Lecture Notes in Geoinformation and Cartography

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Intelligent Systems for Crisis Management

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Foreword

Dear Reader,

It is my pleasure to present to you the results of the 8th Gi4DM Conference. To my knowledge it is the first time that scientists, R&D technicians, and emergency management officers have collaborated to produce joint books and learn from each other's expertise in this manner. I think there is great need for such interaction. With the rapidly improving digital means of our time, a number of questions arise concerning our job. We need technological support. The lack of relevant information is a reoccurring theme in almost every inspection report that I have seen. The effectiveness of my colleagues, both within the firebrigade and between the first responder agencies, is greatly enhanced with timely data about all aspects of the incident. We spend a considerable amount of resources on the project Net Centric Crisis Response to enable such information exchange. But there are a number of challenges to these developments. What are the consequences to our ways of working given the improved information position? What amount of information processing can we handle in what phase of the incident management? How do we enforce more interoperability between all those systems on which we have become more and more dependent? And who keeps Murphy at bay with all that complexity and technology? These questions cannot be answered on paper alone. They require iteration, inquiry, and inspiration. They require the willingness to cross the boundaries of cultures, tribes, and the comfort zones of our own four walls.

GI4DM is about maps.

I believe that Geographic information systems could be the core discipline for further learning about possibilities and limitations of technologies that support emergency management. Maps are the key to the common operational picture. Maps help to envision future risks that turn out to be closer than what both citizens

and councilors see as comfortable. Maps help to see a common cause in times of need. It is for that reason that the firebrigade invests in digital maps, both in vehicles, in command containers as in the crisis rooms all over the country. It is for that reason that my fellow commanders and I have embraced a new reference architecture (VERA) for information management this very year.

I am grateful for this opportunity to foster more research collaboration. I hope it will produce long-standing relationships and open up new communication channels. I hope you find some of the content of this book intriguing. Emergency management will always be about dealing with uncertainty, but we can do our best.

Thank you for your time.

Frans Schippers
National Chief Information Officer of the Dutch Firebrigade
Director of Regional Safety Authority Kennemerland

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Introduction

Technology and systems for risk and disaster management have advanced greatly in the last few years. Systems for early warning, command and control, and decision making have been successfully implemented in many countries and regions all over the world. However, many aspects related to efficient collection and integration of geoinformation, applied semantics, and situation awareness are still open. Could sensor technology help to find victims? How can new paradigms such as crowd sourcing and granular computing help in intelligent and fast response? What is the role of iPhone/iPad apps in the frame of large information systems for disaster management? What kind of vocabularies and semantics are required to enrich the spatial information, and how can they be translated on the fly? What other tools are needed in command and control systems for efficient coordination in an emergency response scene? Which icons are most appropriate in case of cross border emergency situations? To advance the systems and make them intelligent, an extensive collaboration is required between emergency responders, disaster managers, system designers, and researchers.

Noting the great importance of geoinformation for disaster and risk management, a group of researchers, professionals, and vendors has been getting together for eight years at the Gi4DM Conference. Gi4DM is coordinated by the ad hoc committee on risk and disaster management by the Joint Board of the Geo-information Societies (JB of GIS). Seven editions of this series have taken place in Delft, The Netherlands, (March 2005), in Goa, India, (September 2006), Toronto, Canada, (May 2007), Harbin, China (August 2008), Prague, Czech Republic (January 2009), Toronto, Italy (February 2010), and Antalya, Turkey (May 2011).

Gi4DM 2012 is specifically important because it was initiated by the Public Safety Regions of The Netherlands. For the first time, the emergency responders contacted researchers proposing to share several years of experience, discuss problems, and brainstorm about possible solutions. The Safety Regions took a significant role in the preparation and organization of the conference, which took place at two locations: the University of Twente Holland Casino, Enschede for the scientific sessions, and the former Twente Military airport for the demonstrations

and field tests. The objective was twofold: to give researchers possibilities to talk with officers and validate their direction of research and to give technicians the chance to work with their prototype systems in real field tests. Vendors were also largely encouraged to participate and show products that can pass interoperability tests. The emergency response officers were able to see tests and demos displaying the state-of-the art technologies. One of the most remarkable parallel events was the European urban search and rescue exercise held at Troned Safety Campus,[1] which provided a test site for an earthquake scenario at the former Twente airport.

The focus of the Gi4DM 2012 Conference has emerged from an intensive discussion between researchers and practitioners. A number of important conference topics were identified such as geospatial data modeling and visualization, sensors and processing of sensor data, requirements and analysis of systems for emergency response, and disaster management, as well as best practice examples from running systems. The topics covered by the Gi4DM 2012 papers were: Cross-border and cross-sector semantics, Semantics and situational awareness, Agent-based systems, Multiplatform and multisensor data collection and processing, Crowd sourcing and volunteered geographic information, Design requirements and design processes for information systems, Simulation, decision enhancement systems, and Evacuation and navigation systems.

This volume is inspired by the topics presented above and addresses the main goals of the Gi4DM 2012 Conference toward sharing research achievements and practice experiences. The volume consists of 29 peer-reviewed chapters, of which 20 are scientific papers and 9 are short best practice papers. These were selected on the basis of double-blind reviews from among the 65 papers submitted to the Gi4DM Conference. A new review approach was applied for all received papers. Each paper was reviewed by two scientific reviewers and one practitioner. The purpose of this approach was to evaluate not only the scientific contribution of the papers but also the practical relevance of the research. The authors of the papers were encouraged to revise, extend, and adapt their papers to fit the goal of this volume.

The selected papers are organized in four parts: *Data Modeling and Visualization*, *Sensors and Data Integration*, *System Requirements and Analysis*, and *Best Practices*.

The first part consists of seven papers which illustrate how simulation and navigation techniques can advance and facilitate decision making during emergencies. The papers in this group clearly state the importance of semantics in emergency response. Bakillah et al. present a generic data model for agent-based evacuation simulation, which takes into consideration relevant social parameters such as type and size of group under risk, socioeconomic status, previous experience with disasters, and so on. Wang and Zlatanova propose an extension of a routing algorithm to deal with moving obstacles. The approach aims at supporting emergency responders' navigation within dynamically changing environments. A two-level routing strategy within complex indoor environments avoiding static

[1] http://www.vrtwente.nl/troned/

obstacles is proposed by Liu and Zlatanova. This strategy uses indoor semantic models to reduce computational complexity and still provide several types of passable routes. Al-Salman et al. discuss an approach for decision making that allows disaster managers to specify qualitative queries based on semantic descriptions. The last three papers concentrate on simulation and visualization of hazard events. Zelle et al. discuss a new approach for smoke plume modeling. Ishida et al. present a simulation system for evacuation of people as tsunami precaution, considering information about the ground, underground, and within buildings. The goal is also to provide data about possible refuge buildings and evacuation guidance methods and systems. The last paper in this part presents an advanced method for flood simulation and visualization making use of high-resolution point cloud data. Despite the large volumes of data to be processed the system allows real-time interaction.

The second part *Sensors and Data Integration* consists of eight papers which demonstrate the integration of sensor and GIS data. The papers clearly demonstrate that GIS and SDI have become important instruments for data integration and decision making in risk and disaster management. Hassanzadeh and Nedovic-Budic discuss the use of crowdsourced to outline damaged areas after an earthquake. The study concludes that such data are better suited for the determination of hot and cold spot areas rather than to provide exact locations. Kerle argues that the traditional charter-type mapping needs to move away from one-directional mapping, and proposes collaborative mapping as an alternative for a better understanding of maps. Two papers present mathematical models. Youn et al. suggest that large amounts of sensor information require good sensor models and present their mathematical model. Khamespanah et al. illustrate how the Dempster-Shafer theory can be used to integrate and resolve the conflict among different experts' viewpoints to arrive at a decision regarding the measure of seismic vulnerability. The remaining papers in this part concentrate on different approaches for information extraction by integrating sensor information and GIS data. Borovelli et al. discuss the provision of satellite precipitation data via GeoServices; Vatseva et al. discuss the added value of GIS for seismic data assessment, which also allows for real-time support; Fernández et al. elaborate on the use of GIS and SDI for landslides and propose a methodology for determining the susceptibility in different return periods from landslide inventories. Finally, Dragos proposes a methodology to create a GIS-integrated complex tool, which allows flexible integration of data and procedures to assess the vulnerability of a transportation network.

The third part *System Requirements and Analysis* contains five papers, which reflect advances in command and control systems. The papers highlight that geo-information has become an important component of command and control systems. Steenbruggen et al. present an extended investigation of the net centric working, which is considered as one of the most promising approaches for information sharing in emergency situations. Mäkelä and Virrantaus concentrate on the evaluation of collaboration. The authors argue that verbal reports created after SAR exercises are not sufficient to estimate the level of collaboration and propose a formal model. Řeznik et al. provide an extensive overview of command and control

systems and present a system architecture for emergency support. Nushi and van Loenen concentrate on accessibility of SDI for disaster management and propose a method for evaluating SDI. In the same direction but for a specific hazard is the contribution of Abidin et al.

The fourth part which is the last, *Best Practices*, is a selection of short papers presenting systems and approaches that have been proved in real-world situations or are in development. Nico van de Weghe et al. present a crowd sourcing platform, which makes use of Bluetooth. Kinugasa et al. elaborate on evacuation system tested in Kyoto. Broer elaborates on the new Dutch program Virtual Police Korps and its attempt to provide real-time intelligence to the first responders with linked open data and a secure 'Appstore'. Van Persie et al. present a system, which allows integration of UAV videos in firefighting. De Bruin and Wijngaards present a system for secure sharing of information according to which participants obtain only those data relevant to their role in the emergency management process and their context. Genc et al present an approach for information flow management, which intends to overcome security problems. Van Aalst et al. discuss an option to link all information with generic keys using base registries, an approach used in the Dutch emergency response sector. Peters et al. elaborates on use of icons as semantic vehicle to deal with vocabulary challenges. Panneman et al. discuss network information management as an alternative to other approaches for adoption of innovative technologies.

The papers in this volume identify important tendencies of using geoinformation for emergency response. Clearly, geoinformation or all the information with location or spatial extent is of critical importance. The research and developments are now focused on making the system intelligent and interoperable. The visualization approaches have been significantly advanced. The geodata are not only visualized but also used for simulations and predictions. The importance of semantics and semantically rich models is appreciated not only by researchers but also by practitioners. Sensors information is becoming increasingly important since much value is given to crowd sourcing. This fact was also confirmed by the interest in the special session dedicated to crowdsourcing.

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