Annals of the University of Petrosani, Electrical Engineering, 23 (2021)

OPERATIONAL SYSTEMIC MODEL OF OCCUPATIONAL SAFETY AND HEALTH MANAGEMENT INTENDED TO MINIMIZE ELECTRICAL RISKS

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Abstract: The existing systems, applied and validated on occupational safety and health management in electrical organizations, seem to focus on management functions, national and international guidelines, quality standards and principles, to define, describe and ensure conditions for the implementation of occupational safety and health management systems. In this paper, the systemic approach has been adopted to develop a systemic model of occupational safety and health management. The purpose of the model is to maintain the electrical risk in an acceptable range in the operations of an organization whose object of activity is the supply and distribution of electricity, regardless of the internal, external and risk management context in which it is located.

Keywords: Occupational Health and Safety (OHS), Systemic Model, Safety Management System (SMS), electrical risk.

1. INTRODUCTION

Most of the available approaches, applied and validated on occupational safety and health management in economic organizations in the field of electricity, seem to focus on management functions, national and international guidelines, quality standards and principles, to define, describe and ensure the conditions for the implementation of the occupational safety and health management systems of the industrial organizations [1, 7, 9, 20, 21]. These approaches may be a necessary and useful step in the effort to effectively manage workers' safety and health, but may or may not be comprehensive enough to properly address all the complex issues associated with occupational risk management in the complex context of current

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challenges of the major changes in the dynamic reality of emerging work environments [22, 24, 27, 33]. It seems that the need to identify, develop and implement a new pragmatic approach, realistic and adapted to the conditions, but - at the same time - ***systemic*** of occupational safety and health management, is becoming more and more stringent [6, 12].

In this paper, the systemic approach has been adopted to develop a systemic model of occupational safety and health management. In this context, we will define the term "***systemic***" as an attempt to interpret events as a whole in their causal course and to see events, including technical failures and human errors, as "*products of the functioning*" of a system and, in this regard, to analyze the consequences of scenarios (accidents / incidents / occupational diseases / damages / major accidents / property damage, etc.), as a result of the systems operation. ***The ultimate goal of the model is to maintain the electrical risk in an acceptable domain, in the operations of an organization whose object of activity is the supply and distribution of electricity, regardless of the internal, external and risk management context in which this is situated***. We consider that when the features of the model (i.e. embedded systems, their associated functions and communication channels) are operational and functioning efficiently, then the probability of failure / malfunction should be significantly lower than otherwise.

2. LITERATURE REVIEW

Traditionally, both scientific research and practitioners have tended to approach the analysis of electrical hazards by focusing on the technical aspects and looking for the immediate causes of accidents or incidents after they have taken place [2, 3, 19, 28]. Major accidents occurred have highlighted the need for a proactive approach to safety [8]. In addition to the perpetuation of events with severe consequences and as a direct consequence of these, the emergence of new regulations and international standards has required organizations to improve their safety performance. [16]. As a result, companies have been forced to move from a prescriptive, regulatory approach to a ***flexible, tailored*** and ***more dynamic*** approach to analyzing, assessing and - most importantly - managing operational risk affecting their important components of the activity, including risks to safety and health of workers [18].

In the prescriptive approach, regulations explain how to "achieve safety", while in the flexible approach, regulations make explicit what organizations need to do, but leave it to decision makers (CEOs, Boards, top managers etc.) how achieving / materializing the predetermined safety objectives [17].

For a long time, safety approaches have focused on the dysfunctions that immediately precede an unwanted event [20], understood as "***active causes***" or "***human errors***" that have a direct and immediate impact on the integrity of the system. More recently, especially in the last two decades, however, an understanding of the substrate of organizational error has been the focus of the process of minimizing the risks of accidents at work, incidents and major accidents [21]. OSH approaches seem to focus on management functions, guidelines, industry safety standards, quality principles, to establish the OSH management system in organizations [4, 5, 13, 14].

Such well-established approaches have the potential to be a step forward in safety management, but not infrequently they may not be sufficient for effective risk management in the practice of industry organizations, especially due to the emphasis on formalization of documents to the detriment of actual implementation. Moreover, it is openly stated (and up to a point, in line with reality) that such approaches are ***"systematic" in the sense of "methodical" and / or "orderly"*** [25, 32].

This means that the above-mentioned approaches tend to focus on organizational functions that deal with policy, organization, planning, auditing, performance measurement, etc [26]. All these functions are of course necessary, but they may not be enough to ensure the effectiveness of an OHS management system [23]. However, an SMS must be more than that, and we mean - first of all - that it must be "systemic", meaning that an SMS should try to consider the organization as a whole; that is, from top management to frontline workers, from the base of the hierarchical line, communication channels, people (with their values, beliefs and attitudes), etc. In addition, it should take into account the "external environment" (or what the ISO 31000: 2018 standard calls the external context of the organization); that is, all those circumstances that are outside the system represented by the organization, but to which the system's response will be necessary; for example, political, economic, legislative, stakeholder factors, etc. [15]. In short, a ***systemic and contextual approach is needed.***

We define systemicity as an attempt to see things as a whole and to consider undesirable events, including *failure / human error* as a result of the operation of the industrial system and, in particular, to interpret *death / injury / temporary incapacity for work / disability / property damage, etc*., as a result (obviously, undesirable) of the very functioning of the systems [34].

3. MATERIAL AND METHOD

In further research, we have taken a systemic approach to develop a systemic model of occupational safety and health management, which addresses explicit the "environmental" factors in detail and includes the development of the recursion concept [29]. We also developed a case study on the application of the model in an industrial company in the field of electricity supply and distribution, in order to illustrate its own characteristics and particularities of the model.

The ultimate goal of the proposed model is to maintain risk within an acceptable range of an organization's operations, from the primary perspective of workers' safety and health, and is proposed as a *sufficient* structure for an effective safety management system. Its foundation is based on an increased preventive potential, in the sense that if all the subsystems and connections involved in the model are present in the reality of the organization and work correctly / efficiently, the probability of occurrence of dysfunctions should be lower than in the opposite case.

The approach adopted starts from the *Viable System Model* (VSM) developed and proposed by Golineli [11] and the *Failure Paradigm Method* (FPM), proposed by Fortune and Peters [10]. A "***viable system***" is defined as a system that is able to maintain a separate existence. It is argued that in any *viable system* there are five necessary and sufficient subsystems involved interactively and interdependently in any organization / organism that is able to preserve its own identity independently of other such organizations / organisms coexisting in a common environment, in a given context [30, 31].

On the other hand, the *Failure Paradigm Method* facilitated the identification and analysis of examples of good practice, not only useful but - we can say - decisive in understanding aspects related to the human component, so important in discerning the "*human error*" component in the approach analysis of potential accident scenarios. Table 1 summarizes the main methodological elements characteristic to the developed Model of Systemic Management of Occupational Safety and Health (MSMSSM). Starting from these systematized characteristics in the first phase, we elaborated the block diagram of the structural organization of the proposed MSMSSM, represented in figure 1.

Table 1. ***Fundamental features of the proposed MSMSSM model***

Crt. no.	Characteristics of the developed model
1.	MSMSSM and "its environment" (external context)
2.	Stratified (recursive) structure combined with relative autonomy
3.	A structural organization consisting of a "basic unit" in which it is necessary to perform five functions associated with systems 1-5. • System 1: Implementation of OSH policy • System 2: OSH coordination • System 3: OHS operationalization • 3 * system: Audit • System 4: Development • 4 * system: Confidential reporting system • System 5: OSH Policies • "Communication channel".
4.	Commitment to OSH
5.	*RMA* (Maximum Acceptable Risk), *Viability* and *Acceptable Risk Range* concepts.
6.	"Paradigms" are intended to act as "templates" providing essential features for effective communication, control and "human factors".

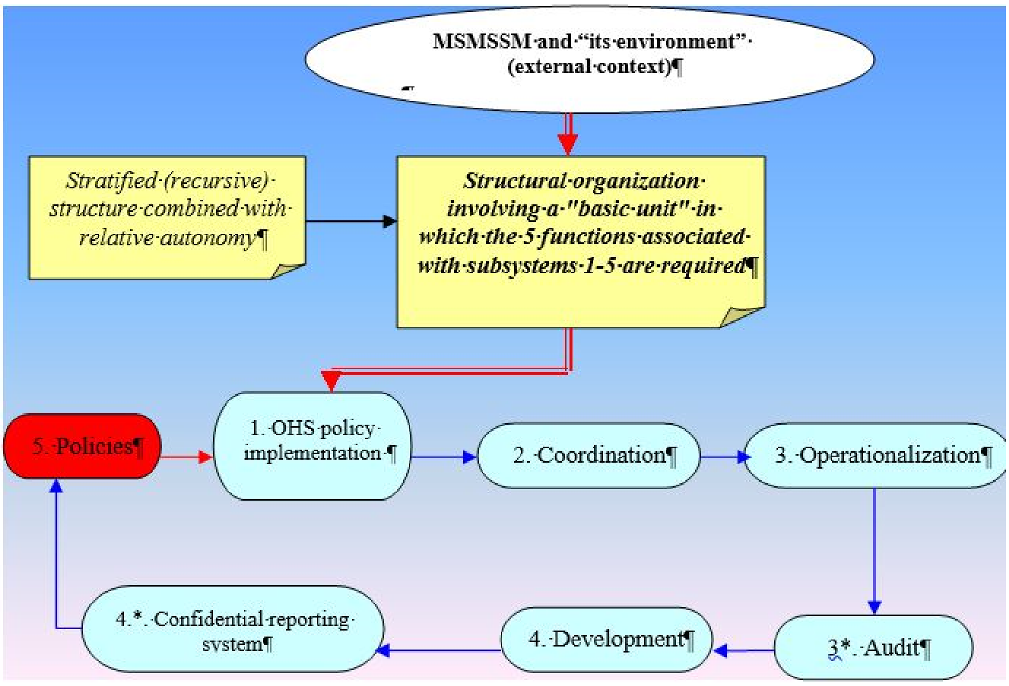

Fig.1. Block diagram of the proposed structural organization of the MSMSSM

In the following, we have provided a detailed description of the three basic features of the model, namely: (1) MSMSSM and its "environment"; (2) "Recursive structure"; and (3) Structural organization (systems 1-5).

According to the Explanatory Dictionary of the Romanian Language, recursion is "the intrinsic property of a process, program, phenomenon, etc. to be able to be described, decomposed, processed and analyzed**". Recursion** is a process that is done by appealing to a simpler form of it. In mathematics and computer science, "recursion is a way of defining certain functions. The function is recursive, if its definition uses a reference to itself, creating at first sight a vicious circle, which is only apparent, not real. Recursion is closely related to iteration, but if the iteration is the repeated execution of a part of the program, until a condition is met (e.g. while, repeat, for), recursion involves the repeated execution of a module, but during its execution (and not at the end, as in the case of iteration), a condition is verified whose dissatisfaction implies the resumption of the execution of the module from its beginning".

A recursion can be seen as a "level" that has other levels below or above it, and can be assimilated to stratification. The concept of recursion is intended, in the context of the present research, to identify the level of the organization modeled or considered for analysis. Very often, in the literature it is not very clear whether an SMS refers to an entire organization, to several parts of it or only a part of the industrial organization.

4. MODEL DEVELOPMENT AND CASE STUDY AT THE ORGANIZATION INVESTIGATED IN THE FIELD OF ELECTRICITY DISTRIBUTION

The organizational structure of MSMSSM was developed as interacting in a defined way with its "environment", through the operations of system 1 and system 4, as illustrated in Fig. 2. "Environment" is understood as the set of circumstances to which the MSMSSM must be able to provide certain answers. In a broad sense, we have equated the environment with what ISO standard ISO 31000: 2018 calls the "*external context*". The "environment" is outside the system, but it interacts with it; it is the source of the circumstances in which the system's response is needed; therefore it is important to consider it. System 4 treats both the "*total environment*" represented by an ellipse delimited by a dashed line and the "*future safety environment*" incorporated in the "*total environment*", as we represented in figure 2. The "*future safety environment*" takes into account threats and opportunities for the future development of OSH. If the MSMSSM is to be effective, it must have the means to scan, interpret and respond to the implications of all those external factors. We consider that the external context may include, but is not limited to, the following:

- cultural, political, legal, regulatory, financial, technological, economic, natural and competitive environment, international, national, regional or local;
- factors and trends having a decisive impact on the organization's objectives;
- perceptions and values of external stakeholders.

Whenever a line appears in figure 2 representing the SSMS model, this is a communication channel, except for the lines connecting the balancing loop between systems 4 and 3. Table 2 summarizes the external "environmental" factors that will have to be taken into account by MSMSSM.

Table2. ***Considered structure of external "environmental" factors***

Crt. no.	Social and political factors	Economic factors	Physical factors
1.	a. Legal requirements	l. Insurers	n. Geographic location
2.	b. Safety, Health, Quality and Environmental standards		
3.	c. Legislation enforcement practices		
4.	d. Major accidents or catastrophes		
5.	e. Non-governmental organizations and Occupational Associations		
6.	f. Public opinion	m. Economic conditions and commercial interests	o. Climate conditions
7.	g. Technological level		
8.	h. Suppliers of goods and services		

9.	i. Workers representatives (trade unions)		
10.	j. Production markets and the labor market		
11.	k. National, regional and local culture		

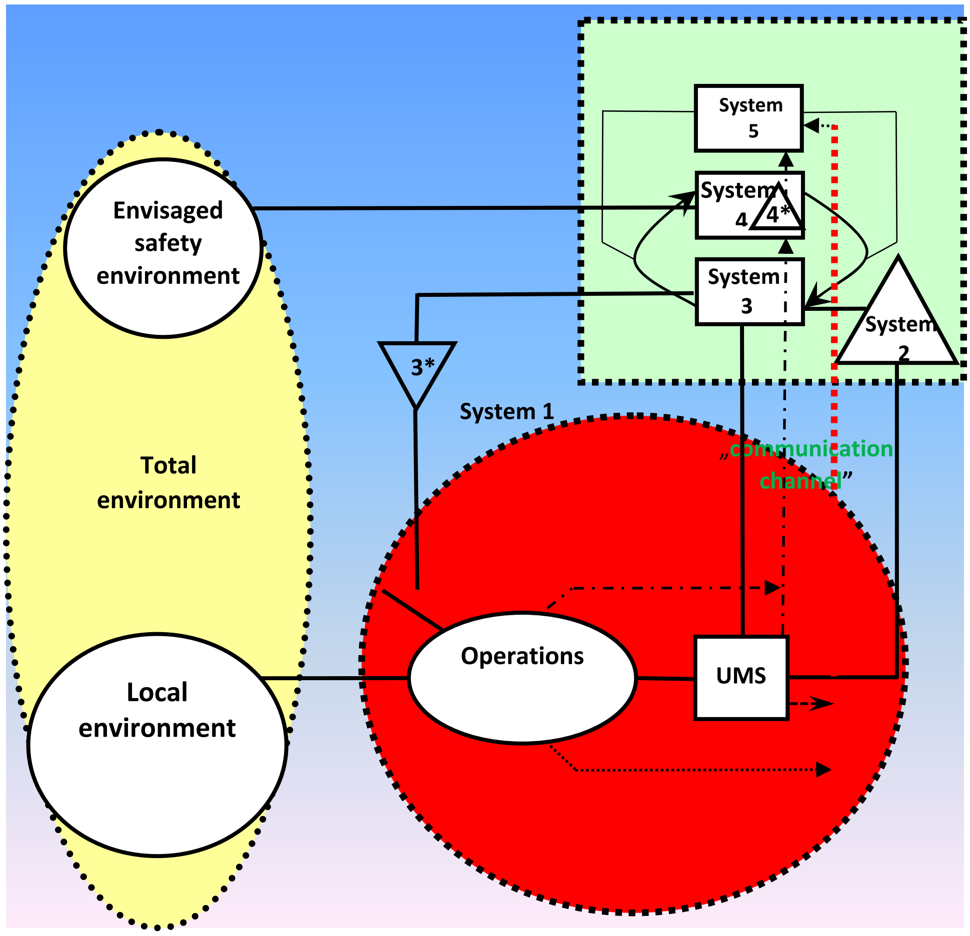

Fig.2. Systemic model of occupational safety and health management system (adapted from Santos-Reyes et al, 2001)

The main activity of the investigated organization is the supply and distribution of electricity to its customers. The activities carried out within the Organization are focused on the following aspects: operation of electrical installations, customer service and troubleshooting, distribution of electricity to consumers, development and modernization of energy installations, management of system informatics. Also, within the Organization, related activities are carried out, such as: dispatching, telecommunications, PRAM services. The distribution of electricity is carried out through networks and high voltage substations as well as through medium and low voltage networks and substations.

There are three Electricity Distribution Companies in this Organization, namely:

- ***Level I Electricity Distribution Company***, being the electricity distribution operator, serving the southern and central area of Transylvania. This company operates in the counties of Sibiu, Alba, Brasov, Covasna, Harghita and Mures, and covers an area of 34,100 square kilometers. The company has more than 2,120 employees and provides services to approximately 1.13 million consumers through a distribution network with a length of over 57,300 kilometers.
- ***Level II Electricity Distribution Company***, being the electricity distribution operator, serving the North-West area of Transylvania. This company operates in the counties of Cluj, Satu Mare, Maramureș, Bistrița-Năsăud, Bihor and Sălaj, being spread over an area of 34,160 square kilometers. With a tradition of 120 years, the Company has more than 2,240 employees and provides services to approximately 1.26 million consumers, through a distribution network with a length of over 68,700 kilometers.
- ***Level III Electricity Distribution Company***, being the electricity distribution operator, serving the northern part of Muntenia. This company operates in the counties of Prahova, Galați, Buzău, Brăila, Vrancea and Dâmbovița, being spread over an area of 29,000 square kilometers. With a tradition of 120 years, the Company has a number of over 2,260 employees, through a distribution network with a length of over 70,700 kilometers.

  Figure 3 includes the strategic objectives of the organization.

Fig.3. The strategic objectives of the Organization under investigation

In 2019, the Organization made the transition from the Integrated Quality Management System - Environment - OSH from OHSAS 18001: 2007 to SR ISO 45001: 2018 and its recertification, according to the requirements of the international reference standards SR EN ISO 9001: 2015, SR EN ISO 14001: 2015 and SR ISO 45001: 2018, by the certification body SRAC Cert affiliated to IQNet, in October of the same year. Figure 3 illustrates an example of a recursive OSH management system applied to the case of the organization that was the object of the analysis, in the field of electricity supply and distribution. The vertical interdependence of safety management systems is highlighted.

It should be emphasized that each of the above subsystems can be broken down into additional subsystems depending on the practical level of interest. In principle, each subsystem that is part of system 1 at level 3 may be further decomposed, depending on the level of interest of the SMSSM modeler or the analysts involved in the process. MSMSSM contains a structure that promotes "relative autonomy" and local capacity to solve electrical risks.

"***Relative autonomy***" means that each operation of system 1 of the MSMSSM is responsible for its own activity, with minimal intervention of systems 2-5. The organizational structure will facilitate decision-making at the local level; thus, decision making is distributed rationally and efficiently throughout the organization. Decision-makers in system 1 should be relatively autonomous in making their own decisions and will be able to act independently, based on their own understanding of the risk, the level of safety and the specific tasks. In view of the above, it is important that subsystems have "relative autonomy" in carrying out their tasks, while complying with the safety requirements of the management system as a whole. The decision on the extent of relative autonomy is a sensitive / difficult issue and it certainly should not be possible for subsystems to become isolated. However, it is important to ensure the highest possible degree of relative autonomy, but its exercise is compatible with the efficient operation of the SMS assembly.

The MSMSSM model has a “*basic unit*” in which it is necessary to perform five functions associated with systems 1–5. Systems 2-5 also facilitate the function of system 1, as well as ensuring the continuous adaptation of the organization as a whole.

System 1 is considered to be the core of MSMSSM. Essentially, it is the "*place*" where an organization's business process takes place, and therefore the risks are there (there may be other risks, due to the interaction with the "*external environment*"). System 1 implements safety policies in System 1 operations, consisting of all operations within an organization that are directly involved in the "core" activities of the organization.

How system 1 can be further "broken down" or "*fragmented*" is a key question; for example, system 1 could be broken down by *geographical* or *functional* criteria.

The role of ***System 2*** is to coordinate the activities of System 1 operations in relation to the overall environment of the SMSSM. System 2, together with the management units of system 1, implements the safety plans received from system 3. It informs System 3 about routine information regarding the performance of System 1 operations. In order to carry out plans of System 3 and needs of System 1, System 2 collects and manages safety information for System 1 operations. There is potential for certain organizations in the ”Total Environment” to create some conflict situations in the operation of the system 1. An example of a coordination activity could be the resolution of any conflicts that may arise between the operational departments (Network Operations Division) and the auxiliary departments (Common Services Division or Risk Management Office) which act as the electricity supply and distribution branch.

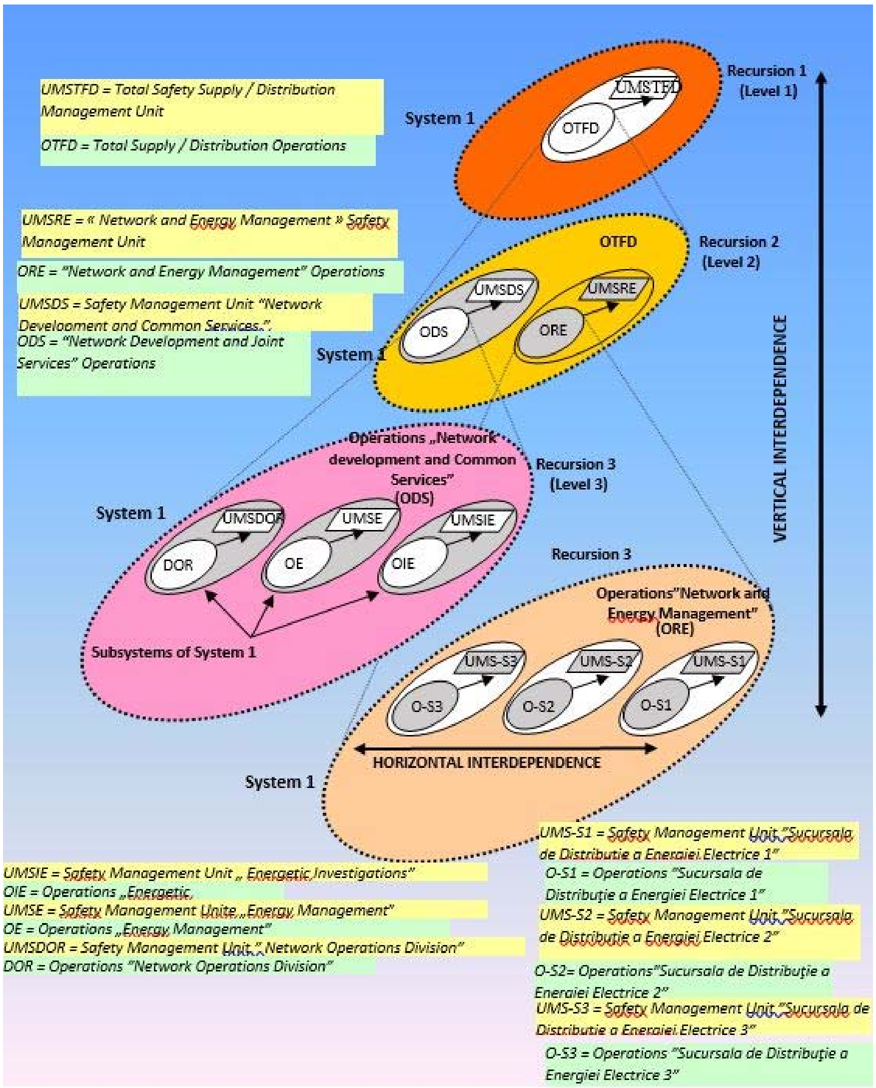

Fig.4. Recursive structure of MSMSSM. Applying the systemic model to the investigated organization in the field of electricity supply and distribution

System 3 will be directly responsible for maintaining the risk within an acceptable range in system 1 and will ensure that system 1 implements the organization's safety policy. It will perform its day-to-day functions in accordance with its own safety plans and the strategic and regulatory security plans received from system 4. The purpose of these plans will be to anticipate and act proactively to maintain the risk arising from the operations of subsystems forming part of system 1, substantially below the *maximum acceptable risk*. System 3 will require from systems 1, 2 and 3 * either information directly related or indirectly related to the safety performance of system 1 in order to be able to formulate its programmatic safety plans. These plans are then communicated to systems 1, 2 and 3 *. System 3 will also be responsible for allocating the resources needed for System 1 to implement the organization's safety plans.

System 3 * will be part of system 3 and its function will be to perform sporadic audits in system’s 1 operations. System 3 * intervenes in the operations of system 1 according to the safety plans received from system 3. System 3 will need to ensure that accountability reports received from System 1 not only reflect the current state of System 1 operations, but are also aligned with the overall objectives of the organization.

System 4 will aim at safety research and development objectives, for the continuous adaptation of the system as a whole. Taking into account strengths, weaknesses, threats and opportunities, System 4 will be able to suggest significant changes to the organization's safety policies. System 4 will also address the current needs of system 1 and its potential future requirements are reflected in the "local environments" of system 1. On the other hand, system 3 communicates to system 4 all relevant requirements of the existing safety performance system related to the operations of system 1. In addition, system 3 will need to clarify the difficulties that the current (existing) level of performance of system 1 will face in trying to assimilate and implement new safety developments that are not in line with pre-existing safety technologies, and - in particular - with the level of safety culture existing in the analyzed industrial company / organization.

System 4* will be part of System 4 and will cover confidential reports or concerns from any employee about any aspect of OSH, some of which may require direct and immediate intervention by System 5. This means that system 4 * analyzes all the information that comes through this channel and develops and plans actions to act on what has been reported, so that these or similar incidents or causes do not become a cause for concern in the future. Workers, groups / teams or departments within the 4 * system should have both authority and responsibility, due to their ability to understand the need for confidentiality.

System 5 is responsible for deliberating safety policies and making regulatory decisions. According to the alternative safety plans received from system 4, system 5 considers and chooses realistic, pragmatic, feasible alternatives that aim to keep the risk within an acceptable range throughout the life cycle of the total system.

5. CONCLUSIONS AND FUTURE RESEARCH

The developed systemic model of occupational health and safety management is a dynamic system, which aims to maintain the risk of an electrical nature (generator of severe consequences with high frequency in the studied organization) in the acceptable field in a consistent manner, for all operations of an organization in the electrical field. The model consists of a set of five necessary, sufficient and interrelated subsystems, generically called systems 1-5, described in detail in the paper. On the other hand, the model possesses an organizational structure that interacts in a defined way with its local "environment" and with the external environment (the external context of the organization), both influencing the system and being influenced by it. The structural organization of the model ensures the integrated premises for the continuous adaptation to threats and opportunities, with the identification and treatment of weaknesses, as well as the capitalization / amplification of the strengths. Moreover, the structural organization of the model is intended to manage security in a consistent manner by simultaneously addressing the interdependencies of an organization both vertically and horizontally. Finally, the model is intended to help ensure a structural organization that can facilitate the implementation and development of the ***safety culture***.

If the characteristics of the model, i.e. the systems, their associated functions and the communication channels are properly implemented and work efficiently, then the probability of failure will be lower, considerably increasing the ***preventive potential***. The model can be applied proactively in the case of a new system or an existing one, as well as reactive. In the latter case, any undesirable event that has already occurred can be examined using the model to minimize its repeatability. The proposed model can also be used as a "template" for examining an existing safety management system.

As future research, it is intended:

(a) the application of the model in a proactive manner, by extending the case study carried out in the case of an industrial organization in the field of electricity supply and distribution;

(b) applying the model in a 'reactive' context, in order to highlight the strengths offered in the process of increasing confidence in measures to prevent risks that have already materialized, in order to illustrate its potential as an investigative tool;

(c) quantitative assessment of the effectiveness of an existing occupational health and safety management system using the concept of viability, considered as the ability to maintain the risk within an acceptable range for a predetermined period of time.

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