DMT-EOC - AN INTEGRATED APPROACH FOR TRAINING AND DECISION SUPPORT OF EOC MEMBERS

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ABSTRACT

To minimize loss of life the first three days after an earthquake are the most important and therefore demand the right decisions in a very complex environment. Beside the resulting responsibility and the time pressure members of an emergency operation centres (EOC) have to make their decisions on the base of limited, uncertain and dynamically changing information. A result of the work in the Collaborative Research Center (CRC) 461: “Strong Earthquakes: A Challenge for Geosciences and Civil Engineering” is the Disaster Management Tool (DMT). One of its modules, the DMT-EOC, deals with these problems by providing a training environment for table top exercises (EOC-TRAINER) and assistance for EOC members after a real earthquake disaster (EOC-ADVISOR).

A major goal during the conception of the system was the development of a flexible and extendible architecture able to integrate different concepts and programming interfaces. The system provides a simulation to serve as environment for the exercises as well as a background for the evaluation of real decisions. The EOC-ADVISOR additionally combines operation research approaches for an optimal resource allocation with the reviewing of user decision by a rule-based evaluation using a multi-agent system (MAS). The decision support is based on the Recognition-Primed Decision (RPD) model, an approach to describe the natural decision-making process of persons in the disaster response domain. The paper gives an overview of the models behind the system components and their implementation.

INTRODUCTION

After earthquake disasters in urban areas with a substantial destruction response teams are often overstrained with the typical course of events. To limit human losses they need the support of an emergency operation centre (EOC), which should provide an effective and integrated disaster management. As the example of Hurricane Katrina showed, this often turns out to be a major problem not only of under-developed countries. The causes for the problems are manifold but missing experience with the handling of disasters and shortcomings in information processing as well as coordination are typical problems. The disaster management tool DMT developed in the German Collaborative Research Center 461: “Strong Earthquakes, a Challenge for Geosciences and Civil Engineering” tries to meet these problems (Gehbauer et.al., 2007). This paper describes some components of the DMT developed to support the response operations in an EOC.

While members of an EOC are specialist in their domain their training and experience are mostly based on day-to-day business. But disasters demand other procedures as well as the coordination with other organisations and the decision-making in a very complex situation. The DMT presents different approaches to improve the decision-making of EOC members in disaster situations: (1) Support Training in regular and demanding sessions; (2) Enhancing communication and information distribution; (3) Providing help with information processing; (4) Supporting the decision-making process with active and passive advice. These approaches build the DMT-EOC component with its modules EOC-TRAINER and EOC-ADVISOR described in this paper and the EOC-MIS (Management Information System) not discussed (cf. Werder, 2007).

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This paper discusses the advantages of computer-based training sessions and how software tools can help decision-makers by systematically supporting their decision-making process. It starts with an overview of the system architecture and then discusses the use of the EOC-TRAINER component for exercises. The main part deals with the decision support component EOC-ADVISOR describing the integration of the computer-based support in a human decision-making process.

**SYSTEM ARCHITECTURE**

The system is designed to allow the arbitrarily addition and removal of components depending on its usage. While the simulation is used for decision support as well as training, there is a clear distinction between the real world and simulation. Everything connected to the real world is implemented in the agent environment. Anything covering the simulated world runs in the simulation environment. A special Mediator Agent establishes the connection between simulation and agents and steers the simulation.

The architecture of DMT-EOC can be divided into three elements: simulation, decision support and a user interface for the human computer interaction (HCI) (Figure 1). The modular and distributed design of all elements of the system allows an easy integration of new functionalities and configuration for different tasks. To ensure the interoperability of the system components, the system provides a common database to store static and dynamic data as well as an XML-based standard format for information exchange DMT-IXS (DMT-Information Exchange Standard). Especially the DMT-IXS format allows an easy integration of external components based on different programming languages or development frameworks.

DMT-IXS format defines an XML Schema (XSD) a data format and rules encoding of information. It integrates the ideas of different XML-based communication standards for disaster management, namely MayDayML in the MESA Project (www.projectmesa.org) and CAP (Common Alerting Protocol) and EDXL (Emergency Data Exchange Language) from the OASIS (www.oasis-open.org) consortium. DMT-IXS has some differences and
extensions to these standards but the integration of a system based on these standards can easily be made. As all system components of the DMT use the DMT-IXS format, agents receive the same type of message from a response resource, regardless if it is simulated or a real-world resource. This ensures interoperability with non-agent based systems like the Field Unit Expert System or the Simulators.

Agents

The agent environment is implemented as a multi-agent system (MAS). Its framework follows the FIPA Agent Management Specification (www.fipa.org), which defines the physical infrastructure for an Agent Platform (AP) in which agents can be deployed and consist. The Agent Management System (AMS) is mandatory for every AP. It has supervisory control over the access and use of the AP and offers white pages services to other agents. Additionally, the Directory Facilitator (DF) provides yellow pages services so agents may register their services with the DF or query the DF to find services offered by other agents. There are three types of agents:

- **Interface Agents** are responsible for the human-computer interaction and visualize the results of the simulation and the advice of the decision support agents. Depending on their task they have different capabilities. While the EOC agents include a geographic information system (GIS), an interface for the decision support and a messaging tool, the agents for field units only consist of the messaging tool for receiving orders and sending reports.

- Each **Mediator Agent** represents a simulation in a multi-agent environment. It translates messages from the agent to the simulation environment and vice versa. The Mediator Agent sends a message from a simulated response resource in the same format as an interface agent of a real world resource would do. Therefore, simulated and real resources can be mixed for training applications. A **Proxy Agent** doesn’t translate messages but receives and sends them in the XML-Format of the DMT. Its only task is to distribute messages between different environments, e.g. the FIPA-ACL environment and an E-Mail service.

- The **Decision Support Agents** are response-related and combines the Belief-Desire-Intension (BDI) concept with an inference engine. The BDI approach was very much influenced by Bratman (Bratman, 1987) and software agents following this paradigm have been applied successfully to different real world problems such as the fault diagnosis for the space shuttle or air-traffic management (Ingrand et al., 1992). A BDI-agent pursues its given goals (desires), adopting appropriate plans (intentions) according to its current set of data (beliefs) about the state of the world. An inference engine uses expert knowledge stored in a rule base (or knowledge base) with inference rules. Based on these rules information about the current situation is analysed by forward chaining, an approach typically used in expert systems (Jackson, 1999). The rule base and the plan library are based on the analysis of emergency plans and standard operation procedures as well as expert surveys. Depending on the input an agent chooses to process it (1) by an elementary layer including methods for information which can be handled directly, (2) a planning layer including plans and rules which are solely based on the agent’s deliberation and (3) a co-operation layer which handles situations that requires co-ordination with other agents. The currently implemented decision support agents for EOC members can be seen in Figure 2. They provide their advice as a kind of service which can be inquired by a human decision-maker by the Interface Agents. The **Decision Support Agents** continuously evaluate the situation in the disaster environment autonomously to keep track of the dynamic changes, even without interaction with a human.
As described later these three agent types collaborate to provide the decision support of EOC members.

Simulation

The simulation reproduces the dynamic aspects of the disaster world and the response operations of the resources. It is realised by an interaction between resource simulators and environment simulators, e.g. fire fighting is an interaction between the fire simulator and the fire brigade simulator. The platform of the simulation environment is the High Level Architecture (HLA).

Figure 2. The system architecture

HLA was developed by the Defense Modeling and Simulation Office (DMSO) of Department of Defense (DoD) with the main goal of building a platform for war gaming and training taking into account the interoperability and reuse of different simulation components. It is an approved platform for distributed simulations and since 2000 an Institute of Electrical and Electronics Engineers standard. For each simulation the Run Time Infrastructure (RTI) provides the central service for the interaction of the simulators. These services include, for example, management, data distribution or time management. The RTI defined is the central component of an HLA-based simulation which transfers all communication flow between the simulators (for more details see Institute of Electrical and Electronics Engineers (IEEE), 2000). HLA is mainly considered a standard for simulation-based military training (Lolar 2002; Sjöström et al., 2003). Nevertheless, some simulators for comparable fields like logistics (Reyns et al., 1998), emergency medical treatment (Pettitt et al., 1998) or natural environment modelling (Gerrard et al., 1999) have been developed. More recently there have been increasing efforts to apply HLA to civilian domains, such as traffic and logistics (Strassburger, 2001) or emergency management (Klein, 2001). In the simulation environment two types of simulators can be distinguished, the environment and the resource simulators.

The disaster environment simulators provide a realistic representation of the area struck by a disaster. Broadly speaking, they describe how the disaster situation would proceed if no further response activities were initiated. These simulators have complete knowledge of the actual situation including, for instance, real damage states of buildings or health states of injured and trapped persons. Therefore, the world resulting from these simulators can be specified as the Complete Information World (CIW):

- The earthquake simulation EQSIM is based on the capacity-spectrum-method (Fiedrich, 2002) to estimate building damages, which provide the input for training scenarios or initial damage estimation after real disasters for an EOC.
The casualty simulator models the health state of injured persons. The initial health state depends on the location of a person in a collapsed building and is decreased depending on the state of the rescue operation, e.g. if the person is trapped (Coburn et al., 1991), rescued or on the way to a hospital.

The Fire simulator uses an approach comparable to Takai (Takai, 1999) consisting of three physical models which calculate (1) the way fire spreads within a burning building, (2) the possibility of neighbouring buildings catching fire and (3) the extinguishing process from fire fighting (Torvi et al., 2001).

The resource simulators consist of federates for air and ground reconnaissance, SAR-teams, fire fighting units, construction machinery for road clearance and support for SAR-teams and ambulances for the transport of the injured persons (see Figure 2). As the simulators represent units in the field they have limited access to the information provided by the environment simulators. Each single resource has a sight radius in which it can sense the disaster world at a specific resolution. The assignment of tasks to the resources can only be initiated by external stimuli such as orders by EOC members. The subsequent operations such as movement and resource work at the assigned areas are simulated within the resource simulators according to technical specifications (for more details see Fiedrich et al. 2000).

The resulting information from the simulators combined with a pre-disaster database leads to an Incomplete Information World (IIW). This mimics a real disaster situation for members of EOC during an exercise. It is needless to say that the evaluation of user decisions during a real disaster is based on the information of the CIW, while the results of such simulations are still very uncertain because the initial information for such a simulation already represents an incomplete view to the real disaster situation.

EOC EXERCISE

Three different types of exercises for EOC members can be distinguished. (1) Table top exercises are run by a facilitator and they usually have a master event list. This list comprises more or less independent general problem statements and the participants discuss possible actions without time pressure. (2) Functional exercises are used to test one or more emergency functions in real time. Therefore, the input is made via messages and the consequences of the decisions are estimated by experts located in separate rooms. Exercises of these two types are inexpensive but the main problem is the limited dynamics for dealing with unforeseen actions and the need for rational and scientifically sound experts. (3) Real time field exercises are more realistic because they include field personnel as well as EOC staff. The communication flow and the participants are the same as in a real disaster. Although very realistic, these exercises are rather rare, because they are very expensive and time consuming in preparation. Therefore, virtual training for emergency response is getting more and more popular, but its application is far from common (Jain, 2003). The use of dynamic, virtual environments has, however, been part of military training for some time.

Exercise with the DMT

The EOC-TRAINER provides a virtual training environment for real time exercises of an EOC. By replacing missing field personnel with simulated response units it generates a virtual real time exercise without having the need of a full scale exercise. The major advantage is the universal facility of mixing real world and simulation during the training exercises. Because field exercises are very expensive fewer real teams will be practicing during a typical exercise, normally not enough to stretch the members of an EOC like it would be in a real disaster situation. For such cases additional resource simulators must be added to make the experience more realistic. So the EOC members can train their
communication with real humans and also practice their decision-making under realistic conditions.

The integration of exercise and disaster response like in DMT-EOC also bears practical advantages. From an economical point of view it is cheaper to be able to integrate training abilities in an existing system for disaster response. In addition the user acceptance for a system will be much higher if they already know it from practical exercises instead of having to take special courses for it. The adaptability of a system also allows its use in day-to-day business and regular use of a software system ensures its steady advancement and modification to current necessities.

DECISION SUPPORT FOR EOC MEMBERS

Decision-making during disasters is marked by key features like dynamic conditions, uncertain and missing data, time pressure and the need for real-time reaction, ill-defined tasks and goals as well as significant consequences for mistakes. The EOC-ADVISOR supports the planning process of EOC personnel during the response phase. Typical functions of EOC members include a huge variety of different responsibilities such as the declaration of a local emergency, dissemination of emergency information to the public, resource tracking, etc. The advice functions of the agents are more or less related to the topic of resource management. Beside the presentation of the techniques used in EOC-ADVISOR the following section will review the current range of realistically applicable computer-based decision support for disaster management from the authors’ view.

Decision-making in disaster management

To build a decision support system for an EOC it should first be considered how humans make their decisions to understand what needs they may have. Taking a look at different models describing human decision-making processes in command and control (C2) environment two approaches can be identified. The first ones are analytical models describing decision-making as an analytical process where the problem and/or different solutions are analysed in detail to find a proven optimal result. Examples for this approach are the Multi-Attribute Utility Analysis (MAUA) and the Decision Analysis. The second ones are recognitional strategies in which the decisions are based on the application of the experience of the decision-maker with similar situations. The Recognition-Primed Decision (RPD) model can be assigned to this type (Klein, 1997).

To choose the right support for the decision-makers in an EOC it has to be determined which model matches their decision-making strategy. As Klein developed the RPD based on the experiences of commanders in the fireground environment it seems that this matches the situation after an earthquake. But as the situation in an EOC does not seem as stressful as in the field, it could be assumed that an analytical process is also possible. What speaks in favour of the use of the RPD model is the stress resulting from the time pressure in which a solution must be found and from the responsibility for many lives. In additional, the decision-makers in an EOC are generally former field commanders and therefore they are used to this decision-making process. Both facts have been approved in interviews with EOC members and personnel of a training facility for disaster management in Germany.

Decision-makers in an EOC are usually domain experts with many years of experience. But the management of an extensive disaster like a major earthquake will most likely be a task that exceeds their abilities. Computer systems could be used to provide adequate support. To see which specific tasks need to be supported, the following section will describe the RPD model before discussing where computers can assist decision-makers and can help to improve the quality of decisions.
The RPD model is based on the assumption that domain experts make decisions without performing rather time-consuming analyses. Instead they rely on their ability to recognise and classify a situation. Based on this they are able to find a matching workable and efficient solution in a timely manner. Especially time is an important factor in decision-making after disasters because acting too late may result in an out-of-control situation and have a direct impact on the number of victims. So time is a key feature for the design of the decision support system. Figure 3 shows the RPD model. It consists of two parts: recognition and evaluation.

In the recognition phase the decision-maker tries to develop situational awareness and to recognise similar events. If no instant match can be found further diagnosis of the situation is needed. The model states two typical strategies for this, feature matching and story building. In the feature match the decision-maker tries to match the information describing the current situation with pattern of cues from his experience. If matches found are inadequate, due to the lack of experience or a unique situation, story building strategies may help to construct an explanation. The observed cues of the current situation are coherently linked together. This builds sets of hypothetical stories in the mind of the decision-maker which are then compared to the observed events to find the most probable explanation.

The recognition process has four results: (1) Relevant cues are identified in the recognition phase and describe what to pay attention to in the recognised situation. (2) Based on the situation there are plausible goals which should or could be achieved. (3) A course of actions is recognised which will reach the goals. (4) Expectancies about what should change in which way and what should happen. The expectancies serve as a way to monitor whether current recognition is still reasonable. Changes in the environment or new information could lead to the result that the current chosen recognition might not match the situation and has to be changed or modified. To clarify such an anomaly the diagnosis has to be repeated as it is influenced by the changing parameters and the input of new information.

Before the course of action defined by the recognition can be implemented the decision-maker tests it. He mentally simulates the actions and their possible results. If this evaluation of the actions shows resolvable problems he modifies them and tests again. In case of a severe mismatch the decision-maker might chose a different course of action based on the
current recognition or he examines a new one. The evaluation process only checks for plausibility ("Does it works?") and not for quality ("How well does it works?"), a point where a computer system may improve this evaluation.

Depending on the complexity of the problem steps in the recognition or evaluation are skipped. If the situation is directly recognised and the reaction is obvious, we have a simple match in which the recognition and evaluation are left out and the course of actions is implemented directly. Another possibility is that the decision-maker instantly recognises a similar situation but has to modify his solution slightly. In this case he skips the recognition and develops the course of action by modifying the solution in the evaluation phase.

**Computer based decision support**

After taking a look at the human decision-making the question remains how computers can support this process. Agent technologies enable the design of software that can reason autonomously (Boden, 1994) and thus provide an opportunity for intelligent decision support. There are a number of approaches which try to apply agent technology to areas relevant to emergency response, including earthquake disaster response (Tadokoro et al., 2000), forest and bush fire firefighting (Au, 2000; Jaber et al., 2001) and flood management (Molina and Blasco, 2003). The RPD model was also the starting point for several research approaches. Liang (Liang et al., 2001) used neural networks to represent experiences during the feature matching process. There are also attempts to use agent technologies in combination with the RPD model to simulate human behaviour (Sokolowski, 2003) or to provide support for decision-making in teams (Yen, 2005).

So far these approaches are not able to improvise on given situations and can’t replace a human as decision-maker during a real disaster. Beside the fact that orders from computers will not be easily accepted by humans, there are problems in the interaction between man and machine. Especially between the domains involved in disaster management misunderstandings due to different terms and abbreviations is a typical problem. In addition so far the scope of computer systems is limited to specific problems and can not be adapted to unforeseen situations. Going back to the RPD modelling all aspects of decision-making for a specific domain create the need to compile huge knowledge bases. Especially the modelling of the story-building aspect seems to be a problem because as till now a machine cannot match a human in the ability to improvise and adapt to a new situation.

Following all this, it does not seem reasonable to replace a human decision-maker or elements of his decision-making by currently available software. This fact is supported by discussions of the author with decision-makers in the emergency response which identified two potential sources of problems with computer-based support systems:

1. **Blind trust**: Users accept a system and develop a blind trust in its advice. A simple example is the experience in control centres for fire brigades in Germany. Depending on the keywords extracted from a situation description the system automatically generates a combination of response units based on the standard operating procedures. In most cases these suggestions are accepted without further consideration. This may be appropriate for most situations but may also result in inefficient decisions because the system does not have access to or does not consider all facts.

2. **Missing acceptance**: Others users do not accept computers in general or do not trust in their ability to provide help. Possible causes for this are that they are not used to working with computers or they have experienced ill-designed systems. Apart from this the idea that computer systems may replace humans is often present. Therefore, in order to ensure user acceptance, it is important to introduce computer-based support carefully and step by step.
As a conclusion to what is technically feasible and what is reasonable from the practical point of view, it seems clear that a decision support system for an EOC shouldn’t provide solutions that a human can implement directly. Instead, EOC-ADVISOR supports the phases of the decision-making process. The RPD model serves as a guideline for elements that needs to be supported as well as their order and interdependencies. As this includes varied tasks, different types of interaction models are used ranging from active advice giving to a more passive criticising or an evaluation of decisions.

**Decision support based on the RPD model**

To decide what should be supported the strengths as well as the weaknesses of computers and humans have to be considered. In general, computers are unbeatable in computing power for well structured problems and they are uninfluenced by feelings. Humans in contrast are far better at improvising and adapting to unknown situations by relying more or less on their feelings and instincts.

The situation in an EOC seems predestined for an extensive computer-based support as computer systems could easily being provided in most cases. Command centres often already have special rooms equipped with or prepared for computer systems and even mobile command centres e.g. in trucks existing. Beside this a computer system provides information EOC members would need anyway like a map to review the situation and a messaging system for communication. If such software is accepted it is a small step to simple decision support components providing automatic processing of incoming information and more complex systems giving advice to users or evaluating their decisions.

In the DMT-EOC the EOC-MIS provides a user interface with messaging, map support as well as context sensitive information filtering. It builds the foundation for the interface of the EOC-ADVISOR. Its concept is to support the user according to the phases of a decision-making process based on the RPD model. Figure 4 gives an overview of the methods used in the EOC-ADVISOR. While it focuses on the resource allocation during response operations after earthquakes it could easily be adapted to other disasters and tasks as well.
Recognition

The requirements for support during the recognition phase depend on the time that has passed after the initial disaster event. While the first hours are affected by the uncertainty about the situation, an overflow of incoming information is the major problem later on.

To deal with the initial uncertainty a simulation of the disaster is useful. Earthquake parameters available minutes after the earthquake event can be used to calculate initial damage estimates. The EQSIM component of the DMT provides a classification of the expected damages for each single building (Baur et al., 2001). Based on this information the planning process for the resource allocation can start earlier and planning of reconnaissance operations can be optimised. When the load of incoming information increases filtering and information processing techniques support the user. The electronic messaging system linked with a GIS includes context-sensitive message filtering, for example only showing information for a specific unit or area on the map. The enrichment of a map with information allows a more efficient access. Combined with the filtering a decision-maker can focus on the information relevant to his current problem.

The evaluation of the reports from an operation area depends on the general situation as well as the assignment and the goals of the person analysing them. For the EOC-ADVISOR a diagram used in the crisis management in Germany (Figure 5) is taken as inspiration. For an operation area it lists sources of danger and objects that could be affected (Knorr, 2000). Realised as an electronic score card it helps the decision-maker to keep track of the situation in each operation area and to allocate the available resources. Additionally the matrix quantifies the situation evaluation of the user and makes them accessible for the decision support agents which are limit in their abilities to extract information from a message in natural language.

As an initial step to use the matrix evaluation it must be configured. A user can enter his priorities or select from presets available for different functions in an EOC. The importance of things that could be affected (lines in diagram) is rated on a scale between “less important” and “very important”. After configured each new operation area gets its own evaluation matrix. The fields in the matrix are filled out in a cooperative process between the user and the system by evaluating messages containing reports about the situation in the operation area. The system provides automatic evaluations by predefined scores for special events stored in its rule base or determine the evaluation by appropriate BDI methods. Examples are the risk for persons inside a damaged building and fire propagation. The risk for persons is evaluated depending on the building damage, its occupation class and the time at which the disaster took place. For the fire propagation the decision support agent starts simulations and analyses their result.

For the additional content the system questions the user in a structured way taking into account dependencies between the sources of danger. For example a detected fire may lead to questions about a potential explosion and the risk for an explosion may lead to a risk for a building collapse. The automatic system evaluation and the structured questioning lead to a low expense for the user in the situation evaluation. Beside the fact that the user gets a better overview of the risks in his operation areas by looking at the colour keyed matrix (Figure 5), it allows the collaboration in the situation evaluation between EOC members. This helps achieving a common situational awareness.

Based on this risk assessment the operation areas can be prioritised. Some risk factors have a positive effect on the priority and others have a negative or no affect. The fire propagation and the injury risk for persons are examples for positive factors regarding the priority for fire brigades, while a high risk for an explosion is negative for SAR teams. The influence of the different risk factors on the priority calculation depends on the domain of the decision-maker.
Based on this calculation operation areas are grouped to one of four priority levels. Giving no exact ranking avoids a misplaced trust in the result and still forces the EOC member to make his own evaluation. The boundaries between the priority levels are dynamic, ranging between minimum lower and maximum upper values. Amongst other facts the number of operation areas and the available resources are taken into account. Based on this information the decision-maker has to choose the operation area which he rates to be the most urgent.

![Sources of danger matrix](image)

**Recognition products**

The results of the recognition phase are **cues, actions, goals and expectation**. The priorities for the different operation areas based on the current information are the cues of the decision-maker. The actions he takes are the allocation of resources to the different operation areas. His goal is to archive an optimal result with the available resources. A model for the expectations of the decision-maker is a matter of the ongoing research. Based on this expectation model it will be possible for the decision support system to monitor anomalies.

Concerning the development of actions the system provides support for the allocation of resources to operation areas. As precise suggestions on actions may seduce an unquestioned adoption the system only provides a selection of available resources that matches the situation. The decision-maker still has to decide the detailed compilation. In this process sources of risk are accounted for, too. Examples are a fire with respiratory toxins where fire brigades with breathing protection equipment will be recommended or a collapsed reinforced concrete building where SAR teams with special equipment are recommended. The system also tries to select the resources with the shortest and least risky routes to the operation area. But the final decision is still the responsibility of the decision-maker, who may even select units that are not in the proposed list.

**Evaluation and Implementation**

As last step before sending the response resources to the different operation areas the decision-maker reviews his actions. The system supports him with criticism on possible mistakes and with the ability to simulate potential consequences.
Critique of user actions is an unobtrusive interaction mode for a decision support system (Guerlain et al., 1999). The system tests the chosen units with different methods to give comments on possible mistakes. First it checks the rule base for violations based on the risks matrix of the operation area where the unit is allocated and general situational rules. Examples are the breathing protection and special SAR equipment given in the last paragraph. The system also checks whether the units have access to the operation areas. If matching simulators for the allocated resource types exists the decision support agent use them to check the deployment of the units for potential problems and plausibility, e.g. if a blocked road could be cleared with the deployed resources or if additional equipment is required.

If simulators are available the decision-maker can review the results of simulations by himself and compare different courses of action. This computer support for the mental simulation of user actions adds a qualitative element to the evaluation phase, as the decision-maker is able to test different strategies for the given situation to find the best matching solution.

Based on the result of the simulations and the criticism of the system the decision-maker may choose to implement his course of action directly, modify it or even choose a new one.

As an electronic messaging system is integrated in the DMT-EOC the user just has to acknowledge his chosen actions and appropriate orders are automatically sent to the selected resources. The recognition phase will start again with the processing of the information of new incoming messages.

CONCLUSION

The paper presented the DMT-EOC a practice-oriented approach for training and decision support for disaster response operations in an emergency operation centre. The integration of training and decision support elements in one system showed promising results. The ability to use the same simulators in both fields of application shows synergistic potential. The RPD model is used as a model for the decision-making of EOC members and the system accompanies the user in each step of the decision-making process.

However, user acceptance of the decision support system in general and the approach to use the RPD model to design the decision-making as well as the user interaction still has to be evaluated. Even if the evaluations are positive the work on the DMT-EOC is far from being completed. The implemented ranking system has to be adjusted with further tests and additional expert judgements. Also the potential of the integration of new feature like fuzzy logic for the modelling of credibility and reliability of information sources seems promising. Hopefully in the future further simulators and decision support agents for new disaster situations like flooding may be integrated.

ACKNOWLEDGEMENTS

The research in this article is funded by the Deutsche Forschungsgemeinschaft (DFG) as part of the Collaborative Research Center (CRC) 461 “Strong Earthquakes: a Challenge for Geosciences and Civil Engineering” and the state of Baden-Wuerttemberg. The DMT is developed in cooperation with the General Inspectorate for Emergency Situations in Romania and the German Federal Agency for Technical Relief (THW). Additional help in the evaluation of the decision support component is provided by the German Academy for Crisis Management, Emergency Planning and Civil Defence (AKNZ).
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