IETI Transactions on Ergonomics and Safety
http://ieti.net/TES/

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

THE IMPORTANCE OF HUMAN RELIABILITY ANALYSIS IN RISK ASSESSMENT PROCESS

Bojan Bijelić [1, a], Milena Stanković [1,b], Miroljub Grozdanović [1,c]
[1]University of Niš, Faculty of Occupational Safety
[a]bojan.bijelic@znrfak.ni.ac.rs, [b]milena.stankovic@znrfak.ni.ac.rs, [c]mirko@junis.ni.ac.rs

Abstract Human factor has significant effects on risks that can occur in any system. Better understanding of these effects is of a great importance for system's safety. The main purpose of this paper is to emphasize the role and importance of human reliability analysis in the risk assessment process. By giving an overview of historical development of human reliability analysis methods, with advantages and shortcoming for each generation of methods, this paper points out the need for further research in this area.

Keywords: Human factor; human error; human reliability analysis; risk assessment.

1. INTRODUCTION

Most of existing systems are to some degree influenced by a human factor. Humans are directly or indirectly involved either in creation, development, maintenance or work of systems, so they have a significant influence on systems' reliability. Reliability of technical systems shows a constant and steady growth in recent year due to technological progress and has reached a very high level. Due to this, the focus of reliability research has changed and the human reliability is now getting more and more attention. Therefore it's necessary to properly understand the influence of human factor on systems and determine the best ways to assess that influence.

Involvement of human factor always brings a possibility of human errors; this issue can be dealt with either by fully eliminating the human factor, which is hardly achievable, or by reducing the possibility of human error [1]. The concept of human error may look, at first glance, as unnecessary to define, but it's exactly the opposite. There are some difficulties in explaining this concept and even some authors avoid giving an exact definition of this term. Some of the existing definitions are:

• "departure from acceptable or desirable practice on the part of an individual that can result in unacceptable or undesirable results" [2];

• "the failure to perform a stated task (or the performance of a forbidden action) that could result in disruption of scheduled operations or damage to property and equipment" [3];

• "human error as any member of a set of human actions that exceeds some limit of acceptability" [4];

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

• “an action that fails to meet some implicit or explicit criterion, but that definition begs the question of what is the criterion” [5];

• “any member of a set of human actions or activities that exceeds some limit of acceptability, i.e. an out of tolerance action [or failure to act] where the limits of performance are defined by the system” [6].

Risk can be defined as an effect of uncertainty of objectives [7]. Risk cannot be avoided and ignoring it can have serious consequences, therefore it is necessary to properly assess the risk and determine ways to manage it. Risk management represents a process in which organization based on the assessed risks takes appropriate measures to reduce potential hazards and their consequences as much as possible.

Very important tool for human reliability analysis are methods used in human error analysis. Historically, these methods have developed in three directions, according to which they are grouped into three generations. Practically, the development of each new generation of methods was an attempt to overcome observed deficiencies of the previous generation.

The primary goal of this is emphasizing the role and importance of human reliability analysis in the risk assessment process. By giving an overview of historical development of human reliability analysis methods, with advantages and shortcoming for each generation of methods, this paper emphasizes the need for further research in this area.

2. DEVELOPMENT OF HUMAN RELIABILITYANALYSIS METHODS

Serious industrial accidents happening worldwide, that had a serious number of casualties and for which human factor has been determined as a significant contributor, expedited the development of human reliability analysis methods. The need for creating good quality tools and methods for thorough analysis of human factors lead to a development of significant number of different methods and each of those methods gave a certain contribution. Development of human reliability analysis methods started at the beginning of 1970s, most of the methods were developed in the mid-1980s, for so called first generation methods, and in the mid-1990s, for second generation methods (Figure 1). A large number of methods were developed primarily for use in nuclear power plants and then later modified for use in other industrial areas.

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

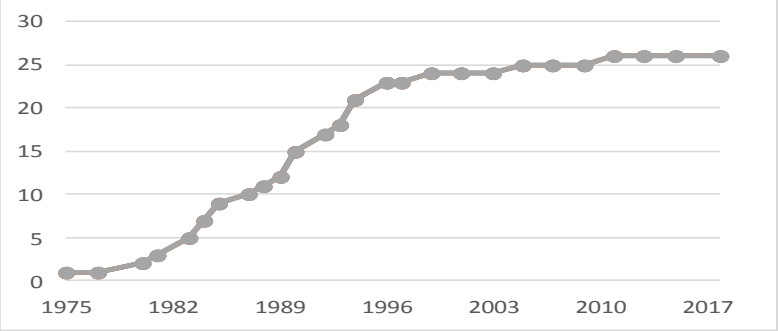

Figure 1. Cumulated number of HRA methods (modified by [8]).

First generation of human reliability analysis methods were developed under the great influence of probabilistic risk assessment and these methods viewed humans simply as mechanical components of systems - they used the so called mechanistic approach. The majority of existing methods belong to this generation and are representing one of the first attempts to involve the human factor in the risk assessment process. Some of the most important methods of first generation are [1, 8, 15, 16, 17]:

- Technique for Human Error Rate Prediction (THERP),
- Human Error Assessment and Reduction Technique (HEART),
- Accident Sequence Evaluation Program Human Reliability Analysis Procedure (ASEP),
- Simplified Plant Analysis Risk Human Reliability Assessment (SPAR-H),
- Human Reliability Management System (HRMS),
- Justification of Human Error data Information (JHEDI),
- Paired Comparison (PC),
- Absolute Probability Judgment (APJ),
- Success Likelihood Index Method/Multi-Attribute Utility Decomposition (SLIM/MAUD),
- Human Cognitive Reliability (HCR), etc.

The main purpose of first generation methods is to identify human error and quantify the probability of human error by focusing on the behavioural aspect of the human performance. The main disadvantages are neglecting the impact of the environment, organizational factors and cognitive processes in which human error occurs. Although methods of this generation have been criticized for their view on human error, they are also most applied and validated in practice thanks to their simplicity and quantitative aspect.

Attempts to overcome the shortcomings of first generation methods lead to the development of second generation methods in the beginning of the 1990s. The second generation deviates from the mechanistic approach in an effort to better understand the context in which human error occurs. Methods of this generation go from a quantitative approach, typical for probabilistic risk assessment, to a qualitative approach for the estimation of human error [9]. Taking into account the cognitive aspect and the cause of the error, instead of focusing on frequency of human error like first generation methods, helps us to better understand the background behind a human error. Second generation methods are [1, 8, 15, 16, 17]:

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

- A Technique for Human Event Analysis (ATHEANA),
- Cognitive Reliability and Error Analysis Method (CREAM),
- Connectionism Assessment of Human Reliability (CAHR),
- Méthode d'Evaluation de la Réalisation des Missions Opérateur pour la Sûreté (Assessment method for the performance of safety operation (MERMOS)), etc.

The main characteristic of second generation methods is focusing on context in which task is performed. The main disadvantages are lack of better inclusion of human cognition and heavy reliance on expert judgment [10]. Most of the second generation methods are still not validated in practice.

The development of third generation of human reliability analysis methods starts at the early 2000s. These methods are basically modified methods of first generation based on experience gathered from methods of first and second generation. Currently there are only two methods belonging to this generation: Nuclear Action Reliability Assessment (NARA) and Railway Action Reliability Assessment (RARA). NARA is an improved version of HEART, a first generation method, created especially for application in nuclear power plants, while RARA is modified version of NARA for application in railways transportation.

3.HUMAN ERROR ASSESSMENT AS AN ELEMENT OF RISK ASSESSMENT

Industrial accidents, such as Bhopal, Three Mile Island and Chernobyl, lead to increased interest in research of impact of human error, i.e. impact of human reliability on systems. Simple framework for understanding human error (Figure 2) consists of three parts as follows:

- context in which human error happens;
- human fallibility;
- barriers that can prevent human error [11].

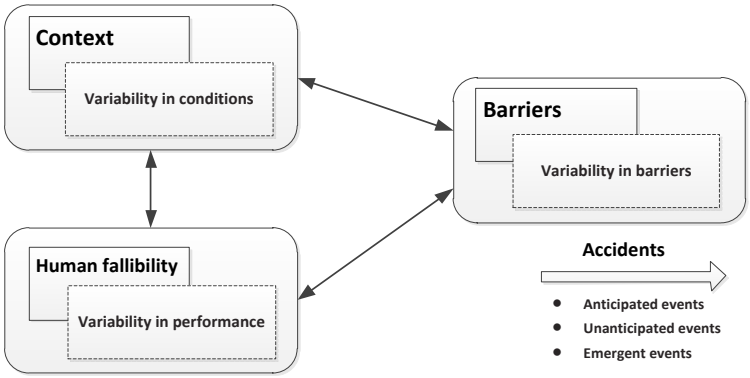

Figure 2. Framework for understanding human error and its potential for adverse consequences [11]

IETI Transactions on Ergonomics and Safety
http://ieti.net/TES/

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

Since human factor is often found as the cause for a vast number of accidents, it is clear that it must be included in the risk assessment process [8]. Risk assessment is a process that consists of identifying and analysing hazards while determining the severity of possible consequences and the probability of occurrence of an unwanted event [12]. Risk assessment is an essential part of any risk management process and cannot be complete without considering the human factor. This whole concept called human reliability analysis aims to analyse the influence that humans have on system's functionality and easily fits into the framework of risk assessment (Figure 3). Risk assessment that includes a human reliability analysis allows analysts to have an overview of all risks in the system and to determine the role that human factor plays in the emergence of risks [13].

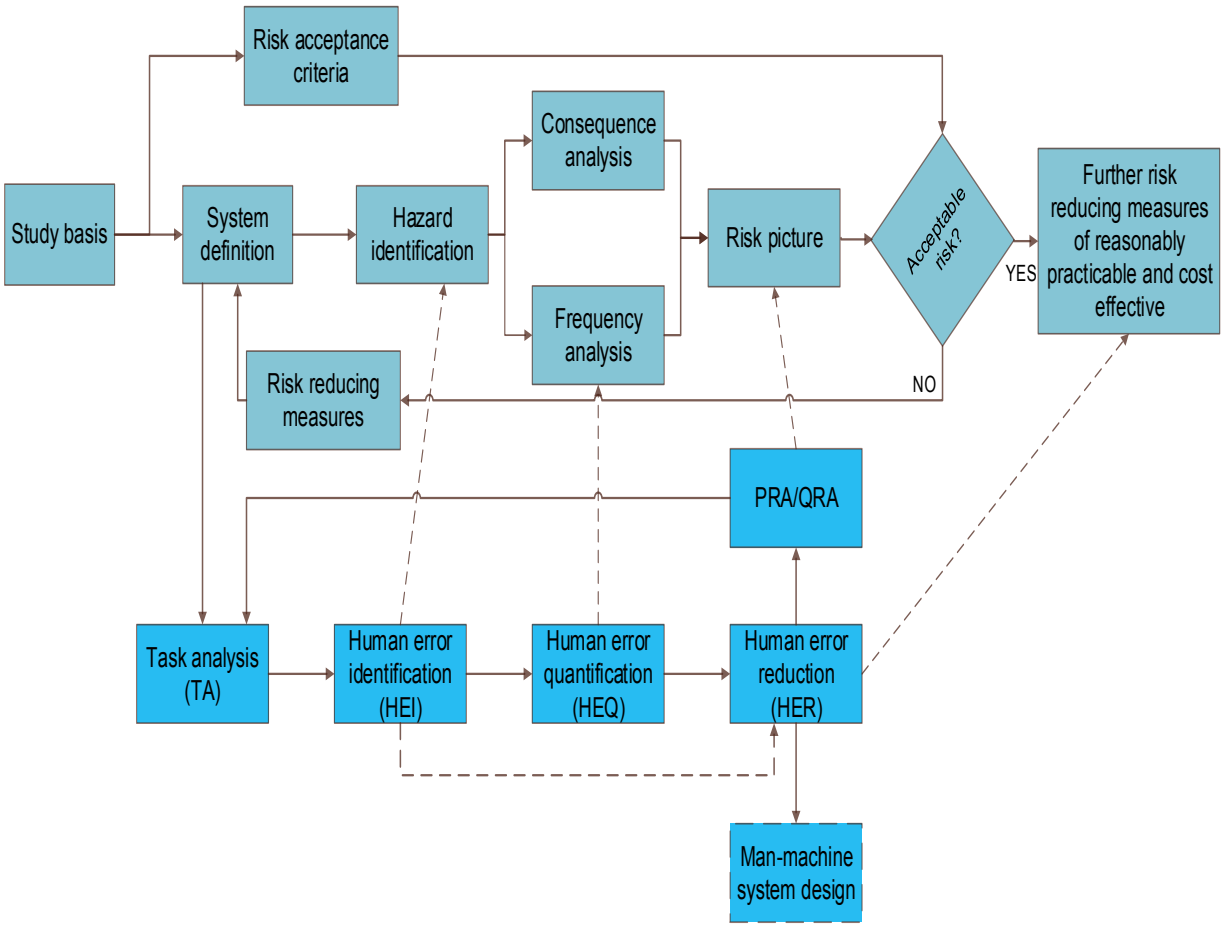

Figure 3. The Human Reliability Analysis Procedure in Risk Analysis [14]

Human reliability analysis was created for use in probabilistic risk analysis and has found its purpose for both assessing the risk of human error and as a tool for reducing the system's vulnerability [8]. In order to incorporate the result of human reliability analysis in risk analysis it is necessary to present those results in a quantitative form, and for this it is the best to calculate the probability of human error – HEP.

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

4. CONCLUSION

Research of human factor is a necessity especially in the light of increasing automation of production systems. Human error is not something that can be simply eliminated. Therefore it's necessary to find way to manage risks brought by the human factor, as an inevitable part of any system. Risk assessment is the first step toward the successful risk management. Unfortunately most current views on human reliability are oversimplified. Human reliability cannot be properly analysed without fully understanding the context in which work is performed. Inadequate analysis of human factor in process of risk assessment is often caused by assessor's ignorance i.e. his lack of knowledge in area of human reliability analysis.

Slowdown in the development of human reliability analysis methods is evident in recent years. Clear indication of this is the existence of only two methods of third generation that emerged in the 21st century, which are actually modifications of first generation methods and do not represent significant innovations. There is plenty of room for new research in this area and for development of new methods that will assess the analysis of human reliability not only from the engineering aspect, but also from the aspect of psychology and ergonomics.

References

[1] Kirwan B., 1994, *A guide to practical human reliability assessment*, CRC press. London.
[2] Bea R. G., 1998, Human and organization factors: engineering operating safety into offshore structures, *Reliability Engineering & System Safety*, 61.1-2, pp. 109-126.
[3] Dhillon B. S., 2012, *Safety and human error in engineering systems,* CRC Press, London.
[4] Swain A. D., and Guttmann H. E.., 1983, *Handbook of human reliability analysis with emphasis on nuclear power plant applications,* US Nuclear Regulatory Commission, Washington, D.C.
[5] Sheridan T. B., 2008, Risk, human error, and system resilience: fundamental ideas. *Human factors,* 50.3, pp. 418-426.
[6] Swain A. D., 1989, Comparative evaluation of methods for human reliability analysis. No. GRS--71. Gesellschaft fuer Reaktorsicherheit mbH (GRS).
[7] International Organization for Standardization, 2009, ISO 31000: Risk Management: Principles and Guidelines.
[8] Hollnagel E., 2005, Human reliability assessment in context, *Nuclear Engineering and Technology*, 37.2, pp. 159-166.
[9] Baziuk P. A., Rivera S.S., and Mc Leod J. N., 2016, Fuzzy Human Reliability Analysis: Applications and Contributions Review, Advances in Fuzzy Systems.
[10] Griffith C. D., and Sankaran M., (2011). Inclusion of fatigue effects in human reliability analysis, *Reliability Engineering & System Safety*, 96.11, pp. 1437-1447.
[11] Sharit J., 2012, *Human error and human reliability analysis*, Handbook of human factors and ergonomics, pp. 734-800.
[12] American Society of Safety Engineers, 2011, ANSI/ASSE Z590.3-2011 - Prevention through Design: Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes. Des Plaines, IL.

2018, Volume 2, Issue 2, 1-7, DOI: 10.6722/TES.201812_2(2).0001

[13] Gertman D. et al., 2005, The SPAR-H human reliability analysis method, US Nuclear Regulatory Commission.
[14] Stojiljkovic E., Glisovic S., Golubovic T., 2014, Risk Assessment of Industrial and Environmental Monitoring Systems – The Significance of Human Reliability Analysis, *Facta Universitatis, Series: Working and Living Environmental Protection*, 11 (2), 145 – 152.
[15] Stojiljkovic E., Bijelic B., Grozdanovic M., Radovanovic M., Djokic I., 2018, Pilot Error In Process Of Helicopter Starting, *Aircraft Engineering and Aerospace Technology*, 90 (1), 158-165.
[16] Stojiljkovic E., Glisovic S., Grozdanovic M., 2015, The Role of Human Error Analysis in Occupational and Environmental Risk Assessment: A Serbian Experience, *Human and Ecological Risk Assessment: An International Journal*, 21 (4), 1081-1093.
[17] Stojiljkovic E., Janackovic G., Grozdanovic M., Savic S., and Zunjic A., 2016, Development and Application of a Decision Support System for Human Reliability Assessment – A Case Study of an Electric Power Company, *Quality and Reliability Engineering International*, 32 (4), 1581-1590.