Introduction

Milan Konecny, Sisi Zlatanova and Temenujka Bandrova

Recent large natural and anthropogenic disasters have clearly shown various shortcomings and failures in existing technologies and policies for efficient early warning and emergency response. Many barriers exist to making data available, providing the most appropriate data and allowing the systems work together. Most currently available geo-data are designed, stored, and managed by organisations that normally have distinct mandates. Under normal circumstances, these organisations operate largely independently of each other. The presentation of data is adapted to the needs and tasks of particular groups of users. Early warning and emergency management require different types of systems.

Emergency management starts with an alert for a disaster, continues with management of the critical situation by taking care of people, properties, nature, and so on, and finishes when people, assets, and animals are out of danger. There are always specifics in the management of different emergencies: a terrorist attack differs from natural disasters, such as floods, fires, earthquakes, or industrial failures such as a fire in a nuclear plant or the release of dangerous substances. Many aspects remain similar, however: time is critical; the primary emergency responders are the same; the systems share characteristics, and so on. In contrast, early warning is more of a monitoring activity that is performed continuously. Data coming from various sensors are constantly evaluated, interpreted, analysed and estimated. The responsible specialists (or early warning systems) alert citizens and the responsible emergency specialists only if anomalies are observed. In a way, early warning is still undervalued by society. National and local governments invest in the development of early warning systems only after large disasters (e.g., tsunamis, earthquakes) take place.

Geo-information techniques have already proven that they can significantly facilitate early warning and emergency response. Nowadays, we can acquire and supply enormous amounts of geo-information, based on which we can make better decisions throughout the disaster management cycle: in the use of natural resources, in environmental protection or to fight disasters and their aftermath. The maintenance and accessibility of spatial information has improved as well. Spatial Data Infrastructures (SDIs) are being developed in many countries, which may be responsible for an increased use of spatial data. There is growing understanding of the importance of SDIs for early warning and emergency response at a very high political level. Various examples can be found at the national and international level, including GMES (Global Monitoring of Environment and Security) and INSPIRE (Infrastructure for Spatial Information for Europe) in Europe, the activities of the Department of Homeland Security in North America, the International Charter and activities of international institutions such as the World Bank and United nations (e.g., United Nations Office for Outer Space Affairs). International geospatial organisations are contributing to this process by organising conferences and working meetings to discuss new challenges and set up new research agendas. The ad-hoc committee on 'Risk and Disaster management' of the Joint Board of Geospatial Information Societies has taken the responsibility for preparing a booklet compiling the best practises for using geo-information in disaster management by July, 2010.

Clearly, the various systems for early warning and emergency response differ, but they serve the same purpose: saving human lives and reducing property losses. Therefore, the systems must be user-centred and ensure that every person receives the information that will help them save lives and minimise damages to critical infrastructure. Furthermore, it is critical that the two phases use the same information. Both phases should be able to benefit from the same maps and models, the same sensor data products, and the same visuals. While early warning specialists will rely on the analyses/estimates of in situ sensor information to alert the population, emergency responders will use the predictions and simulations to support better decision making. Although this is not the case at the moment, the editors of this book firmly believe that this will happen in the very near future.

It is often discussed that timely information (able to create a good situational awareness), fast access, unified standards, user-friendly interfaces and appropriate visualisations are some of the success factors for precise decision-making in emergency situations. To be able to develop such systems, many disciplines and technologies must be integrated: sensors, communication and localisation, database management, modelling and analysis, semantics, visualisation and simulation. The role of cartography in particular is very important.

Cartography is one of the disciplines that provide tools and models to improve the user perception, orientation, knowledge acceptance and understanding. Visualisation of information is not an isolated element of the information transfer process; it depends not only on the type of data but also on the type of user (gender, age, disability, behaviour, preference, habit, task responsibilities, and so on). Many currently developed systems for crisis management use static cartographic tools based on pre-defined models and visualisations. Methods and approaches used in cartography can greatly help in presenting data by adapting the visualisation with respect to the context of the user, and enhance the decision-making process with visual analytics and simulations. The data must fit the user concepts, serve the tasks to be performed and be represented with respect to the emergency level. Moreover, a larger range of users must be covered. In addition to systems for specialists (emergency responders in the field and decision makers), the population should also be taken into consideration. Citizens must be educated in how to use this data (maps and models), whether in analogue or digital form.

We note that cartography can support emerging technologies and the possibilities to customise geo-information to individuals. Specialists who are developing early warning and emergency response systems often overlook centuries-old cartographic principles (which are aimed at user usability and perception) and concentrate too much on the technical realisation. They think that as long as the data are displayed on the computer screen, their task is completed. This approach often leads to reduced readability and sometimes to confusion and even misunderstandings. For example, the data may be too dense and unclear on the display, or the symbols and colour composites may be strange and convey the wrong message. Frequently, the tools to manipulate the maps (or 3D models) are clumsy and inappropriate for work under stress. Users in emergency response need helpful support by maps and not lots of data that are difficult to see and understand.

The editors believe that impetus is necessary to encourage the standardisation of symbols for emergency response, context-aware visualisation, visual analytics and tools for interaction and immersion with data. Future maps for emergency management must be better adapted to the individual user. Extended research should concentrate on map usability in both map content and visual controls to make the use more intuitive. The effect of the advanced technology is lost when the end users do not understand the information on the display and cannot place it in their mental map.

New cartographic areas are evolving; e.g., ubiquitous or pervasive mapping including context and adaptive mapping, which are expected to be largely applicable for emergency response. These are based on investigating the personal skills, abilities and preparedness of users to understand and use maps in emergency situations. They can be adapted for all layers of human society: geo-professionals, emergency responders in the field and in command and control centres, emergency managers at various levels, and citizens, young and old, disabled and healthy. The development of digital cartography is strongly influenced by ICT and vice versa; digital cartography is enhancing efforts to play a more important role in the current information and knowledge society. There is clear cooperation between cartographers and users. A tremendous shift from analogue maps to ubiquitous mapping has been observed. Ubiquitous mapping aims to realise technical solutions for map creation and usage, anytime, anywhere and by/for everyone. Moreover, ubiquitous mapping aims to evaluate and predict the effect on society.

This volume is inspired by, and addresses many of, the topics discussed above. The volume consists of 29 peer-reviewed chapters. These were selected from among the 79 papers presented at the Symposium on Cartography and Geoinformatics for Early Warning and Emergency Management: Towards Better Solutions, held in Prague, Czech Republic, January 2009. The symposium was jointly organised by the ICA Working Group on Cartography in Early Warning and Crises Management (CEWaCM), the Ad-hoc Committee on Risk and JBGIS and the ISPRS WG IV/8 3D Spatial Data Integration for Disaster Management and Environmental Monitoring. The authors of the papers were encouraged to revise, extend and adapt their papers to fit the goal of the book.

The chapters in this volume are organised in three parts: *Geo-information processing and modelling, Geo-Information Services* and *Advanced cartographic visualisation*. A short overview of the chapters follows:

Geo-information Processing and Modelling: The twelve chapters in the first part discuss general aspects of using geo-information in disaster management and addresses approaches for modelling data. In the first chapter, Annoni et al. provide an extensive discussion of the existing data collection and data access technologies and their applicability for early warning and emergency response. Several examples from Europe illustrate the use of these technologies. Altan and Kemper elaborate on the use of geo-information in all phases of the disaster management cycle, providing appropriate examples from the earthquake vulnerable area of Istanbul. The remaining nine chapters concentrate on methods and approaches for modelling data. The analysis and preparation of information are particularly critical for early warning and emergency management. Four chapters reflect this aspect. Two chapters present methods for gathering information about a population immediately after a disaster strikes (Zeug et al.) or in advance for better risk estimation and preparation (Freire). Kemec et al. present a framework to help risk managers select data moles (3D) in order to better estimate the vulnerability of a given area. Breuning et al. introduce a 3D/4D geo-database that aims at efficient geo-data retrieval. The developed model is tested for landslides. The next two chapters (Condorelli and Mussumeci, and Voženílek and Zajíčková) discuss safe (fast) navigation approaches to support fire fighters. The last four papers present methods for damage estimation. Hahmann et al. use SAR images to detect water bodies (in case of flooding). Maugeri et al. elaborate on an approach for estimating the hazard to pipelines as a result of earthquakes. Vu and Matsioka present a prototype for quick damage detection based on a Geo Grid system. The prototype has been successfully tested using a QuickBird image of Yingxiu, Sichuan, China. Kranz et al. conclude this part with a very detailed overview of the rapid mapping techniques applied for monitoring the evolution of several Darfur camps between 2002 and 2008.

Geo-information Services: Part II consists of nine chapters that discuss system architectures and applications based on open services and the Web. M. Reichardt et al. discuss the heterogeneous challenges in geo-information and elaborate on the activities of the Open Geospatial Consortium (OGC) toward interoperable solutions. Reznik continues the theme on interoperability of data and services and discusses the results of a comparative study on metadata as described in INSPIRE, ISO and OGC specifications. Two chapters present approaches for enhancing and adapting web services and systems architectures for emergency management. Based on several existing services, Muller et al. present a successful experiment with a Multi-Criteria Evaluation service. Maiyo et al. elaborate on the relevance and importance of web services for detecting damage and present an appropriate service architecture that makes use of satellite images. The next three chapters are devoted to systems for early warning for: tsunamis (Raape et al.), managing sensor data (Casola et al.) and landslides (Ortlieb et al.). Muler et al. present an approach to integrate multi-criteria evaluation analysis (a kind of a common process model) in SDI. Annunziato et al. express doubts about the success of GSDI for worldwide emergency response activities and present an alternative geo-reporting system (not intended for SDI). Kozel et al. conclude Part II by reporting their experience in the development, configuration and testing of the Contextual Map Service.

Advanced Cartographic Visualisation: This part concentrates on research and experiments related to map usability, map perception and map context issues. In the first chapter, Fraser analyses the role of the cartographer and suggests that 'the cartographer leading the mapping for early warning and emergency management must be highly trained, educated and skilled.' The chapter investigates the designers and users of the cartographic products that are developed in six cases: a forest fire and a landslide (Australia), mining (China), a hurricane (USA), a tsunami (Thailand) and a volcanic eruption (Montserrat). Kubicek et al. investigate the structure and tasks of the primary emergency responders (fire fighters, medical service and police) in the Czech Republic and specify needed data and visualisation tools. The authors conclude that the only appropriate approach to meet all of their needs is adaptive mapping, which can be achieved by context-aware services. Two chapters concentrate on cognitive issues. Stahon et al. focus on requirements for users working under stress. The authors present the investigation on different map representations among 74 participants. Bandrova et al. study the knowledge of young people about emergency response procedures, maps and symbols and conclude that they need special maps and symbols. The research is performed in the four countries of Austria, Bulgaria, the Czech Republic and Slovakia. The last four chapters present various approaches for improved cartographic visualisation and visual analysis. Jern et al. demonstrate the power of visual analytics by a set of tools for interactive exploration and analysis of data. The authors are confident that such tools will greatly improve the perception and understanding of data. Krisp and Špatenková present an enhanced visualisation (based on kernel density estimation) of fire density areas. The authors conclude that such approaches give a better overview compared to the traditional dotted approach. Lienert et al. present a framework to support flood management. The framework generates web-based, real-time visualisations of hydro-meteorological data. The last chapter concentrates on the appropriate symbology for emergency response. The author, Friedmannová, elaborates on the need for specially prepared maps for emergency management and presents a set of symbols designed with respect to the context of the user.

This book is intended for professionals, researchers and students with interests in access to and visualisation of information. Research areas such as data collection approaches, sensor networks, data processing, 3D reconstruction, database management, spatial analysis and decision support systems are barely (or not) covered. This book reflects recent challenges, research, and developments in European countries. We hope that this well-defined focus will make this volume even more interesting for our colleagues and professionals from other parts of the world.

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