Decision Making in Response and Relief Phases

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1 Introduction

Human beings will never be completely protected from natural, industrial or man-made disasters and accidents, since one can hardly predict when and where the next emergency situation will occur. What the humans can change is the way they respond to disasters. The whole disaster management sector requires urgent developments toward better, more elaborated and appropriate means for facing man-made and natural risks. This is already realised and accepted as a high priority task by many organisations, governments and companies in Europe and all over the world (Cutter et al 2003).

Amongst all Response and Relief Phases are the most appealing ones (Zlatanova and Holweg 2004). In these phases disaster and risk management needs to ensure interoperability of emergency services, to provide appropriate information at the right place and in the right moment and to ensure high-quality care for citizens. An extended cooperation is needed across different sectors involved in risk management such as the Health Sector, Police, Fire Brigade, municipality and civil protection, which is beyond their specific services and communications. To fulfil these sophisticated tasks, new knowledge-based systems have to be developed that allow different service units to operate together (and understand each other) in any critical situation (Zlatanova et al 2004).

There are some underlying problems that complicate an adequate risk prevention or crisis response:

- Lack of good communication between the different actors at different levels;
- Lack of information about the 'information';
- Lack of data standardization;
- Lack of up-to-date information about development of the disaster (victims, rescue teams technique, damages, etc.);
- Access to existing data and action plans is in general very slow.

In the years after 9/11, the attention is increasingly shifting toward cutting-edge technologies based on multi sensor communications (Haala and Böhn, 2003), 3D geospatial information (Kwan and Lee 2005, Lee2004, Zlatanova et al 2005), indoor-positioning (Togt et al 2004) and (3D) visualisation on mobile devices (Kray et al 2003, Rakkolainen and Vainio, 2001). The importance of the standard procedures for communication were recognized by the Open Geospatial Consortium and the Working group on Disaster management became again active.

Parallel to developing new technologies and approached for data access and sharing, the process of decision making has to be improved.

In this paper we will focus on the decision-making process with respect to risk management in the relief phase. We firmly believe that the decision making process can be improved by using adequate spatial data, e.g. disaster plans which usually exist in municipalities and control centres. These data are not sufficiently used on different levels of the decision making process. A knowledge based system is needed able to search, analyse and provide consistent geo-information, process and assess new-coming information from affected areas and ensure intuitive, easy-to-understand information on different devices to facilitate the work of all the actors involved in decision-making process.

The paper is organised in five sections. The next section describes the specifics of decision-making process in disaster management. Section 3 suggests a framework for system development. Section 4 discusses the crises management procedure in Netherlands and presents first implementations. The paper concluded on further research and shortcoming developments.

2 Knowledge Typologies & Problem Solving

Decision making in disaster management differs from regular daily situations. Crisis response has the following specific characteristics:

- decisions are taken within a network of many actors, that must coordinate their activities;
- decisions have to be taken under time pressure and stress;
- uncertainty creates the need for ad hoc decision-making often made based on experience and intuition rather than information;
- external pressure, such as that of media, affects decision makers and decision-making;
- quality assessment of the decision-making process is done afterwards.

Under these circumstances the main question is how does the decision-making process look like and how can the existing information systems meet the user-needs under these extreme circumstances?

Decision makers in crisis response often deal with complex situations. They have to make decisions on the basis of the information they are provided with, which might be incomplete and even wrong. Most decision support systems (DSS) however only support circumstances which lie in the known and knowable spaces and do not support complex situations sufficiently (French, 2004).

From the knowledge management perspective some researchers proposed a typology of decisions. An example is so called Cynefin model (Snowden, 2002) which describes four decision spaces: know, knowable, complex and chaotic. Each space has it's own need for information. In the know, knowable the information can, till a certain level, be predicted. In the complex and chaos area there is no way to know the causality in advance.

French provides his perspective on crisis response by saying that the context of crisis response can fall into any of the four spaces and can evolve in any of the others. Many cases have clearly shown that the context in handling major risks and crises almost inevitable passes into the complex domain. In this situation, social, political and economic issues become increasingly important in the decision-making process. This has major implications for decision support and decision support systems.

Several options to avoid this problem exist:

- Look both at DSS and knowledge management systems which can handle both explicit and tacit knowledge;
- Look for more collaborative, creative tools to draw together and build a variety of perspectives on the issues;
- Develop supporting information systems infrastructure for crisis management which include support for the communication process with the public and stakeholders.

Our intention is to investigate all the options in order to set up an appropriate DSS for risk management. When we are able to improve the decision-making process in order to improve and handle our risks better with sophisticated application of (new)technology one question still remains:

Will the user accept the new way of working? And maybe even more important: is he able to perform better?

Introduction of new technology often changes the organizational structure and the way people have to work. Eventually the users of the system in the changed organization plays the most important role. Within this research the developed SDI and the supported decision-making process will be assessed in order to quantify the acceptance and the performance of the users involved in the decision-making process of spatial planning and in crises response situations.

3 Research Framework

To be able to develop DSS to be used in crisis response we have defined a framework which consists of four general phases organised in eight steps (Figure 1).

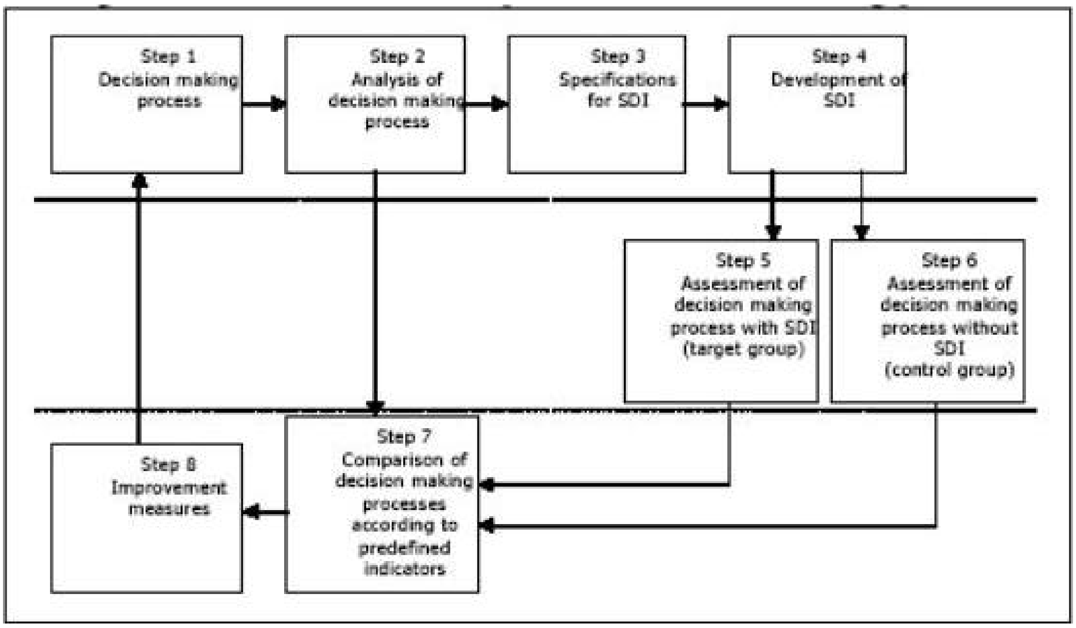

Fig. 1. Framework for desision -making

Analysis of the Decision-Making Process

The first two steps analyse the current decision-making process in crisis management. Some elements are:

- An inventory of several perspectives on risks. The Dutch Ministry of Internal Affairs has defined 19 disaster types. Currently there is a “disaster plan”, which is in use for al of the disasters and describes mainly the tasks and responsibilities of the emergency units. It is very general and not for a specific disaster type. The planned inventory will delineate the specifics for managing risks according to the different themes;
- An inventory of bottlenecks in the current decision-making process. Last experience with several disasters such as the Firework (Enschede) and the threats of flooding have revealed some inappropriate decisions. The inventory is ongoing and at this moment it is difficult to give examples and references, but the mistakes have been made through out at all the levels.
- An inventory of bottlenecks in the current use of Spatial Data Infrastructure (SDI) in the decision-making process to prevent or manage crises; The study should clarify whether the current technologies, policies and institutional arrangements are compliant with the current developments within national and international SDI
- A description of indicators that will serve as quantifiers for the future decision-making process supported by the developed SDI;
- Definition of criteria and requirements for development of SDI.

SDI Specifications

The analysis of the decision-making process in the first steps provides valuable information for the building of the SDI for risk management. SDI is related to the way the spatial information will be managed, accessed, shared and visualized in crisis situations. Three general problems can be distinguished:

- It is well known that the information available is designed, stored, and managed by organisations that normally have distinct authorizations. In normal circumstances these organisations operate independently of each other. They are only partly designed to work in a multidisciplinary environment, and their systems reflect this status with known limitations to their interoperability.
- Spatial data is managed by different systems (CAD, GIS, DBMS) in specific details, resolutions, object definition, schemas and formats. Exchange of data is based on creating a copy of data sets in a specific format that is readable by the systems of the other party. Preparations of such files may require days and storage space of several hundreds megabytes. This manner of work is definitely not appropriate for dealing with emergency situations.
- The use of SDI's has the potential to become important decision support systems and can be important in risk communication between government and society.

This experience suggests that the real barriers are not lack of data or insufficient technical capabilities. The current development of Geo-Information Infrastructures (GIIs) at several levels (national NCGI, European INSPIRE, etc.) based on open standards (OpenGIS, ISO TC211, OMG, W3C) further improves this situation. The bottlenecks are in most cases related to the 'information' about the information, i.e. finding the most appropriate data and making data available and the tuning of information towards the information needs of the society.

The lack of interoperability, due to the explosion of many standards and developments, delays systems to be connected and updated without massive investments (often unaffordable for organisations). This results into a partial automation capable of dealing with dedicated tasks but unable to deliver intelligence to multi-user groups.

The development of appropriated SDI will be completed on the basis of:

- Inventory of existing systems, data structures and data formats used in spatial planning and interactive policy making;
- Inventory of systems and data formats for emergency response;
- Inventory of standards which might be suitable for data exchange;
- Inventory of handheld devices, technology for communication and positioning (indoor and outdoor) and available (or coming soon) software tools;
- Investigation of pros and cons of centralized vs. federated vs. collaborative organization of data;
- Development of structures for centralized or federated or collaborative data storage;
- Development of algorithms for data discovery and approaches for data sharing;
- Development of an interface that suits the information needs of stakeholder groups;
- Introducing intelligence, i.e. methods for data adaptation (e.g. for different displays, response time, etc.);
- Developing approaches for data update (e.g. from different mobile sensors) and immediate sharing with all the actors in the crisis situation.

Assessment of the Decision-Making Process

The decision-making process will be assessed in order to qualify the acceptance of usage from the point of view of the user and to quantify the improvement of performance to justify the introduction of a SDI which supports decision-making in the organizations which deal with risk management. The Technology Acceptance Model (TAM; see Davis, 1989) will be used for this purpose and will be tuned in order to adapt the circumstances of the research objective. This will be performed according to the indicators as defined in the first two steps.

The results of these steps will be analysed in step 7.

Improvement and Redesign

According to the results from the previous steps, we will define the most important conclusions and recommendations to improve the decision-making process.

4 The First Prototype of a Knowledge Management System for Disaster Plans

Following this framework, the first prototype of a knowledge management system has been developed called uKnow-RISC. RISC (in Dutch) stands for Spatial Information System Calamities. The system has been developed with the assistance of the Dutch Disaster Relief Sector.

The crises management in the Netherlands is a complex process involving municipalities, police, fire brigade, ambulance and GHOR (Medical Assistance in case of Accidents and Disasters). Depending on the complexity of the disaster, 5 different levels of emergency response are clearly defined by a GRIP (Coordinated Regional Incident Suppression Procedure).

A short description of the levels is given bellow:

GRIP 1 level is in use when one of the following events takes place:

- There is need of structured and coordinated meetings between the emergence response units
- The incident can have administrative consequences
- There is need for more information and data.

If an incident needs more structured coordination, more information, or can have administrative consequences, the emergency response units can decide to use GRIP 1. A CTPI (Coordination Team at the scene) is created and every 15 minutes the officers on duty meet to discus the progress of the situation.

If one of the following events takes place, GRIP 2 is in use:

- The impact area is bigger than the source of the incident(for instance: a toxic cloud)
- The need for one leader in the disaster area (most likely the officer on duty form the fire brigade)

If there is an incident which needs the attention of the emergency response units and there is an impact area, like a toxic cloud from a fire, than level 2 of the GRIP procedure is of use. This means that at the scene the CTPI turns into a CORT (Coordination of the disaster area) and one of the officers on duty takes control. Mostly this is the officer from the fire brigade. There are teams formed also on strategic and tactical level. The ROT (Regional Operational Team) concentrates mainly on the work in the impact area and takes tactical decisions. A Policy team is created (in which the mayor is also involved), which is responsible for strategic decisions. The mayor is responsible for the decisions and actions that are taken.

GRIP 3 is defined for cases when:

- The incident disturbs the public safety
- Serious threats of persons, animals and materiel interests
- When the source or impact area of the incident strikes more municipalities
- The sirens net are used

When the impact area is that big that two or more municipalities are involved the level 3 of the GRIP procedure is always initiated. The involved teams consult with each other and one municipality takes the coordination.

GRIP 4

When the disaster/impact area crosses the boarders of the safety regions or province level 4 of the procedure is in use. Coordination takes place by the province or on a national level.

GRIP 5

This level is under construction by the government, but it is likely that this is going to be a national procedure in case of a big incident.

In most of the cases, large disasters are investigated, studied and analysed in detail to be able to estimate the team work and conclude on improvements. For example the Firework Disaster in Enschede the Netherlands on 13 May 2000 (commission Oosting 2001) showed that there was difficulty on sharing information between the different levels that where involved during the disaster. Even for about twenty minutes the exact location of the disaster was not clear to some of the decision-makers at different levels. In the final report it was written that: “crisis management is mainly knowledge management”. On 30 January 1995 the town Tiel was evacuated due to thread of flooding. The later analysis has shown that the town is situated much higher (than expected) and was no real thread. The mayor admitted later that in the crisis center there was no knowledge on the altitude of the town.

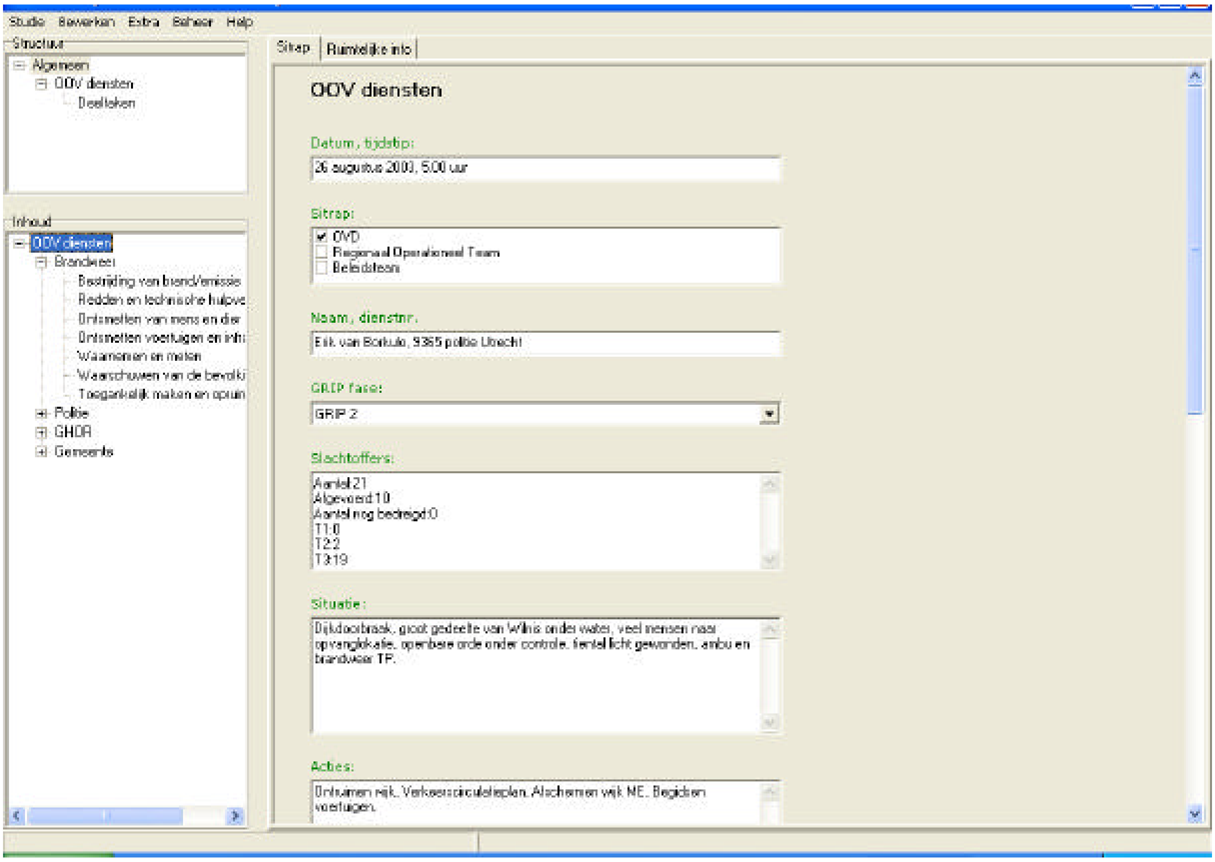

Fig. 2. Layout of uKnow RISC

The information system presented here uKnow RISC (Figure 2) is developed with the ultimate goal to improve the decision-making process. It is built according to existing disaster management procedures and regulations and the corresponding large-scale actions. The starting point of this system is the decision-making structure of the Dutch GRIP procedure (described above), which clearly defines the tasks, powers, and responsibilities of the corresponding organizations that need information on different levels to facilitate decision-making.

Besides this structuring of disaster knowledge and procedures, a link was made to existing sources of information such as the Dutch Register Risk Situations Hazardous Substances (RRGS) and the spatial reproduction of the corresponding risks and hazardous objects (municipal and provincial risk maps).

Using the system, it is possible for the different decision-making layers to communicate regardless of their location. The mayor may remain in the emergency room and the Officer on Duty can go to the disaster location to direct the processes from there. Moreover, the location of the persons involved in the disaster it can be monitored at any time.

The basis of uKnow-RISC is the policy management system uKnow. The system uses Oracle-technology (Oracle Database, Oracle Spatial and Oracle iAS). The Movida Location Toolbox (Togt et all 2004) offers essential components for UKnow-RISC such as webmapping, routing and geocoding. The Movida Location Server takes care of the location definition and helps to define the position of an object or a person, regardless of the location method that is being used (Cell-ID, Wi-Fi, RFID or GPS location). The system can be accessed through any pc, laptop or tablet pc with an internet browser. In case of mobile use, the connection is made through UMTS or GPRS. The risk register and the provincial and municipal risk maps are integrated in uKnow-RISC as well.

5 Conclusions and Further Research

In this paper we presented a framework for improving the decision-making process in disaster management. The first and the second phases of this framework have been successfully addressed. However, the proof of the pudding lies in the phases 3 and 4, which are under development now. With several municipalities agreements have been made for testing the present set-up of uKnow-RISC. Live test of the system will be carried out with the Academic Hospital of the University of Amsterdam (AMC) on the 6th of April, 2005. With the Coordinator of the disaster exercises for the region of Utrecht agreements have been made how the system can be fully tested in the large scale exercises in the UK and the Netherlands. Thanks to the collaboration between different experts, the first results were achieved in very short terms.

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