

Intelligent Crisis Response System (ICRS)

Service system design to support relief workers during crises in the natural gas sector



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1 Introduction

1.1 Problem statement

Emergency situations such as the firework explosion in Enschede show that it is not always straightforward to react on the right scale (Oomes, 2004). Since any crisis situation will demand a fast and appropriate reaction, there is a need for a service that provides a better overview of the actions performed by and the actions needed from relief workers and that indicates the right scale for further action. The aim of this project is to design an IT-based service or service system that supports relief workers in this way. Such a system should allow for a faster and more effective intervention. Also, it can provide a means to evaluate the interactions ex post.

The aim of this project was initially to design an IT-based service system to support relief workers when dealing with a crisis in the energy sector. Crises in the energy sector can be related to either gas or electricity distribution. We choose to focus only on risks associated with the gas infrastructure.

The kinds of crises that can occur comprise explosions (due to gas leaks for example), interruption of delivery and risks associated with the extraction of gas (leaks, collapsing of land). Each kind of risk will require another role for the relief workers. We therefore choose to investigate only one of these scenarios: gas explosions. This kind of crisis situation has characteristics that are comparable to characteristics of other explosions, such as fireworks or some industrial explosions (without hazardous compounds).

It is essential for the viability of any service system that it creates added value with respect to an existing service. Also, it can be useful to design a new service based on existing systems. Therefore we will first investigate which emergency systems are already in place in the case of a gas explosion. Extensive scenarios have been designed to support and organize the actions of relief workers. These scenarios have the form of large paper-based manuals. There are also technical measures such as automatic shutdown of systems (shutdown of parts of pipelines) and communication systems (such as the C2000 network in The Netherlands). Problem owner is the Dutch Government.

The research question is:

How can an emergency service system for (gas) explosions be designed that will facilitate communication, such that relief workers can respond more quickly and accurately to the emergency situation?

In this report will present the design of a service system as an answer to this question. We will call this service system *Intelligent Crisis Response System (ICRS)*. The next paragraph states the structure of the report and the methodology used.

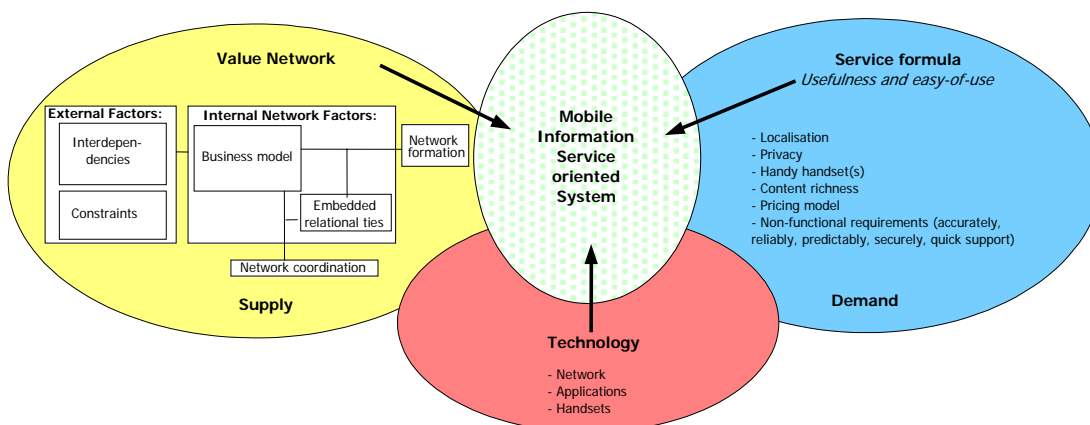


Figure 1. MIES Design Approach. (Source: Van de Kar, 2004)

1.2 Structure of report and methodology

For the design of the service system, we can use a general design methodology for service systems, as identified by Van de Kar (2004). The methodology has proved to be successful for the design of other service systems, for example mobile information and entertainment services (MIES).

Any methodology can be described according to a way of thinking, way of working, way of controlling and way of modeling (Seligmann et al., 1989).

The way of thinking in Van de Kar's methodology is represented in Figure 1. There are three aspects to be considered when designing a mobile information service: a value network, a service formula and technology. Van de Kar proposes that these aspects need to be traded off against each other during design.

The way of working represents the way the design process is carried out. Van de Kar proposes a modified waterfall model (with iterations). Within the scope of this project we cannot complete all the steps (until implementation and testing). We will perform the analysis and preparation steps.

The way of modeling consists of a set of models used to describe and visualize all facets of the service system. In this project, we have used for example storyboards and means-ends analysis.

The way of controlling deals with the organizational aspects of the design process. Within the scope of this project, no extensive contact is possible between the designers and the users of the system. Furthermore, only the first two steps of the way of working will be executed. Therefore, we do not consider the way of controlling an issue at this time. Where possible, a statement will be made on how these aspects should be dealt with while implementing.

Any service system design needs to encompass 4 aspects (TPM, 2004a, see Figure 2): a service concept, a technical architecture, an organizational architecture and operational processes. In this report, each of these aspects will be treated. First, the service concept will be defined. Then, a technical architecture and operational processes can be characterized. Finally, an organizational architecture can be described.

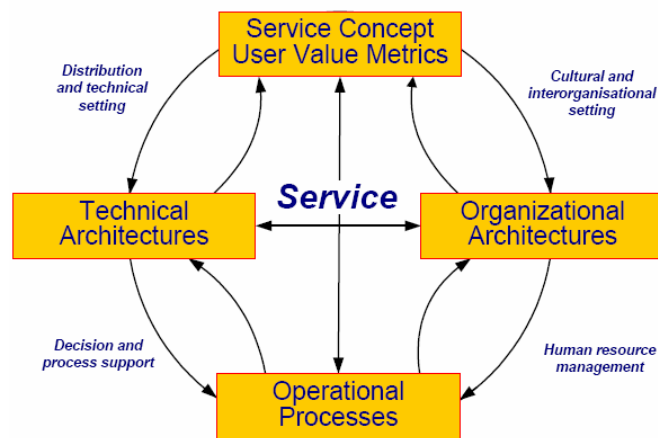


Figure 2. Researched aspects of services. (Source: TPM, 2004a)

The way of thinking as represented in Figure 1 can be related to the 4 components of service system design. The service formula aspect is related to the service concept aspect. The value network represents the organizational architecture and the technology represents the technical architecture. The operational processes will be designed throughout these steps.

Throughout this report, we will also use a meta-model for multi-actor systems design (see Figure 3). Because we will not complete an entire design process, we will only pursue the steps of identifying goals and constraints, listing requirements and defining the solution space.

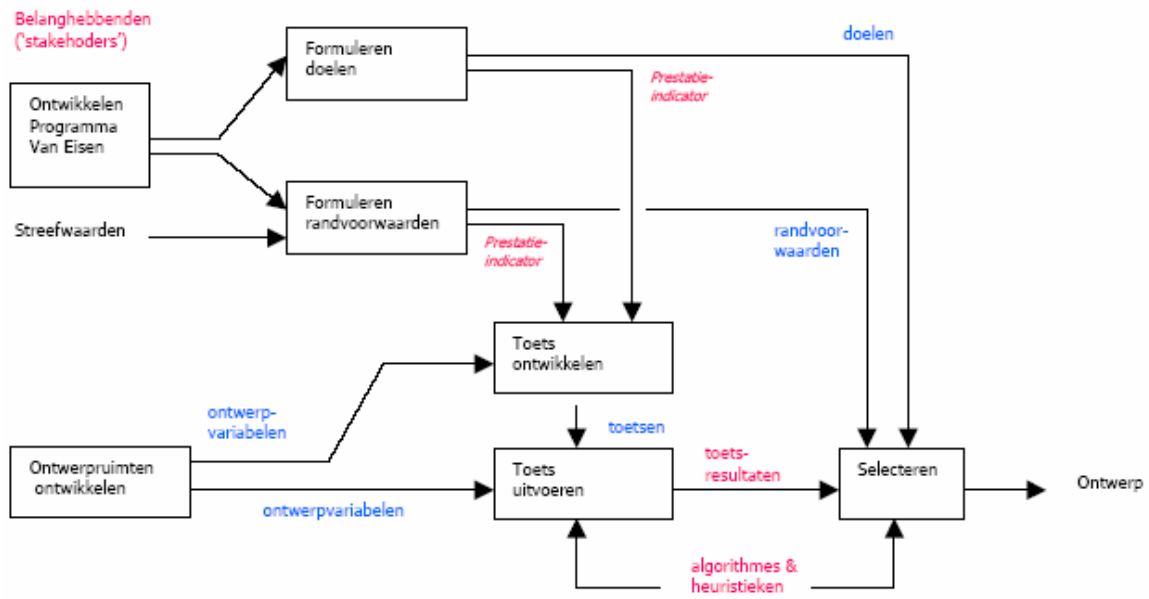


Figure 3. Meta-model for multi-actor systems design. (Source: TBM, 2004)

2 Analysis

The analysis phase is the first phase of the actual design. It encompasses a number of steps. The analysis phase can be modeled according to Van de Kar (2004, see Figure 4). The deliverables of phase are a letter of intention, an overview of technical options and a rough service description. Because the project does not take place in a multi-actor setting, but is designed as an academic exercise, it is not possible to involve organizations when describing the value network. For the same reason, it will not be possible to write a letter of intention.

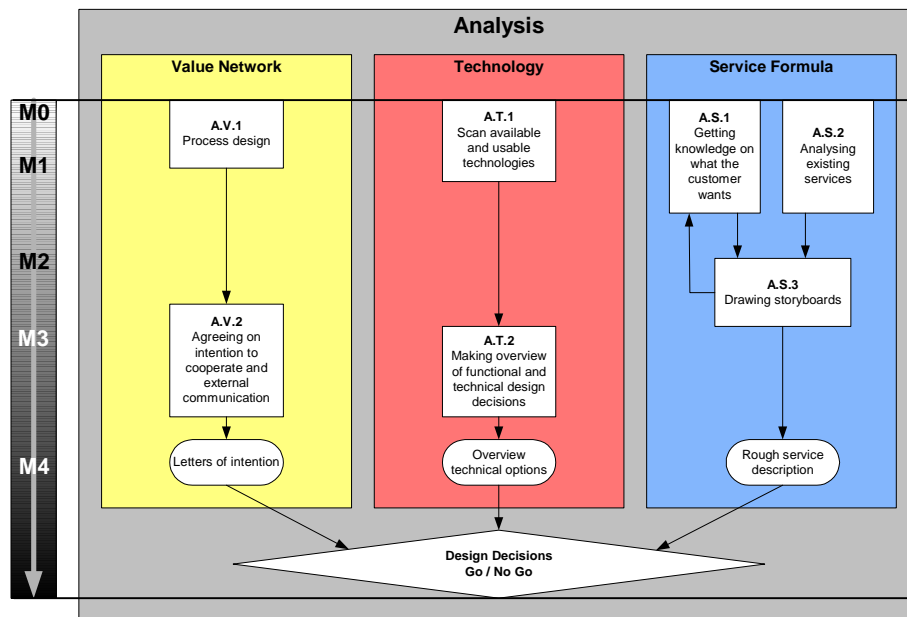


Figure 4. Analysis phase of MIES design approach (Source: Van de Kar, 2004)

2.1 Value network

Because the project does not take place in a multi-actor setting, but is designed as an academic exercise, it is not possible to involve organizations when describing the value network. It goes without saying that if this service system design were to be implemented in practice, the involvement of stakeholders from the value network would be essential, also in the early steps of the design process.

The relevant actors and their roles are described below. A complete detailed list of roles and actors can be found in Table 2 in the appendix.

All organizations of relief workers (police, firemen, ambulance personnel and members of military intervention teams) are users of the system. They use the system and give feedback on how the system works and should work. They fulfill partly the role of content quality monitor. Governmental organizations at different levels are also involved (municipalities, provinces, ministers). They are ultimately responsible for public health and safety and for the performance of relief workers, although they do not directly control their actions. The governmental organizations are also responsible for coordinating actions of relief workers.

A number of ICT companies will be involved in operating the system. Most roles are handled by ICT firms. Several types of ICT-firms should collaborate. Telecom firms (such as T-Mobile, KPN, Orange and C2000) could provide the communication network. They also can provide parts of the users' hardware, in collaboration with mobile phone firms (such as Nokia, Siemens, Getronics, Zenitel and KPN) and navigator system firms (such as TomTom). The navigator firms are involved in the user positioning technology and software. A GIS (geographical information system) firm (such as ESRI, Bentley, Geodan, Isis Benelux, Fugro Inpark, LogicaCMG), together with gas firms, Klic, het Kadaster (the Dutch cadastre) and governmental organizations are responsible for the geographical content. Collaboration is needed to

adapt the raw data to the special needed format. Because of the complexity of these processes, help from a specialized ICT firm will be needed. The platform provider will be based on the TETRA standard of the C2000 system (see C2000, 2004) and an operating system ICT firm (such as Microsoft, Sun Microsystems) will be involved. Other roles have to be fulfilled by a number of specialized ICT firms. The government has several roles in the system. It (partly) finances and will be the marketing provider, customer support provider and the billing provider for all users. Details on how these roles are operationalised will follow later.

To make sure that all actors necessary for a good functioning of the system will cooperate, a letter of intention should be set up. All parties from which participation is needed should intend to cooperate in creating a working product. We will not further discuss this matter, because of the limited scope of this project.

Of course, from the perspective of an investor, the benefits of the system will have to be traded off against the investment to be made. The system must be viable. The viability requirement can be operationalized in the following two requirements:

- Overall benefits > overall costs;
- Benefits > Costs for all participants in the value network .

However, the benefits of the system to be designed cannot be stated in financial terms. It concerns a lower loss of human lives, faster and better treatment of injuries, favorable public opinion, etc. In a time where emergency services are under high scrutiny (terrorism), and in a country where safety regulations tend to be very high (high willingness to invest in safety), it can be expected that the government wants to invest in a system, provided that it is well-designed (fit for purpose, viable, cost-effective, etc). We will discuss the costs and benefits associated with this system in the description of the organizational architecture (chapter 3.3).

2.2 Technology

Communication technology that is useful for the ICRS system is available. The main existing service is the C2000 service (see C2000, 2004). C2000 is based on the European TETRA standard. This is a mobile communication system, comparable with the GSM standard for the public. TETRA is an open standard; all parties can make products to work with it. The TETRA standard is designed for the future and is therefore continually in development.

C2000 is the only system on the market for this purpose and is available in The Netherlands (and some other countries) already. The C2000 system uses self-developed encryption methods. The basic standard, TETRA, is set by C2000 (see C2000, 2004). The C2000 system that is in place already, can be used to build on top of. For technical reasons, the C2000 network consists of three networks:

1. Tetra Landmobiel, for speech and data communication,
2. Tetra Airmobiel, for speech and data communication for airplanes and choppers.
3. Alarm call network, to alarm firemen and ambulance personnel.

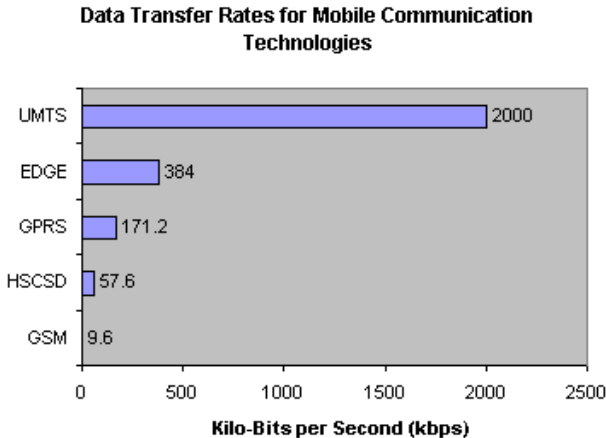


Figure 5. Data transfer rates of various network systems (Source: Source O₂, 2004)

UMTS could be a solution if the C2000 system is too limited or inflexible. The new UMTS network for mobile phones will be able to handle all data needed (see Figure 5).

Numerous ICT organizations deal with this type of communication. Mobile devices are available which can display the information on site and are able to deal with new applications provided in this system.

User-devices which can be used for the C2000 system are developed by three companies: Zenitel, KPN and Getronics (see MinBZK, 2004). When identifying existing and usable technology (hardware, software and netware) based on C2000, the information provided by KPN is not very helpful. The responsible from Getronics could not be reached for additional information. Zenitel was found to be most helpful and willing to provide information. Their website (see Zenitel, 2004) was also very informative. Since the scope of this project does not allow for extensive contacts with possible suppliers, we choose to base our initial design on the products and services of Zenitel.

On the Zenitel website (Zenitel, 2004), we have found some information on mobile devices they supply. This technology has been developed with Clearstone, Motorola, Siemens and Niros Communications AS. Motorola for example can provide MHT800 with a color display and using GPS (Motorola, 2004). This device could possibly be used by relief workers to retrieve and send information. It is suitable for showing images. However, the maximum data transfer for this device is not known. Also, the device is not practical for supplying text to the system, because there is no keyboard or touch screen. Clearstone can provide a device called TETRA CM9000 mobile (Clearstone, 2004). This is a touch screen (non-color) using GPS. This device could also be used by relief workers, but the maximum data transfer is 28.8 kb /second, which is possibly not enough. Also, it is designed to show text and not images.

Nowadays, several navigation systems are on the market. All are based on GPS (global positioning system). GIS systems are an advanced example of these systems. There are numerous devices on the market that support GPS.

<i>Component</i>	<i>Types</i>	<i>Suppliers</i>
Network	C2000	C2000
	UMTS	KPN, Vodafone, T-Mobile, Orange, Telfort
	GSM	KPN, Vodafone, T-Mobile, Orange, Telfort
User devices	Specialized mobile device	Zenitel
	PDA	HP, Sony, Palm, Blaupunkt
	Laptops	Toshiba, HP, Dell
Navigation systems	GIS	TomTom

Table 1. Technological options

Depending on the specific parties involved, there will be preferences for specific technologies. There is a need for consensus on technologies used, because this is crucial for a successful introduction of the system. There are several arguments for choosing to build on top of the existing C2000 system. First, if a new system were to be developed, this would require a huge investment. Using existing technology is cost effective from this point of view. Second, the C2000 network and devices have been developed already and have been adopted by all relief workers. Therefore, there seems to be consensus on this choice of technology and there is no need for an extensive consensus-building process in this matter. This is another reason why it is cost-effective to build on top of C2000.

A possible disadvantage of building on top of the C2000 system is that the flaws of this system translate into the design. An example is that the C2000 devices cannot be used inside hospitals because they can interfere with medical equipment. However, it is unclear whether these flaws could be solved using another communication system. Also, the C2000 system is under continuous development. Therefore, it can be expected that flaws in the current system will be solved.

Another disadvantage of building on top of the C2000 system is that it will limit the parties that can be involved and the advancedness of the service system that can be achieved. Because a lack of publicly available information on the system, we cannot determine with certainty whether this system is flexible enough to support all requirements of the emergency system.

If we choose to design our system using a C2000 network, we can choose a user device that is designed for the C2000. However, the current devices are not advanced enough (the processing capacity is not sufficient and they are not ideal for displaying and/or supplying information). More advanced devices will have to be designed to meet the purposes of the emergency system. This is technically feasible, because some phones and PDA devices on the consumer market already have this kind of processing capacity.

This leads to the following design decisions related to technical architecture:

- Use C2000;
- Develop new device.

2.3 Service formula

This paragraph encompasses a rough description of the service formula. Through identification of customer wants, existing services and storyboards, we will derive some system requirements. Because this phase cannot be conducted in participation with users of the system, it is possible that we will not have derived all the requirements. But this effort does lead to an initial overview of important design aspects.

2.3.1 Customer wants

The problem with the current emergency systems is that the actors involved with a gas explosion crisis often lack the information and overview needed to act effectively. The relief workers on the scene (or on the way) for example do not know the scale of the crisis situation and do not have accurate information on the amount of people in the accident area. But not only relief workers have experienced a lack of reliable information. The coordinating bodies (crisis centers) often have trouble identifying the scale of the incident and need to make decisions based on incomplete information. The aim of this system is to allow for more and faster information availability of both the relief workers and the control center.

Oomes (2004) identifies the types of information needed for an accurate crisis response (see Figure 6). Any emergency system designed to support fast and accurate intervention by relief workers should provide this information. These requirements will be helpful when making design decisions, for example about the needed operational processes.

	Organization awareness	Situation awareness
1. Collect data	members, interactions	measurements, events
2. Analyze data	<i>Who is signing up?</i>	<i>What is going on?</i>
3. Visualize information	organization chart	situation map

Figure 6. Requirements for support for relief workers (Source: Oomes, 2004)

In order to identify customers' wants, we first need to define the customer. In this case, the customers are the relief workers, i.e. firemen, policemen, ambulance personnel, ME, etc. Customers' wants can be found in different ways, for example using interviews, questionnaires, brainstorming etc. All of these require active participation of the customers. However, since this project is carried out as an academic exercise, with limited means, it is not possible to involve customers actively in the design process.

One way to discover system requirements, without direct participation of the customers, is to perform a means-ends analysis (see Figure 7). The means-ends analysis has been carried out until a level where customer requirements became clear. The aim of the analysis was not to define *how* the system should perform these requirements. This will be done in a later stage.

The system should:

- Indicate right scale for actions;
- Indicate actions to be performed and by whom;
- Decrease delay between occurrence of disaster and start of relief worker intervention on the scene;

- Allow direct access of information from the scene:
 - Organization chart (who is in charge, who is where);
 - Situation map (affected area, safe/unsafe zones, evacuation routes, degree of evacuation, demographic information, congestion of access roads, location of pipelines).
- Allow direct updating of information on the scene:
 - Organization chart (who is where);
 - Situation map (affected area, safe/unsafe zones, evacuation routes, degree of evacuation, congestion of access roads);
 - Pictures of crisis situation.

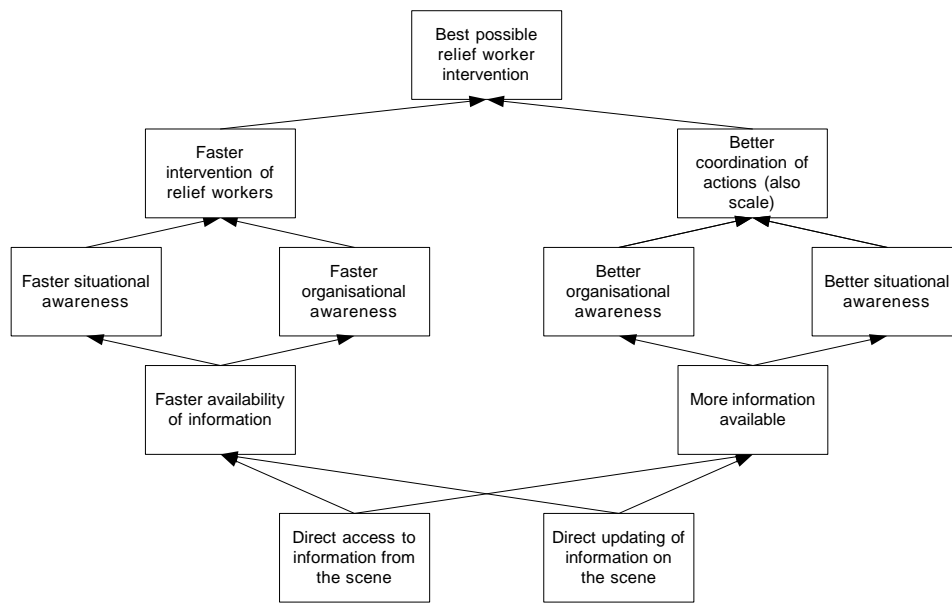


Figure 7. Means-ends analysis of customer needs.

The system to be designed will have to meet the requirements as derived from customer wants. The requirements listed above are case-specific user requirements. Rouse (1991) identified what he refers to as measurement issues for use. These can be seen as requirements related to the use of a system. Effective use of a system requires that:

- The user knows his information needs (user needs);
- The user can communicate his/her needs to the system (requests to the system);
- The system provides the needed responses (responses of the system);
- The user can utilize these responses (usability of the system);
- The usage helps satisfy the user's needs (impact of the system);
- The help is worth the price (value of the system).

The system to be designed will have to meet the requirements as described above. However, a smart design of an IT-based system can have extra advantages. For example, it can provide a means for very effective ex-post evaluation of interactions. All the information regarding organizational and situational awareness can be stored during the intervention. Afterwards, this information can be retrieved and the intervention can be evaluated. Also, a good design will use building blocks that can be used in other systems. Finally, it should take into account technology and services that are already available. Besides all requirements given in this chapter this leads to additional requirements. The system should:

- Allow for information storage for ex-post evaluation;
- Use building blocks where possible;
- Use existing technology where possible;
- Use existing services where possible.

The possibilities for use of existing technology were identified in the previous paragraph. In the next paragraph, possibilities for use of existing services will be identified.

2.3.2 Analyzing existing services

It can also be helpful to examine existing services. Two kinds of services are interesting with respect to the ICRS system: communication services and content related services. Content related services can relate to organizational or situational awareness.

The main existing communication service for relief workers is the C2000 communication service (see C2000, 2004). It supports communication between relief workers (police, firemen, ambulance personnel and military). Because of the flexibility of the system, and its building block characteristics, it is a good starting point for our service system design. Therefore, we will build on top of the current C2000 system to answer to the needs of the users.

An existing content related service that might be used when designing this emergency system is the information about underground infrastructure such as pipelines. In the Netherlands, this information is provided by Klic (Kabels en Leidingen informatiecentrum). Before a construction firm will start digging in a region, it can ask Klic for information about underground infrastructure in that region. Obtaining this information takes a minimum of three days (see Klic, 2004). Klic has no information on the exact location of all pipes, but has information on all squared regions of the Netherlands. There's information on who owns pipes in that region. By asking Klic for information, Klic sends messages to all companies who own pipes in your region to contact you with detailed information.

The low speed of this service and the inexactness of the information provided, this service is not sufficient for the service system we are designing. Another content service is the Kadaster (the Dutch cadastre). The cadastre can provide information on property of parcels and construction density. The information on pipelines is however not explicit and not complete (see Kruif, 2004). At the moment, most of the firms that own pipes are making their data accessible via Internet. Kruif (2004) states that GIS-firms see no need for a centralized pipe cadastre; technology makes that unnecessary and not wanted. Therefore, the information needed is available at the gas firms and they are designing services at the moment. These services can be used when they are accurate and fast enough.

Another existing content service is the TomTom navigation system (see TomTom, 2004). This is the most used commercial GPS system nowadays. It provides all needed services for up-to-date route information and optional indications and adaptability for congestion.

2.3.3 Drawing storyboards

In this paragraph we draw some storyboards (a description of an example crisis intervention) for our system in use, to show how the system should function and what the system should be able to facilitate. First the crisis center will be initiated. Then (and possibly at the same time) the first response by relief workers is initiated. Third, the system makes data available. After that additional data is gathered. Finally, the crisis center can be shut and an evaluation of the response can take place.

Initiation of crisis center

The gas leak was noticed when the first explosion occurred. After the first call to 112 (the general emergency phone number) the personnel, informed with the new system, contacted the system and initiated a new emergency. This is done when there is an indication for a large accident of the type for which a building block is implemented in the system (for now only a gas explosion is foreseen, because of the flexibility of the system, all types of accidents can be implemented). System status 1 is set, comparable to the defense condition (DefCon) system in the USA (see Defcon, 2004). The system initiates the formation of a crisis center automatically. It knows the municipalities and provinces, which have to be involved. Calls are made by the system to the personnel that ought to form this crisis center. They meet at a specialized location, where all resources are available. All systems startup and become available.

First response of relief workers

At the same time the staff member of 112 initiates the first response. He or she judges the seriousness of the situation and sends an initial amount of relief workers to the site. After that, he enters his actions in the system and than his task is done. He waits for another telephone call.

System making data available

Now some data is entered already in the system (an indication of the location and scale), a map of the scene is produced with a radius that needs evacuation and possible routes for evacuation. Information available includes locations of dangerous industry, numbers of people to be evacuated (based on GIS info

and demographics), numbers of relief workers needed, etc. Note that of all data an indication of the accuracy is given (in words and with black to white scale). All users (on the scene and in the crisis center) see that this information is available (and/or updated) on their mobile or static device. In the crisis center a meeting is planned for a first impression on the actions to be taken. The system logs when data is entered and which actions are undertaken. The system status is set according to the scale known so far (Status 2-5). Also the industries in the region that should be contacted to ensure the awareness of the accident are listed.

Additional data gathering and presenting

The relief workers on the site can see the intervention proceeding. One or a few of this staff report what's happening. He is trained for this task and knows and accepts that what he does is as important as the actual saving of lives. The data is entered in the system in a simple, standardized format, for which these employees are trained. They have more information on the scale and the amount of people that are in trouble. Photos of the scene, taken by relief workers, can be sent to the system. All this information is entered in the system. By continually analyzing the available data, more accurate and useful information is presented automatically.

Crisis center close down and evaluation

After the intervention all data entered in the system can be used for a complete and more objective evaluation than possible so far. The accident and the intervention are reconstructed by the system, and information on the effectiveness of actions becomes available. The system and operational procedures can also be improved based on this evaluation.

Extra requirements derived from these storyboards are the following:

- Possibilities to include photographs;
- Must contain a database with an address book of relevant parties (such as hazardous industries);
- Should mention accuracy and/or certainty of information;
- Each operation related to information gathering by relief workers should be made easier (easy retrieval and supply of info; high usability of ICRS interfaces);
- Be able to display maps and graphics as well as text;
- System should allow for decentral supply of information.

3 Preparation

Based on the requirements as identified in previous chapter, we can make an initial design. As mentioned in the outline, a service system design needs to encompass a service formula, a technological architecture, an organizational architecture and a description of operational processes. When these aspects of the design are covered, some performance indicators can be given, that will be used to monitor the performance of the system. In order to structure our design efforts we will again make use of the methodology of Van de Kar (2004).

In order to come to a design that meets all requirements we also use the layers for a technical architecture (see Figure 8). A presentation layer is distinguished from the business layer and the data layer. The presentation layer is made concrete by describing the user interface and navigation (see paragraph 3.1.2). The business layer is described at the paragraph *Value Network* of this chapter. The data layer represents the information content and the required operational processes.

Where possible, all technical components should be developed using building blocks, so that the system can be flexible enough to be adapted for other types of crisis situations. If these were to be designed later, this would save a lot of development and implementation costs.

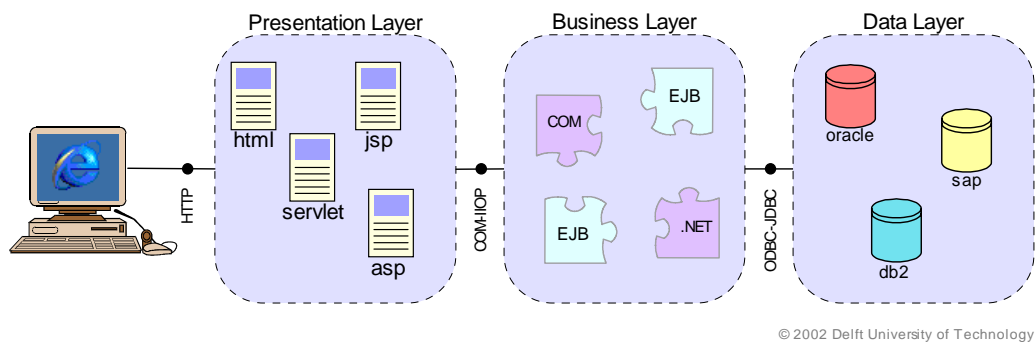


Figure 8. Layers in technical architecture (Source: TPM, 2004b)

3.1 Service formula

The design of a service formula is concluded by a detailed service description. This means that the design should include an overview of the service content, of the navigation and of the user interface. This design should then be tested with users. Unfortunately, the latter is not possible within the context of this project. This is why we used the term ‘initial design’ in the introduction to this chapter.

3.1.1 Service content

The service content relates to more complete information about the crisis situation and faster availability of this information. Through the user interface (described below), users (relief workers on site or on their way to the site or the crisis center) can view this information and add new information to the system. The information contained in the system consists of situational and organizational information. Because of the different operational processes they conduct, relief workers and the crisis center have different information needs and therefore require different user interfaces.

In a field setting; the informational needs for the relief workers and for the crisis center would have been identified in participation with the users of the system. However, since this is not possible, informational needs are listed based on the storyboards and requirements as mentioned in the previous chapter. An overview of these informational needs for relief workers and for the crisis center can be found below. From these informational needs, the needed operational processes are derived.

A complete list of informational needs, including an indication of the way in which the system can provide this information, is presented in Table 3 (for the relief workers) and in Table 4 (for the crisis control center) in the Appendix. An overview of the operational processes required from the users of the system

is also given in the appendix. Table 6 lists the operational processes required from the relief workers and Table 7 lists the operational processes required from the crisis control center.

Note that other operational processes are needed, such as system maintenance and development. These are not listed here, because they are not directly related to system use. We will discuss responsibilities in the section *Value Network* (paragraph 3.3).

3.1.2 User interface and navigation

The user interface consists of a mobile device interface and a crisis center interface. Because of the different operational processes they conduct, they have different information needs and therefore require different user interfaces. Pictures of how the interface could look like are given, together with an explanation how to work with this interface.

The precise looks of the mobile device interface should be tested with users to make it as usable as possible. Important is to work with colors and touch screen to make the interface intuitive. The screen should be large enough to be well readable but still handy (no large laptop).

System Status 3	GAS EXPLOSION	MAP ZOOM + -	REQUIRED ACTIONS	SEND MESSAGE
certainty level: certain		accident location: GRONINGEN		
MOBILIZED: 18 FIRETRUCKS 34 AMBULANCES 25 POLICE CARS 0 MILITARY	HUMAN: 34 DEATHS 20 SEVERE 100 UNSEVERE	DEMOGRAPHICS: 2 HAZARD. INDUSTRY 3 CITIES 116,112 PEOPLE		
ADDITIONAL INFORMATION FOR FIRETRUCKS:				
HAZARDOUS INDUSTRIES Chlorinegas production Gas supply		FIRETRUCKS / FIREMEN 10 large, 6 on site 8 small, 8 on site 54 firemen, 39 on site		

Figure 9. Mobile device interface: accident view

Mobile user interface

The user interface of the ICRS system could look like the picture in Figure 9. An example is given of a gas explosion in Groningen. We can see information needed for a fire truck on his way to the accident. The most important is the system status (3), which gives insight in the seriousness of the accident. The information provided in this screen is certain and intervention is already in taken care of (there are many firemen and trucks on site). By pressing on one of the (with this system status) yellow areas we access other screens.

By pressing the 'map' area we can see our location as a black dot (see Figure 10). Also the driving direction, the accident location and the needed evacuation radius (red circle) are presented.

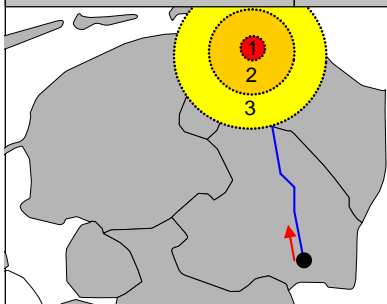
System Status 3	GAS EXPLOSION	MAP ZOOM + -	REQUIRED ACTIONS	SEND MESSAGE
certainty level: quite uncertain		accident location: GRONINGEN		
		DIRECTIONS FOLOW HIGHWAY A44 for 22 KM ROUTE INFORMATION CONGESTION: 15 min. ETA: 23 min. MAP LAYERS ROUTE : ACCIDENT FIREMEN : INDUSTRY		

Figure 10. Mobile device interface: map view

Information on the route is given in a map and with directions, information on estimated time of arrival is given and the congestion is given (both in minutes). The route will be a service built using the TomTom navigation system. It will be coupled with the ICRS system on a C2000 device, such that that the location is selected by the system and not by the user (as would be normally with the TomTom system). Based on this information, congestion and arrival times are estimated. Several map layers can be set on or off. Additional information on other firemen or on industries and gas pipes can be displayed in the map. The certainty level for this information is lower. This indicates that the radius for needed evacuation is unclear. It is possible to zoom in on the map, which is preferable when relief workers approach the accident site.

System Status	GAS EXPLOSION	MAP ZOOM	REQUIRED ACTIONS	SEND MESSAGE
3		+ -		
certainty level: certain		accident location: GRONINGEN		
<p>REQUIRED ACTIONS OF FIRETRUCK 15:</p> <p>MAIN TASK: Evacuate Chlorinegas production site</p> <p>You will be assisted by firetruck 16 and 17. They will arrive 2 minuts after you.</p> <p>Map of production site not yet available</p>				

Figure 11. Mobile device interface: required actions view

When looking at the ‘required actions’ screen we see the task (see Figure 11). Details available are presented. The screen will alarm when new information is available.

System Status	GAS EXPLOSION	MAP ZOOM	REQUIRED ACTIONS	SEND MESSAGE
3		+ -		
certainty level: certain		accident location: GRONINGEN		
WE ARE ON OUR W....				
FREE TXT	Q	W	E	R
	T	Y	U	I
	O	P	del	
STANDARD	A	S	D	F
	G	H	J	K
	L	enter		
PICTURE	Z	X	C	V
	B	N	M	
VOICE				

Figure 12. Mobile device interface: send message view

The last screen can be used to enter information in the system (see Figure 12). This can be a free text message, a message in a standardized format (which can be processed automatically) a photo or spoken message. These standardized messages can be confirmative and informative and are used to make more information available throughout the system.

Crisis center and 112 interface

Because the crisis center has more possibilities to display information and they have to process more information, the interface can be seen as an extended version of the mobile devices. We find it important that the interface feels like the one on the mobile devices, that it is practical and that it gives a good overview of the entire intervention. An overview of the large screen of the ICRS system in a crisis center is given in Figure 13. You can see a zoomable map with a set of layers, a bit more advanced than the mobile interface. All actions are summarized in the actions area in which can be scrolled up or down.

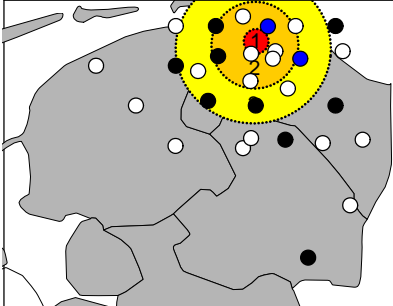
System Status	GAS EXPLOSION	MAP	ACTIONS			
3						
certainty level: quite uncertain		accident location: GRONINGEN				
	LAYERS	FIREMEN	AMBULANCE	POLICE		
	ACCIDENT: FIREMEN	1-4. west on site 5-8. east on site	3. full to hospital 1 4. west on site	1-10. on site 1-7. cutting off area 8-10. handling media		
	INDUSTRY: AMBU- LANCES	9-12. north on site 13-14. south on site	5. empty to site; 10 min 6. empty to site; 8 min			
	GAS PIPES: POLICE	15. to industry 1; ½ hr 16. to industry 1; ½ hr 17. to industry 1; ½ hr 18. at industry 2	7. north on site 8. empty to site; 26 min 9. involved in accident 10. no actions	11-18. at industry 1 19-25. at industry 2		
	MILITARY		11. to industry 1; 2 min 12. to industry 1; 5 min 13. north on site 14. full to hospital 1			
ZOOM						
	+ -	+ -	+ -	+ -	+ -	

Figure 13. Crisis center device interface

The screen is controlled by a (number of) pc's via a computer application. There you can select the layers, zoom, select specific relief workers and enter data. Tasks can be assigned and messages can be sent to individual devices.

It should be noted that the 112 emergency number staff will need a similar device. They will have to initiate the response and will have to fill in information about the type of crisis situation, the location and an initial estimate of actions required from relief workers. They will therefore use a similar device, but with slightly altered functionalities. It could be the exact same device which is configurable.

Usability

For the ICRS system to have value to the users, it should allow for faster and better information sharing. Therefore, the accessibility of information should be as high as possible and the effort to enter information in the system should be small. We can say that usability of the system is crucial for system acceptance. The requirement of usability is related to the user interface. The figures in the previous section provide an example of what the system could look like. As mentioned, it is necessary to test the usability of the devices with users.

Usability can be defined according to CD 9241-11: Guidance on Usability: The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. According to Huis In't Veld (2004), the usability requirement can be split up in 5 lower level requirements: learnability (it should be easy to learn how to operate the system), efficiency (the system should increase efficiency), memorability (it should be easy to remember how to operate the system), few errors (the system should make few errors) and satisfaction (the system should lead to user satisfaction).

It is essential for any system that it is usable. Otherwise, it will not be accepted. With the interface presented by the images above we think usability requirement is met. Usability should be tested by potential users in the early stages of the process. For example, the pictures above, intended to give an idea of the user interface, could be discussed with relief workers. It is also important to take into account the context of use of the system. It will be used in stressful situations, where immediate action is required. Therefore, the system use should be swift and easy.

3.1.3 Performance measures

Now that the service provided by the system, are defined, as well as the operational processes needed to operate it, performance measures can be given. Technical metrics, such as uptime and the degree of capacity utilization, can be used to monitor the technical aspects of the service. Another type of performance measure has to do with the perceived value (about content, usability and such) by the users. These issues should be tested during design as far as possible. However, perceptions and needs might change during the use of the system. Therefore, we suggest to monitor user satisfaction and use the results to improve the system. During the ex post evaluations that take place after each intervention, it is possible to identify the satisfaction about the system, as well as possible improvements to be made.

3.2 Technology

The technology needed to operate the system has largely been discussed in the previous paragraphs. We discussed the communication and navigation systems that can be used and the devices that should be developed to make all functionality available to the user. Another part of the technical design is the database systems. There is a need for a number of databases.

First there is a need for a temporary database where data on the current accident is kept and stored. These data are needed during the intervention and for ex-post evaluation.

Second there should be a permanent database containing up-to-date contact information of crisis control staff and information about gas infrastructure, demographics and hazardous industry. Additional databases to support intervention in other types of crises can be added later. Connections with existing databases should be established. This should be done using web services, because recent developments on information on the location of pipes in the Netherlands use web services to make these available.

Besides the databases there is a need for a model for gas explosions. This model should predict the impact of an explosion with a certain accuracy. The model should give an estimate of the evacuation radius, the stricken area, the severity status and the required scale of intervention.

3.3 Value network

The value that this system represents is difficult or almost impossible to express in financial terms. However, for the system to be viable, the benefits should exceed the costs. It is therefore necessary to give an estimate of the costs and benefits associated with the system.

3.3.1 Benefits

The benefits of the system are for the public, for the relief workers and for the governmental organizations. The benefits can be described along a few dimensions:

Better and faster overview of crisis situation allows for a faster and more effective intervention. The intervention is faster, because more information becomes available earlier. The intervention is more effective thanks to better situational and organizational awareness and increased possibilities for good coordination.

A faster and more effective intervention leads to less loss of lives and less serious injuries, better support to victims, etcetera. Relief workers involved in the intervention will have more job satisfaction because their activities will be supported better and be more effective. It also leads to increased satisfaction by the public about the way the situation was handled. This is important for relief worker organizations involved, but even more so for the governmental organizations, who are ultimately responsible. In the Netherlands, and especially in these times, safety is high on the political agenda and governmental and relief worker organizations are under enormous scrutiny.

The companies who will develop the software and the devices can expect benefits of more commercial nature. Profits on services are about 10% (McKinsey and Company, 1998). Private parties involved in providing the services make these profits. Profits on electronic devices are in the range of 4% (McKinsey and Company, 1998). These profits are for the private developers of the devices.

As a business model for the service, only a subscription model seems applicable. An advertisement model seems unethical and would hamper the usability of the system. The transaction model is suitable when selling the devices, but not for the use of the ICRS system, because we're not dealing with tangible products. An airtime model gives an incentive to reduce the use of the system, which is not helpful for intervention of crises.

A subscription model, for example charging a price per month, seems to be most reasonable for the ICRS system. Relief workers' organizations would pay a fee per year to use the system when needed. This money is used to maintain and develop the ICRS system. It is possible that reasonable charges do not cover all costs. In that case, it is expected that the government and private parties will cover part of the expenses. Private parties involved with the development of technological components of the C2000 system are already willing to participate and bare some of the costs. They do this because of expected revenues and image building.

3.3.2 Costs

A typical business system consists of R&D, product development, marketing and sales, distribution and service (see McKinsey and Company, 1998). Because we are using existing services and technology where possible, only a few phases need elaboration. Costs can be attributed those phases, but it is difficult to get an accurate overview of these costs. In Appendix 5, we have given a rough estimation.

In the R&D phase, the detailed design and testing have to be done in participation with users. In product development, hardware devices and databases have to be developed. Services to maintain and develop the system should be set up.

The devices are to be bought by the relief workers' organizations from the developers (such as Zenitel). Profits on this purchase can finance the development of the ICRS system. The remaining part of the infrastructure and services have to be financed by government and possibly private parties involved in providing the services.

Total investment costs for personnel and their needs are estimated to be 8 million euros. These costs can partly be covered when selling the hardware (3 million euros). The rest of the investment costs could be covered by the government and possibly private parties involved in providing the services.

With a subscription model access is bought by relief workers' organizations to the network and all services. These revenues should cover part of the costs the government makes for maintaining and developing the service system. It is reasonable that the government covers part of the expenses of the service system for the reasons mentioned above. Operational costs of personnel and their needs are estimated to be 2 million euros per year. These can be covered by the subscription fees of 150 euros per device per year. If this amount is found reasonable by relief workers' organizations (this depends on their valuation of the non-monetary benefits), total costs for relief workers' organizations are estimated to be 5.3 million euros per year.

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Appendices

1. Roles in service system

Roles	Description of role	Organizations
Functionality related roles		
Service provider	Provides billable service to the end consumer	Specialized ICT firm
Network operator	Operates the mobile telecommunications network over which the data (service) is transmitted	Telecom firm
Platform provider	Provides the software that defines the general platform on which a variety of services are run	OS firm, C2000
Application provider	Provides the software that makes a service possible and that sit on top of the platform	Specialized ICT firm
Web hosting/presence provider	Operates and maintains the server that hosts a website that is an integral part of the service, particularly relevant to the further development of content	Specialized ICT firm
Content supply chain roles		
Raw content supplier	Supplies content in a format unusable for the mobile service & terminal	gas firms, Klic, municipalities, provinces, GIS firm
Content developer	Transforms raw content into content appropriate for the service and the mobile terminal	GIS firm
Content provider	Provides 'appropriate'/transformed content to the service provider	GIS firm
Content aggregator	Serves as an intermediary between the service provider and the content providers	Specialized ICT firm
Hardware roles		
Equipment provider	Provides the hardware, physical components of network	Telecom firm, mobile phone firm, navigator firm
Handset supplier	Supplies platform or service-specific handsets	Telecom firm, mobile phone firm, navigator firm
Customer relation roles		
Billing provider	Provides billing services to collect revenues from end consumers	government
Marketing provider	Markets the service	government
Customer support provider	Point of contact for customer queries regarding the service; responds to customer queries	government
Content quality manager	Monitors and improves content quality	Crisis Control Center
LBS roles		
Content geo-coding provider	Adds x/y coordinates to the content	Specialized firm, GIS firm
User positioning	Provides the position information of the mobile device	Navigator firm
Positioning technology vendor	Supplies user positioning equipment	Navigator firm
GIS provider	Provides geographical information, and GIS services, necessary to indicate location information of relevant content	GIS firm

Table 2. Roles for actors involved in mobile information services. (Source: Maitland, Van de Kar and Wehn de Montalvo 2003a, as cited in Van de Kar, 2004).

2. List of requirements for service system

- Indicate right scale for actions;
- Indicate actions to be performed and by whom;
- Decrease delay between occurrence of disaster and start of relief worker intervention on the scene;
- Allow direct access of information from the scene:
 - Organization chart (who is in charge, who is where);
 - Situation map (affected area, safe/unsafe zones, evacuation routes, degree of evacuation, demographic information, congestion of access roads, location of pipelines);
- Allow direct updating of information on the scene:
 - Organization chart (who is where);
 - Situation map (affected area, safe/unsafe zones, evacuation routes, degree of evacuation, congestion of access roads);
 - Pictures of crisis situation;
- Overall benefits > overall costs;
- Benefits > Costs for all participants in value network;
- Possibilities to include photographs;
- Must contain a database with an address book of relevant parties (such as hazardous industries);
- Should mention accuracy and/or certainty of information;
- Each operation related to information gathering by relief workers should be made easier (easy retrieval and supply of info; high usability of ICRS interfaces);
- Be able to display maps and graphics as well as text;
- System should allow for decentral supply of information;
- The user knows his information needs (user needs);
- The user can communicate his/her needs to the system (requests to the system);
- The system provides the needed responses (responses of the system);
- The user can utilize these responses (usability of the system);
- The usage helps satisfy the user's needs (impact of the system);
- The help is worth the price (value of the system);
- Allow for information storage for ex-post evaluation;
- Use building blocks where possible;
- Use existing technology where possible;
- Use existing services where possible.

3. Information in service content

Informational needs relief workers

Information	Held by / stored in	Presented by	Collected via
<i>Situational information</i>			
Location	ICRS database (content created from crisis control center / 112)	Map on device	C2000 / web interface (this has to be developed), coupled to GPS coordinates, 112
Stricken area	ICRS database (content created by model / crisis control center)	Map on device	Calculated by ICRS model, then sent to devices using C2000 / web interface (has to be developed)
Type of crisis situation	ICRS database (content created from messages from relief workers on the scene / crisis control center / 112)	Text on device	Via C2000 / web interface (this has to be developed)
Status of situation	ICRS database (content created from model / crisis control center)	Code / color on device	Via C2000 / web interface (this has to be developed)
Certainty of information	ICRS database (content created by model / crisis control center)	Level / color on device	Via C2000 / web interface (this has to be developed)
Photos of situation	ICRS database (content created from messages from relief workers on the scene)	Photo on device	Via C2000 / web interface (this has to be developed)
Route	Model combining TomTom database of roads with congestion data	Map on device	Via C2000 / web interface (this has to be developed)
Congestion (highways)	ICRS database (content created by ICRS model using ANWB information combined with TomTom information)	Map on device	Link to ANWB info system, then sent to ICRS model, results sent to devices using C2000 / web interface (has to be developed)
Congestion (local roads)	ICRS database (content created in ICRS model by crisis control center based on TomTom info and messages from relief workers on the way / scene)	Map on device	Messages from relief workers translated to model input by crisis control center, results sent to devices via C2000 / web interface (this has to be developed)
Nr of dead	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of severely injured	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of slightly injured	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Location of hazardous industry in the area	From fixed database (based on cadastre info)	Map (coupled to location of gas pipelines) on device	Via C2000 / web interface (this has to be developed)
Location of gas pipelines	From fixed database (based on info provided by local gas companies)	Map (coupled to locations of hazardous industry) on device	Via C2000 / web interface (this has to be developed)
Population of	From fixed database (based on	Text on device	Via C2000 / web interface

area	cadastre/municipality/CBS info)		(this has to be developed)
Area to be evacuated	ICRS database (content created by model / messages from relief workers on the scene interpreted by crisis control center)	Map on device	Calculated by ICRS model, then sent to devices using C2000 / web interface (has to be developed)
Evacuation routes	Model using TomTom info combined with congestion data	Map on device	From database with all roads of navigation provider, via C2000 / web interface (this has to be developed)
<i>Organizational information</i>			
Scale of intervention	ICRS database (content created from model / crisis control center)	Code / color on device	
Overview of actions required	ICRS database (overview of individual action messages received)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of ambulances on the way	GPS system of individual ambulances	Text on device	GPS
Nr of ambulances at the scene	GPS system of individual ambulances	Text on device	GPS
Location of all ambulances	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of fire trucks on the way	GPS system of individual fire trucks	Text on device	GPS
Nr of fire trucks at the scene	GPS system of individual fire trucks	Text on device	GPS
Location of all fire trucks	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of police cars on the way	GPS system of individual police vehicles	Text on device	GPS
Nr of police cars at the scene	GPS system of individual police vehicles	Text on device	GPS
Location of all police cars	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of military vehicles on the way	GPS system of individual military vehicles	Text on device	GPS
Nr of military vehicles at the scene	GPS system of individual military vehicles	Text on device	GPS
Location of all military vehicles	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS

Table 3. Informational needs relief workers.

Informational needs crisis control center

Information	Held by / stored in	Presented by	Collected via
<i>Situational information to be retrieved</i>			
Location	ICRS database (content entered by 112)	Map on device	C2000 / web interface (this has to be developed), coupled to GPS coordinates, 112
Stricken area	ICRS database (content created by model / crisis control center)	Map on device	Via C2000 / web interface (this has to be developed)
Type of crisis situation	ICRS database (content created from messages from relief workers on the scene / crisis control center / 112)	Text on device	Via C2000 / web interface (this has to be developed)
Status of situation	ICRS database (content created from model / crisis control center)	Code / color on device	Via C2000 / web interface (this has to be developed)
Certainty of information	ICRS database (content created by model / crisis control center)	Level / color on device	Via C2000 / web interface (this has to be developed)
Photos of situation	ICRS database (content created from messages from relief workers on the scene)	Photo on device	Via C2000 / web interface (this has to be developed)
Congestion (highways)	ICRS database (content created by ICRS model using ANWB information combined with TomTom information)	Map on device	Link to ANWB info system, then sent to ICRS model, results sent to devices using C2000 / web interface (has to be developed)
Congestion (local roads)	ICRS database (content created in ICRS model by crisis control center based on TomTom info and messages from relief workers on the way / scene)	Map on device	Messages from relief workers translated to model input by crisis control center, results sent to devices via C2000 / web interface (this has to be developed)
Nr of dead	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of severely injured	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of slightly injured	ICRS database (content created from messages from relief workers on the scene)	Text on device	Via C2000 / web interface (this has to be developed)
Location of hazardous industry in the area	From fixed database (based on cadastre info)	Map (coupled to location of gas pipelines) on device	Via C2000 / web interface (this has to be developed)
Phone number of hazardous industry in the area	From fixed database (based on cadastre info)	Text	Via C2000 / web interface (this has to be developed)
Location of gas pipelines	From fixed database (based on info provided by local gas companies)	Map (coupled to locations of hazardous industry) on device	Via C2000 / web interface (this has to be developed)
Population of area	From fixed database (based on cadastre/municipality/CBS info)	Text on device	Via C2000 / web interface (this has to be developed)
Area to be evacuated	ICRS database	Map on device	Calculated by ICRS model,

	(content created by model / messages from relief workers on the scene interpreted by crisis control center)		then sent to devices using C2000 / web interface (has to be developed)
Evacuation routes	Model using TomTom info combined with congestion data	Map on device	From database with all roads of navigation provider, via C2000 / web interface (this has to be developed)
<i>Organizational information to be retrieved</i>			
Scale of intervention	ICRS database (content created from model / crisis control center)	Code / color on device	
Actions being performed by all individual trucks / cars / ambulances	ICRS database (overview of action messages sent to each individual device + messages replied to these action messages)	Text on device	Via C2000 / web interface (this has to be developed)
Nr of ambulances on the way	GPS system of individual ambulances	Text on device	GPS
Nr of ambulances at the scene	GPS system of individual ambulances	Text on device	GPS
Location of all ambulances	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of fire trucks on the way	GPS system of individual fire trucks	Text on device	GPS
Nr of fire trucks at the scene	GPS system of individual fire trucks	Text on device	GPS
Location of all fire trucks	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of police cars on the way	GPS system of individual police vehicles	Text on device	GPS
Nr of police cars at the scene	GPS system of individual police vehicles	Text on device	GPS
Location of all police cars	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
Nr of military vehicles on the way	GPS system of individual military vehicles	Text on device	GPS
Nr of military vehicles at the scene	GPS system of individual military vehicles	Text on device	GPS
Location of all military vehicles	ICRS database (content aggregated from individual GPS coordinates)	On map on device	GPS
<i>Ex-post information to be retrieved</i>			
All situational and organizational information needed for ex-post evaluation of intervention	ICRS database	Text and visual information on device	Log all actions, messages and information supplied to ICRS database.

Table 4. Informational needs crisis control center.

4. Operational processes

Operational processes by 112

Information	Source of info	Destination of info	Required action	Mandatory / optional
<i>Situational information</i>				
Occurrence of event	Call to 112	ICRS database	Enter new event in ICRS	Mandatory
Location	Call to 112	ICRS database, TomTom (to be represented on maps)	Enter location in ICRS	Mandatory
Initial description of type of crisis situation	Estimate based on call to 112	ICRS database	Enter description	Mandatory
<i>Organizational information</i>				
Initial estimate of actions to be performed by relief workers	Estimate of 112 crisis control center based on call.	Messages to organizations of relief workers, copy to be saved in ICRS database	Send message to ICRS	Mandatory

Table 5. Operational processes by 112.

Operational processes by relief workers

Information	Source of info	Destination of info	Required action	Mandatory / optional
<i>Situational information</i>				
Type of crisis situation	Seen at site	Message to crisis control center, copy to be saved in ICRS database	Send message	Optional
Certainty of information	In perception of relief worker about own information	Message to crisis control center, copy to be saved in ICRS database	Indicate certainty level when sending message	Mandatory with each info message
Photos of situation	Taken at site	Message to crisis control center, copy to be saved in ICRS database	Send photo	Optional
Congestion (local roads)	Seen on the way to the site	Message to crisis control center, copy to be saved in ICRS database	Send message	Optional
Nr of dead	Seen on site	ICRS database	Send message	Optional
Nr of severely injured	Seen on site	ICRS database	Send message	Optional
Nr of slightly injured	Seen on site	ICRS database	Send message	Optional
Area to be evacuated	Seen on site	Message to crisis control center, copy to be saved in ICRS database	Send message	Optional
<i>Organizational information</i>				
Status of execution of required action	Experienced on site / on the way to site: Confirmation of execution of action, or: Indication of reason for delay of action or reason for impossibility to perform action	Message to crisis control center, copy to be saved in ICRS database	Send message upon receiving action message or upon change of status of execution of required action	Mandatory
Location of vehicle	GPS	ICRS database	None	Mandatory
<i>Operational processes ex-post</i>				
All situational and organizational information needed for ex-post evaluation of intervention	ICRS database	Crisis control center	Evaluate intervention and suggest improvements to be made	Mandatory

Table 6. Operational processes by relief workers.

Operational processes by crisis control center

Information	Source of info	Destination of info	Required action	Mandatory / optional
<i>Situational information</i>				
Initial estimate of stricken area	Estimate of crisis control center based on ICRS model estimate and info from 112.	ICRS database, TomTom (to be represented on maps)	Update radius information (initial value: model estimate)	Mandatory
New information on stricken area	New estimate of crisis control center based on info from relief workers.	ICRS database, TomTom (to be represented on maps)	Update radius information	Mandatory if new info comes available
Updated description of type of crisis situation	New estimate of crisis control center based on info from relief workers.	ICRS database	Update description	Mandatory if new info comes available
Initial estimate of severity status of situation	Estimate of crisis control center based on ICRS model estimate and info from 112.	ICRS database	Update status information (initial value: model estimate)	Mandatory
New information on severity status of situation	New estimate of crisis control center based on info from relief workers.	ICRS database	Update status information	Mandatory if new info comes available
Certainty of information	Perception of control center about own information	ICRS database	Enter certainty level with each entry of information	Mandatory with each message or entry of information
Congestion (local roads)	Messages from relief workers	ICRS database, TomTom (to be represented on maps leading to new route estimate)	Translate info from relief workers to model input and enter info	Mandatory with each new congestion point reported
Implications for hazardous industry in the area	Alert and required action created by ICRS based on cadastre info, radius information and address book	Hazardous industry	Alert hazardous industry (telephone)	Optional (only if deemed necessary)
Initial estimate of area to be evacuated	Estimate of crisis control center based on ICRS model estimate and info from 112.	ICRS database, TomTom (to be represented on maps)	Update evacuation area information (initial value: model estimate)	Mandatory
New information on area to be evacuated	New estimate of crisis control center based on info from relief workers.	ICRS database, TomTom (to be represented on maps)	Update evacuation area information	Mandatory if new info comes available

<i>Organizational information to be retrieved</i>				
Initial estimate of scale of intervention	Estimate of crisis control center based on ICRS model estimate and info from 112.	ICRS database	Update scale of intervention (initial value: model estimate)	Mandatory
New information on scale of intervention	New estimate of crisis control center based on info from relief workers.	ICRS database	Update scale of intervention	Mandatory if new info comes available
Actions to be performed by all individual vehicles	Estimate of crisis control center based on situational and organizational info in ICRS database and initial estimate from 112.	Messages to devices of relief workers, copy to be saved in ICRS database	Send messages to individual devices of relief workers	Mandatory if new info comes available
<i>Operational processes ex-post</i>				
All situational and organizational information needed for ex-post evaluation of intervention	ICRS database	Crisis control center, relief worker organizations	Evaluate intervention and formulate improvements to be made	Mandatory

Table 7. Operational processes by crisis control center.

5. Cost estimation

The following is based on McKinsey and Company (1998): the percentage of supplementary personnel costs; annual personnel costs; accommodation costs.

Detailed design and testing (2 years)

	<i>personnel costs</i> euro / (fte * year)	<i>suppl. costs (75%)</i> euro / (fte * year)	<i>total</i> euro
5 fte project coordination	40,000	30,000	700,000
2 fte interface	50,000	37,500	350,000
20 fte hardware	40,000	30,000	2,800,000
10 fte databases	50,000	37,500	1,750,000
Accommodation costs	1,500 pp per year		111,000
<i>Subtotal</i>			5,711,000

Product development (1 year)

	<i>personnel costs</i> euro / (fte * year)	<i>suppl. costs (75%)</i> euro / (fte * year)	<i>total</i> euro
2 fte project coordination	40,000	30,000	140,000
5 fte interface	50,000	37,500	437,500
10 fte devices	40,000	30,000	700,000
10 fte databases	50,000	37,500	875,000
Accommodation costs	1,500 pp per year		40,500
<i>Subtotal</i>			2,193,000

Total personnel investment costs: ca. 8,000,000 euro

Maintenance (per year)

	<i>personnel costs</i> euro / (fte * year)	<i>suppl. costs (75%)</i> euro / (fte * year)	<i>total</i> euro / year
1 fte commercial manager	60,000	45,000	105,000
10 fte content	50,000	37,500	875,000
5 fte technical maintenance	40,000	30,000	350,000
Accommodation costs	1,500 pp per year		24,000
<i>Subtotal</i>			1,354,500

Continuous Development (per year)

	<i>personnel costs</i> euro / (fte * year)	<i>suppl. costs (75%)</i> euro / (fte * year)	<i>total</i> euro / year
1 fte commercial manager	60,000	45,000	105,000
2 fte interfaces	50,000	37,500	175,000
2 fte devices	40,000	30,000	140,000
2 fte databases	50,000	37,500	175,000
Accommodation costs	1,500 pp per year		10,500
<i>Subtotal</i>			606,000

Total operational personnel expenses per year: ca. 2,000,000 euro

End user costs

	<i>investment</i> euro	<i>depreciation time</i> year	<i>total</i> euro / year
15,000 mobile devices	1,000	5	3,000,000
25 crisis center interfaces	5,000	5	25,000
5 servers	50,000	10	25,000
<i>Subtotal</i>			----- 3,050,000
	<i>subscription fee</i> euro / year		<i>total</i> euro / year
15,000 subscription fees	150		2,250,000
<i>Subtotal</i>			----- 2,250,000

Total end user costs per year: ca. 5,300,000 euro

Numbers of devices needed are based on CBS data and own estimates (see CBS, 2004). Investment costs and depreciation times are own estimates. Note that the crisis center interfaces includes pc's, beamers and large screens.