International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:4, No:6, 2010

The Management in Large Emergency Situations – A Best Practise Case Study based on GIS for Management of Evacuation

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Abstract**—**In most of the cases, natural disasters lead to the necessity of evacuating people. The quality of evacuation management is dramatically improved by the use of information provided by decision support systems, which become indispensable in case of large scale evacuation operations. This paper presents a best practice case study. In November 2007, officers from the Emergency Situations Inspectorate "Crisana" of Bihor County from Romania participated to a cross-border evacuation exercise, when 700 people have been evacuated from Netherlands to Belgium. One of the main objectives of the exercise was the test of four different decision support systems. Afterwards, based on that experience, software system called TEVAC (Trans Border Evacuation) has been developed "in house" by the experts of this institution. This original software system was successfully tested in September 2008, during the deployment of the international exercise EU-HUROMEX 2008, the scenario involving real evacuation of 200 persons from Hungary to Romania. Based on the lessons learned and results, starting from April 2009, the TEVAC software is used by all Emergency Situations Inspectorates all over Romania.

Keywords**—**Emergency evacuation, Searching Features, TEVAC (Trans Border Evacuation) software system, User Interface Design.

I. Introduction

MOST of the time, major emergency situations imply people evacuation from the endangered area. In fact, the intervention efficiency of professional emergency services resides in their capacity to protect lives and goods. While in case of "normal" intensity fires or floods, these services can adopt offensive tactics as fire fighting or a dike consolidation, during a disaster, the only efficient action is the evacuation of people and goods from the threatened areas.

"Emergency evacuation" [9] is a measure of civil protection taken prior, during or after an emergency situation occurs, when the alert situation is declared, which consists in removing people, animals and goods, away from the threat or actual occurrence of a hazard, in a systematic manner from potentially endangered or affected areas, to safe places which ensure survival and protection conditions. In the case of a small scale evacuation, the operations do not involve major problems.

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When we are talking about hundreds of people who need shelter as they leave the disaster area, the lack of a reliable decision support system can generate victims. Yet, such a system never existed in Romania, even if its necessity has been proved once again during the major floods in recent years.

In November 2007, a work group emerged from the Emergency Situations Inspectorate "Crişana" of Bihor county and decided to develop such a solution.

The success of this project was confirmed by the recommendation addressed in April 2009, to all the county emergency inspectorates by the General Inspectorate of Emergency Situations, to use TEVAC software (Cross border evacuation software).

The project began in the best possible way, with the participation of two officers from the inspectorate, as "Dutch evacuated persons" at the Olympic Offspring exercise that took place on the 28th of November 2007.

The exercise consisted in a real-time evacuation of more than 700 - people from Terneuzen – Nederlands to Zelzate – Belgium, one of its goals being the comparative test of four evacuation process informational systems. This event has practically been the birth date of TEVAC software.

In the first half of 2008, the regular phases of the software design project have been covered, such as defining the work flow the database structure or the design of the user interfaces. This type of software can be tested only in the conditions that resemble real situations. This condition was achieved during the EU-HUROMEX 2008 project [10], an international emergency situations exercise attended by more that 500 - people from eight countries. During this exercise, 160 - people have been evacuated from Gyula - Hungary to Chişineu de Criş – Romania.

II. Defining the Evacuation Process Concept

The design phase of TEVAC software system development project began by defining the concept of evacuation process. Thus, all the stages of an evacuation have been documented according to the legal aspects and international lessons learned and best practices, starting from the moment when the evacuation order has been issued until the evacuees have been accommodated. In the general context of an unclear legislation in this domain, the Olympic Offspring exercise experience and the support of Dutch experts has played an important role in covering this part of the project.

The final step of this process was the evacuation exercise during EU-HUROMEX 2008. The evacuation concept is

schematically presented in Figure 1a (the evacuee's reception center, the mobile medical point and the accommodation center) and Figure 1b.

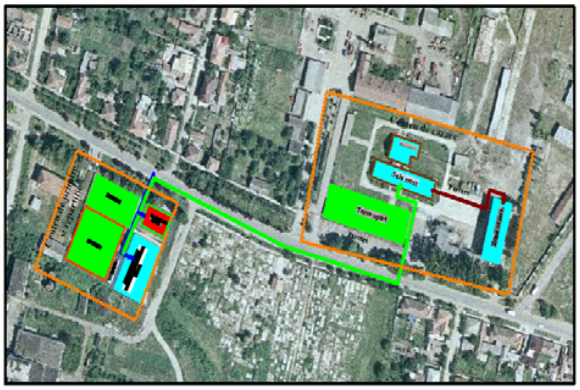

Fig. 1a. The evacuation concept
(the evacuee's reception center, the mobile medical point and the accommodation center)

Fig. 1b. The evacuation concept

Relying on the Dutch model, the evacuees were directed the evacuees reception center - ERC which was organized in a sport hall. This solution was chosen because there are buildings of this type in many urban or even rural locations, which allow the temporary sheltering of a great number of people and the playing area can be easily organized into specific areas. At the same time, the vestibules and other annexed spaces can have specific purposes, such as: resting areas for pregnant women, a medical office or "mother and child" rooms (Figure 2).

Over time, using the sport halls as reception center for evacuees proved to be a good practice, which had been confirmed during the EU- HUROMEX 2008 exercise.

III. GENERAL ARCHITECTURE OF THE SYSTEM FOR EMERGENCY MANAGEMENT

The general architecture of the integrated decision support system for emergency management has been detailed in [6] and showed on the Figure 3.

Fig. 2 .The way a sport hall have been organised to cover the needs of an "evacuees reception center" - ERC

The components of the Integrated DSS for Emergency Management are:

EVRIS- evaluation of the risk associated to emergency events. This component is dedicated to the recording of every identified emergency event and of the estimated effects for pre-defined values of parameters describing dangerous event in a database. Data about the probability to reach of these dangerous values are also recorded. This component enable the interrogation of database configuring the parameters which describe impeding event, giving also an imagine of the degrees of associated effects.

MEPREV– prevention messages concerning emergency events.

10GIS – Associated GIS. Typically, emergency management depends on large volumes of accurate, relevant, on-time geo-information that various organizations systematically create and maintain. During emergencies, GIS enables emergency managers to quickly access relevant data about an affected area. The geospatial aspects may be explicit, such topographic maps, providing background information, or implicit, e.g. demographic data about population distribution in an affected area. In the same way either dedicated tools are used to analyze or incorporate geospatial aspects or the information is integrated via interoperable GI components or GI services in a specific emergency management application. Types of data usually needed in emergency management can be classified as follows [2]: data on the emergency phenomena, their location, frequency, magnitude and so on; data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation and so on; data on assets that might be destroyed if the event takes place: infrastructure, settlements, population, socioeconomic data and so on. At present the *Emergency Situations Inspectorate "Crisana" of Bihor County, Romania* using an "in house" system for particularly GI management and is part of *Oradea Local GIS Consortium.*

MAPER – dangerous substances. Mainly task of this component is to identify the characteristics of dangerous substances and estimate the effects of possible accidents involving dangerous substances. This component manages

also the data concerning commercial societies that stores transport or generate the dangerous substances.

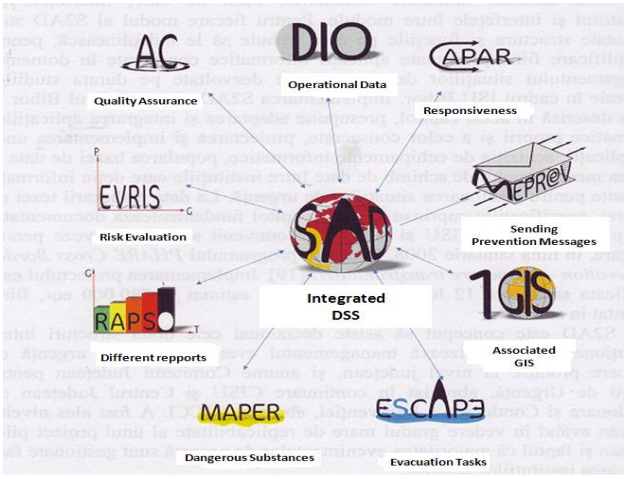

Fig. 3. Integrated DSS for Emergency Management: S2AD (adopted from [6])

ESCAPE – evacuation in emergency situations. This component give the possibility to elaborate the evacuation plans for the affected localities, their re-evaluation and updating if necessary, elaboration in real time of an evacuation plan if necessary as well.

CAPAR - responsiveness. The design of this component is around of "support function" having as task to quickly provide the answers of the questions such as: Who is responsible for population's evacuation? Which and what available quantity of absorbents? How many devices for recovery are available?

RAPSO – different reports about various situations. At *Emergency Situations Inspectorate "Crisana" of Bihor County, Romania* is a complex application for collecting and processing of the data about the effects of sorely emergency situations.

AC – Quality Assurance. This component gives to the users the possibility of improvement. One of the modules, DQAT, developed for five languages; give the access to their four sections: prepare, adjust, evaluate and practising.

DIO – Operative Data.

A prototype of the Integrated DSS for Emergency Management has been developed at *Emergency Situations Inspectorate "Crisana" of Bihor County, Romania*, using the option for "in house" development software and based on user interface design idea described on the next section.

IV. User Interface Design

One of the lessons learned during the international exercises was that the people don't have to wait in line during an evacuation. The TEVAC software system was designed based on this principle, the user interface being identical with the form filled by the evacuated people (Figure 4). Also, in order to speed up the registration process predefined lists (drop down lists) and predictable writing functions were used.

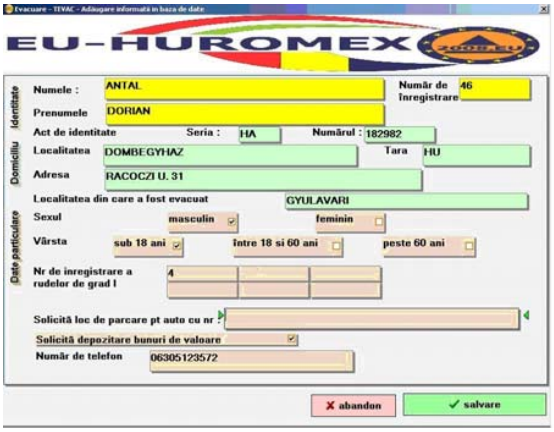

Fig. 4. The user interface is similar with the registration form

Using a network of four computers - 160 persons were registered in about 60 minutes, the necessary time to input data for one person being about 90 seconds [7], [8]. Using large open spaces, as is the sport hall and the proper organization of the space, avoided crowding in the registration area and during the evacuation process in general.

After the evacuees had been registered, the TEVAC "repartition for accommodation" module - quickly generated the repartition lists and according to this list the evacuees were sent to the accommodation centres.

Before the repartition process starts it is possible to visualise the current situation of the available rooms and the status of the people who were not placed yet.

The default method prioritizes the repartition of relatives in order to regroup the families; the next rule is to accommodate women and elder people downstairs, then to group people by their residence in order to form mutual interest communities.

V. Searching Features

The TEVAC software system also played an important psychological role by allowing relatives to find each others, using the database created during the registration process.

The software system allows advanced searching features including the use of geospatial criteria (search by consecutive filtering of fields, search by the value of a field, or by one part of a text in all fields).

"Search by filling in the filters" method is used when details about the searched person are known and consist in filling-in the filter fields, as shown in Figure 4 (e.g. Registration number, name, surname, etc.). This method can generate complex reports such as:

- *The list of all women distributed for accommodation, being over 60 years old, evacuated from Calarasi and having the first name Georgeta*
- The number of the persons who requested to store valuable goods.

The "Advanced search" method is used only when general information is known. For example, we do not know whether Vladimir is the name or the surname, the person is living in Galați or is evacuated from Galati only.

The "complex search" method is used when operative

reports are needed. The method can generate complex reports by combining the *advanced search* with the *filling the filter* method. For example a list of all children without relatives in the camp and which were evacuated from Galati without having the residence in this city can be generated at the moment of departure from the evacuation camp.

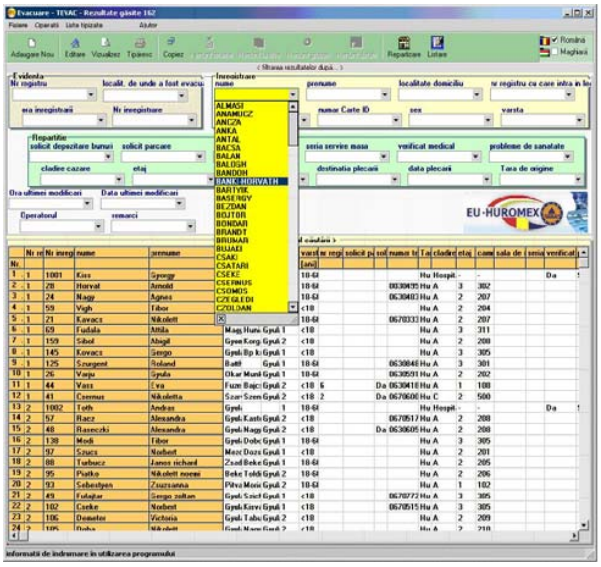

Fig. 5. The software has complex searching features such as ”Search by filling in the filters” method

VI. Discussions and Future Works

"*Solving large-scale evacuation problems is overwhelming*" [1]. "*No one can just sit down with a map and draw lines and figure out the best answer to problems like these.*" [1].

Starting from April 2009, the TEVAC software system is used by all Emergency Situations Inspectorates all over Romania.

The lessons taking into account for next generation of TEVAC software system are:

- Threat must be detectable;
- Geographical data must be immediately available [5];
- Correct positioning of equipment and personnel could avert the disaster.

Three major issues are especially critical:

- Advanced planning to identify and map those areas at risk is critical [6];
- Advanced modelling of those areas considered at high risk;
- Real time capabilities are needed to track an event and deploy assets.

A. Future works

One of the critical problems is that the needed spatial and non-spatial data is usually geographically dispersed and stored in heterogeneous databases. The new generation of information systems including GIS should be able to solve semantic heterogeneity [3].

Another problem consist on the fact that an Integrated System for Emergency Management is a multidisciplinary approach and is based and have to be based on the new information technologies (GIS, Web services, ontology, semantic integration), expert’s knowledge about structure and processes in the hazard management system, hazard emerging and possible effects on living environment, as also combine the knowledge of expert’s working in different domains. This will improve the process of emergency management.

The new models and services will be specialized for application in involved organizations and public services. The adoption of a real-time traffic information management model [11], [12] is absolutely necessary in order to manage the best the problems created by traffic during evacuation. So, the solution efficiency provided by proposed system will be especially valuable for all local communities and local authorities from Romania.

The advantages of successful information integration in emergency management GIS applications are obvious for many reasons [4]:

• Quality improvement of data due to the availability of large and complete datasets.
• Improvement of existing analysis and application of the new analysis.
• Cost reduction resulting from the multiple use of existing information sources.
• Avoidance of redundant data and conflicts that can arise from redundancy.

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