ERMA : Un outil d'aide à la décision dans les situations d'urgence

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ERMA: A SUPPORT TOOL FOR DECISION-MAKING IN EMERGENCY SITUATIONS

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Résumé

Cette communication présente les principaux aspects du système ERMA – une plateforme informatique dédiée à l'aide à la décision pour la gestion des risques naturels et industriels majeurs. Constitué de plusieurs modules (aide à la décision ; tableau de bord d'indicateurs ; gestion des processus ; système d'alerte), ERMA apporte une valeur ajoutée à chaque étape de la gestion des risques et des situations d'urgence. L'ensemble du système a fait l'objet de tests terrain: en Espagne (accident industriel) et en Roumanie (inondation).

Summary

A crucial aspect in managing emergencies caused by natural or technological hazards is the decision-making process. Important decisions must be taken, often in a very short time, under stress and with reduced or partial information. In such a context, risk management systems can be a helpful tool. This communication presents the essential aspects of ERMA (Electronic Risk Management Architecture) system, a platform based on service oriented architecture device as a support tool for risk management in emergencies.
ERMA consists of a Decision Making Assistance System (DMAS) which collects data and compares them with a set of key indicators (Key Indicator System); it proposes the actions to be taken (Process Management Component). The system is GIS based, so that every single task can be georeferenced. GIS is also used for mapping the dangerous phenomena (e.g.: a flood, a toxic cloud). The DMAS is linked to a warning module that enables to develop an appropriate and massive warning strategy. Both the DMAS and the warning system are connected to a citizen relationship management system which furthers communication with the public and channels citizen feedback. The whole system has been tested through laboratory tests and by using it in two complementary field trials. The results have been quite satisfactory.

1 Introduction

In the event of an emergency caused by natural or technological hazards, important decisions must be taken, sometimes in a very short time, under significant stress and with reduced or partial information. These decisions can imply delicate aspects, as often they can affect population (for example, in the case of evacuation of a given area). In such cases, the decision-making process can be a difficult step for authorities or, generally speaking, for those responsible of the emergency. Previously prepared actuation procedures are required, together with the adequate information concerning a set of variables which depend on the emergency (water level in case of a flooding event, concentration of a dangerous gas in air in case of toxic cloud, etc.).

In such a context, risk management systems can be a helpful tool to optimize the emergency services actuation and to take the best decisions. Furthermore, in some cases a quick and massive action must be taken (for example, informing a sector of the population on a given risk).

The combination of risk management systems with the most modern Information and Communication technologies can lead to an optimum tool to support the decision-making process in such situations.

Specific decision scenarios, such as resource management and mapping tools, are already supported by IT tools for command centres. However, workflow management services and key indicator systems are rarely found even though their added value for crisis assessment is proven.

The ERMA (Electronic Risk Management Architecture) system has been devised as a complete reference platform for risk management in emergencies. It has been developed in the 6th Framework Program of the European Commission (Priority FP6-2006-IST-5-2.5.12, ICT for Environmental Risk Management. Contract no. 34889). A specific focus has been placed on the needs of small and medium-sized communities

The ERMA platform includes:

- a key indicator-based decision support system combined with a workflow management system,
- an early warning system to alarm emergency staff and concerned citizens,
- a system for citizen relationship management to support the communication with the citizens as well as team collaboration software for rescue organizations and other authorities.

This communication presents the essential features of ERMA, as well as the procedures applied to test it both at laboratory and at full scale levels.

2 Risk and emergency situations

The ERMA targets are the specific needs of small and medium-sized communities in order to assist them in efficiently managing all aspects inherent to the risk management coming under their respective responsibilities, from the preventive aspects to decision-making during a crisis and post-emergency analysis.

The hazards threatening a community can be classified in three categories:

- Natural risks: earthquakes, landslides, floods, hurricanes and tornadoes, snow falls, tsunamis, and volcanoes.
- Technological risks, related to the sudden release of large amounts of energy or dangerous substances (fires, explosions, toxic clouds, toxic spills to water, radioactive releases, etc), are usually associated to the existence of industrial sites, sea-ports, and transportation of hazardous materials by road or rail.
- Man-made risks related to the activity and the existence of people: forest fires, abnormal conditions in the basic supplies to the population, etc.

Although these hazards have some common features, they are essentially different from the point of view of surface covered (usually a larger scale in natural risks), probability in a given zone, scenario dynamics, etc. Thus, emergencies should be treated in different ways, although a common aspect is the convenience of warning the population in time.

Because of these different features, these hazards may require a diverse treatment from the point of view of crisis management and population warning. Most natural hazards –a flood, a snow fall or a volcanic eruption– can be often foreseen within a certain time, which gives a safety margin to inform and alert the population (earthquakes are the exception). Instead, a toxic release from an industry implies a very short time and an explosion will probably occur without warning at all. Thus, according to the type of hazard, the essential variables involved in the emergency will be different: the key indicators, the response time, the instructions to the affected population, etc.

2.1 A key aspect: warning the population

In emergency situations, an essential aspect can be the need of warning the affected population about the existence of a hazard and giving them the adequate instructions (in fact, a previous complementary action should have been developed, informing the population in advance on what could happen and what should they do if it happened). This information must be given on time, and only to the population directly affected by the hazard. This implies that some previous analysis should have been performed in order to establish the diverse zones at risk in the event of different accidental scenarios. For example, if the hazard is a toxic release, a previous simulation would allow establishing the area affected and thus the population at risk for the diverse accidents foreseen and the most common meteorological conditions (local wind rose).

The time elapsed between the start of the emergency and the moment at which the effects will reach the affected population can vary a lot. In certain floods, the process is relatively slow and the risk can be predicted with enough time to warn everybody and evacuate them without any major problems. However, in the case of a toxic cloud under stable atmospheric conditions, the cloud will move at the wind speed and some inhabited area can be reached in a rather short time. This means that the corresponding authority will have a much reduced time to take a decision (in this case, it will usually be to send the instruction of confining at home) and, once the decision taken, the time to warn the population will be also very short.

In such circumstances, if a previous risk analysis has established which is the population at risk (i.e. the population to be warned) a quick and massive information to this population will reduce drastically the consequences. In this sense, the modern communication technologies and, more specifically, the mobile phones, have introduced a new possibility which plays a significant role in the ERMA project.

3 ERMA Structure and technical features

The ERMA platform is based on a Service Oriented Architecture (SOA) and as such, it is made of an ad hoc collection of small modules or services, meeting a large scale of needs related to risk management. All of these independent subsystems are called *ERMA components*, which forms a geographically distributed software system, able to handle issues of scalability (increasing number of users and work load) and fault-tolerance. In this sense, ERMA is flexible and extensible and also easy to customize to special requirements of end-users.

Figure 1 shows a diagram of the ERMA's main structure. The core of the system is the DMAS which mainly performs two different tasks: a) collects data from the sensors which are monitoring several risk variables and assesses these data by the key indicators implemented (Key Indicator System); and b) proposes the actions to be taken, i.e. guides the users in executing necessary steps by displaying the process models that apply to every emergency (Process Management Component). This system is GIS based, so that the location of every single task can be geo-referenced. GIS is also indispensable for mapping dangerous phenomena (e.g.: flood, toxic cloud), public risk communication, etc. The DMAS is linked to a warning module (Warning Component) that enables a specific situation alarm service, i.e. to develop and implement an appropriate warning strategy. Both the DMAS and the warning system are strongly connected to a citizen relationship management system (Citizen Portal), which furthers communication with the public and also channels citizen feedback. Moreover, ERMA supports collaborating work as a virtual forum and as a repository of information (Team Collaboration Component). This component shares and distributes hazard related information among authorities and stake-holders. Finally, the SOA allows ERMA to be connected to other external risk management architectures and platforms, like ORCHESTRA [1] or OASIS [2] and also external systems like weather or traffic information can be linked and their information displayed or processed. Following, the diverse components are described in detail.

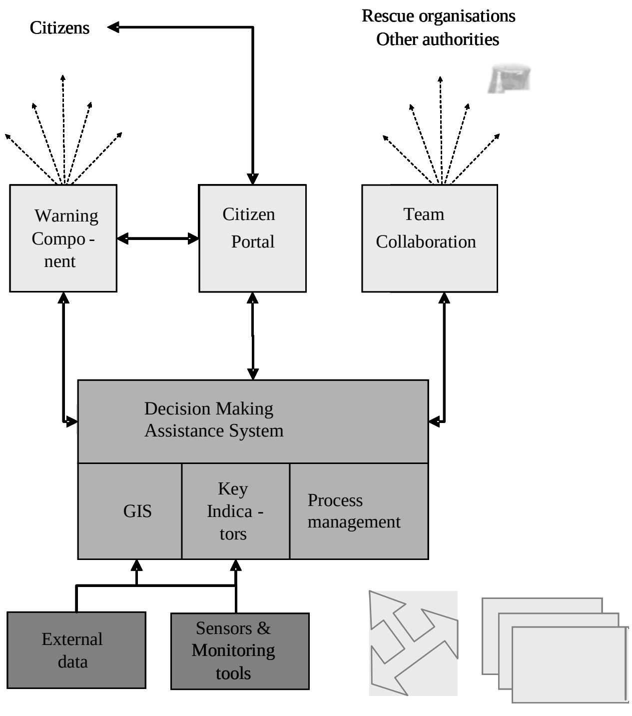

Figure 1. General architecture of the ERMA system

3.1 The Key Indicator Component (KIC)

A difficulty for local authorities, risk managers and municipality staff, is to monitor a diversity of hazards – each with its critical threshold or emergency level. ERMA's Key Indicator Component serves that purpose. Indicators are tools to support decision-making by local authorities, in order to manage properly risk, emergencies and crises. Provided that appropriate threshold values have been pre-defined, the monitoring of indicators can enable decision-makers to make sufficiently early decisions regarding risk management, for instance when a pre-warning should be triggered, and/or when pre-positioning of emergency management resources should be conducted. The KIC is able to collect data and automatically support decision makers in their effort to make the right decisions. Within KIC threshold values for any kind of situation can be set and the incoming data can be continuously analyzed to discover any deviation from normal levels.

The purpose of the KIC is threefold: a) Support ERMA users, i.e. local authorities, for monitoring of a pre-selected set of hazards and risks. Monitored items include natural and technological hazards. The KIC has also the capacity to monitor the status of environmental media (e.g. water quality; concentration of toxic in the atmosphere etc.), and also operates as a database storing historical values of monitored items. b) Perform automated function, comparing the value or level of monitored items with a pre-selected set of threshold values. c) Allow ERMA users to gain lead time for acting the appropriate organizational response and action in relation to hazards and risks levels in the even of an emergency, like issuing automated warning to ERMA users in case a threshold is exceeded, suggesting relation between exceeded threshold and type of risk situation or suggesting early measures for response to hazards and risks.

3.2 The Process Management Component (PMC)

Because of the diversity of hazards or risks sources, decisions to be made are seldom clear-cut. In particular, decision-makers – such as local authorities or their services – often lack decision options in emergency situations. ERMA's Process Management Component (Figure 2) should serve that clarification purpose, based on pre-identified scenarios.

Should the situation evolve into an emergency, a correlated process is opened by the PMC. In principle, the structure and contents of this component are tailored according to existing emergency management procedures, such as contingency plans. Predefined process models collect experience, organizational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams, etc. Alternatively, the user is free to load a different process, to define a new process, or to adapt processes to the current situation. Ad-hoc processes allow one to plan and execute not yet modeled series of actions in specific occasions in order to customize pre-defined patterns to event-specific requirements. Once defined and completed, they can be adapted, stored and reused later for similar situations. Moreover, the use of the PMC eases the definition of complex scenarios, so that each step and respective information exchange can be modeled. In case of an emergency, involved staff can concentrate on extreme and unusual events while routine jobs are guided by quality-assured process models.

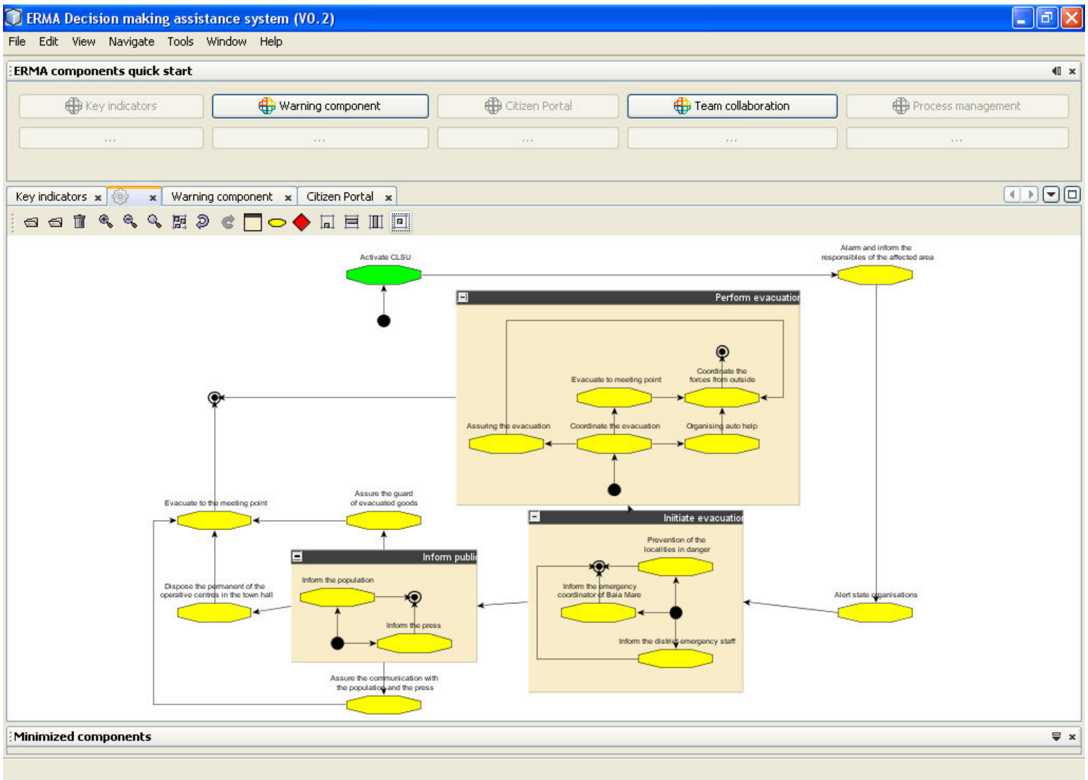

Figure 2. ERMA's Process Management Component

3.3 The Warning Component (WC)

Warning requirements vary depending on the risk situation that is confronted by individuals. Depending on hazard intensity, individual vulnerability, available communication systems, individual preferences, the warning strategy should be adapted. This is the aim of ERMA's Warning Component. Today modern telecom technology enables efficient methods for alert population. Maturing of telecom infrastructure combined with the penetration of mobile devices among the population especially in Europe makes telecommunication channels ideal as means for alerting.

The WC represents the channel for alarming affected citizens. WC's purpose is to provide warning services to individuals located in a hazard-prone area, informing the public faster and better in right time and at right location. Warning recipients are informed via SMS or pre-recorded phone messages. Form and contents of these messages is defined according to recipient's profile (e.g.: language; socio-cultural features etc.). Based on this system, local authorities keep track of social dissemination and processing (i.e. receiving and understanding) of the warning messages. It has to be said that WC operates complementary to other existing warning dissemination channels, i.e. loudspeakers, sirens, etc.

3.4 The Team Collaboration Component (TCC)

Municipality decision-makers and staff, risk managers, emergency services, private companies, river basin authorities, the general public and the media etc. are all stakeholders of the local risk landscape. ERMA operates as a virtual forum where all these actors can be. It supports collaborative work, by means of the Team Collaboration Component.

The TCC serves as a repository for information, i.e. as a multi-authored database and resource centre for risk-related data or documents. It allows sharing of short textual information, forms, movies and images, documents and the like between rescue organizations and/or authorities. The TCC also offers additional representation of the organizational structure in directory of ERMA authorized users, and provides calendars and user discussion forums. This component contributes to sharing lessons learned and to trust-building among stake-holders.

3.5 The Citizen Portal (CP)

This component is meant to perform both Geographic Information System (GIS) and citizen relation management operations (Figure 3). It provides and retrieves information to and from citizens in a very detailed way. The component can hold information before a crisis situation, in order to give suggestions on how to keep remote and interested citizens up to date, and it can publish post-even information (debriefing material, lessons learnt, etc.) once the emergency situation has occurred. The CP also holds contact addresses and can be used to inform responsible organizations about worrying or unusual situations. Hence, the ERMA user gets a broader picture of the situation or detects hidden problems.

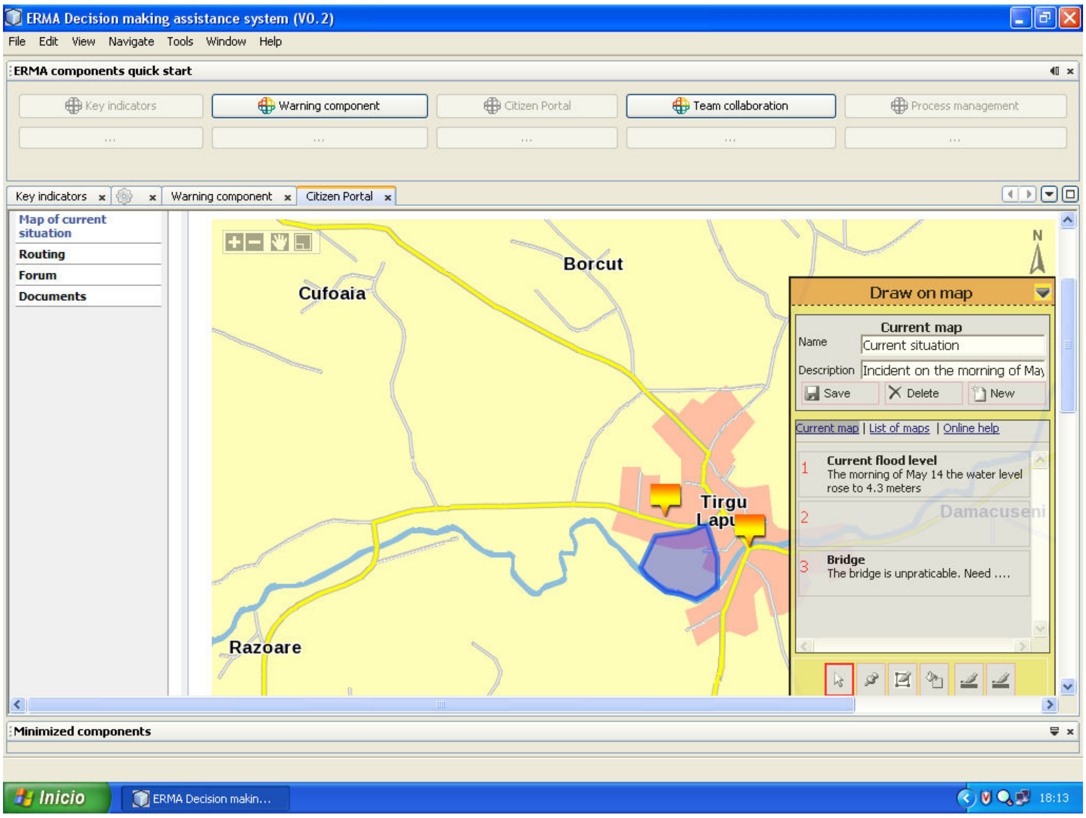

Figure 3. ERMA's Citizen Portal

4 ERMA testing

The development of new software and its application to a real situation requires a previous set of tests that assures the operability of the system. A good balance between development phases and evaluation phases had to be found. Therefore, tests were divided into Laboratory tests and Field trials.

The purpose of the Laboratory tests is to asses the operability of the system from the IT technical point of view, in other words, it means to draw first conclusions concerning usability, efficiency as well as applicability of the ERMA system and to provide a useful tool to know in advance the features that must be improved before running the field trial. This will allow optimizing the time, cost and efforts during the field test. In the other hand, the aim of the field trials is to prove the operability of the ERMA system from the risk management perspective, applying it to a real case scenario.

The evaluation method of both tests consists in the application of a questionnaire specially prepared to summarize the users' impressions, as well as the strengths and weaknesses of the system. Also interviews and debriefing sessions were carried out after each test in order to resume the points of view of the participants and risk management experts.

4.1 Laboratory tests

The laboratory test participants were divided into three groups: Emergency managers, Emergency Services and citizens. Each one of these groups used certain components of the ERMA system. A list of tasks designed to prove the ERMA functionalities concerning to each group was given to the participants. For example, one of the tasks for the Emergency managers was to upload the emergency process flow sheet into the PMC: one for the Emergency services, to calculate the fastest route to reach the affected zone, and one for citizens to get an account into the citizen portal. At the end of these tests the results were analyzed and the technical problems found were solved by IT experts.

4.2 Field trials

In order to prove the system from the risk management perspective, two emergency scenarios, evaluating both technological and natural disasters, were chosen. The first one consisted of a toxic cloud situation resulting from the collapse of a storage tank in the facilities of the Port of Santander (Spain). The second one corresponded to a flooding situation in the community of Targu Lapus (Romania).

Field trials were conducted following previously developed storyboards that reflect the timeline of each emergency situation and include the actions to be followed by every actor involved in the emergency plan such as fire brigade, medical service, citizens, etc. This allowed evaluating the performance of the ERMA system applied to a real situation and obtaining the feed back from all the people involved.

The result was a functional system allowing the management in an easy and organized way of an emergency situation, and leading to a good communication among all the actors involved in the performance of an emergency plan.

5 Some considerations on the development of ERMA project

The ERMA project has been developed by a team composed by eight partners: Unified Messaging Systems (Norway), Fraunhofer Institute (Germany), CAS Software AG (Germany), YellowMap (Germany), Institut National de l'Environment Industriel et des Risques (France), Universitat Politècnica de Catalunya (Spain), Santander Port Community (Spain) and Consiliul Local Targu Lapus (Romania). The first four are organizations working in the IT field, while INERIS and UPC are active in the risk management field. Santander and Targu Lapus were end-user partners, i.e. organizations in which frame ERMA was tested through two respective field trials.

The eight partners have worked together without any significant problems. Some difficulties arose at the beginning from the fact that IT partners did not know much about risk and emergency situations and risk management partners did not know much about IT systems. However, these obstacles were overcome by organizing a number of working meetings (both real and virtual) and by establishing an active net with very frequent contacts. The experience has been quite positive and has opened interesting perspectives for further future work.

6 Conclusions

The collaboration between IT partners, risk management partners and end-users has led to the development of a powerful tool allowing both a quick decision-making process and rapid population warning. ERMA has proved to be very helpful for the management of emergencies.

References

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[2] OASIS (2005). Overall presentation of OASIS. from http://www.oasis-fp6.org/documents/Oasis.pdf (01/2007)