A HIERARCHICAL MODEL FOR EMERGENCY MANAGEMENT SYSTEMS

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Pe baza unei analize critice a câtorva modele de sisteme de management a situaţiilor de criză sau a dezastrelor naturale, atât clasice cât şi apărute recent în literatura de specialitate, ce ia in consideraţie diverse criterii: aplicabilitate, avantaje, limitari, restricţii, cost, timp, arie geografică, lucrarea işi propune să ofere sugestii pentru implementarea sistemelor inteligente de management al crizelor şi dezastrelor şi pe baza acestora să propună structura unui sistem complex multi-nevel de management al situaţiilor de urgenţă al cărui model include asistarea riscului, prevenirea daunelor, limitarea efectelor şi capacitatea de intervenţie.

As result of a critical analysis of some crises and disaster management systems models from the classical and recent literature, according to different criteria such as: applicability, advantages, limitations, cost, time, geographical area, this paper aims to offer suggestions of how to implement intelligent systems for crisis and disaster management and on this basis to define the architecture of a complex multilayered emergency management system whose comprehensive model includes risk assessment, disaster prevention, mitigation and preparedness.

Keywords: risk/crisis/disaster/emergency management, hierarchical models, disaster risk reduction

1. Introduction

The risk and crisis management systems are support decision systems placed at the highest level of a hierarchical intelligent system of alerts, which could be implemented in different domains where exists the risk of happening an undesirable event that can disturb the good function of a critical infrastructure.

An alert system should announce an operator or competent authorities and sometimes the population about the existence of an abnormally from normal conditions. The final objective is to prevent or minimize physical and economical losses through intervention of in charge factors with the cause of alarm. In case

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that the source in under control, like an automatic industrial process, or natural phenomena with catastrophic effects, the purpose is minimizing damages or costs, if any defense is possible. In both cases, intelligent reaction is necessary.

2. Concepts and definitions

Let begin to some definitions for terms and concepts apparently similar, but having individual characteristics that make the difference.

Risk management is the identification, assessment, and prioritization of risks (defined in ISO 31000 as the effect of uncertainty on objectives) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. In industry risks can come from uncertainty in project failures, accidents, natural causes and disasters as well as deliberate attacks from an adversary [1].

Crisis management is the process by which an organization deals with a major event that threatens to harm the organization. Three elements are common to most definitions of crisis: (a) a threat to the organization, (b) the element of surprise, and (c) a short decision time. In contrast to risk management, which involves assessing potential threats and finding the best ways to avoid those threats, crisis management involves dealing with threats after they have occurred. It is a discipline within the broader context of management consisting of skills and techniques required to identify, assess, understand, and cope with a serious situation, especially from the moment it first occurs to the point that recovery procedures start. There are 3 phases in any Crisis Management Model [2]: 1. The diagnosis of the impending trouble or the danger signals. 2. Choosing appropriate Turnaround Strategy; 3. Implementation of the change process and its monitoring.

Disaster management is the discipline of dealing with and avoiding risks, including usually four phases: Mitigation, Preparedness, Response, and Recovery [3]. There are not essential differences between crisis management and disasters management, only that the last is more specific. However, there is another concept derived from disaster management who covers nearly the whole discussed thematic area, namely the *emergency management* [4].

Emergency Management is the generic name of an interdisciplinary field dealing with the strategic organizational management processes used to protect critical assets of an organization from hazard risks that can cause disasters or catastrophes, and to ensure their continuance within their planned lifetime. Hazards are categorized by their cause, either natural or human-made. The entire strategic management process is divided into four fields to aid in identification of the processes. The four fields normally deal with risk reduction, preparing resources to respond to the hazard, responding to the actual damage caused by the hazard and limiting further damage, and returning as close as possible to the state before the hazard incident. Emergency Management is a strategic process, and not a tactical process, thus it usually resides at the Executive Level in an organization. From fields that are under this last definition our paper refers to an *Effective Emergency Management System* that relies on a thorough integration of emergency plans at all levels of the organization, and an understanding that the lowest levels of the organization are responsible for managing the emergency and getting additional resources and assistance from the upper levels. This system aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them. Its scope is much broader and deeper than conventional emergency management and so allows disaster risk reduction.

3. Classical models of disaster management systems

In the literature, there are a lot of models that respect the classical principles of the disaster management such as Traditional model, Expand and Contract model, Kimberly's model, Tuscaloosa model, Circular model, Manitoba integrated model, etc.

Traditional model contains only two phases: Pre-Disaster risk-reduction model phase and Post-disaster recovery phase [5]. The first stage contains preparation, mitigation, and prevention. The second stage contains response, recovery, and development. It is a trivial model that doesn't consider the moment of which the crisis occurs. Moreover, data integration and decision making is not easily achieved. The Traditional model is shown below in Fig. 1.

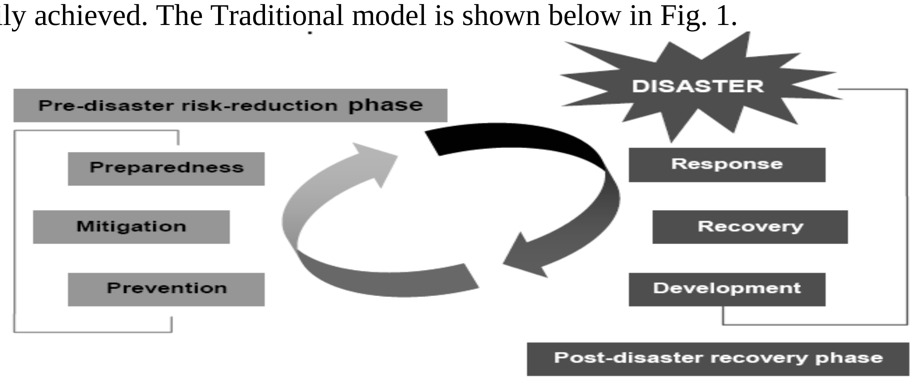

Fig.1. Two-phase traditional model (after[5])

In the Expand and Contract model [6], the activities and actions occur simultaneously and overcome the sequential nature limitations in the traditional model. This model doesn't consider the external or internal factors related to the hazard event. Moreover, in case of any hazard event other strengthens factors could appear during the event that might have effects on the event and this model doesn't take it into consideration. Unfortunately this model is not applicable for different cases of disaster. Also budget, cost, time, technology, infrastructure, supply chains are not taken into consideration by the authors of the proposal.

Kimberly model [7] and **Tuscaloosa model** [8] decompose the disaster management cycle in four phases: mitigation, preparation, response and recovery. The main difference is that Kimberly model considered the mitigation and the response on the same base level, and the recovery on the top level (see.fig.2a), while Tuscaloosa model (see.fig.2b) limited the effect of disaster by inserting the mitigation at the beginning and the end of the cycle.

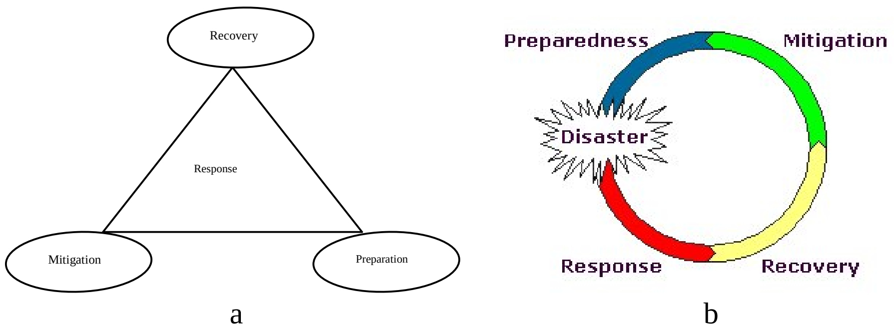

Fig. 2. Four phases models for disasters a)Kimberly model; b) Tuscaloosa model

Both Kimberly and Tuscaloosa models require well trained employees in order to apply these phases effectively and can be utilized only in specific situations: emergency management in hospitals. Moreover; high budget will be expected for the employees.

Kelly [9] decomposed the disaster management cycle into eight phases. He proposed a **circular model** that reduces the complexity of disasters and also handles the nonlinear nature of disaster events. The ability to learn from actual disasters is the main advantage of this model. The circular model is shown below in Fig. 3. This model requires developing a comprehensive database of disaster impact and input output information which needs well trained personal to handle this information. Moreover, highly tech infrastructure is badly needed to achieve reasonable results.

Fig. 3. Kelly's circular model (after[9])

The **Manitoba model** [10] decomposes the disaster management cycle in six phases: a strategic plan, hazard assessment, risk management, mitigation, preparedness and monitoring and evaluation (see fig.6). The model describes the long term desired state of the disaster management in the health sector. It is incorporated with the four main elements of the hazard assessment, risk management, mitigation and preparedness. The balance between preparedness and flexibility is considered a main advantage of this model. Moreover, high tech infrastructure is needed for this model to enable adapting any modifications and updated information. For that, highly well-trained people are required to handle this infrastructure. This model requires a high annual budget to setup this model if needed. The cost of training the end users on this system is very high. The evaluation stage in this model is based on judgment.

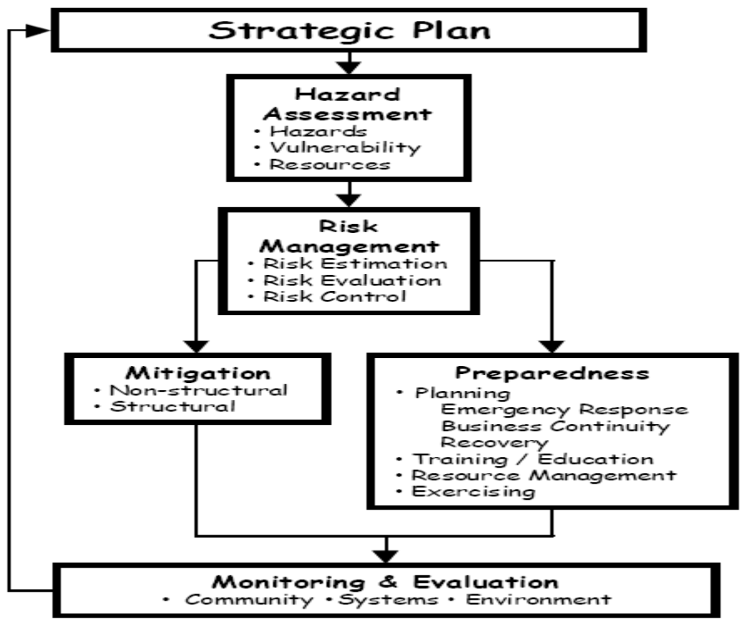

Fig. 4. The Manitoba model

4. Recent multi-layer models for crisis and disasters management

In his impressive monograph [11] Craddock presented two models of crisis management, that cover also the area of the disaster management, being more general. The first model presents the main phases and the activities of crisis timeline, namely four phases: pre-incident phase, incident occurrence, post-occurrence phase and post- incident phase. Each phase describes the main activities needed to handle the crises before incident occurring, at the time which the incident occurs and the consequences, and the restoration actions required in the post occurrence phase. At the end of the last phase, normality returns and activities return to those of the pre-incident phase. The boundaries between the different phases are flexible and some phases may overlap.

The second model is aiming at understanding the technological capabilities required to respond to a crisis. It is based on determining the set of resources and a plan required by the incident commander in order to handle an incident that has just occurred. This requires a set of information resources, resilient communication to get information from the main source to the commander, and plan implementation. The technologies used in the second model produce an efficient plan at the time of occurrence and used during planning and preparing for future incidents. This second model is shown below in Fig. 5.

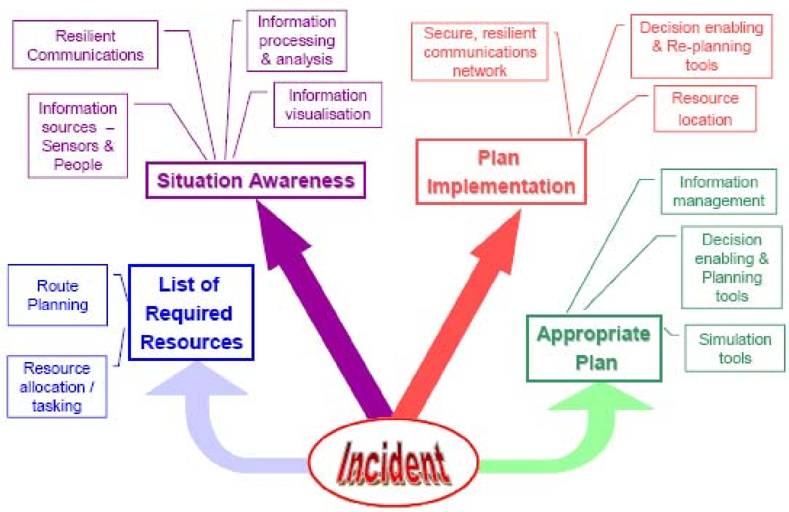

Fig.5. Planning resources for crisis management (after [11])

It is clear that these two models are for specific applications despite the followings requirements:

- Huge budget, since it needs a high technology to apply this model for different geographic places.
- Well-trained people that are able to integrate the information between the different geographic places.
- The cost of preparation of the pre-occurrence of the disaster is very high.
- Although the first model is considered to be a timeline of a crisis, it can be concluded that some crises occur once in the period of the time so there is no need for the feed back.

- It can be shown that the principle of supplying the chain management is included in these two models, so the user of these models will face restrictions such as political issues and/or cultural environment.
- When a crisis occurs, then that will require a full manpower to be part of recovery process team. Also that might not work out.

One of the most sophisticated model that allow a complex simulation for crisis management using the organizational specification on a high level of abstraction was created by Quillinan *et al* and was included in ALIVE project to handle response to crisis in Netherlands [12]. They defined three models for: the role dependency graph, interaction structure diagram and land mark patterns. These models used to represent the crisis management scenario. They defined a multi-layered architecture that contains a small middleware kernel AgentScape operating system and high-level middleware service. The lower layer implements basic mechanism while the higher layer implements agent platform specific functionality and policies. This model is shown below in Fig. 6.

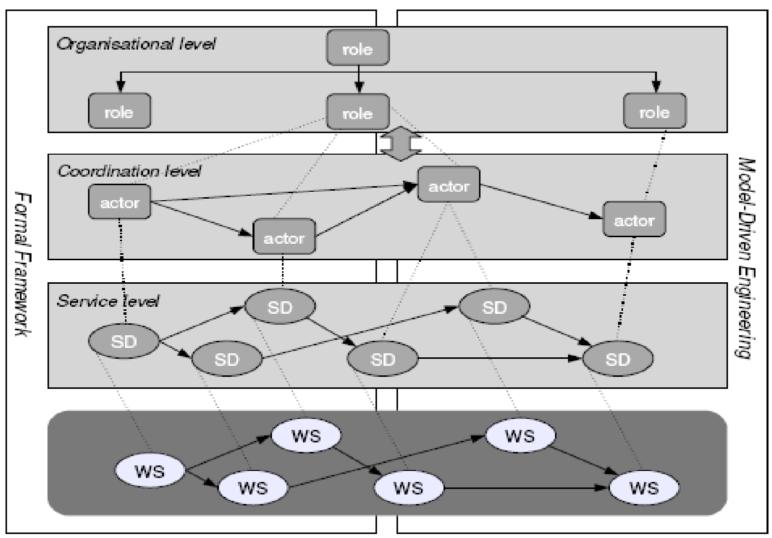

Fig. 6. Multi-layer Quillinan model (after [12])

After reviewing this model we conclude the following:

- The main limitation is that it can be implemented only to the Netherlands.
- This model can be considered a virtual model so the degree of success can not be guaranteed.
- This model can be used for certain and limited area of crisis.
- The model don't consider how time can be synchronized over a distributed system

5. An improved system model for emergency management

After this analysis the authors has developed a distinguished model that introduces an improvement over existing models by encapsulates all the required activities of disaster (emergency) management. This model has the ability to handle different scenarios by supporting different stages and phases of disaster management cycle. It solved the difficulties related to the logical models, integrated models, and cause models. This model contains six main components instead of four fundamental phases. It includes strategic planning, hazard assessment, risk management, disaster management, monitoring and evaluation. The model presents a two-layered framework and mitigates the disaster by performing these actions in a sequential manner, which justifies the acronym HSEM (Hierarchical System for Emergency Management). The relationship between hazard assessment and risk management is showed in the first layer, while the second layer highlights the relationship between the risk management and the disaster management. The model is shown below in Fig. 7.

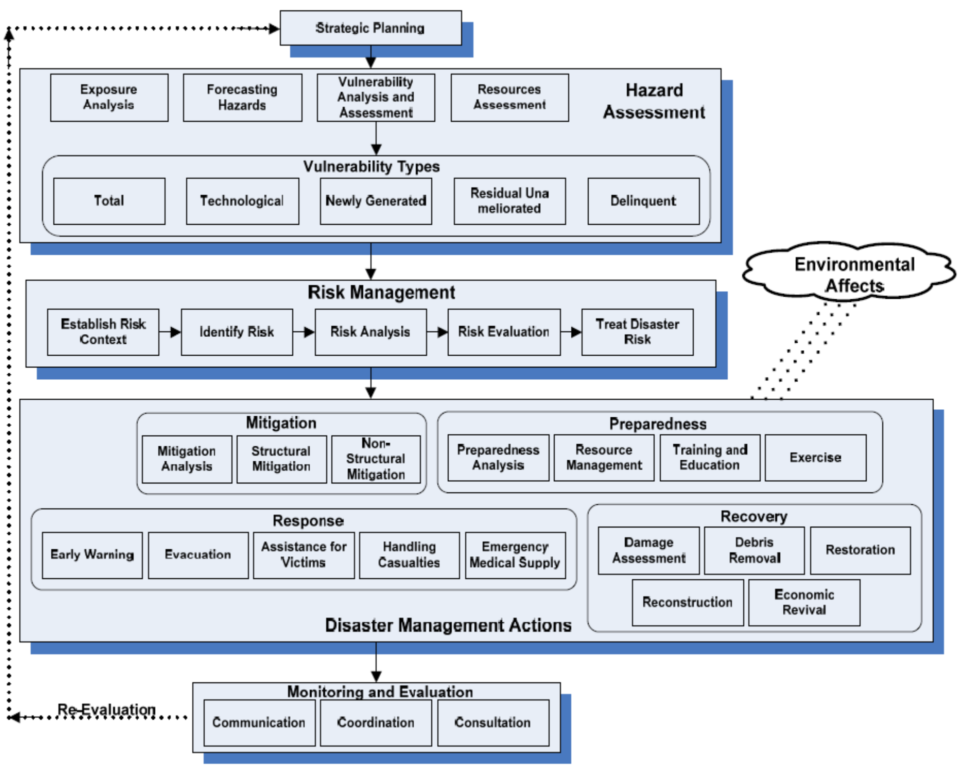

Fig. 7. The complex HSEM model

HSEM will facilitate the availability of relevant data for post-disaster, and recovery phase. It provides an efficient, reliable and secure exchange of the required information and allows an efficient management of risk.

The risk concept depends on hazard, exposure and vulnerability. Reducing the total risk depends on reducing the side effects of any or more of these three variables. This idea presented the risk as a triangle, where each side represents one of the three independent factors: hazard, exposure, and vulnerability in equal [13]. The risk is represented by the area inside the triangle.

The proposed HSEM is a comprehensive and integrated natural disaster and risk management model that discussed the management of all types of natural disasters. The natural disaster risk is defined as a function based on four important factors: hazard, exposure, vulnerability and emergency response and recovery capability, taking into account that the increased number of natural disasters is the result of the increased exposure and the delay of reducing vulnerability [14].

6. Conclusions

The primary purpose of this paper was to make some suggestions of how to implement intelligent systems for disaster management, in the larger approach of emergency management including disaster risk reduction. A special attention is paid for systems that assure support for decisions of the operators and assistance for repair the technical defects that occur during technological processes. To respond crisis situations, the personnel often analyze great volume of process data and are obliged to filter quickly not useful information, to find the principal cause of a situation in witch alarms appear, to implement an action to remediate the situation. There is, at the international level, a request for technologies in processes control witch assists operators in analysis process information and to implement corrective control strategies when special situation appears [15].

The second objective of the paper was the definition of the framework of a complex multilayered emergency management system named HSEM. HSEM is a comprehensive model that includes risk assessment, disaster prevention, mitigation and preparedness. Instead of focusing on a single disaster it is used to reduce disaster comprehensively. It worked on multilevel, multidimensional and multidisciplinary to improve the disaster reduction and response. This model is considered a dynamic model that is able to maintain multi-interdependency between events, actions, actors, context and the other factors involved in the process.

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