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Emerging Applications of Decision Support Systems (DSS) in Crisis Management

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1. Introduction

The recent financial crisis, the growth of the frequency of extreme risk events are motivations for a new analysis of the mechanisms and processes that implies high risk and high uncertainty. The new dynamics and the severe impact of the extreme events (natural hazards, terrorism, technological accidents, and economic/financial crises), but also the complexity of interventions have motivated the scientific community to find new efficient solutions for decision making process dedicated for crisis management, especially for solving the following aspects: time urgency, the complexity of event, the volatility/ rapidly changing of event/ decision conditions, the chaotic surrounding environment ingredient, the human behaviour in critical situations (emotional stress), the consequences for decision failure, poor data, frequent interruption during the decision making process.

Extreme risk events are no longer only high impact - low probability events. Indeed, the literature demonstrates that these types of events are more frequent and also their impact is also more critical. The governments are responsible not only for the post crisis management of extreme events. In this case, better knowledge could offer opportunities to reduce the impact.

Emerging aspects regarding the integration of the concept of hybrid DSS in the treatment of extreme risk management will be presented. The efficiency of using intelligent ingredients in decision support systems (DSS) is linked to the human limits but also on the dynamics of huge data in the context of imprecision and uncertainty. Different applications for the use of hybrid DSS in flood and drought risk management, asymmetric risk and crisis management exercises will be also presented.

Many extreme risk events are associated with modern human environment and in this case the spectrum of risks is changed with a difference between the perceived possibility and reality (Renn, 1992). Extreme risk is expressed by the potential for the realization of unwanted, adverse consequences to human life, health, property, or the environment. In Kaplan, Garrick (1981) is proposed the risk triplet (S-scenario, P-likelihood, D-possible consequence), a framework that responds to the nature of disaster events that can occur, how likely is a particular event, what are the consequences.

Decision makers in extreme risk environments should respond in a new different manner because modern crisis management requires urgent developments toward better, more elaborated and appropriate means for extreme risks. Extreme risk management needs to ensure a better interoperability of different emergency services (police, fire chief, health sector, civil protection) to provide the appropriate information (of course, after data fusion and data filtering) at the right place in the critical moments. The new global environment is very complex and the dynamics of changing is difficult to understand. Decision making in critical or special situations is very complex because the systems are complex, the dynamics is difficult to understand, and adaptability is essential. Even the technologies to cope with the crisis and high risk events have developed considerably there are some underlying problems that complicate high risk prevention and multiple crisis response: an inadequate communication between different actors and different levels; the relative inadequate data fusion, selection, filtering and standardization impacted information database; the difficulty to update information about the development of the extreme risk (victims damages, rescue team technologies, in the case of natural/man-made hazards, or specific information in the case of financial crushes and crises); the access to existing databases and action plans it is relatively slow.

The interest is to develop an integrated framework capable to support emergency decisions via a better understanding of the dynamics of extreme events and a better detection and management of new risk situation. In this case, the focus is on the characteristics of genericity and adaptability of the framework in order to build a flexible, adaptive, robust and efficient system that does not depend on a particular case and it is easy to be extended in a creative manner.

In an uncertain and highly dynamic environment this type of applications could offer a robust but adaptive support for all decision making factors. Based on this type of applications is possible to build a generalized framework capable to support different types of decisions, not only in economy and finance, but also in military and law enforcement applications, in critical periods, or in high risk events.

2. An introduction in extreme risk modelling

First step in management of extreme risk events is to identify the most critical endpoints assessed in terms of the possible impacts on humans, communities, and environment. Then, it is necessary to specify the particular nature of each risk that could affect the endpoints in both terms of the likelihood and the degree of damage. The exploration of possible external impacts which might occur is based on the following aspects related to the risk triplet $R=R(S_i, P_i, D_i)$: the impacts/damage position outside/inside our control area; the scale of these impacts and their degree of irreversibility; the trans-boundary characteristics of these impacts; the potential threat to human ethics/morality.

The typical risk scenarios require an integrated perspective in selecting the adequate mix of risk reduction measures such as increased natural hazards damage potential due to urban development and agglomeration; increased systemic risk due to cascaded facilities or organizations; a severe decline in preparedness of local communities that wait for the government action (via public warning systems) and a low ability to minimize losses; a critical environmental degradation.

An extreme risk framework could be build considering the following processes: the problem formulation (potential risk events examination); risk assessment (provides an objective and integrated judgment in terms of scientific evaluations regarding extreme risk events identification, pathways, exposure assessment, exposure-damage response assessment); risk management and first subjective decision making process to select regulatory measures from alternative options. There exist conceptual/functional separations between risk assessment and risk management. The explicit representations of risk scenarios can provide a better assessment and permits regulatory decisions under volatility and uncertainty. In the literature is underlined the critical role of risk communication and stakeholders participation in extreme risk analysis.

Another branch of the literature is focused on the relationships between hazards and damages in terms of risk or vulnerability (Wisner, 2004). In the "pressure and release" (PAR) model the aim is to understand risk in more realistic terms of vulnerability in the field of disaster sciences based on the disaster risk model of Alexander (1993) expressed by:

$$\text{Risk} = \text{Hazard x Vulnerability} \tag{1}$$

In Smith (2001), the risk is modelled in a similar way:

$$\text{Risk} = \text{Hazard (Probability) x Loss (Damage)/Preparedness (Resilience)} \tag{2}$$

In Wisner (2004) "risk" is viewed as "hazard time's vulnerability" or a unit measure of the possible damages under an exposure probability to the hazards. The overwhelming tendency in both theory and practice is to view extreme risk management as a holistic process involving prevention, planning, acute response, recovery, and learning (Comfort, 1988; Nudell, Antokol, 1988; Coombs, 1999; Fink, 2002; Regester, Larkin, 2002; Curtin, Hayman and Husein, 2005). Preventing all extreme threats from materializing is not only implausible; it is simply impossible (Wildavsky, 1988). Prevention requires that one knows the source and dynamics of threats, but the literature shows this is impossible (Reason, 1997; Pauchant, Mitroff, 1992; Anheier, 1999; Gauld, Goldfinch, 2006). The decision maker will take into account the following operational steps: size up the event situation; activate the DSS; add the real time information and select the type of event scenario; adapt the base event scenario; simulate and evaluate the final scenario and the recommended decision; implement decision.

In principle, an integrated framework for extreme risk analysis should include the following four steps: scenario formulation - collection and analysis of data related to hazards in terms of their possible origins, pathways, and mitigation; extreme risk assessment – the list of potential extreme events together with their exposure or vulnerability; extreme risk management - with development of mitigation measures and procedures based on the output from the risk characterization; communication by using a dedicated platform to enable a better understanding of the rationale behind the categories of risk assessment.

In the modern literature are presented a lot of applications, procedures and activities capable to anticipate, prepare for, prevent, reduce different types of risks/losses associated to different type of crises, but there are only few integrated frameworks to deal directly with the extreme event. In this case, the decision makers need a huge technical assistance to support decision making process before, during, and after extreme events.

All these applications are based on a huge quantity of data, a dynamic or real time selection between alternatives and the implementation of the final solution should be define with precision, but also with adaptability and creativity. Other aspects are related to the possibilities to integrate and to mix different types of models, methods and techniques/decision tools and to understand the limits of acceptability. DSS is one of the most efficient technologies in the treatment of extreme risk and crisis, because it offers adaptability, robustness and is easy to use in a modular-adaptive framework. Soft computing techniques could be used together withy DSS/ IDSS not only as a mathematical ingredient, because its efficiency is given by a better capability of selection, a higher speed of analysis, and also on adding the advantages of adaptability, flexibility, and modularity.

3. Emerging techniques to understand extreme risk management (ERM)

Extreme risks are high impact, high uncertainty, and low probability emergency events with high negative impact/losses due to uncertainty spread to different levels; in the case of financial events appear also the contagion phenomenon. Extreme events demand immediate action because of serious threats to the environment; contagion brings a new dynamics in recent financial events. The urgent need for action is to respond hints that the time interval is very short. Managers should act in time, but with surgical precision because crisis represents critical turning points with decisive changes. Extreme risk and multiple crises could be describes as the manifestation of an unexpected risk that develops very quickly in to an emergency/disaster situation. An emergency/disaster situation contains also surprise and response elements. Emergency response represents the synthesis of knowledge based on experience, procedures and activities to anticipate, prepare for, prevent, reduce or overcome all the risks associated with extreme events. The interest is to offer framework easy to use, but efficient in reducing the negative consequences. A complex system supports a variety of key decision across a wide range of decision making and integrates two processes: how to recognize and size up a situation and how to evaluate the course of action (CoA).

The steps supported by an intelligent system are: size up the situation using the embedded information; search a knowledge base and recognize the first type of similar situations; diagnose the historical experience against the problem; adapt and modify the solution of the historical data base to work in the new context; rehearse the solution to verify that it is likely to realistically work; the implement of decision.

The literature reveals that decision makers do not normally use the classic rational choice techniques, but they rely on experiences; it is not the intention to find the mathematical best way, but to find a first good enough solution implemented and move to the next step (this natural style is called recognition-primed decision making, RPDM). Modern decision makers face specific gaps: some decision makers are afraid to apply RPDM based on past experiences, but others do not have a personal knowledge base of past experiences enough to cover unfamiliar extreme events. A simple framework capable to rapidly support the decision maker with experience for the past or from others scenarios and to guide the decision maker to rapid near optimal decision, is useful for small scale events, but an intelligent tool is needed for complex systems.

The decision support system (DSS) concept, launched before PCs, was focused on the use of interactive computing in unstructured/quasi-structured decision making activities. Sprague (1980) argued this limitation for solving only unstructured problems and proposed an extension that includes every system. Druzdel and Flynn (2002) define DSS as an interactive system based on computer, capable to assist the user in selection activities; in this concept DSS provide data based management and refined the conventional access to information and the capability of find function via a support in building rational models. McNurlin and Sprague (2004) described DSS as "computer based systems that help decision-makers confront ill-structured problems through direct interaction with data and analysis models".

The decision support system (DSS) concept, related to an interactive, flexible, and adaptable system developed for an intelligent decision making support, offers a better information management for a better coordination of activities. DSS are very efficient instruments in complex situations/complicated environments, where decision makers need a robust support to analyse multiple sources of knowledge (Martinsons, Davison, 2007). DSS was used with success in management and the evolution was always linked to the dynamics of informatics systems, databases and expert systems. The new IT application has decisive influence DSS, with application that spread in all domains of activities. Modern DSS are able to support operational capability and strategic decision making in complex systems. A decision making framework for extreme risk should consider a structure based on quantifying decision variables decoupled in their own control systems. These variables are combined through the practical conditions offered by knowledge based infrastructure to include all decision scenarios. Because each decision scenarios affect the system in a different way, these effects can be also used to rank decisions and, in this way, to offer a better adaptability of the global framework. The main objectives of DSS are related to a better adaptability of decision making and the build of a preliminary study for decision making in technical case where is not possible an efficient planning of such activities.

The characteristic elements of a dedicated DSS are: addressing unusual problems and assist in improving the quality of decisions to resolve them; DSS is a productivity enhancement tool for decision-making activity of the expert who holds an active control system; construction and development cause an evolutionary DSS - makers, system developers that are influencing each other in a process that does not end at a specified time; DSS has a data integrator and is adapted to the particularities of the individual application and user, limited to just one method or information technology; DSS may have several stages of completion, from the core of system to application systems; DSS can be addressed according to its stage of development and more users (decision makers, analysts, and developers of tools).

DSS is a technology capable to improve the ability of managers in decision making to better understand the risks and the dynamics of the extreme events within the constraints of cognitive, time, and budget/liquidity limits. In principle, DSS design is based on the following three capabilities: a sophisticated database management tool with real time access to internal and external data, information, knowledge; powerful modelling capabilities accessed by the portfolio of models used by the management; friendly, but powerful interface designs that enable interactive queries, reporting and interface graphical user.

Since a crisis begins with events, first step in decision making process is to categorize/ rank the events and propose a first selection of the proper models. Let a knowledge base with N different cases corresponding to N different events, each having its own model, and a situation vector filled with environmental and costs parameters. Based on situation vectors, some cases are selected as possible candidate events that are associated to the portfolio of models; the models get the necessary information from the corresponding database (online data entered in the infrastructure through human user or automated systems and offline data collected for corresponding similar situations/ events). Models are equipped with controllers that compute the performances of decision variables. It results scenarios for solving the problem with different performances (time, costs). The interest is to find the optimal solution that offers a few numbers of ranked possible scenarios, with their effect degree and the decision maker can select one of them. It is useful to introduce a system capable to gets the decision maker idea about the scenarios, to refine the decision for the future same cases and to allocate the higher degrees.

The purposes of a DSS (Fig.1) is to offer a better support for decision makers, allowing better intelligence design, or selection via a better understanding of the whole problem and its dynamics, a better managing knowledge via efficient solutions for non structured decisions.
The main characteristics of a special purpose DSS are the following:

- a structured knowledge that describes specific aspects of the decision makers environment, how to accomplish different tasks;
- it incorporates the ability to acquire and maintain a "complete" knowledge and its dynamics;
- it incorporates the ability to select any desired subset of stored knowledge and to present the global knowledge in different customized ways/reports;
- it offers a direct interaction with the user (decision maker) with adaptability and creative flexibility to the situation and users.

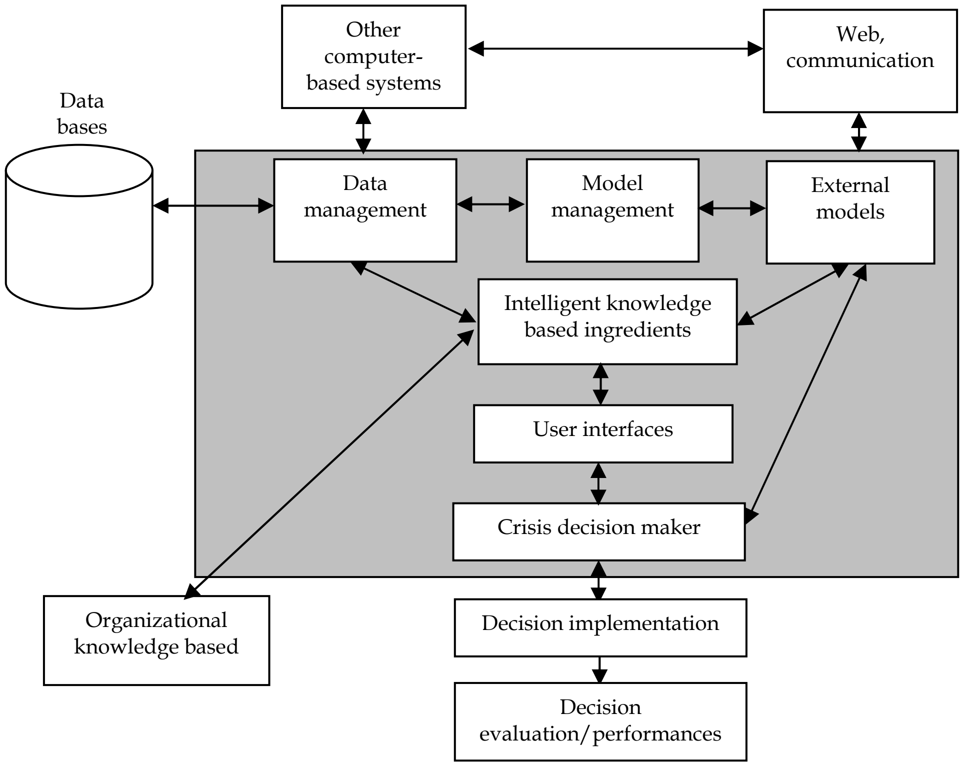

Fig. 1. The decision making process in crisis management

DSS-ERM should offer an intensive level of use in decision making process, both in the case of a crisis and before/after the crisis. This ability is based on the dynamic analysis of the current situation and „similar" past situation. The output of using this instrument could be represented by direct effects (a better decision capability, better efficiency, better objectivity in decision making process, less errors and ambiguities in communication, a good stimulus to adopt excellence and the new style of work, a better use of creativity and innovation) and indirect effects (creation of new skills and new jobs, more efficient, better competitive, better adaptability of the structure to critical situations).

4. Principles to construct an integrated DSS for extreme risk/ crisis management (DSS - ER/CM)

The system should be built and implemented in a flexible and evolutionary philosophy. It should be considered good knowledge of different applications that implies extreme risks, a good identification of the task linked to the capabilities of decision makers, a capability to refresh data/knowledge bases, a good knowledge and selection of adequate methods for the design. The basic aspects regarding the building of DSS-ER/ CM architecture is presented in Fig. 2. In this case, the system is modular and should be evolved. The flexibility will add good capability to modify in an efficient manner and the better adaptability to the treatment of new risks/events.

Decision makers that deal with crisis situations need intelligent instruments like software tools capable to deal with the questions related to the global perspective thinking, the response to unpredictability of human reaction under stress, and the impact of communication systems failure. In crisis management, the interest is to integrate different types of risk, the interactions between these risks at different levels to provide a dynamic complete picture that take into account all possible hazards and the phases of related planning including mitigation, preparedness, response, recovery after extreme event with the aim to express a structured solution. Automation, networking, systems integration and intelligent decision support improve the performance of complex decision, such typical for crisis management. The use of vague concepts is important in the context of uncertainty/ imprecise information and artificial methods (knowledge bases, fuzzy logic, multi-agent systems, natural language, genetic algorithms, and neural networks) could develop emerging capabilities that mimic human characteristics (approximate reasoning, intuition, and just plain common-sense). The main features of a dedicated DSS for crisis management are: real time data, efficient response, a user friendly interface to support decision makers that work in difficult conditions, a good quality of information, data recovery capabilities.

In the concept of Intelligent Decision Support Systems (IDSS) (Gadomski, 1998; Guerlain, Brown, 2000; Turban, 2004) are developed effective smart systems for problem solving and decision-making (Turban, 2004; Dahr, Stein, 1997) that deal with complex, imprecise and non-structured situations. IDSS are dynamic because they develop and implement more effective and productive support systems. The need for IDSS arrives from the growing need for relevant/effective DSS to deal with a dynamic, uncertain, complex management environment, the need to build context-tailored, not general purpose systems, the increased acceptance that intelligent technologies can improve decision quality and work productivity. In order to obtain an optimum solution, this type of DSS should be real-time, distributed, robust, and fault tolerant. The assistance process is provided by taking into account the elements or subsystems of high uncertain/ vague information in a changing dynamic and stochastic scenarios. The main generic capabilities are related to the independence from specific database management systems, the data fusion capability, the level of integration of resources management, the accuracy of the graphical interface, the way to detailed in time information, the use of post-action verification procedures and an efficient access to the technical documentation and history.

The critical need for the integration of intelligent ingredients in DSS is linked to the human decision makers limits: cognitive, economic, time and competitive demands. Both data management and knowledge management (facts and inference rules used for reasoning) are very important. The decision maker do needs a robust framework capable to capture imprecision, uncertainty, learn from the data/information and continuously optimize the solution by providing interpretable decision rules (Sousa, 2007).

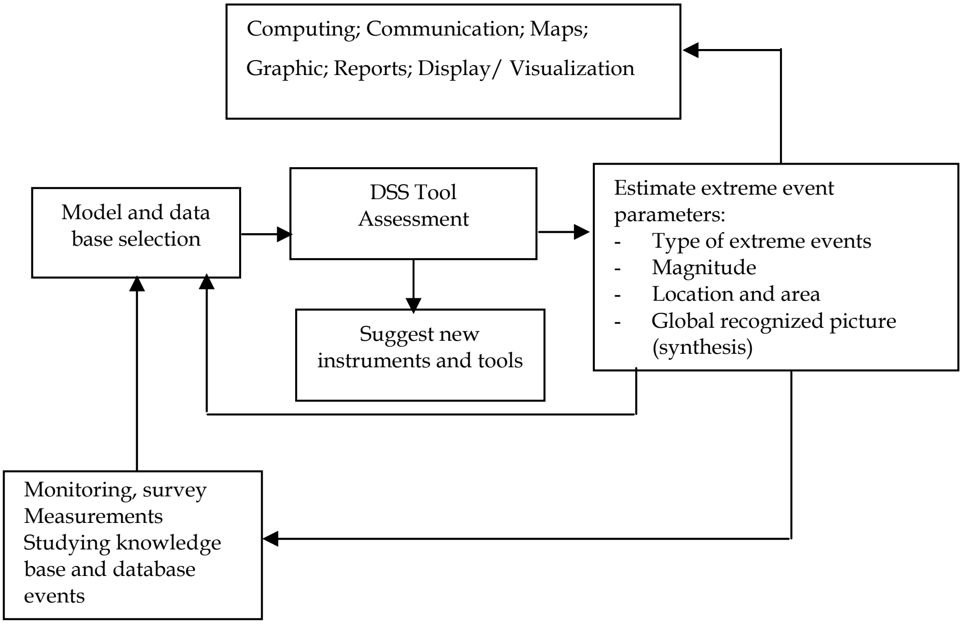

Fig. 2. Basic steps in building a DSS-ER/CM architecture

Fuzzy logic (FL)/fuzzy inference systems (FIS) applied to DSS provide formal methodology to capture valid patterns of reasoning about uncertainty. Artificial neural networks (ANN) use the capabilities of rule extraction from a trained network positions. Evolutionary Computing (EC) is a powerful global optimization instrument based on the simulation of evolution by iterative generation and alteration processes operating on a set of candidate solutions (Abraham, 2002). Due to the complementarities of these instruments (ANN, FIS, EC), the interest is to integrate various type of intelligent instruments to form a synergic integrated framework system.

ANN is defined by the architecture, the connection strength between neurons, node properties, learning rules and the objective function of the ANN represents the complete status of the network. After initialization, the learning process adapts the weights to changes for handling imprecise information. The training patterns can be thought of as a set of input pattern - output pattern pairs. The generalization represents the capability of the network to provide a correct matching in the form of output data for a set of previously unseen input data. In the Conjugate Gradient Algorithm (CGA) the search is proceeds along the conjugate gradient direction to determine the step size, which optimize the performance function along the line. The next search direction is determined so that it is conjugate to the previous search direction. The interest is to combine the new steepest descent direction with the previous search direction.

FIS are based on the concepts of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning. The architecture of FIS contains a rule base, which contains a selection of fuzzy rules; a database, which defines the membership functions used in the fuzzy rule; a reasoning mechanism, which performs the inference procedure. FIS employ different inference models: Mamdani-Assilian, with the rule consequence defined by fuzzy sets, Takagi-Sugeno, with an inference in which the conclusion of a fuzzy rule is constituted by a weighted linear combination of the crisp inputs.

EAs are population-based adaptive methods for optimization, based on the principles of natural selection and survival-of-the-fittest. This dynamics of populations could be expressed by:

$$x[t+1] = s(v(x[t])) \tag{3}$$

Fuzzy controllers use a model of the expert knowledge that specifies the most important properties of the process. Adaptation of FIS using evolutionary computations has been widely explored in the literature (Abraham, 2000).

The contingency management tool (CMT) is a distributed system based on fuzzy logic; knowledge based systems and distributed systems concepts that provide decision support for a global picture of critical situations. The advantages of using an intelligent decision support tool for contingency management, as the CMT, are: reduction of the global risk, an overall increase of efficiency and reliability, a global view of the recognized picture based on a better quality of information, DSS for human resources in real-time in critical situations, DSS for training and experimentation. The use of soft computing techniques is welcome because it results a better capability of selection, a higher speed of analysis, and also on adding the advantages of adaptability, flexibility, modularity.

Fuzzy set theory (Zadeh, 1965) is a generalization of the conventional set theory that provides a strict mathematical framework to deal with the uncertainty inherent to phenomena whose information is vague/ imprecise and allows its study with some precision and accuracy. Fuzzy logic allows expressing knowledge with linguistic concepts (Ross, 2004; Zimmermann, 1996) and provides a good way to express imprecision that is inherent in the vagueness of such concepts (Jackson, 1999; Ross, 2004). Expert Systems (Turban, 2004) proceeds knowledge intensive tasks to perform inference for determining a priority list of which subsystems should be fixed and in what sequence. In crisis management it is difficult to decide which systems should be fixed first. Expert Systems allow different reasoning processes such as the fuzzy multi-criteria. The advantage of using cooperation supported by communication networks enables the separation of data, the transparent access, the sharing of computational power, decentralized decision processes, thereby enabling the increase of robustness, redundancy and efficient resource usage (Sousa, 2006).

There are a lot of efficient applications of CMT: DSS for management of actions in crisis context, DSS for management of equipment repair priorities under disaster/emergency situations, DSS for in time advice on the selection of resources for increase reliability and prevention of failures/ incidents, human resource training for contingency situations. Any critical facility subject to extreme events is a possible candidate for using the CMT. The application for risk management responds to a hierarchical and distributed decision making process that offers a specific infrastructure (libraries, knowledge bases, databases, and inference engine) and a set of generic templates that reduce the time to market a customized application. CMT collects and compiles input information on the status of the subsystems and the dynamics of risks (Sousa, 2006).

The analysis of the performances of a DSS is very important because it offers the possibility to compare, to select, to update, to improve the knowledge (models, database), but also the time to response and the capability to adapt to rapidly changing conditions. The main performance parameters for an integrated DSS-ER/CM are focused on the following aspects:

- employ a naturalistic decision model (allow decision maker to characterize event size up information as a starting point; support user in recognizing a similar problem; support user in analyzing recognized case; support the user in customized the selected analogous problem to better fit the real time conditions; support the user in implementing the final decision as an efficient CoA);
- employ case based reasoning to take advantages of expertise and historical database experiences (implement an intelligent capability; implement a knowledge base of observation; allow flexible/ adaptable observation knowledge base modules; allow revision of observation);
- trigger recognition with partial characterization of an event is limited (allow fuzzy input; recognize an event with limited information; allow a mixture of known/ unknown information; fusion capabilities);
- use system parameters that end user is likely to have available (operate on a standard laptop/ PDA; the use of an Internet connection);
- establish a central network based capability for training and experimenting (establish an web based, game oriented version for multiple applications; implement a training mode; implement a capability to improve the performances to predict decisions from each web based training session; capture web based gaming statistics; implement a capability to improve the performance to predict decisions from each web based gaming session).

In Fig. 3 are presented a simplified view regarding the performances of a dedicated DSS for crisis management.

For a better efficiency, DSS - ER/CM should operate on a standard IT infrastructure (windows based PDA/ laptop, Internet connection) and will employ a user friendly GUI (Graphical User Interface). Once the application is downloaded (with known expertise condition), direct human interface with the system will be limited to interaction during performance. Output data are provided in typical reports (both for training and experimentation) designed by the user, according to the user preferences.

Maintenance will be provided through automatically updates accessible for different type of end users. Real time diagnostics should be performed by experts to ensure the properly operation, but no support equipment will be required (updates ensure that the performance is optimal via a permanent adaptation).

5. Applications regarding the use of DSS in extreme risk management

5.1 Applications of DSS in flood risk management

Flood risk is the most frequent extreme risk event especially in the last decades. Modelling flood dynamics could be expressed by a warning system as a technical way to reduce flood risks, but also to manage adverse situations. The potential benefit of a flood forecast depends on the accuracy/precision of data/ models, the efficiency of users to build decision based on the large spectrum of information for monitoring and warning, the efficiency of operation for protection and evacuation. The situation could change the thinking of risk manager and real time information is not sufficient because a huge quantity of data should be fused, filtered and proceeded.

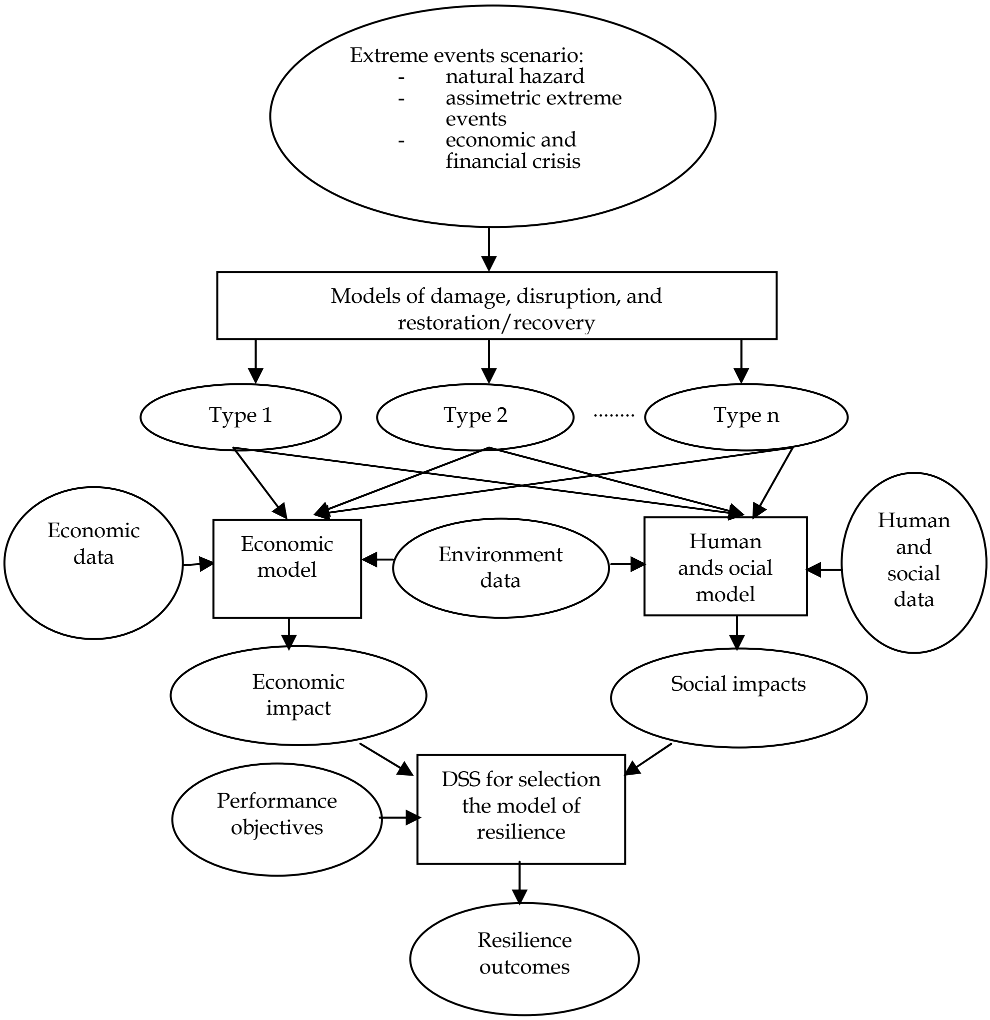

Fig. 3. The performances of dedicated DSS-ER/CM

The classic literature on prediction of flooded areas was focused mainly on deterministic models. A new branch of literature uses soft computing (especially artificial neural networks - ANN) to simulate the critical level or the dynamics of flood in a real-time monitoring framework. ANN is an empirical modelling instrument that has an ability to identify highly complex relationships input - output in a black box type model which does not require detailed information about the system. Nevertheless it learns about the relationship between input parameters and controlled and uncontrolled variables by studying previously recorded data. The advantages of ANN lie in its ability to handle huge quantity of data from nonlinear dynamical systems and, especially, when relationships are not fully understood.

The advantage of DSS in modelling flood risk management is given by its interactive nature, flexibility in approach and also on the capability to provide graphic interfaces. It also allows the identification of the critical training/testing of the model by simulating different input data. The use of DSS is efficient in the estimation of the critical level of flood warning. Flood warning system (FWS) based on DSS can immediately inform the people living downstream to take precautions and evacuation/rescue before the event. The FWS developed by the Khetchaturat and Kanbei is based on the following steps: the selection of areas that flood frequently occurred; prototype system design and data modelling flood phenomenon; the development of an early warning network between the web server and users in the area via the Internet; the development of DSS for flooding. In this framework, the authors had obtained good results.

DSS-ANN for flood crisis management is represented by a parallel, distributed processing structure composed of three layers: an input layer for data collection, an output layer used to produce an adequate response to entry, and intermediate layers capable to act as a collection of features detected. Network topology consists of a set of neurons connected by links and organized in layers. Each node in a layer receives and processes weighted input from the previous layer and sends its output to nodes in the next layer through links. For each link is assigned a weight that represents an estimator of the force connection. Weighted summation of inputs is converted to output according to the transfer function.

DSS-ANN for flood warning is efficient in the monitoring process of a flood risk zone, meaning that the orderly evacuation can occur before the actual onset of flooding and require long term sustainability. Integrating human knowledge with modelling tools lead to the development of DSS-ANN to assist decision makers during the different phases of flood management. DSS-ANN is developed as a planning tool to address both virtual and specialists, but also all those who have different positions in the management of flood risk management and also contributes to the selection of the options to reduce damages (using an expert system approach), forecasting floods (using ANN), and modelling operations according to the impact of flooding.

5.2 Applications of DSS in drought risk management

Drought is another extreme event with a major impact on economic, social, and environment. In this case, management is only a reactive one. DSS tools should address multiple risks related and, also, build the global picture of vulnerable areas to effectively manage this type of events. In the literature are presented different frameworks based on DSS instruments to help farmers to assess this type of risk. In the classic architecture built on four levels (knowledge, information, data, and presentation), experts use the knowledge base as a tool to express the interpretations of the problem and permits the interaction with users in a simple way. Knowledge base used to develop specific knowledge domain includes sequential techniques, data mining, modelling and simulation techniques, and other innovative knowledge-based models.

DSS based on geo-spatial information provides real-time drought assessment, in an easily accessible online interface. The algorithms based on data mining permits an effective identification of the correlation between global climate events and local drought conditions. Methods based on knowledge discovery in DSS are based on association rules that identify relationships between the influenced parameters. Association rules are easy to understand; experts in the field can use this joint decision making process. This framework enables each level to make application for any lower level using an open standard interface. For example,

the database knowledge permits the construction of a drought index. If data base are limited, data layer can retrieve data from relational databases to distributed space and standard queries on the data layer to give a response to the request higher.
Web-based DSS is another interesting instrument for drought risk management. It provides information for farmers, experts, end users, capable to improve the efficiency by allowing resources to better manage this type of risks.

5.3 Applications of DSS in asymmetric extreme risk management

Asymmetric threats refer to weapons/tactics used to circumvent the technological superiority and include the use of surprise or the use of weapons/tactics in an unplanned/unexpected manner. Asymmetry is present on each side: open information on the potential targets/victims, versus highly secretive, compartmentalized behaviour of terrorists. Asymmetric attacks exploit vulnerabilities outside of the accepted laws arm conflicts. Terrorism is the main asymmetric threat and represents a calculated use of violence to destroy human life and critical infrastructure/key resources or/and inoculate fear for intimidation societies. The specific characteristics of terrorist threat are related to the key role of uncertainty, limited deterrence, and the private - public good nature for providing security. A key feature is represented by the generalized, diffused nature of it (where, when and how terrorist may strike) also linked to the degree of uncertainty. If the authorities had advance knowledge of the timing and location of a future asymmetric attack, actually thwarting it would be a relatively minor affair, involving the deployment of limited police/military power. Antiterrorism represents the defensive measures to reduce the vulnerability of people and property, while counter-terrorism represents the offensive response to prevent, deter, and interdict terrorist tasks.
Operational trends are continuously changing. The technological evolution increase the knowledge of the operational theatre and the speed of response, but a huge load of uncertain data and information generated by environment still remains a problem. DSS is a computerized system capable to complement human decision in the context of human limitations. Situation awareness (SA) is essential for decision makers and the improvement of decisional process enhances also the performance of SA via the concept of the right information, at the right place, at the right time (Endsley, 2005). In the literature, there are presented solutions on contextualized user centric task oriented knowledge services (web and portal techniques) and the progress on visualization and human computer interaction devices. A new architecture developed along with information management concept and typical mechanism for special forces to effectively interoperate with IT between joint environments and with different other government departments. The critical issues (common data and service access, information exchange/ sharing, infrastructure security, privacy/ confidentiality) should be also integrated in this architecture.
MUSKETEER (MUlti environment decision Support and Knowledge Exploitation TErrorism Emergency Responses) is a complex program capable to identify, refine, develop, and integrate decision support and knowledge exploitation tools and demonstrate the efficiency of improving, the forces ability to respond to the asymmetric attacks. The interest is to build a framework to support the creation maintenance and sharing SA (common operational picture – COP, and to assist complex problem solving and decision making at different levels and different locations).

5.4 Applications for crisis management exercises (DSS-CME)

The objectives of CME are: to enhance the efficiency and operability of structure in crisis situations; to enhance the capability of all actors involved and their confidence to act adequately in crisis situations; team-building – partners should trust one another in terms of communications and valuable contacts are facilitated and consolidated; capabilities to gain additional awareness of the necessity for collaboration; it permits the identification of vulnerabilities of strategies; CME reveal where and when it is necessary to work together; it permits the identification of vulnerabilities in interdependencies of critical infrastructures across sectors; training for design new structures concepts and measures of performances.

The content and form of exercises depend on the type of extreme risks involved, the level of exercise, and the types of actors involved.

a. Discussions based exercises address possible mechanism, processes, plans and policies for any given DSS-CME on a theoretical level. Procedures and possible solutions are analyzed and different strategies are compared. Even if these exercises are less about testing existing procedures, then developing new responses to crises they imply the introducing a new innovative topics.
b. Action oriented exercises are focused on realistic scenarios and represents an important experience for actors, because it permits the identification the deficiencies. This type of CME provides an interesting way for intensive training at very low resources.
c. Target oriented levels of CME:
   - in implementation level mechanism are clearly organized; it is easy to be implemented in a real world situations;
   - in tactical exercises the priorities are coordination, collaboration, and decision making, including joint-exercises;
   - the strategic exercises is focused on the interaction between the organizations involved and the complex decision associated.

CME are efficient because they permit an important gain of knowledge with very low allocated resources. In the case of formation of decision makers the exercises begin with simple basic, low level of complexity exercises with the interest to test the efficiency of communication channels. Next step is to add value through more complex exercises, including networking and joint-exercises.

6. Conclusion

There is an emerging interest for different applications of DSS in critical decision making for extreme risk and crisis management. The nature of DSS tools have changed significantly and are equipped now with a variety of intelligent tools such as graphics, visual interactive modeling, artificial intelligence techniques, fuzzy sets, and genetic algorithms that adds new capabilities, well adapted for extreme risk and crisis management. The focus is to demonstrate the efficiency of using DSS in an extended list of applications, including all the phases in the management of natural hazards, terrorism, technological accidents, but also financial crises and multiple crises. All these problems should be treated in a multidisciplinary, modular and scalable framework, flexible, adaptive, and robust. This framework should be also design in a friendly manner, so that users can input new data/task easily. DSS-ER/CM is flexible so that new risks and impact functions can be easily incorporated by users and it should incorporate also financial-economic modules. In this philosophy, DSS-ER/CM could improve decision making process in extreme risk management with impact on the global efficiency in multiple crises management.

DSS-ERM/CM supports real time decisions based on a high number of parameters and criteria, where knowledge is expressed using vague and uncertain concepts, difficult to asses for human knowledge. Fuzzy logic, artificial neural networks, genetic algorithms are appropriate ingredients capable to support the objective to represent human knowledge. An innovative solution is the integration of the contingency management tool (CMT), a powerful knowledge-based system tool. To cope with the need of decentralised decision-making, it requires the development of an inherently distributed system. DSS mixed with CMT system ingredient enables the following features: the support decision under critical situations reducing the risk of questionable decisions; risk reduction through preventive actions; increased level of response supported by better training; it overcomes critical cases when experts are not available; give the information availability for an effective support to decision makers with a global perspective, in real time. The use of CMT in extreme risk management responds efficiently to a hierarchical and distributed decision making process that offers a specific infrastructure (libraries, knowledge bases, databases, and inference engine) and a set of generic templates capable to reduce the time to market a customized application. In this philosophy, DSS-ERM could improve decision making process in extreme risk management with impact on the global efficiency in multiple crises management.

In this chapter are presented the aspects regarding the integration of the concept of hybrid DSS in the treatment of extreme risk management. The critical need for a more efficient use of intelligent ingredients in DSS is linked to the human decision makers limits: cognitive, economic, time and competitive demands. Both data management and knowledge management (facts and inference rules used for reasoning) are very important and decision makers need a better framework, capable to capture imprecision or uncertainty. More than that they learn from the data/information and optimize the solution in order to provide interpretable decision rules. In chapter four some applications for the use of hybrid DSS in flood and drought, asymmetric extreme risk management together with the treatment of crisis management exercises (CME) are also presented. Future work should be more focused on the valuation of these types of frameworks in a way that permits better networking capabilities, costs reduction and the minimizing of the duration for periodic updates.

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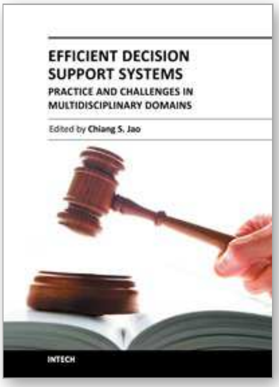

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