Comparative Study of Performance Influencing Factor in IDHEAS-G and SPAR-H

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***Keywords:** Performance Influencing Factors (PIF); IDHEAS-G; SPAR-H.

1. Introduction

Human Reliability Analysis (HRA) is a systematic approach used to evaluate and quantify the potential for human errors in complex systems. It focuses on understanding and managing the influence of human performance on the overall reliability and safety of a system or process. HRA involves analyzing the tasks performed by individuals, identifying potential error sources, and assessing the likelihood and consequences of those errors [1].

When conducting HRA, various factors that influence human performance are depicted through multiple contextual elements. These contextual elements are given different names depending on the approach used, such as Performance Shaping Factors (PSFs), Performance Influencing Factors (PIFs), Performance Affecting Factors (PAFs), Error Producing Conditions (EPCs), Common Performance Conditions (CPCs), and others [2].

In this study, the contextual elements will be referred to as performance-influencing factors (PIFs). Different methods of HRA employ different PIFs to depict event context. Furthermore, these PIFs are defined in distinct ways across the various HRA methods, resulting in variations in the calculation of human error probability.

The objective of this study is to compare the PIFs used in SPAR-H and IDHEAS G, with the aim of establishing a correlation between the PIFs employed in the two HRA methods.

2. Definition of PIF

PIFs are factors that combine with basic human error tendencies to create error-likely situations [3]. PIFs encompass the attributes of individuals, the nature of their tasks, and the overall organizational environment, all of which affect human performance. They are factors that determine the likelihood of error or effective human performance. PIFs are used in HRA to identify potential human failures, optimize the factors that may influence human performance, analysis of human error cause, and human error probability quantification.

2.1. PIFs in SPAR-H

In SPAR-H, PIFs are regarded as factors that positively or negatively affect human performance [5]. An interesting characteristic of SPAR-H is that this method is one of the few methods, which can affect positively human performance by some PIF in their structure [5]. During the development of SPAR-H PIF, NRC identify 8 PIF capable of influencing human performance, and the same list of PIFs will affect both the failure probability base for action and diagnose. The SPAR-H PIFs are listed below:

a. Available time
b. Stress/Stressors
c. Complexity
d. Experience/Training
e. Procedures
f. Ergonomic/HMI
g. Fitness for duty
h. Work Processes

2.1. PIFs in IDHEAS-G

The definition of PIF in IDHEAS-G is identical to that of SPAR-H, but they differ in their structure when it comes to applying PIF in the calculation of human error probability. Unlike SPAR-H, the PIFs in IDHEAS are not directly multiplied to the nominal HEP for HEP quantification. Moreover, IDHEAS-G uses 20 PIFs for the cognitive aspect in determining the HEP, and it does not consider time as one of the PIFs. The table 1 below provides a description of the PIFs used in IDHEAS-G: PIFs structure in IDHEAS-G models the context where the human action is taken using the 20 PIFs divided in four context groups. These context groups are Environmental and situation, System, Personnel, and Task.

Table 1 - PIF in IDHEAS-G distributed in four context groups [6]

Environment and Situation	System	Personnel	Task
• Work location accessibility and habitability • Workplace visibility • Noise in workplace and communication pathways •Cold/heat/humidity • Resistance to physical movement	• System and I&C transparency to personnel • Human-system interfaces • Equipment and tools	• Staffing • Procedures, guidelines, and instructions • Training • Teamwork and organizational factors • Work processes	• Information availability and reliability • Scenario familiarity • Multi-tasking, interruption, and distraction • Task complexity • Mental fatigue • Time pressure and stress • Physical demands

3. PIF Correlation

In this study, the PIFs in IDHEAS-G and SPAR-H were correlated to better understand the relationship amongst the two methodologies. This correlation was carried out by comparing each PIF definition in IDHEAS-G and SPAR-H to find out any possible similarity amongst the PIFs. The final outcome is represented in table 2 below:

Table 2 - PIF correlation table

PIF n#	IDHEAS-G	SPAR-H	
1	Workplace Accessibility and Habitability	Stress/Stressors	*
2	Workplace Visibility	*	*
3	Noise in Workplace	Stress/Stressors	*
4	Cold/Heat/Humidity	Stress/Stressors	*
5	Resistance to Physical Movement	Stress/Stressors	*
6	System and I&C Transparency to Personnel	Complexity	*
7	Human-System Interface	Complexity	Ergonomics/HMI
8	Tools and Parts Availability and Usability	Complexity	*
9	Staffing	Experience/Training	Fitness for Duty
10	Procedures, Guidance, and Instructions	Procedures	*
11	Training	Experience/Training	*
12	Team and Organization Factors	Work Processes	*
13	Work Processes	Work Processes	*
14	Information Availability and Reliability	*	*
15	Scenario Familiarity	Experience/Training	Procedures
16	Multitasking, Interruptions, and Distractions	Complexity	*
17	Task Complexity	Complexity	*
18	Mental Fatigue	Stress/Stressors	Fitness for Duty
19	Time Pressure and Stress	Available Time	Stress/Stressors
20	Physical Demands	*	*

After performing the mapping of the PIFs in IDHEAS-G and SPAR-H methods, it was observed that IDHEAS-G has a much more detailed and comprehensive structure than the structure proposed by the SPAR-H method. SPAR-H incorporates PIFs with a more simplistic and broad definition in its structure, making it difficult to apply in cases where more specific factors are necessary to determine their contribution to the risk of a human failure event. On the other hand, the IDHEAS-G methodology aimed to achieve a deeper level of detail in its PIF structure, resulting in a much more detailed qualitative analysis. This allows the analyst to extract specific information on areas that can be improved and optimized in terms of the factors contributing to the risk, as well as enabling a more precise quantification due to the specificity achieved in each PIF through its attributes. In summary, the level of detail in the IDHEAS-G methodology increased the number of PIF topics from 8 to 20, with a subdivision into attributes covering a greater variety of NPP specificity and accident scenarios. The relationship between IDHEAS-G and SPAR-H is illustrated using the concept graphical diagram in figure 1 below.

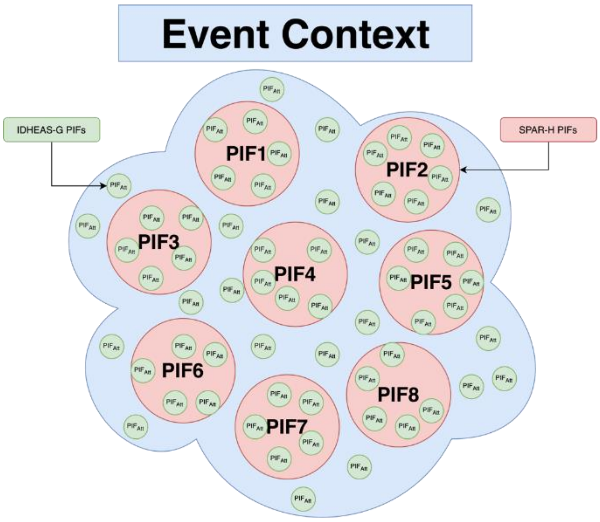

Figure 1 - Concept graphical diagram of SPAR-H and IDHEAS-G correlation

4. Base Human Error Probability (BHEP)

The Base Human Error Probability (BHEP) in Human Reliability Analysis (HRA) is the baseline probability that a human error will occur during a particular task or activity. It represents the probability of human making error without the influence of PIF or any mitigating factors. BHEP is utilized as a starting point in the computation of probability of human error in a given circumstance, which is then subsequently updated based on the factors that influence human performance.

4.1. BHEP in IDHEAS-G

The concept of BHEP in IDHEAS – G is different from the usual HRA methodologies for HEP estimation. IDHEAS-G identifies three PIFs – information availability and reliability, task complexity and scenario familiarity as the base PIFs, the various states of these base PIFs are referred to as BHEPs. In addition, the base HEPs for information and availability, scenario familiarity and task complexity are further used to deduce the base HEP for cognitive failure mode (CFM) $P_{CFMBase}$ for the three PIF. $P_{CFMBase}$ is calculated as the probabilistic sum of the base HEPs for the three PIFs:

$$(1)\ P_{CFM_{Base}} = 1 - [(1 - P_{INF})(1 - P_{SF})(1 - P_{TC})]$$

Where P_{INF}, P_{SF} and P_{TC} are the base HEPs for information availability and reliability, scenario familiarity and, and task complexity, respectively. The base HEP for each of the attributes without the influence of other attributes are given below:

$$P_{CFM_{Base}}(detection) = 1 \times 10^{-4}$$
$$P_{CFM_{Base}}(understanding) = 1 \times 10^{-3}$$
$$P_{CFM_{Base}}(decisionmaking) = 1 \times 10^{-3}$$
$$P_{CFM_{Base}}(action) = 1 \times 10^{-4}$$

$$P_{CFM_{Base}}(interteam) = 1 \times 10^{-3}$$

The figure 2 below illustrates the mode of connection of PIFs in calculating the HEP in IDHEAS-G:

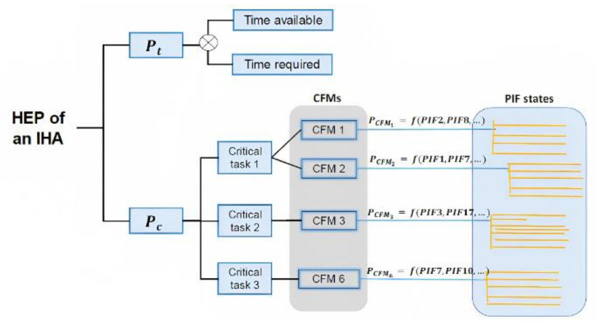

Figure 2 - Connecting of PIF and CFM in calculating HEP [5]

4.2. BHEP in SPAR-H

SPAR-H basically entails Base HEPs for diagnosis and action response procedures. These values represent the human error rate without the interference of PIFs. Below are the PIFs:

Diagnosis: $Base\ HEP = 1 \times 10^{-2}$
Action: $Base\ HEP = 1 \times 10^{-3}$

The Base HEP due to diagnosis is based on a value from THERP (NUREG-1278) table 20-1, while the base HEP due to action was calculated using information from two sources WASH – 1400 and various action task in THERP[7]. The figure 3 below illustrates how PIFs are used in the quantification of HEP in SPAR-H.

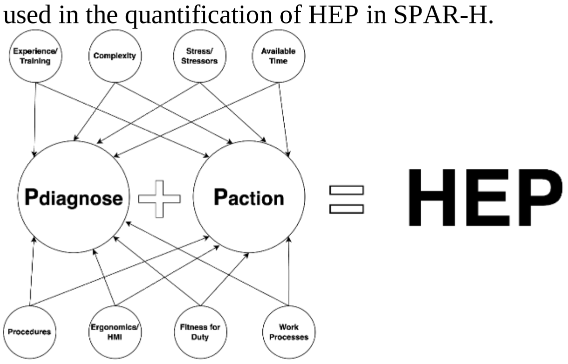

Figure 3 - Connection of PIF quantification of HEP in SPAR-H

5. Conclusion

IDHEAS-G has 20 PIFs with each PIF having different attributes – this makes it flexible and easier to describe new event scenario and technology development. On the other hand, SPAR-H uses 8 PIFs to assess event context. Furthermore, the mapping of the PIFs carried out for IDHEAS-G and SPAR-H shows that the PIFs in SPAR-H are broadly defined while that of IDHEAS –G are more specific, this differences could result to different HEPs computations for the same human failure event.

Acknowledgement

This work was supported by the 2023 Research Fund of the KEPCO International Nuclear Graduate School (KINGS), the Republic of Korea.

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