# Spatial Information for Risk Management

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**Key words**: Spatial Information Management (SIM), Geodata, Risk Management, Disaster Management.

## SUMMARY

In many countries the use of geodata is state of the art in the field of risk management. Many have now recognized the value added that can accrue from the use of geodata in developing strategies for disaster prevention and preparedness. To be exact, spatial information is needed for the prevention of disasters as well as for the coordination of rescue brigades when they eventuate. Besides, spatial data are used to document and visualize the event of a disaster. Also, one will further down the road find geodata assisting disaster management specialists develop recovery plans after catastrophes have taken their toll. These are among issues that this work aims to bring to light.

After a brief introduction, this write-up defines the terms "disaster" and "risk management" and then outlines the stages of risk management. The palette of available geodata and examples for "best practice" in this field of activity are contents of the following two chapters. Finally, conclusions and recommendations close the authors' modest contribution on the subject.

## ZUSAMMENFASSUNG

Im Risikomanagement ist in vielen Ländern die Verwendung von Geodaten Stand der Technik. Dabei wird die räumliche Information zur Prävention von Katastrophen und zur Koordination von Hilfskräften im Katastrophenfall benötigt. Räumliche Daten dienen aber auch der Dokumentation von Katastrophen und sind wichtiger Bestandteil in der Wiederherstellungsphase nach einem Katastrophenfall.
Nach einer allgemeinen Einführung und der Definition der Begriffe „Katastrophe" sowie „Risiko-Management" werden die Phasen des Risikomanagements vorgestellt. Die Palette an für diesen Tätigkeitsbereich verfügbaren Geodaten und erfolgreiche Beispiele der Verwendung von Geoinformation für Aufgaben des Risikomanagements werden in der Folge behandelt. Schlussfolgerungen und Empfehlungen bilden den Abschluss dieser Präsentation.

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**Gerhard MUGGENHUBER and Reinfried MANSBERGER, Austria**

## 1. INTRODUCTION

”Heavy rains flood Istanbul, dozens stranded”, “Flash flood in Cornwall leaves villagers missing”, “China quake strands 125,000”, “Landslides and floods kill 9 as typhoon approaches Japan”. Numerous headlines like these ones that “adorn” the online-version of the “International Herald Tribune” (IHT, 2004) in a single week in August 2004 indicate the huge amount of disasters that plague our planet. And the list and impact of potential threats to humankind and environment are very long and staggering. Just think of the recurring earthquakes, floods, hurricanes, landslides, avalanches, epidemics, famines, droughts, water and air pollutions, soil contaminations, fires, train and airplane accidents, terrorist, hostile military or paramilitary actions, explosions, etc and the number of people who fell victim to these calamities.

That said, it is now in order to conceptualize disaster by way of a definition and a brief discussion. The World Health Organzation, WHO for short, defines disaster as “The occurrence that causes damage, ecological disruption, loss of human life, deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community area” (MERREA, 2004). Apparently, it usually has enormous impact on society in terms of social, environment, and economic disruptions. Natural catastrophes, technological accidents, or human-induced events have often resulted in loss of human life, severe property damage (including infrastructure), or/and environmental resources which are some times irreplaceable.

In general disasters cannot be done away with. But, a number of them can be prevented and /or the consequences prevented. This becomes evident when the root causes of most disasters, which are related to the actions of human beings, are put in perspective. Often disasters are enhanced by or result from the recklessness of mankind itself. Thus, overpopulation, deforestation, overgrazing, poor physical infrastructure, irresponsible waste disposal like dumping, inadequate health care, lack of preparedness, etc and insufficient emergency plans in case of disaster are some of the ingredients that constitute disaster-induced injury or loss of live as well as the damage of infrastructure and environment. The alleviation of the impacts of catastrophes has always been a big challenge for society and item IV/23 of the UN Millennium Declaration demonstrates the increasing awareness of this challenge and the commitment to do some thing about it. "We resolve therefore [….] to intensify cooperation to reduce the numbers and the effects of natural and man-made disasters […]" (UN Millennium Declaration, IV/23, 2000).

Risk management is a useful tool to achieve this goal and it supports those involved in mitigating the outcomes of disasters as well as the victims. Risk management includes “all aspects of planning for and responding to disasters, including the pre- and post- disaster activities and it refers to the management of both the risks and the consequences” (MERREA, 2004).

Disasters never respect administrative or national boundaries. They are cross border phenomena. Therefore, risk management requires, depending on the size of the affected area or the scale of the disaster, the cooperation of local, regional, federal or international authorities and institutions. This cooperation has several dimensions and the discussion below will zoom in on one of these dimensions and drive the point of this paper home. “It has often been said that the top three problems encountered during a disaster are communications, communication, and communication. Receiving, organizing, and sharing information in a timely manner is critical to efficient disaster mitigation” (Zak, 2004). An essential part of this information is spatial-related and enables seamless knowledge across boundaries on topography, infrastructure, and environment. Put another way, an effective risk management demands spatial information.

Time series data and long-term statistics on the subject seem to point to an increasing amount of disasters per year. Also, one may wonder if the increasing trend in disaster frequency is due to the growing vulnerability of our society. The authors believe that the world has not suddenly become a more risky place. The reason for the rise in the number and amplitude of risks may have to do with human practice that involves in expanded use of resources (perhaps bordering on overexploitation) with no or little consideration for the consequences. On one side, health risks have been continually reduced as a result of medical innovations with the exception of a few new pandemics like AIDS and SARS. In general, this is obviously a success of the permanent process of developing measures against upcoming risks and the resulting social and environmental impact. On the other side the increasing risks due to the extension of human settlements to risky areas, changing ways of life and other factors noted above require a systematic approach to risk management and thereby enable disaster managers as well as victims deal with catastrophic events.

## 2. STAGES OF RISK MANAGEMENT

Starting here with a review of the typology of disasters may be useful in order to give context to the upcoming discussion and also to signal well in advance relatively more successful areas of intervention if and when risk management becomes at issue. So, broadly characterized, the most common types of disasters are (a) natural disasters with geophysical origin like earthquakes, volcanos, land slides, (b) natural disasters of climatic origin like floods, drought, winds storms, fires, avalanches and (c) Man-made disasters like wars, pollutions of soil, water and air, deforestations and terrorism. Often the conditions for increased likelihood of natural disasters and even the framework for fast spread of diseases are man-made. Investigations for avoiding or at least reducing the impact of potential disasters require professional risk management that can be viewed as a process having different phases:

### 2.1 Prevention Phase

Within this phase risks and vulnerabilities are identified and analyzed; measures to avoid disasters like land use planning, structural improvements with long-term impact are introduced.

### 2.2 Preparedness Phase

The question "For What Are We Preparing?" leads to the consideration of the concern "Does Security Equate to Safety?" Preparation for prevention must go hand in hand with the preparation to respond and to recover including educational goals like:

- To integrate all the political, social, and economic forces impacting the preparedness.
- To become aware of the global and local mechanism and scientific relationships
- To foster the development of new methodologies and technologies.
- To consider the challenges and positive implications of predictive modelling processes, and as models for viable strategies, dynamic planning, and solutions.

Where can these elements for modelling be found? These will shortly be picked up and dealt with in the next chapter including presentation of some examples that illustrate these issues. What criteria are manifest that parallel the factors in play with disasters? What forces factors impact the success and/or failure of interventions? What fundamental strategies remain untried? These questions can be addressed through exploring the experiences gained and applying modelling equations based on those experiences.

The emergency preparedness, disaster management, and safety communities are the vital elements to be called upon to actively participate in any emergency or disaster, and in all aspects of prevention, preparedness, response, and recovery. The test for these professionals will be in understanding their role in prevention, establishing and utilizing a fundamental change in the planning process, cooperating openly and working together as a cohesive force, and in recognizing and meeting the challenges posed by unexpected phenomena. This will require the development of unique critical thinking approaches, new methodologies and technologies, skills applications to unpredictable experiences, and the potential to apply predictive modelling.

### 2.3 Recovery and Response

Any successful recovery requires a holistic approach with responsibilities to be in coincidence with resources and a well working cooperation which should be tested as part of the preparedness phase.

A large part of a successful recovery planning and implementation strategy is to ensure that senior management is actively involved in the holistic recovery process. To ensure that management is prepared to perform as part of the team during a crisis, testing must be performed. The testing, evaluation and measurement of the process will contribute to creating an effective plan. Components of this plan will include, but are not limited to the following points.

- Roles of management in recovery
- Means of testing capabilities
- Means of evaluating testing

### 2.4 Monitoring and Documentation

Monitoring and documentation are permanent tasks that need to be considered in all phases. Even after a disaster it is extremely important to monitor in time and to evaluate performance in order to avoid making similar mistakes in planning and recovery.
The vulnerability of a society is the deficit on efficient mitigation. The following formula is valid independent from the height and source of risk:

Vulnerability = Risk - Efficient Mitigation

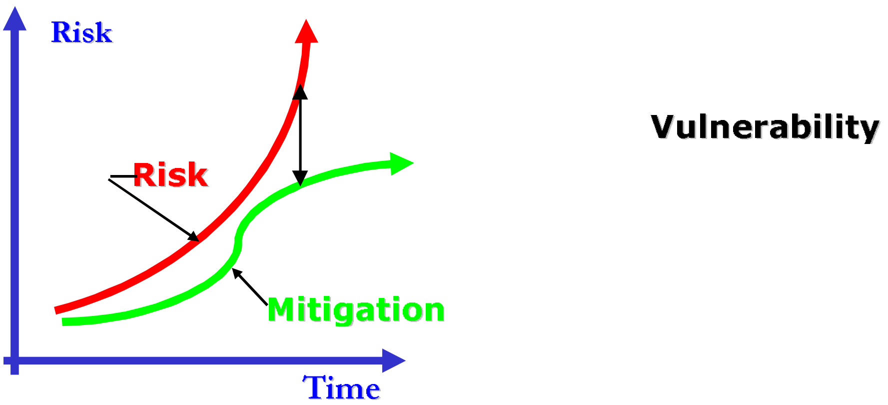


**Figure 1:** Risk-Mitigation-Diagram, adapted from (Kötter, 2003)

## 3. GEODATA FOR RISK MANAGEMENT

### 3.1 Awareness of the Vulnerability of a Society

Spatial information management (SIM) brings about increasing awareness about the vulnerability of society that result from man made factors like poverty, social segregation, water, air and soil pollution, water scarcity, land consumption and sealing. In a situation where disasters are likely to occur, it is obvious that deficits in spatial planning have an impact on vulnerability of a society and the shortfall increases the risk for a community to suffer the consequences.

Natural disasters like floods, wind, storms, fire and avalanches are a serious disruption of the functioning of a society. SIM is used to reduce the vulnerability of a society in the pre-disaster phase for risk assessment (zoning of disaster prone areas), mitigation (land use planning) and preparedness (monitoring and early warning systems). In the recovery phase, SIM is used for elaboration of physical plans with a possibility to look at different scenarios and develop strategies for reconstruction.

### 3.2 Human Infrastructure

The human infrastructure which is endangered by risks is needed not only for daily life but most of this is required for measures of risk management as well. Thus strategies for developing emergency plans require precise information and documentation, sound modelling. Taking the situation of reduced road network during flooding as an example shows the requirements for sound models, advanced GIS-tools as well as trained and coordinated experts in case of emergency.

### 3.3 Information Required for Modelling as well as for Decision Making

Recent developments introduced improved modelling techniques based on the wide range of data like topographical data – including digital terrain models - and semantic information (e.g. tectonic data) which has been collected all over the globe (Digital Globe). Environmental data including land cover and land use as well as climatic conditions have been added to a great extent. The following examples may prove the result and benefits from all these efforts.

## 4. EXAMPLES/GOOD PRACTICE

### 4.1 Availability of Information

In case of major crises, the civil protection authorities of the affected country (or the EU Civil Protection Unit) can invoke the International Charter "Space and Major Disasters" (Disastercharter, 2004). Through the Charter the requesting party obtains easy and free of charge access to satellite data, with top priority in satellite tasking. Weaknesses of this system are due to limited satellite resources, exclusion of conflict-driven crisis and lack of services for data interpretation other than on an ad-hoc basis.

To improvement of effective aid requires an increased quality and quantity of information. This applies both for those who need to decide rapidly whether to deploy resources and for those – including NGOs, as well as public authorities – that operate on the ground in remote areas with limited communications and poor infrastructure. In this context, satellite-based imagery plays an increasing role, especially to provide a rapid update when existing maps are obsolete. Satellite imagery has to be complemented by other topographic, socio-economic and statistical data in order to meet specific information demands.

### 4.2 Information About Land

Needless to say, information about land becomes an important part of modelling and planning within the framework of *disaster risk management***.** Endeavors that can be cited in this regard include:

- The Government of India and UNDP started a joint *Natural Disaster Risk Management Programme*.

- GMES is a joint initiative of the *European Commission* and the *European Space Agency* , designed to establish a Global Monitoring of Environment and Security - *www.gmes.info*.
- Remote Sensing & Land-Use Changes - *www.geo.ucl.ac.be/Disasters.htm*.

### 4.3 Monitoring of Environment

**GMES** - Global Monitoring for Environment and Security aims at building a tool to address global and European regional problems like environmental degradation and changes: (a) meeting Europe's environmental obligations, (b) Supporting sustainable development by integrating the environmental information, (c) Contributing to the security of citizens by providing information support to decision-makers and to operational actors such as civil protection teams and NGOs.

**INSPIRE** - Infrastructure for Spatial Information in Europe aims at making available relevant, harmonized and quality geographic information for the purpose of formulation, implementation, monitoring and evaluation of community policy-making.

**India** - The Government of India and UNDP started a joint Natural Disaster Risk Management Programme (www.ndmindia.nic.in) under which a database for disaster risk management and sustainable recovery is built.

### 4.4 Integration of Efforts

The challenge lies in the mobilization of professionals and volunteers and in fostering a joint approach across administrative and national boundaries. Very often these groups can be trained through drills and made to learn what to plan for in order to achieve security, safety, and sustainability. Public-private partnerships like the City of Seattle's Emergency Network Project "Impact" address the importance of community-wide participation. Unless every level of a community is represented, response to disaster events will not address community and business needs and the negative impacts will be more significant.

### 4.5 Disaster Prevention

#### 4.5.1 Simulation of snow avalanches

Being a country within the Alps, the living area in Austria is restricted and endangered by approximately 9000 documented torrents and 5800 documented avalanches. Of these, 1800 avalanches are known to potentially affect the road network, 1000 the settled areas and about 140 the railroads. Therefore, recognition, registration and assessment of risk potentials in alpine areas are important preventive measures that are routinely undertaken to protect people as well as infrastructure from being damaged by avalanches, landslides and floods. However, there is a trade off here which has to do with reductions in the market value of the parcels on which avalanche barriers are built and also the multiplicity of the protected parcels.

For an effective risk management many different data and parameters have to be collected (e.g. terrain data, soil data, hydro geological properties, vegetation, weather conditions), and analysed to predict the dimensions of natural disasters or to enable the construction of protection facilities against avalanches, floods and landslides. In the illustration cited below, GIS is used for the storage, analysis, post processing and finally for the visualisation of parameters, data and results of analysis.

The basic concept of ELBA-SIM – a simulation model for avalanches - is based on hydraulic theory. The simulation model is fully integrated in a GIS-environment and allows the run-off calculation with respect to different weather conditions, snow heights, etc. in a very short time.

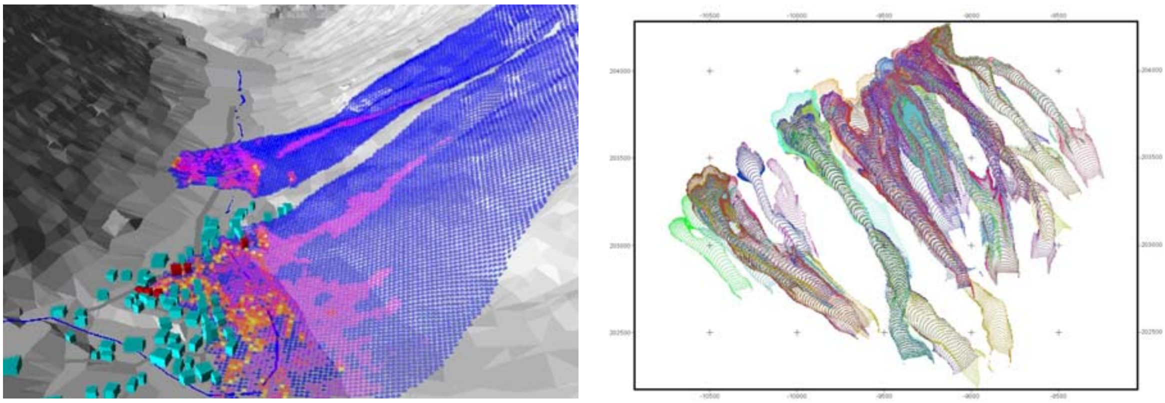

**Figure 2:** Left image: Area covered by avalanche after 18 seconds (Volk et al. 2000); Right image: Simulation results for different from start preconditions (Fuchs et al. 2000)

Using the simulation method presented above, areas exposed to risk or areas of danger can be calculated and visualized for long-term as well as for short-term risk management. The "Dynamic Danger Plans" which are among the output of this exercise will point out the degree of danger for each parcel. And by merging this information with land register and cadastral data, the owners of 'endangered' land can be determined.

The planning phase for protection facilities can merge layers that show exposure to different risks with cadastral and land register data to assess and evaluate the degree of risk for specific parcels. As the protection of parcels is related also to an increase in the value of the same, the owners of the parcels that benefit from protective interventions can be forced to contribute to the costs either directly or through taxation.

### 4.5.2 Implementation of a Danger Area Plan

The Danger Area Plan outlines areas with a specific risk for natural disasters (e.g. avalanches, land slides, floods). The degree of risk is indicated in different colours, whereas the red zones (see Figure 3) point out areas with the utmost probability of a natural disaster impact. Usually the different zones are linked with different land use restrictions. The composition of Danger Area Plans is entrusted to the Regional Offices of Risk Protection which are subordinated to the Austrian Ministry of Agriculture, Forestry Environment and Water Management.

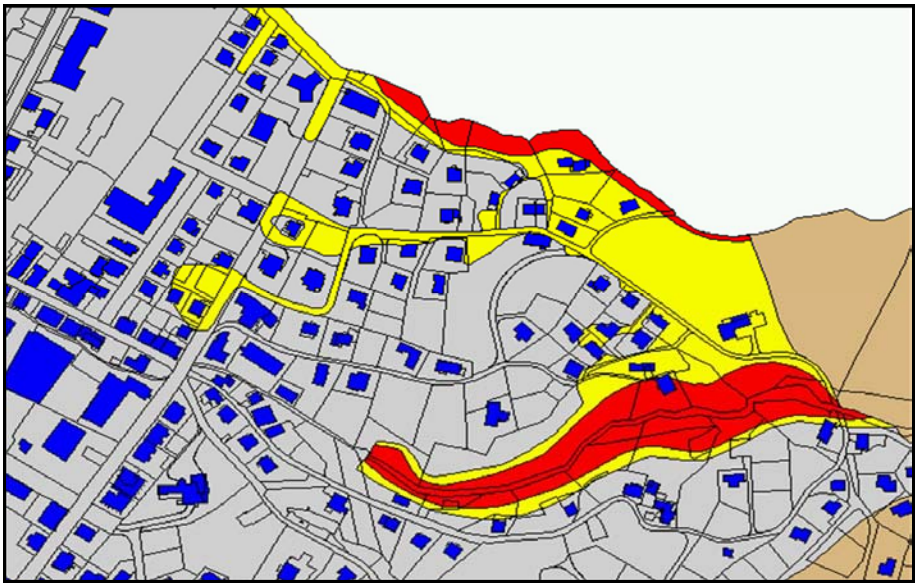

**Figure 3:** Danger Area Plan

Danger Area Maps are produced for municipalities with a given risk probability. As Austria is a mountainous country with plenty of turbulent flows, this kind of spatial information is has become indispensable and available for almost all Austrian communes. Citizens have free access to these maps in the concerned municipality or in the Regional Office of Risk Protection. Danger Area Maps are not yet published on the Internet.

## 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

*Vulnerability is the outcome of increasing risks and shortfalls in efficient mitigation mechanisms:* As shown in chapter 2 vulnerability is the difference between existing risks and available possibilities to mitigate the same. Thus, the challenge for the society lies in attaining decreases in the number and magnitude of risks as well as in making sizable increases in the capacity that will be deployed to mitigate risks.

*Risk management cannot totally avoid disasters, but it can reduce them and minimize the undesirable impacts:* Effective early warning mechanisms allow timely evacuation of people and movable property. Well-developed emergency plans enable concerted and targeted interventions through rescue brigades and other means. In a controlled situation like this, there will no or very little room for anyone to be caught by surprises.

*Spatial data are highly demanded for risk management and the documentation of disasters:* To develop effective early warning systems and suitable emergency plans, potential risks must be identified, analysed and evaluated. These tasks are invariably based on the availability of up-to-date geodata as well as proper methods of spatial data management. As has been shown in the foregoing, the simulation of natural disaster processes requires spatial data describing topography, land coverage, environment and climate. This also impacts the recovery process as the latter normally starts immediately following the disaster event and needs to take stock of the magnitude of damage as soon as possible. In this connection, the use of photogrammetry and remote sensing enable an objective documentation and the possibility for subsequent geometric and semantic data acquisition. Finally the quantitative documentation of disaster impacts helps to improve the models for the disaster processes.

*Deficit on research in the field of risk management:* recently many research institutions have begun to focus their activities on Natural Disaster Management. Emergency plans are state of the art in numerous areas with heightened risks (earthquake zones). Especially the industrial countries have invested a lot on infrastructure to prevent or minimize the impact of disasters and to establish mechanisms that aim to forewarn about impending floods, avalanches, hazards. However, the task is far from accomplished and there is still a demand for more research work in the fields of vulnerability analysis, disaster prevention, prediction of catastrophes, rescue operation, etc with a view to fine tune and optimise existing measures and also to figure out new coping mechanisms.

*Efficient risk management requires interdisciplinary work and cooperation:* The complex processes of natural and manmade disasters can only be dealt with in a multidisciplinary approach. Therefore, the existing silo mentality must be replaced by a collective interdisciplinary thinking of geoscientists, environmental experts, computer scientists, legal experts and specialists in the field of rescue services. Cooperation and information exchange between and among different levels of public and private institutions on domestic and international level is also necessary.

*Implementation of institutions for risk management:* staff positions must be established in different levels of administration (municipality level, provincial level, state level, regional level, global level) with the task to develop strategies and programmes for all stages of risk management. Surveyors must assume a key role in these staff positions.

*Assignment of responsibilities must be in congruence with allocation of resources:* Decision-makers must be aware about the high demand on human and financial resources for efficient risk management. The power of disposition on the resources and the amount on resources must be in accordance with the degree on responsibility for risk management.

*FIG has to promote the competence of surveyors in the field of risk management:* Surveyors have many of the skills and the expertise needed to elaborate risk management plans in general and spatial data acquisition and processing in particular. They have thus role to play that is commensurate with their expertise. Of course, this may entail a departure from conventional thinking. As a body that brings together surveyors and as an organization pioneering new ideas, the International Federation of Surveyors (FIG) has to promote among stakeholders and decision makers the potential contribution of the profession in all phases of risk management. Also, FIG has to organise scientific and professional meetings about disaster management. And finally it has to support research, implementation and improvement activities related to disaster management.

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## BIOGRAPHICAL NOTES

**Gerhard Muggenhuber** has some 20 years of professional experience in management of cadastre and Geo-Information in Austria as well as abroad. Therefore he has an excellent knowledge in the management of geoinformation. In his present function as Vice-head of international affairs of BEV – Federal Office of Metrology and Surveying - he contributed to international initiatives in Eastern- and Central Europe like the Word Bank “Initiative on Real Property Rights”. Gerhard Muggenhuber is elected Chairman of FIG-*Com.3 (Spatial*

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**Reinfried Mansberger** currently works as an Assistant Professor at the Institute of Surveying, Remote Sensing and Land Information at the University of Natural Resources and Applied Life Sciences in Vienna (BOKU Wien). In 1982 he obtained his Master's degree in surveying at the Technical University in Vienna. From 1983 until 1987 he was appointed as a research and teaching assistant at the Institute of Applied Geodesy and Photogrammetry at the Technical University in Graz. He obtained his PhD degree at the University of Agricultural Sciences in Vienna (BOKU Wien). He is council member of the Austrian Society for Surveying and Geoinformation and he is actively involved in FIG as Commission 3 Vice Chair on Administration and Information. He is an elected member of the European Faculty of Land Use and Development. His research work is focusing on Land Use Planning, Land Information, Environmental GIS Applications, and Cadastral Systems.

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