IT for risk and emergency management : consolidating methodologies for user-centred design

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Abstract. Managing risks and emergencies caused by natural and technological hazards is a complex task for local authorities, emergency services, and their partners in risk management. When making risk-related decisions, processing available data and information can be arduous. In that context, information and communication technologies (IT) can help. This has been demonstrated in several research projects funded under the FP6/IST framework and programmes. Several risk and emergency management tasks appear particularly demanding. These are: monitoring risk levels in a multi-hazard context; organising emergency response at municipality level; disseminating warning messages to the population; communicating risk-related information to the public. ERMA (Electronic Risk Management Architecture), an FP6/IST project, aims at developing a system and a set of tools that will help authorities conduct these tasks. Building ERMA relies on a user-centred methodology that capitalises upon participatory approaches developed in the field of Information Technology (IT) and Risk Management (RM). This paper describes the rationale of the ERMA project; the methodology followed; the functions and modules of the ERMA architecture.

1. Introduction: local authorities confronting risks and emergencies

1.1 A situation with multiple hazards and risks

With communities exposed to a variety of natural, technological and other man-made hazards, as well as to severe public health issues, local authorities must deal with a great load of data and information. Two types of situations should be considered:

- In *usual situation*, local authorities are usually presented with the following duties or tasks:
    - Ensure monitoring of existing hazards and risks
    - Avoid additional exposure of human and material assets to hazards
    - Provide community members with information on hazards, vulnerabilities and risks
- In *emergency situations*, local authorities are confronted with the following duties or task:
    - Identify when monitored hazards overpass a pre-defined threshold
    - Issue pre-warning to staff in charge of risk management, and/or issue early warning
    - Issue general warning to the affected population and/or community subgroups
    - Implement emergency management measures

Understandably, the effective implementation of risk and emergency (RM) duties and tasks often suffers from a lack of accurate information on ongoing hazards and risks. This is particularly the case with highly dynamic hazards, or hazards with high kinetics – such as flash flooding for instance. In that case, up-to-date data is often missing. In other cases, it can be difficult to manage or optimise the available large quantity of information. Last but not least, a problem is when available data or information is characterised by a high level of uncertainty.

1.2 Information and communication technologies: a role to play

As shown in other projects of the FP6 / IST programme (e.g.: RIMS; OSIRIS etc.), information and communication technologies (IT) can help decision-makers and risk experts or managers to make more appropriate decisions – this includes making decisions more easily or faster. IT tools or systems considered here include: hardware and software; modelling; mobile communication devices; grid computational facilities; computer-based mapping; automated messaging etc. Risk and emergency management functions supported by IT tools and solutions include:

- Access to background data and information for risk characterisation
- Hazard monitoring and mapping, including real-time transfer of monitored data
- Issuing of pre-warning and general warning, possibly automated
- Monitoring and management of emergency situation (updates; staff; supplies etc.)

1.3 Involving users in the design of IT solutions

Experience shows that application of IT to risk and emergency management (RM) is neither always easy, nor successful. Expectedly, the development of IT applications to RM should follow a user-based approach, whereby end-users' needs are considered early in the design process of considered tools or systems. The present paper therefore consolidates lessons learned in IT applications to RM, and indicates expected added-value from the ERMA architecture.

2. IT solutions for risk and emergency management

2.1 A growing interest in IT applications to risk management

In the last years, the "*Information Society*" has increasingly become a *leitmotiv* on the application of Information Technologies (IT) to environment-related issues (Di Castri, 1998). In the field of natural hazards for instance, this trend could be witnessed by the number of activities developed during the UN-voted *International Decade for Natural Disaster Reduction* (IDNDR)[1]. Rapid developments in information technology and modelling have emerged, helping to cope up with the complexity of disasters and to deepen the understanding of natural hazards (Herath, 1999). These include:

- Hazard mapping for land-use planning;
- Provision of timely warning at community level;
- Knowledge management and E-learning on natural and technological hazards;

Another example is the IST Programme of the EC-funded Framework Programme 6, that did support several projects – all aiming at an application of IT solutions and techniques to disaster risk reduction[2]. As part of these initiatives however, several key questions did emerge:

- What are the hazards and risk management decisions that should be considered?
- What are the relevant technologies to be selected?
- Is it realistic to consider that all data needed for IT systems will be available?
- Is it realistic to consider that IT systems can be fail-proof and/or fail-safe?
- To what extent is it possible to anticipate the behaviour of IT users?

2.2 Challenges of IT applications to RM

Lessons learned from daily practice of disaster risk reduction, and emergency management at community level, show that local authorities often confront many difficulties. These add to threats posed by natural, industrial and man-made hazards and include:

- Lack or limitation of knowledge on existing hazards and risks
- Need to manage large amount of data and information
- Diversity of sources collecting, processing and disseminating data
- High expectations from the population in terms of safety level

In addition to the above, the development of IT-based options (systems, tools and services) for risk and emergency management can be made more difficult, or even jeopardised by several key features. Municipalities and local authorities in charge of risk and emergency management are often ill-prepared to use IT solutions for conducting RM tasks and duties. Reasons include:

- Cost of IT systems: not affordable for many small and medium sized communities

[1] See http://www.unisdr.org

[2] Visit the online CORDIS database at http://cordis.europa.eu/search/index.cfm

- Value of assets exposed: might be considered insufficient to justify investment in IT
- Municipality services often ill-prepared for IT systems (e.g.: low computer literacy)
- "Real-life" decision often features adhoc processes for which IT might be too rigid
- Social acceptability of IT systems and tools is not guaranteed

The above-listed elements – only to mention a few – pose many difficulties to the feasibility of an information system, decision-support tool like ERMA.

3. ERMA: a service-oriented architecture for risk management

ERMA in a few words

The ERMA project develops a comprehensive risk management platform which is based on a SOA orchestration of relevant systems. Interfaces to other systems will augment the ERMA service portfolio where needed. Figure 1 shows the ERMA architecture with different modules to be integrated and the respective information flow.

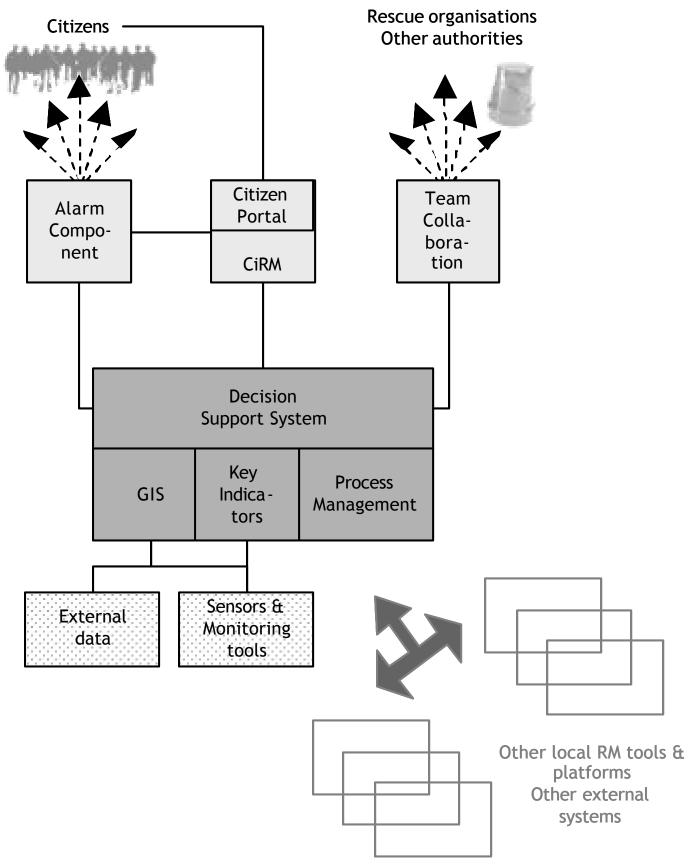

Figure 1: The ERMA platform and components

Optional components (presented in light grey in the figure) will be linked by SOA (Service Oriented Architecture) to establish loosely coupled and interoperable services, which can be integrated or deselected for individual requirements. The decision support system (DSS) serves as core component integrating the application logic and scheduling other functions when demanded. The ERMA components are described in the following sections. Wherever available, screen captures are provided, that give an indication of the possible functions to be offered by the ERMA components.

- *Component 1: ERMA Decision Support System (DSS)*: The DSS of ERMA will perform the following tasks:
  - collection of sensor data, and assessment by key indicators,
  - comparison with criticity thresholds,
  - visualisation of measured data in specific region, deduced state and actions, and finally,
  - display of process models for corresponding tasks (figure 2), and
  - editing and processing of process models.

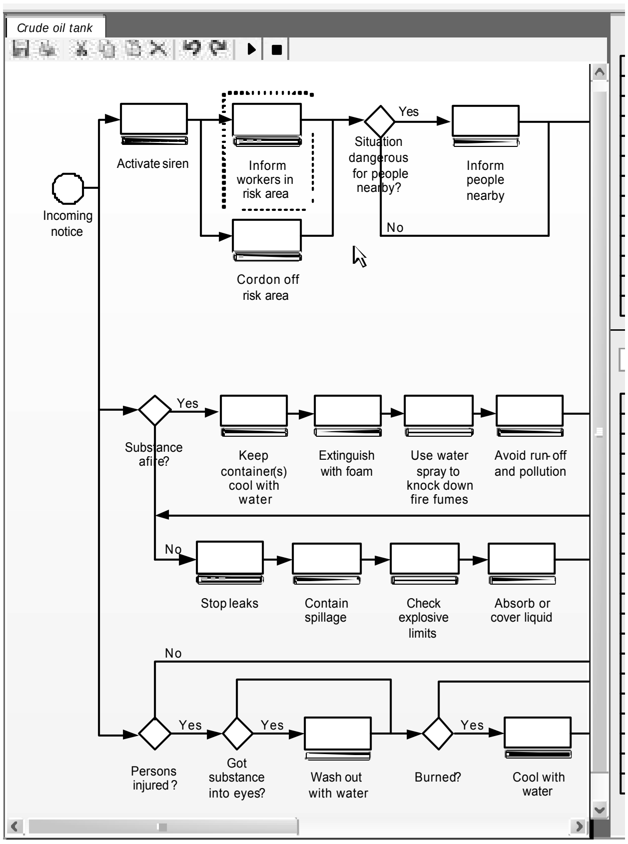

Figure 2: Mockup of process management component: display of processes

The process management system will detail the proposed key indicator actions and guide users in executing the necessary steps. These steps in turn have been documented before and the target community has the possibility to adapt existing process models to its own needs in advance or directly in the crisis situation (ad-hoc processes). The exchange and adaptation of process models and instances will be possible, which allows the re-use of models across different organisations. Each reference process describes certain patterns of actions to be taken depending on the event at hand. As such, predefined process models collect experience, organisational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams. Ad-hoc processes allow one to plan and execute not yet modelled series of actions in specific occasions in order to customise 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 process workbench will ease the definition of complex scenarios, so that each step and respective information exchange can be modelled. In case of an emergency, involved staff can concentrate on extreme and unusual events while routine jobs are guided by quality-assured process models.

- *Component 2: Customer Relationship Management (CRM) and Citizen Relationship Management* (CiRM). Customer relationship management (CRM) covers methods and technologies used by companies to manage their relationships with clients.
  - Information stored about existing customers (and potential customers) is analyzed and used to this end. Typical CRM solutions support the following features (example from CAS Software AG, 2006): address Management ; complete view of the customer's dossier; calendar, appointments and tasks ; phone calls; correspondence and vouchers; project management and project files; marketing operations and mailing lists; ERP data integration; prsonalisation; etc.
  - CRM is not just a technology, but rather a holistic approach to an organisation's philosophy in dealing with its customers. In companion with the introduction of e-government applications, the interest of the public sector in the application of CRM rises. Citizen Relationship Management (CiRM) (Schellong, 2005) systems focus on providing citizens with timely, consistent, responsive access to government information and services using multiple channels like web access or mobile communication devices. CiRM promises to strengthen the links and co-operation between government and its citizens, realising operational efficiencies.
  - Concerning ERMA, the functionality provided by CRM systems builds the base for the citizen relationship management. Most of existing commercial systems are far too complex for small communities to be suitable in the context of ERMA. Easy adjustable and manageable systems are required that also incorporate the different needs of the private and public sector. One aim of ERMA is to adjust an existing system to the requirements of citizens and small communities in the context of risk management. As such, the CRM/CiRM module of ERMA will support more collaborative work among risk management partners – for instance for exchanging data (e.g.: risk levels) or information (e.g.: emergency plans).
  - Part of the CiRM will also be a citizen information portal, which furthers communication

with the public and also channels citizen feedback and calls to the responsible position.

- *Team collaboration software* allows sharing of short textual information, forms, movies and images, documents and the like between rescue organisations and/or authorities. Additional features like chat functions, notifications on changes and upload, calendars, address and contact lists supports information exchange between all concerned parties.
- *Alarm Component*. Historically sirens have been used to alert population against war related threats like bomb attack or other major disasters. Lots have happened from the introduction of sirens in the mid thirties until now. The threats have changed and so has also the technology and the behaviour of the population. Today modern telecom technology enables new methods for efficient alert of 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 main components of a telecom based alert system are illustrated in figure 3.

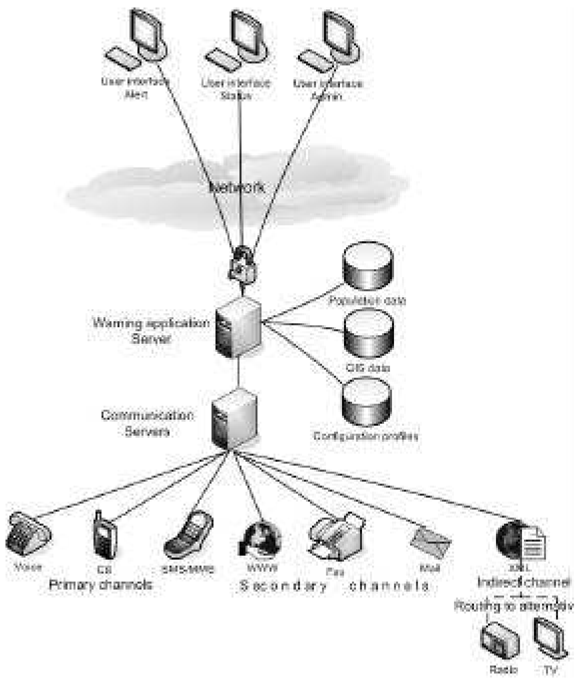

Figure 3: Telecom-based warning system. Source: UMS company (Norway). Website: http://www.umscom.com/)

The ERMA system will feature a georeferenced, GIS-based warning system. The system shall enable users (e.g. community's decision-makers and municipality staff) to develop and implement an appropriate warning strategy: sending the right message, in the right time, to the right recipient, and using the right channel. Based on this system, local authorities keep track of social dissemination and processing (i.e.: receiving; understanding etc.) of the warning messages.

See figure 4 for an example of the user interface.

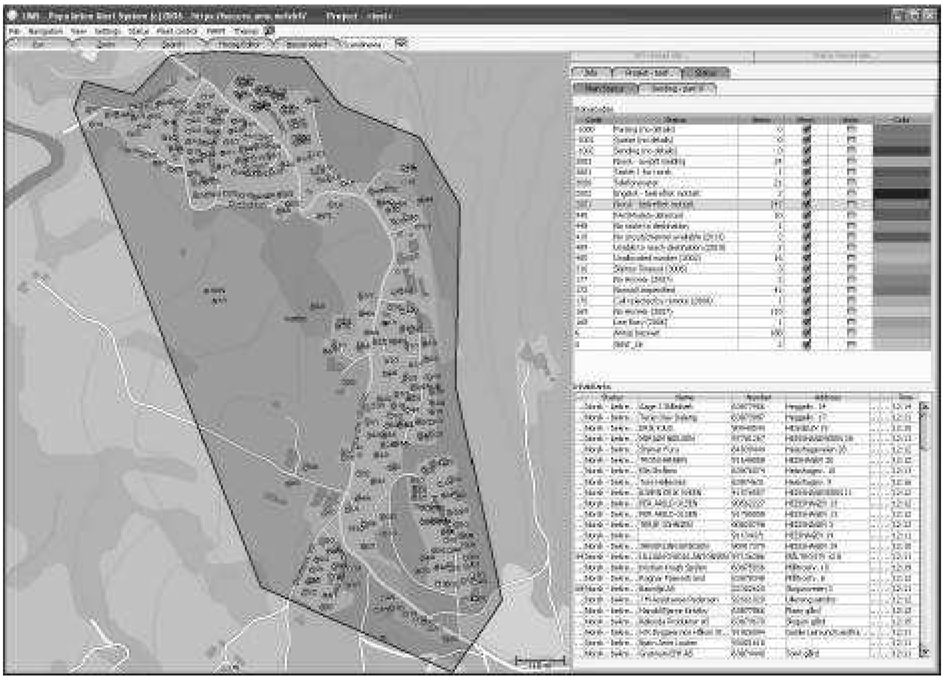

Figure 4: Possible interface for the GIS-based warning system developed by the UMS company (Norway). Source: http://www.umscom.com/)

- *Connection to other information services via SOA:* ERMA's implementation is based upon SOA (Service Oriented Architecture) in order to link all its components and to allow connections to other external risk management architectures and platforms like ORCHESTRA and OASIS. Also, external systems can be linked and their information displayed or processed. For example, weather information from a commercial or state provider will be integrated in the key indicator system to support the decision process. In this manner ERMA is flexible and extensible and such easy to customise to special requirements of end-users.

4. Involving end-users in the development phases of ERMA

The involvement of end user requirements in the development of ERMA includes the following activities:

- user requirement elicitation by field surveys with questionnaire and consultation workshops.
- elaboration of use case scenarios in cooperation with the 2 involved end users.

- derivation of process models, fine tune again with selected emergency scenarios of users.
- installation, integration with existing systems and techniques, with training sessions.
- field trials, incorporation of user feedback, adaptation of the system.
- publication of results, public discussions, and organisation of a final event with more users.

All these activities will allow to incorporate early in the design phase user and domain specific requirements. In addition, the system can be tailored to existing emergency practices and such lower the reluctance barrier of the staff involved. Final test and user feedback will improve the prototype and therefore build a first step from prototype to commercial available system.
Development of the ERMA system is realistic only, if there is an opportunity for end-users to contribute to the process of needs' assessment. Only a clear understanding of actions taken and decisions made by users will allow the ERMA system to be useful for risk and emergency management. Consequently, two end-users are members of the ERMA project consortium[3]. These are: the Community Council of Targu Lapus (Romania); the Santander Port Authority (Spain). Each end-user presents a different profile. In Romania, the end-user is formed by elected local authorities, municipality council and staff, and emergency management services (e.g.: fire forces). In Spain, the end-user is formed by the administrative and technical authority responsible for an international port area facing the Atlantic Ocean. Accordingly, site-specific hazards, exposed assets, risk management procedures and technical-organisational resources should be considered. This diversity will therefore be an opportunity to develop an ERMA system that is adaptive to very different end-user contexts.

5. Conclusion

ERMA started in September 2006 with a two year perspective. It will provide a first prototype to be tested at two user sites in 2007. Final findings about the performance of the platform and its customisation prospects are expected by the end of 2008. Currently the user requirement state is finalised with first mock-ups which have been presented to the user sites. Next step is the definition of emergency scenarios as use cases which will be translated to process models. Mock-ups and use cases will be presented in the ISESS 2007 conference in order to trigger a discussion about user-centred design and process support for the risk management domain..

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[3] For more, up-to-date information on the development and achievements of the ERMA project, please visit: http://www.erma-project.org

References

Di Castri, F. (1998) Environment in a global information society, Nature & Resources, Vol. 34, N°2, April-June 1998, UNESCO, Paris

Herath, S. (ed) (1999) Proc. International Symposium on Information Technology Tools for Natural Disaster Risk Management, UNU/INCEDE/AIT, Bangkok, INCEDE Report 11, University of Tokyo, p. 383

Schellong, A. (2005). CRM in the public sector: towards a conceptual research framework. Proceedings of the 2005 national conference on Digital government research, 326-332.