Commission Briefing on Human Reliability Program Activities and Analyses

March 3, 2014
Agenda

• Opening Remarks
  Mark Satorius

• Introduction to Human Reliability Analysis
  Richard Correia

• Use of Human Reliability Analysis
  Sunil Weerakkody

• Human Reliability Research Program
  Sean Peters

• Conclusion
  Richard Correia
Human Reliability Analysis (HRA)

- **Human Reliability Analysis**
  - Addresses the questions:
    - What actions do humans need to take?
    - How likely will they succeed or fail at performing those actions?
  - Integral part of probabilistic risk analysis.
    - What are the consequences of errors?

- **Human Reliability Analysis is important**
  - Human errors are significant contributors to events and accidents.
  - Input to our regulatory decision process.
  - Helps us understand influence human reliability has on overall risk.
  - Identifies important information that can be used to reduce human errors that contribute to risk.
Human reliability analysis is used in the Regulatory Framework

– Used in bases for orders, rulemaking, oversight, licensing, generic issues, accident precursor events and research products.

– Example: Used in the accident sequence precursor analysis for the Robinson NPP event in 2010:
  • Equipment malfunctions, 2 fires and operator failures.
  • Weaknesses in operator training, emergency operating procedure and command and control in the control room were important contributors to plant risk.
  • Important lessons learned

– Other examples:
  • Consequence study of a beyond design basis earthquake affecting a spent fuel pool
  • Containment filtered vent regulatory analysis
Human Reliability Analysis (cont.)

• Staff developing human reliability analysis methods
  – Positive interactions and feedback from members of the Advisory Committee on Reactor Safeguards and extensive collaboration with staff, internal and external stakeholders.
  – Improved method uses best features from existing methods.
  – Generic method under development, can be tailored for various applications.
Regulatory Applications of HRA

- Reactor oversight process
- License amendment reviews
- Rulemaking
- Commission orders
- Near-term task force related activities
Examples of Use

• **Oversight:** Assessing the risk-significance of loss of shutdown cooling event at Nine Mile Point Nuclear Power Plant:

  – Treatment of human error probabilities governed the risk significance of the finding for the Nine Mile Point event.

  – Due to minimal automatic actuations, human error probabilities dominate some shutdown risk assessments.
Examples of Use (Continued)

• **Commission Order EA-12-049**: Mitigating Strategies
  – Reliability of human actions performed outside of the control room are critical for success of the “Transition Phase.”

• **Rulemaking**: Containment Filtered Vents
  – Probability of human error of actions performed by operators outside of the control room will influence the results of cost-benefit analyses that support the technical basis.
Needs of the Office of Nuclear Reactor Regulation

• Methods
  – Clear guidance on strengths and weaknesses of application of various methods used to assess human error probabilities of actions performed inside control room by operators
  – A method to assess human error probabilities of actions performed outside of the control rooms by operators and other plant personnel
Needs of the Office of Nuclear Reactor Regulation (Continued)

• Data
  – Continued collection of data to assess human error probability of operator actions inside control rooms (e.g., SACADA - Scenario Authorizing, Characterization, and Debriefing Applications)
  – Data to quantify reliability of actions performed outside of the control room
HRA Research Program

• Build state of the art methods to support the NRC’s HRA related work

• Needs identified by Staff Requirements Memoranda (SRMs) and User Needs

• 3 SRMs guide this development
  – SRM-M061020 – HRA Methods
  – SRM-M090204B – HRA Benchmarking and Data
  – SRM-SECY-11-0172 – Expert Judgment
Activities Taken to Address SRM on HRA Methods

Activity 1 - International & US Benchmarking of Methods (Halden and South Texas Project Nuclear Operating Company)

• Compared methods vs simulator experiments
• Compared analyst to analyst variability
• Findings of Benchmark Studies
  – HRA analyst predictions generally provided reasonable results with some variability
  – All methods have particular strengths and limitations
  – Better guidance is needed
Activity 2 – Workshop of HRA Expert

• Findings
  – No single existing method can be easily adapted for all NRC applications
  – Analyst to analyst variability seen as biggest single issue

• Outcome/Decision
  – Take the best pieces of existing methods and build one integrated method for the NRC to use
  – Improve on identified HRA issues
  – Improve analyst to analyst variability
Activity 3 – Integrated Method Development

Need an enhanced method to reduce variability

- Multiple methods for internal at-power events
- Each having guidance limitations
- Scientific basis and data limited
- Variability when applying methods

Need a generic methodology to support diverse HRA applications

- Existing methods are not adequate to cover a broad set of applications (e.g., external events, Medical)
- Little data for external events
Project Goal and Key Objectives

Goal
• Develop a generic HRA methodology to reduce variability and support a diversity of applications

Key Objectives
• Conform to the PRA standard and HRA Good Practices
• Retain and integrate strengths of existing methods
• Have enhanced capabilities to address key limitations in state-of-practice
• Have a state-of-art technical basis and be generic and flexible enough to support diverse applications
Development Strategic Framework

Scientific literature

A structured cognitive basis framework for human error analysis

Existing HRA methods

A generic methodology for diverse HRA applications

IDHEAS method for internal at-power events

Application-specific HRA models

IDHEAS - Integrated Decision-tree Human Event Analysis System
Human Reliability Analysis Process

• Qualitative Analysis
  – Understand PRA scenario
  – Identify and define human failure events
  – Analyze tasks
  – Assess feasibility of human actions

• Human Failure Quantification
  – Identify crew failure modes
  – Analyze performance influencing factors
  – Estimate human error probability
  – Integrated analysis
Key Features of IDHEAS

• Integrated guidance for every step of the HRA process
• Structured qualitative analysis guidance
  – Human failure event identification
  – Task analysis and crew response tree
  – Feasibility assessment of human actions
• Human error probability quantification model
  – Crew failure modes
  – Decision trees used to estimate human error probability
  – Questionnaires used to assess performance influencing factors
• Detailed guidance for documentation
Initial Testing

Three HRA analyst groups independently tested IDHEAS on several PRA scenarios.

Preliminary results:

• All the parts work as intended, with improvement to the key limitations in the state-of-practice
• Good traceability and clear documentation
• Reasonable inter-analyst variability
• More analysis effort upfront, reduces deliberation
• Desire for user-friendly implementation guidance, i.e., a users’ manual
A Generic Methodology Supporting Diverse Human Reliability Analysis Applications

• Methodology adaptable to other uses such as:
  – Level 2 and 3 PRA
  – Reactor shutdown operations
  – External events
  – Fuels, materials, by-product

• Generic methodology addresses:
  – Broad spectrum of human actions without detailed procedures
  – Coordination and cooperation among multiple entities
  – Complicated decision-making
  – Performance influencing factors in severe conditions (e.g., radiation)
## Path Forward

<table>
<thead>
<tr>
<th>Product</th>
<th>Path Forward</th>
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<tbody>
<tr>
<td>Cognitive basis framework for human error analysis</td>
<td>(Completed) Use in NRC’s HRA and human factors engineering</td>
</tr>
<tr>
<td>IDHEAS method specific for internal at-power events</td>
<td>(Method development finished)</td>
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<tr>
<td></td>
<td>Test in HRA applications (2014 - 2015)</td>
</tr>
<tr>
<td>Generic methodology to support a diversity of applications</td>
<td>Tailor it for specific applications, e.g., decision-making in Level 2/3 PRA</td>
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<tr>
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<td>(Beginning in 2014)</td>
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<td>Finalize user guidance and develop regulatory guidance (2016-2017)</td>
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Activities 4 & 5

Activity 4 - Expert Judgment Guidance Development

Activity 5 - NRC’s HRA Data Program Upgrade

- Developed database
- Collecting operator simulator exercise data
- Collaborating with international partners
- Developing baseline human performance data
- Performing targeted human performance experiments
Data Sources

South Texas Project Nuclear Operating Company – Operating Crew Exercise Data

NRC’s Human Performance Test Facility at the University of Central Florida – Baseline Human Performance Data – 3 Loop Westinghouse Plant

Halden Reactor Project (Norway) – Targeted Human Performance Experiments
Conclusion

• Human reliability analysis is important for our regulatory decision processes.
• Staff developing an integrated human reliability analysis method that can be tailored for multiple applications.
• Methods have state of the art technical basis.
• Integrated with the HRA program for continuous improvement.
Acronyms

• HRA – Human Reliability Analysis
• IDHEAS – Integrated Decision-tree Human Event Analysis System
• NRC – Nuclear Regulatory Commission
• PRA – Probabilistic Risk Assessment
• SACADA - Scenario Authorizing, Characterization, and Debriefing Applications
• SRM – Staff Requirements Memorandum
Backup Slides
Backup Slide 1

IDHEAS Process

Human failure events in PRA scenario

Tasks

Monitoring plant, diagnosing problems, following procedures, …

Cognitive Functions

Detection  Understanding  Decision making  Action

Crew Failure Modes

- Key alarm not attended to
- Data misleading or not available
- Critical data misperceived
- Wrong data source attended to

Performance Influencing Factors

- Distraction
- Alarm design
- Perceived urgency
Estimation of Human Error Probabilities

- The human error probability of a failure mode varies with different failure scenarios (i.e., combinations of the performance influencing factors);
- The probability for each failure scenario was estimated through a formal expert judgment panel.

Example - Crew failure mode – Key alarm not attended to

<table>
<thead>
<tr>
<th>Failure scenario</th>
<th>Performance influencing factors</th>
<th>Human error probability</th>
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<tbody>
<tr>
<td>1</td>
<td>High distraction, Poor alarm design, Low perceived urgency</td>
<td>0.1</td>
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<tr>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
<td>High distraction, Good alarm design, High perceived urgency</td>
<td>0.005</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
<td></td>
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<tr>
<td>7</td>
<td>Minimal distraction, Good alarm design</td>
<td>&lt; 0.00001</td>
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