U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Commission Briefing on Human Reliability Program Activities and Analyses

May 29, 2014

Agenda

- **Opening Remarks** Michael F. Weber
- **Introduction to Human Reliability Analysis** Richard P. Correia
- **Uses of Human Reliability Analysis** Sunil D. Weerakkody
- **Human Reliability Research Program** Sean E. Peters
- **Conclusion** Richard P. Correia

Introduction to Human Reliability Analysis

- 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 can be 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.

Introduction to Human Reliability Analysis (cont.)

- 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

Introduction to Human Reliability Analysis (cont.)

- Staff developing human reliability analysis methods
  - Integrated Decision-tree Human Event Analysis System – IDHEAS.
  - Positive interactions and feedback from 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.

Applications of Human Reliability Analysis

- Reactor oversight process
- Risk-informed license amendment reviews
- Rulemaking
- Operations

Examples of Use

- **Oversight**: Assessing the risk-significance of H. B. Robinson Fire Event in 2010:
    - Event consisted of equipment malfunctions, 2 fires and operator failures.
    - Performance deficiencies included failure to comply with emergency operating procedures and failure of command and control in the control room.
    - NRC staff's assessment of the extent of operators' ability to succeed dominated the risk significance of the performance deficiency.

Examples of Use (Continued)

- **Risk-Informed Licensing Actions**: Assessing the human error probability assigned to Control Room Evacuation
  - The operators' ability to successfully evacuate the control room in a timely manner and assume control at the remote control panel is a critical input to fire PRAs.
  - NRC staff's assessment of this issue may be a deciding factor in meeting quantitative acceptance criteria in RG 1.174.
  - The staff has developed acceptable approaches to quantify the operators' ability to succeed.

Examples of Use (Continued)

Rulemaking: Containment Filtration Strategies

- Successful completion of numerous actions that licensee staff (e.g., operators, maintenance workers, fire fighters) must perform outside of the control room will influence the results of the regulatory analysis that supports the technical basis.

- NRC staff uses established guidance (e.g., SRP 18, NUREG 0711, NUREG 1852, JLD-ISG-12-05, Appendix C) to ensure feasibility and reliability of ex-control room operator actions.

- Then, NRC staff uses informed judgment of experts to assign reasonable values for likelihood of success (human error probabilities).

Examples of Use (Continued)

Operations: Licensee's Use of HRA in support of their Operator Training

- Licensee's typically use HRA insights in a plethora of applications
  - Licensing
  - Oversight
  - Design reviews
  - Procedure reviews

- In addition, licensees use PRA in support of their operations:
  - Licensee's PRA staff shares risk-significant operator actions with operations staff and training department.
  - Licensee's training department uses risk-significant actions as an input in training operators.

Needs of the Office of Nuclear Reactor Regulation

- Methods
  - There are numerous methods available to us to model human error probabilities inside the control room.
  - Enhanced guidance on strengths and weaknesses of application of these various methods will be beneficial (IDHEAS).
  - A generic human reliability analysis method supporting diverse human reliability applications for additional situations such as ex-control room actions, will be beneficial.

Needs of the Office of Nuclear Reactor Regulation (Continued)

- Data
  - NRC and industry have been collecting data relating to human actions inside the control room.
  - Continued collection of such data to assess the reliability of operator actions inside control rooms will be beneficial (e.g., SACADA - Scenario Authorizing, Characterization, and Debriefing Applications).
  - Collecting data to quantify reliability of complex actions such as those performed outside of the control room will be beneficial.

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 help 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 Experts

- 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
  - Reduce analyst to analyst variability

Activity 3 – Integrated Method Development

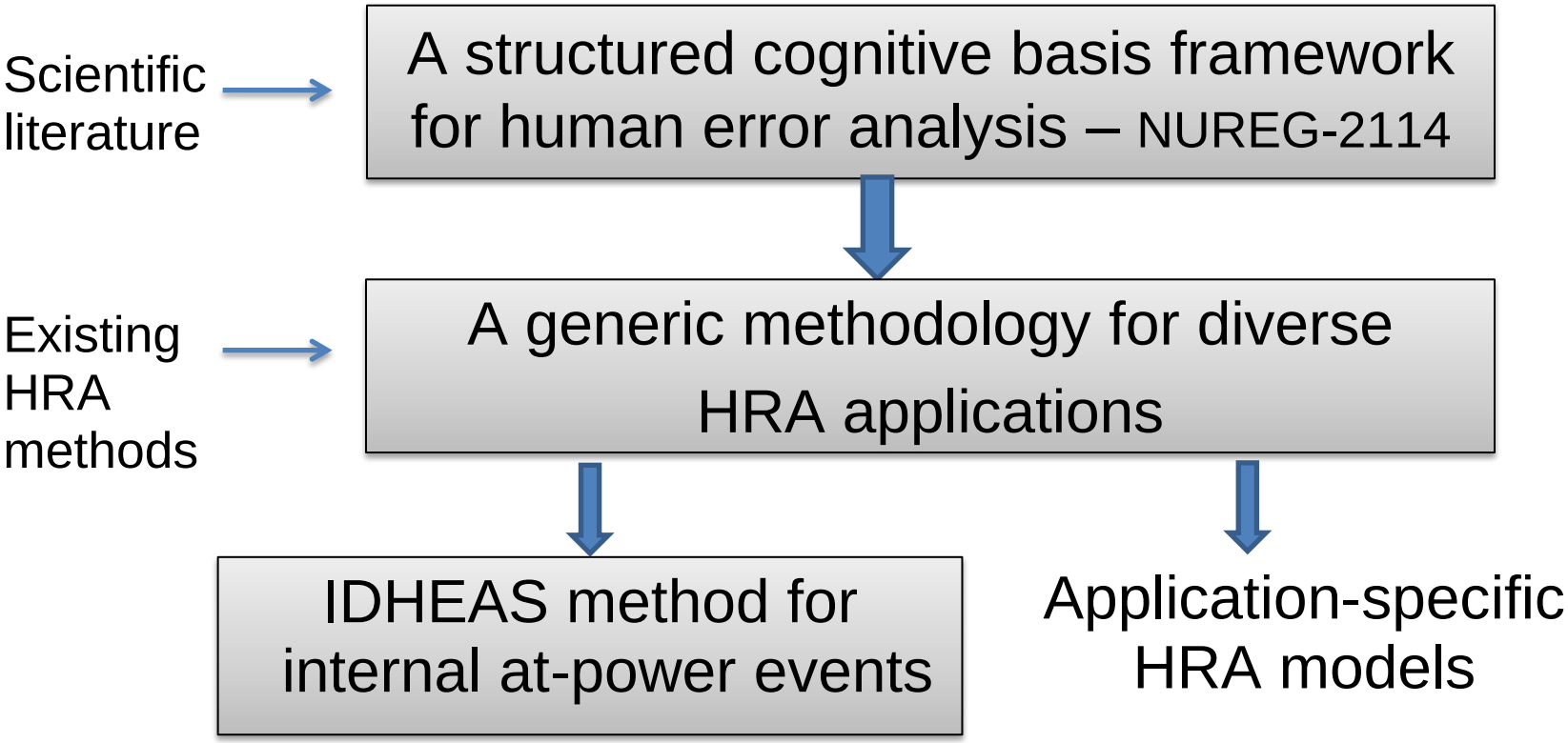
Goal

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

Key Objectives

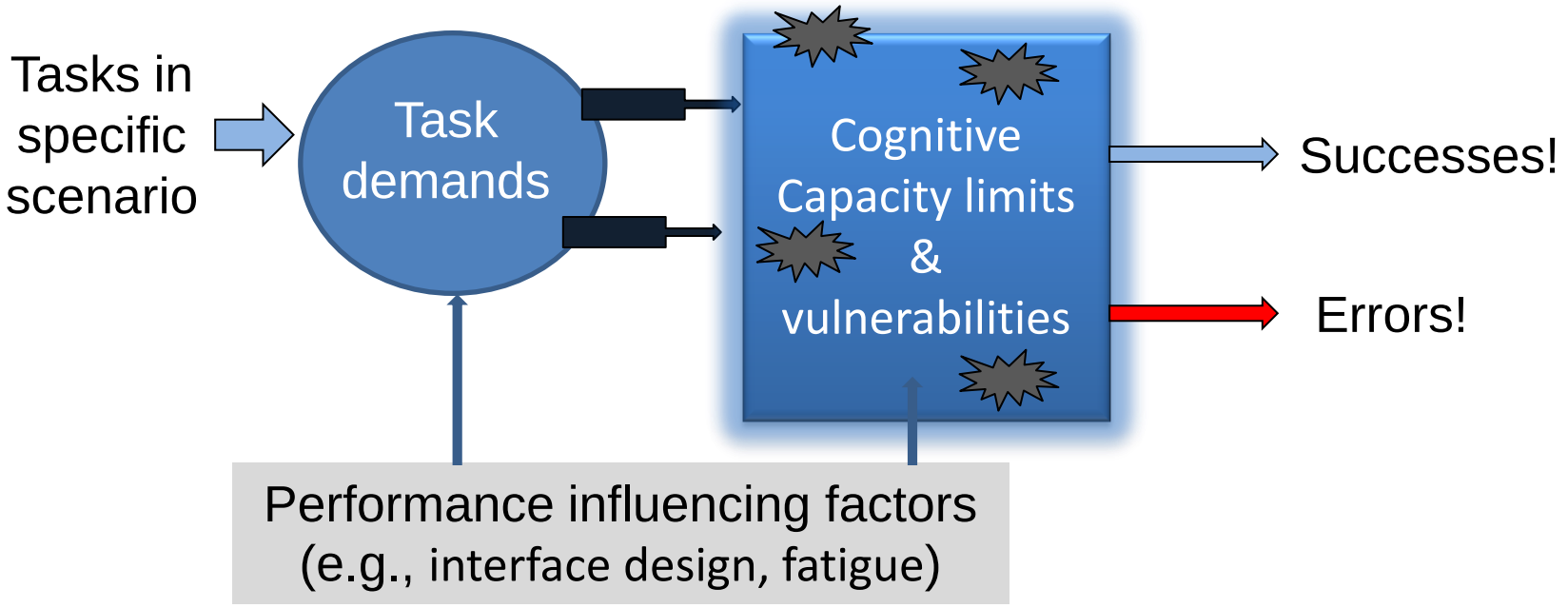
- Conform to the PRA standard and HRA Good Practices
- Retain and integrate strengths of existing methods
- Have enhanced capabilities to address key limitations in state-of-practice
- Have a state-of-art scientific basis and be generic and flexible enough to support diverse applications

Development Strategic Framework

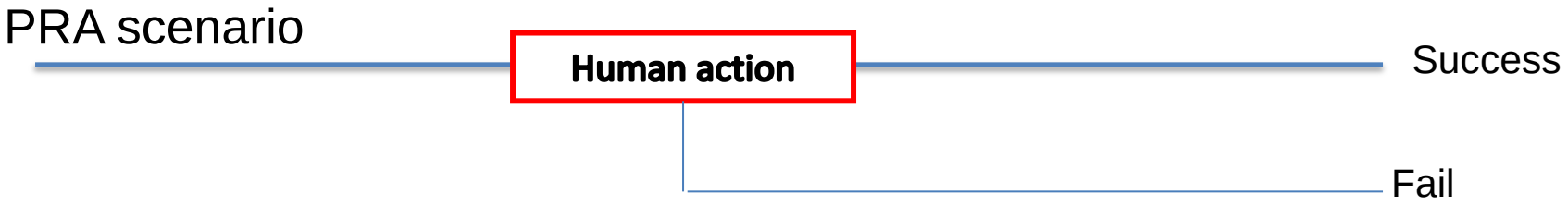


IDHEAS -Integrated Decision-tree Human Event Analysis System

How does an experienced operator perform?

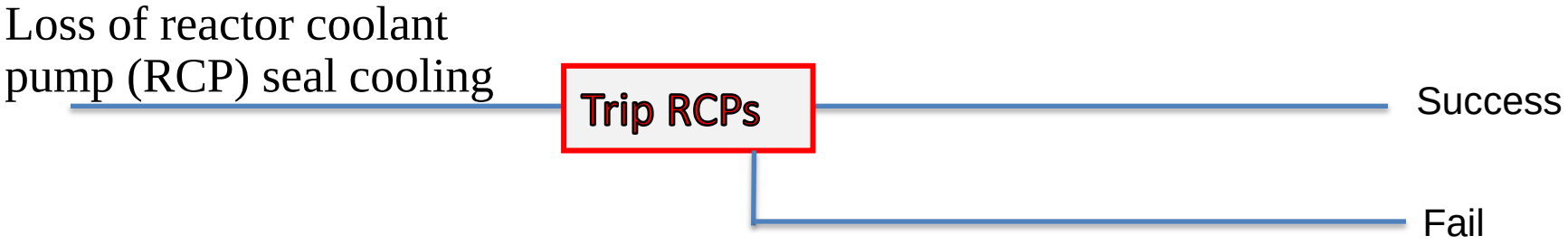


Human Reliability Analysis Process



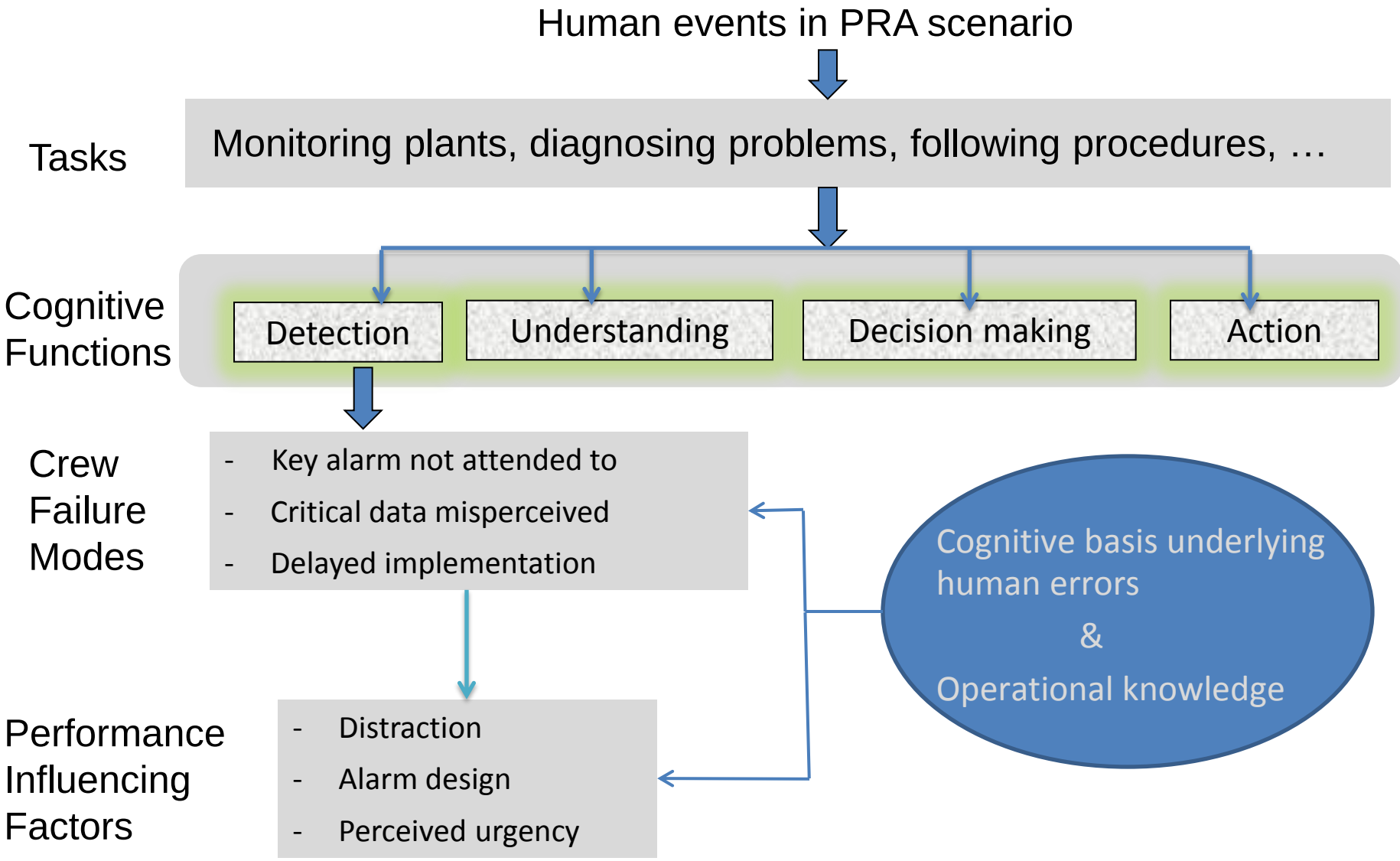
- Qualitative Analysis
  - Understand PRA scenario
  - Identify and define human failure events
  - Analyze tasks
- Human failure quantification
  - Identify crew failure modes
  - Analyze performance influencing factors
  - Estimate human error probability

Basis for HRA – Human performs tasks through cognitive functions



Human activities	Underlying cognitive function
• Detect and respond to alarms • Check plant parameters	Detection
• Assess plant status • Diagnose loss of seals	Understanding
• Decide to trip RCPs	Decision-making
• Execute procedures	Action execution

IDHEAS process



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 failure scenarios were estimated through a formal expert elicitation process – (Experts in Operations, HRA/PRA, Cognitive Sciences).

Crew failure mode – Key alarm not attended to

Failure scenario	Performance influencing factors			Human error probability
1	High distraction	Poor alarm design	Low perceived urgency	0.1
2				
3				
4	High distraction	Good alarm design	High perceived urgency	0.05
5				
6				
7	Minimal distraction	Good alarm design		< 0.0001

Reducing HRA Variability
IDHEAS Key Features

- Integrates Method Strengths
  - Provides guidance on every step of the HRA process
- Enhanced guidance for qualitative analysis and task analysis
- Explicit Model
  - Use the cognitive basis structure to model human failures
- Explicit PIFs
  - Basis for the PIFs, and questionnaire to assess PIFs
- HEPs estimated through a formal expert panel and well documented

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

Product	Path Forward
Cognitive basis framework for human error analysis	(Completed) Use in NRC's HRA and human factors engineering
IDHEAS method specific for internal at-power events	(Draft method complete) Make enhancements and test in HRA applications (2014 - 2015)
Generic methodology to support a diversity of applications	Tailor it for specific applications, e.g., Containment Filtration Strategies Rulemaking (Beginning in 2014) Finalize user guidance and develop regulatory guidance (2016-2017)

Activities (Cont.)

Activity 4 - Expert Judgment Guidance Development

- SRM – SECY-11-0172

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

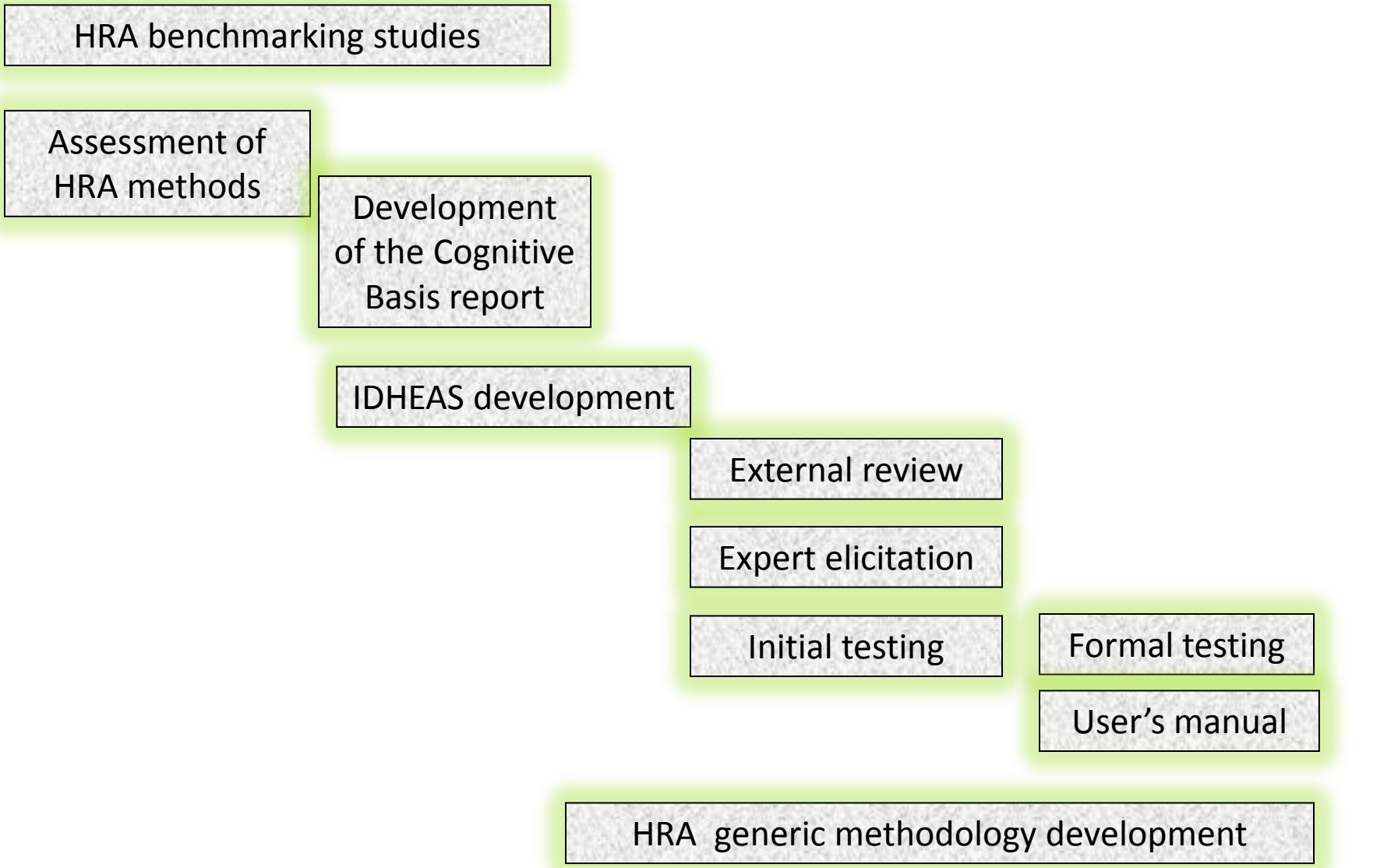
- Human reliability analysis supports safety and security regulation
- Staff is developing an integrated human reliability analysis method and a generic method that can be tailored for multiple applications
- Methods supported by state of the art technical analysis and operator experience
- The HRA program continuously improves

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
- RCPs – Reactor Coolant Pumps

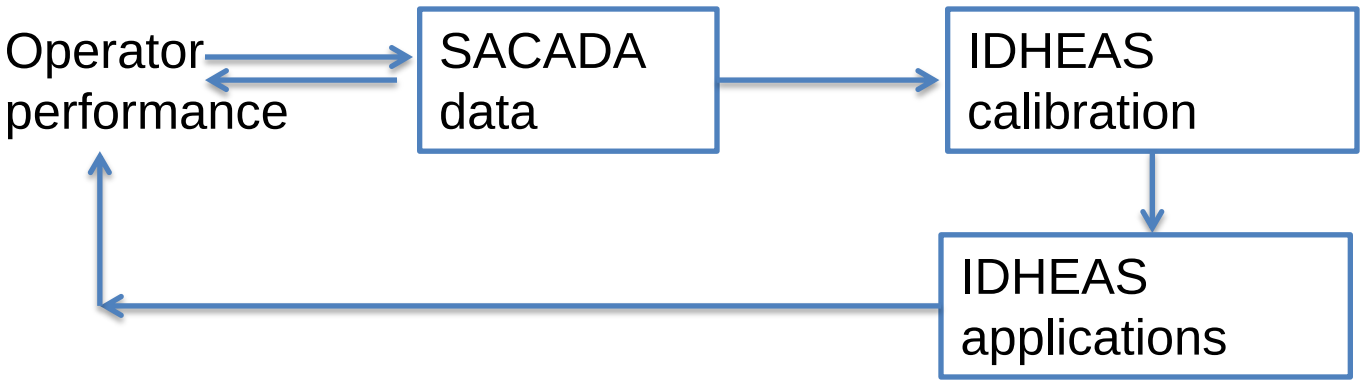
Backup Slides

Timeline of HRA method evaluation and development

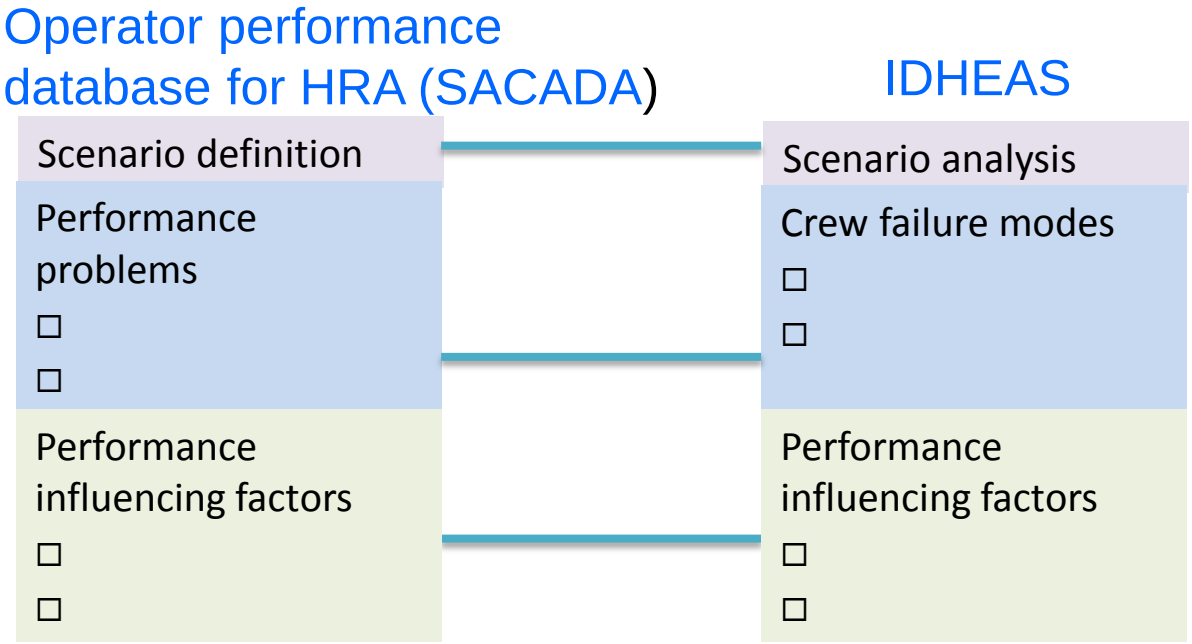


Looking Forward - Operator Performance and IDHEAS

The operator performance data enhances IDHEAS and vice versa

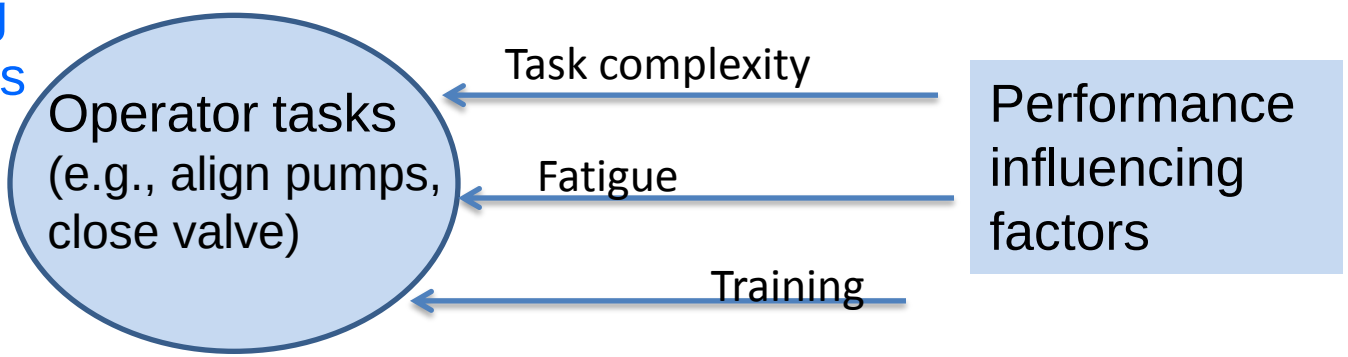


The operator performance database and IDHEAS share the same structure



Enhancement in IDHEAS: Using an explicit cognitive basis

Existing methods



IDHEAS