

# **DSS for Health Emergency Response: a Contextual, User-Centred Approach**

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Keywords: DSS, decision support system; health emergency response; contextual design; contextual analysis; user-centred evaluation.

## **Abstract**

The paper presents the design approach and architecture of a Decision Support System (DSS) for the Hellenic Centre for Emergency Health Care (EKAB, <http://www.ekab.gr>). The DSS supports the cooperation and decision-making processes at the EKAB call centre concerning the effective activation and allocation of appropriate resources mainly: ambulances, healthcare personnel and other public emergency resources like fire fighting and police. The DSS is a geographic web-based mash-up that builds on top of existing information systems and databases, and collects, aggregates, records and presents various types of dynamic information about medical incidents in real time, thus promoting evidence-based medicine. Additionally, the system provides a number of user interfaces (web-based and mobile) for call centre operators, radio centre operators, ambulance personnel and administration. A contextual approach was necessary for the design of the system that was based on various related methods, and included field observation of the current ways of work at EKAB sites, design and development of data resources and user interfaces and user centred evaluation of system prototypes. The operation of health emergency response is life critical and requires decision-making that must be informed with various data about medical incidents; in order to support the decision making process, the design of interactive information systems has to take into account the existing ways of work of the people involved, in order to be adopted and used in everyday work flow.

**Keywords:** DSS, Contextual Design, User-Centred Approach, Web-based, Mash-up, Health Emergency Response.

# 1 Introduction

Medical decision-making is influenced by numerous factors that can be classified according to Haynes et al (2002) into: (a) research evidence relevant to a clinical problem or decision; (b) physiological rationale; (c) individual experience. In addition, the context of decision-making severely affects the choice and mix of decision criteria: decisions tend to rely solely on human judgment when the timeframes are short, the situation is stressing, the available information is incomplete, and when there is a lack of recorded evidence about similar past situations. Health emergency response is a perfect example of such a stressing environment: it requires the intense and continuous cooperation and decision-making of various people and roles involved in life-critical situations of providing urgent medical care.

Health emergency response systems have been studied from a number of perspectives. A large stream of research has focused on service optimisation issues (Derekenaris et al. 2001; Yoo et al. 2005; Haghani & Yang, 2007); other systems emphasise on technology related to network and information technology integration (Kyriacou et al. 2003); while other approaches focus on remote medical intervention through telemedicine (Chu & Ganz, 2004). Regardless of the focus of each approach, it is widely admitted that any approach for health emergency response should build upon current norms, practices and knowledge of people and organisations involved. According to Carver & Tarroff (2007) “*a user-centred systemic approach is required with a major emphasis on user requirements driving technological developments (for the design of emergency response systems)*”.

The paper presents the design approach and architecture of a Decision Support System (DSS) that supports the real time representation, communication and logging of various types of information about incidents that require urgent medical assistance for the case of the Hellenic Centre for Emergency Health Care (EKAB, <http://www.ekab.gr>). The overall approach is based on various user-centred design and evaluation methods, including contextual design (Beyer & Holtzblatt, 1998) and paper prototyping

(Snyder, 2003) as well as on methods of classic systems design (Cross, 1998) (especially the objectives tree method), principles of information systems design and development (Hirschheim et al. 2008) and detailed software design based on UML (Pascal, 2004). The user-centred design approach is particularly relevant for this project, since that users are not well-acquainted with technology and it was necessary to seamlessly integrate their current work practices with the designed system. According to Liu et al (2006) a large number of technically innovative decision support systems fail into actual use because they have little relevance to the real world and clinical needs.

The proposed DSS is a geographic, web-based mash-up application that integrates and represents various types of dynamic information about health emergency response (like location of incident on city maps, dynamic indication about road traffic, progress status about the incident, etc.) in a similar way to other web-based dynamic mash-ups like the open-access system of marine traffic (<http://www.marinetraffic.com>) (Lekkas et al. 2008). The DSS delivers useful information at the coordinating centre and the points of care and records incident management data like calls, transportations, hospitals' treatment, patients' health problems and response times. This provides the necessary data and network infrastructure for evidence-based decision making. Evidence-based decisions do not rely on human judgement and previous clinical experiences alone, but take into account a wide range of data about the situation at hand including recorded past similar cases.

The paper is structured as follows: Section 2 presents related work in terms of a review of approaches and systems supporting health emergency response and background in terms of the user-centred methods used for this work. Section 3 presents the contextual analysis which took place at the sites of EKAB and identified the particular ways of work highlighting breakdowns and requirements for the proposed DSS. Section 4 presents the design of the DSS for health emergency response focusing on its functional architecture and the user interfaces; in addition, the first positive evaluation results are outlined. Finally, section 5 presents the discussion and conclusions of this work.

## **2 Related work and background**

### **2.1 A review of relevant systems for the support of health emergency response**

The area of health emergency response has been studied extensively in scientific literature. A large stream of this work deals with addressing technical and optimisation issues to minimise response time and operations effectiveness; another stream of work deals with the integration and interoperation of state-of-the-art mobile technologies for pre-hospital care, while a third one deals with identifying requirements and design guidelines for health emergency response systems.

More specifically, Derekenaris et al (2001) present a solution to the problem of ambulance management and emergency incident handling by integrating a geographic information system (GIS), a global positioning system (GPS) and a global system for mobile communication (GSM) technologies. This approach focused on finding the best route of an ambulance, by proposing specifications for data structures for the implementation of the graph representing the road network. The approach of Yoo et al. (2005) addressed the problem of health emergency response on top of wireless networks by achieving the real-time transmission of patient images and vital sign signals simultaneously in a moving ambulance application. Haghani & Yang (2007) developed an optimization approach to assist the dispatch centre operators in assigning emergency vehicles to emergency calls, while taking into account prognosis for future demands. These approaches view the problem of effective health emergency response from a technical perspective and do not incorporate directly the specific requirements and current ways of work of the people involved in the health emergency response centres.

Kyriacou et al. (2003) developed a system for supporting doctors' computer-mediated intervention using a platform that allowed the transmission of vital biosignals and still images of the patient through the GSM mobile telecommunication network. This approach provided emergency telemedicine and home monitoring solutions in various contexts such as ambulances, rural health centres and other remote health points such as in navigating ships. In addition, Chu & Ganz (2004) introduced a cost-effective portable teletrauma system that assisted health-care centres in providing trauma information required

throughout the pre-hospital procedure through transmission, over commercially available 3G wireless networks, of a patient's video, medical images, and electrocardiogram signals. The above approaches to emergency response enhance healthcare provision in terms of ensuring information availability to hospitals and by taking immediate action when required by telemedicine.

A third aspect of related work in healthcare emergency response is about the identification of specifications and guidelines for the design of systems and services. In Turoff et al. (2006) a systematic development of a set of general and supporting design principles and specifications for a dynamic emergency response management information system is outlined. A set of general guidelines for design is proposed but their approach is not related to some specific context of work and therefore needs to be applied in practice to show its potential. Furthermore, Carver & Tarroff (2007) note that “*although the research has led to a good understanding of the human impacts of automation, there is still a tendency for technology to drive development not fully taking into account its systemic impacts*”. We can add to this that a user-centred approach is required to drive the design and development of health emergency response systems that takes into account the specific context of work practices so that proposed designs fit well with people’s prior experiences and ways of work.

## **2.2 Methods used to apply a user-centred approach**

The methods used for carrying out this work are based on Contextual Design (Beyer & Holtzblatt, 1998), which is a customer-centred approach for interactive product and systems design. The methodology is inherently user centred since it requires observation in the context of people’s work, and systemic in the sense that it helps the design team to build a rich picture (Checkland, 1981) about the situation at hand, created from the multiple perspectives of stakeholders. EKAB is a complex organisational system and any attempt to introduce information systems should take into account the current ways of work and adapt to the requirements of people involved. The main steps and methods include:

Contextual inquiry: a semi-structured method for observation and interview with focus 0(Holtzblatt & Jones, 1993), at the customer workplace during working hours, with the designer at the role of the observer that keeps notes and models of the work taking place. A large number of interviews were conducted at three EKAB regional offices in Greece (there are twelve overall).

Work models: these represent the work observed with emphasis on breakdowns such as delays, misunderstandings, paper-based documentation (which is vanished in the long term, not contributing to “organisational memory”), uneven work distribution, etc. Contextual design proposes five work models that offer different perspectives about the work: flow models (mainly reflecting: roles, duties, interactions, and breakdowns), sequence models (mainly reflecting the breakdown of a duty to tasks and actions, timing, and breakdowns), artefact models (mainly reflecting physical objects used to conduct the work in sketches or pictures along with notes for breakdowns), cultural models (mainly reflecting the pragmatic influence of people, roles and departments to others, indicating breakdowns) and the physical model (of the place the work occurs, also indicating breakdowns).

Consolidation and interpretation: The design team reviews the findings of the observation (contextual inquiries) in group meetings. The design team consisted of four members: a researcher, an interaction designer and two system designers and developers. This process results to a thorough understanding of the current situation emphasising on breakdowns that need to be addressed. The consolidation of work models results to consolidated knowledge that reflects the overall situation of the work in multiple perspectives. This consolidation and interpretation process helped the design team to yield a thorough understanding of the current situation emphasising on breakdowns that need to be addressed.

Work redesign: This is achieved using various methods according to contextual design including: the vision (in a similar way to Ackoff, 1981), which reflects the ideal way of work if all identified breakdowns could be resolved given an unrestricted set of resources and time; the storyboards, that provide simple and explanatory pictorial uses of the proposed interactive system from the user perspective; the user environment design, which presents a functional view of basic areas of the proposed system placing emphasis on what the system does and not how this is achieved. In the present

work the functional architecture of the proposed system is identified as well as storyboards of future uses that were used to communicate the ideas with the EKAB personnel.

Paper prototyping: Paper prototyping (Snyder, 2003) allows quick exposition of ideas about the new system and handy proposals for changes, corrections and additions. Later on, prototyping can be evolved by computer-assisted designers, e.g. with the use of sketching and prototyping software as well as SDKs (Software Development Kits). In the present work, user interfaces are developed incrementally, first on paper, then in wireframes (Brown, 2007) and then on detailed screen designs. These were evaluated by the personnel at the three EKAB regional offices.

The application of user centred-design methods was enhanced with methods of classic systems design (especially the objectives tree method) (Cross, 1998), principles of information systems design and development (Hirschheim et al. 2008) and detailed software design based on UML (Pascal, 2004).

### **3 Contextual analysis**

#### **3.1 A brief description of the problem area**

EKAB was founded in 1985 by the Ministry of Health and Social Solidarity, aiming at the urgent medical care and transportation of citizens in emergency healthcare situations. EKAB has twelve regional offices that function as self-reliant annexes in cities of prefectures. The transportation means that EKAB allocates in country regions include: ambulances, special mobile medical units, medical motorbikes, city vehicles mobile medical units, helicopters (mainly for dispatches from Greek islands), mobile coordination centres, mobile units for destructions support (e.g. in cases of earthquakes), and hospital ambulances.

EKABs' main activity is the effective coordination of medical and nursing care for all citizens, anywhere, whenever needed, as well as their safe and rapid transport in medical units. The effective

operation of EKABs' services in each region is achieved by the establishment of operational centres, that:

- Accept all calls for urgent medical help, record and evaluate them according to the degree of emergency.
- Select and mobilize the nearest to the place of incident suitable ambulance or special mobile medical unit, so that to respond in the shortest possible time.
- Monitor and guide the ambulances' personnel in the benefit of specialized help.
- Activate and coordinate units of other public organisations (fire fighting, police, etc) in cases of complex and large-scale incidents.
- Maintain continuous communication with the organisations of reception of urgent incidents (public hospitals or regional health centres), and inform them for patients' condition transported to them.
- Record data and information for identified incidents.

### **3.2 Problem Area Analysis**

The basic methods used to conduct the analysis of the problem space were contextual inquiry and contextual design work models. This first phase of the project lasted for approximately two and a half months and it included observation of the work of all personnel at three principal EKAB sites and semi-structured interviews with workers and administration (Oikonomou et al. 2009). The contextual work models that were developed included: work flow, sequence, artefact, cultural and physical models (Beyer & Holtzblatt, 1998). The consolidated work model that resulted from the contextual analysis is depicted in Figure 1. This model outlines at a high level of abstraction the most important roles, duties, interactions and breakdowns that occur in everyday workflow in a contextual and holistic manner, which are briefly presented below.

EKAB addresses several thousand calls every day. The duration of a health emergency situation is defined in four stages: “Recognition”, “Preparation”, “Travel” and “Treatment”. When a call is received at the call centre of EKAB, the operator answers the call and follows a protocol for communication which aims to determine: whether the call is real or fake (unfortunately fake calls do happen!), the level of emergency, and the location and people involved. The process of responding to an incident also includes paper-based documentation of the calls and incidents (“incident cards”) as well as a characterization of the incident based on the caller’s past experience.

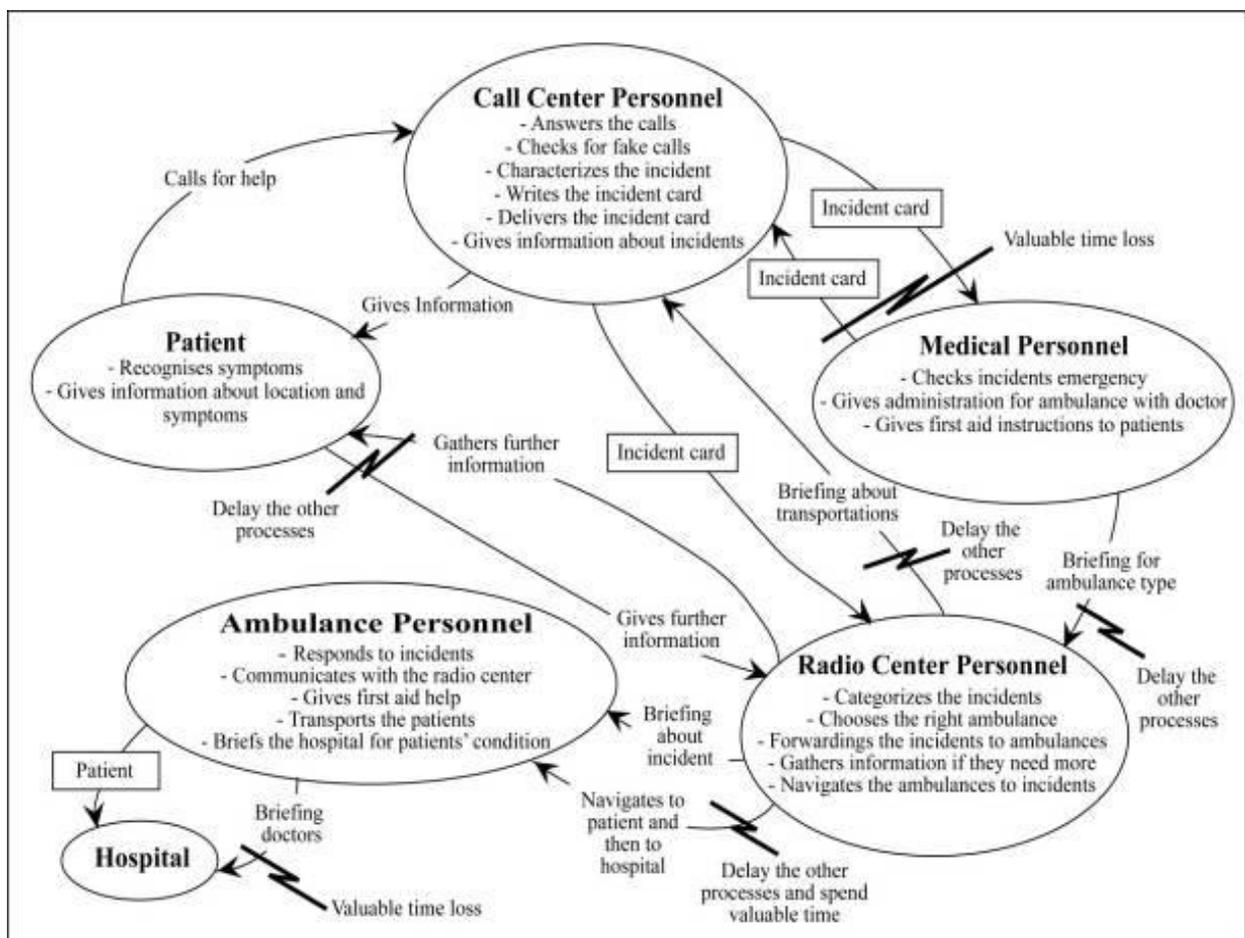


Figure 1. A consolidated work flow model of EKAB’s operation.

The incident cards are passed to operators who take over to locate available ambulances (or other types of mobile units, depending on the incident and current resource availability) and communicate with their personnel in order to handle the emergency. The operators make use of radio communication to locate available ambulances and have to make decisions about which ambulance is the most appropriate to be

assigned with the incident on the basis of their experience about geographic information, regardless other dynamic information like road traffic, current ambulances' equipment, etc.

The current organisation and operation of EKAB creates various breakdowns (delays, misunderstandings, lack of important information for efficient decision making, and so on) that affect the quality of provided services, including: lack of personnel in some departments, immobilized ambulances, handwritten incident cards, lack of history records, delay in incident characterization, mistakes in patients' address, navigation through the radio centre operator that is based on printed maps, lack of information about ambulances' exact location, lack of information concerning the road conditions, lack of information about the incidents and what the ambulances' personnel are going to face, loss of time because of the incidents cards delivery through the call centre operators, and many more.

More specifically, the most relevant actions along with related time delays and breakdowns that have been identified in the health emergency response operations, include:

1. At the call centre: (a) The call-answering protocol can take up to 15-20'' (seconds), and includes a predefined set of questions to verify the realness of the incident; following this protocol would not be necessary for every situation, if a call identity verification would be a part of the call centre infrastructure: the operator would simply know who is calling and just cross-check with the online information provided. (b) The time allocated for the completion of the hand-written incident card (about 30''), would be significantly reduced if some of the data were automatically filled-in (e.g. by the call identification software and by an automated search to the database of previous incidents). (c) The transportation of paper cards to the officer on duty in order to get them reviewed and signed happens in a face-to-face manner from many operators simultaneously who need to explain the situation just recorded (at least 30'', while phones are ringing); it would save much time if a DSS could prioritise incidents for the officer on duty on his computer screen. (d) All these delays accumulate to a well-known problem in EKAB (which is empirically known, but has not been measured), that of long call response times for citizens:

many calls are in queue while operators fill cards and interact with the officer everyday and the call centre operators daily receive citizens' complaints about their delay to answer their calls.

2. At the radio centre: The map route instructions can vary from 10'' for an easy to find route to about a 60'' overall for an out of the city route or one with which the driver is not familiar; furthermore, delays due to traffic jam may not be safely measured (empirically, they can rise up to a hour in Athens, and up to 5'-10' (minutes) in other Greek cities). It has been reported by all drivers and radio centre personnel that that they would greatly appreciate any system that would provide them with timely information and instructions on the best route that should be followed. This system should also take into account road traffic conditions as well as unexpected traffic jams or road blocks (e.g. due to some car accident).
3. At the transportation section (e.g. the ambulance): (a) Finding out the exact place of the medical incident usually takes about half a minute (30''); this could also be marked precisely to the real time geographic system. Also, (b) the immediate and periodic transportation of vital information to the systems' database via mobile applications can also contribute to more accurate doctors' briefing, especially with respect to life-critical situations that require continuous monitoring of vital signs.



**Figure 2. A consolidated sequence model of EKAB's operation.**

For example, Figure 2 shows a consolidated sequence model (one of a number of sequence models produced) for the task of addressing a call for transportation. This identifies various breakdowns: delayed completion of the card with data that have been already retrieved (paper-based completion), hand-by-hand transportation of the card to EKAB operators (who are located to another office), delayed

and error-prone route planning based on printed maps that disregard valuable information like: empty mobile units on the road, traffic congestion, and so on. These breakdowns arise every day and have obvious consequences on EKAB's response times, while they make the work of EKAB personnel mentally demanding and stressful.

The most important issue in the case of emergency is the overall reaction time of the system including effective mobilisation of resources. The need for a DSS that can support the communication and operations of EKABs' personnel, and more specifically: call centre operators, radio centre operators, ambulances' personnel, doctors of coordination centres and administration has been evidently recognised by this study. The proposed DSS can significantly enhance the quality of EKAB services, mainly in terms of providing accurate information fast to everyone involved in health emergency response, minimise response time and optimise resource allocation.

The overall response time of health emergency response ranges from 8'-20' (minutes), depending on various factors like the type of incident, the work load of call centre personnel. Also, several errors can happen in the process that can generate more delays and decrease the quality of health emergency response services. The response time will be reduced to several minutes per incident by minimizing delays at various stages of the process. Also, the proposed DSS could minimise human errors that occurs due to work pressure. Furthermore, the DSS will gradually develop a database about cases and incidents that will complement human judgement and experience thus contributing to evidence-based decision making. All these factors certainly contribute to added value of provided services for all, including citizens, workers and medical personnel.

### **3.3 General functional specifications for the proposed DSS**

The interpretation of breakdowns of the current operation of EKAB took place in a number of group meetings of the design team along with feedback from the participants in the analysis. A first outcome of this process was a list of general functional specifications of the proposed DSS:

1. The DSS should be a mash-up application that collects information from various sources and integrates them to a uniform user interface. Particular functional specifications related to the mash-up metaphor include:
  - a. Geographic information about city maps and the location of ambulances (and other mobile units) as well as the location of the incidents must be visible.
  - b. Dynamic information about road traffic and the ongoing status of incidents must be integrated.
  - c. Different markers for different types of information (e.g. incidents, ambulances, hospitals, police stations, etc) must be used.
2. A large number of paper-based functions should be automated, including:
  - a. Fill-in of incident cards at the operating centre.
  - b. Online updating of incident cards from other sites (i.e. mainly ambulances and hospitals).
  - c. Online notification of new pending incidents at the radio centre.
  - d. Online view of road traffic conditions for supporting decision-making about selection of ambulances from the radio centre.
  - e. Dynamic knowledge representation and monitoring of emergency response allowing for fast take up by changing personnel shifts and minimising human errors due to work pressure.
3. A number of user interfaces should be build on top of the mash-up application, mainly allowing access from mobile phones and devices. In addition, these interfaces should take into account the current ways of work and integrate artefacts currently used in paper to allow for usability in terms of connecting current practices and terminology to the proposed DSS. These artefacts include:
  - a. Incident cards that describe incoming incidents
  - b. Forms to be filled with information about personnel, hospitals, ambulances and their equipment, etc.

- c. Geographic maps, as indicated above
- d. Telephone lists, calendars, etc.

The presented specifications are gradually refined to the architectural design of the DSS, which is presented in the next section.

## 4 Design of the DSS for emergency response

### 4.1 Relevant subsystems and functional DSS architecture

The analysis of the problem situation has resulted to the identification of a number of relevant subsystems that represent the major components of the proposed DSS (Figure 3):

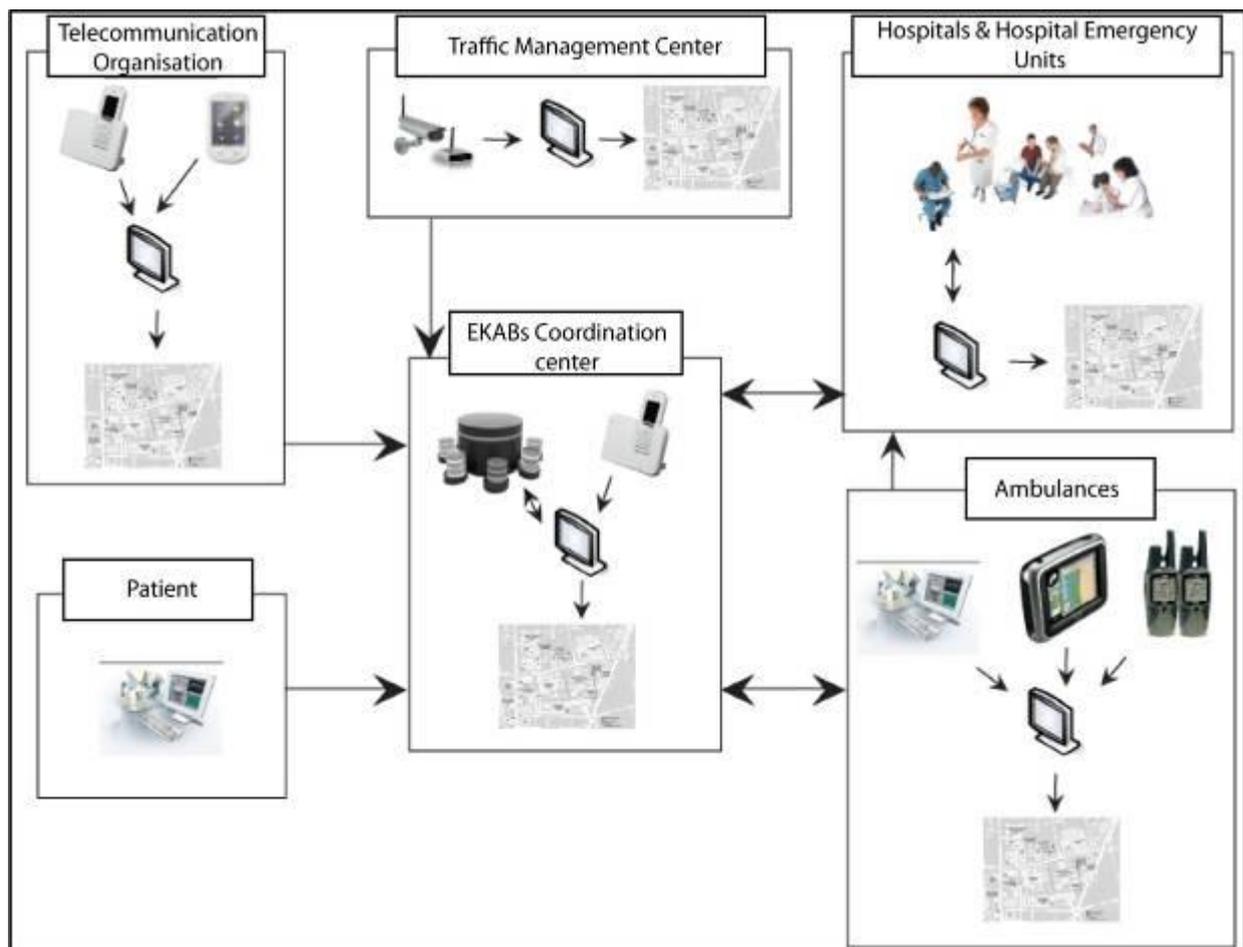


Figure 3. Relevant subsystems of concern of the proposed DSS.

1. Telecommunications organisation: This subsystem should provide EKAB with call recognition of any type of calls including those from mobile phones, stationary public phone "booth" and confidential numbers. In addition, the location (exact geographical coordinates based on telephone number) of the caller as well as other data that mapped to this number, like address, phone owner's name, age, etc. should be pointed out.
2. Traffic management centre: this should provide EKAB with dynamic information about the current condition of the road network including road directions, traffic congestions, and unexpected events like road blocks due to repair works or demonstrations.
3. Hospitals and hospital emergency units: This subsystem will provide EKAB with information about the current situation of the status (on duty or not) of the hospitals. In addition, the available clinics, the doctors on duty along with direct communication information and bed availability should be provided.
4. Patient: This subsystem should be used by the ambulance personnel to report on patient(s)' symptoms and condition, including vital measurements (e.g. blood pressure) that can be made on site or during transportation as well as to update the level of importance of the incident according to their experience onsite.
5. Ambulances: This subsystem should transmit the current location of the ambulance (or other mobile unit), its current status as well as information about its equipment and current staff.
6. EKAB coordination centre: This subsystem will integrate the above information into an integrated DSS that will provide dynamic information about the progress of health emergency situations.

The proposed DSS is a mash-up application which will be installed mainly in the coordination centre of EKAB and will integrate information from interconnected subsystems that will be located at other major organisations.

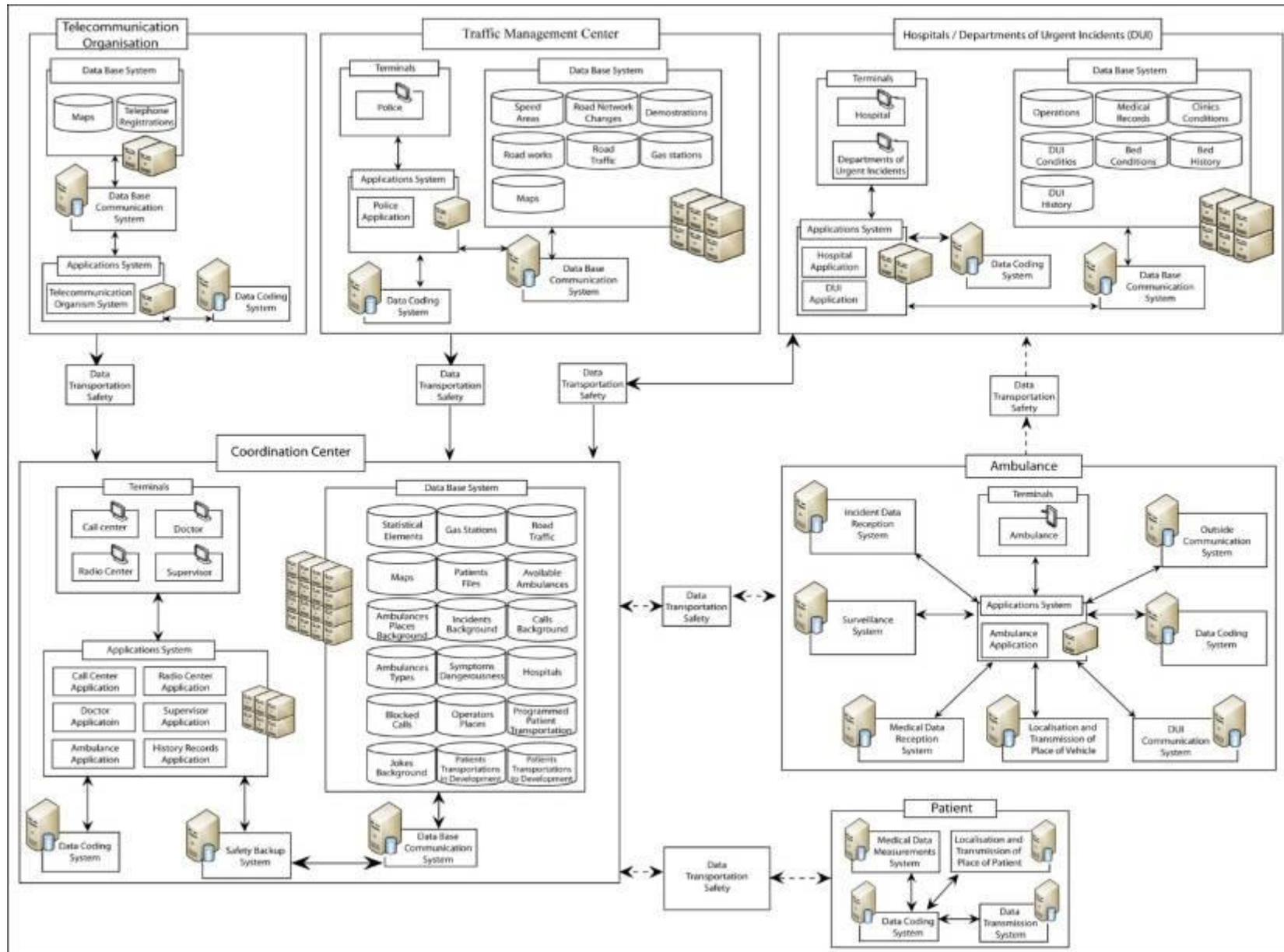


Figure 4. Functional architecture of the proposed DSS for emergency response.

The components of the proposed DSS, which enhance the current ways of work and provide evidence for decision-making at EKAB, are depicted in Figure 4 and include:

- **Digital maps:** most information is represented on digital maps, using appropriate markers that provide additional information and links to web sites (e.g. for the case of hospitals). The basic types of information that is placed on maps includes the location of patients/incidents, the location of the ambulances, the location of hospitals, the location of gas stations, the various obstacles of road network, the road traffic, the course that an ambulance should follow in order to reach its destination and alternative routes.
- **Road conditions:** the telecommunications management centre should periodically transmit data about the condition of the road network.
- **Ambulances availability and equipment:** ambulances on duty are represented on the system with information about their crew and equipment.
- **The hospitals:** information about the current status and work load of hospital clinics can be viewed so that the centre can take this into account when directing mobile units.
- **Symptoms and condition of the patient(s):** The ambulance personnel should fill-in symptoms and comments about the condition of the patient(s), thus providing a more elaborated update on the incident characterisation than that provided from the call operator.
- **Incidents history:** A database will store incident cards, along with various types of information about each incident like times for “recognition”, “preparation”, “travel” and “treatment”, caller’s identification information, level of emergency and so on.
- **Calls history:** The calls will be recorded and registered in a database for future recuperation by the administrator of the system, as well as for better management of recalls. This will also include the history of fake calls.
- **Statistical data:** The data generated by incident management (mainly including calls, transportations, hospitals’ treatment, patients’ health problems and response times) will be considerable

enhance the effectiveness of health emergency response at all levels, ranging from faster response times and better work conditions for EKAB personnel to the optimisation of resource and fleet management.

The proposed DSS makes use of the following technologies:

- Database technologies that are based on current information and data infrastructure which are accessed via Web services (Benslimane et al. 2008).
- The website is based on the Asynchronous JavaScript and XML (AJAX) technology (Ullman & Dykes, 2007) for allowing interactive user interface responses to user requests and actions.
- The server side is loaded with scripts that process a wide range of optical, textual and sound content and it exploits dynamic map APIs, such as the one provided by Google at no cost for noncommercial applications.
- Other network technologies employed include GPS (Global Positioning System) for ambulance's and patient's location and the GSM (Global System for Mobile communication) network for mobile communications.

The DSS collects aggregates and presents various types of useful information at the coordinating centre and the points of care. Furthermore, it records incident management data like calls, transportations, hospitals' treatment, patients' health problems and response times. These functions are necessary for supporting the coordinating centre personnel in making decisions about allocating resources to medical emergencies. Furthermore, these functions also assist clinical personnel in making decisions about patients' transfer to appropriate clinics and urgent first aid. Notwithstanding the importance of human judgement and previous experiences, the proposed DSS will contribute to well-informed decisions that will be based on evidence about the detailed account of the current medical situations at hand as well as recorded experiences about past situations.

#### **4.2 User interface design for the DSS for health emergency response**

Various user interface prototypes have been developed to illustrate the major aspects of the proposed DSS for health emergency response. The main guidelines for the design include the following:

- The user interface should represent information on the geographic map at various levels of detail.
- Support for tabbed browsing in order to allow for information management at various stages of emergency response.
- Inclusion of information and terminology that is already used in the current situation to better support user comprehension and navigation.
- A simple and usable design in order to be used by all users including those that were not computer literate.

Taking into account the fact that the large majority of the personnel are not familiar with the use of computer-based systems, the user interfaces are designed in a simple design fashion. Information is categorized and represented on geographical maps and on tabs for better browsing (Figure 5). Four information groups are used that categorize the information at the calls' centre user interface: call elements, patients' elements, patients' description of illness and the incident characterization. These information groups are laid out around a geographical map that represents with markers and summaries related information to the incidents. In addition, four tabs are used: the incident, recall, hospitals and calls. Those tabs include incidents history, the primary and the secondary elements that are available to the user concerning the current task.

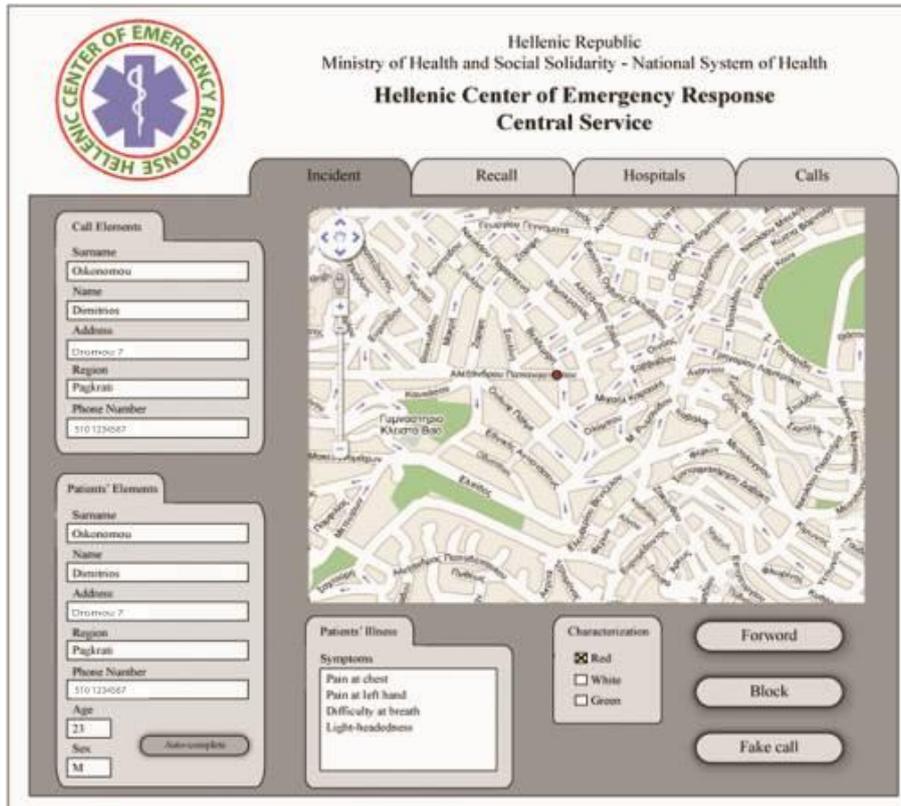


Figure 5. User interface prototype of the proposed DSS at the call centre.

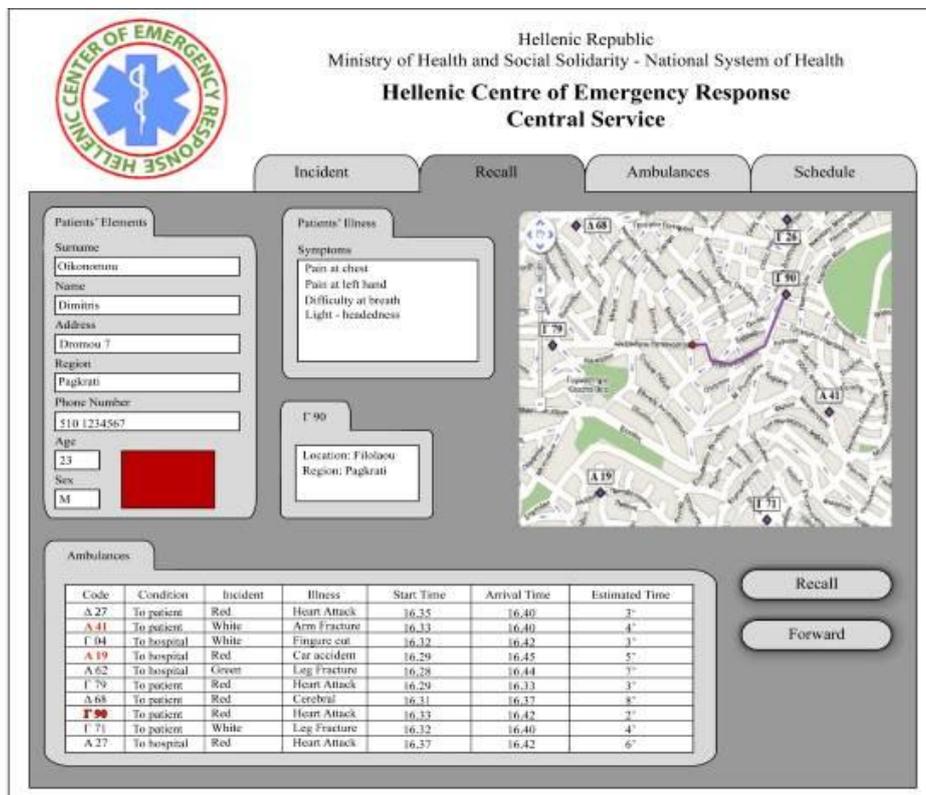


Figure 6. User interface prototype of the proposed DSS at the radio centre.

The radio centre user interface has the same structure with the calls' centre (Figure 6). Additionally in this case, the labels categorize the information in patients' elements, patients' illness, ambulances and ambulances codes. The map representation shows all available ambulances including those that they are heading to a patient or a hospital and necessary information about each one. The tabs are categorized in incidents, recalls, ambulances and schedule.

In the ambulances (Figure 7), the incoming information is transmitted as fast as possible and the content is limited only to the critical in a clear format, since the ambulance personnel face life critical incidents and work under pressure. The ambulances' user interface represents information categorized in different labels, providing only the necessary information, for example the patients' symptoms and under this label the measurements of the patient sent to EKAB. In response, the mobile application can receive emergency care guidelines that are appropriate for each incident. The navigation is simple, big text size is used and simple phrases should make clear the use of each button.

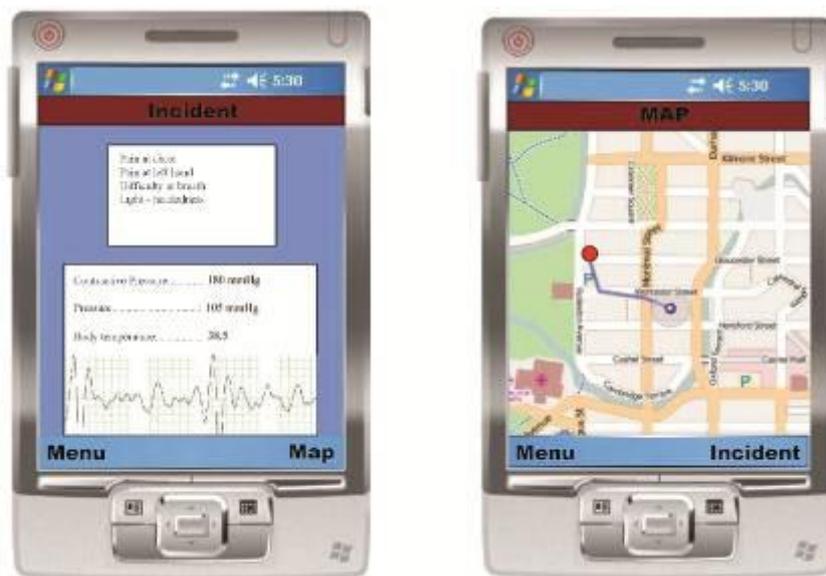


Figure 7: User interface prototypes of the proposed DSS via mobile access from at ambulances.

### 4.3 Evaluation

The evaluation of the proposed system prototype was made with actual users including call centre personnel, ambulance crew and doctors on the basis of user interface prototypes and videos illustrating scenarios that arise from current operation. The importance of prototype evaluation has been widely

identified in interactive systems design practice and literature (Beyer & Holtzblatt, 1998; Snyder, 2003; Brown, 2007) as well as in DSS literature (Yoo et al. 2005), since that it enables evaluation during the design process and generates feedback from real users fast and before (or during) the software development phase.

The goals of the project and the system prototype were presented to the personnel of the three regional offices and comments and questions were gathered by the design team. Furthermore, semi-structured interviews were conducted with the personnel at the three sites in order to get their opinion and feedback about the proposed system. A number of questions were asked to the personnel including: their impression of the interface at first sight and after testing; if the terminology and operations were understood; if they would be willing to give up their current way of work and use the proposed DSS; The interviews were recorded and a number of improvements were identified for further development of the system.

The results of the evaluation were very encouraging. Despite that the personnel is generally reluctant to the use of new technologies, they recognise that updating their work practices would improve effectiveness and efficiency. They admitted that the proposed DSS collects and aggregates information that is necessary for decision-making in emergency health response situations. The ability to see aggregated information about medical incidents and hospitals in a geographic mash up in real time and navigate through the maps was seen as essential for supporting them to make decisions especially about which ambulance and personnel to send to a particular incident, and to which hospital should this incident be delivered.

With regard to the design of the proposed DSS, the users found it generally simple to use, and that the operations and terminology employed matched their daily language and norms. Despite that all people interviewed had not used a similar system before, they expressed their willingness to try the application in pilot operation. Finally, a number of issues were also identified with respect to terminology and functionality that will be addressed in the next version of the system. A particular aspect of future work in this respect is the availability of typical emergency care guidelines that are appropriate for particular

medical incidents for physicians and other clinical personnel located in the ambulances and at the points of care.

## **5 Discussion and Conclusions**

This paper presented the contextual analysis, design and evaluation of a DSS for the support of health emergency situations in EKAB. Currently, EKAB operations are poorly supported by information systems with consequences in service delays, information unavailability and work overload that have serious impact on the overall quality of service and the public image of the organisation. EKAB faces life critical situations of emergency and should be equipped with contemporary information systems and technologies in order to offer high quality services to citizens. The operations of EKAB should immediately be enhanced to significantly improve its purpose, impact, and services.

The paper argues for the need of a user-centred approach for the design of health emergency response systems and presents an application of related methods in a pragmatic case study. Health emergency response is characterised by an intense and stressing work flow that must be based on clear evidence of the situations at hand and the smooth cooperation and decision-making among a large number of roles and personnel at different geographic locations. In addition, it is critical that the information systems in support of these processes are adapted to people's work norms and processes, in order to be easily adopted and used; otherwise they will increase complexity and stress, especially to novice users of information technology.

The work presented is based on a contextual analysis of the current ways of work of the people involved in the EKAB call centres and proposes the design of a DSS that integrates and enhances these particular norms and ways of work. The contextual analysis generated a large number of breakdowns of the current ways of work and a set of requirements and specifications that need to be incorporated into the proposed system. Furthermore, the evaluation of the proposed system was made with its actual users in scenarios that arise from current operation emphasising on the user interface prototypes of the proposed system in order to allow for improvements from the perspective of its potential users.

We have applied a number of user-centred design methods for interactive information systems development, which are often not used in the practice of healthcare informatics: many healthcare information systems tend to rely on technologies of-the-shelf –, neglecting the particular norms and ways of work, and therefore, hindering user acceptance. The user-centered and contextual approach is particularly relevant to this project, since that our users are not well-acquainted with technology and we wanted to seamlessly integrate their current work practices with the designed system.

The paper also presented the architecture of the proposed DSS, which is based on the mash-up metaphor that builds on top of existing information systems and databases. It has to be noted that the proposed system is not a classic DSS that focuses on a particular knowledge domain and investigates alternatives, but a more comprehensive system that contributes to awareness about critical medical incidents and provides various types of information and notifications about the progress and status of these incidents and related events. The DSS handles evidence-based medicine issues by establishing an information and network infrastructure that aggregates and presents facts and experiences that can enhance decision making in emergency health care situations. The primary users of the proposed DSS are the call-centre personnel and the physicians, who are currently making decisions relying solely on their experience in a demanding environment without any practical support of information systems. The proposed DSS contributes to user-driven healthcare, provided that we consider an encompassing definition of ‘users’ to include other related roles beyond the primary ones of patients and physicians, like the emergency healthcare call-centre personnel.

After the successful evaluation of the prototypes of the proposed DSS, the technical development is ongoing on the basis of the technologies of the Google Maps API; Web services (Benslimane et al. 2008); and Asynchronous JavaScript and XML (AJAX) (Ullman & Dykes, 2007). Particular issues that are of interest during development include the visualisation of dynamic information in mash-ups (such as the marine traffic system: <http://www.marinetraffic.com>, Lekkas et al, 2008) and personalisation of the user interfaces according to different types of user requirements (Koutsabasis et al, 2008).

It is envisaged that this work can be a useful example of a contextual and user-centred approach for the design and development of health emergency response systems that can generate evidence for

contemporary decision-making. This work takes into account the particular requirements of the particular human activity system at hand, and builds on existing ways of work in order to propose designs that are feasible both in technical and human activity terms. After the establishment of the basic information and network infrastructure that the proposed DSS will provide to health emergency response, future work includes the detailed modelling, integration and visualisation of patients' basic physiological information onto the mash-up application. This will enable clinical personnel located at hospitals or at the emergency centre to provide advice and healthcare guidelines to personnel located at the medical incidents.

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