hybrid

- Agree on deterministic baseline case(s) to compare with deterministic standard (add sensitivity “what-if” cases)
- Use probabilistic approach to capture “what-if” questions and uncertainty analysis
- Multiple lines of reasoning
- Continuous improvement of both approaches
Hybrid Approach – Idaho Example

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Probabilistic/Hybrid Approaches

- **Increased Use of Integrating Platforms**
  - Large number of realizations encourages use of integrated model
  - Many different platforms (GoldSim, Ecolego, FRAMES, AMBER, RESRAD update)

- **Input Distributions**
  - Increased data requirements (defense)
  - Risk Dilution (potentially non-conservative)

- **Abstraction/ Upscaling/ Benchmarking**
  - Alternative to multiple realizations with detailed transport model
  - Very challenging part of move to probabilistic
Monitoring and surveillance can serve multiple roles (e.g., establish baseline, public safety, managing uncertainty)

Challenges for comparisons of environmental monitoring and surveillance activities with PA results (e.g., timing, not predictions)

There are needs for a broader view of monitoring as a means to manage uncertainties in performance assessments (“data collection”)
Performance Monitoring

- Need to think more broadly about what constitutes “monitoring” for situations where migration is not expected for long times
- Link to indicators identified in PA calculations and models
- NRC monitoring interested in as-built properties (measurable)
- Experiments, field studies, etc. can be used as surrogates to build confidence in assumptions
Examples of Technical Advances (Process-Level)

- Improving models and data related to degradation of barriers
  - Physical and Chemical Degradation
  - Corrosion
- Approaches for abstraction
  - INL, SRNL, LANL
- Improving representation of chemistry and geochemistry for soils, barriers and waste forms
  - Solubility
  - Improved $K_d$s
  - Coupled modeling
- Improved understanding of probabilistic modeling for PA

Cover (infiltration)
Grout/Concrete (chemistry, flow, diffusion)
Metal Tank (flow, diffusion)
Example Challenges

- Improve sharing of information and modeling approaches
- Input Distributions
  - Defensibility, Risk Dilution
- Abstraction
  - Determining what is good enough
- Probabilistic Sensitivity Analysis
  - Distinguishing global sensitivity from sensitivity at peaks (time, location)
- Monitoring
  - Better job of using monitoring directed at managing uncertainties in models
- Advanced Computing
  - Effective balance of science and compliance

<table>
<thead>
<tr>
<th>First 10,000 years</th>
<th>Sensitivity Index</th>
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<tbody>
<tr>
<td></td>
<td>Well A</td>
</tr>
<tr>
<td>Tank X failure scenario</td>
<td>11</td>
</tr>
<tr>
<td>Vadose zone thickness</td>
<td>5.6</td>
</tr>
<tr>
<td>Pu Kd (sandy soil)</td>
<td>4.9</td>
</tr>
<tr>
<td>Saturated aquifer thickness</td>
<td>4.4</td>
</tr>
<tr>
<td>Pu Kd (clayey soil)</td>
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Conclusions

- PA is a mature process with widespread global experience
- Managing uncertainties in PA is a holistic process (safety case), not just probabilistic calculations
- Potential for inconsistency with growing use of PA-like assessments is a significant concern, needs to be addressed up-front and throughout process (improved sharing of information)
- Healthy tension between simplicity and realism in models. As complexity increases, data requirements increase and defensibility can become more difficult
- Technical advances are generally made in areas of greatest concern for a specific problem and decision to be made (e.g., barriers, chemistry)
- Challenges largely based on move to probabilistic approaches, but also need for new approach to monitoring
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