Alternative Methods for Incorporating PRA Concepts Into the Safety Decision-Making Process

Mark Abkowitz
Vanderbilt University – CRESP
Member – Nuclear Waste Technical Review Board

Workshop on Risk Assessment & Safety Decision Making Under Uncertainty
Washington, DC
September 2010
Risk and the Safety Decision Making Process

- Evaluate Initial Risk
- Acceptable Risk?
  - Yes: Monitor & Review
  - No: Develop Safety Control Alt.
    - Evaluate Modified Risk
      - Acceptable Risk?
        - Yes: Implement Safety Control
        - No: Other Alt.?
          - Yes: Policy Change Needed
          - No: No
Decision Making Framework

- Type of safety decision
- System characteristics
- Potential threats
- Performance measures
- Decision criteria
Seeking Effective Safety Controls

- Low Implementation Cost
- Large Risk Reduction Potential
- High Achievability

[Star symbol]
Probabilistic Risk Assessment (PRA)

• Define risk categories

• Develop scenarios of *reasonably foreseeable events* in each category
  – What can go wrong?

• Assign frequency of scenario occurrence
  – How likely is it?

• Determine impacts of each scenario
  – What are the consequences?

• Use likelihood and consequence to estimate risks
Reasonably Foreseeable Scenarios

Risk Categories

- Product/service quality
- Customer relations
- Financial management
- Information systems
- Supply chain
- Distribution
- Infrastructure & equipment
- Employee health & safety
- Security
- Social, political, economic
- Community & environment
- Natural hazards

Risk Factors

- Design & construction flaws
- Deferred maintenance
- Economic pressures
- Schedule constraints
- Inadequate training
- Not following procedures
- Lack of planning & preparedness
- Communication failure
- Arrogance
- Political agendas
Potential Consequences

- Acute fatalities & injuries
- Long term human health effects
- Environmental degradation
- Property damage
- Business & community interruption
- Clean-up, remediation & disposal
- Increase in enforcement activities
- Demand for new regulations
- Loss of public confidence
The PRA Spectrum
PRA Methods, Uses & Requirements

- Quantitative PRA
  - Absolute Risk
- Semi-Quantitative PRA
  - Relative Risk
- Qualitative PRA

Increasing Complexity
More Data Needed
<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Very High</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>High</td>
<td>High</td>
<td>Very High</td>
<td>Very High</td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
</tr>
</tbody>
</table>

**Consequence**
Absolute PRA Results

- **Frequency of N or more fatalities**
  - 1E-5
  - 1E-4
  - 1E-3
  - 1E-2
  - 1E-1

- **Number of fatalities**
  - 1
  - 10
  - 100
  - 1000

Legend:
- Motor spirit
- Ammonia
- LPG
- Chlorine
- National total

- **Intolerable**
- **ALARP Region**
- **Negligible**
Hybrid PRA

- Uses qualitative PRA approach to preserve limited resources.

- Utilize results to decide where more quantitative PRA is warranted.
How Safe Is Safe Enough?

• Is our operational safety as low as is reasonably practicable?
  – Establish benefit/cost of various risk reduction strategies
  – Implement improvements until reaching threshold for minimum return on investment

• Should we be continuing this operation?
  – Establish a threshold risk (e.g., chance of being struck by lightning)
  – Has our risk appetite been exceeded?
Be Careful What You Ask For!

- A more sophisticated PRA is not always better.
- It depends on the number of model parameters and data requirements.
- One can end up with more assumptions and greater uncertainty than with a simpler approach.
- Even if the approach is valid, can the risk assessment results be presented in a meaningful way to the decision-maker?
Wrap-Up Comments

• A variety of PRA methods exist, ranging from highly qualitative to highly quantitative techniques.

• The preferred approach depends on a number of factors:
  – level of concern for the problem
  – system complexity
  – data quality
  – available resources
  – type of output desired

• A variety of PRA approaches can be o.k. as long as they are holistic and systematic.