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Hazard Identification and Risk Assessment in Sustainable Enterprise

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Abstract. Risks are a complex problem that, if they occur, will cause unwanted change in the cost, schedule, or technical performance of an engineering system. Hazard analysis involves the identification of hazards at a facility and evaluating possible scenarios leading to unwanted consequences. The hazard analysis stage is a very important part of the risk management process, as no action can be made to avoid, or reduce, the effects of unidentified hazards. Risk assessments are tools that are used for preparing a scientific basis to reduce the risk. The methods currently used in hazard identification and risk assessment are HAZOP, FMEA, FTA, ETA, SWIFT, PRA, PHA, ESD, HACCP, MOSAR, and MORT. Following the comparative analysis of these methods a novel approach to risk assessment using expert system is proposed. Some conclusions and research perspectives will be presented in the final part of the paper.

Keywords: Hazard Identification, Risk Assessment, Risk, Sustainability, Sustainable Enterprise, Decision.

1. Introduction

Risks are the events that, if they occur, will cause unwanted change in the cost, schedule, or technical performance of an engineering system. Thus, the occurrence of risk is an event that has negative consequences to an engineering system project; the risk is a probabilistic event [1].

Risk assessment is an analytic technique that is used in different situations, depending upon the characteristic of the hazard, the existing data, and requirements of decision makers [2].

Risk based decision making is a process that organizes information about the possibility for one or more unwanted outcomes to occur into a broad, orderly structure that helps decision makers make more informed management choices [3]. It is a driving consideration in decisions that determine how engineering systems are developed, produced, and sustained.

Critical to these decisions is an understanding of risk and how it affects the engineering of systems. Applied early, risk management can expose potentially crippling areas of risk in the engineering of systems. Successfully engineering today's systems requires deliberate and continuous attention to the management of risk. Managing risk is an activity designed to improve the chance that these systems will be completed on time, within cost, and meet performance and capability objectives.

The authors conclude that risk management in sustainable enterprises is a cyclical and continuous process which is coordinating activities to direct, control or treat risks including monitoring, communication, and consultation with satisfying the needs of present generations without compromising the ability of future generations to meet their own needs [4].

This paper presents a complete and comprehensive statement of methods used in assessing and identifying risk in the enterprise. In the literature there is no such analysis in which methods are presented, but also their strengths and weaknesses.

2. Methods Comparative Analysis of Hazard Identification and Risk Assessment Methods

Risk assessment in the enterprise is a pillar in achieving objectives and mission following, and proper treatment contribute to enterprise development.

The authors conducted an analysis of the methods exposed above, showing weak and strong points in a systematic and comprehensive manner. This analysis is exhibited in Table 1.

Table 1: Comparative Analysis of Hazard Identification and Risk Assessment Methods

Name	Advantages	Disadvantages
HAZOP [5]	Ends with a final report based on a template for registration under IEC Standard 61882. Able to foresee all hazards and possible accidents. Immediate data available for analysis of quantitative risk assessment.	Requires a group of 5-6 persons experienced in this technique and with knowledge of analyzed system. Time and resource consuming (about 6 people).
HAZID [6]	Provides a quantitative description of the degree of variation or uncertainty (or both) in assessing risks. Additional information and potential flexibility offered.	Holding data describing the input parameters properly. The general lack of data can have negative impact on health and the environment. Takes time, resources, and effort from the evaluator.
FMEA [7]	Provides a systematic image of the important failures in the system. Basis for quantitative analysis. It is a start for the FTA method.	Does not guarantee detection of all failures in the system (especially the people's errors are excluded). Requires knowledge to be applied. Does not indicate the likelihood of system error.
FTA [7]	Logical view of the process. Optimal identification of hazards.	It is used together with other methods of risk analysis.
ETA [7]	The approach is in a logical form. Often used and well known.	It is inefficient when several events occur simultaneously.
SWIFT [7]	High flexibility. Quick because taking into account repetitive errors is prevented.	Work is at the system level, some hazards may be overlooked. Dependent on the leader's and the team's experience and skills.
PRA [8]	Provides a quantitative description of the degree of variation or uncertainty (or both) in assessing risks. Additional information and potential flexibility offered.	Holding data describing the input parameters properly. The general lack of data can have negative impact on health and the environment. Takes time, resources, and effort from the evaluator.
ESD [9]	Graphical method, easy to use having systemic exposure.	In the case of more complex systems with a large set of different elements is not an effective method.
HACCP[7]	Optimal identification of hazards that may occur in the food sector. It aims to prevent rather than analyzing the final products.	The scope is confined to the food. Lists used in the evaluation can sometimes be too general, evaluation is difficult without assessors who know all the entries in the system.
MOSAR [10]	Systemic analysis technique. Identified risks can be quantified later.	Time consuming, including complex techniques for identification of hazards. The risk of identified hazards must be calculated later.
MORT[10]	Optimal identification of hazardous events complex system.	The complexity of the decision tree.

By integrating the advantages of these methods, the authors developed an expert system for risk assessment.

3. The Expert System for Risk Assessment in Sustainable Enterprise

Companies' risk evaluators or assessors need to know how to balance the contingency of risk with their specific contractual, financial, operational and organizational requirements. In order to achieve this balance, there have to be made a correct and complete risk identification and analysis.

Risk assessment determines future decisions, identify new alternatives or opportunities within the organization. Understanding the disadvantages of all the factors is very important. This increases the probability of success and reduces losses in the enterprise. We recognize that the most common risk assessment tools are checklists have been transform into a much more efficient tool.

The development system is an expert system design using the VP-Expert generator (version 2.1 – Educational Version). Production rules determine the knowledge representation model used. Production rules determine the knowledge representation model used. In the PRA.KBS knowledge base, there are if-then structure rules.

The established knowledge base rules were: rules for awarding point's variables; rules for calculation of the partial scores and total score and rules for probability and severity of consequences assessment; risk arising from hazards in accordance with the total score obtained. For all variables there were assign 0 value, if the hazard exist (the answer from general checklist is YES) or 1 if hazard does not exist (the answer from general checklist is NO). Each value has an importance expressed by a factor with predetermined values (0 or 1). For all variables, the pondered factors must be introduced manually by the assessor/user during to knowledge base interrogation process.

If the risk is identified as unacceptable some actions must be taken immediately for diminishing or elimination. If risk is identified as acceptable is recommended a plan of action to reduce it or to ensure that it will not evolve - remain at the same level.

The architecture of the expert system is the simple one. The expert system has a modular architecture, presented in Fig. 1. The four modules of the system are EN (environment), TH (technological), EC (economic) and SC (social), each having a knowledge base with specific expert knowledge represented under the form of production rules. All modules are using the inference engine of VP-Expert, an expert system generator.

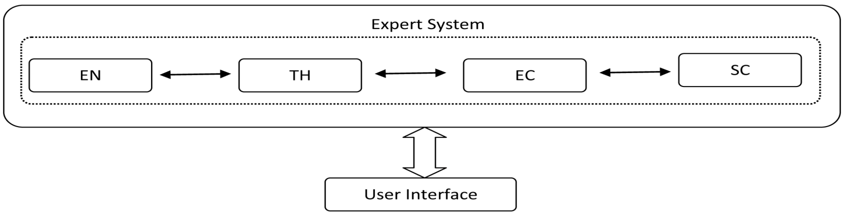

Fig 1: The Modular Architecture of the Expert System

The four modules are the responsibilities of the sustainability: environment, technological, economic and social [3]. The sustainable enterprise will be characterized by its ability to achieve a proper balance between the long-term production capacities (product with the generic sense here) and own resources or the ones from the environment. This company will be involved in supporting local and regional sustainable development and will have to integrate itself in the horizontal and vertical development of an economic environment [11]. Risk assessment leads to enterprise's stability, to enterprise's sustainable development.

The purpose of module EN is to make a diagnosis of the environmental, taking into account different parameters. Also, this module is doing the environment risk assessments. The module TH makes the technological risk assessment. The EC realizes the economic risk assessment and the SC module makes the social risk assessment. The research work involved the integration of all four responsibilities of the sustainability (environment, technological, economic, and social) into a risk assessment expert system. The basic components of each module of the Expert system shows in Fig. 2: a knowledge base, the inference engine, and the databases with hazards (for the environment responsibility, technical responsibility, economic responsibility, and social responsibility).

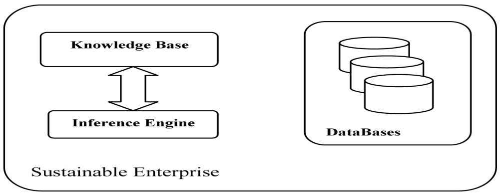

Fig 2: The basic components of each module of Expert System

4. Conclusions

This paper is based on a literature review on the risk assessment and hazard identification methods. The risk assessments approaches are applied in various areas and the problems solve. It was found that the currently used methods for hazard identification are HAZOP, FMEA, FTA, ETA, SWIFT, PRA, PHA, ESD, HACCP, MOSAR, and MORT. Each method have their limitation therefore this paper attempt to formulate integrated risk assessment tools. Risk is a complex problem that requires experience from the evaluator, but depends on his abilities also.

Understanding the disadvantages of all the factors is very important. The most difficult aspect of this review was deciding on the amount of detail to be included for each technique: too little and the review becomes little more that a list, too much and it becomes an unreadable tome. A subjective assessment of the advantages and disadvantages is given, but the real question about hazard identification is related to its ability to carry out the task of identifying all the relevant hazards.

Future research directions are aimed at optimization and application of the instrument in companies in Romania.

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