Spatial Data Infrastructure for emergency management: the view of the users

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ABSTRACT:

Spatial data play an important role in decision-making during the response phase of an emergency situation. Emergency management is a multidisciplinary activity of the fire brigades, the police forces, paramedics and the government. A spatial data infrastructure is expected to facilitate and coordinate the exchange and sharing of static and dynamic spatial data between all the emergency forces. Within the emergency forces awareness of such multidisciplinary spatial data infrastructures is rising.

A socio-technical viewpoint has been adopted that means that spatial data infrastructures are being regarded as worthwhile only if they are meeting genuine user needs. The users' need are the driving force for spatial data infrastructure development therefore the user requirements need to be defined in the initial phase of the development process. The user requirements are a user's description of the functionality and performance characteristics of the spatial data infrastructure. In this paper concepts of spatial data infrastructures and user requirements are presented. Then needs and requirements for an ongoing research and development project in the Netherlands are defined according to the spatial data infrastructure components: data, people and technology.

KEY WORDS: Disaster, SDI, Infrastructure, User, Requirements

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1. Introduction

A disaster is an event that disturbs public security and which threatens life and health of many people. It has a huge impact on the environment and it may cause serious material damage. Geographical Information Systems (GIS) are increasingly used in emergency management since they provide tools to more efficiently support of emergency management information needs (Diehl and Heide, 2005). GIS allows for an effective visualisation of a disaster situation. By placing the accurate physical geography of a disaster event on a computer monitor and then append with other relevant features, events, conditions or threats, people can make decisions based on these GIS data. This visualised information can be of critical relevance to the disaster manager.

To fight the incident, safe lives and restrict the damaging consequences of the disaster, first responders of emergency forces go into action, i.e. the fire brigades, the police forces, paramedics and the government. These emergency forces have their own tasks, but they need to cooperate for effective disaster fighting. They fight the same disaster, make use of each other's operational information about the development of the disaster and they use the same environmental and topographic data. Clearly, a dedicated Spatial Data Infrastructure (SDI) built to support emergency management information needs, would greatly facilitate the work of the emergency forces.

The SDI is expected to facilitate and coordinate the exchange and sharing of static and dynamic spatial data between the emergency forces. SDI should also be able to provide the means to diverse organisational and governmental agencies to participate in the full range of emergency management activities. Within the emergency forces awareness of such multidisciplinary SDI's is rising. Presently, progress in computer technology is observed, which makes numerous new applications and extensions of GIS simultaneously available for policy advisors and decision makers of different emergency units (Scholten et al, 1999).

For the development of a SDI for emergency management, user requirements are very important (Diehl et al, 2006). Determination of the user requirements is the initial and decisive stage of a development process. The user requirements are a user's description of the functionality and performance characteristics of the proposed product, an SDI in this case. The user requirements operate as a communication tool between the user and the developer. Well-formulated user requirements are essential to the success of a project. Vagueness and contradictions in this initial state can propagate through the life cycle of the SDI and result in an expensive infrastructure which is not fit for use.

This paper concentrates on user requirements for a SDI in order to support emergency management. After a short discussion on the components of a SDI, the paper presents the study on determining user requirements. In the investigation of user requirements various end-users are interviewed for their needs for different functionalities such as accessing, delivering, visualisation and providing metadata of spatial data. The requirements are analysed using the components of SDI. In this paper the focus is on Spatial Data Infrastructure at regional level. The investigations are performed at the Dutch Region Gelderland-Midden.

2. Emergency management in the Netherlands

Emergency management in The Netherlands is divided into five phases, see figure 1: a pro action phase, a prevention phase, a preparation phase, a response phase and a recovery phase (Borkulo et al, 2005). The pro action phase aims at preventing insecurity: it concerns the removal of structural causes of insecurity and the prevention of new insecure situations. One might think of the removal of dangerous installations or the inhibition of construction in areas that are vulnerable to floods. The prevention phase aims at the restriction of risks: it concerns mainly the restriction of the effects of a disaster before a disaster takes place for in case of an accident. The preparation phase is the preparation for the actual operation of the emergency forces. Preparation focuses on situations where (despite pro action or prevention arrangements) a disaster takes place. This phase includes the preparation on the disaster response, like the training of the different emergency forces: fire brigades, the police forces, paramedics and the municipalities. The response phase is the phase that the emergency forces take action against real emergencies like disasters or huge incidents. The recovery phase is the phase of after care; it concerns the entire arrangements to return to the normal situation. This phase includes activities like aid to victims or reparation. This phase might last a very long period after a disaster. In some situations this can last for years.

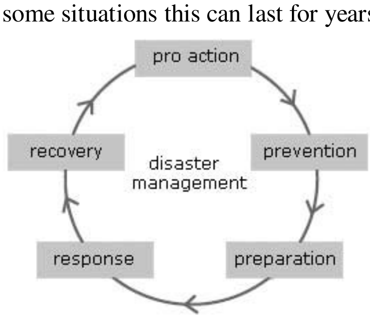

Figure 1 The cycle of phases in Dutch emergency management.
(Adapted from: Ministerie BZK 2003)

The pro action, prevention and preparation phase take place before an actual disaster happens. Despite all the efforts in risk prevention to ensure that disasters will not take place, it is unrealistic to believe that disasters will not happen at all. It is an illusion to achieve a 'zero-risk' situation. There will always be a small statistical certainty that a disaster will take place and therefore there is need for emergency forces (Neuvel & Zlatanova, 2006). In the Netherlands 18 different types of disaster can take place (Ministerie BZK, 2003).

Disaster in relation to traffic and transport
1. Aviation accident
2. Accident on water
3. Traffic accident on land

Disaster with dangerous material
4. Accident with inflammable/ explosive material (in open air)
5. Accident with toxic gasses (in open air)
6. Nuclear accident

Disaster in relation to public health
7. Treat to public health
8. Dispersal of disease

Disaster in relation to infrastructure
9. Accidents in tunnels
10. Fire in big buildings
11. Collapse of big buildings
12. Disruption of utility

Disaster in relation to population
13. Panic in large groups
14. Large-scale disturbance of public peace

Nature disaster
15. Flood
16. Nature Fire
17. Extreme weather conditions

Disaster on distance
18. Incident out of city boundaries, in which citizens of that city are involved

The type of the disaster determines substantially the nature and extent for the emergency activities. The organisation of emergency management and the decision-making during a disaster situation in the Netherlands can be divided into five different levels of scale. In normal situations when an incident takes place the emergency centre is alerted through a 1-1-2 phone call (similar to 9-1-1 in the USA). The dispatcher in the emergency centre mobilises the required emergency service: i.e. fire brigade, the police force or ambulance. During relatively small incidents each mobilised emergency sector works autonomously, although there can be some consultation with each other at the place of the incident.
However, as the incident is enlarging more coordination between the emergency forces is necessary. Then the emergency forces collaborate and they work according to a predefined and pursued emergency management organisation structure. This organisation structure consists of four different levels; these levels are called GRIP-levels (Ministerie BZK, 2003). Each GRIP-level has specific procedures and the responsibilities of the emergency employees are predefined and written down in protocol documents.

From level two (GRIP-2) the incident is big: i.e. the effected area is bigger then the source area where the incident happened (Borkulo et al, 2005). From this level the incident is called a disaster and single-headed command is required. The emergency management organisation is now led from three different coordination teams: operational, tactical and strategic coordination. Operational coordination takes place at the location of the incident; the strategic and tactical coordination takes place in coordination centres. The strategic coordination team decides what should be done to respond to the disaster and how to communicate to the public. The tactical coordination team gets strategy orders from the strategic coordination team and decides how to execute the strategy. The tactical coordination team act from the location of the regional coordination centre and they are connected with the operational coordinators, who are in the field. The operational team actually responds to the emergency situation. There is one leader at each coordination level and the final responsibility is at the highest involved government official. In case of GRIP-2 that is the mayor. The government has the final responsibility for emergency management (Ministerie BZK, 2003).

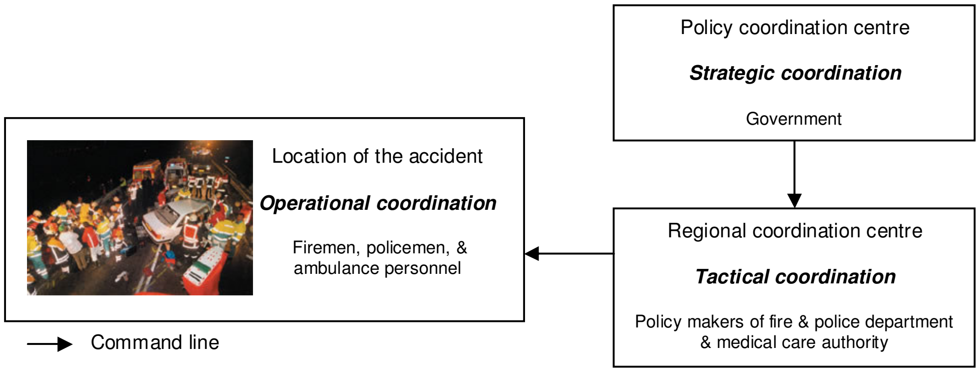

Figure 2 Distinction between operational, tactical and strategic coordination

As depicted in figure 2 emergency forces all work at the same disaster however they work at different locations. For effective disaster fighting all emergency forces benefit if they make use of each others operational information about the development of the disaster. Besides the operational dynamic data they use in their work activities the same environmental and topographic data. Most of the data for emergency management has a spatial component, i.e. location. Geographic Information Systems (GIS) with the capability of spatial data display, analysis and management have proven to be crucial in responding to, and recovering from disasters (Amdahl, 2002). However, there are current studies (Mansourian et al, 2005) showing that although spatial data and GIS can facilitate emergency management, there are substantial problems with collection, access, dissemination and usage of required spatial data for emergency management (Borkulo et al, 2006). Such problems are especially critical for the disaster response phase (figure 1) with its dynamic and time-sensitive nature (Mansourian et al, 2005). Therefore any problems or delay in data collection, access, usage and dissemination has negative impacts on the quality of decision-making and hence the quality of disaster response. Proper exchange of data between all the emergency forces involved at the different locations would reduce redundancy, could save lots of time and money and could improve data quality. Spatial Data Infrastructures is an enabling platform for data sharing (Rajabifard 2006). A SDI therefore would be the solution to support the emergency management information needs and it will increase efficient and effective emergency management.

3. Spatial Data Infrastructure - SDI

A Spatial Data Infrastructure is an initiative intended to create an environment that will enable a wide variety of users to access and disseminate spatial data in an easy and secure way (Nebert, 2004). In principle, SDIs allow sharing of data, which is extremely useful, as it enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets (Mansourian et al, 2005). A SDI should be developed to support decision-making and based on partnerships at corporate, local, state/provincial, national, multi-national and global levels (Rajabifard, 2006).

There are different names used for the concept of SDI, i.e. spatial information infrastructures, geographical data infrastructures and geographical information infrastructures. There also exist SDI at different levels from global to local. All these concepts use the term infrastructure. Many people think of an infrastructure in terms of physical features. Robert Pepper of the US Federal Communications Commissions however explains that infrastructure contents more than just the physical features: “When we talk about infrastructure, we tend to think about wires – hardware. Infrastructure is far more than that. It is people, it is law, it is education to be able to use systems” (Loenen, 2006). He is right not hardware but data and people are the main components of a SDI.

3.1 SDI components

Data and people are the core components of a SDI; however a SDI is much more than data. SDIs consist of several core components see figure 3. The SDI’s encompass people, data, policy, access networks and technical standards. Different categories of core components could be formed based on the different nature of their interactions within the SDI framework. Considering the important and fundamental role between people and data as one category, a second can be considered consisting of the main technological component: the access networks, policy and standards (Crompvoets et al, 2004). The technical components are required for facilitating the relationship between people and data.

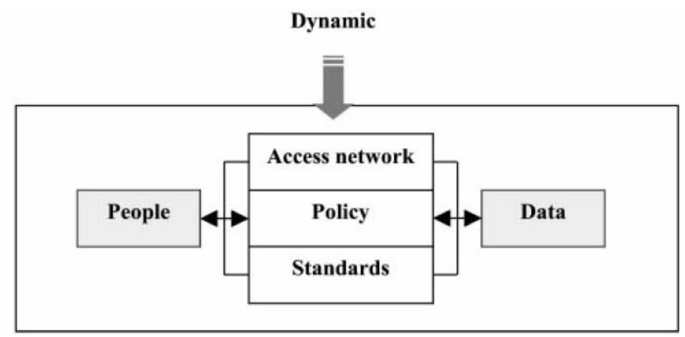

Figure 3 Nature and relations between SDI components (Rajabifard et al, 2002)

The nature of both categories is dynamic due to the change of communities (people) and their needs, which in turn require different sets of data, and due to the rapidity with which technology develops, so the need for mediation of rights, restrictions and responsibilities between people and data may change. This suggests an integrated SDI cannot be composed of spatial data, services and users alone, but instead involves other important issues regarding interoperability, policies and networks. This in turn reflects the dynamic nature of the whole SDI concept (Williamson et al, 2003).

Policies also embrace the institutional framework. These policies and institutional framework decide who collects and gathers what data and who and who would be allowed to use it. Sometimes even certain technology for data collection is required. Further, policies may decide on the quality of the information, e.g. require adherence to predefined standards. The quality of data collection relies on qualified people and the quality of the used technology. The policies decide who may access the information and what extent of use is permitted (Loenen, 2006).

3.2 Socio-technical viewpoint: *the needs of the users*

In computer science there has been a gradual shift in emphasis: For many years systems have been imposed on organizations because technology made them possible, rather than because there was a genuine demand for them: Information systems have been driven by technology-push rather than by demand-pull.
Increasingly a *socio-technical* viewpoint has been adopted, with the definition of 'information systems' being expanded to include not only the hardware and software but also the people involved. Increasingly there has been a movement towards a 'demand led' view of computing. That means the information systems are being regarded as worthwhile only if they are meeting genuine user needs (Reeve & Petch 1999).

TECHNO-CENTRIC COMPUTING	SOCIO-TECHNICAL COMPUTING
• focus on technology	• people and technology
• technology push	• demand pull
• because it's possible	• because it's needed
• others are doing it	• WE need it
• hierarchic	• democratic
• specified by technologists	• specified by users

Figure 4. From techno-centric to socio-technical computing (Reeve & Petch, 1999).

During the nineties we were witnessing the beginning of the transformation of GIS from a technology-pushed industry towards a more mature, user-demand-pulled industry in which the emphasis is not on technology but on the successful integration of GIS into organizations (Cullis, 1994). We see similar developments regarding SDIs. For the first generation of SDIs, from the mid-1980s, data was the key driver for development and the value of SDIs was measured in terms of their productive output, the savings for producers/providers of spatial data.
However the transition to the second generation of SDIs occurred around 2000. For the second generation, the use of that data (and data applications) and the users' need are the driving force for SDI development. The second generation has a more holistic understanding of the financial and socio-cultural benefits of SDI development, as well as support for spatial decision-making. The first generation of SDIs has a product-based approach: i.e. the model tends to be data-

producer led, focusing on data production, database creation and centralization. The second generation, conversely, has a process-bases approach: it focuses on the creation of an infrastructure to facilitate the management of information assets instead of the linkage to existing and future databases. It is driven more by data sharing and re-using data collected by a wide range of agencies for a great diversity of purposes (Rajabifard, 2006). At this moment the use of the data (and data applications) and the need of users are the driving force for SDI development.

3.3 SDI & emergency management

Spatial data is especially useful in the response phase. GIS specialists generate maps of the source areas of the disaster, hazardous and safety locations, ingress and egress routes. Other maps include for instance travel plans; emergency forces drop points and logistical support facility locations. During the response phase action plans are developed constantly. Maps are the key component of these plans. They will be updated all the time and will provide an overview of the disaster spread conditions and the affected and potential effected areas. It will help crew to get a comprehensive situation overview and to be aware of the context of the disaster and it helps them to formulate strategies and tactics. Maps also provide valuable information for citizens and the press.

Thus, data provide the solution to analyze, visualize and understand the problems caused by the disaster. In emergency management many different actors are involved in and they use much spatial data. For effective emergency management these data should be exchanged. Because there is a disaster situation this should be exchanged in a very fast and secure way. SDI provides a lot of benefits for the emergency management disciple. Some benefits of data sharing among emergency management organizations are listed bellow:

- GIS requires large quantities of current and accurate digital data. It is not necessary for each organization to try to possess all the data in their own GIS. The emergency forces can safe significant time, money and effort when they share the burden of data collection and maintenance. Especially the savings in time are very relevant for emergency management during the disaster response phase, making the difference in the number of victims and the size of the hazardous areas.
- Within the emergency management discipline in The Netherlands the municipalities are a huge source of (static) spatial information. The fire department is the organization that delivers the most information about the disaster during the response phase (=dynamic data) and this information is the basis for decision making of all the emergency forces.
- Shared data allows more users to work with data and consequently estimate the quality of data. In the preparation phase an increased number of users can find and correct errors in the data. For the disaster response phase it is also important that a lot of people are familiar with the spatial data sets. This will reduce the number of mistakes that will be made because of lack of time due to the disaster.
- Sharing data of common interest will reduce duplication and it will enable the emergency forces to defray some of the costs of producing and maintaining the data. Mechanisms to facilitate the use and exchange of data are a major justification for developing and expanding a SDI (Williamson et al, 2003).
- Sharing of spatial information in the preparation phase helps the policy makers to develop high quality contingency plans because a complete overview of the spatial data availability will provide a better understanding. It also provides an overview whether the amount of data is complete or insufficient and whether the data is up-to-date.
- Sharing data would allow for producing overviews of the disaster situation and informing citizens and press with very little effort. The benefits for the emergency forces will come from trust of the citizens in emergency management. Thus the benefits of shared data go beyond the organization involved in emergency management.

Shortly, it can be concluded that data sharing will: 1) increase efficiency of work and 2) provides a better method for communication and collaboration among the different actors within and among the emergency forces. This is a very important conclusion for a common framework for shared decision support.

Within the emergency forces, awareness of such multidisciplinary SDI's is rising. In the Netherlands there are currently two innovation projects that aim the improvement of spatial data exchange between different instances for emergency management. These projects are:

1. *Geographical Data Infrastructure for Emergency management (GDI4DM)*

   This project GDI4DM seeks to develop strategies for a Spatial Data Infrastructure to support decision-making and information exchange during the emergency management phase (GDI4DM Consortium, 2006).
2. *Geo-information for risk management*

   This project investigates the role of geographical information in decision making to support the development of the application of geographical information as support in spatial decision making in the area of risk management.

Outside the Netherlands there are also initiatives. For instance:

3. *ORCHESTRA*

   Orchestra is a project financed by the European Communities. The overall goal of *ORCHESTRA* is to design and implement an open service oriented software architecture that will improve the interoperability among actors involved in Multi-Risk Management (Orchestra Consortium, 2006).

4. *INSPIRE*

   The initiative *INSPIRE* (INfrastructure for SPatial InfoRmation in Europe) aims at making relevant, harmonised and quality geographic information available for the purpose of formulation, implementation, monitoring and evaluation of Community policy-making (Inspire Initiative, 2004).

5. *GMES*

   The 'Global Monitoring for Environment and Security' (*GMES*) represents a concerted effort to bring data and information providers together with users, so they can understand each other better and make environmental and security-related information available to the people who need it. This is done through enhanced or new services (Genacs consortium, 2005).

In this paper the definition of SDI of Loenen 2006 is adopted. A SDI can be defined as a framework continuously facilitating the efficient and effective generation, dissemination and use of needed spatial data within a Dutch regional emergency management community, i.e. Gelderland Midden (the main city of this area is Arnhem). Further, the user point of view is taken as a starting point of developing a SDI. Therefore the objective of a SDI should be:

1. to provide users the spatial data they need
2. in a way the users need it
3. and in an efficient way

4. User requirements

One of the most important components of SDI is software and, as usual, projects about developing computer-based systems are prone to failure. The literature studies report that many systems are late or over budget and systems failed to meet the users' expectations. Kotonya (1998) argues that in the vast majority of cases, these system failures are not due to incompetent staff or poor software engineering. Rather, they are a consequence of problems with the requirements for the system. Also Dorfman confirms this dedication: "In nearly every project which fails to meet performance and cost goals, requirements inadequacies play a major and expensive role in project failure" (Dorfman, 1997).

There is a lot of literature about requirements and the process of requirement acquisition. Terminology causes problem, i.e. there are many different definitions and scopes of requirements and the requirements acquisition process. For example, Goguen (1996) states that requirements are properties that a system should have in order to succeed in the environment where it will be used. Kotonya (1998) presents requirements as descriptions of how a system should behave, application domain information, constraints on the system's operation, or specifications of a system property or attribute. Davis suggested in 1990 that requirements engineering is the analysis, documentation and ongoing evolution of both user needs and the external behaviour of the system to be built (Jirotka & Goguen, 1994). Sommerville and Sawyer define requirements as a specification of what should be implemented. They are descriptions of how the system should behave, or of a system property or attribute. They may be a constraint on the development process of the system (Wiegers, 2000). Although there is no commonly accepted definition, the tendency hardly differs. All definitions above approximately state that requirements are a specification of what should be implemented. It includes how a system should behave, application domain information, constraints on the system's operation and specification of a system property or attribute.

One can view the requirements from different perspectives. There is the user's view, i.e. **what** a system should do to link up with the user's work domain. Else, there is the developers view, i.e. **how** the system should behave. This links up with the system development domain. Within the scope of this paper, we adopt the following definition of user requirements: see figure 5

> User requirements are a user's description of the functionality and performance characteristics of the Spatial Data Infrastructure.

The initial phase of a development process is the best phase to define the user requirements. This is the decisive stage of a development process: well-formulated user requirements are essential to the success of a project. Vagueness and contradictions in this initial state can propagate through the life cycle of the SDI and result in an expensive improperly functioning infrastructure, as illustrated in figure 5. The core of this problem is that the SDI developers are not familiar with the expectations of the users. They do not have a good picture in mind of how the business of the user runs and should run and therefore do not know what the users expect from the SDI. The developers are experts in the SDI domain but not with the business ambitions of the users. The users on the other side are an expert in the work domain for which the SDI will be built but they are not fully able to comprehend what a SDI system could bring them. They often do not know the possibilities and the constraints of systems. Often it is the case, that even when the users and the developers speak to each other face to face they do not fully understand each other because their divergent knowledge areas and lack of empathy. Before the development begins, requirements specialists may form the conduit for the communication between the users and developers. They must mediate between the domain of the users (and other stakeholders) and the technical world of the developers (The Standish Group 1994).

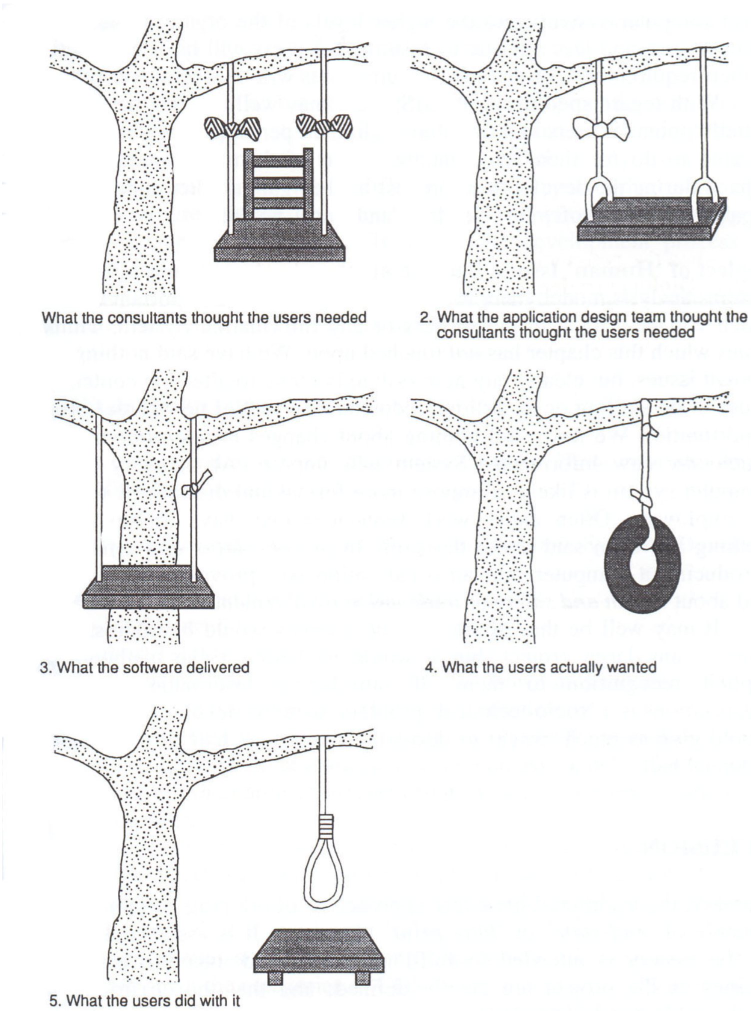

Figure 5 Without user requirements users do not always get what they want (Reeve & Petch 1999).

User requirements therefore function mainly as a communication tool between the user and the developer. This approach agrees with the requirements definition of Dorfman (1997): A user requirements document describes the behaviour of the system as seen from the outside, i.e. from the point of view of the user. These requirements serve to communicate with the developers, who need to know what is expected of the system elements for which they are responsible, and who also need information about those elements with which they must interface (Dorfman, 1997).

5. Requirements for SDI in the Netherlands

The Dutch regional emergency management community Gelderland Midden requires a technical solution to improve the decision making during the response phase of an emergency situation and to increase efficiency in their work processes. The general requirements which set out in broad terms what such a technical solution should do are similar to the characteristics of Spatial Data Infrastructures. The most important needs of Gelderland Midden are:

1. That the SDI should allow different actors at different locations to access the SDI.
2. The SDI provides these actors with proper access to the spatial data they need.
   These data can be text-documents or text-messages as well as maps. These data can be static data as well as dynamic data that arise during the response phase. The latter alter continuously during the response phase.
3. It should be possible to the actors to exchange the data, especially the dynamic data, in a proper, efficient and secure way.

A SDI is the solution for Gelderland Midden. As appeared from the general requirements is for emergency management the interrelationship of the SDI components classified by Rajabifard et al. (2002) and discussed in paragraph 3.1, important.

5.2 SDI Data component

SDIs are tools to provide an environment within which people and technology interact to activities for using, managing, sharing and producing spatial data. However, to empower SDI framework implementation and optimalisation: technical and institutional policies of access to useable data need to be addressed. People need to be able to access accurate, exchangeable, consistent and up-to-date spatial data resources to make informed decisions. This process relies on the availability, accessibility and applicability of data to support decision-making (Feeney, 2003).

When a disaster takes place it is required that data are available to support evaluation of the extent, impact and development of the disaster and therefore support decision-making. Availability refers to data resources which must be available to the emergency forces in advance through the SDI. Data sources include for instance spatial reference data, spatial thematic data, metadata and symbols. Although the work processes of the emergency forces are currently multidisciplinary organised there are still slightly different terms and abbreviations between the different disciplines.

Therefore it is important that the spatial data resources are provided with clear legends and metadata so that the data are clear to all actors of the emergency forces and potential third parties. A standardised set of symbols is currently in development for all the emergency forces to improve multi-discipline visualisation of the disaster. Another requirement with respect to availability is the existence of simple tools to search for the required information and simple access to the databases.

During an emergency situation it is required that the available data can be processed. Therefore a toolbox with drawing tools and symbols is essential. The SDI must also facilitate access to and the exchange of these derived data resources to other actors then the data producer. This is required to happen in a very rapid way, because fast decision-making can safe lots of injured people and limit the impact on the environment.

Besides this simple processing of data by using drawing tools, it is also desirable to build relationships between different types of data, merge multiple layers into synthetic information, weigh outcomes from potentially competing alternatives and forecast (Feeney, 2003). Feeney (2003) describes that inroads have been made in promoting data availability. But that the shortfall in many current SDI frameworks occurs in the promotion of the applicability of data to support decision-making beyond data discovery and visualisation through to analysis and modelling. Technologies and applications which may need to be employed to use the data include user interfaces, models, overlay, integration and transformation techniques. Despite the range of tools available that are able to enhance the application of spatial data for decision support, much of the potential applicability of spatial data is currently being underestimated. This is also the case in emergency management in the region Gelderland Midden. The main reason is that development of a first multidisciplinary SDI should be realised with a maximum of benefits at a minimum of costs. Visualisation and exchange of existing data resources and simple processed data are sufficient for the time being and it can be realised with not too many costs. Moreover the more advanced applicability functions can not be used by everyone, for that is special trained personnel required. Although the need for the advanced functions is currently underestimated at the users it should be realised to look for the future. This is also the case with 3D data: at the moment there is no 3D data in use however it is likely that it will not take a long time before 3D will be applied in emergency management (Zlatanova et al 2005).

5.3 SDI technical components

Anyone wishing to access the data resources of the SDI for emergency management must utilize the technical components (Rajabifard, 2002). The *access* network component of a SDI is critical from a technical perspective to facilitate the use of data by people (Crompvoets et al, 2004). With respect to access it is required that the SDI should be easily accessibly for people working at stationary locations, i.e. the coordination centres, as well as for mobile users.

Therefore it must be possible to access the information by different kinds of hardware like normal computer and laptop screens, but also a pda should be able to access the SDI properly. The mobile emergency forces must have access to the SDI everywhere in the service area, whether it is in the city or in the forest. It must be possible to access SDI from stationary locations outside the service area. For in special cases when the normal coordination centres cannot be reached because of the disaster. Or for access of specialised national institutes and higher governments: e.g. national government, to support the regional emergency decision-making.

The SDI should be a reliable infrastructure that is not relying on a normal internet connection and normal electricity for in case there is no internet connectivity or power, instead it operates on a special secure infrastructure. It is also required that the SDI makes many back-ups that will be saved at multiple locations. Time is a crucial factor in emergency management therefore a very fast response time is required and the SDI should be suitable for quick data input, data update and data transfer.

Because of security and privacy it is not intended that anyone can get access to the SDI so there should be *policies* for access and use conditions. Other policies and guidelines are required for SDI that corporate spatial data access and pricing, funding, spatial data transfer, custodianship, metadata and standards (Crompvoets et al, 2004).
A connection between the SDI for emergency management and the existing C2000 is required. C2000 is a restricted telecommunication network for the Dutch emergency forces. To ensure interoperability amongst the data resources and access mechanisms defined by an SDI, *standards* are essential. One should think about metadata standards and standards on data quality. It is required to use an open, service oriented software architecture to improve the technical interoperability of the SDI with other systems and it allows the expansion of the system with extra functionalities. Another reason to choose for service oriented architecture is to follow the architecture of the Orchestra project. (Orchestra is a project financed by the European Communities. The overall goal of Orchestra is to design and implement an open service oriented software architecture that will improve the interoperability among actors involved in Multi-Risk Management).

5.4 SDI people component

The employees of the emergency forces are the key in emergency management. For almost all decisions in emergency management data are required. The SDI develops mechanisms to facilitate the availability and access to integrated data and interoperable technologies (Feeney, 2003). Within emergency management different people are involved with different levels of education and different levels of experience. It is important that all these people can work with the SDI easily, even in situations of stress. Therefore it is required that the user interface is very straightforward. One must be able to use the menus and icons in an almost automatically way. Because of the huge amount of data a structure of the data and straightforward search mechanism are required to find the desired data.

Interrelated to this is the requirement to have a SDI that can also be used in the daily routine work because working with an unfamiliar system will contribute to critical delays and will contribute directly to operator stress which will inevitably lead to 'expensive' errors in threatening situations (Diehl et al, 2006). Another aspect is that a training module is required. In the training module the SDI can be explored but more important the SDI can be used in the training of emergency fighters. Emergency fighters practice a lot, the SDI must provide a tool to train with different scenarios.

5.5 User requirements: an iterative process

As described in paragraph 4 the definition of user requirements should best be performed in the initial phase of the development process, it involves analysing the user's requirements. The next phase is specifying a SDI to satisfy these requirements. In projects that use a waterfall approach the requirements are defined at the beginning of the life cycle and they are presumed to remain constant over time (Schwaber et al, 2006). However the subject of user requirements is far from easy. Although the general requirements will mostly remain constant over time, the specifications of the requirements may change since users may change their mind once they see the possibilities more clearly. Discoveries made during later phases may also force retrofitting requirements (Goguen et al, 1993). To ensure that the SDI satisfies the user's requirements an iterative approach is a better choice. It can be very useful to give the user hands-on use of the SDI. Prototyping is an effective way of providing this hand-on experience. With a prototype, the user can exercise the SDI just as though it were already operating in his own environment and thereby can provide vital feedback to the developer on the suitability of the specification (Gomaa, 1990). The feedback would be used to design and develop a functioning SDI which satisfies to the user's needs. In the development process of a SDI for emergency management in Gelderland Midden the iterative process will be used.

The project at the Dutch regional emergency management community Gelderland Midden is progressing. Currently the requirements to SDI are clarified. The users and their requirements have been identified with respect to the 25 emergency management activities (as specified in the Netherlands). These 25 emergency management activities have been studied and the work processes, data and users have been well-defined in UML Schemes (Snoeren, 2006). At this point the general requirements are refined into concrete specifications, When these specifications are validated these become the foundation for all the engineering activities that follow. For the evaluation elaborated questionnaires are prepared to check whether these specifications actually fit in with the current way of working in the emergency management organisation and it collects information about possible foreseen improvements and long-term wishes. The questionnaires are going to be sent to a carefully selected group of people (acting on the field or in the commando centre in emergency situations). The elaborated investigation of the user requirements for a SDI for emergency management in the region Gelderland Midden will be completed in the coming months. Then the development process of a prototype can start.

6. Conclusion and further work

Spatial data resources play an important role in decision-making during the response phase of an emergency situation. For a Dutch multi-disciplinary regional emergency management community more appropriate tools to exchange and access are very useful. It can be concluded that data sharing will: 1) increase efficiency of work and 2) provides a better method for communication and collaboration among the different actors within and among the emergency forces. We have discussed the role of SDI and its components in order to facilitating emergency management in the Netherlands. We firmly believe that elaborated analysis of user requirements in the initial phase of SDI development process is critical for the success of the SDI. Our initial studies on the processes and manner of work in the Dutch region Gelderland Midden have revealed the first general needs, which can be summarised as:

1. SDI should allow different actors at different locations to access the SDI.
2. SDI should provide these actors with secure, fast, reliable access to the spatial data they need.
3. SDI should allow for data exchange, especially the dynamic data, in a proper, efficient and secure way.

The next shortcoming step is the completion and analysis of questionnaires. The questionnaires should provide the necessary insights for development and implementation

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