Differences in HRA Method

"Understanding Methodological Differences in HRA"

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1 HRA in PSA

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Background

Human actions play a critical role in nuclear power plant safety.

- PSA evaluates the overall plant risk by considering both **hardware failures** and **human errors**.
- Human actions can **prevent accident progression** or **contribute to system failures**.
- HRA estimates the probability of unsuccessful operator actions, known as **Human Error Probability (HEP)**.
- **Accurate HEP estimation is essential** for reliable PSA results and risk-informed decision making.

➔ The accuracy of PSA depends not only on equipment reliability but also on the accurate evaluation of human reliability analysis

1 HRA in PSA

Background

Why Compare Different HRA Methodologies?

Several HRA methodologies have been developed over the years.

Ex) K-HRA, IDHEAS-ECA . . .

Although they all estimate **Human Error Probability (HEP),** each methodology:

- is based on a different theoretical foundation,
- considers different influencing factors, and
- uses different quantification procedures.

➔ **Same Human Failure Event (HFE) may result in different HEP estimates.**

2 Comparison of K-HRA and IDHEAS-ECA

2 Comparison of K-HRA and IDHEAS-ECA

Overview of K-HRA and IDHEAS-ECA

Overview of K-HRA

- Developed by **KAERI** for nuclear power plant PSA
- Based on the **Stimulus–Organism–Response (SOR)** framework
- Separates human errors into **diagnosis** and **execution** errors
- Quantifies **HEP** using task-related and performance-related factors
- Relativley Simple and widely used in Korea

2 Comparison of K-HRA and IDHEAS-ECA

Overview of K-HRA and IDHEAS-ECA

Overview of IDHEAS-ECA

- Developed by the U.S. NRC
- Introduces Cognitive Failure Mechanisms (CFMs) and Performance Influencing Factors (PIFs).
- Evaluates failures throughout the cognitive process rather than only the final action.

➔ More structured and comprehensive assessment

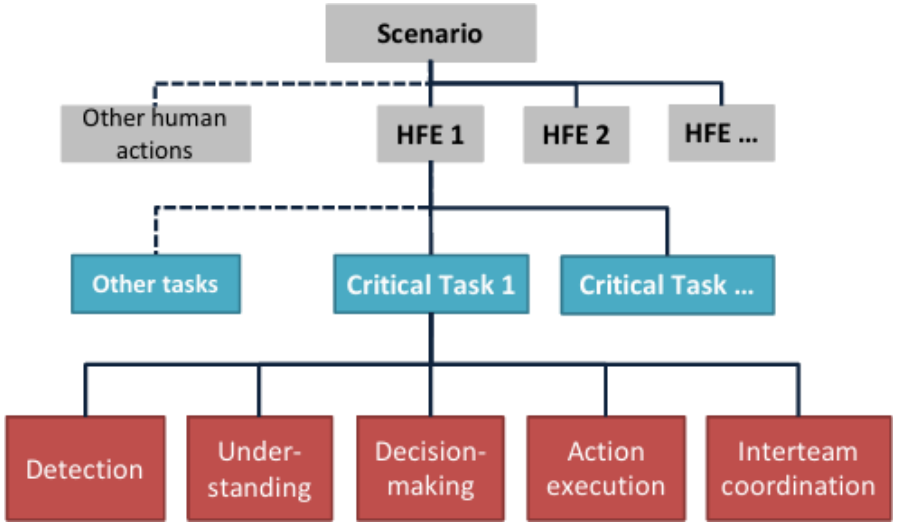

Figure 1. IDHEAS-ECA Hierarchy for Modeling a Human Event

2 Comparison of K-HRA and IDHEAS-ECA

Comparison Table of K-HRA and IDHEAS-ECA

Category	K-HRA	IDHEAS-ECA
Types of Human Error	- Diagnosis Error - Execution Error	Failure due to - the CFMs - uncertainty in time available - time needed
HEP Calculation Process	- Calculating the execution error probability by deriving each critical action failure probability with PSF and adding up all critical action failure probabilities - Calculating the diagnosis error probability by using the THERP time reliability curve and multiplying PSF	- Calculating the failure probability due to the CFMs by applying CFMs to each critical task, deriving CFM probability with base HEP and weightings, and adding up all CFM probabilities - Calculating the failure probability due to the time uncertainty by using probability distributions of available time and required time
Reflection of Time Factor	Estimating - the probabilities of diagnosis error - recovery failure by time factors (available time, operating time, etc.)	Estimating - the failure probability due to time uncertainty in time available - time needed

3 Results of the HEP Estimates

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Comparison Table of K-HRA and IDHEAS-ECA

Analysis Method

- **22 post-initiator HFEs** were selected for comparison.
- Both methodologies were applied under **identical analysis conditions**.
- HEP differences were attributed to **methodological characteristics**.

HFE No.	Description	Method 1 K-HRA	Method 2 I DHEAS-ECA
1	Operator Fails to Makeup ASG TK 001BA or Connect JPD for ASG Water Source	7.780E-04	2.490E-03
2	Operator Fails to Start ASG PP 001/002/003PO	1.320E-03	5.630E-04
3	Operator Fails to Initiate EAS Actuation Signal	9.410E-03	5.400E-04
4	Operator Fails to Operate EAS Recirculation	9.410E-03	1.160E-03
5	Operator Fails to Perform Bleed Operation	7.300E-03	4.800E-03
6	Operator Fails to Perform Cooldown Operation for RRA Operation (SGTR)	1.540E-03	5.640E-03
7	Operator Fails to Perform Cooldown Operation for RRA Operation (SLOCA)	2.350E-03	3.040E-03
8	Operator Fails to Perform Feed and Bleed Operation	3.070E-02	2.580E-02
9	Operator Error to Isolate Affected SG, 001GV	1.140E-02	4.000E-04
10	Operator fails to transfer LXX Power Supply from Normal to Alternate Source (2HR)	8.200E-03	3.200E-04
11	Operator Fails to Refill RWST	5.230E-03	2.950E-03
12	Operator Fails to Initiate Emergency Boration	4.130E-03	4.000E-04

3 Results of the HEP Estimates

Comparison Table of K-HRA and IDHEAS-ECA

HFE No.	Description	Method 1 K-HRA	Method 2 I DHEAS-ECA
13	Operator Fails to RCP Seal Injection from PTR 001BA	1.270E-02	6.700E-04
14	Operator Fails to Perform Hot Leg Recirculation	5.470E-04	1.600E-03
15	Operator Fails to Operate RIS Recirculation	9.410E-03	5.400E-04
16	Operator Fails to Operate RIS Injection	9.410E-03	5.400E-04
17	Operator Fails to Trip Reactor via Reactor Trip Switchgear or MG Sets	6.680E-04	3.330E-02
18	Operator Fails to Generate MSIS Manually	9.410E-03	1.160E-03
19	Operator Fails to Reactor Trip	9.410E-03	3.330E-02
20	Operator Fails to Perform RRA System Operation	2.530E-03	1.200E-03
21	Operator Fails to Operate Standby DEG Chiller and Pumps	4.070E-03	2.660E-03
22	Operator Fails to Initiate EAS Actuation Signal	9.410E-03	5.400E-04

3 Results of the HEP Estimates

HFE Comparison between K-HRA and IDHEAS-ECA for FRAMATOME NPP

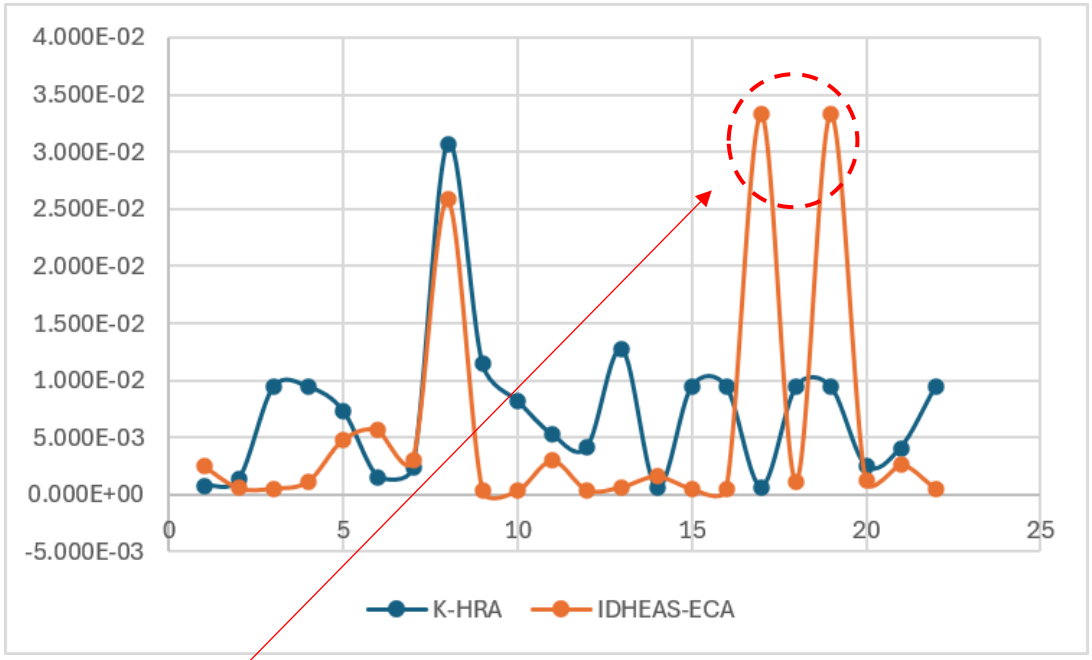

Figure 2. HFE Comparison between K-HRA and IDHEAS-ECA for FRAMATOME NPP

HFE No. 17 & 19

- Manual reactor trip requires critical operator decision-making.
- Incorrect actions may cause unnecessary reactor trips.
- IDHEAS-ECA explicitly considers **PIFs** and **CFMs**.
- Higher cognitive workload and psychological stress → Higher HEP.

➔ **IDHEAS-ECA is more sensitive to cognitive and psychological factors than K-HRA**

4 Conclusions and Future Work

4 Conclusions and Future Work

Key Findings and Implications

1. Methodological differences

- K-HRA and IDHEAS-ECA reflect different perspectives on human performance
  - K-HRA: Procedure execution-oriented approach
  - IDHEAS-ECA: Cognition and decision-making-oriented approach

2. Comparison results

- HEP estimation varies depending on the HRA methodology
- IDHEAS-ECA is more sensitive to cognitive factors and task complexity

3. Implications

- No single methodology is universally superior
- Multiple HRA approaches can improve PSA confidence through cross-validation

Future work

- Extend comparison to diverse accident scenarios and plant conditions

THANK YOU

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