MEDWIN PUBLISHERS
Committed to create value for Researchers

Ergonomics International Journal
ISSN: 2577-2953

Human Reliability Analysis from the Ergonomics Perspective: Towards a Systemic Approach

Petrillo A*

Department of Engineering, Parthenope University of Naples, Italy

***Corresponding author:** Antonella Petrillo, Department of Engineering, Parthenope University of Naples, Italy, Email: antonella.petrillo@uniparthenope.it

Opinion

Volume 1 Issue 2

Received Date: September 11, 2017

Published Date: September 15, 2017

DOI: 10.23880/eoij-16000108

The evolution of socio-economic environment during the 20th century caused a rapid increase in two important issues: the risk and the complexity of the processes [1]. These two factors combined with several numbers of technological changes contributed to increasing the complexity of work systems.

The increasing complexity of industrial systems requires the adoption of adequate approaches to manage emergency situations in case of accidents and disasters. In this context the analysis of human reliability represents a crucial task [2]. In fact, the human factor is a predominant element in the study of accidents/disaster, both in probability level, but also in terms of severity of the expected effects [3].

From methodological point of view methods of Human Reliability Analysis (HRA) could represent a good prospect to assess the likelihood of human error [4]. HRA is a set of techniques which describes the conditions of the operator during the work, taking into account errors and unsafe actions [5]. In other words, HRA aims to describe the physical and environmental conditions in which operators shall carry out their tasks, considering errors, skills, experience and ability [6].

However, literature review shows that the human reliability analysis is an issue of growing importance in the scientific world. But, there are some limits. The major limit of HRA is related to the uncertainty which does not allow calculating the probability of human error [7]. Furthermore, several human reliability models follow a static approach, in which human errors are described as omission/commission errors [8,9].

But this is a limited approach since it reduces factors in their quantification and the quantification of likelihood of human error. To solve this kind of issue, it could be strategic to consider the human reliability from the ergonomics perspective and socio-technical systems environment in order to promote the ability of the human operator to recognize an unwanted process and to avoid it.

Humans and social systems are not bimodal. Everyday performance is variable and this – rather than failures and “errors” – is why accidents happen. Since performance shortfalls are not a simple (additive or proportional) result of the variability, more powerful, non-linear models are needed [10].

It is crucial to answer to the following questions: *What does it mean human reliability?* and *What is the relationship between socio-technical systems and Ergonomics?*

According the above questions, HRA is a very important approach related to the contributions of humans to the resilience of systems and to possible adverse consequences of human errors or oversights, especially when the human is a crucial part of the large socio-technical systems as is common today.

Some ergonomists ignore the potential benefits of error identification in HRA. But it is clear that HRA could be useful to gain valuable error reduction related to socio-technical systems insights beyond to quantify human error likelihoods or probabilities.

In other words the problem is to understand the “nature” of ergonomics, to understand people and their interactions, as well as the relationships between these interactions. Interactions occur between people and elements of socio-technical systems.

As pointed out by Wilson [11], people interact with several elements: 1) other people (cooperation interactions); 2) remote agents (temporal and spatial interactions); 3) structure, policy and roles (organization interactions); 4) supply chain (logistics interaction); 5) environment (setting interactions); 6) task; 7) hardware and software (interface interactions) and 8) society, finance and politics (contextual interactions).

Considering the great number of involved factors it is necessary to tackle the problem using a new *safety management paradigm* called *resilience engineering*. In a dynamic and ever changing business environment, socio-technical systems are subject to increasing variability. Socio-technical systems are non-linear and event outcomes are intractable. Complex relations between input (causes) and output (effects) give rise to unexpected and disproportionate consequences.

Resilience engineering has become a recognized alternative to traditional approaches to safety management. It emphasises the need to be proactive in the management of core processes, including but not limited to safety, and to anticipate (and hopefully forestall) major changes in safety and other critical performance domains. On the other hand, it represents the optimist stance and its agenda is to develop ways to control or manage a system's adaptive capacities based on empirical evidence. It is a useful "tool" to cope with the complexity of the real world.

In other words, it could be effective to explore the significance of modeling the interactions of ergonomics, human reliability and system components in everyday work, by the "integration" of tools and scientific methods.

Application of a recent systemic method, i.e. the Functional Resonance Analysis Method (FRAM), in order to define dynamically the system structure, could represent a "solution". Based on the principles of resilience engineering, this method can be used to determine how variability in daily performance could affect the system and lead to desirable or undesirable events. FRAM method has been introduced by Hollnagel (2012) [12] inspired directly to the principles of Resilience Engineering and aiming to assess the safety characteristics of processes and systems, considered as a whole. The FRAM is a method to develop a representation or model of how something happens. This model can then be the basis for various kinds of analyses (reactive, proactive). A FRAM model represents the functions that sufficient and necessary for an activity to take place – not when it goes wrong but when it goes right.

As stated by Hollnagel, Resilience Engineering could be defined as "*the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*" [13]. In this perspective, the attention is focused on how and why things are fine and how adverse events may occur. Or in different words, the attention must be focused in understanding how something happens and when it works and when it doesn't.

From a methodological point of view, the four principles of FRAM can be summarized as follows

1. **Equivalence of failures and successes:** Failures and successes come from the same origin, i.e. everyday work variability.
2. **Principle of approximate adjustments:** People as individuals or as a group and organizations adjust their everyday performance to match the partly intractable and underspecified working conditions of the large-scale socio-technical systems.
3. **Principle of emergence:** It is not possible to identify the causes of any specific safety event. Many events appear to be emergent rather than resultant from a specific combination of fixed conditions.
4. **Functional resonance:** The functional resonance represents the detectable signal emerging from multiple signals interacting in unintended ways.

Figure 1 represents the FRAM modelling framework.

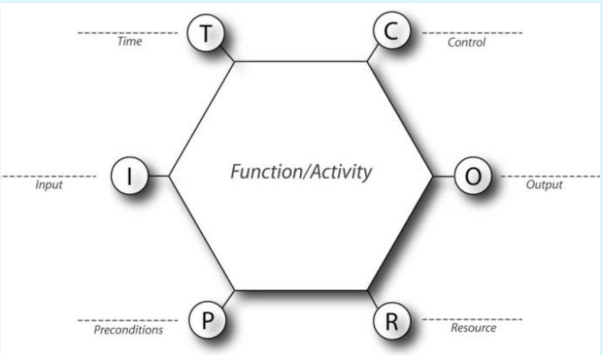

Figure 1: The FRAM "Snowflake"

A function can be described by the following attributes:
• Input (I): that which the function processes or transforms, or that which starts the function.
• Output (O): that which is the result of the function, either an entity or a state change.
• Preconditions (P): conditions that must be exist before a function can be executed.
• Resources (R): that which the function needs, or consumes, to produce the output.

• Time (T): temporal constraints affecting the function (with regard to starting time, finishing time, or duration).
• Control (C): how the function is monitored or controlled.
To control an emergency scenario, it should be demonstrated problem detection skills and re-planning strategies. Of course, it is difficult to imagine how events and conditions may combine. Thus, the primary purpose of this modelling step is to identify the critical functions of a system. After the key functions have been identified, the next step is to generate a high-level description of each function. A growing number of risks therefore remain unknown.

A FRAM modelling process typically consists of four phases: 1) identify what functions need to be modeled; 2) Identify conditions that could lead to change in performance; 3) Identify areas where functional resonance could emerge and 4) Identify how performance variance can be monitored and controlled.

Beyond the of "practical and methodological procedures" we would like to conclude this dissertation observing that, definitely, it is required to return to the human factor as the "center" of complex systems. It means giving it new, even greater but more sustainable responsibilities. Thus, this opinion aims to introduces in the ergonomic field studies a methodological point of view based on resilience engineering principles and FRAM method in order to construct a model to highlight constraints and contradictions in complex system.

The proposal is radical; it is a paradigm that aims to develop a *just culture* focusing on prevention. Changing the paradigm is not easy, requires a tremendous effort, and requires abandoning old and well-established schemes. It is a sort of "neo-humanism" of complex systems, where man is the measure of the system that is built around, he/she does not fit the system, but vice versa. The safety and well-being of people become emerging, thanks to virtuous functional resonance between all the elements of the system.

References

1. Weick KE, Sutcliffe KM, Obstfeld D (1999) Organizing for High Reliability: Processes of Collective Mindfulness. In: Sutton RS, Staw BM (Eds.), Research in Organizational Behavior, JAI Press, Stanford, 1: 81-123.
2. Dhillon BS (2014) Human Reliability, Error, and Human Factors in Power Generation. Springer.
3. Jung WD, Kang DE (2005) Developing a Standard Method for Human Reliability Analysis of Nuclear Power Plants.
4. Reason JT (1990) Human Error. Cambridge University Press, Cambridge,UK.
5. Hollnagel E (1998) Cognitive Reliability and Error Analysis Method (CREAM). Elsevier.
6. De Felice F, Petrillo A, Zomparelli F (2016) A Hybrid Model for Human Error Probability Analysis. IFAC-PapersOnLine 49(12): 1673-1678.
7. Boring RL (2007) Dynamic human reliability analysis: Benefits and challenges of simulating human performance. Risk, Reliability and Societal Safety 2: 1043-1049.
8. Thiruvengadachari S, Khasawneh MT, Bowling SR, Jiang X (2005) Human-machine systems reliability: Current status and research perspective. IIE Annual Conference and Exposition.
9. Righi A, Saurin TA (2015) Complex socio-technical systems: characterization and management guidelines. Appl Ergon 50: 19-30.
10. Holden RJ (2009) People or Systems? To blame is human. The fix is to engineer. Professional Safety 54(12): 34-41.
11. Wilson JR (2000) Fundamentals of ergonomics in theory and practice. Appl Ergon 31(6): 557-567.
12. Hollnagel E (2012) FRAM: The Functional Resonance Analysis Method: Modelling Complex Socio-technical Systems. Ashgate, London.
13. Hollnagel E, Pariès J, Woods D, Wreathall J (2011) Resilience Engineering in practice. A guidebook. Ashgate, London.