


Joint Board of Geospatial Information Societies United Nations Office for Outer Space Affairs

Geoinformation for Disaster and Risk Management

Examples and Best Practices




Geoinformation for Disaster and Risk Management

Examples and Best Practices

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This publication is the result of the collaboration of many scientists who are dedicated to the implementation of geospatial information for risk and disaster management.

Preface

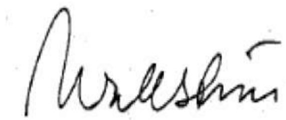
Each year, disasters arising from storms, floods, volcanoes and earthquakes cause thousands of deaths and tremendous damage to property around the world, displacing tens of thousands of people from their homes and destroying their livelihoods. Developing countries and poor communities are especially vulnerable. Many of the deaths and property losses could be prevented if better information were available on the exposed populations and assets, the environmental factors in disaster risk, and the patterns and behaviour of particular hazards. Increasingly, this information is becoming available with the help of technologies such as meteorological and earth observation satellites, communication satellites and satellite-based positioning technologies, coupled with hazard modelling and analysis, and geographical information systems (GIS). When integrated into a disaster risk reduction approach, and connected to national and community risk management systems, these technologies offer considerable potential to reduce losses to life and property. To do his requires a solid base of political support, laws and regulations, institutional responsibility, and trained people. Early warning systems should be established and supported as a matter of policy. Preparedness to respond should be engrained in society.

The primary aim of this booklet is to explain to governments, decision makers and disaster professionals the potential uses of geoinformation technologies for reducing disaster risks and losses, based on the knowledge and experience of experts in these fields. In July 2009, the Joint Board of Geospatial Information Societies and UN-SPIDER* jointly invited individuals and groups to contribute articles for the preparation of the booklet, describing their research work and experiences on the application of geospatial technologies as a contribution to a decision support forum. The Booklet covers all regions of the world and all aspects of disaster risk and its management. We commend this booklet to you in the hope that improved application of geospatial information will support better understanding and action to reduce the number and impact of disasters in future.

Margareta Wahlström

Special Representative of the Secretary-General

for Disaster Risk Reduction



** About UN-SPIDER: In its resolution 61/110 of 14 December 2006 the United Nations General Assembly agreed to establish the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), which has as its mission statement: "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle". The UN-SPIDER program is achieving its aims by being a gateway to space information for disaster management support, by serving as a bridge to connect the disaster management and space communities and by being a facilitator of capacity-building and institutional strengthening, in particular for developing countries.*

UN-SPIDER is being implemented as an open network of providers of space-based solutions to support disaster management activities. Besides Vienna (where UN-OOSA is located), the program also has an office in Bonn, Germany and will have an office in Beijing, China. Additionally, a network of Regional Support Offices multiplies the work of UN-SPIDER in the respective regions.

Preface by JBGIS

The Joint Board of Geospatial Information Societies (JB GIS) is a coalition of leading international geospatial societies which has as its primary goal to speak on behalf of the geospatial disciplines at an international level, especially to the United Nations and other global stakeholders. Its second goal is to coordinate activities between the geospatial professional societies and scientific organisations. The JB GIS is a co-operative network which exists through the support of its member organisations. For more information please refer to the (http://www.fig.net/jbgis/).

The current members of the JB GIS are the:

- ✓ Global Spatial Data Infrastructure (GSDI) Association
- ✓ IEEE Geoscience and Remote Sensing Society (IEEE-GRSS)
- ✓ International Association of Geodesy (IAG)
- ✓ International Cartographic Association (ICA)
- ✓ International Federation of Surveyors (FIG)
- ✓ International Geographic Union (IGU)
- ✓ International Hydrographic Organization (IHO)
- ✓ International Map Trade Association (IMTA)
- ✓ International Society of Photogrammetry and Remote Sensing (ISPRS).
- ✓ International Steering Committee for Global Mapping (ISCGM)

The JBGIS and its members take great pride in their contributions of geospatial information and technologies for disaster management and emergency response. There is a broad range of examples of applications of geospatial data for this purpose described in this booklet including: the application of high resolution satellite data for monitoring of the size and growth of the refugee camps; the use of Geographic Information Systems (GIS) for a global disaster alert and coordination system, to audit recovery after the Indian Ocean Tsunami, and mapping volcanic eruptions; the use of satellite images for forecasting potential health effects caused by dust storms, rapid mapping of flooding in flood prone areas, fire detection, earthquake damage assessment, topographic mapping and disaster recovery; the application of global navigation satellite systems (GNSS) such as GPS for detecting structural deformation during construction, and for a low cost landslide monitoring system; using satellite radar data for monitoring changes in the ground surface structure of the volcano; and using a communication chain for transmitting rainfall and river level data for warning of the danger of flooding. These examples demonstrate the breadth of current applications of geospatial information and provide directions on future applications of geospatial technologies for disaster management and emergency response.

We trust that this booklet will provide impetus for emergency relief teams, local administrators and international coordinating response teams to further develop applications of geospatial information and technologies for disaster management and emergency response.

Mark Cygan	Michael G. Sideris	William Cartwright	Stig Enemark	Keith Ferries	Orhan Altan	Abbas Rajabifard
Chair, JBGIS	Pr. of IAG	Pr. of ICA	Pr. of FIG	Pr. of IMTA	Pr. of ISPRS	Pr. of GSDI

Introduction

National governments, international organizations and research institutions worldwide have set to work to improve disaster management in all its phases: mitigation, preparedness, relief and response, and recovery and reconstruction. Many governments have put the formation of a hazard-resistant and disaster-coping society on their political agenda as an important factor of sustainable economic development and better quality of civil life. In this respect, the awareness of new geospatial technologies and their successful utilization in disaster management is becoming crucial.

These technologies are emerging very fast. Meteorological and earth observation satellites, communication satellites and satellite-based navigation and positioning systems may help to improve prediction and monitoring of potential hazards, risk mitigation and disaster management, contributing in turn to reduce losses of life and property. Global navigation satellites and earth observation satellites have already demonstrated their flexibility in providing data for a broad range of applications: weather forecasting, vehicle tracking, disaster alerting, forest fire and flood monitoring, oil spill detection, desertification monitoring, and crop and forestry damage assessment. Monitoring and management of recent natural disasters have greatly benefited from satellite imagery, such as the Indian Ocean tsunami in 2004, floods (Austria, Romania, Switzerland, and Germany in 2005), hurricanes (USA in 2005), forest fires (Portugal, France, Greece, Australia in 2005, 2008), earthquakes (Pakistan in 2005, Indonesia in 2006, Haiti 2010), etc.

The use and exchange of geospatial information in disaster situations is facilitated, on national and international levels, by initiatives and programmes on harmonisation of geospatial data and building of spatial data infrastructures, such as GMES and INSPIRE in Europe, the United Nations Geographic Information Working Group (UNGIWG), Homeland Security and Digital Earth. Sensors and in situ data have been increasingly integrated for early warning and hazard monitoring. Systems maintaining geospatial information are becoming more elaborate and multi- functional than ever before. Many of these systems can meet requirements for early warning and real-time response, and provide suitable models for elaborated predictions, simulations and visualizations.

However, the knowledge about the full range of the application potential of geospatial technologies is the domain of specialists in the geosciences. Therefore, the Ad-Hoc Group on Risk and Disaster Management was formed in 2008, with Orhan Altan as chairman, within the Joint Board of Geospatial Information Societies. It is the goal of the Ad-Hoc Group to create and foster knowledge transfer between international geo-science bodies working on disaster and risk management with different technological backgrounds, and to ensure political support for the utilization and development of geo-technologies in this field.

In fulfilment of its mission the Ad-Hoc Group initiated this publication in order to highlight geospatial technology which has been successfully used in recent disasters. It is a major goal of the book to make disaster managers and political decision-makers aware of the potential and benefits of using geospatial information in every phase of disaster and risk management.

The project started in January 2009 with an open call for contributions describing best practices and experiences. To coordinate the preparation of the booklet the Ad-Hoc Group appointed a working committee as follows: Orhan Altan, Piero Boccardo, Sisi Zlatanova (all ISPRS) and Robert Backhaus (UNOOSA/UN-SPIDER) Committee meetings were held in Prague, Zurich, Milan, Istanbul, Delft, Turin and Haifa to discuss the submitted abstracts and papers and to give guidance to the contributors. Only technology in action was considered. The papers had to be written for a wide-spread audience, with a minimum of technical detail. The booklet should demonstrate that geo-information and satellite technology is used to manage disasters in all parts of the world and helped in various responce and recovery operations.

With regard to these goals 16 contributions were selected. The geographical distribution is shown in the figure below. Disasters in China, Germany, Greece, Haiti, Hungary, India, Indonesia, Italy, the Philippines, Sudan, and the USA are analyzed in detail. Some of the most devastating natural disasters such as the South Asia tsunami and the Haiti Earthquake, as well as humanitarian crisis situations such as the Sudan refugee camps reveal the international efforts in providing maps and satellite imagery.

Meeting of the Committee in Istanbul (2.10.2009)

The papers can be subdivided into four thematic groups. The first group presents technologies, systems, and approaches that are intended for global early warning, monitoring and support. A second group of papers addresses the integration of satellite and airborne products for immediate response and damage detection in large impact disasters in Haiti, Mexico and Sudan. The third group demonstrates fusion of sensors networks measurements, imagery and GIS data for monitoring and simulation of floods, landslides, tunnels and earthquakes. The last group illustrates the benefit of integration of imagery and GIS data in post-disaster situations and for risk management.

The booklet starts with a chapter presenting the Global Disaster Alert and Coordination System (GDACS). It is one of the first and most used portals which provide alerts and impact estimations after major natural and environmental disasters. The partnership with scientific and hazard-monitoring institutions allows collection and communication of near real-time hazard information, which can be further combined in a GIS with demographic and socio-economic information.

The importance of GDACS is growing, and the number of its users increasing. The second chapter is dedicated to the global monitoring and alert service on floods provided by the non-profit association ITHACA (Information Technology, Humanitarian Assistance, Cooperation and Action). After a short introduction outlining the major phases of disaster management, the authors discuss the data needs for the identification of water bodies and floods. Several approaches based on medium and low resolution satellite imagery and radar data are briefly explained and illustrated for several use cases in Bangladesh. The approaches aim at providing rapid mapping in the first hours of a flood. The system developed within ITHACA is operational worldwide. In chapter 3, Oertel et al. focus on wildfire monitoring by infrared sensors on a satellite constellation. The authors discuss and evaluate currently available sensors and data products, highlighting the characteristics of a relatively new (launched in 2001) satellite equipped with Infra red sensors for quantitative analysis of high-temperature events such as wildfires and volcanoes. They advocate further development of this system towards a dedicated Fire Monitoring Constellation, which would ensure a daily observing cycle with a spatial resolution of 250m.

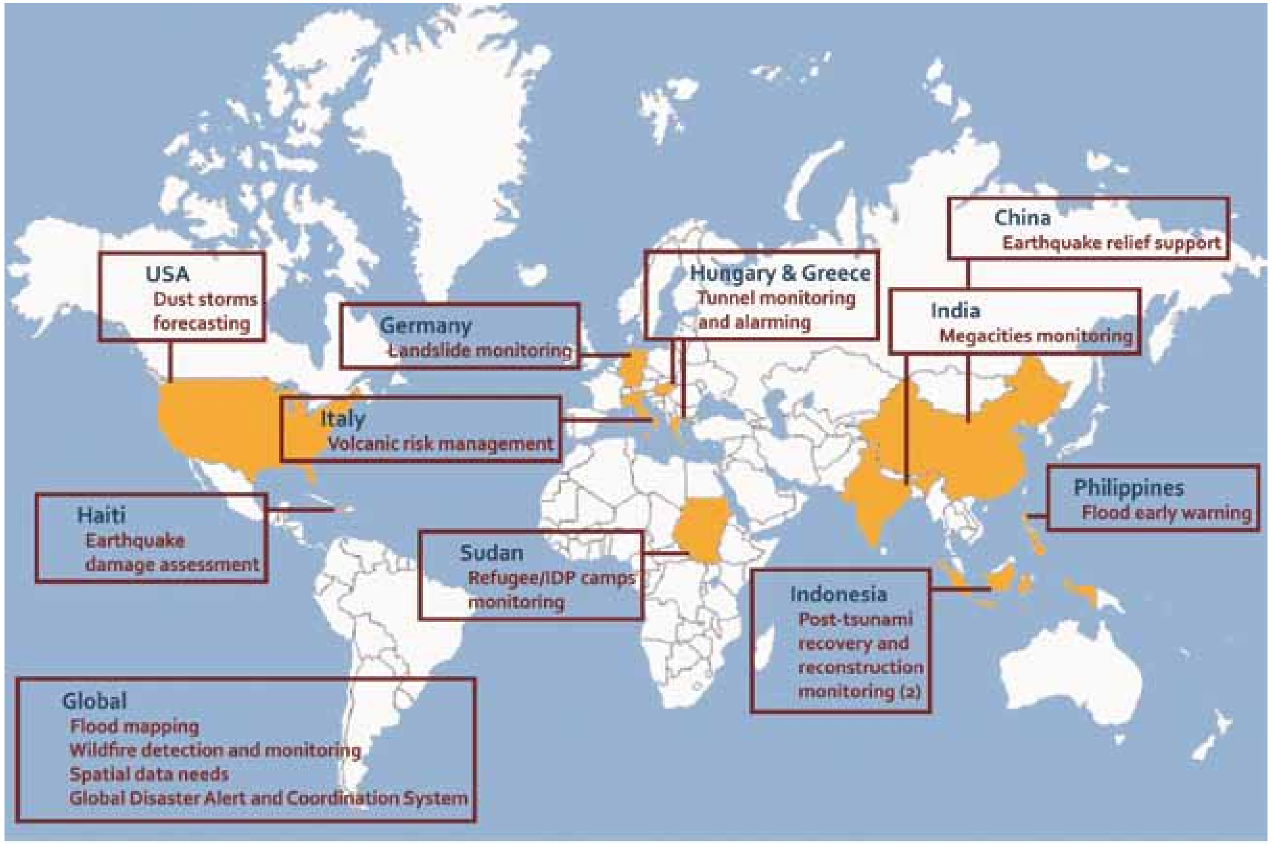
Chapter 4 enlarges the thematic scope through the question on what additional information (spatial and non-spatial) is needed for successful crisis response in general, besides disaster-specific data. The author, Shirish Ravan, groups the additional information into the categories baseline data, utility and infrastructure data, and thematic data on terrain and natural resources. The informational value of these data is briefly outlined. Since these data sets are maintained by different institutions, the author emphasizes the development of Spatial Data Infrastructures and Web-based mapping services for local governments as key elements for successful management of crisis situations. Chapter 5 provides an extended study on the use of a specific type of airborne products (orthophotos) in the post-Tsunami reconstruction phase in Aceh, Indonesia. In contrast to the other chapters this one investigates the demand for such data by different organisations. Well-illustrated with several diagrams, the study clearly reveals that the use of spatial data was critical to the successful completion of the aftermath phase.

However many problems related to timely delivery of data, availability of data and costs have been reported. The study confirms the importance of Spatial Data Infrastructure, as discussed in Chapter 4.

Chapter 6, 7, 8 and 9 demonstrate satellite-based technologies applied in cases of large impact disasters such as earthquake (Haiti, China) and dust storms (New Mexico), and for monitoring of refugee camps (Sudan). In the case of Haiti, appropriate maps showing most affected areas and road accessibility were provided in the first few days after the earthquake, in support of the provision of humanitarian help by the World Food Program. Although optical imagery was widely used, it was not sufficient for obtaining a complete picture of the devastation. Web-based systems were set up on the spot using open source tools. Mobile systems equipped with webcams and GPS also appeared to be very successful.

The authors, Ajmar et al., argue that many developing countries need access to participatory (community) maps such as Open Street Maps or Google Map Maker, to enable citizens and experts to quickly exchange information.

In chapter 7, Suju Li et al. present an extensive overview on the large number of satellite images (n=1257) provided in support of the earthquake response and relief activities in China in 2008. The authors note, however, that requests for earth observation data should be carefully planned to ensure complete coverage of the affected areas at different time periods. In chapter 8, Morain and Budge discuss a satellite-based system for dust monitoring, concluding that such systems might be of great importance for the mitigation of health risks. A very interesting application of satellite products in humanitarian actions is presented by Kranz et al. in chapter 9. The authors present an approach for monitoring the extent and growth of displaced persons camps using very high resolution satellite images (1m). The mapping products were delivered two days after receiving the satellite data. The feedback from the user organizations was very positive.



Geographical distribution of cases

Chapters 10, 11, 12 and 13 present examples of technologies fusion (ground sensors, satellite products and GIS) for several medium scale disasters. Kerle and Neussner present a local flood early warning system, which consists of rain and river level gauges and a command and control system for processing the data. The system can alert citizens at every administrative level and did not miss a single flooding event, being activated 13 times since 2007. Glabsch et al. report on tests of a low-cost land slide monitoring system based on a network of point stations with permanent position control. The system is completely modular and allows long-term monitoring as it is powered by solar energy. Data handling and processing is managed by different software packages and all the measurements are archived in a database management system. Klaus Chmelina presents the Kronos system, which is dedicated to tunnel structure monitoring. The Kronos software is being successfully applied for the metro in Budapest and Thessaloniki. Spinetti et al. present their system for monitoring Mount Etna, Italy. The system monitors surface deformation, surface temperature and gas and particles emissions into the atmosphere. These parameters (obtained from satellite imagery and radar) are used by decision-makers for better understanding the situation after an eruption.

Chapters 14, 15 and 16 demonstrate the use of geo-information in a more societal context, addressing auditing disaster-related aid, and estimation of population growth in megacities. Bijker et al. (chapter 14) describe their approach based on land cover change detection between the start and at the end of the audit period. The maps were derived from satellite images. The study clearly shows that the method is cost-effective and also served to demonstrate to the local authorities the importance of geography in policy implementation for disaster areas. Similar conclusions are also drawn in the last chapter by Nolte et al., related to the role of remote sensing and GIS for the sustainable development of megacities. The authors argue that information on population density and its spatial distribution is one of the most crucial requirements for resilient disaster management. These parameters can successfully be monitored with remote sensing technology and processed with GIS packages. The last chapter 16 presents a number of emergency situations, in which GIS was successfully applied for response or recovery. The authors Cygan et al convincingly illustrate that GIS aids in establishing complete situational awareness by linking people, processes and information.

The editors believe that this booklet is a helpful demonstration of how geo-information technology can be efficiently integrated into disaster management, encompassing data collection (remote sensing, sensor networks, mobile systems), data processing, and production of maps, which are further integrated, analyzed and visualized in GIS/Web-GIS. Many more advanced exciting technologies (3D visualization and simulation) are in the process of development, prototyping and testing and will be available in the coming years. The authors believe that this book will contribute to a better understanding and acceptance of these technologies. The book is complemented by the mission profiles of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) and the JBGIS member societies

The book is intended to target political and administrative decision-makers as well as administrative emergency practitioners, but also technical experts from different disciplines including computer science, information technology, engineering, and disaster management.

The editors would like to thank the members of the Joint Board of Geospatial Information Societies for approving the project, and the United Nations Office for Outer Space Affairs, the United Nations World Food Programme, the foundation Compagnia di San Paolo and ITHACA for all the valuable support given to the realization of this book. Furthermore the editors want to express their sincere thanks to two persons, namely Prof. John Trinder and Dr. Gerhard Kemper. Prof. Trinder took care of the proofreading with unprecedented capacity. Dr. Kemper designed the layout of the booklet with his well-proven competence. Without their help this publication would not have been realized.

We wish to thank the ISPRS Council for their encouragement and support for all stages of the preparation of the booklet to its completion.

Orhan ALTAN Robert BACKHAUS Piero BOCCARDO Sisi ZLATANOVA

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Global Disaster Alert and Coordination System

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Introduction

The Global Disaster Alert and Coordination System (GDACS), established in 2004, is a cooperation framework under the United Nations umbrella with the aim to consolidate and strengthen the network of providers and users of disaster information worldwide, in order to provide reliable and accurate alerts and impact estimations after sudden-onset disasters and to improve the cooperation of international responders in the immediate aftermath of major natural, technological and environmental disasters.

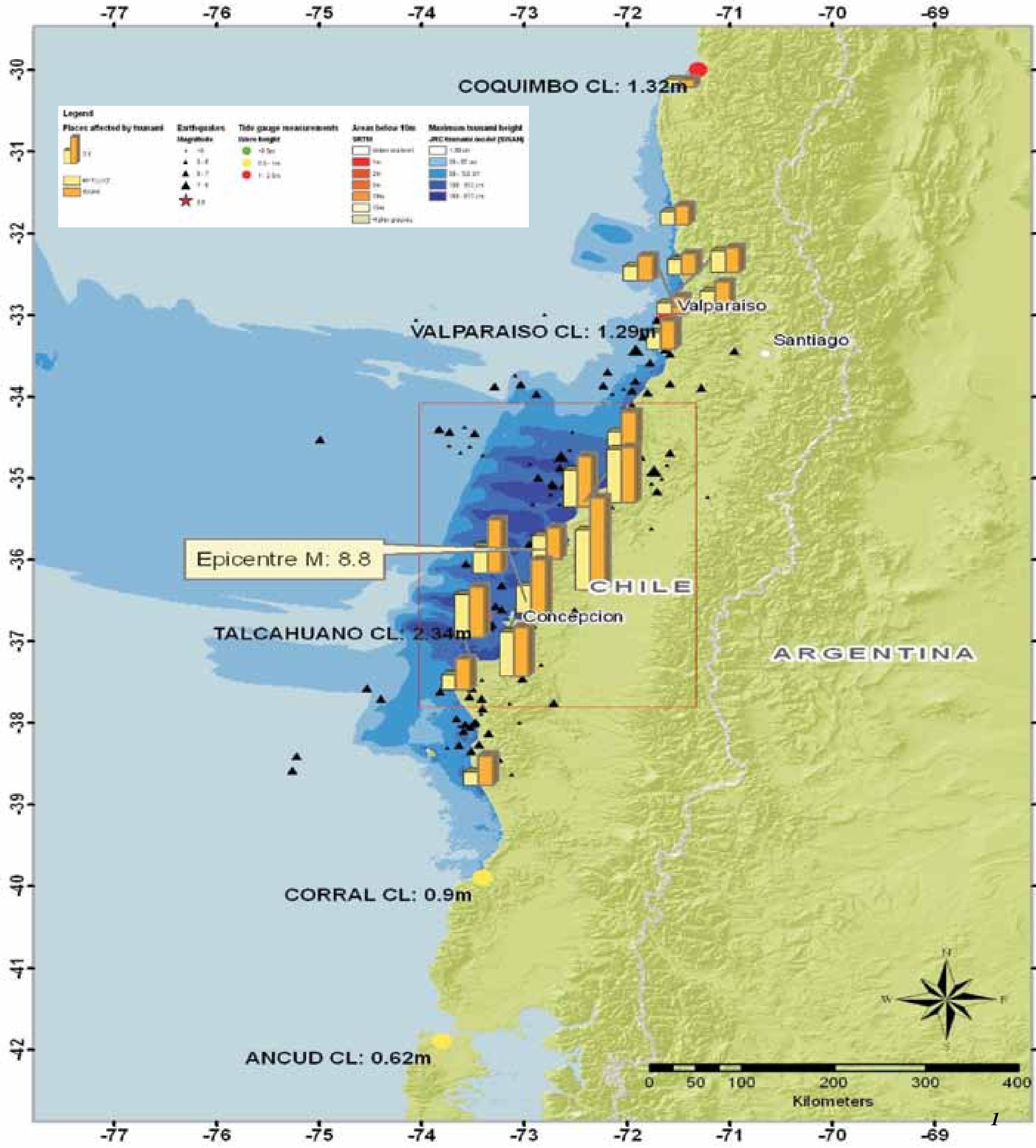

Figure 1: Estimation of Tsunami Impact for Chile earthquake M8.8 27/02/2010 06:34 AM UTC (GDACS Situation Report + JRC)

For the first five years (2004-2009), GDACS was funded by the European Commission. This resulted in the development of an integrated web-based service that combines critical disaster information systems under one umbrella. During this period, GDACS introduced its services to international disaster responders in meetings, workshops, seminars and disaster response exercises. The main information service providers in GDACS are

- ✓ the European Commission Joint Research Centre (JRC) in Ispra, Italy,
- ✓ the United Nations Office for Coordination of Humanitarian Affairs (OCHA), with the Virtual OSOCC or Virtual On Site Operations Coordination Center and ReliefWeb and
- ✓ the United Nations Operational Satellite Applications Programme (UNOSAT).

GDACS comprises three elements:

1. Web-based automatic alert notifications and impact estimations (JRC) for earthquakes, tropical cyclones, floods and volcanoes.
2. A community of emergency managers and emergency operation centres in responding and disaster-prone countries and disaster response organisations worldwide.
3. Automatic information exchange between web-based disaster information systems (presently: JRC, Virtual OSOCC, ReliefWeb and UNOSAT).

Today, many governments and disaster response organisations rely on GDACS alerts and impact estimations, and utilise the Virtual OSOCC for information exchange and cooperation with other actors in the first phase of major disasters.

GDACS has around 10000 subscribers, most of whom represent governmental or non-governmental disaster response organisations. Several countries have included the use of GDACS services, in particular JRC's automatic alert and impact estimations and the Virtual OSOCC, in their national disaster response plans.

An on-line survey that was carried out in 2008 among GDACS users showed that most organisations rely heavily on its services both with regard to automatic alerts and impact estimations, as well as its network of disaster managers and coordination platform.

<u>Figure 2:</u> The GDACS website (http://www.gdacs.org) shows near real-time information for earthquake, cyclone, flood and volcano disasters.

Three ingredients for success

Multi-hazard approach

GDACS was born out of a need to reduce the need to monitor several web sites for several disaster types. The European Commission Office for Humanitarian Aid (ECHO), one of the largest donors of humanitarian aid, expressed the wish for a single portal to access information on any natural disaster. This has driven the early development of GDACS, or global disaster alert system. Only later was the system integrated with an information system for “coordination” response, which proved successful and will be described later.

GDACS provides global multi-hazard disaster monitoring and alerting for earthquakes, tsunamis, floods, volcanoes and tropical cyclones. These hazards have very different physics and are studied in disconnected scientific communities. Through partnerships with scientific organisations and other hazard monitoring institutions, GDACS collects near real-time hazard information, which is combined in GIS models with demographic and socio-economic data. GDACS performs a consequence analysis with a risk formula combining the magnitude of a hazard with an element at risk (such as the amount of people in the affected area) and a vulnerability factor accounting for physical and socio-economic resilience of the affected area. For tsunamis, GDACS uses a novel tsunami system developed at the Joint Research Centre, which through 135000 pre-calculated scenarios, can provide an immediate assessment of tsunami risk .

A system of systems based on open standards

As research in early warning and alert systems is developing rapidly, existing data and models will soon be outdated. In order to provide a robust framework for cooperation, GDACS was designed from the beginning as a system of systems. Individual components can be exchanged with newer, better components that provide more added value for emergency responders.

As a means to achieve interoperability of models and systems, GDACS has promoted the use of standards for information and communication. The two most important standards in the GDACS framework are RSS (a communication standard) and the GLIDE number (a content standard).

The first, Really Simple Syndication or RSS, is a well-established XML format for exchange of messages. Because it is so simple and widely used, almost any organisation has the ability to produce RSS feeds, making it a very useful standard. Over the past few years, JRC has assisted several organisations to start producing RSS feeds, making their information interoperable with GDACS.

The second standard, the GLobal IDEntifier for disasters or GLIDE[1], is a unique identifier for a disaster, pioneered by the Asian Disaster Reduction Center. Its purpose is to allow many organisations to link their databases on disasters. This is not a trivial problem, because a disaster is a loosely defined concept used in different ways in different research and practitioner communities. The components of a GLIDE number consist of two letters to identify the disaster type (e.g. EQ - earthquake); the year of the disaster; a six-digit, sequential disaster number; and the three-letter ISO code for country of occurrence.

[1]: *http://www.glidenumber.net/*

Current scientific partners:

- ✓ Earthquakes: US, Italian, European, German, Chinese and Russian seismological institutes
- ✓ Tropical cyclones: Pacific Disaster Centre
- ✓ Floods: Dartmouth Flood Observatory, NASA, Ithaca
- ✓ Volcanic eruptions: Smithsonian Global Volcanism Program
- ✓ Tsunamis: NOAA, UNESCO

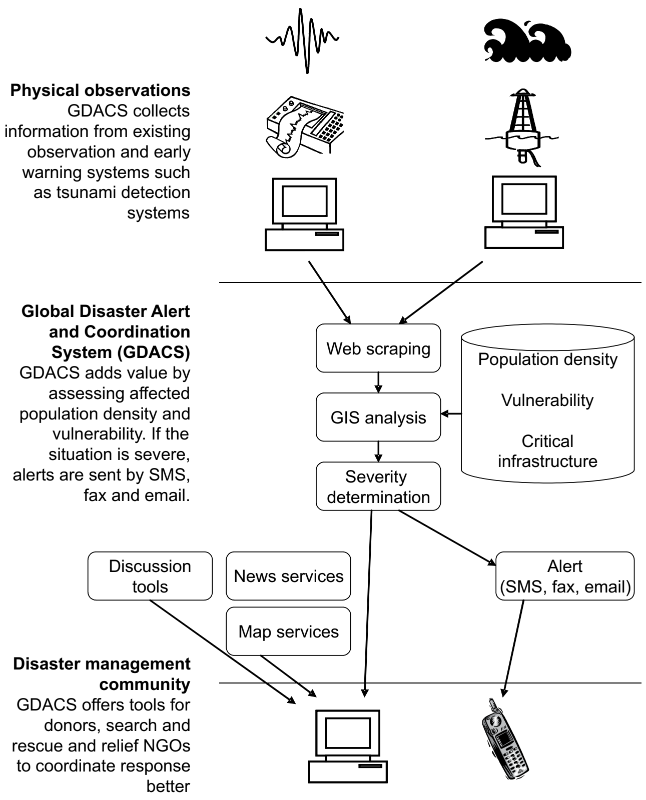

Figure 3. Principle of GDACS system

GDACS also supports more complex standards (such as Open Geospatial Consortium standards) or emerging standards (KML was adopted soon after it emerged). Supporting (and syndicating) different standards is an essential characteristic for a system of systems.

A community built on trust

During major disasters, information exchange between international responders and the affected country is critical. In the immediate aftermath of a disaster, international responders seek to have an overview of the situation in order to provide a quick but measured response. The affected country, on the other hand, is burdened by managing the disaster internally and handling the international responders. The challenge in this environment is to make sure information is not misused. Quick release of uncertain information can result in adverse effects. For instance, inaccurate information picked up by media and distributed can cause panic in the affected population.

The main purpose of the GDACS Virtual OSOCC is to facilitate decision-making for international response to major disasters though real-time information exchange by all actors of the international disaster response community. The GDACS Virtual OSOCC is a platform for informal information exchange for a well-defined, private, professional community of disaster managers. Virtual OSOCC members include:

- ✓ Emergency management authorities of affected countries;
- ✓ International responders (including search and rescue teams, relief teams, govern-mental and non-governmental actors);
- ✓ OCHA response communities, including the United Nations Disaster Assessment and Coordination (UNDAC): a stand-by team of disaster management professionals.

The community excludes press, media and non-professionals. This, and the fact that community members meet occasionally at OCHA training courses, makes for a level of trust among members which is essential to the free sharing of informal information during major disasters. Informal information, as opposed to official information, is not necessarily accurate, complete, and can be partially true or of a restricted nature; but is very valuable to professionals who understand its value and its risks. A major benefit of informal information is that it is more timely than official information. For instance, the community exchanges information on the humanitarian assistance they are planning to provide, before it is officially approved by their governments. This can avoid duplication and overlap in response without the risk of being negatively perceived when initial offers of assistance are withdrawn.

In addition, through the Virtual OSOCC the United Nations Assessment and Coordination Team (UNDAC) can be effectively mobilised through on-line workflow procedures including SMS and e-mail. During crises, all Virtual OSOCC users have the opportunity to create e-mail and SMS messages that are sent automatically to subscribers to inform about critical situation updates during disaster response operations. In between crises, the Virtual OSOCC facilitates management of UNDAC, INSARAG and UN-CMCoord training, meetings and workshops through e-mail notification, on-line participant registration and discussion of background material. It also provides its users with a discussion forum for any area of interest, including information exchange on best practice and lessons learned after disaster response operations.

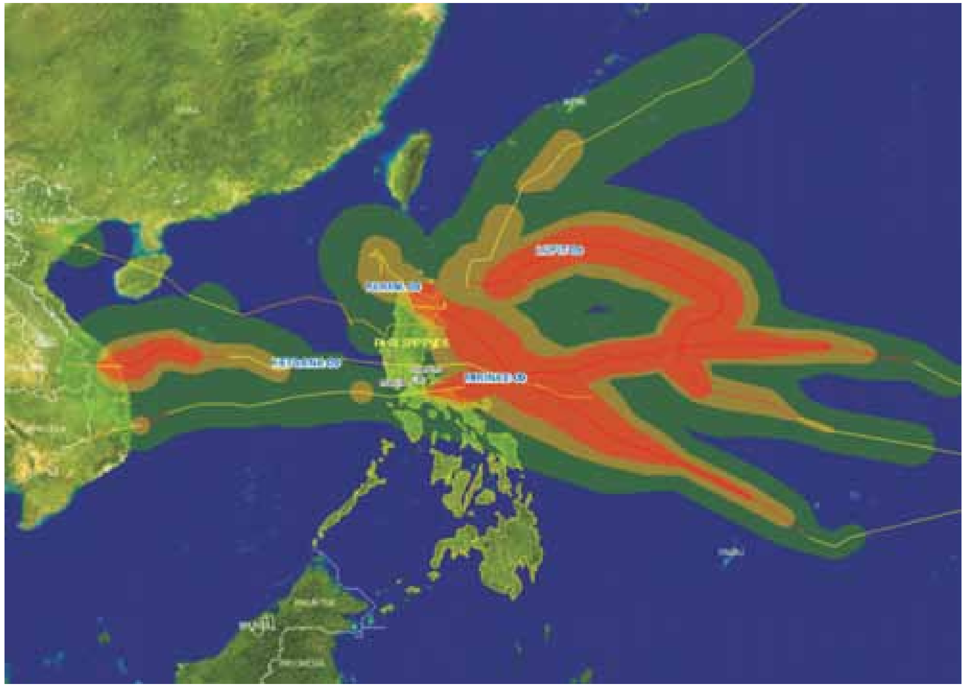

Figure 4:. *Example - 2009 Typhoons in Pacific, affected areas calculated in real-time by Joint Research Centre for GDACS.*

Example 2009 Typhoons in South-East Asia

In 2009, 4 typhoons hit the Philippines over a short period, continuing towards Vietnam and China. First Ketsana (PAGASA name Ondoy), a category II cyclone, past by the Philippines with low intensity winds but heavy rain, and subsequently hit Vietnam. This was followed a few days later by the Category IV Typhoon Parma (Pepeng), hitting the Philippines with winds strengths over 240 km/h. Less than three weeks later, Category I Typhoon Lupit (Ramil) and Category II Typhoon Mirinae (Santi) hit the Philippines.

The GDACS alert system used predicted tracks downloaded from the Pacific Disaster Center, to estimate population at risk. Detailed warnings were sent up to 54h in advance of landfall, indicating affected cities, airports and ports. GDACS automatically sent out email, SMS, fax and voice alert messages to registered users. However, warnings were not sent to the Philippines for the Ketsana Typhoon, since the winds were low intensity and most damage was caused by associated floods, which currently cannot be modelled. This is an area where the GDACS alert system will be improved.

Disaster managers activated the GDACS Virtual OSOCC on 27 September immediately after landfall of typhoon Ketsana in the Philippines, and a second time, more than 24h before the typhoon's landfall in Vietnam. Through the GDACS Virtual OSOCC, OCHA alerted the United Nations Assessment and Coordination (UNDAC) team for all four typhoons, which resulted in rapid deployments of UNDAC teams on 29 September (Ketsana), and on 19 October (Lupit). To facilitate international coordination, all four storms were managed in the same discussion thread, where information from 23 governments and disaster response organisations was exchanged in real-time from 27 September to 3 November. This included situation updates from the Philippines Emergency Coordination Centre several times per day, as well as details about capacity and deployment status of 17 international relief teams. Furthermore, 12 governments reported their planned in-kind or cash contributions. Nine satellite-based maps were published on the GDACS Virtual OSOCC within two days after the landfall of the storms, most of which were linked automatically to the discussions through the GLIDE number. GLIDE was also used to integrate related media updates and reports from ReliefWeb.

GDACS alerts	Country	Alert level	Issued UTC (lead time)	Landfall UTC (duration)	Wind speed at landfall (category)	Affected (wind > 120 km/h)	Reported impact
Ketsana (Ondoy)	Vietnam	Orange	27/09 18h (24h)	28/09 18h (24h)	165 km/h (II)	2.2 million	687 killed $1 billion
Parma (Pepeng)	Philippines	Red	01/10 6h (24h)	02/10 6h (36h)	219 km/h (IV)	1.6 million	465 killed $0.5 billion
Lupit (Ramil)	Philippines	Green	19/10 0h (54h)	21/10 6h (54h)	147 km/h (I)	0	Minimal
Mirinae (Santi)	Philippines	Orange	27/10 18h (54h)	30/10 0h (12h)	165 km/h (II)	640,000	106 killed

Way forward

Global monitoring, satellite data and crowd-sourcing

Analysts in emergency situation rooms have the difficult task of making sense of a very dynamic stream of information from multiple sources with various degrees of reliability, such as early warning systems, media reports, crowd sourced data, social networking, email, expert reports, sensor data and satellite imagery. Since not all information is of equal value, the challenge for global multi-hazard disaster alert systems is to establish standards for quality of information governing the inclusion of certain information sources in a system of systems. GDACS is the principle cooperation platform for information providers where such standards are continuously being evaluated and revised.

Scientific and operational information providers in regional networks, member countries and response organisations are encouraged to participate in GDACS meetings, workshops and simulations to explore possibilities for integration of new monitoring systems in the GDACS system of systems. The JRC and UNOSAT are facilitating this process for disaster alert/impact systems and satellite based maps.

Towards a global network of emergency management entities

The GDACS community is growing rapidly, which brings its own challenges. With many new members entering the community, information exchange still lacks predictability, quality and standardised formats. In addition, many organisations make information available only after the internal analysis and decision making process has been completed, often by disseminating situation reports or through entries on the Virtual OSOCC.

GDACS is working towards building a global network of emergency management entities or disaster operation centres, cooperating using standards for the exchange of operational information. Emergency management and disaster operation centres in regional networks, member countries and response organisations should participate in GDACS meetings, workshops and simulations to explore possibilities for better cooperation and to agree on procedures for information exchange and coordination in major disasters.

The GDACS Secretariat in the ERCC, OCHA-Geneva is facilitating this process.

Flood Mapping in Support of Humanitarian Organizations

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Introduction

Nowadays, the world is facing disasters on an unprecedented scale: millions of people are affected by natural disasters globally each year and in the last decade, more than 80% of all disaster-related deaths were caused by natural hazards. When an event hits regions of the world where local authorities are not structured to deal with their complex effects, the authorities normally ask for the intervention of international organizations, such as UN agencies. Those organizations are charged with the activation of emergency procedures in order to satisfy the immediate needs of the affected population, and in the long-term prepare protracted relief and recovery operations.

The different events that may generate the need for humanitarian intervention may be in three groups:

- ✓ sudden disasters which affect food access and/or cause population displacements;
- ✓ slow-onset disasters, such as droughts and crop failures;
- ✓ complex emergencies that may involve conflicts, widespread social and economic disruption and large population displacements.

photo by "WFP/G M Akash/Bangladesh"

Risk management may be undertaken in three different phases: pre-disaster, response; and post-disaster. They must be managed through different activities and actions as shown graphically in Figure 1. Pre-disaster activities are required to develop and deliver risk assessment, establish preventative actions and prepare the operative structures for managing an eventual emergency event or disaster. In the response and post-disaster phases, actions planned in the pre-disaster phase are executed, focusing firstly on saving lives and, secondly on social and economical recovery.

Short-term emergency response capacities, long-term risk reduction, development and environmental protection activities are sectors in which a Spatial Data Infrastructure (SDI) may significantly improve efficiency, allowing for easy access to geospatial reference data. Data classification, data discovery and data sharing are crucial for ensuring that all activities of the risk cycle are executed efficiently and effectively

Methods

In this chapter, the different and sequential phases of early impact activation of emergency response, from the alert to the release and distribution of value added information, will be described with the help of a few examples.

Alert

The alert is the event that triggers early-impact activation. Early-warning systems are of particular importance, as they must combine characteristics of reliability and timeliness. Alert systems based on humanitarian news networks, such as Reuters AlertNet, are often reliable and precise, but have no predictive capabilities. Mathematical data models, combining basic input data in order to derive the evolution of physical phenomena can help in predicting an event but may not be sufficiently precise, especially for complex phenomena. Prevision of the formation of a cyclone and its path benefits from the consolidated knowledge of the parameters controlling atmospheric circulation and diffuse sensors used for the data acquisition (Figure 2). Modelling of a flood event implies a combination of atmospheric conditions with land surface factors, both natural (morphology, soil types and saturation level, vegetation status, etc.) and anthropic (land use, canals, dams, etc.), having high spatial and temporal variability (Figure 3). In an attempt to gain the most information from both systems, content integrator services has been developed; GDACS is a web-based platform that combines existing web-based disaster information management systems with the aim to alert the international community of major sudden-onset disasters and to facilitate the coordination of international response during the relief phase of the disaster. Once a specific event is identified and is expected to have a considerable impact on population and infrastructures, an alert is issued and the response phase of emergency management starts.

Data sources

The rapid mapping activities aimed at supporting the first stage of disaster management are generally based on satellite remote sensing data. Different types of satellite data can be used, mainly according to the type of disaster and the approximate extent of the affected areas:

- ✓ Low/medium resolution multispectral optical imagery (i.e.: MODIS, ALOS AVNIR, DMC, Landsat),
- ✓ High resolution optical data (i.e.: Spot, Formosat, Ikonos, WorldView-1; Quickbird),
- ✓ Medium resolution radar data (i.e.: Envisat, Radarsat, ALOS Palsar),
- ✓ High resolution radar data (i.e.: Cosmo-SkyMed, TerraSAR-X).

Figure-1: Risk Cycle Diagram (source: GMES)

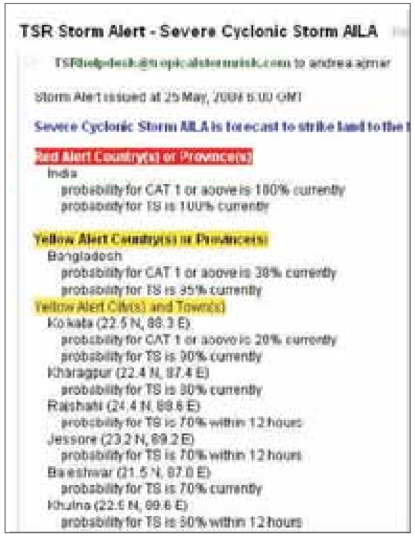

Figure 2: Severe storm alert, based on meteorological analysis

Figure 3: Flood early-warning system

The aforementioned data belongs to two main families: public-domain data (generally accessible through the web (i.e.: MODIS, Landsat); or commercial imagery that should be purchased through reseller companies (i.e.: Eurimage, Spotimage, DigitalGlobe). Sometimes it is possible to freely access satellite data on the basis of scientific agreements between Space Agencies and Principal Investigators in charge of a specific research (i.e.: ESA Category-1 users).

Rapid mapping activities can benefit from the possible activation of the "International Charter for Space and Major Disaster" that, since November 2000, aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users.

Extraction of water bodies

As widely reported, radar images enable the easy identification of water bodies; therefore they are the main input data for flood analyses (Aduah et al. 2007, Henry et al. 2003, Schumann et al. 2007). The all-weather capability of the radar technology and the possibility to acquire data also during night time, are crucial advantages of a radar based approach. On the other hand, they are affected by geometric distortions (layover, foreshortening and radar shadows), which are hard to model, especially in mountain regions. Radar images acquired by satellite platforms before and after the event are commonly used for the definition of flooded areas. The collection of an archive radar image for identification of the water levels before the event can be skipped if reliable and updated water bodies data are available as defined in the so-called NWED (Normal Water Extent Database) (Wang et al. 2002). Water areas can be identified on both before and after images because of the near specular reflection of electromagnetic radiation emitted by the radar sensors, by water bodies which are nearly smooth surfaces when compared with the wavelength of the radar emission (similar to mirror reflection). Hence water can be easily identified by its low radiometric values or dark appearance on radar images. By using change detection techniques, it is possible to isolate the flooded areas, by distinguishing them from the normal areas covered by the water bodies. Figure 4 shows a detail of the first images acquired by the Italian Radar Satellite Constellation Cosmo-Sky-MED, to support the AILA cyclone emergency which occurred in May 2009 (the cooperation of the Italian Space Agency and the e-GEOS company is acknowledged). Figure 5 displays the extracted water bodies, classified as "Reference Water" and "Flooded Areas" based on data available before the event.

A different approach is used to define flooded areas based on multispectral optical data processing. For several reasons, the MODIS sensor is generally used for large-scale flood monitoring (Brakenridge et al. 2003, Voigt et al. 2007, Aduah 2007). The MODIS mission provides daily worldwide coverage; images and derived products are in the public domain. Furthermore, low geometric resolution (250-500-1000 m) MODIS data allow a regional view of the observed phenomena. Therefore, the use of MODIS data permits a multi-temporal small scale analysis of the evolution of the flood event in the areas of interest. The water bodies and flooded areas are detected by a classification procedure of MODIS primary reflectance data (Figure 6), available in near real-time through the NASA/GSFC MODIS Rapid Response System. For classification purposes specific radiometric indexes are defined, such as the NDWI (Normalised Differential Water Index), which is useful for detection of water bodies and flooded area

Figure 4: Cosmo-SkyMED image - ©ASI 2009 (30 m, May, 30th 2009) covering coastal areas of Bangladesh

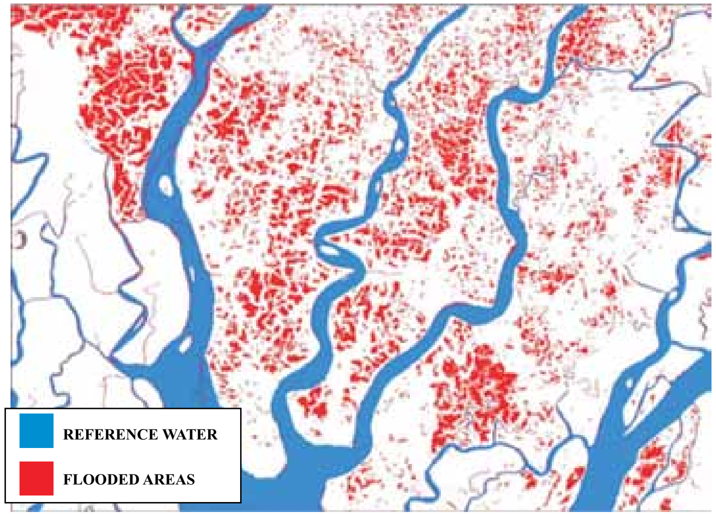

Figure 5: Reference water (blue) and flooded areas (red) identified trough radar imagery

and for reduction of cloud effects. It is possible to isolate the flooded areas using reliable water body data or images acquired before the event (Figure 7). The main disadvantage of an approach based on optical imagery is that cloud coverage that can drastically reduce the areas that can be analysed and cloud shadows may lead to classification errors.

Affected population estimates

The number and distribution of potentially affected populations is another type of important information requested by managers responsible for the distribution of humanitarian help. A rapid estimate of this information can be obtained by overlaying potentially flooded and effectively flood affected areas with population distribution data; one globally consistent source of this kind of data is the LandScan Global Population dataset (Dobson et al. 2000).

Use of the GIS Zonal Statistics function enables calculation of statistics of raster values (LandScan Global Population data is raster based) within zones defined in another dataset, which in this case are the affected areas. This procedure allows estimation of people living in potentially or currently flooded areas, or in areas isolated by floods. On-field assessment, even based on statistical samples, should permit correction of estimates. In the case of the AILA cyclone, using updated local census datasets, the estimate of the affected population (3,436,000) performed on the basis of satellite derived information was as accurate as the figures (3,469,264) derived by field assessment.

Output

Outputs of an early-impact analysis are normally in the form of cartographic products. As for the extraction of value added information, the availability of precise and accurate reference geographic datasets is essential for precisely communicating the results of the analysis. Data should be represented following cartographic rules, both in relation to output map scale and according to representation rules. According to United States Geological Survey (USGS) mapping standards, for example, a map representing outputs derived from the analysis of MODIS images with a ground resolution of 250m should be represented with a map scale of 1:500,000.
The implementation of a Spatial Data Infrastructure (SDI) has the objective to provide to the user, tools for spatial data discovery, evaluation, downloading and application, together with pre-defined representation rules established and shared at international level. Other map elements, such as title, legend, scale and north bar, graticules, overviews, disclaimers etc., can be automatically adapted and updated as a function of map scale, content and represented area. The result of the automation process is the preparation of a maptemplate, ready to incorporate the output of the analysis process and minimizing the effort for managing all ancillary but essential components of the cartographic output (Figure 8).

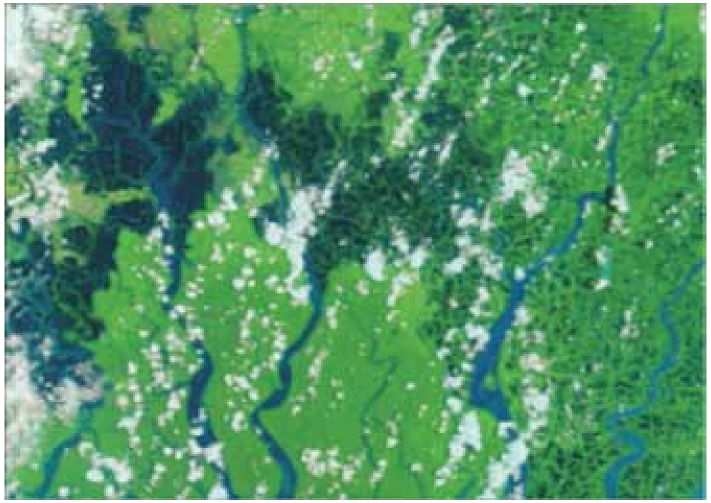

Figure 6: MODIS Aqua false colour image - NASA GSFC, MODIS Rapid Response (250 m, May, 26th 2009). Detail covering the coastal areas of Bangladesh

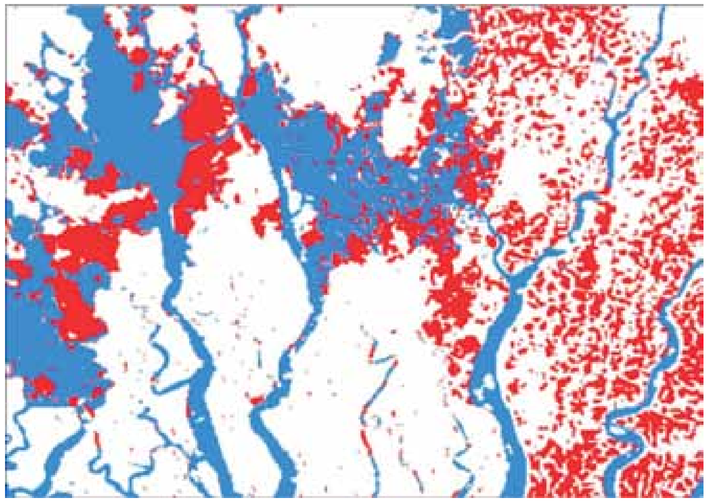

Figure 7: Reference water (blue) and flooded areas (red) identified through optical imagery

Dissemination

Dissemination process has the same importance as the analysis and map production phases. Final products should reach decision makers at the right time and in the right place.

The decision on how to transfer the information must take into consideration environmental factors and network connectivity, with the knowledge that these infrastructures may have also been seriously affected as a consequence of the event.

Integration of map products with adequate metadata in a standard format is of great help during discovery and exploitation phases.

Normal methods of dissemination of data include:

- Delivery as an attachment to e-mails to a pre-defined mailing list;
- Inclusion into web pages, where a search engine would help in identifying the searched product;
- The delivery to specific portals, focused on emergency management and with a large circulation (Figure 9).

RSS and GeoRSS feed technology are a useful means for advising potential users of the availability of new and updated content.

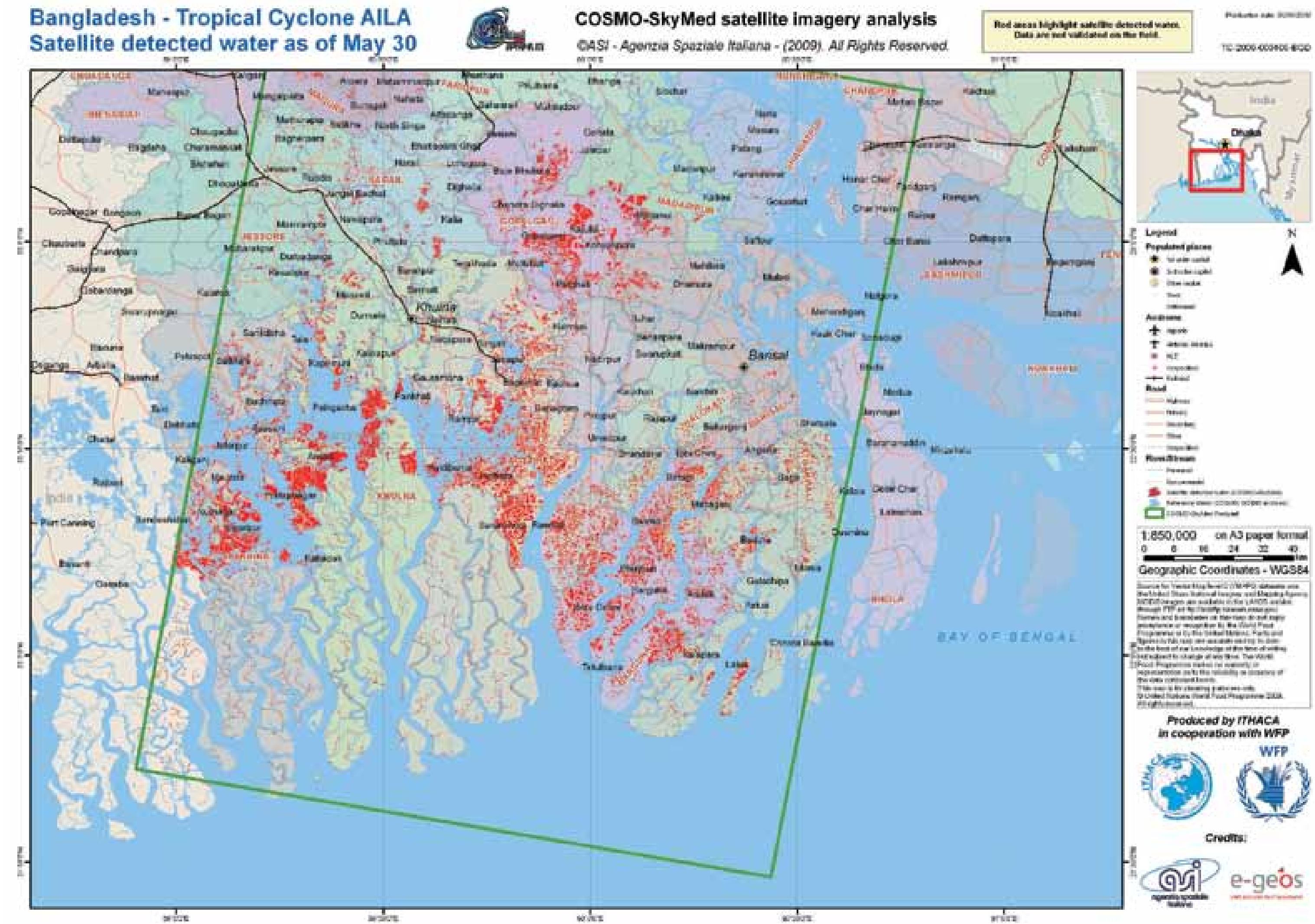

Figure 8: Cartographic representation of flood affected areas on the basis of a map template

Figure 9: Map included into the AlertNet web portal

Discussion and conclusions

The paper mainly focuses on the use of medium/low resolution satellite data (both optical and radar) to identify flooded areas required for rapid mapping. As clearly highlighted this kind of data allows the performance of a first assessment of the affected areas and affected population. Radar images have the main advantage that they are not affected by cloud coverage, but the acquisition has to be triggered and it can take several days before the data is available. Optical data such as MODIS are acquired on a daily basis and are in the public domain, but unfortunately they suffer from the probable presence of clouds during floods/cyclones events.

In case the main aim is to support the logistic operations in the context of emergency response, information on accessibility of the road network are the main concern. Very high resolution satellite data (geometric resolution varying from 0.6 m to 2.5 m) permits the creation of specific products showing the flood impact on the infrastructure, with particular emphasis on the road network.

According to the authors' experience in the field of rapid mapping, cooperation with humanitarian and governmental entities working in the impacted country is the best way to achieve continuous feedback from the field, thus allowing the generation of value-added products which comply strictly with the requirements of the users in the field.

Acknowledgements

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Detection and Monitoring of Wildfires by a Constellation of Small Satellites with Infrared Sensor Systems

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Introduction

Fire activity is a global phenomenon characterized by strong spatial and temporal variability. Wildfire is an important ecosystem disturbance with varying return frequencies, resulting in land cover alteration and change, and atmospheric emissions on multiple time scales. Catastrophic wildfires in the last few years have again stressed that sound fire management decisions (including justification of a possible severity ranking) on the deployment of fire fighters and of limited technical equipment on the ground, rely very much on timely and detailed information on location, intensity, direction and rate-of-spread of the fire fronts.

Figure 1: Micro-satellite for Bi-spectral InfraRed Detection (BIRD) on Low Earth Orbit (LEO)

In general, information on wildfire activity is used for (Csiszar 2008):

- ✓ global change research, estimating atmospheric emissions and developing periodic global and regional assessments, (i.e. quantification of the fire impact on climate),
- ✓ fire management and ecosystem management planning,
- ✓ operational purposes (preparedness and wildfire suppression),
- ✓ development of informed policies.

Satellite earth observation is appropriate to provide repetitive data at spatial and temporal scales necessary for detection and monitoring of wildfires. Existing and currently planned meteorological and environmental satellite sensor systems are able to provide useful coarse scale data sets for: (a) fire danger assessment, (b) fire occurrence detection, and (c) post-fire assessment. Unfortunately, the relative coarse spatial resolution of these data sets with a pixel size larger than 1km for detecting electromagnetic radiation in the mid and thermal infrared wavelength bands - is insufficient to accurately locate individual fire fronts and to assess their strength. However, it is these attributes that are very important for fire management decisions.

Some Relevant Definitions

An international expert team in (Csiszar 2008) defined the "Fire Disturbance Essential Climate Variable" which includes Burned Area as the primary variable and two supplementary variables. The "Fire Disturbance Essential Climate Variable" is one of the Essential Climate Variables (ECV`s) defined by the Global Terrestrial Observing System (GTOS).

Burned Area is defined as the area affected by human-made or natural fire and is expressed in units of area such as hectare (ha) or square kilometre (km2). Information on Burned Area, combined with other information (combustion efficiency and available fuel load) provides estimates of emissions of trace gases and aerosols. Measurements of Burnt Area can be used as a direct input (driver) to climate and carbon-cycle models.

Active Fire is the location of burning at the time of the observation and is expressed in spatial coordinates (or by an indicator of presence or absence of fire in a spatially explicit digital raster map, such as a satellite image). Detection of active fires provides an indication of regional, seasonal and inter-annual variability of fire frequency or shifts in geographical location and timing of fire events. Active fire information is also required by some algorithms used to generate burned area products. Detection of active fires can also serve as part of the validation process for burned area products.

Fire Radiative Power (FRP) is the rate of emitted radiative energy by the fire at the time of the observation and is expressed in units of power, such as Watts (W). The methodologies to derive FRP use physical-empirical approaches to derive rates of total emitted radiative energy from narrow-band, unsaturated radiance measurements.

There is a strong empirical relation between FRP and rate of combustion, allowing CO2 emission rates from a fire to be estimated from FRP observations. Multiple FRP observations can in principle provide estimation of the total CO2 emitted during the fire through estimating time-integrated Fire Radiated Energy.

The ratio the FRP (W) of a single fire front line to its length (m) is called Fire Line Strength (W/m). The fire line strength is a measure of the burning severity, which is directly related to the fire impact on the ecosystem. Estimates of the fire line strength derived from data obtained by a satellite or an aircraft sensor enable the distinction, for instance, between cleaning fires and devastating fires.

Active Fire Satellite Information - Currently Available Products and Gaps

Table 1 shows currently available major satellite derived Active Fire Products with Fire Radiative Power (FRP) information (Csiszar 2008). This is a service provided by currently available sensor systems, such as, the MODerate resolution Imaging Spectro-radiometer (MODIS) on the polar orbiting satellites "Terra" and "Aqua" or the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) on the geostationary satellite Meteosat-8.

Active Fire Products with Fire Radiative Power Information					
Name	Sensor(s)	Coverage		Resolution	
		Spatial	Temporal	Spatial	Temporal
GFED	MODIS ATSR VIRS	Global	1997-2004 (finished)	1° x 1° latitude/ longitude	1 month
WF_ABBA	GOES-E/W	N/S America	1995-present	4 km	30 min
MODIS FRP	MODIS	Global	2001-present	1 km	1 day
SEVIRI FRP	Meteosat-8 SEVIRI	Africa, Europe	~2006-present	3 km	15 min

Table 1: Currently available major satellite derived Active Fire Products with Fire Radiative Power (FRP) information (Csiszar 2008).

Unfortunately, these products only marginally meet the requirements defined by the Global Climate Observation System (GCOS) Implementation Plan. Considering this situation, the Committee on Earth Observation Satellites (CEOS) identified the following information deficiencies (Csiszar 2008):

- ✓ no global products at the specified 250m spatial resolution and daily observing cycle exist,
- ✓ product continuity and consistency between products derived from the various sensors remains unresolved.

Germany's Bi-spectral Infrared Detection (BIRD) Mission

The primary mission objective of the Bi-spectral InfraRed Detection (BIRD) satellite, which was piggyback launched in a 570 km circular sun-synchronous orbit on 22 October 2001, was detection and quantitative analysis of high-temperature events (HTE) such as wildfires and volcanoes (Briess et al 2003). In 2002 - 2004 BIRD very convincingly demonstrated the potential of unsaturated fire data obtained with an earth observation system with a spatial resolution of 200 - 250m for:

- ✓ the derivation of Active Fire Products with Fire Radiative Power (FRP) information and the estimation of the Fire Line Strength of individual fire fronts,
- ✓ the comparison of Active Fire Products, such as FRP, derived from different satellite sensors using data nearly obtained simultaneously.

The principal BIRD imaging payload includes the Bi-spectral Infrared Camera with channels in the Mid-Infrared and Thermal Infrared spectral ranges, and the Wide-Angle Optoelectronic Stereo Scanner WAOSS-B with a nadir channel in Near-Infrared spectral range. The ground resolution of the BIRD nadir channels is 185m in the NIR and 370m in the MIR and TIR. The NIR, MIR and TIR channels have the same sampling step of 185m due to an over-sampling by a factor of 2 of the MIR and TIR data.

A unique feature of the BIRD push-broom type MIR and TIR sensor channels is the real-time adjustment of their integration time (Skrbek and Lorenz 1998). If the real-time sensor on-board processing indicates that some detector elements are saturated (or close to saturation) during the regular exposure, a second exposure is performed within the same sampling interval with a reduced integration time. The data of both exposures are merged during the on-ground processing. This "intelligent" procedure preserves a 0.2°K radiometric resolution for pixels at normal temperatures and eliminates detector saturation over high temperature targets (Skrbek and Lorenz 1998).

Example of MODIS-BIRD Data Comparison

Comparing near-simultaneously collected data from BIRD and lower spatial resolution sensors such as MODerate Imaging Spectro-radiometer (MODIS) on the US environmental satellite "Terra" provides a useful metric by which the enhanced performance of BIRD in terms of fire detection and characterization can be judged (Wooster et al 2003).

Figure 2 shows an area west of Lake Baikal, Russia, observed nearly simultaneously, i.e. within a 30-minute interval, by MODIS/"Terra" and BIRD on 16 July 2003. The comparison clearly shows that only the BIRD data allow an estimation of fire front attributes relevant for fire managers.

Table 2 shows fire attributes of the numbered forest fire fronts, which were extracted from the BIRD image in Fig. 2 (right image) using dedicated algorithms.

Fire cluster (number in Fig.1,BIRD)	**Fire Radiative Power (FRP)** (MW)	**Fire front length** (km)	**Fire front strength** (kW/m)	**Fire front effective depth** (m)
1	1829	8.2	223	7.7
2	150	5.8	26	1.9
3	409	6.5	63	3,2
4	111	4.8	23	1.1
5	126	3.4	37	1.3
6	568	5.0	114	3,8
7	136	6.3	22	1,2

Table 2: Attributes of numbered forest fire fronts in the BIRD image fragment in Fig. 1 (right) of the Lake Baikal area in Siberia, Russia obtained on 16 July 2003.

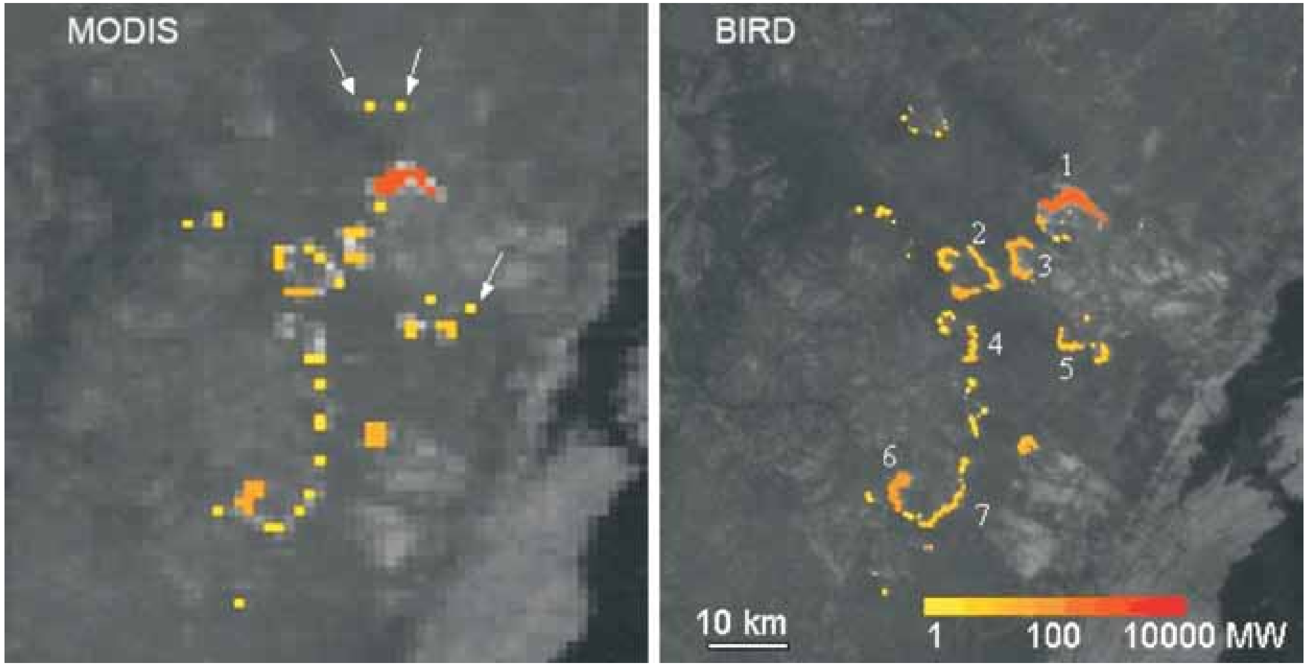

Figure 2: Fragments of forest fire images at Baikal, obtained by MODIS and BIRD on 16 July 2003. Images show the MIR image from each sensor, and detected hot clusters are colour coded according to their Fire Radiative Power (FRP) in Mega Watts (MW). The arrows in the MODIS image fragment show false alarms

Required Classes of Satellite Instruments to Provide Active Fire Datasets

The provision of Active Fire information products requires data records of appropriate multi-spectral imagery, for example, through the following classes of instruments and satellites (Csiszar 2008):

- ✓ SEVIRI-class instruments, extended to a full set of geostationary meteorological satellites, providing frequent but lower spatial resolution observations,
- ✓ MODIS-class observations which should be extended by future "Aqua" and "Terra" type developments through the Visible Infrared Imaging Radiometer Suite(VIIRS) as foreseen in the future US National Polar-orbiting Operational Satellite System (NPOESS) program,
- ✓ Future BIRD-type instruments, required for higher spatial resolution data acquisition with reduced spatial coverage, to augment the more frequent but lower spatial resolution datasets described above for detecting missing smaller and weaker fires.

In-Orbit Verification of On-board Fire Detection and Analysis

Timely provision of information is essential to support decision-making of fire managers in fire suppression planning, crew mobilization and movement. Therefore, on-board processing of fire front attributes, including geo-referencing and their direct transmission to the user on the ground is a challenging task for small satellites, but it should be technically feasible.

Key procedures for on-board fire detection and analysis are pre-processing and extraction of fire attributes.

In-orbit verification of on-board fire detection and analysis will be conducted on Germany's first Technologie Erprobungs Traeger (TET-1). TET-1 is a space-borne verification tool for new small satellite technologies, which is to be performed in the framework of the On-Orbit Verification (OOV) program of the German Space Agency. The successful BIRD mission and the planned on-board extraction of fire front attributes on TET-1 are two important milestones on the way to the creation of a prospective Fire Monitoring Constellation.

Need of a Fire Monitoring Constellation Based on Small Satellites

The demand by fire mangers for repeated, fast, and detailed information for all fire fronts in the areas of surveillance is highly justified. Wildfire activity is at maximum in the afternoon and optimum wildfire observation requires two consecutive data takes at 13 -15 and 16 - 18 clock local time. These local observation times are not convenient to the majority of earth observation missions.

The essential fire attribute information, obtained twice during the peak period of wildfire burning will not be delivered by existing or planned satellite sensors, because their spatial resolution is too coarse and most of these systems have local observation times before noon. Therefore, a dedicated Fire Monitoring Constellation (FMC) must be implemented to secure (i) a spatial resolution of 200-300m and (ii) optimum observation times for fire detection and monitoring in the afternoon.

The FMC must resolve the deficiencies identified by CEOS (Csiszar 2008, chapter 3) by provision of:

- ✓ Active Fire Products at the specified 250m spatial resolution within a daily observing cycle,
- ✓ Continuity and consistency between Active Fire Products derived from the FMC and existing (see Table 1) and planned meteorological or environmental satellite sensors with fire-adapted IR bands, such as, the Sea Land Surface Temperature Radiometer (SLSTR) on Sentinel-3 and the IR sensor of Meteosat Third Generation (MTG) - with coarser spatial resolution (greater than 1km).

The FMC should consist of four small satellites of the BIRD/TET class in low earth orbit and be equipped with compact and intelligent IR sensors and on-board data processing. Active Fire Products from a FMC will be of great value also for fire ecologists, health organizations and national administrations worldwide (Oertel 2005).

Spatial data to complement the use of space-based information for disaster management

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Spatial data the missing link for effective use of space-based information

One of the mandates of the UN platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) is to offer technical advisory support to the Member States with the aim to enable them to use space-based information for disaster management and to improve their access to this type of information. It is observed that the space-based information can be used effectively only when the spatial data on other aspects (for example administrative boundaries, infrastructure details, settlements etc.) are integrated with the space-based information. Spatial data layers come from various sources such as field surveys, topographic maps, and thematic maps derived from interpretation of satellite images etc. These spatial data layers can be used for analysis and modelling along with scientific information to prepare risk maps related to various hazards.

Depending on its organizational structure and technical capabilities, each country represents a unique situation with regard to its readiness to use the space-based information for disaster management.

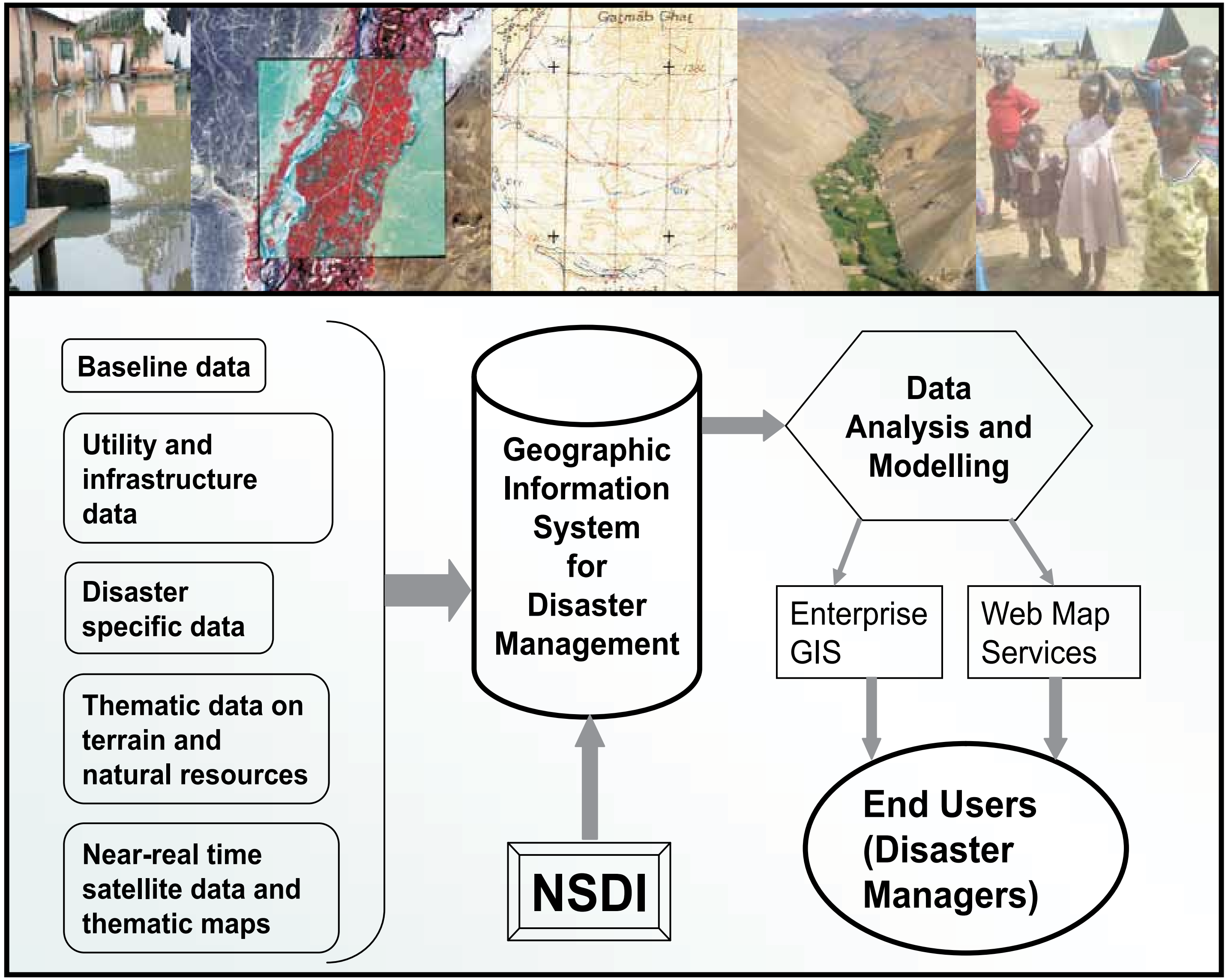

Figure 1: Conceptual framework - The Spatial Information for Disaster Management

Up-to-date thematic and baseline spatial data are a basic requirement for an effective use of space-based information for risk mapping and disaster management. Below are some typical challenges experienced during an evaluation of the use of space-based information for disaster management in several countries:

- ✓ Non-availability of baseline and thematic spatial data in the framework of GIS
- ✓ Baseline and thematic spatial data may be available, but scattered at different locations with non-uniform data standards that limit data integration
- ✓ Baseline and thematic spatial data may be well organized centrally but not integrated with risk related data

Nature of spatial data required for disaster management

The spatial data should be linked to non-spatial data (attributes) and field based data so that they can be visualized in the form of maps, which can further be used in map based modelling to provide inputs for risk mapping. Spatial data should serve the needs of pre-disaster and post-disaster activities. The data listed below can either be static or dynamic in nature. Most of the elements of baseline data are static, as this data remains valid for a long time. Near real-time data, such as satellite images and thematic maps interpreted from satellite data, are considered as dynamic data as they provide information on recent happenings.

Spatial data requirements differ depending on the need to address disasters in rural areas or in towns or cities. This document mainly focuses on spatial data requirements to target the needs of disaster risk mapping in rural areas, where the focus is on large scale areas rather than the more confined urban areas. Spatial data requirements for urban systems are not covered in this document.

Spatial data requirements for risk mapping and disaster management are described according to the following broad categories:

- ✓ Baseline data layers
- ✓ Utility and Infrastructure data layers
- ✓ Disaster specific data layers
- ✓ Thematic data on terrain and natural resources
- ✓ Near-real time satellite data and thematic maps

The discussion below provides a generic description of data layers under each category. The goal is not to provide an exhaustive listing of spatial data requirements, but to provide a listing of data layers needed to address the basic requirements for disaster related risk mapping, together with the data that need to be used in conjunction with the space-based information.

Table 1:
Baseline spatial data for disaster management

Data	Description	Relevance to disaster management
Administrative units	National, provincial/state, district boundaries, locations of towns and villages	Data on administrative units and human settlement locations are a basic requirement. They are the base layer to which attribute data such as demography, socio-economic data and amenities/services etc. are linked
Demographic and socio-economic data	Includes the characteristics of human population and its distribution based on age, sex, ethnic groups, income, education etc.	Demographic data provide detailed attributes (social and economic) of population at risk. The source of this information is often provided by the statistical service of the country.
Amenities	Rescue services including army, fire, police, medical services, evacuation locations such as schools/shelters, communication, gas stations etc.	Information on amenities helps to understand available rescue services in the area at risk or affected areas which can be mobilized during a disaster.

Baseline data layers

Baseline data serve as the reference data related to the permanent features of the landscape such as administrative boundaries, human settlements, rivers, drainage, roads and basic infrastructure etc. Theme specific data layers are normally referenced to the baseline data layers. In the pre-disaster stage, baseline data should provide inputs to assess risks, including the identification of hazard prone areas/ locations and vulnerabilities, and the preparation of plans for risk management, early warning, and preparedness. During the response phase, baseline data should help to locate the areas affected by the hazard. Once such an area or location is known, baseline data, as shown in Table 1, should provide: an inventory of affected population; demography of affected population; socio-economic parameters; rescue services; and amenities available in and around the location that can be mobilized during an emergency situation. (Table 1)

Utility and Infrastructure data

Utility and infrastructure data provide inputs to better understand specific risks and also to prepare specific disaster management plans. Most of the infrastructure data is in network form. Having infrastructure network data in GIS format allows network specific modelling such as optimal routing, allocation, flow models etc. (Table 2)

Data	Details	Relevance to disaster management
Transport network	Entire transport network including roads and other modes of transportation	Updated transportation network provides analysis such as access to disaster affected area, evacuation routes etc.
Dams and canal network	Locations of dams and canal networks with attributes on related risks	Information can be analyzed to understand the population, natural resources and infrastructure risk due to potential dam overflows
Electricity network	Transmission and distribution network	Electricity is one of the essential utilities for the continuation of the rescue efforts. Data on electricity networks is important input in disaster management plans at a local level.
Cadastral details	Maps at cadastral level showing links with land records	Cadastral mapping using high-resolution satellite data is common practice. Such data provides critical input to the humanitarian agencies and the Government for determining loss of productive land or land owned by displaced families and for determining compensation for losses
Region specific utility network	Gas pipelines, oil pipelines, canal network, bridges etc.	Data on utility and infrastructure helps to identify vulnerability associated with these critical facilities and services; and in planning the responses during a disaster.

Table 2: Utility and infrastructure data for risk mapping

Data related to disaster risk reduction

Often risk is expressed in the form of hazard maps. Their preparation calls for the collection of risk related data, including data on major accident hazards, such as chemical, biological, and nuclear hazards, as well as transport accidents, climate-related hazards. Normally such data needs to be collected by the local government. It is also important to have data on 'actors', or whoever supports particular activities.

This data can be collected by the local administrators with the involvement of communities. It can include a list of NGOs, social groups, community groups and others who are prepared to be active in a disaster situation. It can also include information on the important services that can be mobilized in case a disaster strikes. This data needs to be location specific in order to be integrated with other spatial data.

Data	Details	Relevance to disaster management
Elevation and slope	SRTM global elevation data at 90m resolution are available and generally useful for risk mapping. Medium resolution DEM at 30m resolution are available from ASTER. High-resolution DEMs can be obtained from high-resolution satellite and aerial data or simply derived from contour maps. Slopes can be derived using elevation data.	Elevation is the most essential information for defining hazard zones and the utility of elevation data depends on its resolution or scale at which it is derived. For mitigation purposes, high resolution DEM can be obtained from other sources.
Land use	Various levels of land use maps are available based on the resolution of remote sensing images used for land use mapping. Land use depicts details about agriculture, forests, wastelands, barren lands, settlements, water bodies etc.	A land use map is a valuable input in assessing agricultural and other natural resources at stake in case of a disaster. It also provides inputs for scientific modelling for risk assessment and to identify risk-management measures.
Forestry	Forest types and additional attributes such as data on composition of forests, biodiversity, biomass etc.	Forests are one of the important environmental parameters, especially in controlling flood, coastal process etc. Detailed forest maps can provide valuable inputs in risk assessment.
Geology	Rocks, minerals and geological features, faults, lineaments etc.	These maps provide inputs for the assessment of a variety of hazards such as landslides, earthquakes, and to some extent floods. Such maps are used for preparedness planning. They also provide input for mitigation for critical facilities.
Soil	Soil type, texture, depth etc.	Soil maps can provide important input for deriving potential landslides zones and other types of mass movements.
River and drainage network	Water bodies, rivers, drainage network	These maps are used to elaborate hazard maps related to floods, as well as during response and post disaster stages.
Geomorphology	Landforms	Information on landforms is useful in land-use planning, soil conservation, design of dams, canals and other structures. It is also used to elaborate hazard maps related to landslides and other types of mass movements.
Watersheds	Watersheds are derivatives of drainage and slope information.	Watersheds are basic development unit in most countries. Sustainable development based on the concepts of watershed development contributes to disaster risk reduction.

Table 3: Thematic data on terrain and natural resources for risk mapping

Thematic data on natural resources and terrain

Satellite data, combined with topographical maps, provide an excellent source for preparing thematic maps related to terrain parameters and natural resources. Some data layers, such as land use and forests, are dynamic in nature and need to be updated frequently, depending on the pace of development in the area. Data layers such as soils, geology, and hydro-geomorphology are static in nature and therefore remain valid for long periods of time. Thematic maps derived from satellite images are important scientific inputs for mapping a range of hazards including flood, erosion, landslide, fire, storm, cyclones, drought. These data layers can be integrated with baseline data for predicting risks related to the natural and manmade disasters. (Table 3)

Near real-time satellite data for disaster management

Near real-time coverage from satellite images helps to provide information on the area impacted by the disaster. These maps should be able to be integrated with the spatial data layers described above. The use of the maps derived from satellite images is well demonstrated in mapping the impact of floods, earthquakes, landslides, mudslides, cyclones and droughts. Usefulness of information depends upon the type of the disaster and the resolution of satellite data. Table 4 provides specific examples where near real-time satellite data can be used for early warning and risk management.

Tools, technologies and methods to improve the use of spatial data

Spatial data, including space-based information can be used for disaster management by adopting specific methods, tools and technologies. It is important for national governments to adopt spatial data infrastructure standards to improve data integration and data sharing. Tools such as web map servers can be used to deliver data to the end users.

Spatial data infrastructure (SDI): Spatial data generation initiatives in a country should be based on an SDI framework to ensure that data generated by different agencies, programmes, and/or projects follows specific standards, to ensure easy data access and sharing.

Enterprise GIS for local Governments: The enterprise GIS approach is capable of supporting all potential users from organizations within a country in a cohesive manner. The countries which already have good GIS infrastructure, NSDI, spatial databases and archives of images, should be encouraged to implement enterprise GIS and extend its node to their disaster management offices.

Web mapping services: With better availability of internet speed, web map servers are considered as the most convenient tool for sharing maps and space-based information with users from different locations. Web Map Service Interface Standard (WMS) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases.

Purpose	Details	Relevance to Disaster management
Mapping impact of disasters	Space-based information available with varying resolutions are sources for mapping the impact of disasters.	Satellite images can potentially provide the earliest information about the impact of disasters and provide required inputs to planning responses.
Vegetation monitoring	MODIS, SPOT (Vegetation 2 sensor), IRS-WIFS provide dynamic information on NDVI which is helpful to assess crop extent and condition. Information can be derived on crop types (cereals, orchards, cash crops etc.), type of agriculture (irrigated, rain fed etc.), cropping intensity, crop vigour and health.	Agricultural maps provide many parameters that can be used to understand the impact of disasters such as droughts and floods. They provide data for a precise assessment of damage to crops and related financial loss in areas impacted by the disaster. NDVI information provides inputs for preparedness planning at a national scale.
Snow cap monitoring	Number of satellites (eg MODIS) have high revisit frequency and provide extensive coverage to monitor snow cover.	In mountainous countries, the amount of snowfall determines whether the country could be facing drought or floods.

Table 4: Utility of near real time satellite data for disaster management

The Benefit of High Resolution Aerial Imagery for Topographic Mapping and Disaster Recovery: Lessons Learnt from the 2004 Indonesian Tsunami

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Introduction

This research outlines a case study in Aceh, Indonesia, in the aftermath of the December 2004 Indian Ocean Tsunami. The main aim of the study was to identify methods to determine and quantifiably assess the benefit of the use of a specific spatial data set in disaster recovery, and it follows on from an earlier study implemented in 2007.

The earthquake and subsequent Tsunami devastated wide areas and hundreds of communities across Aceh. The available topographic data (i.e. relief and the spatial location of man-made and natural features) was approximately 30 years old and contained significant errors. Immediately after the Tsunami there was a large demand for new topographic and spatial data to support the rehabilitation and reconstruction activities, including; the needs of the national Government

Figure 1: One use of the high resolution aerial imagery was to correctly reference spatial plans for the reconstruction of villages devastated by the Tsunami. Plans for the reconstruction of the village of Cot Paya are shown.

master plan for reconstruction, the Spatial planning needs of local Government, town and village action plans, community based mapping, village development mapping, infrastructure services, and disaster, hazard and risk mapping.

During 2005, the Government of Indonesia (GoI), in conjunction with a number of Official Development Agencies (ODA's), initiated at least 10 projects for the capture of spatial data and the provision of updated topographic data and products to the rehabilitation and reconstruction community. This case study focuses on the benefit derived from a dataset of high resolution (25 cm) digital aerial imagery (orthophotos) acquired across the Tsunami affected areas in Aceh.

The results of a detailed data user survey implemented two years after the Tsunami are also presented. They clearly demonstrate the need and the benefit of the use of this data for disaster recovery, showing that this data set critically supported projects worth 28 million Euro and provided further support to projects worth over 880 million Euro. A simple robust methodology quantifying the benefit of the use of spatial data in disaster recovery is also presented. The methodology provides a monitoring mechanism by which the benefit of using the spatial data can be quantified, verified and accounted to either donor or user communities.

Finally, to ensure that any spatial data acquisition campaign undertaken with humanitarian funding is used to its greatest benefit, a number of recommendations detailing mechanisms that must be in place prior to initiation of the campaign are presented.

Overview of NORAD Campaign and data set

The Norwegian Agency for International Development (NORAD) funded the orthophoto project, at a cost of 1.43 M Euro, in March 2005. The Indonesian National Coordinating Agency for Surveys and Mapping (Bakosurtanal) managed the project and made all products available to the recovery community. The products included a digital terrain model (DTM), and digital orthophotos merged into a digital base map with line mapping at 1:10,000 and 1:5,000 map scales. The extent of the data set, totalling 6,249 km2 across the Tsunami affected coastal areas, is shown in Figure 2.

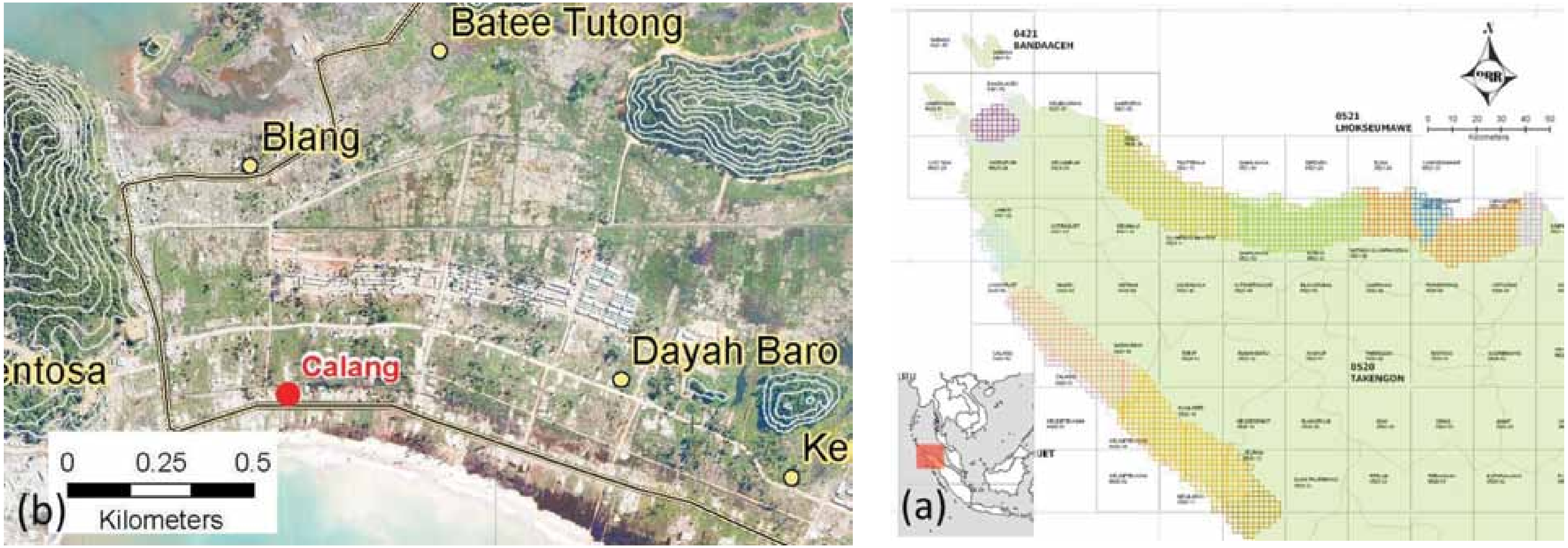

Figure 2: *(a) Location and extent of orthophotos and digital terrain model, and (b) example of orthophoto and contour lines, extracted from DTM, showing temporary shelters in Calang (East Coast Aceh)*

Delays, due to security clearance and permission to fly, meant the flight campaign was only completed in July 2005. All final products were completed and delivered to Bakosurtanal in April 2006. With the exception of the DTM, Bakosurtanal provided all products in August 2006 to the Spatial Information & Mapping Centre, (SIM-Centre) of the GoI Agency for Rehabilitation and Reconstruction of NAD and NIAS (BRR), for distribution to the aid and recovery community (users).

The data set was distributed in three ways, either; (case 1) directly as an electronic data set to users; (case 2) provided as a customised product; or (case 3) enabled for users electronically via web applications. Primary data users (case 1) were given digital (soft) copies of the data set and were bound by a signed data user agreement. During the period August 2006 to July 2008 there was a total of 99 recorded primary data users and over 635 secondary data users (cases 2 and 3). The data set was also used as a core data in Geographic Information System (GIS) training provided to at least 500 local government officials.

Example case studies on data use

To justify their requirement for the use of the data set, all primary data users were obliged to provide project details, which were confirmed with an independent project registration maintained within the Recovery Aceh Nias Database (RAND) of the BRR. The requests for the data set, as is shown in Figure 2a, covered the spectrum of all agencies within the recovery and rehabilitation community. Examples of data usage are presented in the following section.

Asian Development Bank (ADB)

The Earthquake and Tsunami Emergency Support Project (ETESP) of the ADB used the data set in four of their projects. The data was used to support their Spatial Planning and Environmental Management project, Agriculture Sector, Fisheries Sector and Road and Bridges project. Specifically the projects oversaw the preparation of sub-district level Action Plans; the rehabilitation and reconstruction of livelihoods assets post Tsunami in both agriculture and fisheries sectors; support to fisheries rehabilitation in Aceh and Nias and the creation of the design and project preparation documents for road segments within Banda Aceh and on the East coast. The four projects had over 125,000 direct beneficiaries and cost a total of over 79 Million Euro. The data set was used to some extent, in all five phases of each project's lifecycle (i.e. project initiation, planning, operation, monitoring and evaluation and project closure), but was most significantly used in the operational phase of the projects. Over 85 maps were created within the projects from the case study data set and GIS data sets provided.

United Nations Development Programme (UNDP)

The UNDP through its Tsunami Recovery Waste Management Programme (TRWMP) began the program for Agriculture land clearances in January 2006.It removed the heavy deposits of sand, silt and debris blanketing the land, and blocking the irrigation channels and drains. The program cost over 1.5 million Euro and supported 2600 families as direct beneficiaries. The TRWMP used numerous spatial data sets, including the orthophoto data set, to locate areas in greatest need of land clearance, and to work with farmers and community leaders to demark field boundaries, canals and drains.

The orthophoto data set was used as a primary mapping tool to determine areas and potential volumes of waste that required removal and to prepare clearance plans. This information was critical for preparation of heavy equipment contracts required for land clearance. The data set was critically used for project planning, operation and monitoring and evaluation and is estimated that it would cost approximately 200,000 Euro to obtain the same information from different sources.

Data user survey

To asses the benefit of the orthophoto data, a data user survey was undertaken in Aceh, during 2008. The survey, delivered as a questionnaire, was distributed to all primary data users. To encourage a high response rate, the survey was intentionally simple and brief. It was designed to retrieve information to determine answers to the following study questions:

- ✓ Which category of organisation were the main users of the data set?
- ✓ What type of project required the data set and how was it used?
- ✓ At which phase of the project life cycle was the data set most significant?
- ✓ What was the benefit of using the data set?
- ✓ What were the problems with the data set?

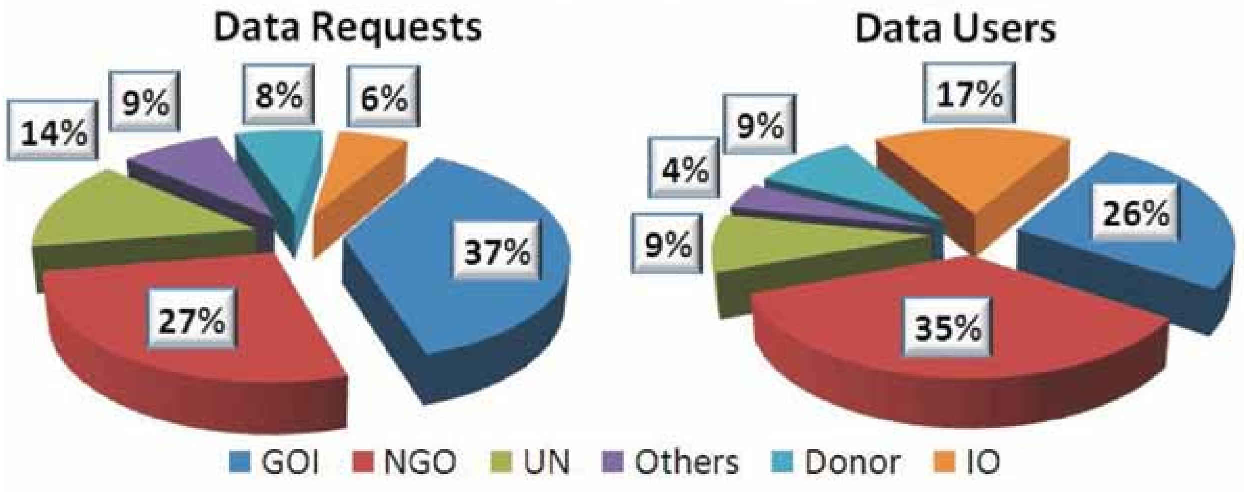

Figure 3: (left) Orthophoto data requests and (right) data users by Agency Type including; Government of Indonesia (GOI); Non Governmental Organisations (NGO); United Nations (UN); and International Organisations (IO)

One of four outcomes were expected from each questionnaire; 1) no response; 2) data set was acquired by user but not used in project; 3) data set was acquired and used but its use was not critical to the successful completion or operation of the project (supported the project); 4) data set was acquired and used and its use was critical to the successful completion or operation of the project. Follow up with all primary data users ensured a relatively high questionnaire response rate (48%).

Two methods were identified to provide a simple means of quantifying the benefit of the use of the data set. The first method uses a project attribute as an indicator of the measure of the overall benefit of the project and also determines if the use of the case study data was critical to the successful completion of the project. The second method considers what information was obtained by using the data set and determines the real cost to acquiring that information from another source. This real cost was only calculated where the use of the data set was deemed to be critical to the successful completion or operation of the project.

Results of data user survey

As shown in Figure 3 (right), NGO's were the most significant data users. Using the standardised DAC5 coding (Development Assistance Committee Coding Scheme 5) to categorise project type, the data, as shown in Figure 4a, was mainly used for Urban and Rural planning purposes (52%).

In all projects the data was used largely for mapping, surveying or identification of features relevant to each of the projects; 95% of the respondents claimed to use the case study data over 300 times to produce maps, and a further 65% claimed to integrate the case study data within a GIS.

The majority of projects used the data in the planning and operational phases of the project, noting that the data was considered to be of most importance during these project phases (see Table 1)

The main concern highlighted by the primary users was that the data was not available for the project planning phase of projects starting before August 2006. Considering the rapid developments in rehabilitation and reconstruction in the Tsunami affected areas, the data, acquired in June 2005, was largely outdated by the time it was delivered to the rehabilitation and reconstruction community.

	Project Phase				
	Initiation	Planning	Operation	Monitoring & Evaluation	Closure
Percent Usage (%)	74	92	87	70	78
Relative Importance (1-high to 5-low)	3.1	1.6	1.3	2.5	3.1

Table 1: Use and importance of data in project phases (1 important, 5 not important)

Determination of the benefit of use of orthophoto data

Calculated by project attribute

Four project attributes were identified as potential indicators of project benefit; 1) number of direct project beneficiaries (i.e. number of families, or number of persons, that would receive a direct improvement in their current situation as a result of the completion of the project); 2) physical extent and coverage of the project area; 3) information on the total cost of the project, and; 4) information on the duration of the project.

The most incomplete and overestimated attribute was project beneficiary, with only 39% of primary users being able to provide a figure; several wildly claiming their project benefited all the 4,031,589[1] residents in the province of Aceh, or all of the estimated 203,998 people who were directly affected by the Tsunami. A similar response was found for the attribute concerning the physical extent of the project. The attribute for duration of project was the most comprehensibly reported upon by 91% of respondents. This attribute was initially included to ascertain if longer running projects had a greater benefit, or if there was a direct link between project duration and project cost.

Finally, the attribute of project cost was selected to measure the benefit of the use of the data set as this attribute was widely reported by the respondents (87%), and could be independently confirmed by cross checking with the RAND of the BRR. When the use of the data set was deemed critical to the completion or operation of the project, then the benefit of the use of the data set was measured as the total cost of the project, Figure 4b.

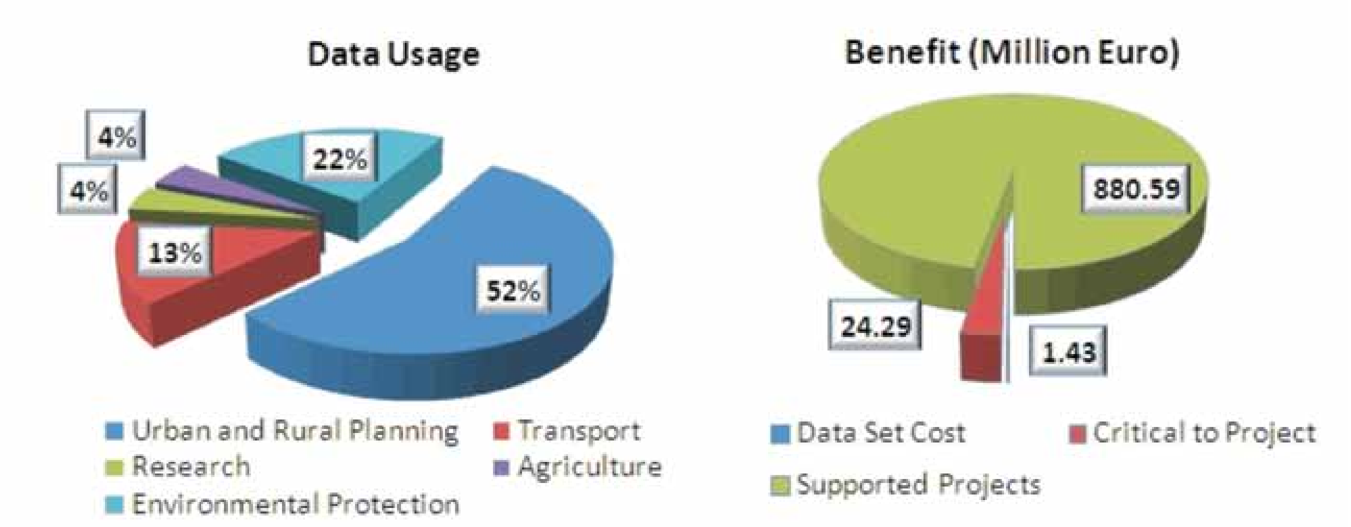

Figure 4: (a) Data Usage and (b) Benefit of Data Set compared to Data Set Costs

Calculated by cost of equivalent information from a different source

If the data set was seen to be critical to the completion or operation of the project, the primary users were also asked to provide an estimated cost of retrieving the same information from another source. All cost estimations were independently verified, considering local conditions, cost and availability of other sources of information. The total cost to provide the same information as obtained from the data set was estimated to be 3.46 Million Euro. Since primary users failed to accurately report their project extent, it is not possible to make a direct area based comparison of obtaining the equivalent information, and therefore cannot be compared directly to the 1.43 Million Euro cost of the orthophoto project.

Conclusions

This study quantified the benefit of using the case study data set by determining if the use of the data set was critical to the successful completion of a project, and then using the attribute of project cost as a measure of its benefit. The data set critically supported projects worth over 16 times its actual cost and supported projects worth over 600 times its actual cost. Over 635 further secondary users of the data set were also clearly identified. The delayed delivery of the case study data set to the recovery community meant that the data could not be used for sectors of reconstruction projects that had an urgent and timely need for completion.

1: Badan Pusat Statistik (Statistics Indonesia) BPS, Sensus Penduduk Aceh Nias (Census of Residents of Aceh and Nias) SPAN 2005

In order to determine and report upon the benefit of the use of spatial data in disaster recovery, the following recommendations are offered:

- ✓ A robust, straightforward procedure must be in place with the data distributor that records simple criteria for each of the data users and related projects;
- ✓ Updating of project information on a regular but limited basis must be enforced, and easily verifiable;
- ✓ Wherever possible, international standards such as the use of DAC5 code for project categorisation, should be included in the methodology

Whilst this report clearly shows that there is a need for the acquisition of EO data and the creation of spatial data in response to a disaster, a number of lessons have been learnt from the spatial data initiatives between ODA's and the GoI in response to the Tsunami in Aceh.

To ensure that the spatial data is used to its greatest benefit, it is specifically recommended that any spatial data campaign undertaken with humanitarian funding, must also ensure the following:

- ✓ A mechanism must be in place to ensure data is efficiently and effectively delivered to the humanitarian aid community in a timely manner;
- ✓ The mechanism must be open and accountable to data providers, donors and the recovery community;
- ✓ The humanitarian aid and recovery community must have knowledge about the availability of the data;
- ✓ To avoid duplication of costs, the spatial data must be freely accessible, (i.e. no cost, or data reproduction costs only), and with an unrestrictive license

Acknowledgements

The authors appreciate the assistance of the SIM-Centre, BRR, in compiling the data for this report, along with participants of the data user survey, and specifically ADB-ETESP, GTZ, BGR ManGEONAD, and UNDP- TRWMP. The FP6 Project Geobene (www.geo-bene.eu No. 037063) and the FP7 Project EuroGEOSS (www.eurogeoss.eu No. 226487) provided support.

Earthquake damage assessment using remote sensing imagery. The Haiti case study.

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Introduction

At 16:53 local time (21:53 UTC) on Tuesday, 12 January 2010 a devastating magnitude 7.0Mw earthquake occurred in Haiti. The epicentre was approximately 25 km (16 miles) west of Port-au-Prince, Haiti's capital, near Léogâne. The Haitian Government reports that between 217,000 and 230,000 people have died, an estimated 300,000 were injured, and an estimated 1,000,000 made homeless. Post Disaster Needs Assessment (PDNA) findings reveal that the total value of damage and losses is estimated at US$7.8 billion: US$4.3 billion represents physical damage and US$3.5 billion are economic losses (OCHA SitRep No.31).

Damage to infrastructure in the 2010 Haiti earthquake was extensive: the main affected areas (Figure 1) included Port-au-Prince, Petit-Goâve, Léogâne, Jacmel and other settlements in southwest part of Haiti.

As of February, an estimated 250,000 residences and 30,000 commercial buildings had collapsed or were severely damaged.

Photo by “WFP/Marcus Prior/Haiti”

This paper is mainly focused on the damage assessment activities performed during the first days after the event and based on satellite and high resolution aerial imagery. The aim is to show best practice of operational tools and geomatics techniques that can be used to provide effective information to the humanitarian organization in the field.

Post earthquake damage assessment

As clearly highlighted in the Disaster Risk Management Cycle the Emergency Response stage is generally composed of different initiatives, such as the Search and Rescue (SAR) operations, the re-establishment of the main logistic routes, the management, coordination and sharing of information, the provision of humanitarian assistance and the initial damage and need assessment. The focus of the activities described in this paper is to provide an initial damage assessment to support the provision of humanitarian assistance, and hence they are not aimed at helping the SAR team. Furthermore, the typical time constrains of this stage do not allow to produce a Detailed Damage Assessment, which is generally performed in the Recovery stage in the framework of the PDNA related tasks.

UN WFP needs

It is crucial to thoroughly understand the needs of the end users of outputs being derived from the Initial Damage Assessment, both to provide products and services as effectively as possible, and to optimize the allocation of resources according to the time constraints. The main end user of the produced georeferenced data that will be described in the following paragraph is the United Nations World Food Programme (UN WFP), the largest UN agency in charge of assisting affected areas, vulnerable populations with a variety of feeding programmes, as well as food-for-work programmes. WFP and partners have delivered food to over 1.2 million people (over 200,000 families) in the greater Port-au-Prince area as part of a targeted food distribution which reached 3 million people in February (OCHA SitRep No.30). Therefore WFP was most interested in having information on:

- ✓ the location of the most affected areas (by means of analyzing the pattern of collapsed buildings) and specifically the areas with spontaneously gathering camps;
- ✓ road accessibility, highlighting the presence of impassable and restricted roads, which are crucial for correctly plan the logistic of the food distribution plans.

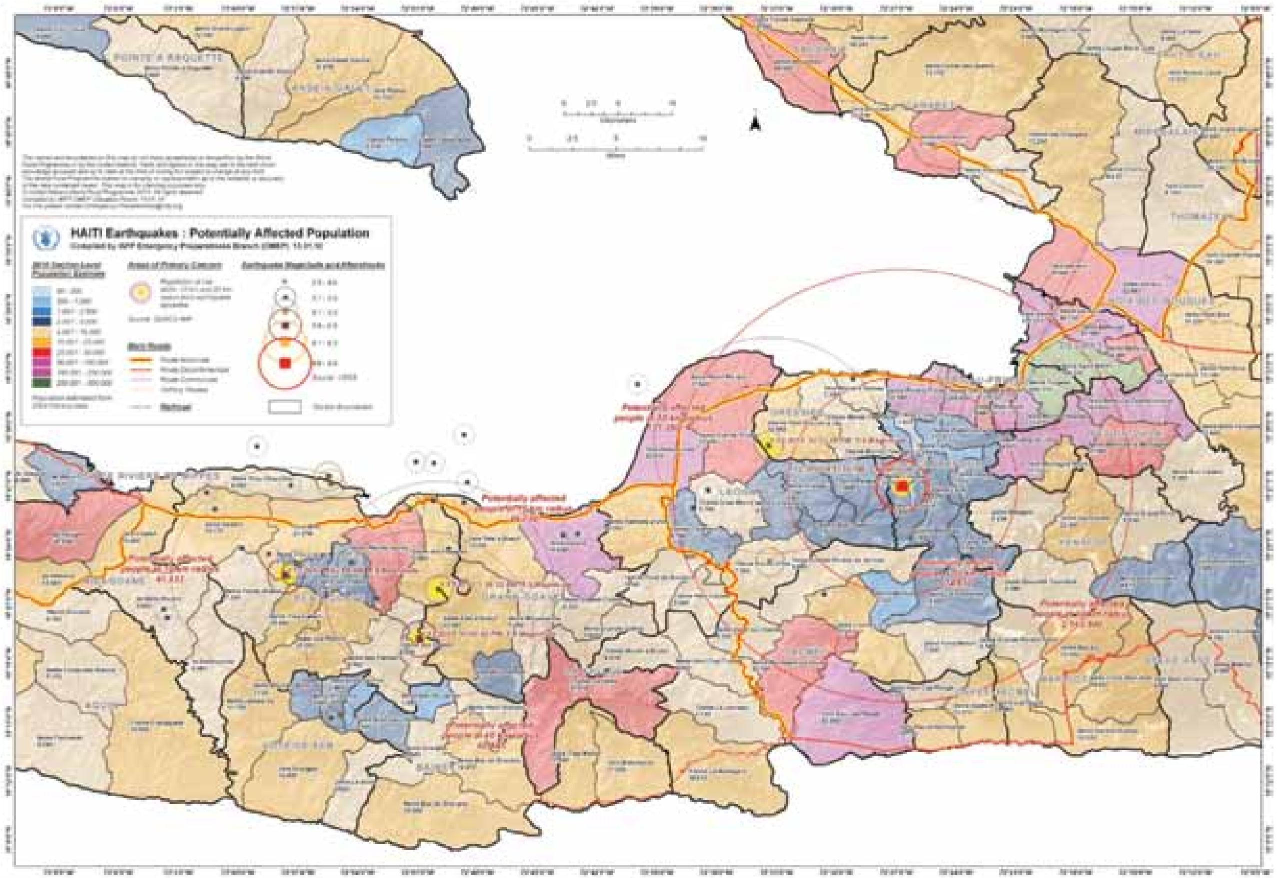

Figure 1: Map showing the potentially affected areas by the Haiti earthquake (Source: WFP, 15.01.2001)

Available remotely sensed data

Timely triggering and absence of cloud cover allowed GeoEye-1 satellite to collect colour, high-resolution imagery (resampled to 50cm for commercial users) over Port-au-Prince within a few hours (Figure 2). Specifically on January 13, beginning at 10:27 a.m. EST, from 423 miles in space, GeoEye-1 collected almost 3,000 square kilometres of imagery. On January 16, GeoEye-1 was again in an orbit over Haiti, and collected stereo imagery over Port-au-Prince. Google made the imagery immediately accessible to everyone, overcoming licensing issues that may interfere with the needs of rapid disaster response. A few days later (17 January 2010) Google arranged for a collection of imagery over the Port-au-Prince area at approximately 15cm resolution to complement the existing imagery, making it again available for download by everyone. The immediate dissemination of the data through Google, by means of direct download or by making them available as base layers in Google Earth/Map, was indeed a crucial turning point. Several OGC compliant Web Services were later arranged to allow GIS specialists to work in their preferred GIS environment, avoiding time consuming download procedures.

The eager efforts of the satellite/aerial data providers, space agencies and funding agencies enabled rapid coverage of the whole country with optical and radar data: among others, the main data acquisition initiatives were performed by DigitalGlobe (optical satellite data, Figure 3) and World Bank-ImageCat-RIT (aerial imagery, including thermal and lidar acquisitions).

Figure 2: Detail of first post-earthquake GeoEye satellite acquisition (50 cm) over Port-au-Prince. Jan, 13th 2010 (Courtesy of GeoEye)

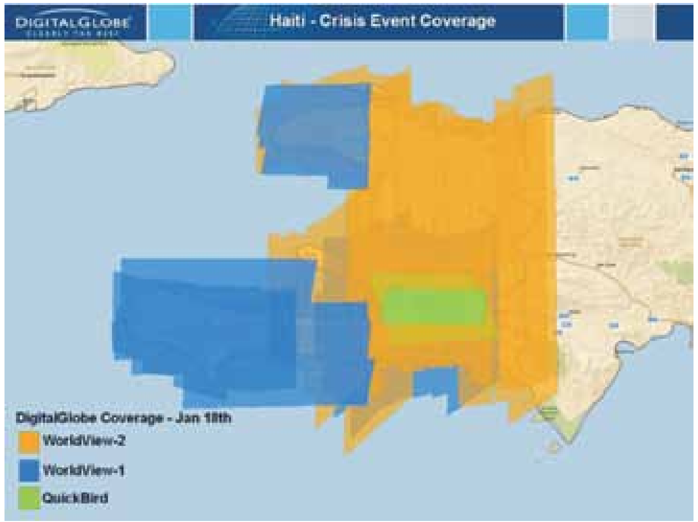

Figure 3: Coverage of the DigitalGlobe constellation as of Jan, 18th 2010 (Source: DigitalGlobe)

Extraction of features of interest

Remote sensing technology is increasingly recognized as a valuable post-earthquake damage assessment tool. As highlighted in the previous paragraphs, it is necessary to have a clear understanding of the end user needs in order to identify which information has to be extracted. For the Haiti response WFP asked as a priority to identify:

- ✓ not accessible or restricted roads, allowing to evaluate the road network accessibility;
- ✓ spontaneous gathering camps;
- ✓ collapsed and damaged buildings;
- ✓ landslides triggered by the earthquake, possibly affecting the logistic network.

Taking into account that the huge amount of high resolution data (covering an extensive area) had to be interpreted under harsh time constraints and that procedures to fully and rapidly automatically interpret images do not yet exist (from a post-earthquake damage assessment point of view), the mapping of the features of interest required manual interpretation involving a large crew of volunteers. The analysis was mainly based on a multi-temporal comparison (with respect to pre-event imagery) of the available satellite data (50 cm) and later updated by means of photo-interpretation of Google high resolution aerial imagery (15 cm). Figure 4 shows examples for each feature of interest

Good management and effective coordination of large crews comprising individuals from a variety of knowledge backgrounds was a hard task, with the main aim to avoid an intolerable waste of time if the interpretation of the same area were done twice. The adopted approach was to grid the area covered by the satellite imagery and to assign each grid cell to single volunteers (figure 5). This simple but effective procedure requires a big effort in the last stage of the workflow involving integration of all the analysis outputs and to create a homogeneous and harmonized database (figure 6). Therefore simple and standard rules for the image interpretation were provided, to minimize inconsistencies in extracting information from all different operators.

Outputs and dissemination

Typical outputs are in form of cartographic products based on the availability of a Spatial Data Infrastructure (SDI) such as the WFP-SDI. Since one of the requirements of the WFP-SDI is to provide a worldwide coverage, the reference layers are typically medium/low map scale datasets, which usually fit the needs of disasters such as floods or cyclones. Earthquake damage assessment obviously needs large or very large maps scale datasets (especially when displaying buildings and road networks) to act as a backdrop to the damage assessment maps. The availability of this kind of reference dataset is generally critical in developing countries such as Haiti. This demonstrates the importance of participatory mapping through media such as OpenStreetMap or Google Map Maker. The participatory approach allowed mapping large parts of Haiti within a few days (Figure 7), albeit on the basis of 'any information is better than no information', since accuracy was not the highest

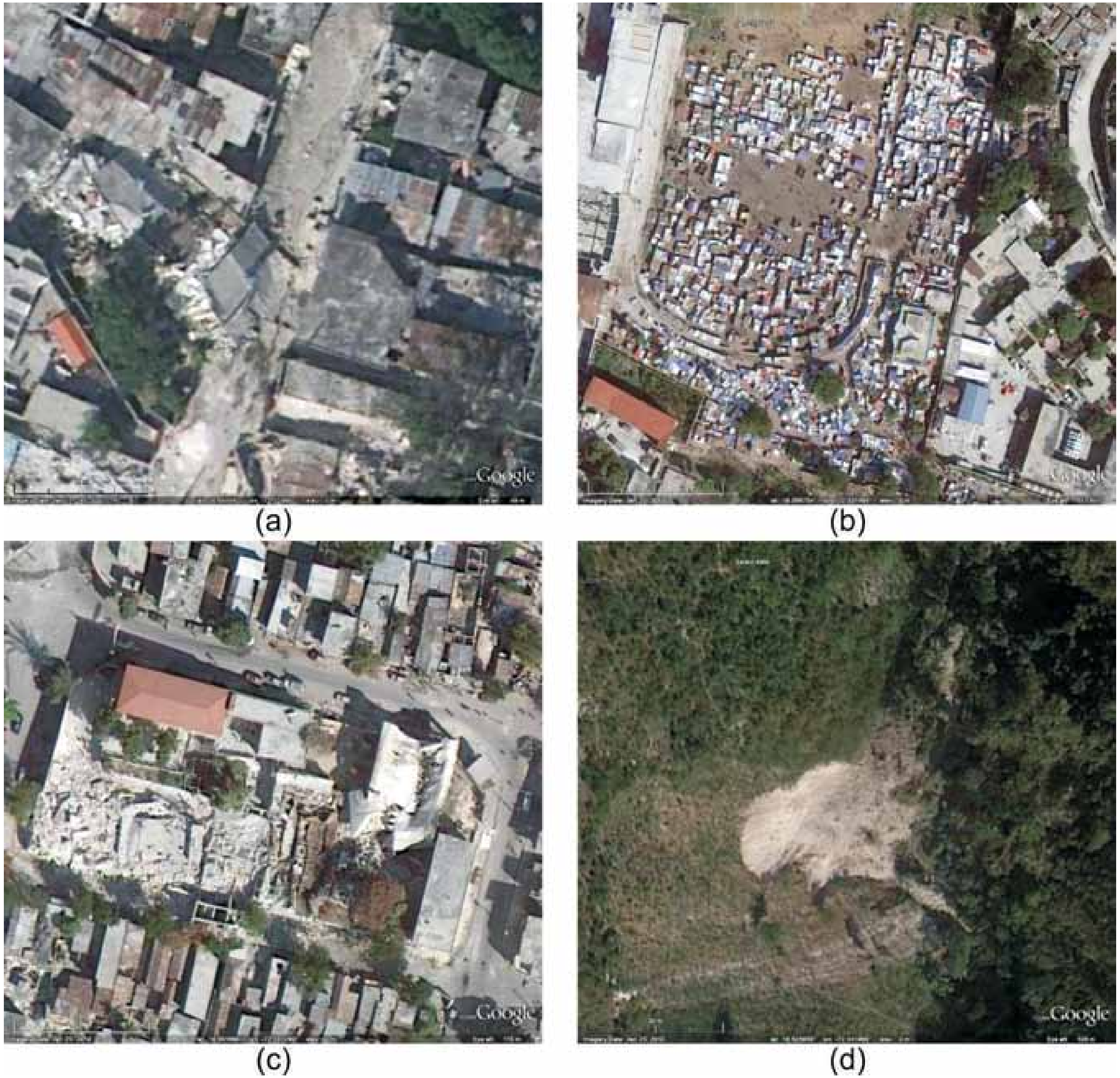

Figure 4: Example (Source: Google 2010) of photo-interpretation of the features of interest: a) not accessible road b) spontaneous camp c) collapsed buildings d) landslide

priority. The updated large scale reference layers were uploaded into the SDI reference datasets, allowing the creation of raster maps based on customized templates (figure 8).

The dissemination process was based on typical methods of data dissemination, including: delivery as an attachment to e-mails to a pre-defined mailing list; inclusion into web pages, where a search engine would help in identifying the searched product; and delivery to specific GeoRSS portals. The focus was on emergency management and a large circulation. Because of the impact of the Haiti earthquake and the number of GIS specialist asking for raw data, an ad-hoc web application was specifically designed and implemented, allowing to display and query the available datasets and also to edit specific features of interest (Figure 9).

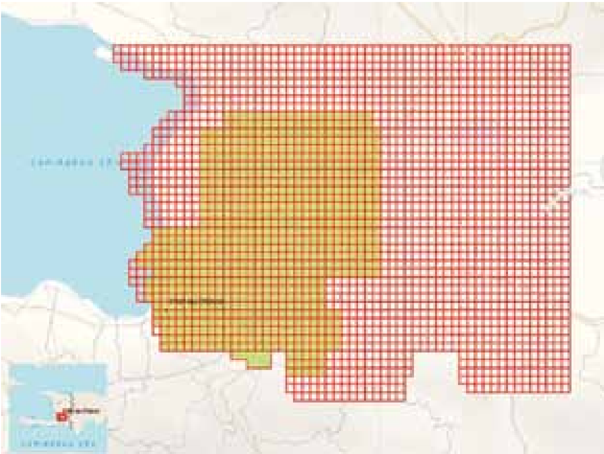

Figure 5: *Coordination Grid (red lines) over the area of interest (green polygon show analyzed cells)*

Figure 6: *Example of damage assessment in the central area of Port-au-Prince*

User feedback

In an emergency, WFP needs information more than almost anything else, to be able to respond quickly and effectively and to plan the next phase of its operation. The mapping products provided by ITHACA in the emergency response phase were very visual and easy for staff without a GIS background to use. They gave a very clear picture to both field staff and decision makers at WFP headquarters. WFP's logistics teams used the maps to know where they could open access routes, where warehouses could be erected, where hospitals were located so that for example, injured people and their families could be helped. The maps told WFP staff where spontaneous camps for displaced people were springing up and where roads were passable to reach them. Distribution sites could then be set up as closely as possible so that as many vulnerable people as possible could be reached. When security during food distributions became a concern, WFP staff could find alternative routes by inspecting the maps, thus allowing them to get their job done as safely as possible in a very complex and challenging environment.

Figure 7: *OpenStreetMap coverage over Port-au-Prince before the earthquake (top), as of February 15th (centre) and February, 26th (bottom)*

After quickly producing Rapid Impact Analysis maps for the capital, Port-au-Prince, the focus turned to badly damaged outlying towns such as Jacmel and Leogane the epicentre where 90% of buildings were destroyed. This helped target where help was especially needed. Then a picture was created of the entire country so that access to rural areas could be assessed. Damaged and destroyed bridges were identified alongside areas where there had been landslides, so that aid could be moved into the countryside. This was especially important as people heeded the Haitian government's request to leave the capital if they had somewhere else to go. It is very valuable for WFP to have this broader picture when it needs to think ahead and plan not only how to help people directly hit by the earthquake, but also to help communities which could otherwise become overwhelmed. WFP's specialist programme officers can decide which is the best intervention strategy food for work or assets, cash vouchers for food, school meals, or a general food distribution.

In Haiti operational mapping developed with a level of detail not seen before within WFP and other humanitarian agencies. WFP has become known for the work it is doing in this field with the help of specialist partners such as ITHACA. Its maps regularly become the operational standard in emergencies and WFP makes sure to disseminate them as widely as possible to a fast-growing audience.

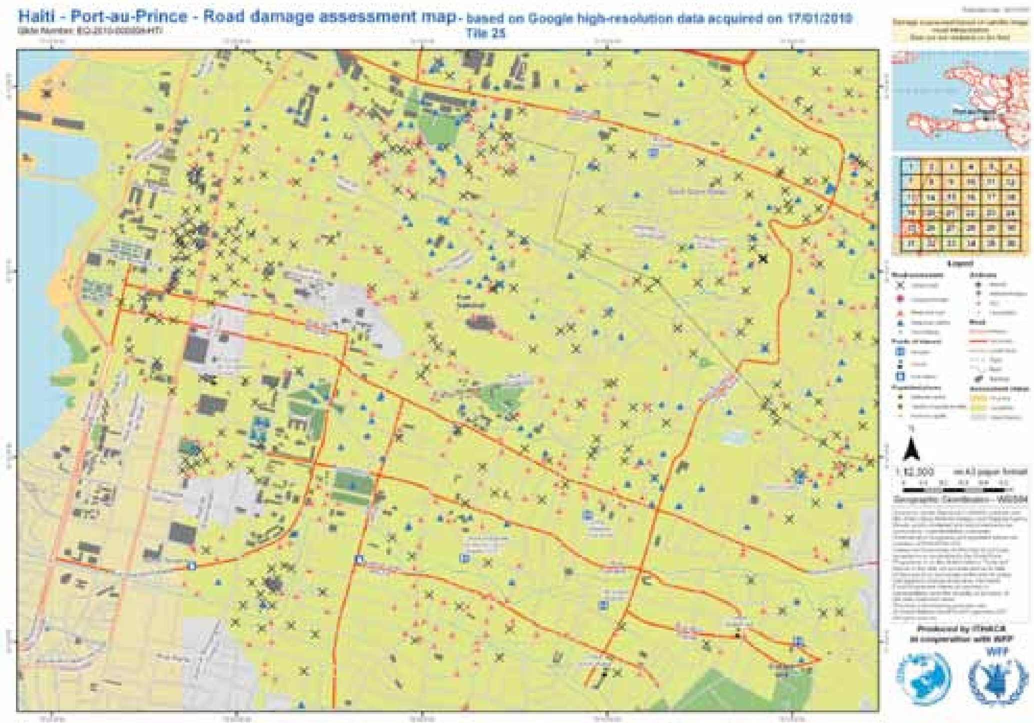

Figure 8: *Example of cartographic product showing the output of the damage assessment analysis*

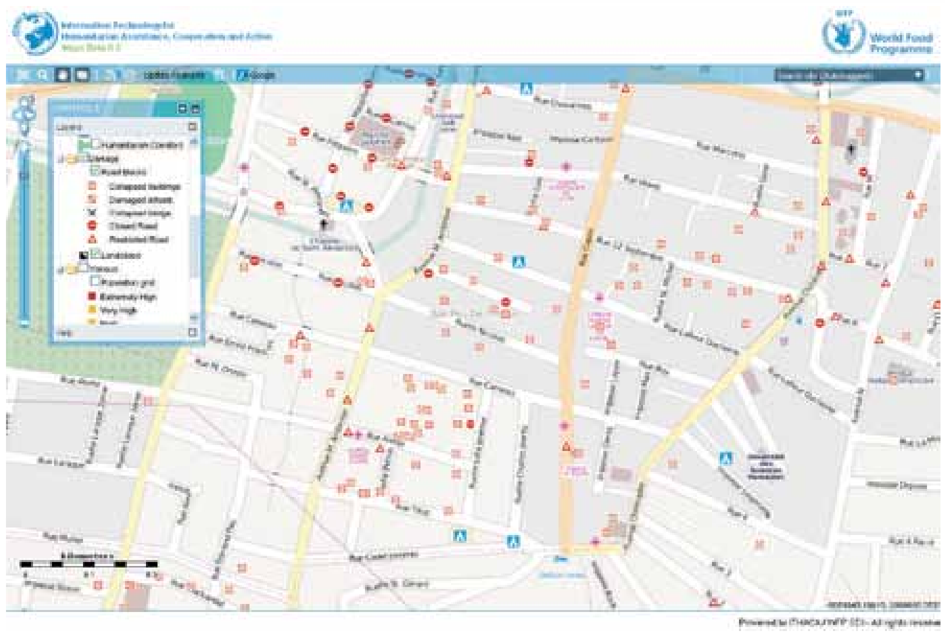

Figure 9: *Web application devoted to data querying, displaying and editing*

Discussion and conclusions

The Haiti earthquake clearly demonstrated that optical remote sensing is a valuable post-earthquake damage assessment tool and that satellite/aerial data providers have the capabilities to timely trigger image acquisition and to make available the data to the humanitarian community. But it also demonstrated that above all the establishment of good coordination bodies equipped with proper supporting tools is crucial.

But if unhappily, persistent clouds had covered the affected areas on the days after the event, all the optical data would have been useless. The role of radar remote sensing (not only aimed at identifying the main faults by measuring ground displacements) in the post-earthquake damage assessment should certainly be a research priority in the radar community. As an operational alternative, the capabilities of new low cost devices aimed at performing ground surveys should be further exploited. Figure 11 shows the user interface and some sample pictures of a LCMMS (Low Cost Mobile Mapping System) equipped with 4 webcams and a GPS (Figure 10) aimed at acquiring georeferenced frames. The system, developed by ITHACA and Politecnico di Torino, allows acquisition of about half million frames and 60 thousand GPS points during a 5 days ground survey in Port-au-Prince.

Figure 10: LCMMS device installed on top of a car during a ground survey in Port-au-Prince

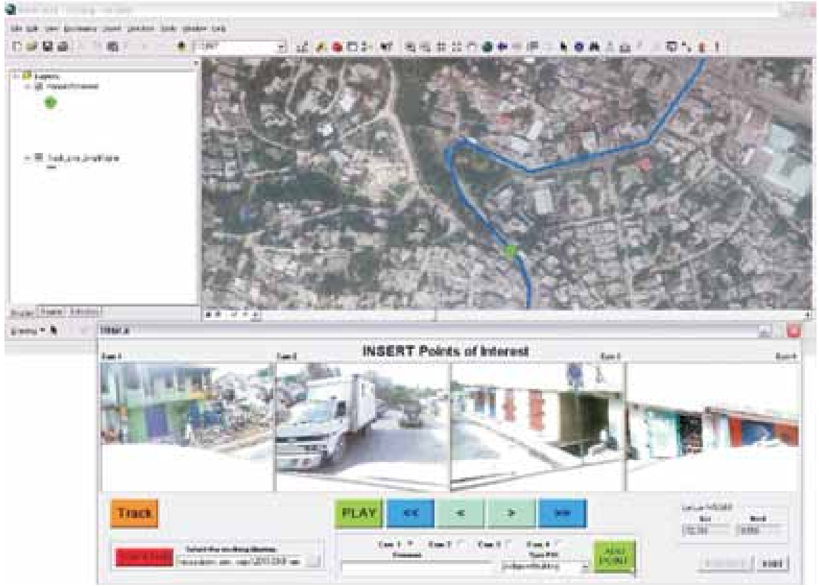

Figure 11: GIS customized software for LCMMS data visualization and processing

Space Technology Application for Wenchuan Earthquake Relief

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Introduction

An earthquake with a magnitude of 8.0 on the Richter scale struck Wenchuan County, Sichuan Province, China at 14:28 CST (06:28 UTC), on May 12, 2008, and known as the Wenchuan Earthquake. The location of the epicentre (31.021N, 103.367E) was at Yingxiu (Fig1), a small town in Wenchuan County, which is located in the earthquake zone in China. The most affected areas were distributed along the southwest to northeast directions from the epicentre.

The earthquake was the most destructive experienced since the People's Republic of China was founded in 1949.

Figure 1: Unmanned airplane image of the Yingxiu town in the Wenchuan County , Sichuan Province taken on May 14th,2008 by NDRCC

The characteristics of the earthquake were as follows:

(1)High intensity: the maximum intensity was XI degree on the China Seismic Intensity Scale

(2) Large area coverage: 500,000km2 over more than 10 provinces, autonomous regions and municipalities, including Gansu, Shannxi and Chongqing were affected

(3) Numerous aftershocks and frequent secondary disasters: there were more than 30,000 aftershocks; the secondary disasters such as land collapses, landslides, debris flows and quake lakes occurred frequently, which caused even more extensive damage.

(4) Difficulties for disaster relief: the earthquake affected areas were mostly mountainous, where many of the lifelines were destroyed by landslides and debris flows making access difficult for disaster rescue teams, and for goods or facilities to be supplied to the severely affected earthquake areas.

(5)Massive losses: the earthquake left 69,227 people dead and 17,923 missing. 15.1 million people were evacuated and resettled, the direct economic losses exceeded 845.1 billion Yuan RMB(124 billion US Dollars) (Speech of Chinese President Hu Jingtao, 2008)

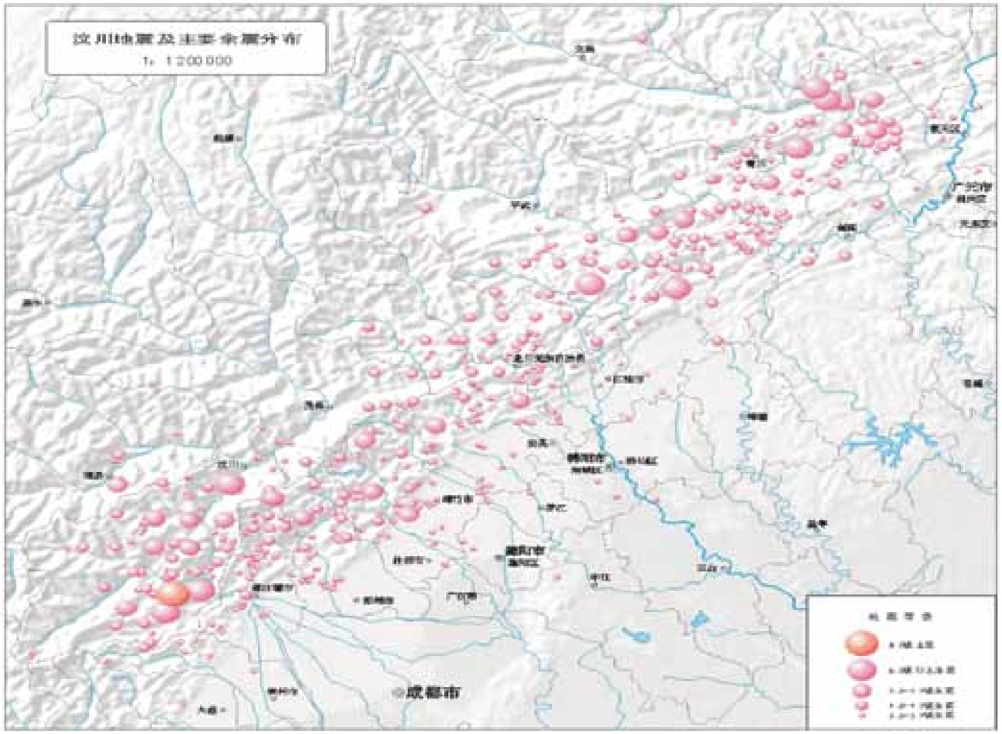
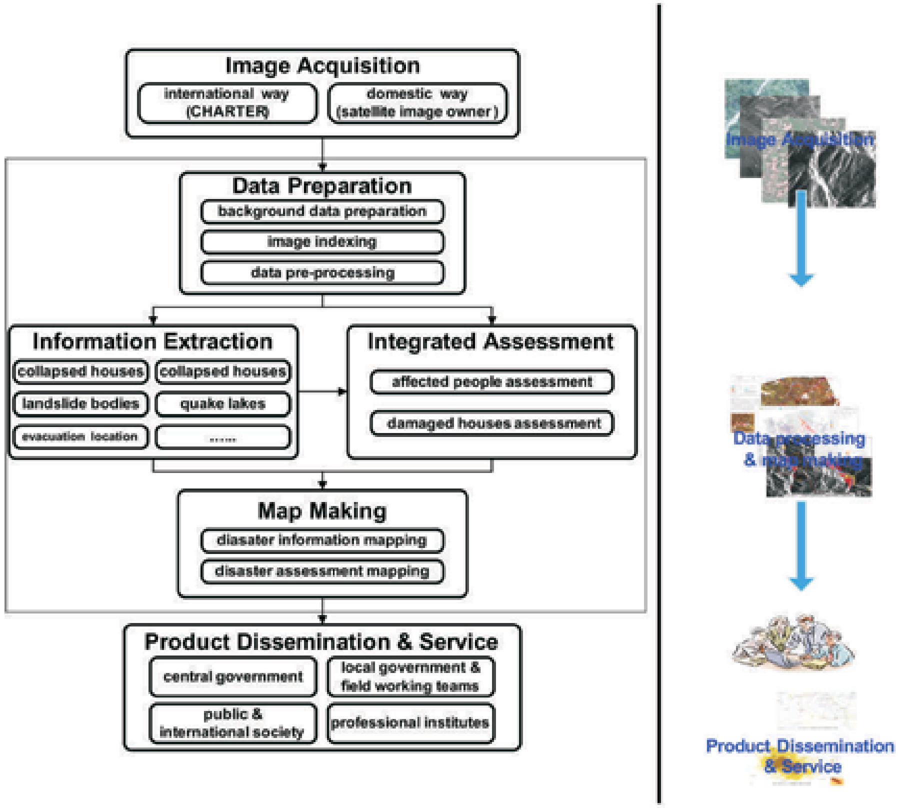


Figure 2: Epicenter distribution of Wenchuan Earthquake and its major aftershocks (Ming Zou, 2009)

Figure 3: Space technology support work flow



Following the Wenchuan Earthquake, the Chinese government organized the fastest quake relief effort and mobilized the largest number of people ever in China's history, to save as many lives as possible and to minimize the losses from the disaster, The first level emergency response was activated according to the national disaster relief contingency plan (Speech of Chinese President Hu Jingtao, 2008). As the decision making support agency for national disaster management, NDRCC immediately triggered the emergency space technology support operations (Fig.3), providing effective information and technical support for national disaster relief. Each process of the operations is described in this article. The experiences and lessons learned have also been summarized and shared.

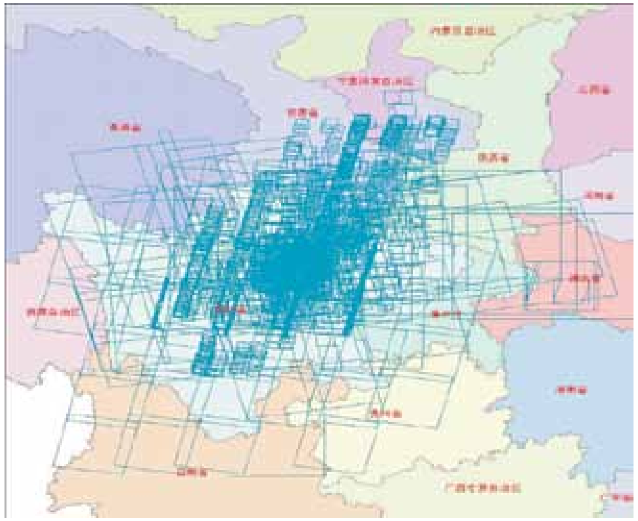
Satellite	Nation/Region	Pre-event images	Post-event images	Total images
RS-1	CHINA	9	246	255
FORMOSAT-2	CHINA(TAIWAN)	3	146	149
CBERS-02B	CHINA	400	25	425
ZY-2	CHINA	7	16	23
BJ-1	CHINA	2	14	16
COSMO-SkyMed	ITALY	0	10	10
QuickBird	USA.	9	28	37
TERRA ASTER	USA.	0	14	14
Landsat-7	USA.	10	4	14
WorldView	USA.	12	0	12
IKONOS	USA.	3	0	3
ALOS	JAPAN	19	21	40
IRS-P5	INDIA	6	27	33
IRS-P6	INDIA	18	0	18
ENVISAT ASAR	ESA	0	16	16
SPOT 5 4 2	FRANCE	122	23	145
TerraX-SAR	GERMANY	0	11	11
EROS-B	ISRAEL	0	10	10
RadarSat-1	CANADA	2	11	13
TOPSAT	UK	0	2	2
UK-DMC	UK	0	4	4
DMG Nigeriasat-1	NIGERIA	0	7	7
Total		622	635	1257

Table 1: The acquired EO images for Wenchuan Earthquake emergency relief

Image acquisition

Within two hours of the earthquake, NDRCC sent requests for EO images of the earthquake affected area to international and domestic data providers. The requests for international data acquisition were sent to the International Charter "Space and Major Disasters". The domestic acquisition requests were sent to the satellite image owner institutions and agents by fax and phone. The first two images were acquired within 24 hours of the requests. A total of 1257 images from 24 satellites and 12 countries were acquired, which included 622 images of archive image and 635 images of newly acquired images; 138 images were kindly provided by International Charter "Space and Major Disasters", and the others were supplied free-of-charge by more than ten domestic agencies, as listed in table 1(Yida Fan,2008).

Figure 4: Index map of all the acquired images (Suju Li, 2009).



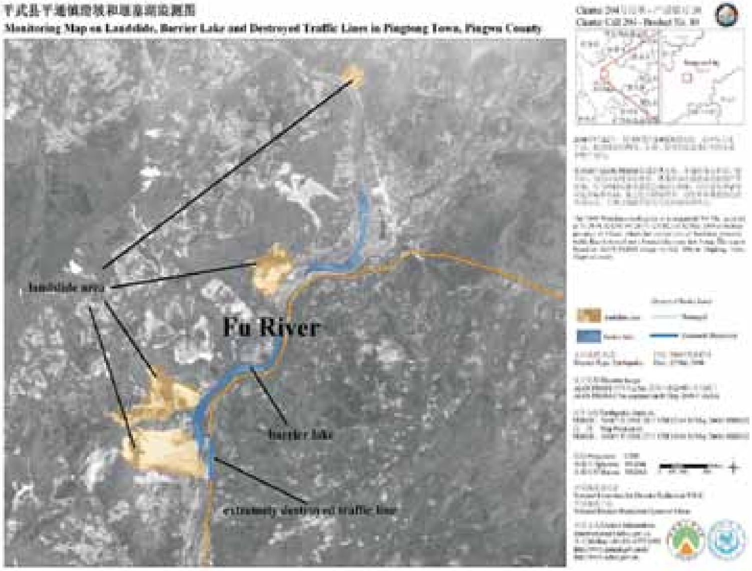


Figure 5: Landslides, destroyed road and quake lake monitoring map in Pingtong town, Pingwu county, Sichuan province

Figure 6: Location map of people evacuated in Mianzhu City, Sichuan province

Airborne remote sensing images of the earthquake affected areas acquired by the State Bureau of Surveying and Mapping of China (SBSM) and Chinese Academy of Sciences, unmanned airborne remote sensing images obtained by NDRCC, field investigation information obtained from field teams, and daily statistic disaster information data acquired at county level from local governments, were also gathered and integrated.

Data processing and map making

Data preparation

Background data preparation

According to the disaster assessment requirements, the background data such as geographic data, spatially relating social statistical data and images of the earthquake affected area, were formatting-processed and uploaded into the comprehensive spatial database in NDRCC, for subsequent information extraction and applications. Before observing the acquired images, pre-assessment maps were produced based on the background data which gave the decision makers the preliminary details about the people and economic loss assessment.

Image indexing
Everyday there were tens or even a hundred images gathered by NDRCC. To quickly search the necessary image, an index map of incoming images was firstly created with indexing parameters registered and linked, such as the satellite name, sensor name, spatial resolution, observing time.

Data pre-processing
The information extraction processing was based on the second level image product. The optical images were processed for geometric precision correction and ortho-rectification into second level. Similarly, radar images were filtering, registered and enhancement to produce second level images. The standard pre-processing stage guaranteed the consistency of the images.

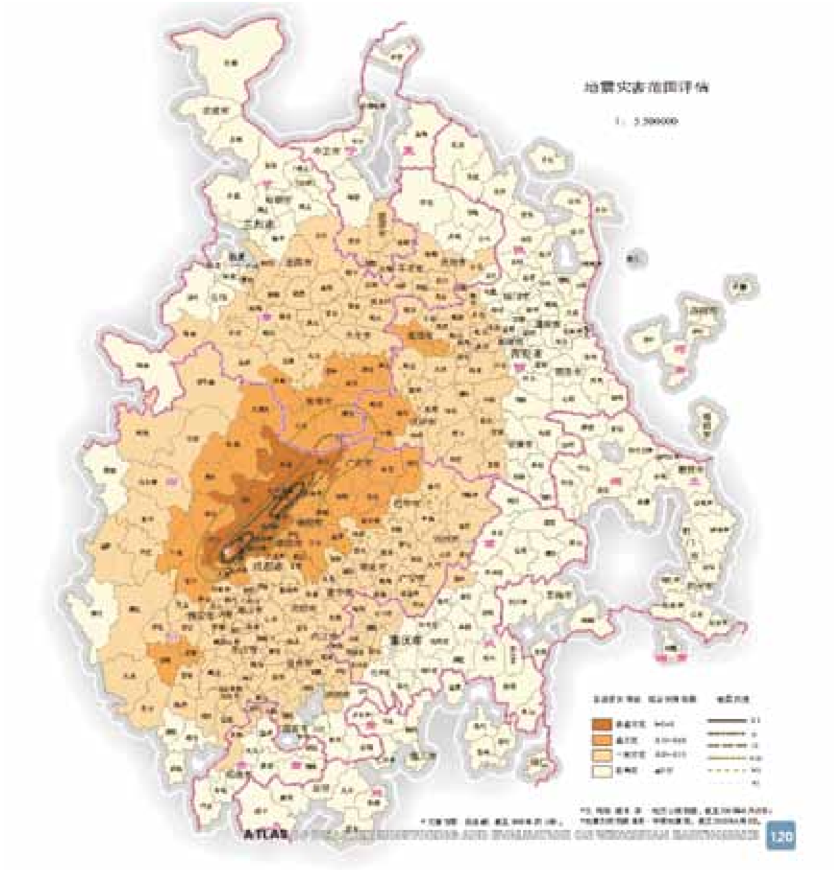


Figure 7: Integrated disaster loss assessment map for Wenchuan Earthquake

Information extraction

Based on the above prepared data, information of collapsed houses, landslides, destroyed roads, quake lakes and other changes to features, the distribution of evacuation routes and other related disaster information were extracted (Fig.5, Fig.6), using the methods of information enhancement and changing detection. Since the goal was mostly to extract objects at the scale of metres, the information extraction was mainly based on high spatial resolution images with resolutions less than 5m. To provide effective and timely support information for disaster emergency rescue and relief, the information extraction should be completed within hours after the image were acquired.

Integrated assessment

To give a general loss assessment of the Wenchuan earthquake, the integrated emergency assessment map (Fig.7) at county level was produced based on interpretation of the remote sensing images, background data and disaster information data. The assessment of affected people and damaged houses at different levels were displayed on the disaster map and used by state councils for reconstruction and recovery planning.

Map making

All the map products were standardized mapping based on a template. Once the information was extracted or assessment results determined, the map could be produced rapidly by loading the information into the template according to specific standards.

Product dissemination and service

There were a total of more than a hundred map products produced during the earthquake emergency relief stage. They were distributed to four different types of agencies in different forms, by fax, email, hardcopy, website or news conference. The first and primary agencies were the central government emergency management agencies to support the emergency rescue, relief, recovery and reconstruction decision making. The second agencies were local government and field teams to support their field deployment. The third agencies were the public and international societies, to support their awareness raising and assistance. The fourth agencies were the professional institutions in support of their scientific research.

Experiences and lessons learned.

Space technology provided effective and timely information for Wenchuan Earthquake emergency response management support. At the same time, some lessons were also learned and should be carefully considered for future events.

Experiences

(1) An inventory of the space resources should be compiled and made a component of the national emergency response working procedures. Full advantage should be taken of international and domestic space data acquisition scheduling to ensure timely acquisitions. Large quantities and multiple types of space borne EO images should be acquired.

(2) Scientifically based effective emergency operational procedures should be developed according to the disaster response requirements and space resources. Forming different working teams which were assigned distinct responsibilities according to the working procedures proved effective.

(3) Social resources must be mobilizing and made best use of. For major disasters, a single agency cannot cope with all the problems. More than 40 professional volunteers from research institutes and universities were mobilization to participate in processing the data and mapping.

(4) Remote sensing cannot provide all the information for disaster management support. Integration of images with social information, statistical disaster information and field investigation were essential.

lessons learned

(1) The observing time and location of the requested EO data should be dynamically planned to ensure they cover all disaster affected area and at different stages. Because of the lack of an observation plan, many acquired images were redundant around the area of the epicentre but there was a shortage of images on the edges of the affected area.

(2) Capabilities to process the massive amount of EO data and extract useful information for emergency response should be improved. It is important to develop automatic or semi-automatic methods for data processing in real-time or near real-time, for example, within 1-2 hours after acquisition (Deren Li, 2009).

Suggested Practices for Forecasting Dust Storms and Intervening Their Health Effects

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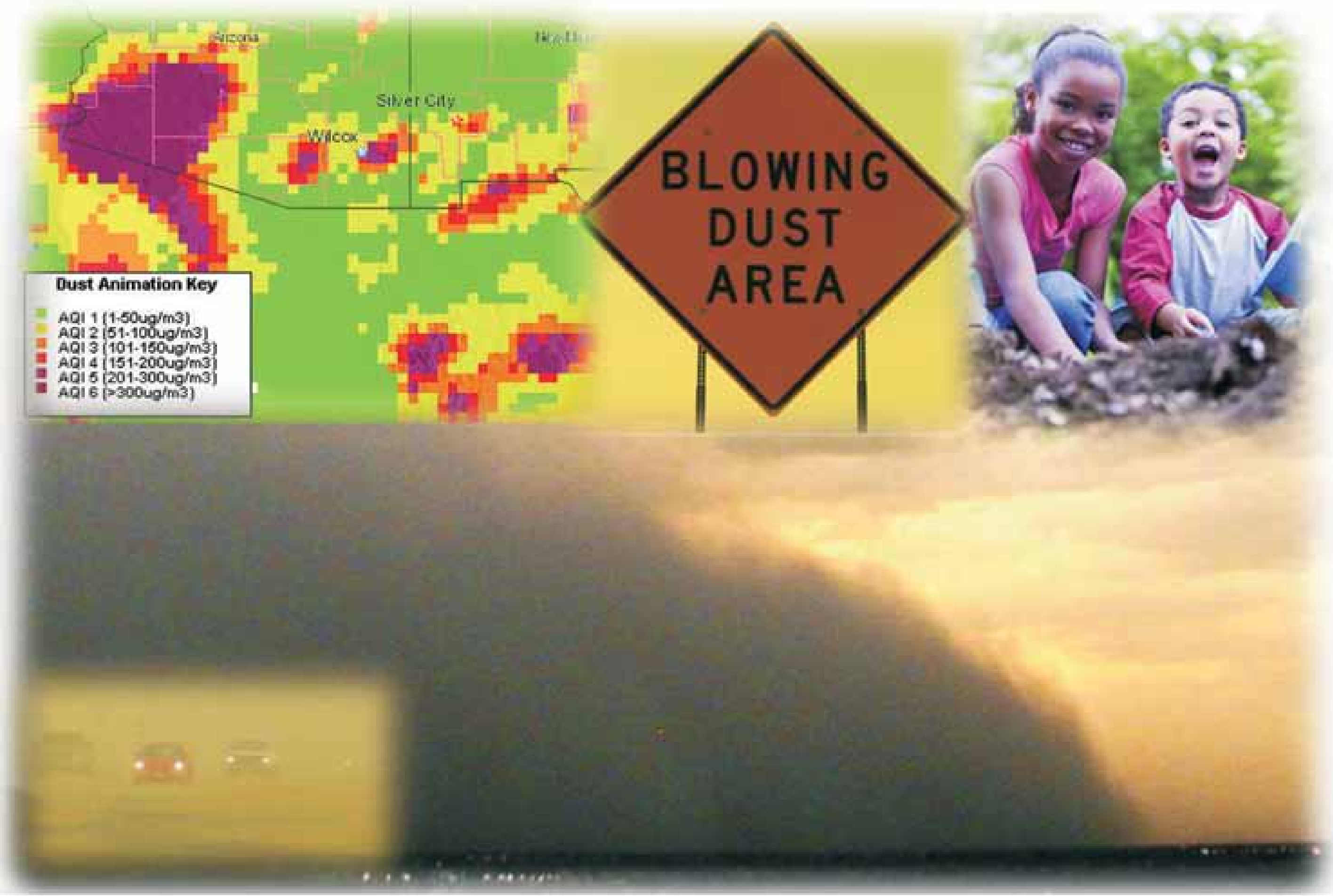

Importance of atmospheric contaminants in health

Respiratory health is exacerbated by exposures to microscopic particles and by microorganisms bound to them. Repeated exposures lead to chronic conditions such as asthma, while chance exposures to particles carrying viruses and bacteria lead to infectious and contagious diseases (Figure 1). Since the 1970s, health concerns shifted from coarse particles (10µm micrometers) to fine particles (2.5µm), and in the past few years have shifted toward particles in the 0.1µm range. There is ample evidence in developed economies that inhalable particulates result in costly health effects for families and societies; stress healthcare infrastructures; and, adversely affect local and national productivity. These trends are a compelling argument for having reliable forecast systems for dust and its movement through the environment.

Dust, smoke, and human health

There is ample literature linking airborne contaminants to health outcomes. Individual health is influenced by interactions among genetic and environmental factors. Many of the latter represent pathways for transmitting airborne infectious or contagious diseases across a population. Prolonged exposures to dust and smoke exacerbate chronic obstructive pulmonary diseases, allergic reactions, and a host of respiratory conditions affecting specific age groups. Moreover, there is evidence that the toll is rising because of climate variability, land-use conversions, and global urbanization.

Much of the world experiences weather-induced dust storms. These are visible from space, but operational weather forecasts do not predict dust events or concentrations. To acquire this information, a dust entrainment model must be embedded into a weather forecast model to simulate dust dynamics at the breathing level. For health applications, the question is whether outputs can be delivered in a timely manner to issue alerts and implement interventions? If so, can these forecasts be linked to health tracking systems? To answer these questions, forecasts must be available daily. They should also integrate satellite observations with geographic and demographic data into systems that can track immediate and long-term exposures. Only in this way will such forecasts provide relevant information for both patient-specific diagnoses and group epidemiology.

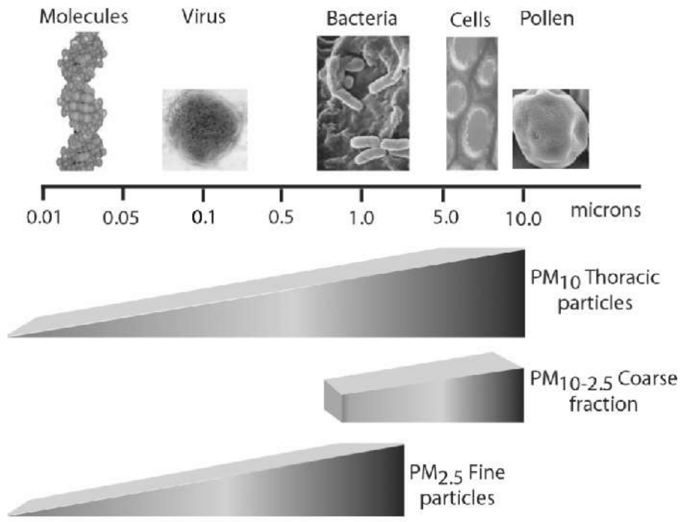

Figure 1: Particle sizes and their associated biophysical impacts (Kaiser, 2005).

Role for satellite observations of dust

Satellite sensors measure global atmospheric data to forecast broad area disasters such as hurricanes and tsunamis. Public health infrastructures that link day-to-day environmental conditions to public health outcomes are just beginning to emerge. There is a growing need to collect, archive, and integrate environmental monitoring data with health services, and an equal need to verify and validate the medical value of these data in decision support tools that streamline disease surveillance. This paper suggests practices for linking ground and space-based air quality observations to respiratory health; provides examples of how satellite data can be used to improve health services; and, suggests ways for how these services can assist health care providers and policy makers to develop better prevention and mitigation measures.

Satellite sensors provide routine, synoptic environmental data; but, their utility is enhanced when used in concert with health records and socioeconomic data in an information systems environment. Epidemiologists are interested in contextual relationships between dust events and associated risk factors such as demographics, life style, access to health care, exposure rates, and genetic heritage. Archived data about these attributes enable disease surveillance to be conducted via a forecast, and via projections over longer periods to assess the causes and effects of dust on health. However, until satellite sensors began collecting synoptic environmental data, there were no long-term archives around which to design epidemiological studies. Health authorities have always been aware of environmental factors, but information gathering for hospital admissions and emergency room visits leave little time to address factors that trigger respiratory and cardiovascular reactions, let alone address possible airborne diseases leading to epidemics.

Approach to Dust Forecasting

Sample satellite-based dust forecast system

Three steps are needed to produce reliable dust forecasts (Figure 2). Step 1 is to assimilate satellite measurements over land into a dust simulator (Nickovic et al., 2001); Step 2 optimizes model outputs to determine model performance; and Step 3 requires public health authorities and health care providers to assess the versatility of dust information for health. The combined system adds a dust forecast to the daily regional weather forecast. Weather parameters include near surface properties, while dust parameters are drawn from Earth observing sensors. The system's performance has been verified and validated by comparing data obtained from ground monitors with modeled dust events between 2003 and 2008 (Morain and Sprigg 2005; Morain and Sprigg 2007; Morain and Budge 2008). These dust forecasts are beginning to be used by health care professionals in the region.

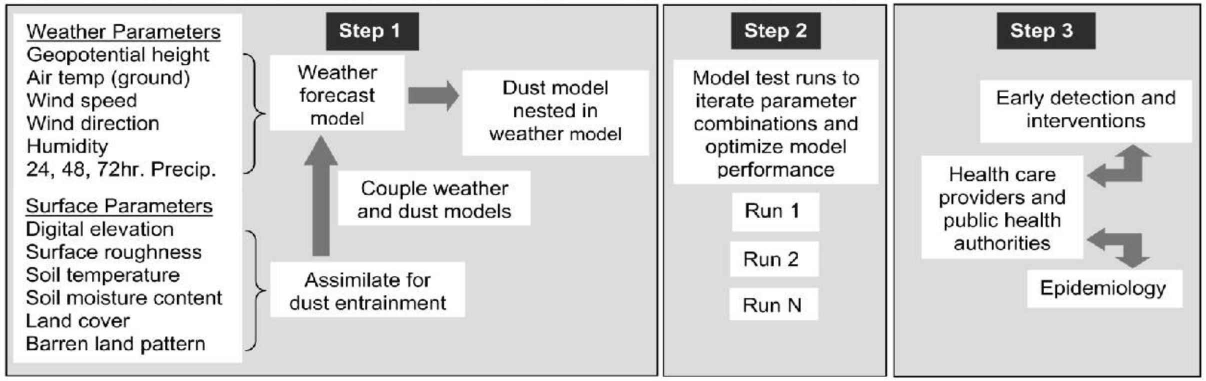

Figure 2: Step-wise procedure for forecasting dust episodes for health surveillance.

Metrics	***Wind Speed (m/s)***	***Wind Direction (°)***	***Temp (K)***	***Definition***
Agreement Index	0.74 **0.75**	0.74 **0.76**	0.71 **0.95**	$1-\frac{\sum_{i=1}^{N}(M_i-O_i)^2}{\sum_{i=1}^{N}\left(\lvert M_i-\bar{O}\rvert+\lvert O_i-\bar{O}\rvert\right)}$

Table 1: Model performance metrics before and after data assimilation. Bold values are after data assimilation. For the equation M = modeled; O = observed

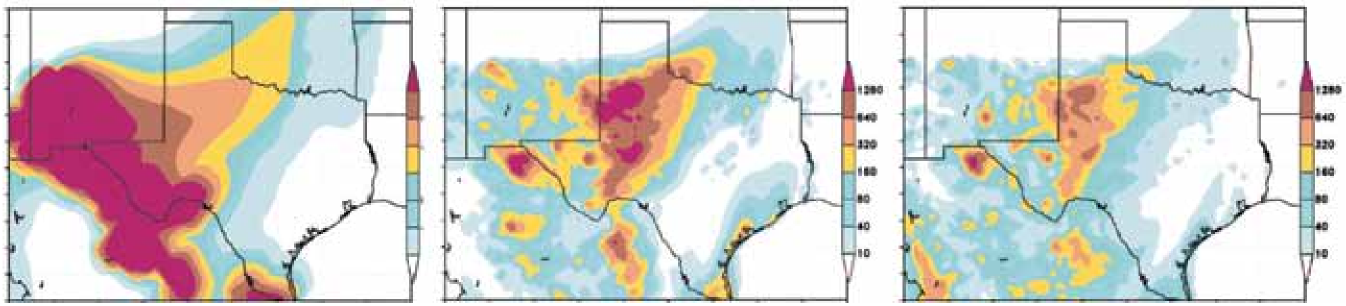

Figure 3: The triptych shows three generations of model improvements for a dust storm across New Mexico and Texas on 15-16 December, 2003. (left) the baseline model performance ***before*** *satellite data were included; (middle)* ***after*** *satellite data replaced baseline parameters; (right) the same storm modeled by a higher resolution, weather forecasting model.*

Improvements in model performance were obtained by replacing surface parameters in the baseline dust model. A series of model runs was executed using combinations of satellite surface measurements. Three parameters in particular, dust sources, digital elevation, and surface roughness, led to substantial improvements. These three parameters, along with surface air temperature, wind speed, and wind direction seem best for modeling dust entrainment. For the PM10 fraction, all runs showed improvement over the baseline run. For the PM2.5 fraction, results were mixed, but were better than the baseline.

Performance statistics were defined for modeled and observed atmospheric parameters (Yin et al., 2005), and an "agreement index" was defined to assess model performance (Table 1). Modeled results agreed closely with observed measures for wind speed and wind direction, but were statistically different for surface air temperature. Results show that the model system can simulate wind speed and direction accurately; and, that surface air temperature largely determines dust entrainment potential. Figure 3 shows three evolutionary stages in modeled dust patterns for the same storm.

Verification and validation

Verification and validation of modeled dust patterns and movements were produced for hour of peak dust concentration and dust episode duration using time-stamped ground observations against satellite measurements. The correlation between modeled and observed dust concentrations shows a tendency to over-predict the severity of events, primarily because satellite observations of the lower atmosphere measure a greater thickness of dust than is recorded by ground monitors. In all cases the timing and duration of dust events was forecasted accurately.

A weather forecaster's approach also was used to assess performance. Statistics for 346 observations were calculated. Only ten air quality exceedances occurred over the entire model domain during these events, suggesting that there were few false alarms. When this method was applied to the Phoenix metropolitan area, the model forecasted 71% of the hourly averages, 29% of the hours exceeding air quality standards for dust, and correctly forecasted 66% of the dust events.

Health tracking and surveillance

There are two basic approaches for health information systems. One is based on medical reporting by primary care givers; the other is based on electronic information gathering through data of historical reports and medical records. Both rely on syndromes that detect outbreaks of illnesses or potential epidemics that might otherwise be missed. The approach in this report adopted an Internet-based syndrome reporting system that facilitates rapid communication between public health officials in local jurisdictions and health care providers (Budge et al., 2006). It is also a reporting and discovery system for primary care physicians and clinicians who want to determine if their patient's syndrome has been reported by others in their jurisdiction. It provides medical and environmental information in three modules: (a) a syndrome information collection module to which doctors submit an inquiry; (b) a communication module whereby public health officials respond to an inquiry; and (c), a data visualization module that permits both parties to review inputs in the medical and geographical domains.

Experience with clinician-driven surveillance systems demonstrates that health professionals will report cases of suspected infectious disease, if the system is fast (less than 15 30 seconds), provides immediate feedback to clinicians on local infectious disease outbreaks, permits selective interaction between public health officials and clinicians on a real-time basis, and is inexpensive. When clinicians see a seriously ill patient with presumed infectious disease, it should take only a few seconds to report that case. Studies suggest that this is less than 0.1 percent of all clinical encounters in human medicine, but these are the cases that need to be identified in near real-time to avoid possible epidemics.

Products that fit user needs

Two types of health needs are met by tracking dust events: those related to interventions that reduce adverse respiratory effects in individuals; and, those involving statistical relations between environmental causes and public health effects. The first use is for alerts issued by school nurses, print and broadcast media, hospitals, doctors, and clinicians who inform the public; the second is for epidemiologists.

Health alerts

As an example of health interventions, the Albuquerque Public Schools (APS) in New Mexico, USA has developed an asthma action plan and standing orders for intervening, mitigating, and treating registered asthmatic students. The action plan has three well defined categories of symptoms. Mild symptoms are addressed by the classroom teacher; moderate symptoms are addressed by a school nurse or other medical provider; and severe symptoms are addressed by emergency response personnel. These categories provide a health basis for dust forecasts that can be e-mailed, faxed, text messaged, or twittered to the APS Nursing Service, and sent to print and broadcast media.

Forty-eight-hour forecasts of atmospheric dust are produced daily and made available at http://phairs.unm.edu, and http://nmtracking.unm.edu. Figure 4 captures a storm crossing southeast Arizona and southwest New Mexico on Jan 6-8, 2008. Individuals at Wilcox and Silver City could view an animation of the dust forecast that ran from 5:00pm (local time) on Jan 6th through midnight on Jan 8th. At left is a clip from the animation centered on the hour of peak dust concentration. The graphs at right show the peak hour and magnitudes for Wilcox Playa (blue curve) and Silver City (red curve). There is a precursor, lower concentration episode at both locations, but Wilcox was eventually hit with three high concentration episodes over the forecast period.

School nurses in the Albuquerque Public Schools prefer a dust alert system that obviates referring to websites or interpreting graphs. They favor a daily written synopsis of dust and air quality conditions across the school District.

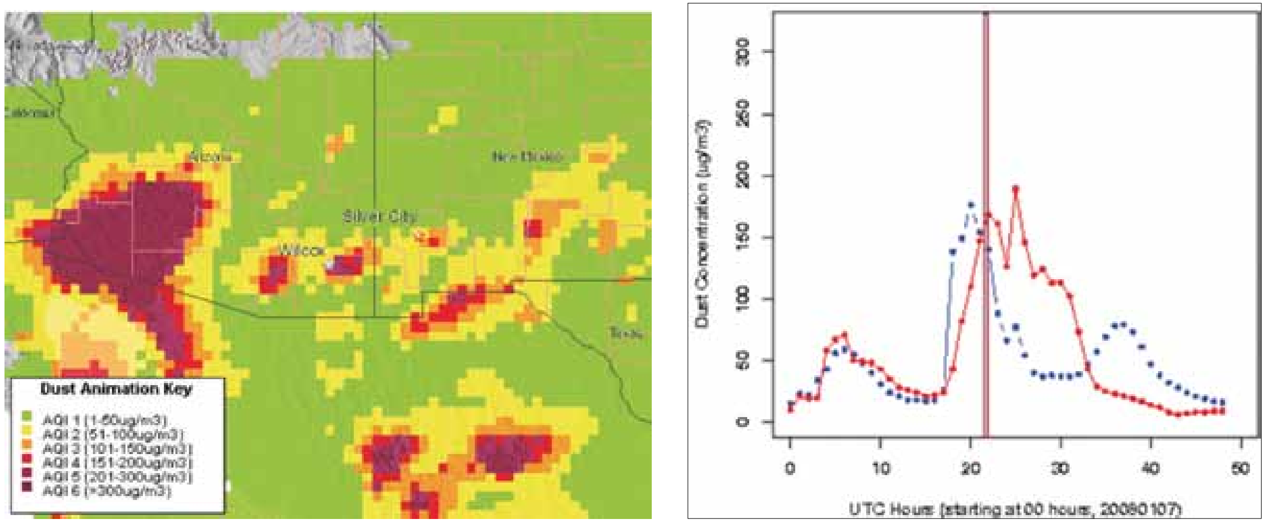

Figure 4: (left), Dust patterns at 1pm on Jan 7th. High concentrations are red and orange colors; low concentrations are green and yellow colors. (right), Timing of peak dust concentrations. The pattern at left is for the hour shown on the vertical bar at right.

Using Figure 4(right) as an example, a synopsis of dust forecasts might read as follows:

- ✓ Wilcox and vicinity: For January 6-8, expect moderate windblown dust late in the evening on the 6th, dissipating gradually throughout the evening and early morning hours but increasing and peaking in concentration to unhealthy levels between noon and 3pm on the 7th. There is a chance for moderate dust between 6 and 8am on the 8th.
- ✓ Silver City and vicinity: For January 6-8, expect conditions as in Wilcox on the 6th. For the 7th, expect a sharp rise in dust concentration to unhealthy levels between noon and 7pm, and remaining high until after midnight. Expect diminishing dust on the 8th.

Epidemiology

Epidemiologists can gain access to archives of dust simulations in the southwestern USA at http://nmtracking.unm.edu. Products are integrated into client interfaces to visualize raster images derived from the modeling system and to combine them with routine GIS operations. These data represent a step toward examining geographically explicit dust patterns for analyses of hospital admissions, or doctor visits that might have resulted from chronic, high level dust exposures.

Daily PM2.5 concentrations from April 2006 were used to identify areas in New Mexico that had high potential for dust-related health issues (Figure 5). At left in the figure, the measure is the proportion of days that 24-hour average DUST2.5 was greater than 15ug/m3. This concentration was used because it is the Federal USA guideline. At right the measure is the proportion of days that exceeded a 24-hour maximum of 35ug/m^3. Up to one-third of the days were forecasted to exceed a level considered to be "unhealthy."

Outlook

Satellite sensing in dry environments is critical for early warning of imminent dust storms to reduce risk of exposure to individuals and populations. Satellite data sets assimilated into models improve identification of active dust sources, and thus, enhance forecasts of dust generation, entrainment, and downwind dispersal and deposition. Products designed specifically with end users in mind are being evaluated by health authorities having operational health and air quality responsibilities. These products are being modified through continuing research, and in time will foster adoption by public health services.

Technologies for making air quality measurements continue to improve, but the data and observations themselves are not systematically stored for retrieval and medical research. Science, technology, and policy communities face huge challenges in: gathering, storing, modeling, interpreting, and disseminating air quality data for tracking health outcomes in populations. Biogeochemical and dynamical processes of airborne pathogens and pollutants must be researched further so that epidemiologists can understand the medical consequences of air masses traversing their regions.

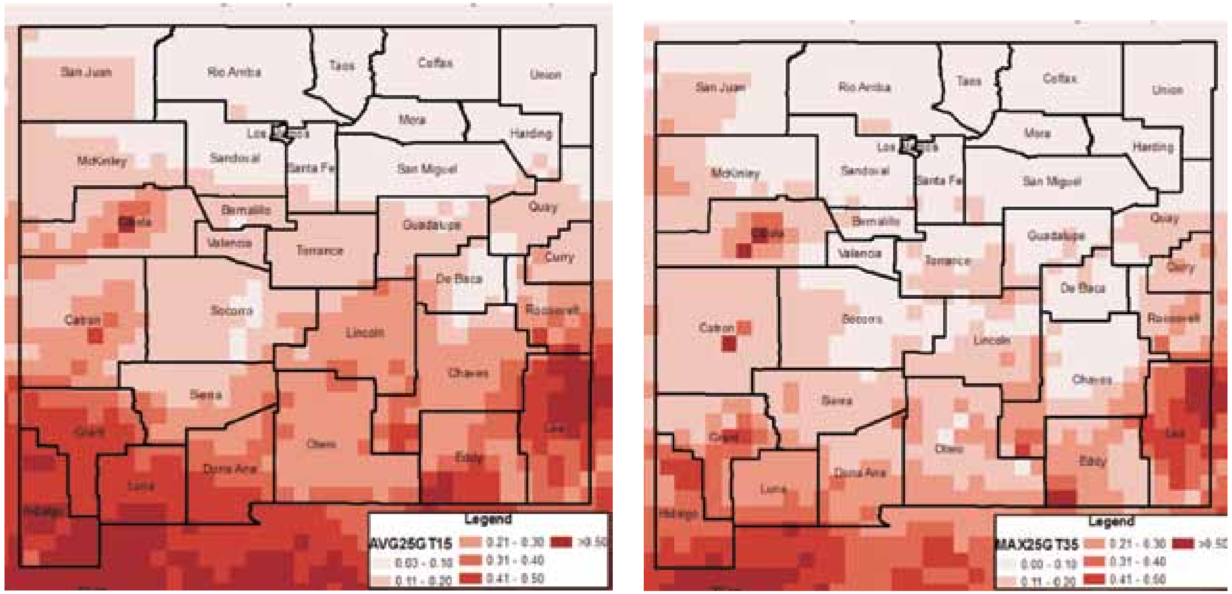

Figure 5: (left), All but the lightest color exceeded the standard daily average concentration of 15 µg/m³ for PM2.5 dust in the USA; (right), the darkest three colors exceeded the 24-hr daily maximum concentration of 35 µg/m³ (from Myers, personal communication).

Long-term archives of global air quality data and information are needed for longitudinal studies based on sentinel or cohort populations. The grand challenge is to add health professionals into efforts that merge environmental surveillance with human health syndromes.

Acknowledgements

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Monitoring Refugee/IDP Camps to Support International Relief Action

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Introduction

According to the United Nations High Commissioner of Refugees (UNHCR), approximately 42 million people were forcibly displaced worldwide at the end of 2008. This includes 15.2 million refugees, 827,000 asylum-seekers and 26 million internally displaced persons (IDP) (UNHCR, 2009c). IDPs are people who had to flee or to leave their homes but stayed within their country of origin without crossing any international state border (IDMC, 2009).

Darfur is only one of many conflict areas in Sudan, the country with the single largest internally displaced population in the world (IDMC, 2009). The conflict in Darfur is caused among other factors by fights for diminished drought affected resources and demands for greater political autonomy; almost 50% of Darfur's total population of about 6 million people, were internally displaced by January 2009. An additional 250,000 people are living in refugee camps across the border in Chad (IDMC, 2009).

Figure 1: *Makeshift shelters and new tents in a section for new arrivals at Ifo, one of the three refugee camps at Dadaab in north-east Kenya (UNHCR/E. Hockstein 2009).*

Refugees and IDPs live in widely varying conditions, from well-established camps to provisional shelters or at worst in the open. Besides the UNHCR many other mainly non-profit organizations address the problems of refugees and IDPs. The management of refugee camps is of particular concern. Uncontrolled growth and arrival of new migrants, environmental pollution and degradation, water supply and sanitation, health and hygiene, plus security are only a few of the challenges facing the humanitarian community (fig. 1 and fig. 2).

This underlines that the establishment and management of refugee/IDP camps require joint efforts by the aid agencies involved and if possible local authorities. The supportive role of geoinformation and mapping tools within this context has been demonstrated in various situations that will be outlined in more detail in the following.

A refugee/ IDP camp monitoring service

Within the recent European Commission funded GMES- project LIMES a working group was established addressing especially humanitarian issues. Among others a specific service supporting refugee/IDP camp management with geoinformation products was successfully set up. Partners brought together their expertise in humanitarian relief, earth observation, geodata processing and analysis, statistics and modelling, to monitor the status of the camps, their growth over time and the environmental situation in the vicinity of the camps. Estimation of population figures from satellite data was another objective of the service providers. Population numbers are crucial information to enhance the logistical support of relief organisations to provide water, shelter and security.

In the present stage of the project (2006 2009) the LIMES refugee/IDP camp monitoring service was requested three times to monitor a total of eight refugee/IPD camps throughout Darfur and Eastern Chad. The work was requested by the Directorate-General for External Relations of the European Commission (DG RELEX), the European Forces (EUFOR) Chad/RCA and the World Food Programme (WFP).

DG RELEX asked for support to monitor the camps of Zam Zam, located 10 km southwest of El Fasher, the capital of North Darfur, and Zalingei a city in West Darfur home to the two large IDP camps at Hassa Hissa and Hemidya. The camps of Kerfi and Abdi are located in eastern Chad and were requested to be mapped by EUFOR. The WFP also intended to launch a pilot-project for camp population estimates. The camps selected for an initial investigation were Dorti and Ardamata in West Darfur close to the city of El Geneina as well as Um Dukhum about 250 km further south close to the Chadian border (fig. 3).

Figure 2: Thousands of people flee the IDP site at Kibati, in Democratic Republic of the Congo's North Kivu province, after hearing gunfire (UNHCR/P. Taggart 2009).

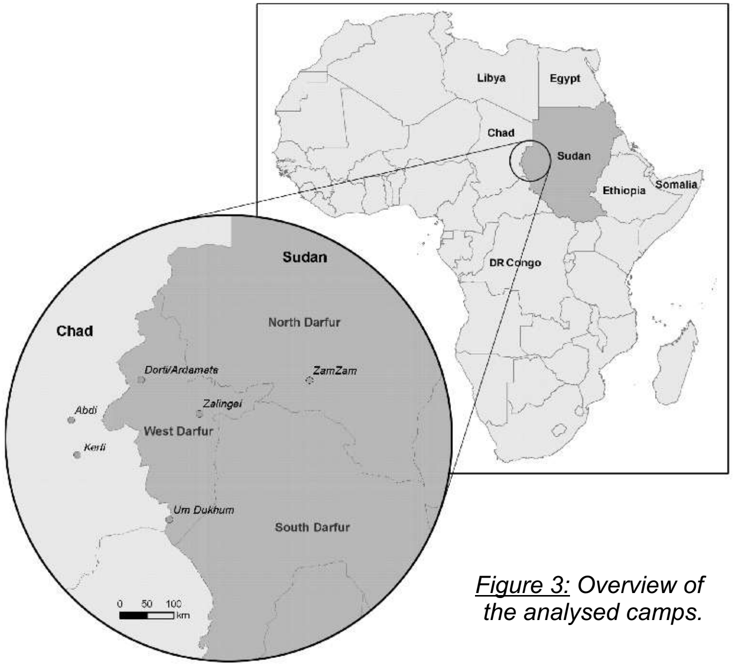

Figure 3: *Overview of the analysed camps.*

The requirements

The general requirements expressed by the requesting organisations were to gather information facilitating a better view of the situation in and around the camps. DG RELEX and EUFOR were interested in assessing the current size of the camps by means of their geographical extents, recent developments, as well as an estimation of the population currently living in the camps. Furthermore, the growth of the camps over time was analyzed to obtain a better understanding of the situation and to draw conclusions for potential further developments.

Another topic of great interest was the impact of the camp development on the surrounding environment. In combination with population figures this might indicate a potential source of future conflict about natural resources, thus mitigating conflicts between refugees/IDP's and host communities.

Besides the above-mentioned two organizations, WFP requested an evaluation of the use of satellite imagery for deriving reliable population estimates of refugee camps for the entire Darfur. The case study aimed to assess the ability of very high resolution (VHR) satellite data together with limited field surveys, to estimate the overall camp population. Furthermore, the scalability of the earth observation methodology should be tested to cover all IDP camps in the three Darfur regions in a future study and for periodic updates.

The Solutions

The monitoring of the size and growth of the camps made it necessary to acquire very high resolution (VHR) satellite imagery. State-of-the-art very high resolution optical satellite sensor technology can provide imagery with a spatial resolution between 0.5 and 1 metre. These resolutions allow a detailed view of the situation on the ground. Buildings, tents, walls and streets as well as vegetation can be visually clearly distinguished. As most camps have existed since the beginning of the conflict in 2003, the monitoring of the camp growth started with satellite imagery from around that year, depending on the availability of data.

Additional geoinformation such as camp boundaries were provided by the customers, as well as digitised by the team. Further information was obtained from published literature, the internet and oral communications with members from relief organisations such as Médecins Sans Frontières (MSF), UNHCR and Intersos. WFP provided GPS ground control points as well as photographs from the respective camps.

Together with a visual interpretation, the analyses utilised semi-automated information extraction methods. Two different object-based image analysis methods (OBIA) combined segmentation, class modelling and knowledge representation techniques. A third approach was based on the analysis of shape and form of the dwellings using mathematical morphology (Kemper et al., 2010). For the camp structure and dwelling density mapping two aspects of the evolution of the camps were analysed (Kranz et al. 2009a): firstly, the growth of the camps from 2002 (Zam Zam), 2004 (Zalingei), and 2006 (Kerfi & Abdi) until 2008, including the structure of the entire populated area in terms of camp area, traditional settlements and dwelling densities; secondly, the number of dwellings in the camps in order to derive an estimate of the number of people present.

Initially an OBIA rule set was developed for the 2004 Zam Zam imagery. Afterwards it was modified and optimized to be transferable to the other regions/camps and different satellite images. In addition, another OBIA rule set was developed for the camps in Chad (Kerfi & Abdi) to cope with the different structure of the camps and for combining the expertise within the group of researchers in the most effective way (Kranz et al., 2009b). This approach of joining the expertise of different research groups was continued and extended to a comparison of different methodologies at the request of WFP. The overall aim was besides generating relevant information for the costumer to further optimize the developed methods and

processing chains to finally derive a more robust OBIA rule set, leading to more reliable results in general. The camp areas were delineated automatically according to a certain threshold in dwelling density.

IDP or refugee camps themselves have an impact on the surrounding environment due to the additional demand of the scarce local resources such as water, grazing areas and firewood. Estimating the magnitude of such impact is of considerable importance with respect firstly to the sustainability of camps and secondly to conflict prevention. There is growing concern about the environmental impact of Darfur's conflict, in particular the impact on Darfur's wood resources which were already being depleted at an estimated rate of 1% per annum before the conflict (UNEP 2008). In situations such as Darfur this depletion also has an impact on the security of the IDPs because the depletion of resources forces them to collect firewood further away from the camps, increasing the risk of attack (UNEP, 2008). The detection and, where possible the quantification of this impact, may provide important information for the management of these camps. A standard application for the detection of changes with satellite imagery is the analysis of archive satellite data with coarse geometric but high temporal resolution for a defined observation period. Such an analysis aims to detect spatial trend patterns, which are an important factor in long-term environmental studies. In this study a time-series analysis of MODIS satellite data from January 2002 to July 2008 was based on the calculation and comparison of the Enhanced Vegetation Index (EVI) of 16-day maximum value composites with a spatial resolution of 250m.

Results

Camp population estimates

Satellite-based extraction of dwellings does not provide rigorous evidence of the actual number of people present at the time of data capture. However, the number of satellite data derived “dwellings” provides a proxy for the number of people present at the time of data acquisition. As no field data about the average household sizes per tent were available for Zam Zam and Zalingei, three different scenarios were generated for the estimation of population figures. These were based on the number of extracted dwellings, various figures from published literature (Giada et al., 2003; Bush, 1988; UNHCR, 2006) and oral communications with Médecins Sans Frontières (MSF), Intersos and UNHCR. Depending on the particular scenario used for the dwelling extraction from the satellite images, these figures have shown good agreements with official population data from the Humanitarian Needs Profile (HNP) of UN OCHA (United Nations Office for the Coordination of Humanitarian Affairs) (OCHA, 2007).

One of the main requests of the WFP was the estimation of population using the number of dwelling structures as a proxy. To obtain a reference dataset, visual interpretations were carried out, as it was assumed that this method would provide the most accurate results for mapping single buildings within the IDP camps. This reference data served then as a comparison of four automatic or semi-automatic extraction approaches. The four methods showed different results. A common problem with all methods was that side-by-side buildings were detected as a single building leading to an underestimation of the number of dwellings. Some buildings were not automatically recognized, because they have similar spectral characteristics as ground. In contrast, an overestimation was observed in other parts because potential “buildings” proved to be fences, shadows or bare soil.

The results show a large variation between the different approaches, reaching more than ± 30% difference between automatic and visually counted dwellings (Table 1).

Method	*Dorti*	*Ardamata*	*Um Dukhum North*
Visual Interpretation	3636	6394	14257
OBIA 1	2352	4869	10281
OBIA 2	2523	3965	15349
Pixel-based Approach	2142	3368	12277
Mathematical Morphology 1	2806	6938	14032
Mathematical Morphology 2	2800	5800	18650

Table 1: Dwelling estimates for the three camps using different approaches

The largest differences occur in the northern part of Um Dukhum, which can be attributed to the fact that this camp is much more widespread, including more open spaces, trees and rock outcrops compared to Dorti or Ardamata sites. Also there is no clear separation between host community and IDP's and there was no camp map available that would allow the exclusion of public facilities. The table shows that there is no clear pattern to be followed. A final assessment of the accuracy will be possible only with field assessments (the field validation planned for October 2009 had to be interrupted for security reasons).

IDP camp structure and dwelling densities

For the Zam Zam and Zalingei camp sites the monitoring of developments between 2002, 2004 and 2008 reveals a major increase in the number of dwellings between 2004 and 2008. Further analysis encompassed density calculations to create dwelling density maps (dwellings per square km), based on the semi-automatically extracted dwellings (fig. 4).

Rapid, partly automated mapping techniques were also applied to analyse the situation in the two camps of Kerfi and Abdi. Results were provided well within 44 hours after data reception as requested by EUFOR. Operational products were generated, highlighting areas of high density dwellings and tents as well as newly settled areas. Up-to-date land use/cover information maps were derived using the surroundings, camp limits, settlement infrastructure and single dwellings as indications of human presence.

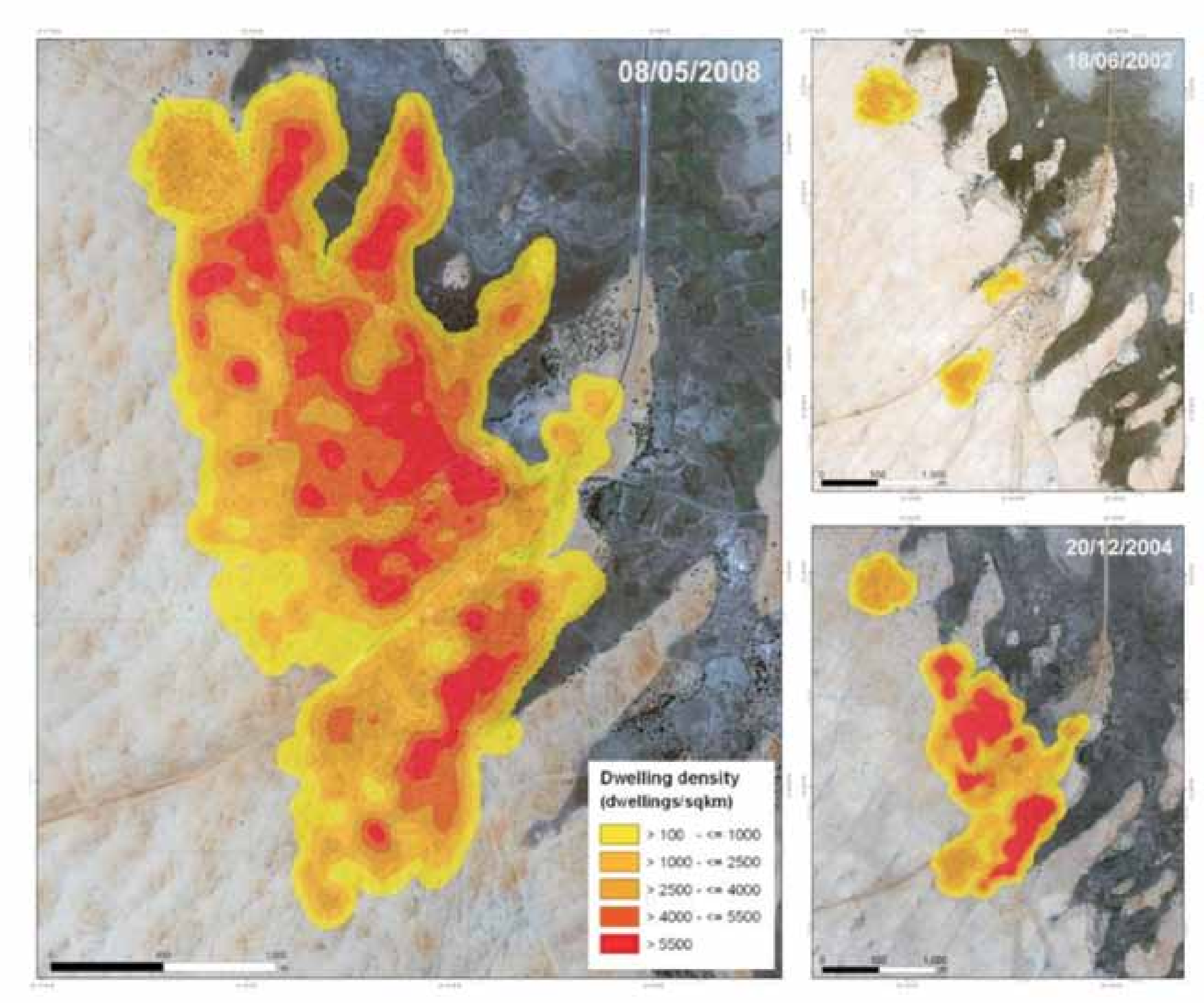

Figure 4: Dwelling density map for Zam Zam IDP camp at three different dates (2002, 2004, 2008).

Environmental impact assessment

The impact analysis for the Zam Zam camp is illustrated in Figure 5. The significantly degraded areas are all on the western side, within 5 to 10km of the camp. Areas closest to camps are generally more secure and are hence the most exploited. IDP's from a camp at Abu Shouk in Al Fashir (approximately 20km away) recently reported that it takes seven days to collect one cart-load of wood (UNEP, 2008). Despite the coarse resolution, the MODIS satellite data provides valuable information for evaluating the impact of IDP camps due to its ability to identify even subtle changes and the availability of long time-series over large areas. The quantitative information may be used to enhance the qualitative information (e.g. UNEP, 2008) available from higher resolution data.

Conclusions

The requests described in this paper were prepared in close cooperation with the end user to ensure that the final maps and interpretations provided the maximum possible benefit and support for the planning of the mission of the respective organizations in the conflict region. The general feedback from the user organizations was very positive but nevertheless there is still space for further improvements.

Remote sensing offers a safe way of analysing refugee/IDP camps and gathered information can be an important contribution to logistical issues of relief organisations. Optical satellite data can be used for an extraction of camp extents, infrastructure, numbers and types of buildings as well as population estimations and monitoring of refugee/IDP camps. However, improvements in single automatic processing steps are still necessary, e.g. the extraction of single dwellings from the imagery, which serves as basis for obtaining reliable population estimates.

Cooperation between a number of partner organizations in these joint activities has demonstrated the advantages of bringing together their different capacities and areas of expertise to provide rapid support to mission planning within the context of a complex crisis situation. Such mutual efforts result in sound and reliable information products that can be rapidly distributed to the requesting organisation. Improvement and expansion of future services, would include the detection and monitoring of other important natural resources such as water.

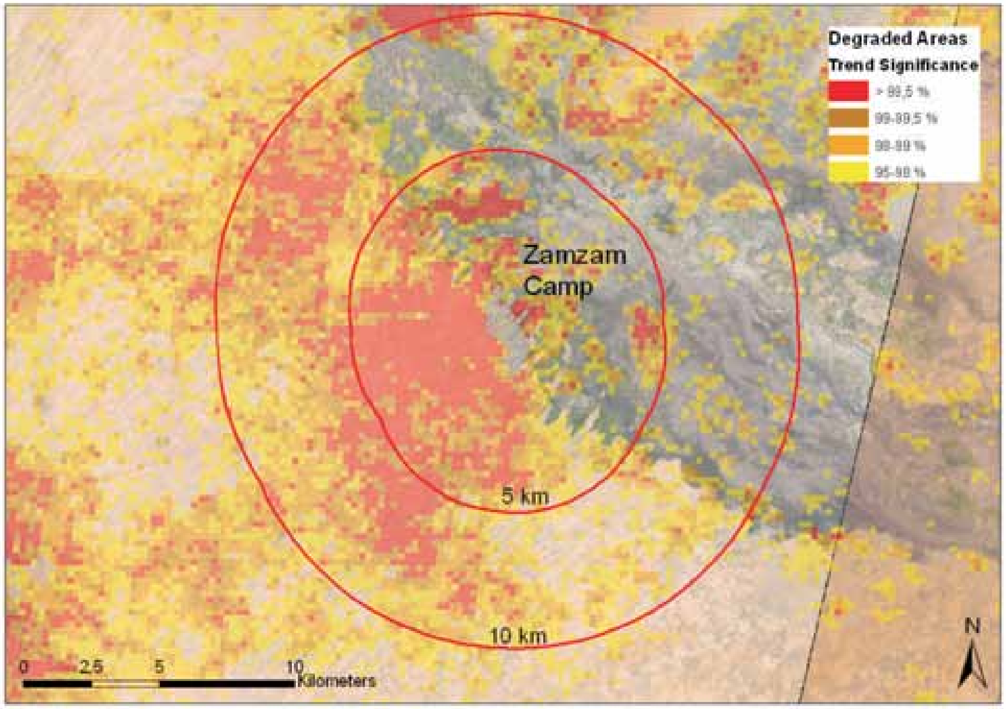

Figure 5: Trend analysis results for Zam Zam camp (orange) withy a 5 km buffer around the camp. The coarse red-transparent pixels show areas with a significant negative trend derived from a modified seasonal Mann-Kendell test.

Local Flood Early Warning Based on Low-Tech Geoinformatics Approaches and Community Involvement A Solution For Rural Areas in The Philippines

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Introduction and background

The vast majority of the more than 200 activations of the International Charter "Space and Major Disasters" to date (International Charter, 2009), including the very first event in 2001, have been in response to flood disasters. Such events come in various forms, at times related to excessive precipitation due to tropical storms, at others caused by snow melt, coastal or river dam breaks, volcano crater rim collapses or subglacial outbursts. With disasters defined as hazardous events causing damage that exceeds the coping capacity of the affected community, the spatial scale of such events is highly variable, depending largely on the distribution and accumulation of assets in threatened areas. Such accumulations are becoming increasingly common, reflecting both global population growth (and the consequent movement of frequently marginalized people into such areas), but also an increase in overall global asset wealth that may be adversely affected (Grimm et al., 2008;

(Grimm et al., 2008; Kerle and Alkema, in press). Global warming, with associated sea level rise and apparently more erratic and occasionally more violent weather patterns, has added to a widespread increase in flood risk. While weather forecasting abilities have greatly increased, aided by sophisticated space infrastructure and computer models, floods continue to affect largely unprepared communities, and often with little or no warning. Some events, such as the floods in Taiwan caused by Typhoon Morakot in August 2009, or in Manila caused by Typhoon Ketsana a month later, are results of extremely high rainfall, but the magnitude of casualties and damages is also a result of poor urban planning, clogged drainage systems, lack of early warning and poor preparedness.

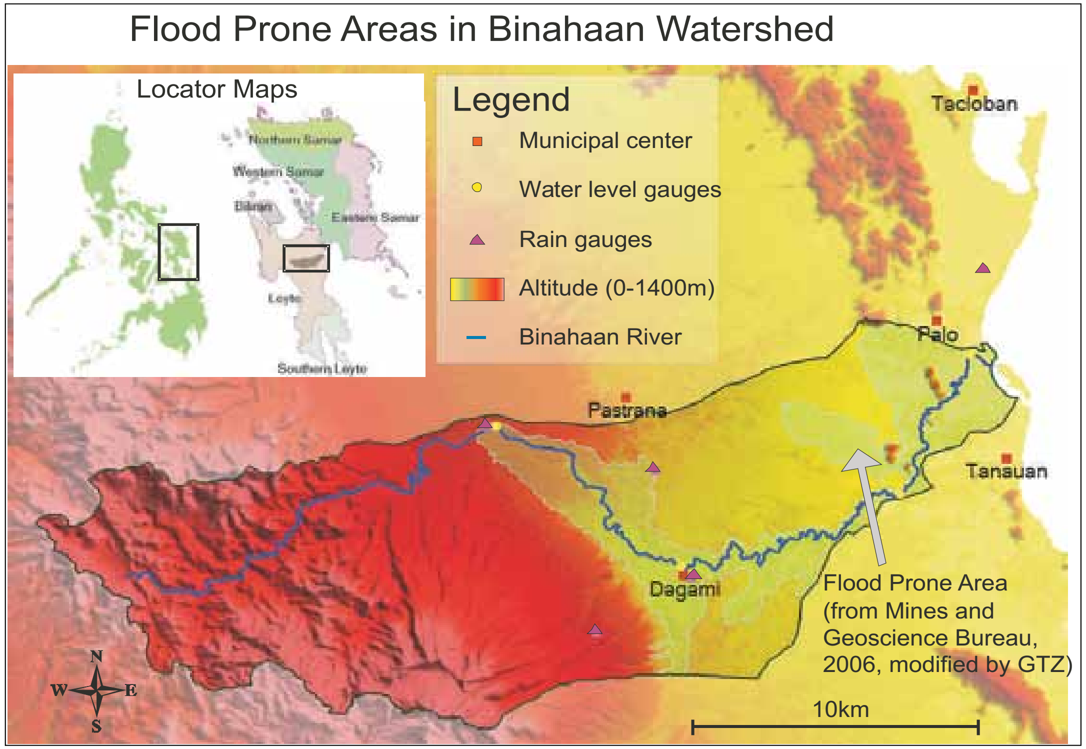
Floods are the most frequent disaster type globally (CRED, 2008), and in some parts of the world also the most costly. The generally straightforward relationship between excessive upstream rainfall and vulnerable areas exposed to potential flooding lends itself well to a geoinformatics-based risk assessment and management approach, and working examples have been widely reported. They can involve detailed maps of elements at risk and their associated flood vulnerabilities, satellite-based precipitation estimates, ground-based weather radar, river flow gauges, and sophisticated preparedness and early warning protocols. Many of the required data acquisition and analysis steps have become standard and automated, and hardware and data costs are diminishing, resulting in the implementation of such solutions also in economically less developed countries (LDCs).

Weather services or related organisations in many countries are monitoring the synoptic weather situation and the levels of major rivers, and are able to warn of impending floods. However, this is typically limited to major rivers or vulnerable urban areas. The part of the population that thus benefits less from such technical advances is the rural population especially in LDCs. According to World Bank estimates some 70% of the World's poor live in these areas, and whatever small development steps are made are readily compromised by frequent disaster events. This, therefore, raises the question to what extent geoinformatics-based flood management solutions can be scaled down and adapted to rural areas. A solution developed as part of a German Technical Cooperation (GTZ) project in Leyte in the Eastern Visayas, the Philippines, is introduced in this best practice case.

The flood situation in the Philippines

The Philippines is made up of more than 7000 islands, and annually affected by two monsoon seasons and on average 9 typhoons that make landfall. While those events can lead to exceptional rainfall, such as the 450mm in 1 day during Typhoon Ketsana, or the more than 2000mm in 2 days during Morakot in Taiwan, local flooding is frequent during monsoon times. The Philippines is a highly mountainous country, and sizeable catchments quickly drain large amounts of rainwater into downstream areas.

Figure 1: Location of the Binahaan watershed in the Eastern Visayas of the Philippines, and overview of the flood monitoring system



The Philippine Atmospheric, Geophysical and Astronomical Service Administration (PAGASA) is responsible for weather and flood forecasts, and does so with well instrumented and automated systems for major rivers. However, such approaches are not practical or affordable for smaller rivers, most of which are consequently not being monitored. For these areas a geodata-based system may still be appropriate, although it has to be low-cost, robust, sustainable and depend on strong involvement of the local population. This best practice example describes a system where the local population is both involved in the data collection and transmission, as well as in the early warning.

The Binahaan River basin flood early warning system

The Binahaan River is located in the province of Leyte in the Eastern Visayas of the Philippines (Figure 1). It stretches from a mountain ridge in the West to the Leyte Gulf in the East, covering an area of 272km2. It has a history of frequent flooding events in the Eastern lowlands, with an average of more than one damage-causing flood per year, and a small number of people having drowned during floods that occurred over the last 2 decades.

The reported damages are largely attributed to reduced harvest due to submerged crops, mainly rice and some vegetables, and also residential buildings and infrastructure occasionally sustaining damages. An increase in water-borne communicable diseases has been observed as well. In the view of local inhabitants the loss of crop, and as a result income, is the most significant impact of the floods. Towards the end of the monsoon periods, when the capacity of the watershed to buffer more water is severely reduced, events with a relatively small return period may be especially serious by causing extensive and widespread disruption.

Objectives and basic setup of the LFEWS

While not reducing the flood hazard, the establishment of early warning systems allows inhabitants of flood-prone areas to bring moveable items susceptible to water damage, such as harvests, livestock, household electronics, furniture and motorized vehicles, to safety. This can be in higher parts of buildings or elevated areas near their dwellings. As a river basin sustaining frequent floods (more than one per year) and with a relatively large flood-prone area (64km2), the Binahaan was chosen as the first site for the establishment of a local flood early warning system (LFEWS) in Region VIII of the Philippines. The LFEWS was developed in accordance with basic principles of people-centred early warning systems.

It consists of rain and river level gauges, an Operation Centre (OC) near the watershed where data are received, analyzed and the decision about a warning is taken. A communication chain down to household level facilitates the transmission of the warning. The LFEWS also includes evacuation routes, evacuation centres and emergency response capacity such as search and rescue teams (Figure 2). The provincial government of Leyte is running the system by setting up the OC, and coordinates the efforts of the four involved municipalities. They, in turn, contributed to the establishment of the system with some community-based approaches. This included hazard mapping with GPS and the development of disaster preparedness plans at village levels. The initial investments for the LFEWS (15,000 Euro) were paid by GTZ, and all running costs are covered by the provincial government. A cost-benefit-analysis estimated that the investment costs are recovered after eight years by reduced losses due to timely warnings.

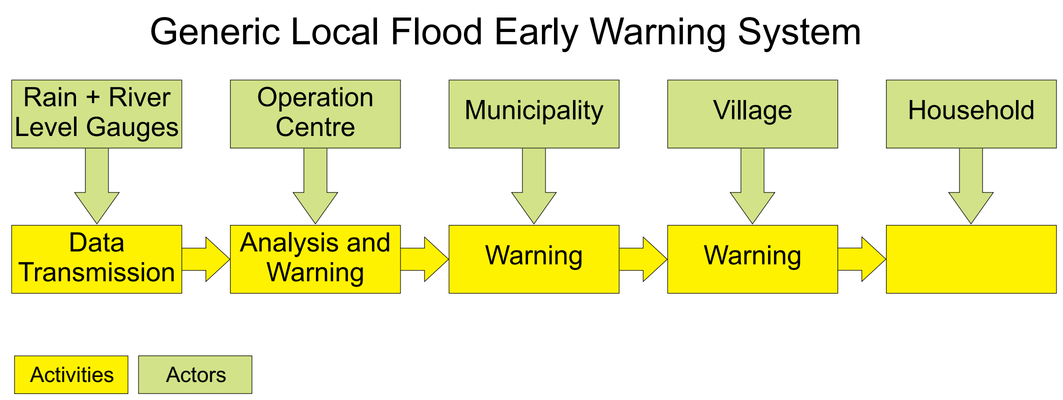


Figure 2: Schematic overview of the Binahaan LFEWS

Command and information chain

The central part of the LFEWS is a communication chain starting with reading and transmitting rainfall and river level data upstream to the OC. In case a threshold is exceeded a warning is issued by the OC and sent to the four municipalities. From there different villages are informed, and the message is passed onto the households. Most steps of the chain use mobile and landline phones, as well as radio communication. Households are often informed with bells or megaphones, which is a simple but robust method.

Warning colour scheme and communicating with the people

The LFEWS supported by GTZ merges local engagement and modern technologies. The rain and river level gauges are partly automatic, but many of them are manually read by volunteers from the community, with data sent by SMS to the OC. While most steps in the communication chain are covered by modern devices such as mobile phones or handheld radios, the final step in the chain is usually a bell made from a cut gas cylinder. Warnings have three stages: alert/standby, preparation and evacuation (Figure 3). Each stage has specific conditions to be fulfilled before the respective warning level is issued, and each stage requires a set of actions from different institutions such as emergency services or the preparation of evacuation centres. The Flood Warning Plan is customized for the OC, the town Disaster Coordinating Councils (DCC) and the village DCCs. It comes in a colour scheme with yellow, orange and red for the three stages. The acoustic warning signals are easily recognised. One bang with a long break is Level 1, two bangs with a long break after is Level 2 and continuous banging is Level 3.

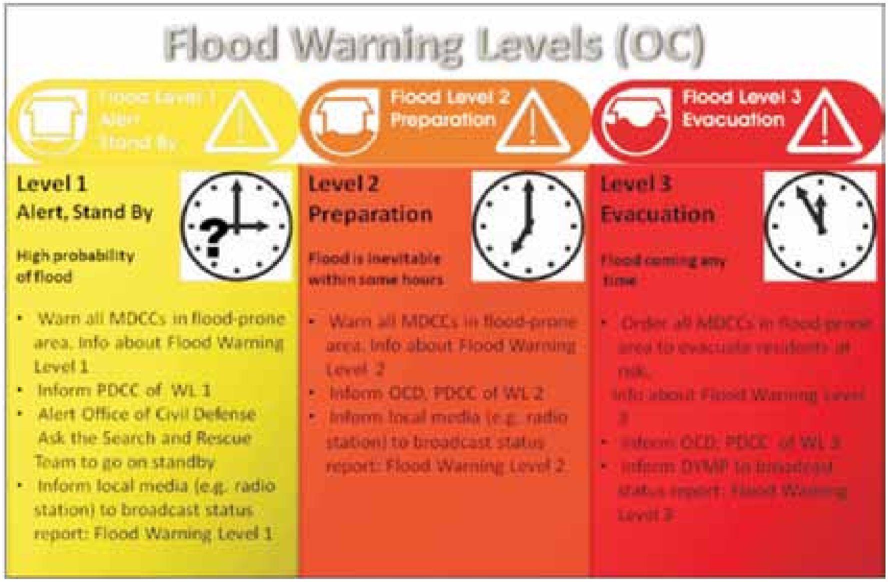


Figure 3: Colour-coded alerting scheme used in the LFEWS.

The potential of low-cost geodata and tools in local flood early warning

In Binahaan it has been difficult to characterize the watershed and the flood prone area from locally available geodata sources. The official topographic map is 50 years old and little statistical data on the socio-economic situation are available. Satellite data can partly fill this gap. The elevation distribution, the current river bed, and the land cover/land use were identified using Shuttle Radar Topography Mission [SRTM] (Kummerow et al., 1998) or Aster Global Digital Elevation Model [GDEM] (see http://asterweb.jpl.nasa.gov/gdem.asp), and SPOT/ASTER optical imagery (e.g. Figure 4).

The local capacity to use geoinformatics for LFEWS is gradually growing but still limited to a small number of institutions, such as universities and a few others. Substantial training is needed to enable more institutions to make full use of the potential of remote sensing and GIS tools. Cost remains a factor limiting the spreading of geoinformatics to many offices. However, the potential of free or low cost tools and data in flood risk management is substantial. There are several free and open-source (FOSS) GIS and remote sensing programs covering a wide range of tasks. Nevertheless, for specific processing tasks, such as for actual flood modeling or more advanced image processing, commercial software is still needed, and was also used in the setting up of the Binahaan LFEWS. Use was made of free or low-cost satellite data (e.g. Landsat, SRTM, or GDEM). The project also used SPOT data obtained via a Planet Action project of SPOT Imaging, which supports projects related to adaptation to climate change. Also the potential of 3-hourly data from the Tropical Rainfall Measurement Mission (TRMM) satellite to estimate real-time rainfall was assessed. These data are available without charge via the internet. Historical ground rainfall measurements were compared with the respective TRMM data. However, for the watershed size considered here, the error of the TRMM data was too large for the data to be used for warning purposes. Nevertheless, the data have been used successfully elsewhere, and new instruments and algorithms suggest that satellite-based rainfall estimates may soon be reliable enough for most areas. Their most significant advantage is that for areas where no rain or river gauges exist, early warning will still be possible. Even where ground instruments are available, real-time satellite estimates mean an extra time advantage

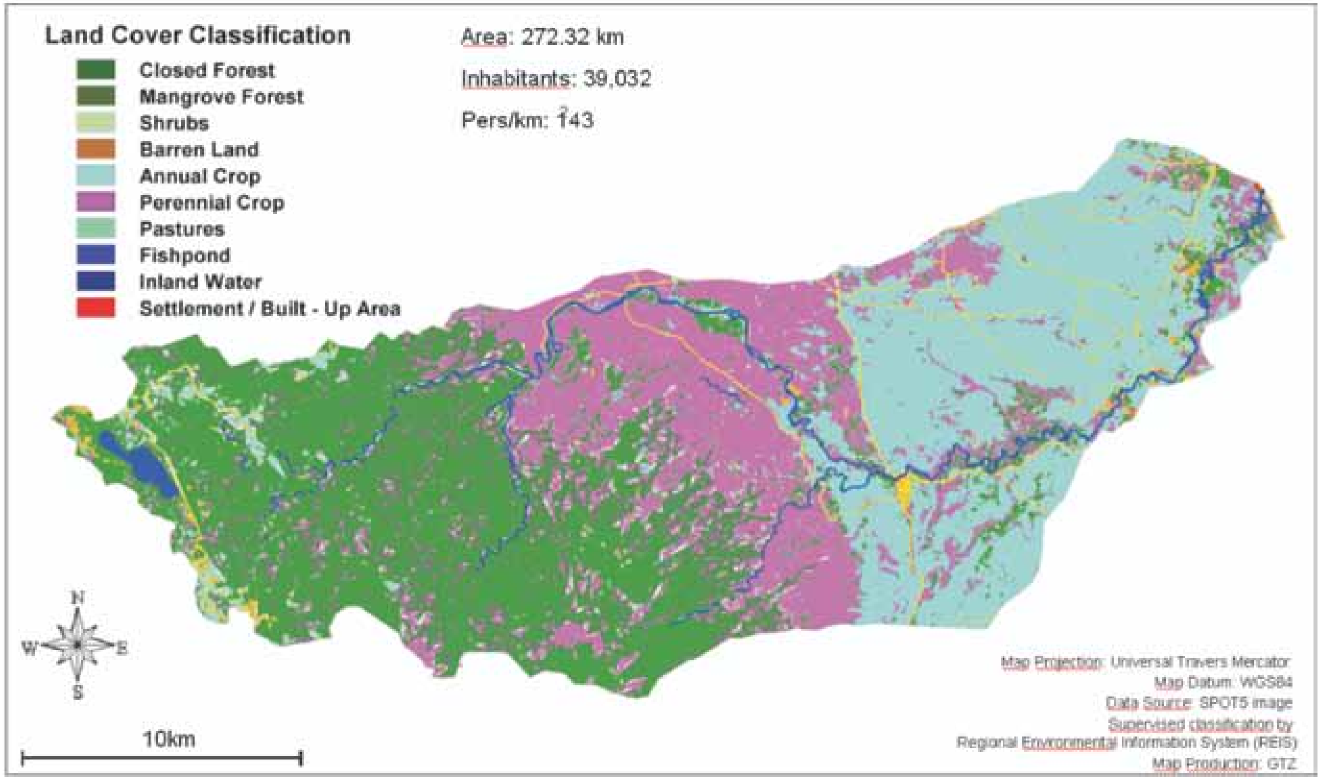


Figure 4: Land use map of Binahaan river basin based on SPOT and ASTER data.

Accomplishments and limitations

The Binahaan River LFEWS has been operating since 2007 and largely without flaws (see also http://www.leyte.org.ph/binahaan/). This means it did not miss a single flooding event and it did not issue a false alarm. It was activated 13 times, giving residents between 3 and 10 hours to move possessions and evacuate. This also includes warnings at Level 1 that do not always lead to a Level 2 situation. A survey revealed that the majority of inhabitants of the flood-prone area are satisfied with the LFEWS, and that flood damage has been reduced.

The data currently available for the hydrology and characteristics of the watershed (e.g. slope map) are not sufficiently precise to run actual computer flood models. This is a constraint, especially when it comes to rare but very high floods not experienced by the generation of people currently living in the river basin. It was also observed that data gathering by community volunteers is at times erratic and does not provide enough reliability for basing the whole system on volunteer contributions.

The LFEWS introduced here is an effective tool to issue early warnings and thus increase preparedness and reduce damage. However, disaster risk management (DRM) is a comprehensive strategy that should also include other aspects of risk reduction, such as careful urban and regional planning (e.g. prohibiting settlements in highly flood-prone areas), or flood hazard reduction via afforestation in the watershed (Smith, 2004; Wisner et al., 2003). Geoinformatics has been shown to be highly useful for all aspects of DRM and virtually all natural hazard types (Ebert et al., 2009; Kerle et al., 2008; Zhang and Kerle, 2008), but a real effort is needed to set up and maintain such systems, which includes building and retaining the required human and technical capacity to lead to a lasting increase in capacity to face environmental hazards (Smit and Pilifosova, 2003). The Binahaan system demonstrates how low-cost solutions can be as effective as expensive monitoring installations, provided they have appropriate political support as well as that of the affected people, i.e. they have a sense of ownership.

Development and Testing of a Low Cost Sensor PDGNSS Landslide Monitoring System using the Example of the Aggenalm Landslide in the Bavarian Alps

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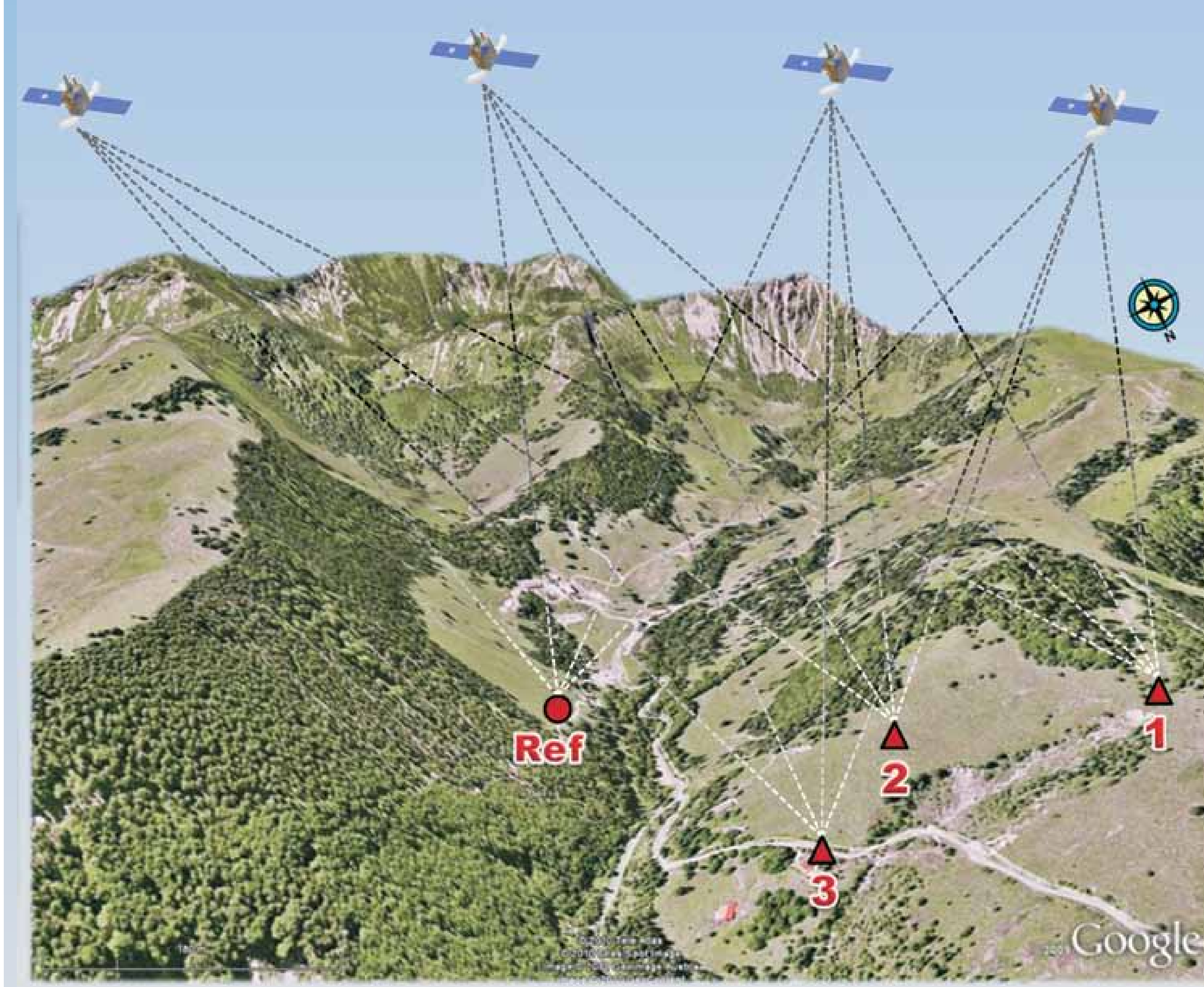
Introduction

Exclusive geodetic and geotechnical instrumentation for landslide monitoring tasks is available today but for economical reasons it is not used on a broad scale. At the same time the number of localities with urgent need for surveillance is rising due to global climate change, increasing tourism in mountainous areas and the build-up of new infrastructure objects such as settlements, roads and railways. This lack of adequate surveillance in future can only be overcome using more cost-effective powerful surveillance techniques. Furthermore, monitoring systems should ensure the delivery of data and meaningful results to all involved stakeholders, using permanently open interfaces. In this sense such monitoring systems should be seen as an essential part of the spatial data infrastructure.



Satellite based positioning techniques are very commonly used for geodetic monitoring of objects such as landslides. Currently a low cost (LC) PDGNSS monitoring system on a commercial off-the-shelf basis, has been developed at the Institute of Geodesy, University of the Federal Armed Forces of Germany in Munich (Pink 2007, Günther et al. 2008, Glabsch et al. 2009) as a cost-effective readily available technique for monitoring tasks.

GNSS NRTP approach - brief theory

To meet the required accuracies of a few millimetres for point position in monitoring applications, only carrier phase (CP) based GNSS methods come into consideration, which is the so-called precise differential positioning (PDGNSS). By using PDGNSS techniques to observe discrete points permanently in a monitoring network, the results should be available with a minimum of delay, involving near real-time processing (NRTP). This approach is based on the evaluation of CP measurements recorded over certain, in principle freely and individually selectable time spans at different locations. Depending on the receivers, the satellite visibility and the expected velocities of the points, usually a time interval of about 15min referred to as an 'epoch' in the following with a recording frequency of 1Hz or similar can be considered for the CP raw data acquisition for landslide monitoring tasks. Once the raw data from several locations at least one should be on stable ground and the others are spread on the slope is available at a central computing location the baseline processing can start immediately.

Standard WLAN can be chosen for permanent wireless communication between the different locations and the central computing station. Thus the combination of sensing, communication and affiliated computing forms a geo-sensor network (GSN) and the locations the reference and object points are designated as sensor nodes (SNs). Since the distances range up to several kilometers, normally special WLAN antennas or alternatively repeater stations are needed on site.

For economical reasons simple LC L1 navigation receivers have been investigated at the Institute of Geodesy (Pink 2007, Günther et al. 2008, Glabsch et al. 2009) as the sensor component at the SNs. The main prerequisite of these receivers is that they must have the possibility to read-out the CP raw data, for instance via RS232 or USB. Most of the simple navigation receivers make use of these data for some internal smoothing operations, but do not have the ability of an autonomous phase-based positioning, as do the customary rovers commonly available in the real-time kinematic (RTK) systems. Finally, the chosen NRTP concept opens up the possibilities of the well-known options of highly sophisticated post-processing for all kinds of simple receivers in a geodetic monitoring network adjustment, which are of course not solely restricted to low cost equipment.

In addition to the length of an epoch, a short delay due to gathering and evaluating all data at the computing station has to be accepted in applying this concept. Considering the expected landslide movement rates and the essential advanced warning times, the concept of "near real-time" should present no limitations on its intended use for early warning of landslides.

System layout - example of GSN Aggenalm (project alpEWAS)

Aggenalm Landslide monitoring concept

The Aggenalm Landslide will be discussed as a practical realization of the above briefly described LC PDGNSS NRTP approach. This work is embedded in a comprehensive development of a widespread and cost-effective GSN for landslide monitoring in the alpEWAS project. The project is funded by the German Federal Ministry of Education and Research (BMBF) in the geo-scientific research and development program "Geotechnologien". For more details please see Thuro et al. (2009a, 2009b) and refer to www.alpewas.de.

Innovative geodetic and geotechnical measuring techniques are applied for monitoring the landslide mechanisms at the test site Aggenalm in the Bavarian Alps. Time Domain Reflectometry (TDR) which is an automated low cost inclinometer, low cost Global Navigation Satellite System receivers (GNSS) and a recently developed reflectorless Video-Tacheometric Positioning System (VTPS) are being investigated in this project. By combining the data of all these different measuring systems, 3D deformation information can be derived not only with high spatial, but also with high temporal resolution, as all three systems can operate continuously. However, at present, the VTPS is used only temporarily at the Aggenalm Landslide site. The three techniques are combined in a multifunctional GSN as shown schematically in Fig. 1. All sensor nodes can be read at two places which are connected to the base station. All data traffic is handled in a WLAN supplemented by some cabled connections for economical and practical reasons. A central computer manages all system operations, e.g. data collection and logging and controlling of the sensor

nodes. For remote maintenance and supervising a DSL internet connection via satellite is set up at the base station using additionally a relay station at the so-called main sensor node. The central station is a personal computer and hence connected to the local power network (220 V). At the Aggenalm Landslide, although not mandatory, the main sensor node with a high diversity of different sensors and functionalities is also cable-connected to the local power network. All other sensor nodes have a battery-operated autarkic power supply (solar panel, charge controller and battery). An additional fuel cell is installed at the GNSS reference sensor node, because during winter the solar radiation at this location is very low. In the following only the GNSS component of the GSN Aggenalm is described.

LC PDGNSS hardware components

Sensor component

To meet harsh environmental conditions, Novatel Smart Antennas are selected as positioning sensors. This receiver type is an encapsulated system of board and antenna. See Fig. 2a for some specifications. Two different models are used at present: older Superstar II receivers with GPS functionality only; and the newer OEMV-1G receivers providing GPS and GLONASS functionality. Besides code based position, the carrier phase is recorded and can be read-out by the serial port. Depending on the satellite visibility such a 12/14 channel L1 receiver with a recording frequency of 1Hz generates about 0.3 0.6MByte of binary data in a time period of 15min.

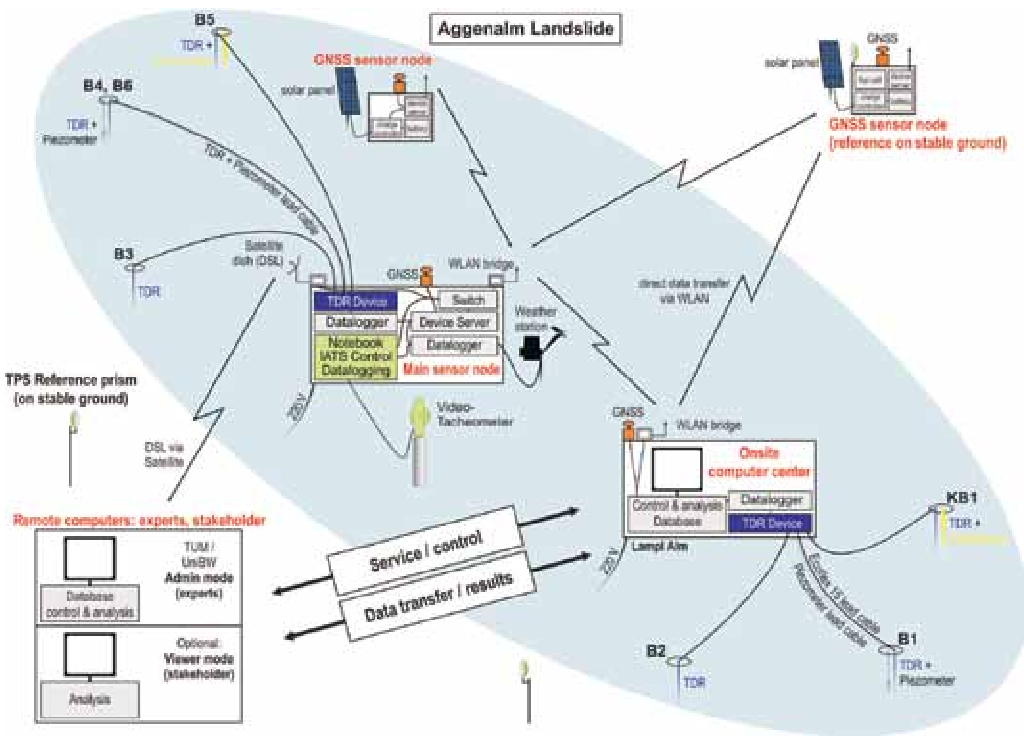


Figure 1: *Schematic configuration of the GSN Aggenalm Landslide (Thuro et al. 2009a).*

NovAtel

Weight: 575 g

Size:
115 mm diameter x
90 mm height

Selected specifications:

	Novatel Smart Antenna	Novatel Smart-V1G Antenna
Rec. type	Superstar II	OEMV-1G
No. channels	12 L1 GPS	14 L1 GPS 12 L1 Glonass
Accuracy CP	1 cm rms	0.15 cm rms

Figure 2a: *Novatel Smart and Smart-V1G Antenna.*

Figure 2b: *GNSS SN (Novatel Smart Antenna, WLAN-Antenna, solar panel, alu-box with battery, charge controller and wireless device server).*

Communication component

Widespread and cost-effective deployment of a GSN especially needs to make use of commercial off-the-shelf wireless communication techniques and standardized protocols. An infrastructural WLAN is used for the connection of the SNs in the field. Compared with conventional radio data transmission, the key benefits of a WLAN are: more cost-effective acquisition; easier addressability of the SNs; lower power consumption in autarkic usage; not subject to authorisation requirements; different possibilities of encryption exist; and a suitable high data transfer rate is achievable, which is a precondition for using the LC PDGNSS approach.

All measuring devices are connected to wireless/wired device servers, which normally operate with two or more serial ports. Such a unit serves as a serial port to an Ethernet converter and comprises an essential interface between every SN and the communication network. To bridge distances of more than 500m, special external antennas are used to provide adequate WLAN connectivity, even in environmental extremes such as heavy rain, ice and snow. However, a more or less free line-of-sight between the transmitters and receptors is essential.

Autarkic power management

Secure energy supply of the SNs is of top priority, especially for long-term monitoring without loss of data and permanent year-round operability in mountainous regions. The concept at Aggenalm provides solar panels together with back-up batteries. Additionally fuel cells are an alternative option. Based on the total power consumption of about 2.9W for a single LC PDGNSS SN as shown in Fig. 2b, back-up batteries with a capacity of 130Ah are chosen to enable the system to operate continuously for up to 20 days without need for recharging. This time span called autonomy factor seems to be suitable for Alpine environmental conditions which receive snow for nearly 6 months in a year and have long periods of overcast sky. Charge controllers protect the batteries from total discharge or overcharge and also transmit metadata to the system administrator predicting potential failures caused by power shortfalls.

Computing resources

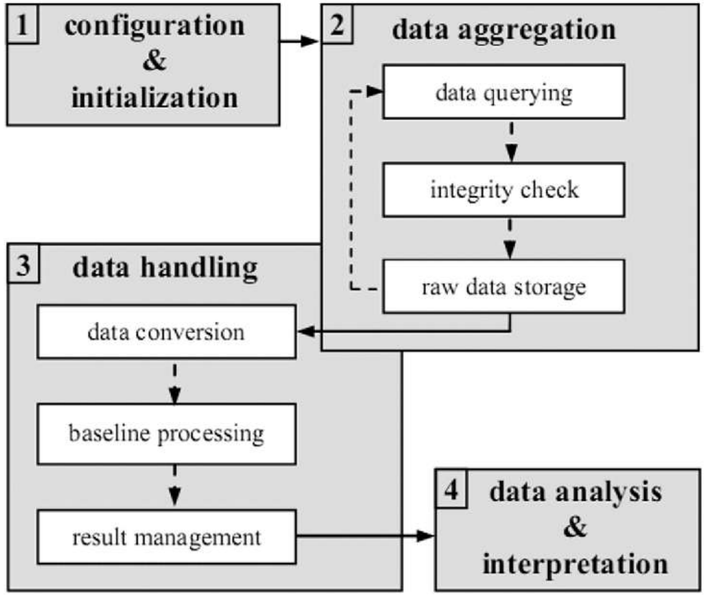
The data sink and processing unit is implemented by a customary personal computer. Demands for PDGNSS computing resources at the Aggenalm are small due to the fact that there are only four SNs on-site. For a steady program running an uninterrupted power supply (UPS) is highly recommended. Remote access and control by a host computer using an internet connection is an indispensable element of the developed system, especially because of maintenance and data backups. Due to missing infrastructural requirements this is performed by SkyDSL in the Aggenalm project, see Fig. 1.

Software

Data handling and processing is accomplished by several different software packages based on a modular design. The core of the PDGNSS monitoring component is the Central Control Application (CCA), see Fig. 3. It is developed using the graphical programming language LabView®, National Instruments. All necessary steps from system initialization, data collection, to the handover of processed and checked baselines for subsequent time series analysis, are actuated and supervised. Several subprograms, e.g. sensor activation are termed as virtual instruments (VIs).

The modular, prospective design offers the option to integrate a great diversity of PDGNSS sensors (Glabsch et al. 2009b). Interfaces permit embedding of existing and proven software packages, especially for baseline processing with e.g. Waypoint GrafNav (Waypoint 2007). From every embedded software tool a command line based control is the essential requirement. Some more details of the CCA are given in Glabsch et al. (2009a).

Figure 3: Central Control Application (CCA) work flow (see Glabsch et al. 2009a).



Some results

The LC PDGNSS system at Aggenalm passed the first practical test in winter 2008/09 very satisfactorily. Snow coverage of 2 metres and temperatures below -15°C had no negative effects on the different components. A winter impression from the site is presented with Fig. 4. Data recording has operated without failure since February 2009. Springtime with snow melt, which is generally a period of extraordinary concern for landslide movement processes, and also a period of continuous and heavy rainfall in June 2009, could be completely observed.

Figure 4: Winter impression at Aggenalm Landslide. The picture shows a Novatel PDGNSS sensor and the weather station.

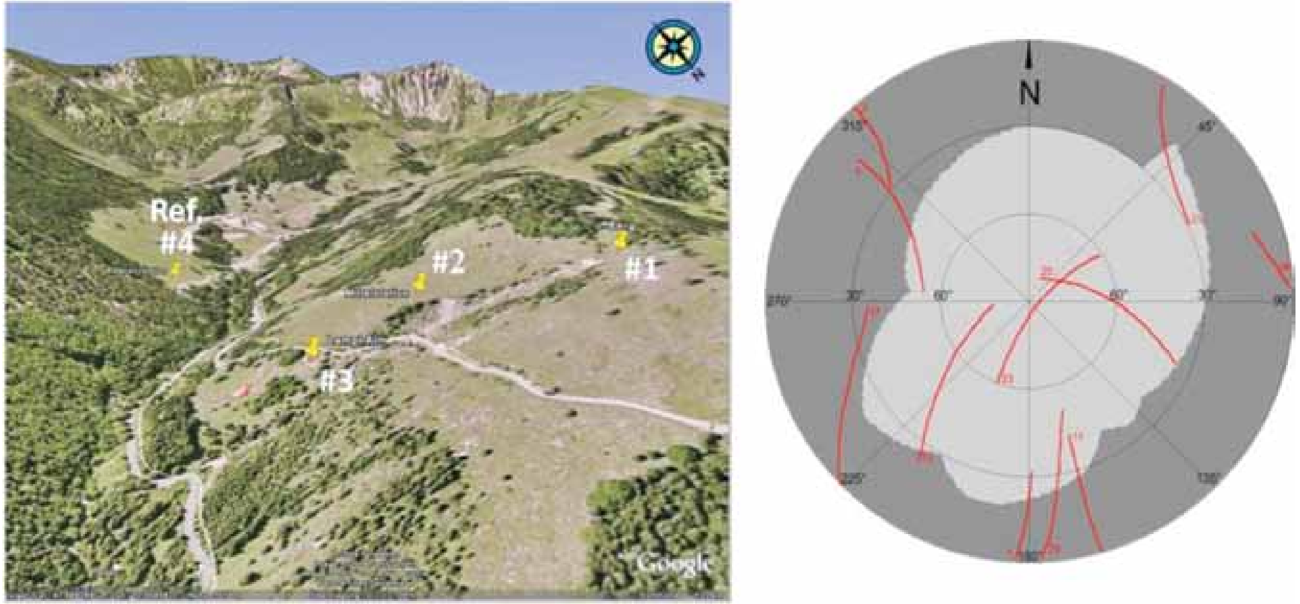


Figure 5: Shadowing situation at the Aggenalm. On the right an obstacle mask for the baseline between SN #1 and #4 for a time slot of 2 hours in summer 2009.

However, no detailed assessment of the slide will be performed here. In focus is only the achievable data quality with the developed LC PDGNSS system.

However, the “raw” GNSS solutions which means the epoch solutions from the baseline processing of each sensor on the slope, have to be filtered to reject outliers and to bypass gaps. Outliers mainly occur due to temporary bad satellite visibility (typically shadowing effects in mountainous areas).

With an increased number of satellites in future, hopefully a much better coverage will be available and reliable GNSS-based positioning will be permanently possible, even under often restricted conditions at landslide sites (see Fig. 5).

The quality of the processed horizontal position raw data (height is worse by a factor of 3) of sensor #3 (Lampl Alm) for a selected day is shown as an example in Fig. 6. After the elimination of incorrect measurements the total variations of the horizontal positions are clearly less than 1.5cm.

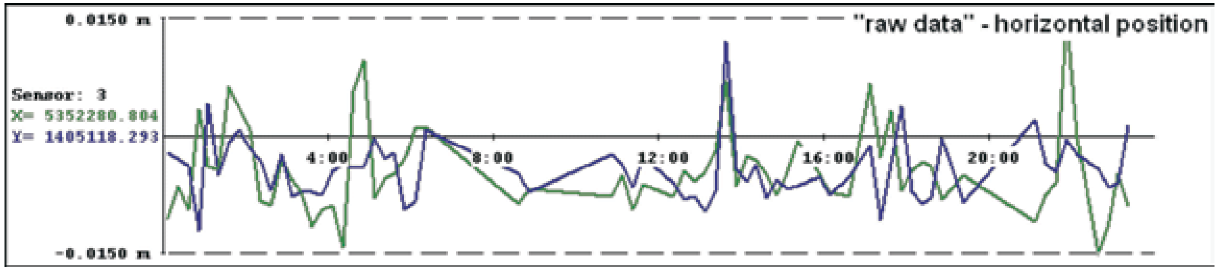


Figure 6: *Variations of the horizontal position during a representative day. Depicted are the 15min. solutions of SN #3 where all outliers are eliminated and the gaps are closed.*

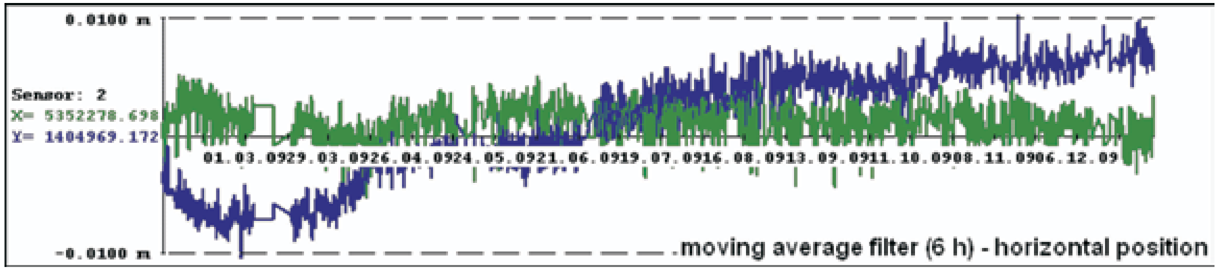


Figure 7a: *Medium-term trend of SN #2 (moving average filter of 6 hours between February and December 2009). Even small movements (in downhill direction) are quite clear. The estimated movement rates of the slide from former sporadic measurements are at the order of 2cm per year which can be confirmed by the developed system. However, small gaps due to system breakdown and other failures in March and December can also be seen.*

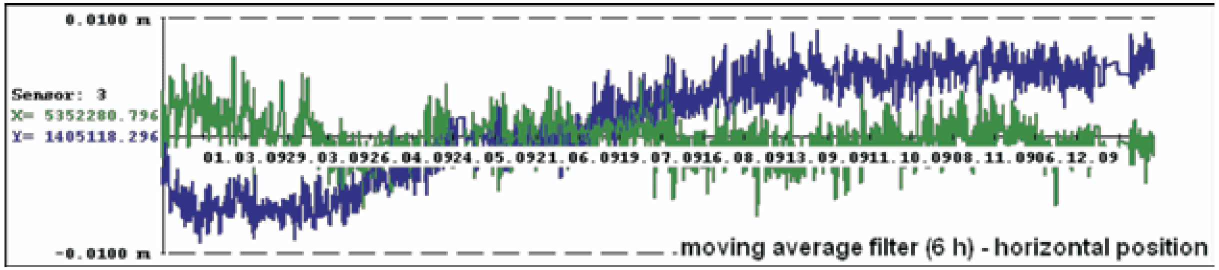


Figure 7b: *Medium-term trend of SN #3 (moving average filter of 6 hours between February and December 2009). For interpretation see text at Fig7a.*

In order to predict long term trends of the deformation process the use of longer filter intervals, e.g. 6 hours, is applicable. Referring to Fig. 7a and 7b even small movements are clearly become visible, e.g. in springtime under the influence of snow melt (April May) or periods of heavy rainfall (which occurred at the end of June 2009 in the Alps).

The depicted results of the LC PDGNSS monitoring system and especially the fact that measuring data is available in near real-time with a high spatial-temporal resolution, allows further geological assessment and interpretation of the landslide. In combination with data from other systems (e.g. TDR, video-tacheometer and weather station at Aggenalm) an additional benefit for geo-mechanical models and prediction of collapse can be obtained by an integrative analysis. In contrast to relative measurement methods such as TDR in boreholes or extensometers for the surveillance of cleavings, PDGNSS provides absolute 3D positions allowing reliable statements about absolute motions and the precise direction in space. The developed LC PDGNSS monitoring component therefore can be seen as a key system for economic landslide monitoring. However, further effort has to be made to increase reliability and accuracy. The actual work concentrates on a comprehensive quality management and on developing additional processing and estimation procedures within the CCA.

Interoperable data access - Integration of the PDGNSS component in the evaluation concept at the Aggenalm Landslide

One important aspect for an up-to-date monitoring system is ease of use of the results. Status information of the observed object - including manifold metadata - should be attained as fast as possible and easily understandable to the corresponding users (e.g. administrators, experts, stakeholders, common viewers). In times of worldwide network-links by the internet, interoperability has top priority. Trouble-free data exchange between heterogeneous systems is only possible with standardized interfaces. Therefore providing open, standardized interfaces is an essential criterion.

Interoperable data exchange requires the unavoidable renunciation of file-based data storage to a flexible and powerful (geo) database solution. The management of huge amounts of data with parallel and permanent access shared normally by several different users is possible due to modern data base management systems (DBMS). To satisfy requirements of "interoperability", the GSN at Aggenalm Landslide uses an open source MySQL database. The data flow and interaction of the three different measuring methods is depicted schematically in Fig. 8. The LC PDGNSS component fits into the complete system as a so-called "sensor plug-in". The flexible design of the developed software package described in section 3.3 allows standalone adaptation, as well as trouble-free integration in a more complex data flow.

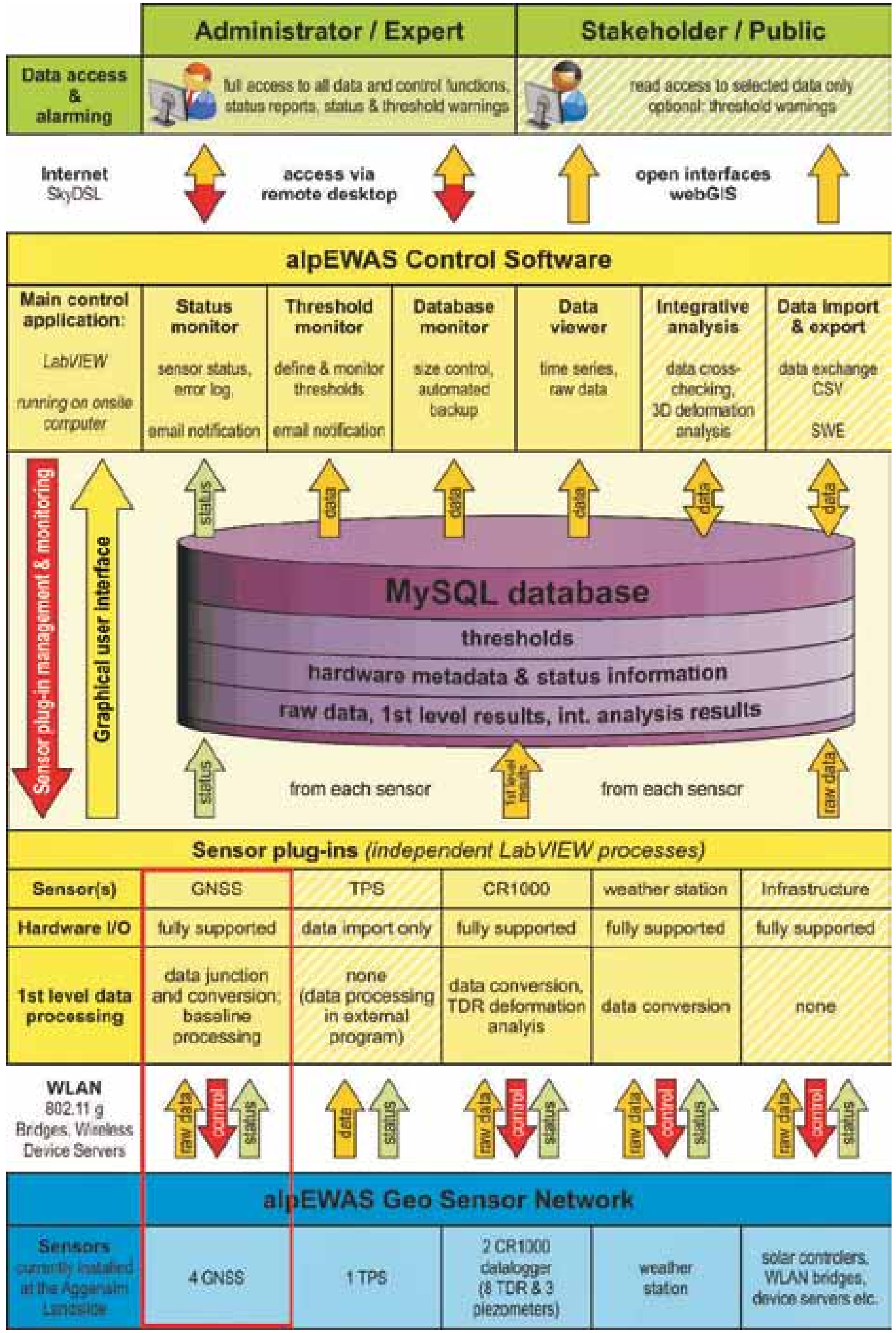


Figure 8: Structure of the alpEWAS sensor control and data management solution. The hatched elements are currently still under development (Thuro et al. 2009b).

Conclusion

The LC PDGNSS NRTP approach described above demonstrates today's possibilities in monitoring tasks with cost-effective satellite methods. The achievable data quality using LC PDGNSS equipment is characterized briefly. Finally, the assignment of a flexible database solution meets the compulsory requirement of interoperable data exchange.

It becomes apparent that while results obtained so far are already very satisfactorily, there is a further need for intensive research and development. Our main work actually concentrates on improving accuracy and reliability of the system, and as well on investigation of suitable “cheap” GNSS sensors. Of course the developed system can also be embedded for location finding in any widespread multifunctional GSN and is not restricted to landslide monitoring.

Acknowledgement

The project “alpEWAS” is supported by a grant of the German Ministry of Economy and Technology within the Geotechnology Program.

Tunnel Monitoring and Alarming Controlled by a Project Information System

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Introduction

Severe disasters happen quite often in underground construction projects such as at urban tunnel sites (see Fig. 1). After such man-made disasters we always ask the same questions: Could we have been warned? Could this have been avoided?

In order to ensure tunnel construction projects are safe and better managed, Kronos has been developed and has already been successfully applied in a number of projects. Kronos is an integrated information system allowing for the acquisition, checking, storage, analysis, visualisation, reporting, and finally a warning system for tunnel project data. Its particular advantage is that, compared to existing solutions, all safety-relevant data produced on site (e.g. monitoring data) is integrated into one single data management system and utilized by most modern and efficient alarm functions. This makes possible the automatic execution of complex monitoring and alarm processes including thousands of data sources such as online monitoring sensors and tunnelling machines. The system is described briefly and two major European tunnel construction sites are presented as examples of its use to monitor and provide alarms on impending disasters.

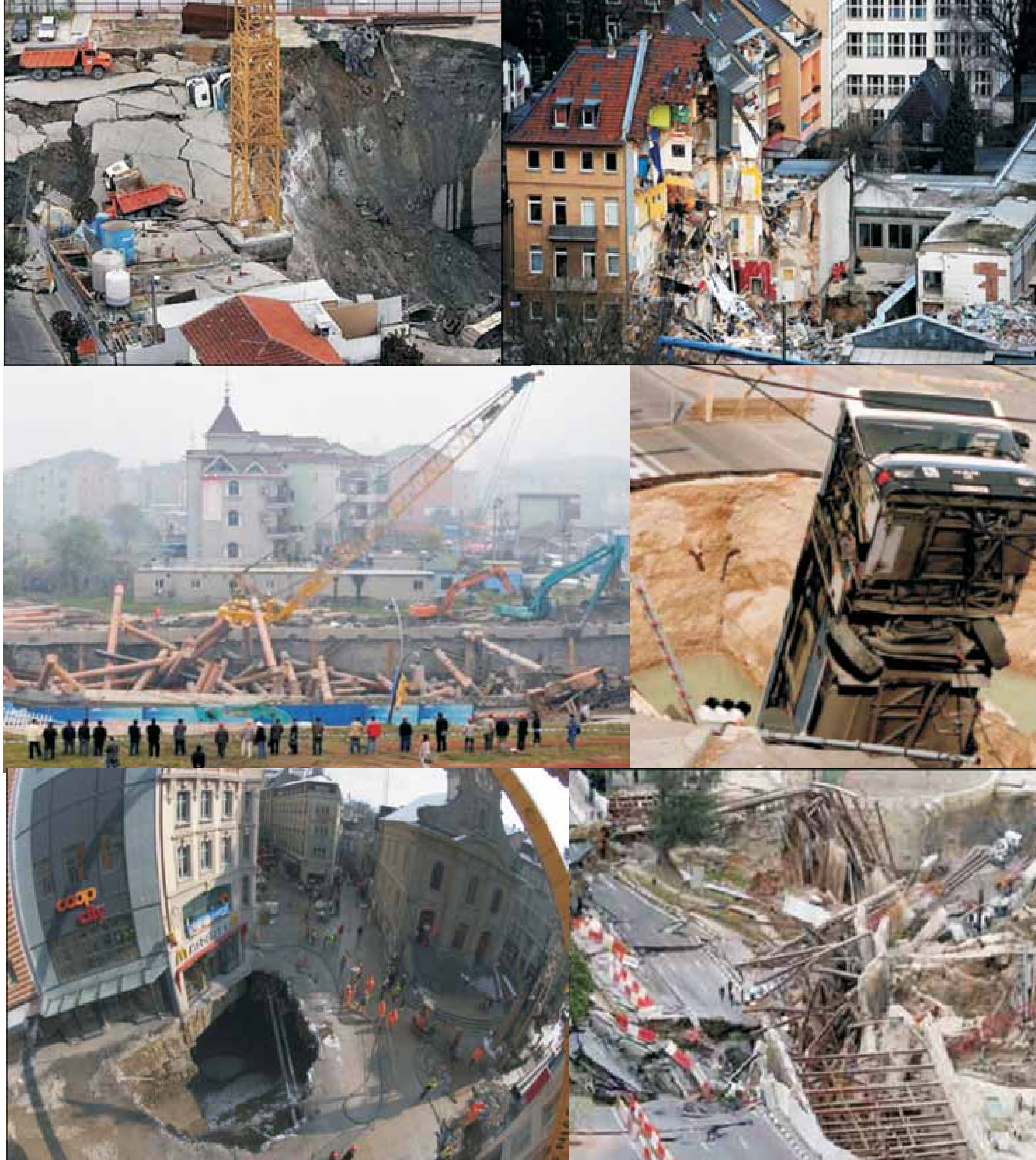


Figure 1: Recent tunnel collapses, from upper left to lower right: Sao Paolo 2007 _ Cologne 2009 _Hangzhou 2008 Munich 1994 _ Lausanne 2005 _ Singapore 2004

Kronos

Kronos is an information system developed by Geodata that is designed to store, manage and utilize the data categories shown in Fig. 2.

Authorized users can access the system either locally or remotely (e.g. via internet) through user-friendly interfaces to carry out data input/output or import/export, produce various types of problem-oriented visualisations, etc. Integrated services perform automatic data acquisition, reporting and alarms and are capable to transfer huge volumes of data from and to the system without user interaction.

Kronos at Budapest Metro Line M4

Project introduction

The new line M4 of Budapest Metro (see Fig. 3) connects the districts Kelenföld in Buda and Rakospalota in Pest. The line has a length of 7.2 km with 10 stations. The excavation of the two parallel tunnels is done with two Tunnel Boring Machines (TBM), each having a total length of 113 m and a cutter head diameter of 6.1 m. The difficult geological conditions on the side of Pest, the passage under historical buildings, and the crossing of the river Danube with a minimum of overburden created a major challenge for the engineers responsible for the execution of an extensive geotechnical monitoring program. The station buildings are constructed by cut and cover and, partly with the New Austrian Tunnelling Method (NATM).

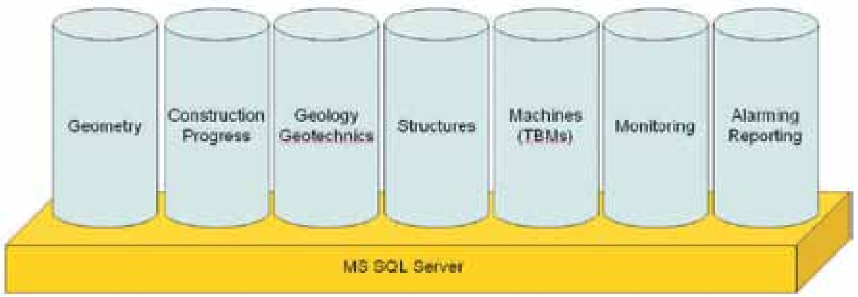


Figure 2: Data categories covered by the information system Kronos

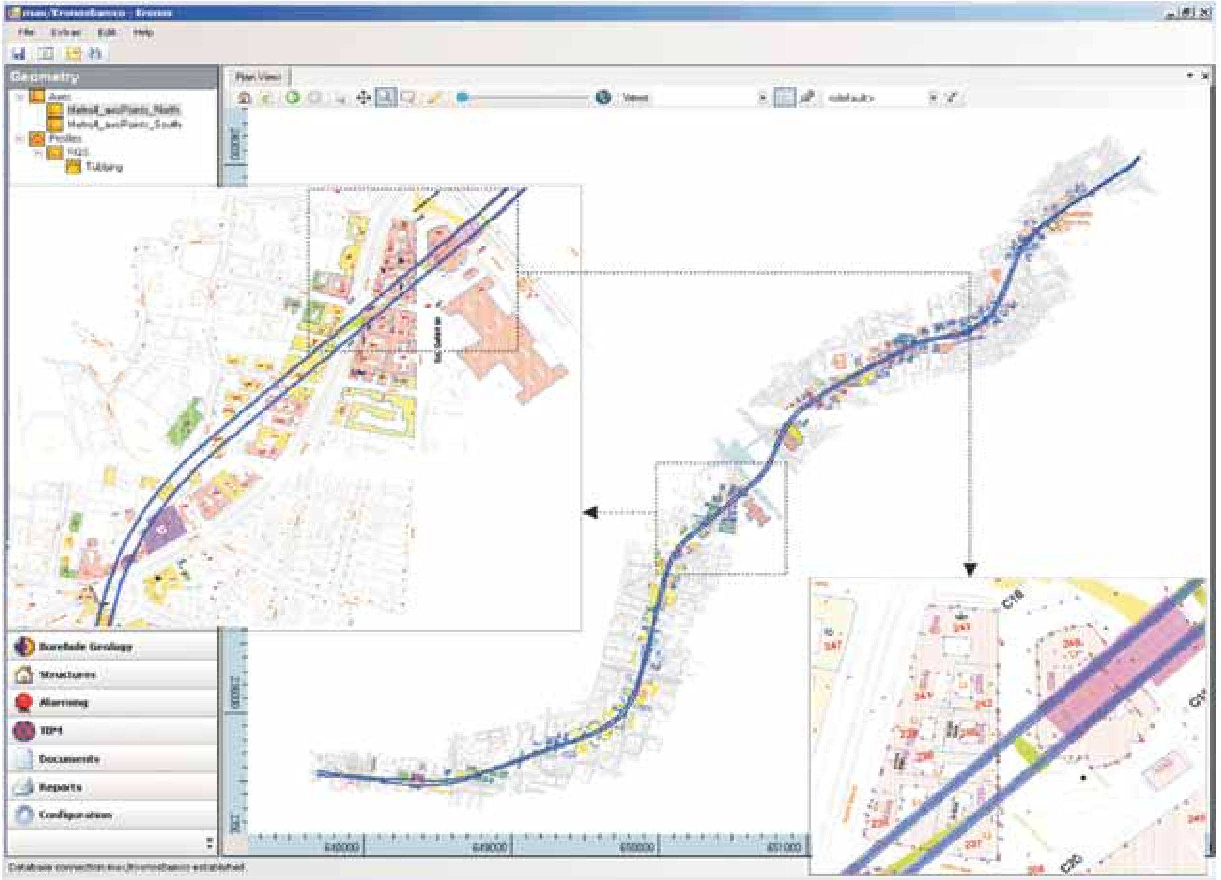
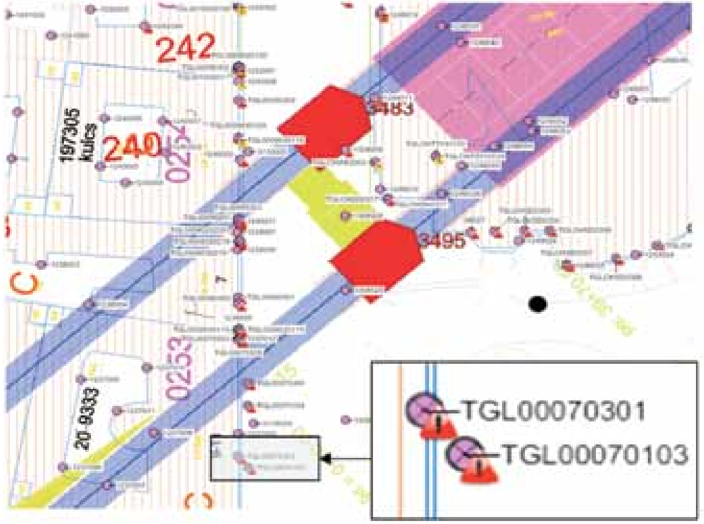


Figure 3: Map of Budapest Metro line M4 displayed in Kronos

Kronos application

The geotechnical monitoring at Budapest Metro is based on different types of monitoring sensors such as 3d targets (measured with totalstations), levelling points, inclinometers, tilt meters, rod extensometers, etc. A total of nearly 10.000 monitoring sensors and points are installed in the city on the surface and underground.



Their monitoring data are transferred periodically from Budapest to the Geodata office in Graz (Austria), where the Kronos database server is located. There, all data are stored and an automatic alarm service is operating. The service manages and executes 260 alarm rules at 3 alarm levels (warning, alert, alarm) that permanently check all data and in the case of a potential emergency immediately and automatically sends alarms to about 31 different alarm receivers on site. As the system not only captures monitoring data but also integrates further project data (e.g. TBM progress), all data can be linked and used for alarms and interpretation. Fig. 4 shows an example where monitoring points on the surface (some indicating an alarm) are displayed live, together with the actual positions of the two operating TBMs so that their influence on the monitored deformations can be better interpreted. Kronos can also use the TBM data to dynamically change the current alarm levels of the monitoring sensors and points and/or even automatically increase their measuring frequency. In this way, a dynamic monitoring and alarm notification can be performed. A unique characteristic of this project is that the system installation follows a modern server hosting concept where data is not stored locally on-site, but transferred over hundreds of kilometres (including across a state border) to a remote, sub-contracted data processing centre that is accessed and distributes data via the internet.

Figure 4: Kronos user interface showing a live-map situation of Budapest city with monitoring points in alarm status while two tunnel boring machines are excavating underground.

Figure 5: Thessaloniki Metro overview map

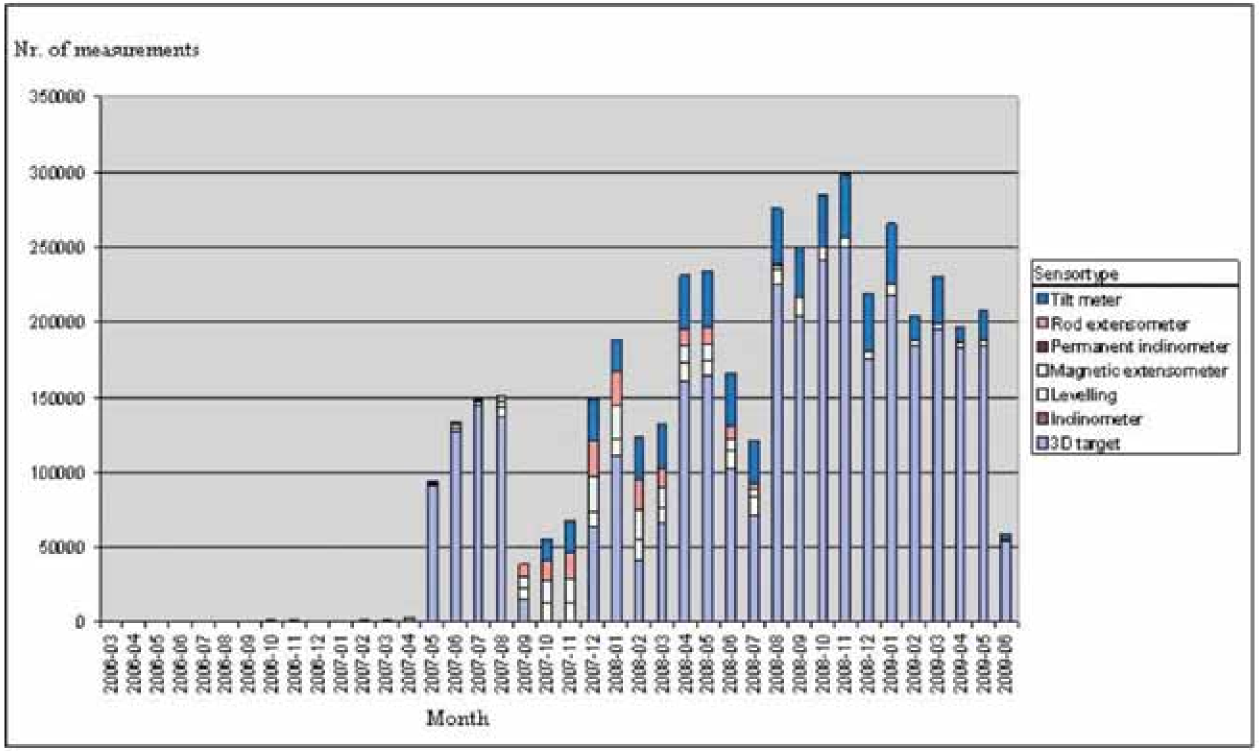


Figure 6: Measurement data transferred monthly to Kronos at Thessaloniki Metro

Kronos at Thessaloniki Metro

Project introduction

The currently built Thessaloniki metro network (see Fig. 5) comprises 13 modern platform stations and 9.5 km of track (with two independent single track tunnels) constructed mostly (7.7 km) by means of two tunnel boring machines. The remaining section of the line is constructed by the cut and cover method.

Kronos application

For the Thessaloniki project Kronos takes over responsibility for monitoring, data management and emergency alarms, but also performs additional tasks such as the on-line transfer and display of data from tunnel boring machines and automatic measurement systems, geological documentation, and document management and automatic reporting. On-site, more than 30 different users (experts from the client and contractor) are connected to the system and receive all necessary project data, and if desired even automatically generated and periodically sent reports. To guarantee the safety of the overlaying and adjacent buildings and structures and to verify the assumptions made during the project planning, a huge geotechnical monitoring program is executed.

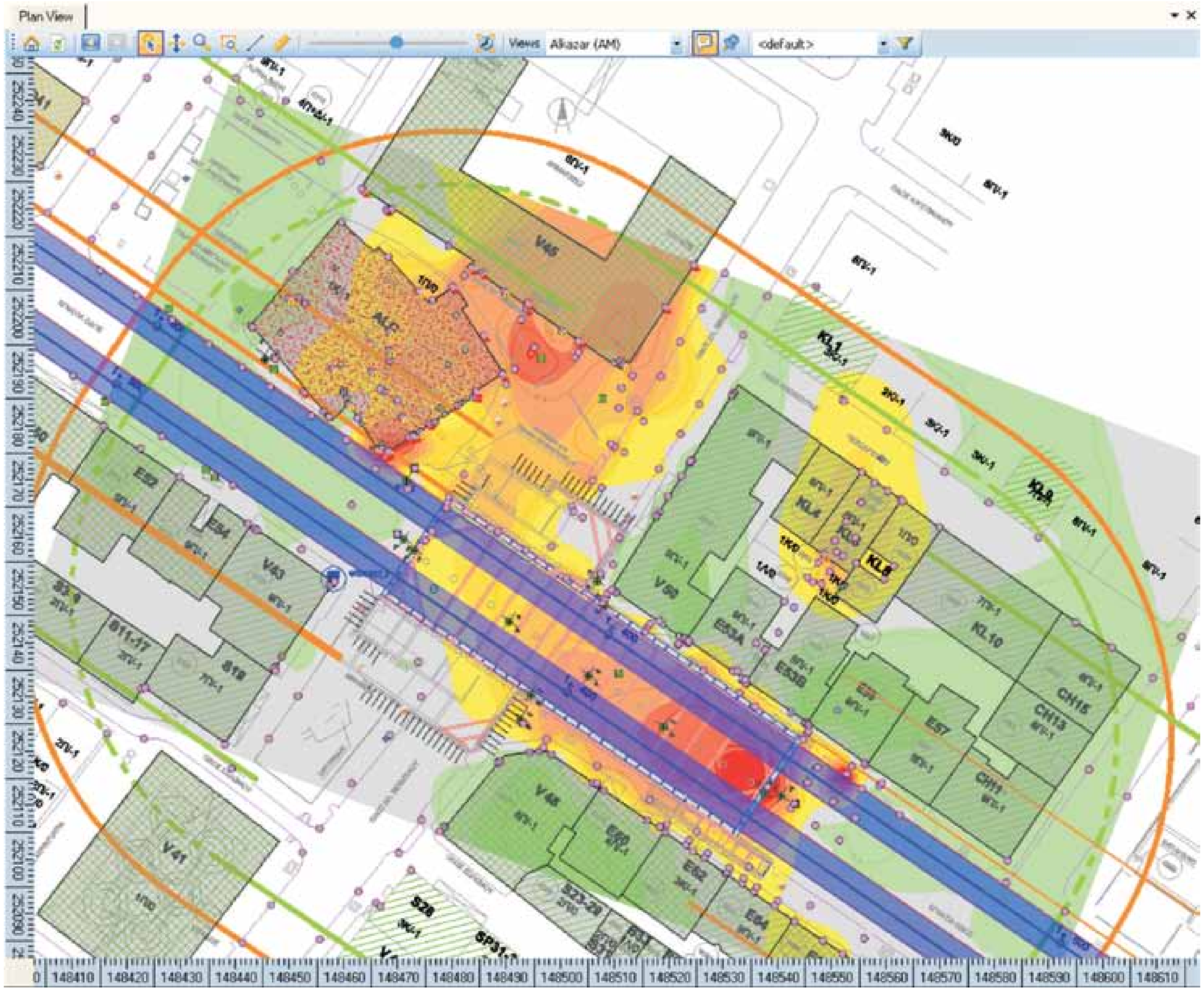


Figure 7: Contour map of settlements measured by automatic totalstations that are connected online to the system allows for live-interpretation of subsidence.

It employs numerous computer controlled online-sensors such as geodetic totalstations that automatically measure every few seconds the 3D coordinates of hundreds of targets installed on buildings and other structures. Fig. 6 shows the huge volumes of measured data transferred to and managed by the system month-by-month, which at its peak reached 300.000 measurements per month.

In the project the Kronos database server is installed locally and also maintained by a local administrator. The many different data sources/providers in the project are either connected online or obliged to provide their data in specified data formats to assure uniform data quality and appropriate data transfer speeds. From the distributed sources an automatic data collection service transfers, checks and imports the data to the database. In case of missing data or data quality problems, corresponding feedback is given immediately. After successful data imports all available online data displays are refreshed (see Fig. 7 and 8) and all further services invoked (e.g. the alarms).

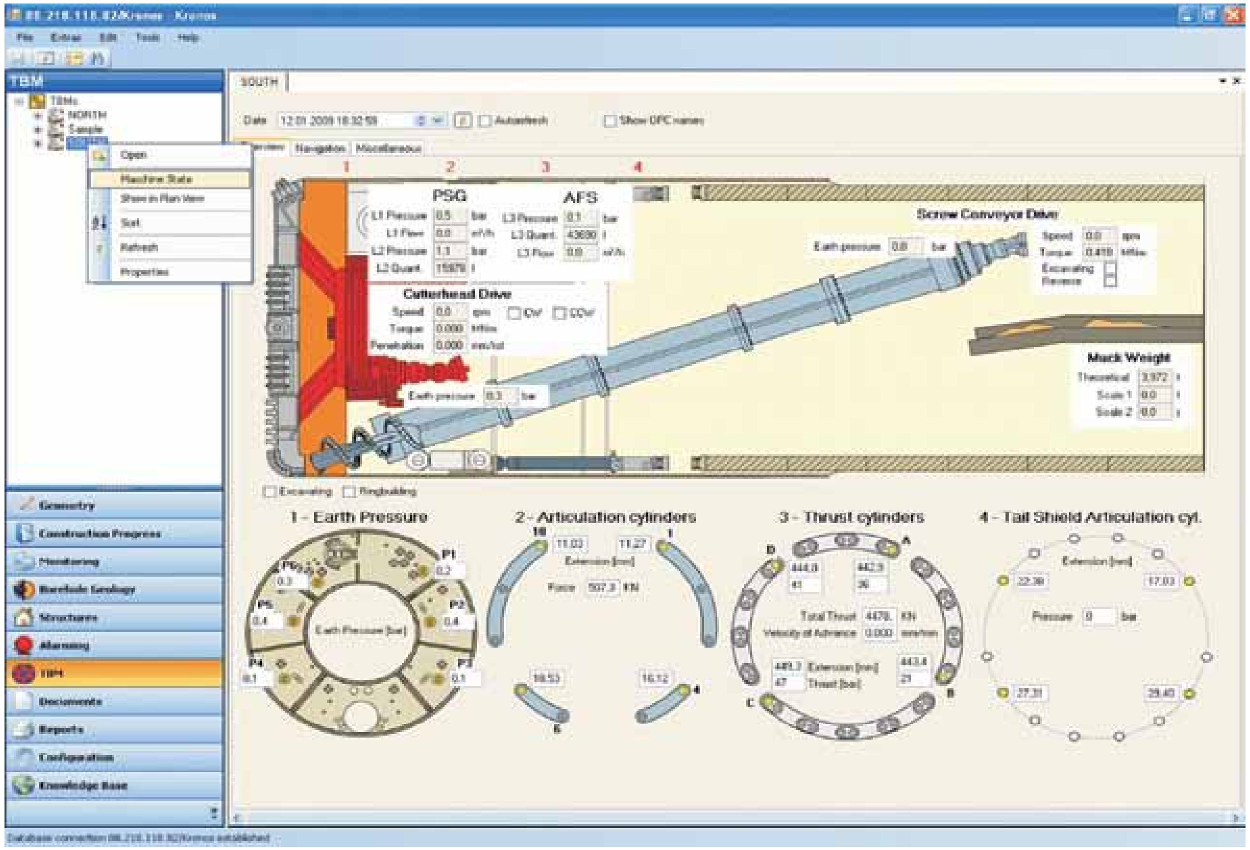


Figure 8: The settlements in fig. 7 can be analysed in combination with the live-display of TBM performance data

Conclusion

The two examples described represent best practice on how a modern information system supports monitoring and alarming for tunnel construction sites. Its main advantage is that it accomplishes a highly efficient site data management where all data is integrated into one central platform and where well-organized and systematic data transfer from and to this platform is realized. No longer is it necessary to deal with data that is stored in various different, disconnected and incompatible systems. Problems arising from time consuming data search, data loss and inconsistencies, erroneous or redundant data are avoided. Further advantages are that all data can be accessed by multiple users, any time, from anywhere and at the click of a button. All relevant information is permanently available, which significantly improves the communication among experts and decision makers. This intelligent and extensive alarm system can take into account all project data. The system thus, contributes significantly to safer tunnel construction.

Volcanic Risk Management: the Case of Mt. Etna 2006 Eruption

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(d) Istituto Nazionale di Geofisica e Vulcanologia (INGV-CT), Catania, Italy
(e) Advanced Computer System S.p.A. (ACS), Roma, Italy

Introduction

Active volcanoes are spread all over the world and are located in specific areas correlated to geologic structures. In the last 10,000 years more than 1300 volcanoes have erupted, but only half of the eruptions have been reported in historical texts. It has been estimated that every year 50 volcanic eruptions may occur threatening about 10% of the worldwide population (Andres and Kasgnoc, 1998). Considering the constant increase in human population and that many major cities are placed in the proximity of active volcanoes, the number of people subjected to the risks caused by volcanic eruptions is also increasing. Explosive eruptions represent a serious hazard not only for the human population, but also for aviation safety. Because of the increases in air routes and in the number of flights, the probability that volcanic ash dispersed into the atmosphere is at flight levels is actually about 20 days/yr. From 1973 to 2000 IATA estimates that more than 1000 airplanes around the world have been damaged by volcanic ash with an economic loss of about $250 million.

Figure 1: The Mount Etna (photo courtesy of B. Behncke (INGV-CT))

In the framework of the FP6 program, the European Union has funded the Eurorisk-Preview (Prevention, Information and Early Warning) project (http://www.preview-risk.com/). The project addresses European Civil Protections with the aim of developing, at a European scale, new tools and information services to support risk management. In this framework, *Earthquakes and Volcanoes* platforms have been developed by a network of partners* for the operative needs of the Italian Civil Protection and using the most advanced research and technology outcomes.

Mt. Etna in Sicily (Italy) and Pico de Teide in Canary Islands (Spain) have been the volcanic test sites. Mt. Etna is the most active volcano in Europe causing several problems to the neighbouring population with its frequent eruptions. Tenerife in Canary Islands is potentially in danger since caldera collapse has occurred in past eruptions of Pico de Teide. Given the high density population and the tourism on the islands, new technologies are needed to investigate its reactivation, as a seismic swarm occurred on 2004.

After intense exchange between partners, the service product chain of Volcanoes platform has been built according to the following steps (Figure 2):

1) Ingestion: acquisition of Earth Observation (EO) satellite historical series;
2) Core process: analysis of satellite data to retrieve scientific products and integration with ground network data;
3) Repository: build the database;
4) Distribution: build the Web portal in a Geographical Information System where the scientific products are shown and available for querying, according to Civil Protection needs.

** Project partners: ACS, COERI, DPC, EMSC, Geopapp, INGV, IREA-CNR, NOA, Telespazio, UCM*

When the service was ready for a past eruption of Mt. Etna, a new eruption occurred in 2006. We took the opportunity to test the service during this eruption.

The EO products

The scientific products consist of geophysical parameters related to the volcano status, derived from the analysis of the Earth Observation data. These parameters differ according to the type of volcanic phenomena. When a volcano is in a quiescent phase the most relevant parameters are: surface deformation, surface temperature, and gas and particulate emissions into the atmosphere. A change in the volcanic behaviour is reflected in changes of these parameters. When the volcano is in the eruption phase, the relevant parameters are the velocity of the active lava flow and the volcanic ash emitted into the atmosphere. All these parameters are EO products when presented as geospatial information in the form of thematic maps.

The Web-GIS

The *Volcanoes* platform has been designed to improve access to satellite derived information. The design of its architecture has been developed to organise and harmonise heterogeneous value-added data and provide a common access point, which should be simple, efficient and comprehensive, including all data exploited by Civil Protection, and able to anticipate possible integration with data coming from other services.

To reach this goal a GIS (Geographical Information System) published on the Web (Web-GIS) was designed. The objective of the web application is to display the EO products, taking advantage of their spatial relationships. Data and EO products are collected and stored in a central repository based on a relational database PostgreSQL.

The Web-GIS displays EO products as images, graphs and data related to monitoring volcanic and seismic risk. It can be accessed by any web browser so that it can be exploited by authorised personnel remotely from their office, or in the field.

The system is organised in the 3 phases of the risk management:

- ✓ Knowledge and prevention
- ✓ Crisis
- ✓ Post-crisis

Image data or thematic maps are selected for display by identifying the EO product and the time window in which the data is to be searched. The Web-GIS can be reached at http://preview.acsys.it/preview/ login.php. Example of EO products selected are the volcanic plume aerosol optical characteristics (Spinetti et al., 2007) in the Knowledge and Prevention section. Due to the adoption of Open Geospatial Consortium (OGC) standards, the user can integrate the data with others stored in their own environment.

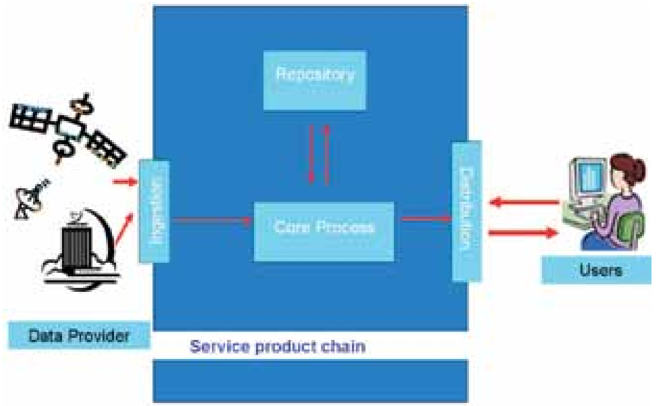

Figure2: This image shows the scheme of the service production chain.

Mt. Etna 2006 eruption

Mt. Etna (3300 m a.s.l.) is located in the eastern part of Sicily and is one the major degassing volcanoes in the world (Romano, 1982). Its quiescent state is periodically interrupted by eruptive periods characterized by lava flows and volcanic ash emissions that cause different hazards and problems to the local population. The ash fallout damages the inhabited and cultivated areas; the volcanic ash that remains in air creates serious hazards to air traffic as it spreads over the East Mediterranean area at high altitude; this causes local economic loss due to the closure of airports.

In mid-July 2006 Mt. Etna exhibited 15 days of lava flows down to an isolated area. A new eruption started in September characterized by lava flows and a series of episodic explosive activities producing ash plumes that drifted several kilometres away from the vent. These episodes occurred frequently from September to December showing weak intensity and short duration compared to 2001 and 2002 eruptions. The 2006 Mt. Etna eruption provided the opportunity to perform the pre-operative test of the project and to sharpen the development tool.

Ground surface deformation measured by SAR

Volcano surface changes (ground deformations) are directly related to what is happening deep below the surface. In general a surface inflation is related to feeding of the magma into the plumbing system, while a deflation is related to the discharge of magma. Most of the deformations can be detected and measured with precise surveying techniques, such as GPS, tiltmeters, EDM and most recently satellite InSAR technique (Interferometric Synthetic Aperture Radar).

This technique combines several radar images recorded by Earth orbiting satellites to show subtle movements of the ground surface over time and to map ground deformation of large areas (Puglisi et al., 2008).

In the begin of the 2006 eruption we tested the efficiency of European Space Agency procedures to rapidly obtain data in order to measure ground deformation using InSAR technique (ESA provided data via Category-1 n. 3560). Figure 3 shows the InSAR core process results for the period July 2005 - July 2006.

The results locate the magmatic source at about 2.7km below the summit of the craters. The source is in agreement with the volcanic activity that occurred in the period Sept-Oct 2006 (Guglielmino et al., 2007). We understand that the operative results derived from the InSAR technique only are useful for monitoring ground deformation if they are accompanied by a historical series of deformations and a model source constrained by ground measurements (GPS data). All these information have been implemented for the Mt. Etna case.

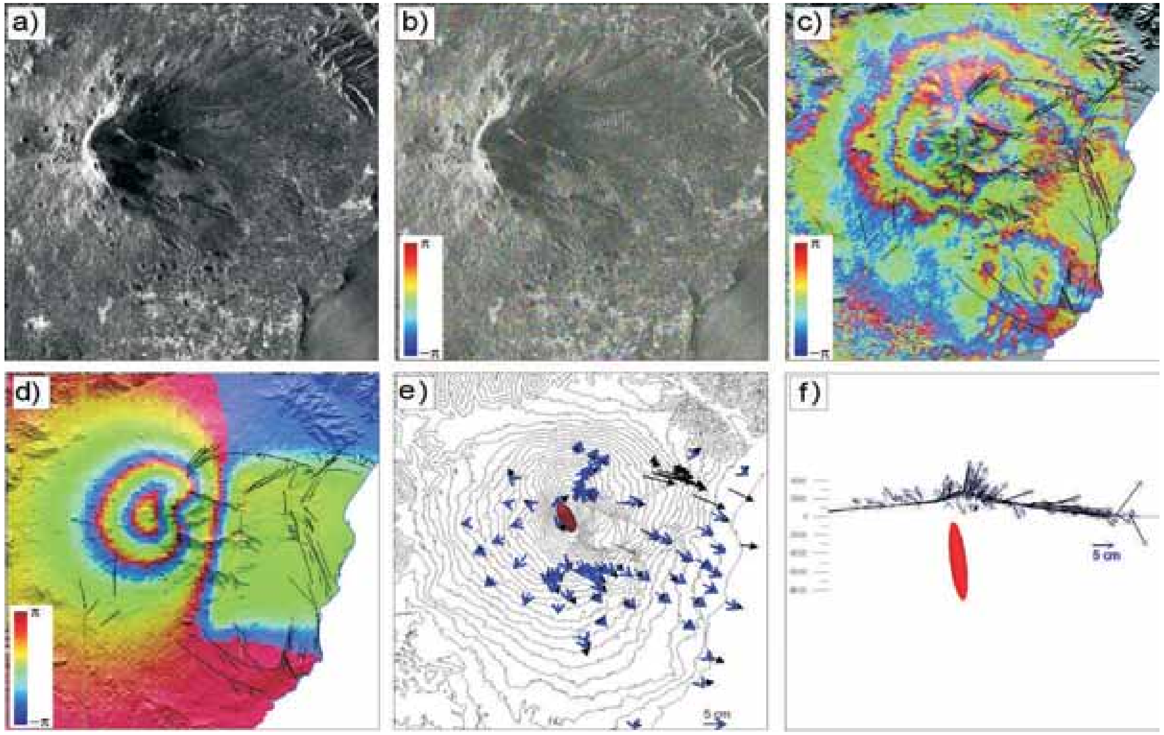

Figure 3: This image shows: a) ERS image. b) Phase interferogram obtained by combining an ERS pair from 20 July 2005 and 5 July 2006. c) Interferogram obtained by subtracting the terrain model. d) Synthetic interferogram obtained by inverting GPS data. e) GPS displacement vectors (July 2005 -July 2006). The black arrows represent the horizontal displacement vectors and the blue are those modelled as compatible with a volcanic pressure-source (in red). f) Cross section showing the source model in red.

Volcanic ash measured by NASA-MODIS satellites

November 24th 2006, at about 03:00 UTC, a paroxysmal event occurred with ash emission lasting about 14 hours (Andronico at al., 2009; Figure 4a). This event produced the largest volume of ash in the entire September-December eruptive period. On that day the wind was blowing from the N-NW direction. A change in wind direction caused the ash plume to move towards the city of Catania. The episode was recorded at 12:20 UTC by MODIS on board Aqua satellite (Figure 4b). The finest ash travelled more than 80km from the summit craters. The ash fallout caused the closure of Catania Airport.

The pre-operative test went through the following steps:

1) The DPC requested activation of the EO volcanic ash product to project partners with an observation preformatted report.

2) Ingestion: after pre-processing, the MODIS data acquired from Telespazio through the Matera ground receiving station were automatically sent to INGV in near-real time.

3) Core process: INGV ran its scientific models and algorithms in order to derive the EO product. The Brightness Temperature Difference procedure with the atmospheric water vapour correction was applied to infrared MODIS channels to detect volcanic ash, discriminate it from meteorological clouds and identify the affected area. The retrieved mean ash optical thickness at 0.55n µ, the mean ash particle radius and the ash loading in the plume were derived to be 0.4, 3.5 µ and 3620 tons respectively.

4) Distribution: ACS developed an interactive web-interface (Figure 5a) linked to the main Web-GIS in the Crisis risk management phase. INGV created the preformatted observation report with the volcanic ash information on: area affected by volcanic ash, the volcanic plume dispersal direction; dimensions and altitude in the atmosphere and the volcanic ash loading (Figure 5b). The preformatted observation report was published in the Web-GIS via WMS standard protocol (Figure 6).

Total time processing was estimated to be less than 1 hour, after receiving MODIS data. The test end when the eruption terminated in late December.

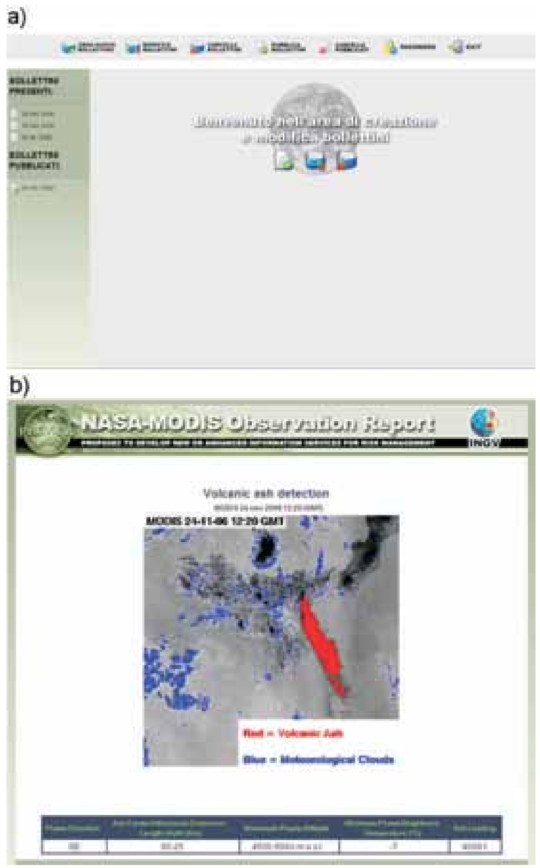

Figure 5: This image shows the report creation: a) Interactive web-interface where INGV insert the volcanic ash information; b) Web-published preformatted observation report.

Figure 4: Mt. Etna ash plume on 24 November 2006: a) picture taken 30 km from summit carters (photo courtesy of B. Behncke); b) MODIS data on Aqua RGB image.

Conclusions

A Web-GIS developed separately for the Earthquakes and Volcanoes platforms has been developed according to end-users requirements. The EO products relating to the selected eruption occurring at Mt. Etna (Sicily) in 2001 have been integrated with the geophysical information derived from the ground network. The Web-GIS has been designed to supply specific information in a user-friendly and efficient way and to support Civil Protection in the decision process.

During the 2006 Mt. Etna eruption we performed a successfully pre-operative test on the two phases. In the first phase, we tested the European Space Agency procedures to rapidly receive the EO data to obtain the ground surface deformation. In the second phase characterized by paroxysmal events with volcanic ash emission, we tested the procedures to give relevant information on volcanic ash to DPC to support their decision making process. This test does not address the precise location of events for prevention and mitigation purposes, but responds to the needs of decision-makers to better understand the situation and to identify vulnerable populations.

The Preview project work and the pre-operative test is an example of successful collaboration between industry and a national body using results from the scientific community in a practical way the for the risk management.

The work carried out will be further developed to an operational stage through the new project SAFER funded by the European Union in the FP7 framework.

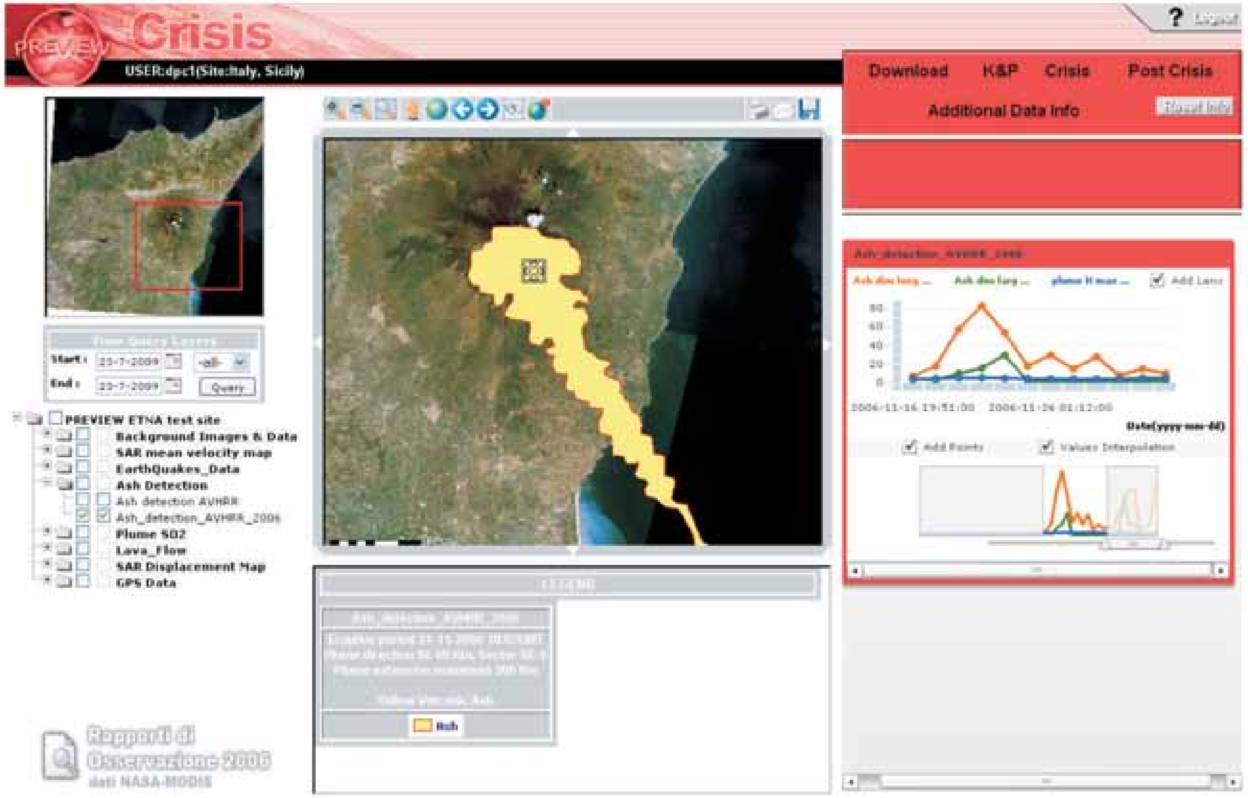

Figure 6: This image shows the Web-GIS portal in Crisis section with the selected volcanic ash EO product. In left bottom is marked the availability of the observation report.

Audit of Indian Ocean Tsunami Aid in Aceh with Geo-information

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Introduction

Supreme Audit Institutions (SAIs) have a role in safeguarding the spending of public funds by providing assurance with their audit activities: they provide assurance on the financial statements of government and public entities. Auditing also has another important function besides assurance; it is a learning tool for management that provides an assessment of weaknesses and strengths in performance.

SAIs have a role in assessing whether governments and public entities are well prepared for natural disasters (disaster preparedness and risk mitigation). They also have a role when disasters happen and government and public entities are planning, coordinating, funding and implementing disaster-relief efforts.

When the Indian Ocean Tsunami happened in 2004, the 189 members of the international organisation of SAIs (INTOSAI) realised that this disaster would also have an effect on the SAIs from affected and

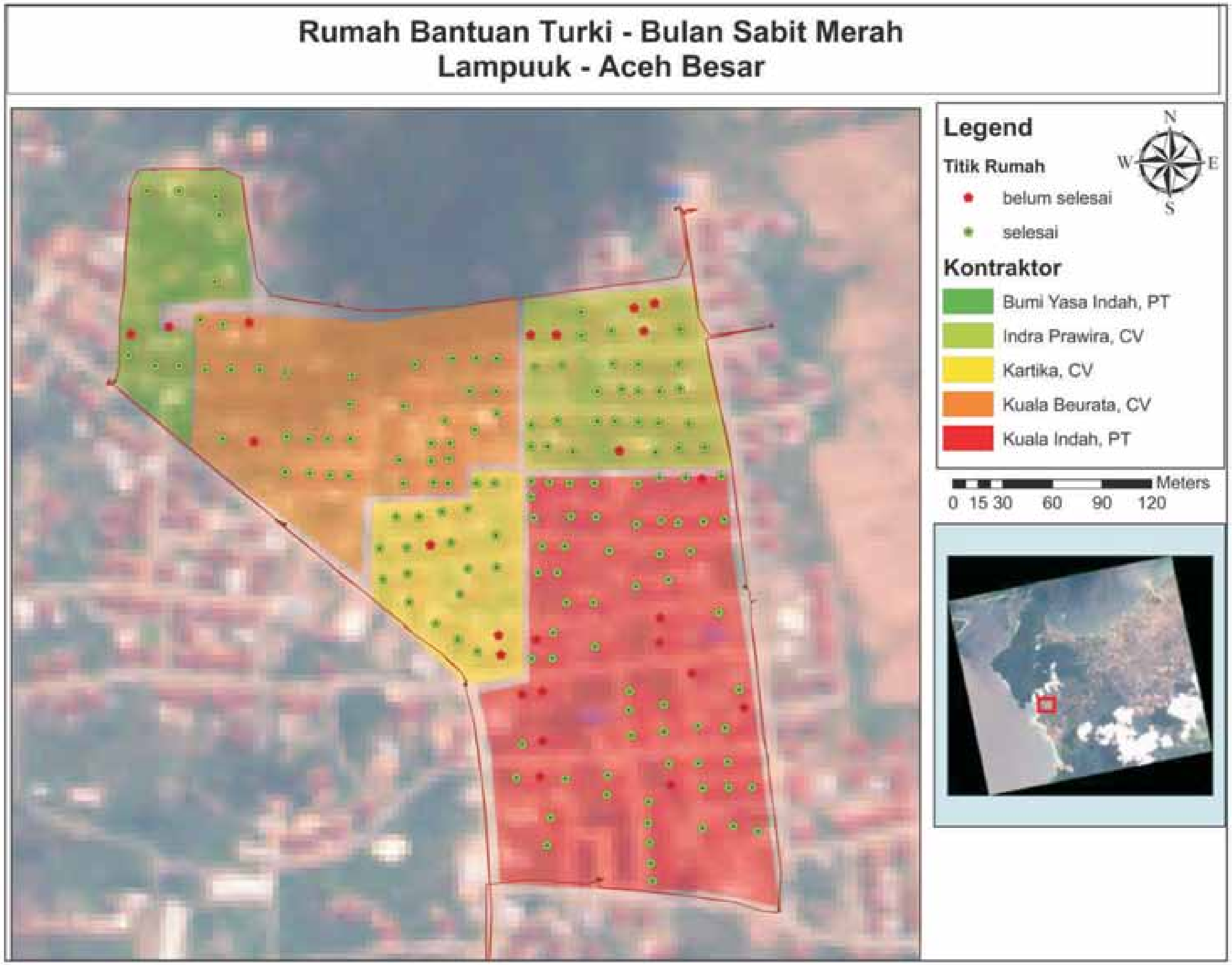

Figure 1: Map of newly built houses in Lampuuk Village with contractor zones, projected on a 2007 KOMPSAT-2 image. The entire village is within 2 kilometres of the coastline. Individual houses are indicated by symbols (green = inhabited, red = not inhabited). The map was made by BPK staff during a training course (Source: SAADRA Program TF 057426). KOMPSAT-2 image courtesy of Korean Aerospace Institute (KARI).

and donor countries. For SAIs of affected countries, such as Indonesia and Sri Lanka, it posed a huge challenge to audit the management of disaster-related aid. But also for SAIs from major donor countries the Tsunami-disaster posed a challenge: how could the SAIs provide assurance on public funds that are mixed with other public and private funds while those funds flow from one organisation to another and from one country to another? To be able to provide assurance, an audit trail is needed to provide insight and accountability into the movement of public funds from source to final destination.

In November 2005 the Governing Board of INTOSAI decided to create a Task Force on the Accountability for and Audit of Disaster-related Aid with the aim to reconstruct an audit trail for the Tsunami-related aid flows and to learn about how to improve transparency and accountability for these flows.

The flow of disaster-related aid is a geographical movement from source to destination. Furthermore, aid (e.g. funds for education) is intended to lead to a certain output (i.e. school building and training of teachers) and finally an outcome (i.e. the education) on a specific location. Geography, therefore, plays an important role in any audit trail, but is specifically important with regard to disasters.

The INTOSAI Task Force was charged with exploring the possibilities of using geo-information in auditing disaster-related aid in order to minimize waste, competition, fraud and corruption of the aid funds. The Task Force's research question was broad: how and under what conditions can the use of geo-information in auditing help to ensure the regularity, efficiency and effectiveness of disaster-related aid?

This paper describes the methodology and results of the INTOSAI Task Force's study into the potential use of geo-information for auditing disaster-related aid.

Detection and mapping of new houses

To study the potential role of geo-information in audit of disaster-related aid, the Task Force focussed on the reconstruction of houses in the Indonesian province of Aceh (Nanggroe Aceh Darussalam, NAD), the most affected area of the Tsunami-hit countries, where over 150,000 houses were damaged or destroyed. The interest was not only if new houses were constructed, but also where, so it could be determined if houses were constructed at the correct location.

Looking at disaster prevention and mitigation, it is also of interest whether newly constructed or reconstructed houses were built in areas that are not prone to disaster. For example, if houses were built too close to the coastline, then the risk for destruction at a next Tsunami would be high and so would the risk of aid funds being wasted. After the 2004 Tsunami, the Government of Indonesia regulated that houses should be built at least two kilometres from the coastline (in some areas the Tsunami reached two kilometres inland), therefore reducing potential risk of destruction. Accurately mapping the location of the reconstructed houses in the province would provide a mechanism to assess compliance with this Governmental requirement. It would also provide the possibility to benchmark between implementing agencies: SAIs auditees are government agencies and private entities such as non-governmental organisations (NGO's). In this respect, situations such as the Indian Ocean Tsunami provided SAIs with the unique possibility of benchmarking government performance against that of private entities.

The basic idea behind the proposed method (see Figure 2) is to use two maps of the objects of interest: one at the start and one at the end of the audit period and to detect the changes by applying overlay-techniques (Bijker and Sanjaya 2008). Use of decision rules for change detection limits the result to provide only the changes of interest. These changes of interest can be sorted by administrative unit when combined with an administrative map and compared to the information supplied by the institution which is being audited. Field sampling assesses the accuracy of the change detection and provides further detail on the nature and origin of the changes and the objects under study. Depending upon the required spatial resolution (i.e. sufficient to accurately locate and measure the object of interest) the maps would usually be derived from satellite images or orthorectified aerial photographs (orthophotos). This generic approach could be applied for all spatial objects under audit, such as forests, houses, agricultural fields, and for environmental impact assessment.

The method depends on data availability at the time of the audit. For the Aceh case study, high resolution (30cm) orthophotos, acquired in June 2005, provided by the Indonesian National Coordinating Agency for Surveys and Mapping (Bakosurtanal) via BRR's Spatial Information and Mapping Centre (SIM-Centre), along with the panchromatic 1m KOMPSAT-2 (Korea Multi-Purpose Satellite-2) images, donated by the Korean Aerospace Research Institute (KARI), acquired in May 2007 were available. Vector data (Topographic Line Map, at 1:10,000 scale) extracted from the 2005 high resolution orthophotos was also available.

Combining the 2005 map of building footprints detailing the start of the rehabilitation phase, with that of 2007 showing the current state at the time of case study, provides all the buildings constructed between clearing the Tsunami debris and the end of the reconstruction period. Overlaying the map of new houses with the map of administrative boundaries provides the number and locations of new houses per administrative unit. These numbers can be compared with the information on housing projects available through the Agency for Rehabilitation and Reconstruction of NAD and Nias (BRR) Recovery Aceh Nias Database (RAND) database and other project information. Lay-out plans of housing projects existed only as paper sketches.

Based on location and degree of completion, as detected by comparing the building footprint maps, the Indonesian SAI, Badan Pemeriksa Keuangan RI (BPK) can take a stratified random or stratified systematic sample of these projects, for auditing according to its audit objective. Fraud is likely if there is a large discrepancy between the quantities of houses built according to the RAND database or project information, and the map of new houses. In such a case, the BPK field teams may want to take extra field samples to determine the reason for this discrepancy. Visualizing the spatial distribution of contractors and projects on maps shows the auditors whether there were likely to be any monopolies of building contractors in certain areas, and focus their audits accordingly. Using the map of new houses, the audit data of the houses in the sample can be extrapolated for the whole study area.

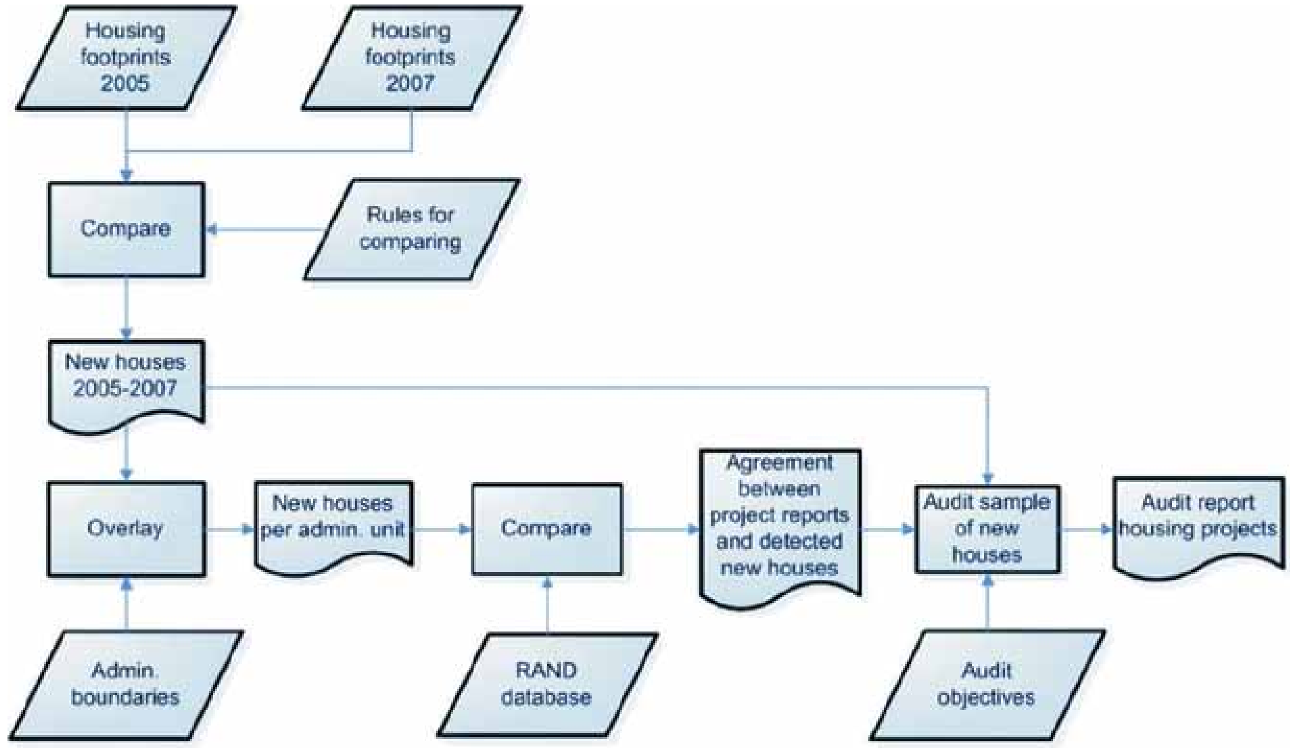

Figure 2: *GIS based method for auditing housing projects*

In the case of the housing audit conducted by the SAI of Indonesia (BPK), the results of the analysis of the KOMPSAT-2 imagery providing the housing footprints for 2007, were not ready before the field teams started their survey, so the method shown in Figure 2, was adapted (Bijker and Sanjaya 2008). While the field teams of the BPK were conducting their survey, suitable remote sensing methods were developed to detect houses on the KOMPSAT-2 imagery and used to create the map of new houses for selected sites (Du 2008).

The field teams took copies of the 2005 orthophotos to the field and delineated the sites of the housing projects on these images, as shown in Figure 3. The project delineations of the field teams were digitized and combined with the map of new houses. In this way, thematic (audit) data of the housing projects could be related to the new houses mapped from the imagery.

Check for compliance with risk regulation

When the available Topographic Land Map and the housing data from the RAND were combined, it was possible to map all settlements within two kilometres of the coastline. A limited number of inspection sites were selected, where it was possible to collect field data including the use of a handheld Global Positioning System (GPS) to ensure positional accuracy. To be able to provide a benchmark, inspection sites were selected from various implementing agencies. To ascertain if newly constructed houses complied with government regulations, it is a straightforward process to simply map the distance from the coast. As can be seen from Figure 4, some of the houses were constructed within 300 metres of the coastline. We can also see from this example that houses built by NGOs are located even closer to the coastline.

Lessons learned

From the housing audit in Aceh Indonesia, it is clear that many limitations exist concerning the availability of data. Data required for the audit do not exist or are not provided by the auditee. The combined use of GIS and remote sensing could help in resolving this problem. Data accuracy and methods to assess the accuracy of spatial (audit) data still require more attention. As with all data used by an audit institute, reliability of the data used in the audit is important for its credibility and the confidence of the general public.

Figure 3: Sketching of housing projects by field team

GIS is a useful and cost-effective technology for the preparation and planning of an audit, and can be used to visualize where risk of fraud is highest and to limit the amount of data that has to be collected in the field, (INTOSAI Tsunami Task Force, 2008). Remote sensing can be used to acquire spatial data, which is not yet available as maps, also allowing independent verification of certain objects and processes. In the field, having the data at hand in a mobile GIS and storing the data immediately in a digital form speeds up the survey and reduces the risk of errors, and also possibly the number of samples needed. For presentation of the results of the audit, maps are very effective for summarizing information and for showing spatial relations.

The housing audit in Aceh has made INTOSAI more aware of the crucial role geography plays in compliance and performance of the public entities it audits. Using geo-information helps SAIs to understand and tackle the complexity of policy implementation in situations such as disaster areas. It also leads to more efficient and effective audits, thus enhancing the contribution of SAIs to good governance. The Netherlands Court of Audit launched a knowledge centre on GIS and Audit to further develop GIS as an audit tool: www.courtofaudit.nl/english/gisandaudit.

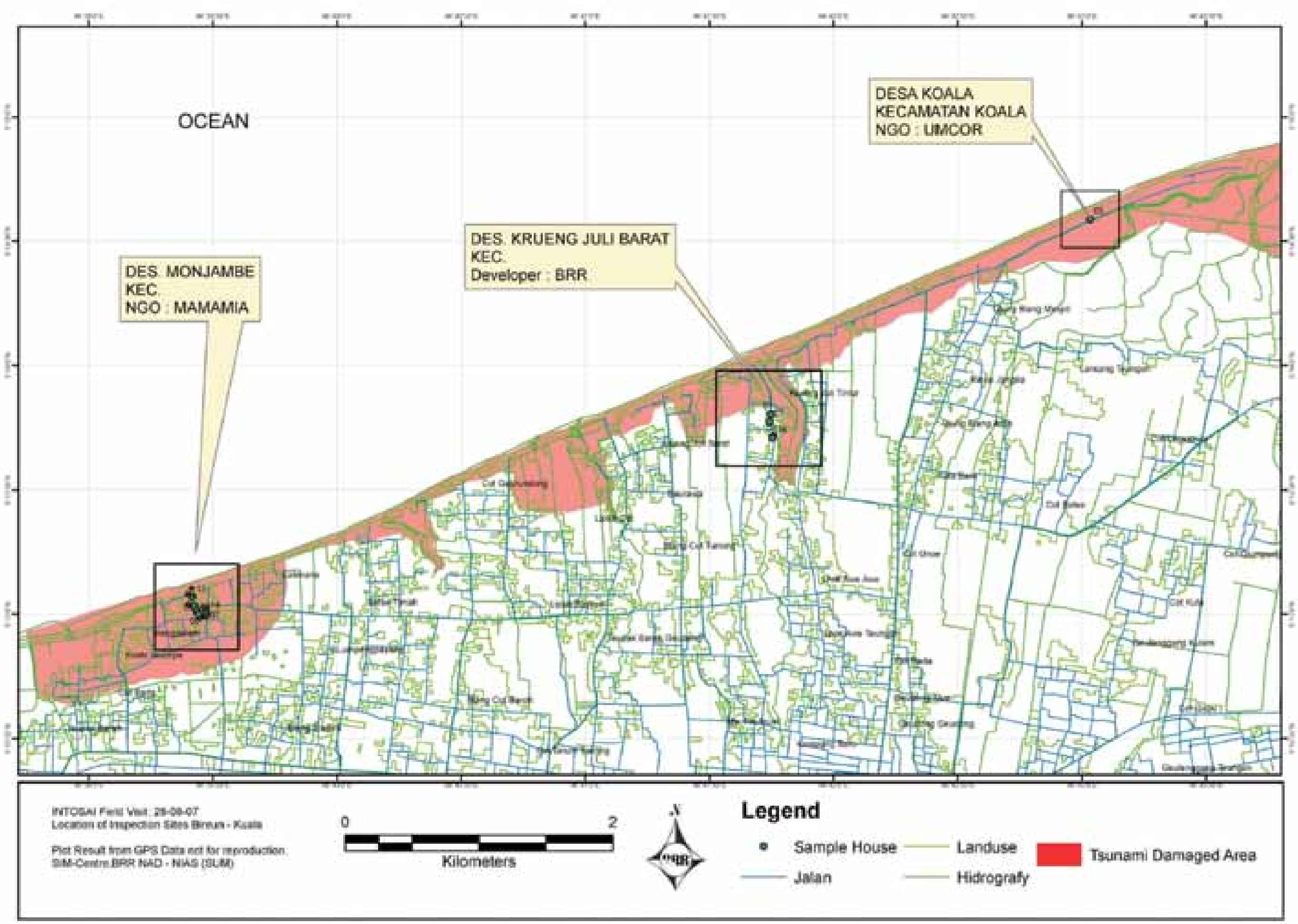

Figure 4: Mapping compliance with risk regulation

Acknowledgements

The authors like to thank the Badan Pemeriksa Keuangan RI, the Indonesian Supreme Audit Institute, and the SIM-Centre, BRR for their support of the pilot study on auditing housing projects with geo-information. Furthermore, they would like to thank the KARI for providing the satellite imagery, the World Bank and the Netherlands Ministry for Development Cooperation for funding the pilot study.

Population Estimation for Megacities: Solving Disaster Management Challenges Using Remote Sensing, Web-GIS and Advanced Technologies

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Introduction and background

The 21st century is the *Century of the City*. More than 3 billion of the earth's inhabitants live within urban settlements (UN, 2008), but by 2050, it is predicted that 6 billion people 70 % of the world's population - will reside in urban areas (UN, 2008). It is expected that urban areas throughout the world will absorb population growth over the next four decades, while at the same time drawing in rural populations.

Comprehensive disaster management seeks to reduce the devastating impacts of natural hazards, through resilient activities undertaken throughout the disaster management cycle; for example, from pre-event risk modelling, to post-event mitigation and emergency response. For casualty and loss estimation, risk models require building and infrastructure inventory data, demographic and socio-economic data. In the case of post-event response, information is needed on the extent and severity of damage.

Inventory data for pre-event risk modelling

From a theoretical standpoint, when developing inventory data to support risk modelling, it is important to follow the principal of model consistency, whereby the level of detail with which a given parameter is measured, is consistent with the accuracy and the reliability of the risk model as a whole. In a methodological context, pre-event risk and loss estimation models operate respectively on different spatial levels such as postcode, district, municipality boundary, region or even country. Traditional techniques for data acquisition and the maintenance of up-to-date inventory databases are very time- and cost-intensive. Taking India as an example, more than 2 million people were involved in the 2001 census building survey.

Of existing inventory development techniques, many were conceived for small scale analyses, and as such, do not match the requirements of either today's or the future's megacities (see, for example, Prasad et al., 2009). *In the case of India, large city extents, rapid and dynamic urban development, and very complex urban structures, demand new methodologies for data acquisition. Introducing efficiencies into the data development sequence is a high priority.*

Remote sensing and GIS/Web-GIS are increasingly recognised as useful tools for facing the challenges of inventory data development for megacities. Satellite and aerial imagery have enormous potential to provide detailed information at different resolutions, across a range of time periods. In addition, with the advent of internet-based records and data sharing, a variety of statistical inventory data are now publicly available. However, the accuracy of these datasets is unknown and their quality is typically non-standardised.

Population inventory for Indian megacities

India is a prominent example of a nation where urbanization is rapid, spatially varied, and exceptionally dynamic. By 2050, India's total population of 1.6 billion is expected to overtake that of China (1.4 billion), of which 0.9 billion will be urban dwellers (UN, 2008). If, as expected, high rates of urbanisation are sustained in coming decades, many cities will reach megacity status (more than 10 million inhabitants) in the near future. Further, due to its geologic setting, India is regularly struck by devastating earthquakes (Ravi, 2008). In 2001, the state of Gujarat (northwest India) was hit by a 7.9M event, causing widespread damage to buildings and infrastructure and 20,000 fatalities (MCEER, 2009). Only 4 years later, 88,000 people died in the Kashmir region following a 7.6M earthquake (MCEER, 2009).

To meet the requirements for standardised and efficient methods of inventory creation set by professionals undertaking risk modelling, a new approach is being developed through cooperation between the Center for Disaster Management and Risk Reduction Technology (CEDIM, www.cedim.de) and ImageCat (www.imagecatinc.com), which uses a combination of remote sensing and secondary sources to generate inventory data products. As a first step, a comprehensive catalogue of inventory parameters employed in risk models spanning different spatial levels was developed. This catalogue includes 30 parameters subdivided into two categories:

(1) Parameters that can be directly extracted from satellite imagery such as building outlines

(2) Parameters that can be inferred by integrating imagery with secondary data such as population density.

The second step involved selecting of a high priority 'pilot parameter'. From historical records of deadly earthquakes, it is evident that the severity of human loss is strongly related to occupancy levels of vulnerable structures during an event. It may be concluded that with the goal of minimising human suffering and loss, *information on population and its distribution* is a crucial parameter for comprehensive disaster management. Accordingly, this was selected as the 'pilot parameter'

Test study site Ahmedabad (Gujarat, NW-India)

The rapidly growing urban agglomeration of Ahmedabad in northern India was chosen as the test site. At the time of the 2001 Census, approximately 3.5 million people lived in Ahmedabad. With an annual population growth rate of 2.4%, the population is projected to reach 4.3 million by 2011. Ahmedabad can, without doubt, be called a megacity of tomorrow, which is at risk from earthquakes (Figure 1). In the case of the 2001 Gujurat event that took place approximately 225km east of the Kutch region, widespread ground motion with a recorded peak ground acceleration of 0.11g (Eidinger et al., 2001) caused significant building damage.

Figure 1: *Examples of buildings affected by the 2001 Gujarat earthquake:*
(Left) ***heavily damaged residential building,***
(Right) ***multi-storey*** *building that has fallen on one side* ***(Bhuj, India) (Image courtesy by M. Markus, 2001)***

Tiered conceptual framework for population estimation

A tiered conceptual framework is proposed for the Ahmedabad case study, which is an application-driven approach, aimed at developing population data for input to risk model parameters. The selected levels correspond to the operating unit of analysis, ranging from postcode/district/city boundaries for risk-sensitive planning, to a single building for response and recovery missions. This framework, which may ultimately be standardised for other cities, poses a number of technical challenges.

For each level, the relevant data have to be identified, their availability verified, and their accuracy evaluated. For example, data from Indian Census are only updated on a decadal basis. In order to integrate census information with other data such as remote sensing imagery, the relevant census data should be projected to match the image acquisition year. Moreover, the significance and accuracy of Census data as well as other statistical data have to be carefully evaluated.

The assumption that data and information reflect reality should be handled with care, as despite efforts to identify uncertainty, residual uncertainties will always remain. Cautious evaluation of available data that includes cross calculation and statistical analysis should lead to a data product that can be called *the most likely status*.

In addition to data-related uncertainties, model-based uncertainties also need to be considered. The modelling of population is typically based on relationships that are assumed to be true for the test site (for example, number of people resident at

different times of day). Since no two cities are alike, the transferability of such relationships needs to be carefully examined. The broadest unit of analysis considered in this conceptual framework is the administrative city boundary (Tier 1). At Tier 1, the approach considers three population estimation models for which processing time, data requirement and cost increase with information detail.

Model 1: City population, uses an areal overlay methodology based on the simplified assumption that population is uniformly distributed across the city. This is a very simple case.

Model 2: Urban population, employs Quickbird satellite images to extract the urban areas (oppose to non-inhabited regions) in which the population is supposed to be uniformly distributed. This assumption is still an oversimplification.

Model 3: Occupancy-based population differentiates occupancy categories within the urban areas so that population can be estimated for each of the categories (Figure 2).

Damage information for disaster response

There is no substitute for real-time or near-real-time data and information in the aftermath of a disaster. Post-event activities require quick and accurate information about damage and casualties to coordinate a response to the catastrophe. Within the re/insurance arena, geographically referenced damage information is vital as an independent source of loss estimation and to determine insurance claims. For humanitarian relief, estimates of affected population and casualties are critical for planning relief and response activities. Although increasingly, disaster information is becoming publicly available through internet posting, its value is often limited by the absence of metadata regarding its time and geo-location (e.g., geotagging), both of which are central to rendering it actionable.

Internet-based loss estimation

One example of a fully-georeferenced risk model is the Internet-based earthquake loss estimation tool InLET (Figure 3), designed and developed by ImageCat (www.imagecatinc.com). InLET is the first online real-time loss estimation system available to emergency managers and responders. Immediately following an earthquake, the United States Geological Survey (USGS) broadcasts Internet alerts using their ShakeCast platform. InLET which 'listens' for such alerts, is automatically triggered and produces loss estimation results based on details of the earthquake event. Integrating hazard intelligence with population and building inventory data from US Census Bureau enables loss estimation algorithms to immediately estimate fatalities and building damage at the level of the census tract. The InLET framework is readily transferable to other earthquake prone parts of the World such as India.

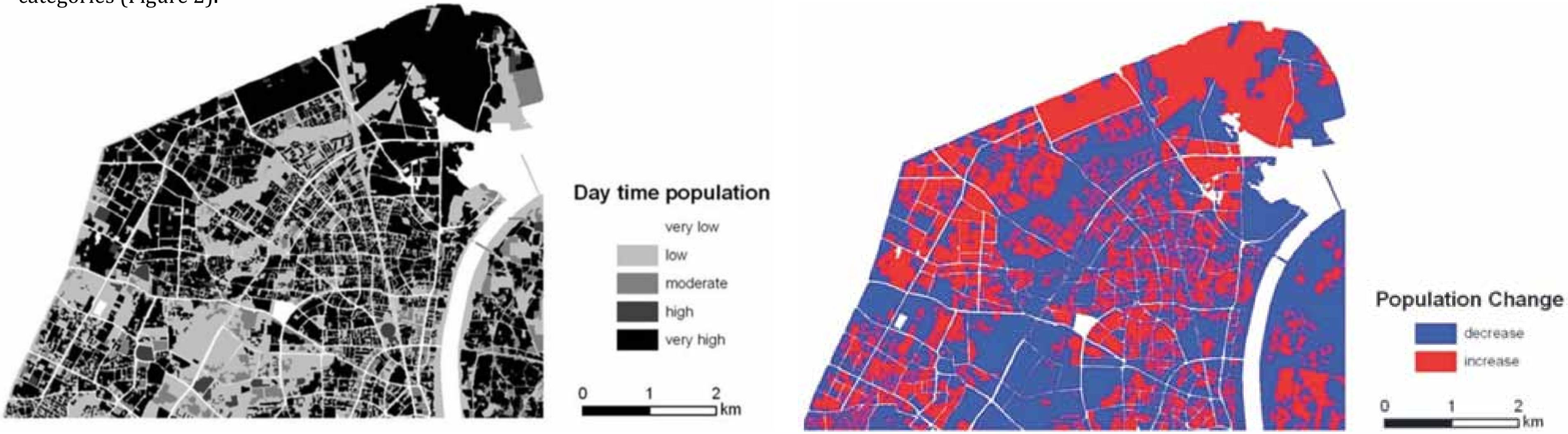


Figure 2: Occupancy-based population estimates at Tier 1 using Model 3. The left figure displays the relative day time population distribution, the right figure displays the population change between day- and night-time population.

Remote sensing and advanced technologies for situation/damage assessment

Post-disaster, satellite and aerial imagery has increasingly become accepted as a valuable source of intelligence for understanding both human and geophysical aspects of disasters. As Gillespie and Adams (2008) note, initiatives such as the International Charter: Space and Major Disasters have made significant headway in making remote sensing-based situation assessments and damage information available.

Currently, general access to Charter data is not available, since it is limited to a group of Authorized Users. In contrast, increasing public access to remote sensing and GIS techniques is the mission of a new initiative known as Community Remote Sensing, which is a flagship project for the 2010 IGARSS Symposium.

The Virtual Disaster Viewer (www.virtualdisasterviewer.com) is one such prototype community remote sensing tool (Bevington et al., 2009). The mission of VDV is to understand disasters though shared knowledge. It is a tandem visualisation and participatory tool, designed for rapid data sharing and information extraction during the initial response phase of disasters. VDV's first foray into the disaster realm was following the 2008 Wenchuan, China earthquake, when it was simultaneously used by a panel of international engineers and remote sensing experts spread around the World, to provide remote damage assessment by analysing high-resolution satellite imagery of the impact zone.

Figure 4 shows building damage assessment results for the Chinese city of YingXiu, which was conducted by more than 100 participants.

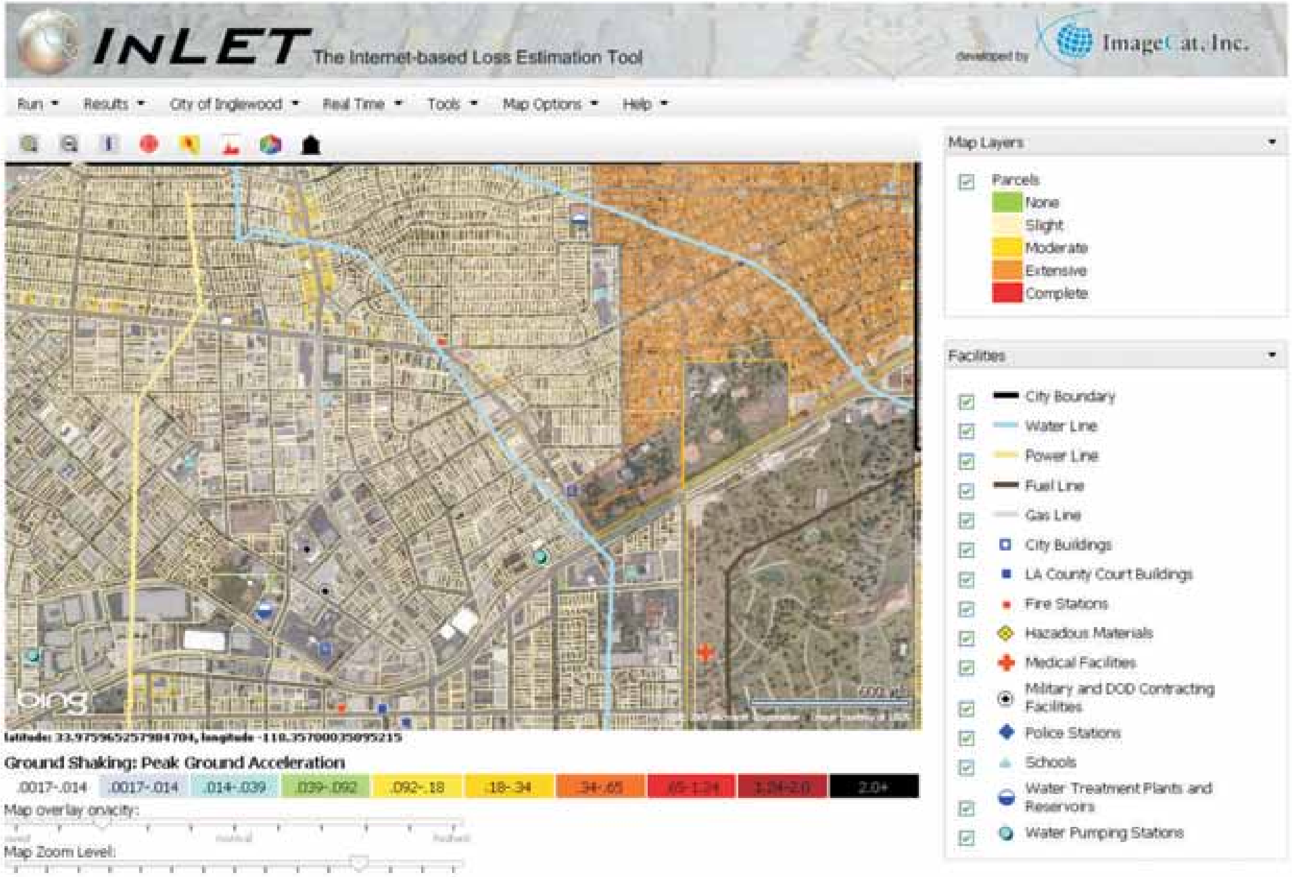


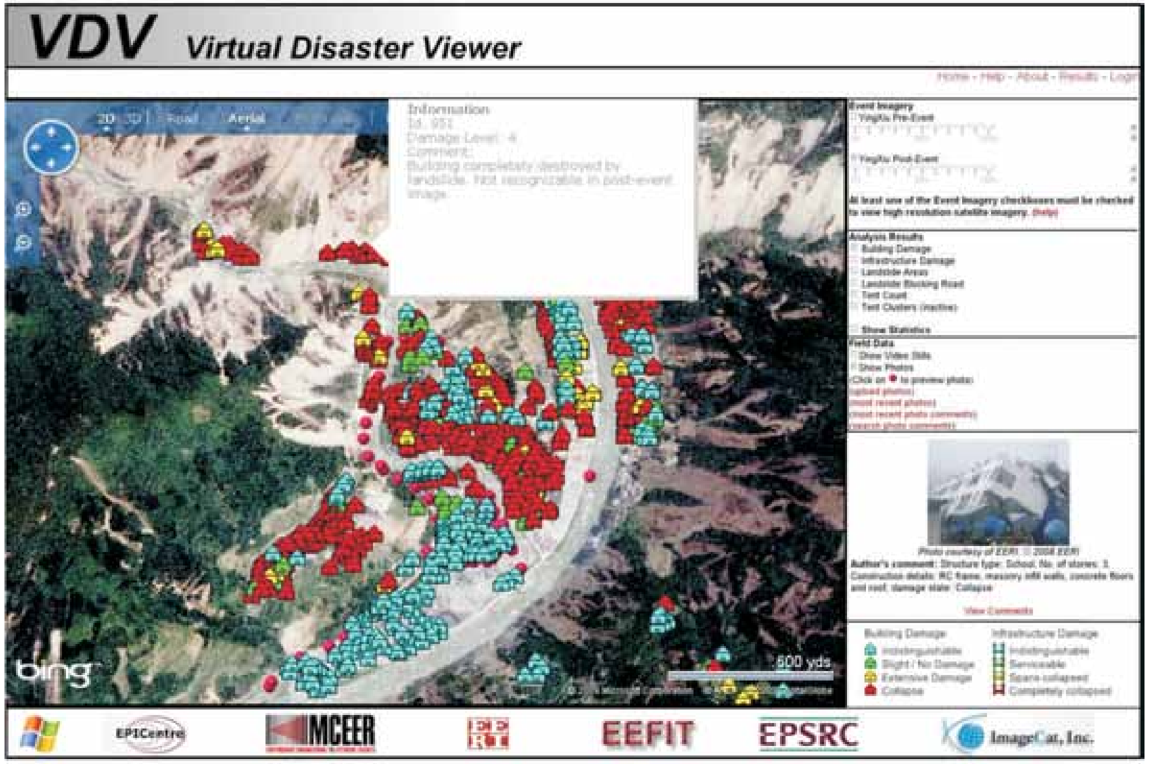
Figure 3: *Inlet is a real-time earthquake loss estimation tool. In an actual event, in less than one minute a real-time USGS ShakeCast alert automatically triggers a loss/casualty prediction. This map displays Los Angeles building damage at a parcel level. A similar system could be developed for other earthquake prone regions of the World such as India.*

VDV has since provided in-field support to reconnaissance teams from EEFIT (EEFIT, 2009) and EERI after recent events including the 2009 L'Acquila and Samoa earthquakes. VDV is also being used as a repository for historical data, making publicly available to the global research community, archives of spatially-referenced data of past events that would otherwise be lost. VDV has considerable potential for cataloguing historic earthquake effects within Indian cities such as Bhuj.

Satellite and aerial imagery provide a holistic perspective across a wide geographic area, particularly when access to a study region is restricted. However, it is not without its limitations, particularly for detecting minor and moderate

damage, together with major effects that are obscured from overhead viewing such as soft storey collapses. A detailed street-view perspective captured using tools like the VIEWS data collection system designed by ImageCat (www.imagecatinc.com) in collaboration with MCEER (www.mceer.buffalo.edu), fills these information gaps.

VIEWS is a notebook-based field data collection and visualization system. It integrates pre- and post-disaster remote sensing imagery with real-time GPS (Global Positioning System) readings and map layers, and operates in conjunction with a high-definition video (HDV) digital camera and digital video recorder. The VIEWS system was first deployed for earthquake field reconnaissance following the December 2003 Bam (Iran) earthquake (Adams et al., 2004), and has since been utilised following events including the Indian Ocean tsunami and the 2008 Wenchuan earthquake.



<u>Figure 4:</u> Virtual Disaster Viewer post-earthquake damage assessment for the 2008 Wenchuan event, simultaneously conducted by more than 100 experts located in Universities, Research Organisations and Companies around the World.

Conclusion

Within the risk management arena, to date, the research focus of remote sensing and GIS has generally been on engineering aspects of urban inventory. Nevertheless, faced with increasing human losses from natural disasters as urban populations expand, the global research community is beginning to recognise the potential of these technologies for estimating socio-economic parameters.

It can concluded that with the goal of minimising future human suffering and loss, *information on population and its distribution* is one of the most crucial parameters for resilient disaster Management. The case study of Ahmedabad demonstrates that population data for different spatial levels, as well as information on the data source and associated metadata are scarce, expensive or unavailable. Initial results indicate that a tiered conceptual framework provides a transparent and consistent system for estimating population at different levels. Implementation of the framework described is currently being completed and initial results are expected in early 2010.

Remote sensing and GIS are also increasingly being used for inventory data development and disaster response within the re/insurance and humanitarian information systems for first responders such as InLET and the Virtual Disaster Viewer (VDV), which enables rapid data development and sharing in the direct aftermath of an event. Initiatives such as the International Charter provide remote sensing-based situation assessment and damage information to authorised users and nations affected by disasters. For a complete picture, aerial and satellite imagery may need to be augmented with street-view information acquired using systems such as VIEWS.

GIS for Emergency Management

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Introduction

- Devastating natural disasters mean there is a great mandate for collaboration among agencies and nations. Geographic information system (GIS) technology is a powerful data management tool that strings together unconnected data sources for quicker analysis, organization, and sharing of information. Not only does GIS provide a graphic user interface that enables the user to quickly navigate through geospatial data, including complex three-dimensional datasets, it also enables organizations to visualize and maintain overall situational awareness during normal operations and emergencies.
- GIS is a flexible technology enabling full integration with other information systems. Linking people, processes, and information together and being able to access that information at command centers and out in the field, are strengths GIS offers agencies as they respond to events. Following are three examples of GIS use in a variety of natural disasters.

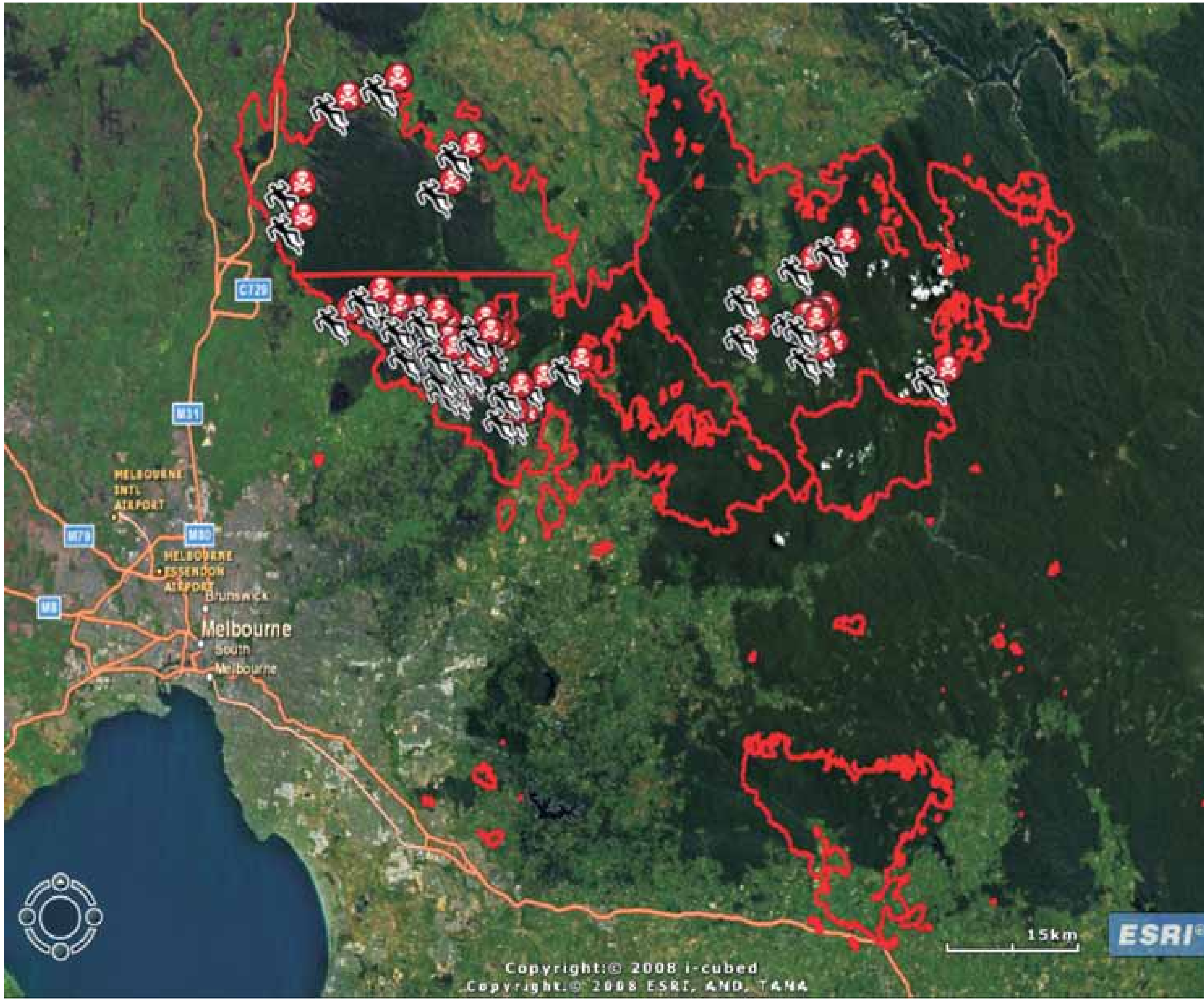


Figure 1: Bushfires in the Kinglake Complex

Case Study: Kinglake Complex Fire, Australia

In February, 2009, multiple days of temperatures above 41ºC (106ºF) combined with low humidity, 13 years of drought, and northerly 100 kilometres per hour winds to create an alignment of forces that produced extreme bushfire conditions that far exceeded the maximum fire danger ever recorded. Melbourne, Australia recorded its hottest day ever, a blistering 46.6ºC (116ºF).

Police in the state of Victoria were directed to search every property within the Kinglake Complex fire perimeter, 222,500 hectares with more than 8,000 properties and structures.. The organization had never carried out such a large-scale emergency damage assessment.

The traditional method for documenting property searches was manual. Victoria Police looked at their current assessment tools, paper maps, forms, and binders and realized they had a problem. There was no time for errors such as forms being incomplete or inaccurate, requiring properties to be searched again. The need for accurate, speedy information prompted the use of geospatial technologies and real-time mobile GIS to determine the extent of the devastation and to document the location of human remains. For 43 days, emergency responders helped carry out search operations. More than 40 GIS personnel worked 3,600 total hours (306 work days).

Each night staff members from the Rescue Coordination Centre drove the 150-kilometre round-trip to the incident command post in Kinglake. They retrieved forms and memory cards for cameras, then manually typed newly captured data from the paper forms into the database. The updated database was used to generate maps depicting areas searched and areas needing to be searched. Search managers monitored field operations on a continuous basis with dynamic data constantly coming into command centres and in turn updated in all mobile devices in the field.
Staff found that the process when collecting information during their massive search was simplified and made faster. Using mobile GIS, thousands of properties were searched and records were created, managed and shared easily.

The officers commented favourably on how much time the application saved them. These were some of the same team leaders who had previously used paper forms and had limited or no prior GIS experience.

Using Mobile GIS to perform the search in less than three weeks meant a faster, more efficient response time and the ability for thousands of homeowners to return to their properties quickly and rebuild their lives.

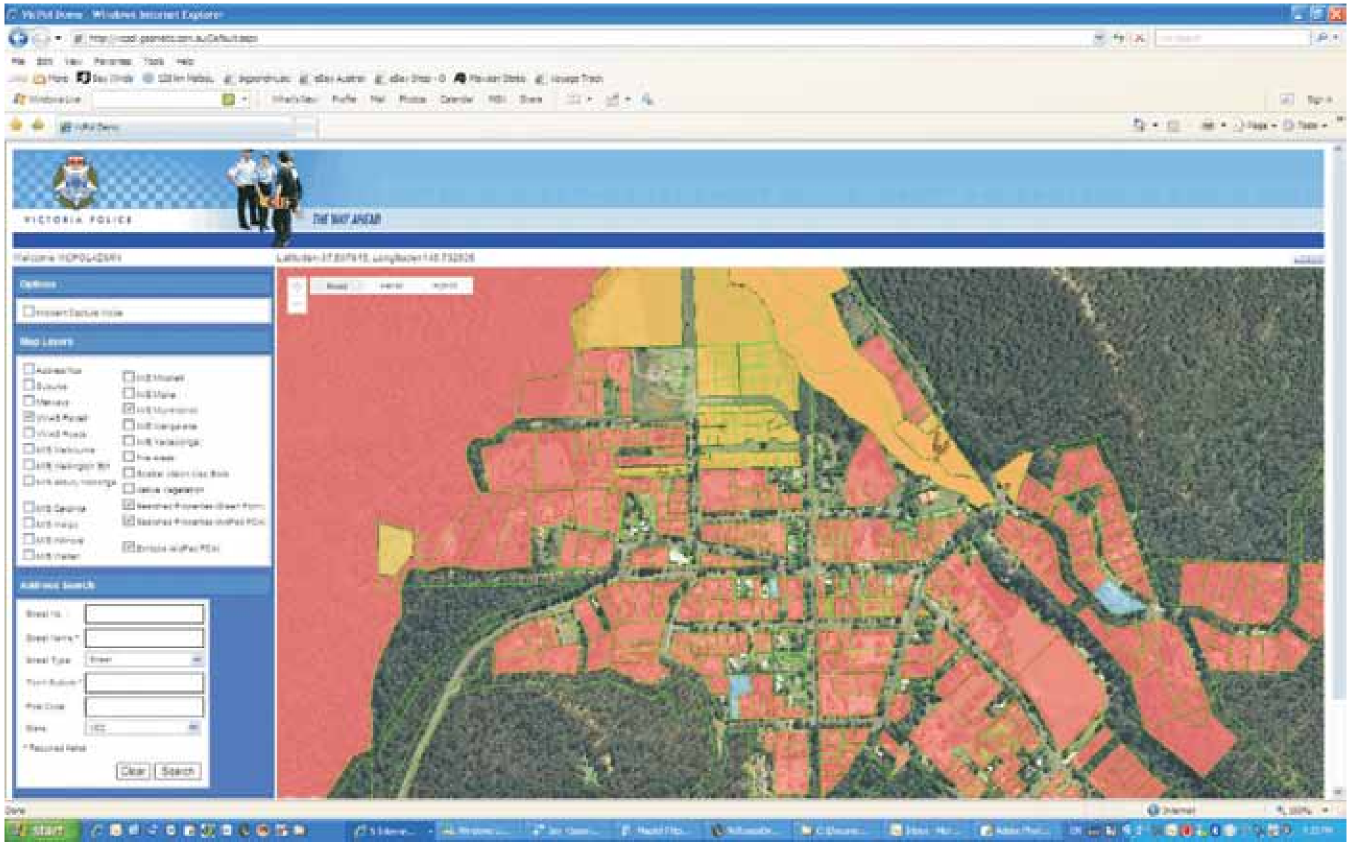


Figure 2: Information was easily integrated into Victoria Police's Web mapping site using a Web map server feed.

Case Study: GIS Enhances China Relief Efforts

On May 12, 2008, an earthquake measuring 7.9 struck Sichuan Province in southwestern China. It was the country's worst natural disaster in more than 30 years. Roads cracked; buildings burst; and terrible destruction resulted in approximately 70,000 killed, 20,000 missing, and more than 5 million homeless.

GIS was used in many ways to assist in response and recovery:

Epidemic Monitoring

An epidemic monitoring and reporting system was developed using mobile phones. Staff visited various clinics and medical facilities to collect data, using GPS-enabled phones and devices that could wirelessly transmit data tied to locations back to the primary epidemic tracking system.

Resource Planning

The Ministry of Civil Affairs Information Center launched the Sichuan Earthquake Portal as a comprehensive earthquake status, relief, and recovery information system. Civil Affairs staff could assess risks and hazards to populations, property, and natural resources while prioritizing where refugee camps should be placed and determining how and where resources needed to be supplied to each camp.

Situational Awareness

The Inner Mongolia Public Security Bureau deployed an Emergency Command System supporting the operation of 20 emergency vehicles. The vehicles, equipped with GPS and GIS, used an automated vehicle location system to track activities. As vehicles picked up injured people and transferred them to hospitals, staff could monitor events from the bureau in real time to see where trucks were at all times and ensure operations were running as smoothly as possible.

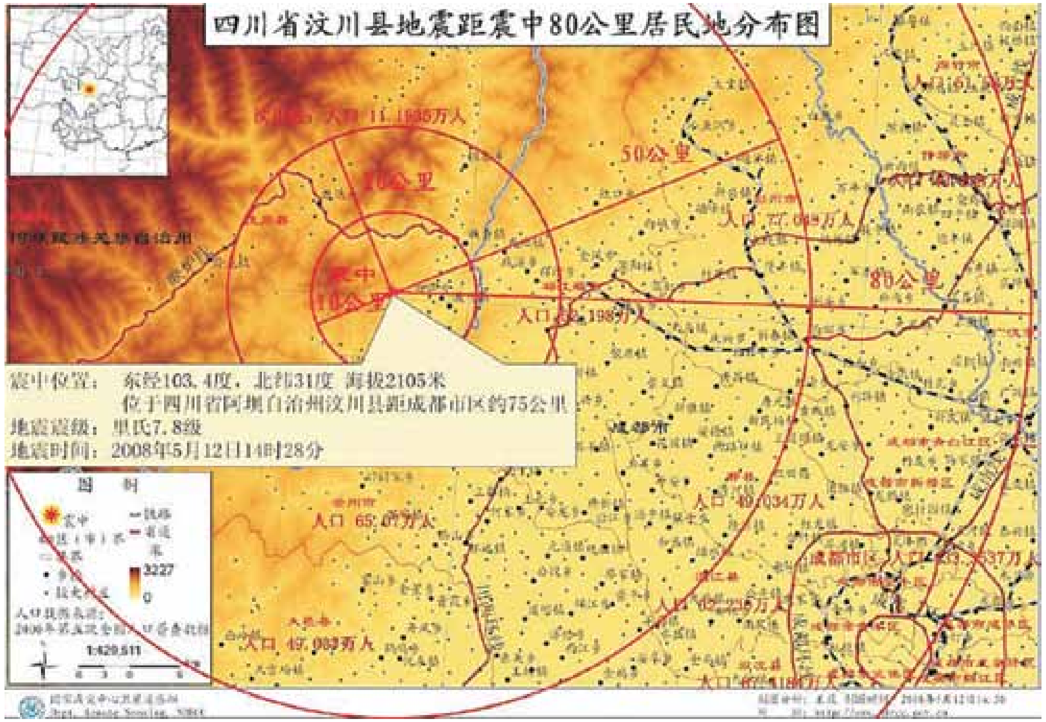
The Ministry of Transport collected image and remote-sensing information to assess road damage. It distributed the new data to other agencies to support their specific missions. For instance, government officials could look at an area where food assistance was needed, see which roadways were not usable, and determine alternate routes to get supplies to where they were needed as quickly as possible.

Health

The Shanghai Bureau of Health used GIS software-based medical support system to send health officials into the field to provide services and situational updates on items such as the number of wounded, types of incidents occurring, available staff on-site, and additional staffing requirements needed. Similar to the work done by China CDC, health staff would visit medical centres and perform statistical audits that were captured on their mobile devices. When they returned to their command centres, the captured data was uploaded for senior health managers to see exactly what was happening and where.

GIS helped create a virtual network that connected people, organizations, and resources and provided an integrated operational platform.

Figure 3: A resident distribution map helped control outbreaks of disease. Rings describe the path of outbreak and population centres affected.



Case Study: Aceh Province, Indonesia

Easily the largest natural disaster in recent history, the 9.1-magnitude earthquake and resulting tsunami on December 26, 2004, brought incredible devastation to many coastal countries in South East Asia. From the beginning, GIS played an important role in relief efforts. GIS maps acted as guides to affected areas and were used to coordinate emergency services and rebuilding.

To begin coordination of the relief effort, emergency responders needed to be guided to affected areas. Maps were required to visualize where supplies should go and which organizations would be able to assist. Within days of the devastation, the United Nations (UN) set up a Humanitarian Information Centre (HIC). Based in tents at the heart of the catastrophe, HIC collected data from the Indonesian government, nongovernmental organizations (NGOs), and international agencies. UN HIC delivered GIS data and maps to the responding humanitarian community, allowing workers to deliver assistance more effectively immediately after the emergency.

GIS Use during Tsunami Disaster Response

Apart from providing informative topographic maps to coordinate relief efforts, GIS was used in specific sectors during the initial response to the disaster.

Health

The most immediate concerns were the containment of any outbreak of disease and prevention of further deaths as a result of starvation. Information on the location and number of survivors, as well as the extent of their injuries, was urgently needed to provide food, water, and medical supplies.
The UN HIC team, working with the UN World Health Organization (WHO), set about collating and evaluating data using GIS to create an accurate picture of the damage and prioritize need. Activities were coordinated and prioritized; field hospitals and mobile health clinics were set up where needed. No major outbreak of disease occurred, and there were few deaths, contrary to expectations after a disaster of this magnitude.

Mobile Resource Planning

Since the main west road and all seaports were not usable, transporting food, water, and medical supplies seemed nearly impossible. GIS was used to plan movement of trucks and prioritize shipments.

Infrastructure

Many groundwater reservoirs were polluted, sanitation at temporary shelters was an issue, and drinking water had to be trucked in to the city. GIS was used to identify risk areas and develop management plans.

Education

Since 50 percent of the schools in the area were damaged or destroyed, GIS was used to discover where best to build, or not build, new schools based on population density and proximity to health facilities. An assessment of damaged facilities was also taken to identify which ones could be restored more quickly.

Housing

The simple act of providing shelter presented many challenges. More than half a million people were left homeless when land washed away and traditional land markers vanished. Land that remained had to be cleared of millions of tons of debris and silt before it could be used again, and many areas were no longer suitable housing locations because of the impact of the earthquake.

The international aid community responded to the problem by going to the field to map where houses once stood and determine who owned the properties. Pseudo land titles were issued with the signatures of all neighbours and the village leader. GIS was seen as a crucial tool to assist this coordination among many agencies as they scrambled to rebuild. While it may take decades for affected communities in Australia, China and Indonesia to fully recover from the devastation, GIS will continue to play an important role in the sustainable development, repatriation, and restoration of the disaster affected areas.

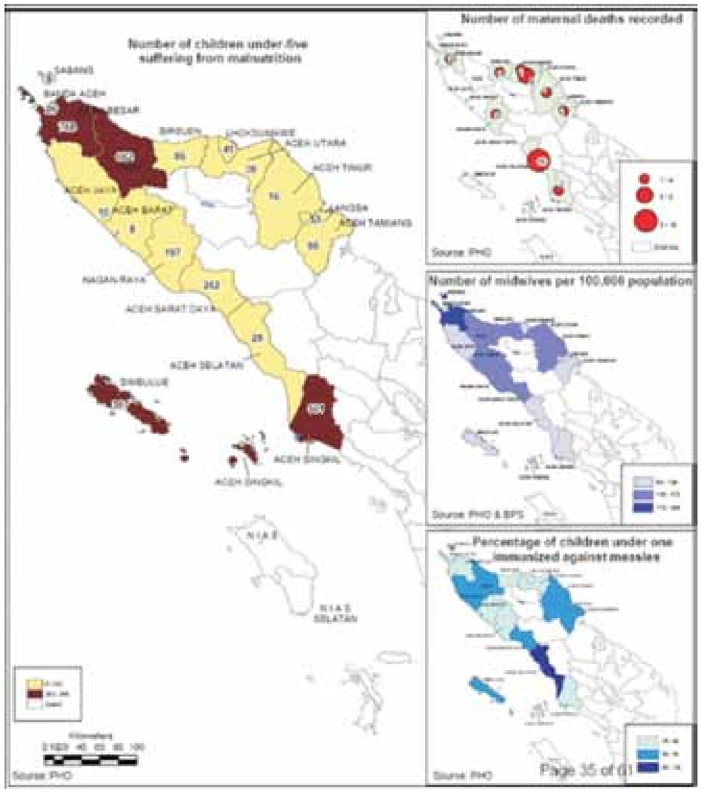


Figure 4: UN HIC worked with WHO to collect and evaluate data, using GIS to create an accurate picture of the damage and prioritize need

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Support from Space: The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)

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United Nations Office for Outer Space Affairs (UNOOSA)

Why Space-based Information for Disaster Management?

During a disaster, situational awareness can mean the difference between life and death. Satellites provide reliable and rapid communication, observation and positioning tools, especially when crucial on-the-ground infrastructure is damaged. Risk assessment, disaster mitigation and prevention also benefit greatly from space-based data. In general terms, applying space technology to support disaster management in its various aspects, requires the application of suitable spectral ranges of electromagnetic radiation for observation and imaging, atmospheric sounding, radio communication, navigation and positioning, while taking advantage of the orbital positions of satellites.

Images from earth observing satellites are used to produce maps of disaster areas for overview information and damage assessment, and to provide specific data layers for applications in Geographic Information Systems (GIS), e.g. for early warning, risk and vulnerability mapping.

Figure 1: Flooded farm land and infrastructure in northern Namibia in January 2010

Satellite communication serves to warn people at risk in remote areas, and to connect a disaster area to the outside world, providing medical information (telemedicine) or geographic information and data to support mapping activities. Global Navigation Satellite Systems (GNSS) provide positional information on disaster related events and objects and support relief forces in the field.

Nevertheless, potential users worldwide are still facing questions about the existence, availability, accessibility, quality, costs, and timeliness of space-based information. There is clearly still a widespread need for an information gateway to space-based information for disaster management support.

Where mechanisms for providing earth observation data for disaster management are already available, their applications are restricted to supporting only response measures in the immediate aftermath of a disastrous event, not for covering pre-disaster activities such as mitigation and early warning, or monitoring of slow-onset disasters. An outstanding example of these restrictions is given by the Terms of Reference of the International Charter Space and Major Disasters.

http://www.disasterscharter.org/web/charter/charter

What is UN-SPIDER ? Mandate and Mission

The world of disaster management and space-based technologies is complex. Knowledge and expertise are widely dispersed. Institutions and practitioners need support, orientation and advice to access and use available data, information, knowledge and services. In recognition of these needs the United Nations General Assembly, in its resolution A/RES/61/110 of 14 December 2006, established UN-SPIDER as a programme implemented by the United Nations Office for Outer Space Affairs (UNOOSA), with the following mission statement:

"Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle."

UN-SPIDER is a platform which advances the use of space-based technologies for disaster management and emergency response, by

- ✓ being a gateway to space information for disaster management support;
- ✓ serving as a bridge to connect the disaster management and space communities;
- ✓ being a facilitator of capacity-building and institutional strengthening.

To fulfil these tasks, the UN-SPIDER core team relies on a global network of Regional Support Offices and National Focal Points.

Figure 2: In the field: mobile satellite-based system for monitoring disaster areas, developed by the Institute for Communication and Navigation of the German Aerospace Center (DLR).

What UN-SPIDER is doing - Its Tools and Activities

The goals of UN-SPIDER are to bring the conceptual tools to reality. In parallel, the organization of international and regional UN-SPIDER Workshops is a well-proven means to raise awareness, to transfer knowledge, to support the establishment of Communities of Practice, and to foster alliances. Between these events, the flow of information is maintained by an E-Newsletter and monthly updates.

SpaceAid

The major field of work of UN-SPIDER comprises activities which might be described as brokering space-based information, by developing and implementing the SpaceAid concept. SpaceAid is UN-SPIDER's framework to facilitate fast and efficient access to space-based information for countries, and international and regional organizations. This includes all types of information provided by earth observation satellites, communication satellites and GNSS. The activation of the International Charter Space and Major Disasters through UNOOSA on behalf of other UN agencies is also part of this framework.

SpaceAid support can be accessed by the UN-SPIDER National Focal Points, UN-SPIDER Regional Support Offices and UN agencies. UN-SPIDER is also working on bringing in local partners. Authorized government agencies as well as major international and regional organizations will also have access to SpaceAid as procedures develop. Users can request the support of SpaceAid through a hotline that can be accessed by telephone, e-mail or fax. A central unit coordinates and follows-up on all requests. This framework is operational on a 24 hours per day/7 days a week basis in order to respond timely to a disaster.

UN-SPIDER requests or facilitates the activation of international provider mechanisms, which includes the International Charter Space and Major Disasters, Sentinel Asia, SAFER etc. This approach may be illustrated by a short case report.

In Montserrat, a British Overseas Territory in the Caribbean, seismic activity at the Soufriere Hills Volcano started to increase on 26 July 2008. This volcano has been intermittently active for 13 years. On 28 July, an explosion took place on the west side of a large lava dome at the summit. The dome partially collapsed, and there was a strong possibility that the explosion had caused instability in the rest of the dome, which could cause further collapses and endanger inhabited areas of the island

The Montserrat Volcano Observatory (MVO) is part of Montserrat's disaster management system and plays an important role in providing early warning to the authorities of a possible eruption of the volcano. MVO Staff however, were not able to make any assessment of the stability of the dome at that time, due to persistent clouds obscuring the volcano. Therefore, aerial surveys or optical satellite imagery could not be applied. An additional challenge was to obtain a set of comparable before/after images that would allow the staff to analyze the terrain and determine the extent of change in the volcanic dome. Within this backdrop Roderick Stewart, MVO Acting Director, requested assistance from the scientific community, including his fellow participants at the recent UN-SPIDER workshop for the Caribbean region, in order to obtain satellite imagery of the volcano.

The assistance obtained led to several satellite imagery acquisitions and the activation of the International Charter Space and Major Disasters. A set of high resolution radar images fulfilled the requirements and were analyzed for terrain change after the explosion. The imagery allowed MVO to determine that the lava dome had not been destabilized by the explosion. As a result, the Government of Montserrat was able to save valuable resources by cancelling an evacuation that had been planned as a precautionary measure. While most of the International Charter activations happen after a disaster has struck, the Caribbean island of Montserrat provided an example of how satellite imagery can be used to assess and prepare for an imminent disaster.

As a Cooperating Body to the Charter, UNOOSA has already been providing such support since 2003. It has requested the activation of the Charter a total of 75 times by the end of March 2010, which makes the United Nations, through UNOOSA, the largest single user of the International Charter. Through the UN-SPIDER SpaceAid Framework, UNOOSA continues to be the main contributor to ensuring access and use of space-based information to support emergency response in developing countries.

In 2009, the SpaceAid framework has provided support to disaster response and recovery efforts in Morocco, Namibia, Tajikistan, Afghanistan, Senegal, Mauritania, Burkina Faso, the Philippines, Samoa, Laos and Fiji (in chronological order), followed by support for response and relief activities in the Solomon Islands, Haiti and Gaza/oPt, Cook Islands, Tonga, Ukraine, Chile, Uganda and Turkey (as of 8 March 2010).

For each disaster, a SpaceAid Updates page is created on the UN-SPIDER Knowledge Portal, accumulating links to all available space-based information and sharing it widely to the disaster response community.

The SpaceAid mechanism is open, and thus not limited in respect of users or providers, and therefore it fills existing gaps in coverage. UN-SPIDER works with commercial providers of imagery and will formalize relations with standardized agreements. Users indicate their needs in consultation with UN-SPIDER experts. User requests are forwarded to all partners of the framework. The providers select products to be provided on a voluntary basis. All partners have the opportunity to contribute to any request, and all opportunities to obtain imagery free of charge will be exploited. Partners inform other potential providers of their intended contribution on the UN-SPIDER Knowledge Portal to avoid duplication of efforts.

In a collective effort, UN-SPIDER works with partners to develop an on-line tool to automatically task available satellites. Once the required technology becomes functional, SpaceAid will also be in a position to task multiple satellites according to the needs of requesting users. Tasking schedules and available products will be forwarded to users.

UN-SPIDER continuously seeks and coordinates possible external sources for funding to provide space-based information to users. Financial resources are pooled to establish a SpaceAid Imagery Fund. This will allow making available high-resolution images and other information in the event of a disaster, to all interested users with no license restrictions. End users, the respective space and disaster management communities, media and interested individuals are being informed on a regular basis of the opportunities and achievements of SpaceAid.

Technical Advisory Support

Technical Advisory Missions are part of UN-SPIDER's support at the national level. Governments or national institutions may officially request a UN-SPIDER Technical Advisory Mission. The mission objective is to assess the existing use of space-based technology and information for disaster management and emergency response, to identify potential areas where space applications could play a greater role, and to provide recommendations on how to improve access to and use of space-based technology and information.

Technical Advisory Missions make use of the expertise available in the regions or internationally. To support national activities, external experts are invited to join a UN-SPIDER mission in the requesting countries, thus enhancing horizontal cooperation in the region and strengthening the links between disaster management and space communities.

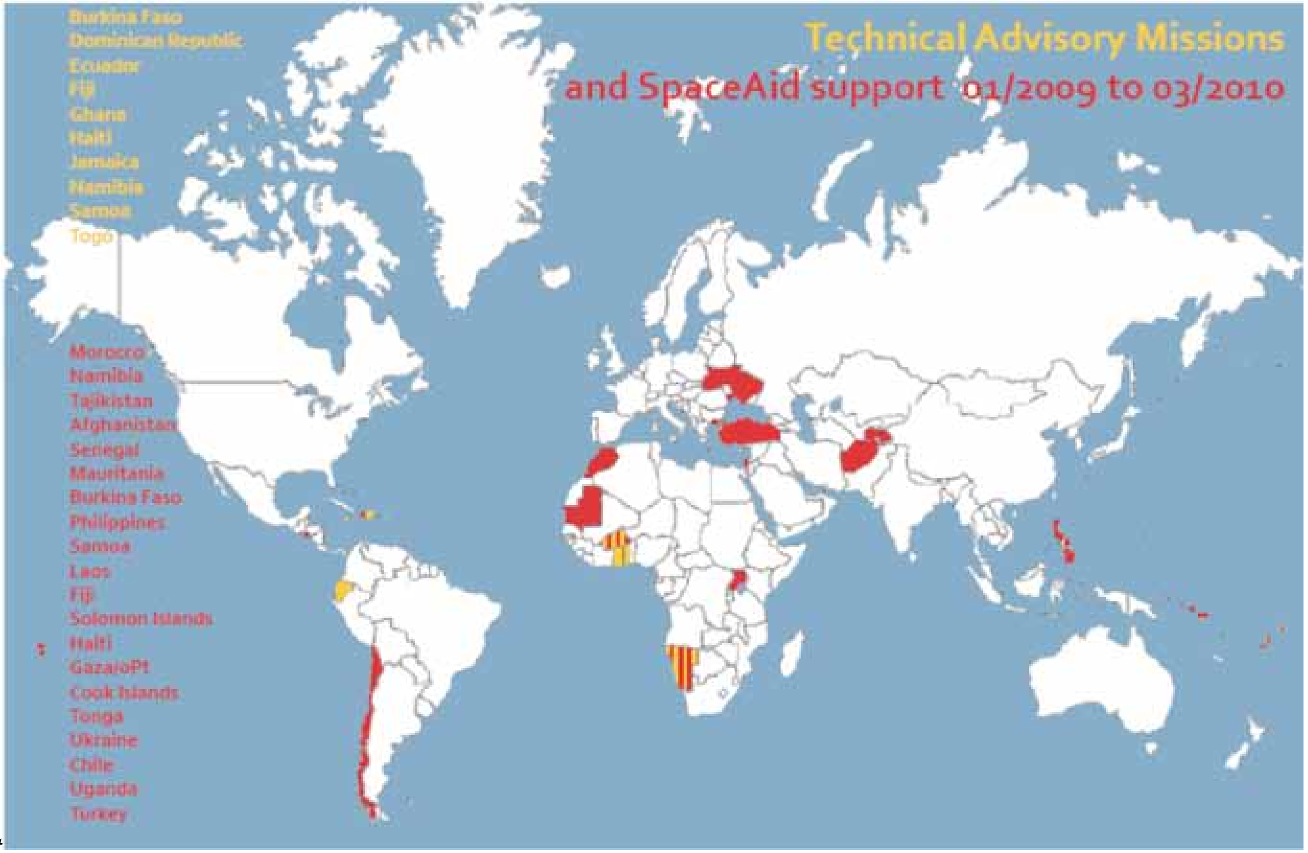


Figure 3: Technical Advisiory Mission and SpaceAid support

Alternatively, technical advice to national institutions may also be provided by other means such as bilateral meetings, telecommunication, video conference, or by facilitating direct cooperation between the national institution and providers of space-based information.

Up to March 2010, UN-SPIDER has carried out formal Technical Advisory Missions to Burkina Faso, Ecuador, the Dominican Republic, Fiji, Ghana, Haiti, Jamaica, Namibia, Samoa, and Togo.

Capacity-building

Capacity-building efforts are essential for UN-SPIDER to fulfil its mission in developing countries. Capacity-building goes beyond training of individuals, and includes the strengthening of institutional frameworks and procedures. Short-term training programmes target specific contents, such as particular tools or processes, with the aim of strengthening the capacity of individuals. Long-term activities are tailored to enhance capacities of agencies or to enhance the synergies among them. Activities in this component include workshops and exercises (2- 5 days), short, intensive training events (spring or summer schools, block courses, 1- 3 weeks), and courses (one to several months).

Workshops will target very specific topics and will be structured in such a way that they concentrate on specific skills. In a similar fashion, contingency and near-real-time exercises will be set up with realistic scenarios in mind to complement other training activities.

Short, intensive training events (for example spring and summer schools or block courses) will include lectures as well as hands-on training on basic space technology utilization, GIS, interpretation and visualization of spatial data, and applications via examples and case studies.

Courses will provide an overall view to use space-based information for disaster and risk management, targeting the use of this information for a variety of hazards and, in the case of emergency response, addressing not only the use of information, but also other spatial applications such as GNSS and satellite communications.

Training activities are carried out through the network of Regional Centres on Space Science and Technology Education affiliated to the United Nations, as well as other Centres of Excellence such as the International Institute for Geo-Information Science and Earth Observation (ITC) in the Netherlands, the Asian Institute of Technology (AIT) in Thailand, the University of Salzburg Centre for Geoinformatics (Z_GIS) in Austria, and with the support of space centres such as the German Aerospace Center (DLR).

The capacity-building efforts are coordinated with the support of the Regional Support Offices and National Focal Points, and with other regional and international organizations such as the International Strategy for Disaster Reduction (ISDR); the Group on Earth Observations (GEO); United Nations agencies, such as the UN Office for the Coordination of Humanitarian Affairs (UNOCHA), the World Meteorological Organization (WMO), the United Nations Development Programme (UNDP) and the United Nations Educational, Scientific and Cultural Organization (UNESCO); and regional organizations targeting risk reduction and emergency response such as the Coordinating Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC) and Caribbean Disaster Emergency Response Agency (CDERA) in the American hemisphere; the Asian Disaster Preparedness Center (ADPC) and the Asian Disaster Reduction Centre (ADRC) in Asia; and the International Federation of the Red Cross and Red Crescent Societies (IFRC).

The UN-SPIDER Knowledge Portal: A Web-based Platform for Information and Communication

What is the Knowledge Portal?

The Knowledge Portal is UN-SPIDER's response to the need for a comprehensive information gateway to space-based information for disaster management support. It is a web portal for information, communication and process support and offers orientation and guidance, and provides updates on the latest UN-SPIDER activities. Information on SpaceAid and updates on current disasters is issued, as are reports about Technical Advisory Missions and UN-SPIDER workshops. Questions about availability, quality, accessibility and costs of space-based information are answered on the Portal.

The portal is open to the public and anyone involved in the fields of disaster management and/or satellite technology. You are cordially invited to visit http://www.un-spider.org and register as a user.

Figure 4: Structure of the Knowledge Portal

What is the content of the Knowledge Portal?

The Knowledge Portal features the following sections: **SpaceAid, Advisory Support, Knowledge Base, Network,** and **About Us**. They offer a combination of guides to space technology application, consultant activities, technical and institutional background information, and communication platforms for users and Communities of Practice. Furthermore, there is a News section where users are informed about recent UN-SPIDER activities and where they can also access current and past issues of the UN-SPIDER Newsletter and monthly Updates. An events calendar informs the visitor about upcoming workshops and conferences. If UN-SPIDER organizes or co-organizes these meetings, an online registration form can be provided on the Portal.

The **SpaceAid** section supports the activities of SpaceAid described above. It is the place where fast and efficient access to space-based information is made available. It contains information on available space-based products and services, on their application, sources, access options and procurement procedures. It covers the full disaster management cycle, all earth-directed space technology, and all types of major natural or man-made disasters. For example, during recent disasters such as the earthquake in Chile on 27 February 2010, an update page on the respective response and recovery efforts was created and constantly amended with information on newly available data.

The SpaceAid section further provides an overview of relevant organizational frameworks such as the SpaceAid framework and the mechanism of the International Charter Space and Major Disasters. The understanding of these frameworks, mechanisms, procedures and workflows is a prerequisite to bringing technological assets to bear on disaster management with the best possible efficiency.

Furthermore, the user finds guidance on space applications and how disaster management can benefit from them. Guides and case reports outlining the underlying principles, methodical workflows and best practices, advantages and restrictions, and accessibility of data and services are offered in order to inform the user and to support the decision making process.

The Visual Globe, which is currently still under development, is a search tool which offers a surface for displaying the content of geocoded items. First and foremost it is designed to support the work of SpaceAid. Information about ongoing and past disasters will be displayed in the respective geographic region. Users on site will have the opportunity to upload ground truth data such as photographs or coordinates etc. to the disaster information on the Visual Globe.

Furthermore it will enable users to find the contact data of experts on certain topics as well as the representatives of Regional Support Offices and National Focal Points based on a geographical search.

Figure 5: The Visual Globe

In the **Advisory Support** section, the visitor is given an overview on the UN-SPIDER Technical Advisory Support framework and respective Missions that are being conducted by expert teams upon specific request. The available reports can give other interested users an idea of how such missions are conducted and how the participants can benefit from them. They also give an idea of which stakeholders can be involved in these missions and how the regional networking can be strengthened through them.

Furthermore, the visitor will find information on the UN-SPIDER capacity building strategy. Once they are fully developed and available, e-learning modules will be announced on this site as well as hands-on courses and other training opportunities.


UN-SPIDER
SpaceAid - Available Space-based Information for:
Earthquake and Tsunami in Chile (27/02/2010)

Figure 6: SpaceAid page on the Knowledge Portal

The **Knowledge Base** provides guides on technologies, on disaster management and on health support. The technology guides offer background information on satellite technology and specific satellite missions, while the disaster management guides provide information about policies and procedures concerning the management of different disaster types. Health support guides focus on the application of space technology in disaster medicine.

The Knowledge Base is meant to supply people involved in disaster management with basic knowledge and background information outside operational situations. The knowledge gained about the application of satellite technology will then benefit the decision making process in the event of a disaster and especially for disaster management policy and emergency planning. Knowledge about technological background and about best practices is crucial for developing mitigation and preparedness strategies.

Given the complexity of disasters on the ground and the organizational tasks of disaster management, guiding information on how to apply a particular technique has to be specific to the type of disaster and the disaster management cycle phase (mitigation, preparedness, relief and response, recovery and reconstruction). Guiding information on the application of a given space technique may also refer to more general humanitarian aspects such as health, critical infrastructure, humanitarian aid and security, e.g. in case of complex emergency situations not attributable to a specific disaster type. In order to facilitate the search for the right information, the Space Application Matrix is being developed. This is an intuitive information retrieval tool which allows combining disaster type, DM cycle phase, and satellite technology to render relevant search results.

The Knowledge Base is complemented by a glossary and directory of institutions whose activities are related to disaster management and the use of space technology.

Network provides links to the UN-SPIDER Regional Support Offices and National Focal Points, as well as access to an extensive contact data base. Furthermore, a communication platform is offered to Communities of Practice that need a joint working space to communicate and share content among themselves or with an open community. If for example, a member of the disaster management community wants to contact a UN-SPIDER National Focal Point or Regional Support Office, they can find contact data and information about the respective institutions on the Knowledge Portal.

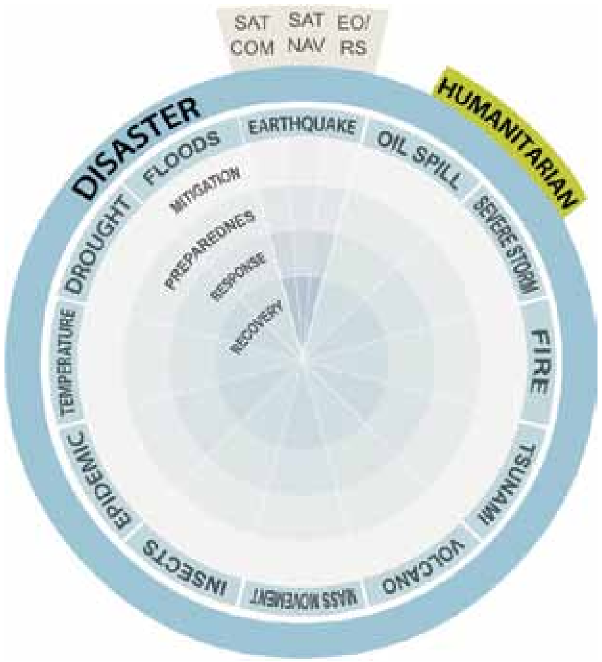


Figure 7: The Space Application Matrix

Further, UN-SPIDER provides space on the Portal to Communities of Practice that wish to cooperate on a certain topic related to the mandate of the Programme. For example, the Expert Group on Capacity Building and the UN-SPIDER Global Thematic Partnership have set up workspaces on the Portal where they can share documents and discuss amongst each other the content and development of their respective projects. The African Sub-Sahara Flood/Disease SensorWeb Pilot Project is also making use of this communication platform and further communities will be supported.

Finally, **About Us** informs about the mandate of UN-SPIDER, its organization and the staff. Current and previous Newsletters and Updates can also be downloaded from here.

It remains to be emphasized that the continued successful operations of the UN-SPIDER Knowledge Portal is dependent on a dynamic user community which provides regular input and feedback. After all, it is a communication tool and not a one-way information platform.

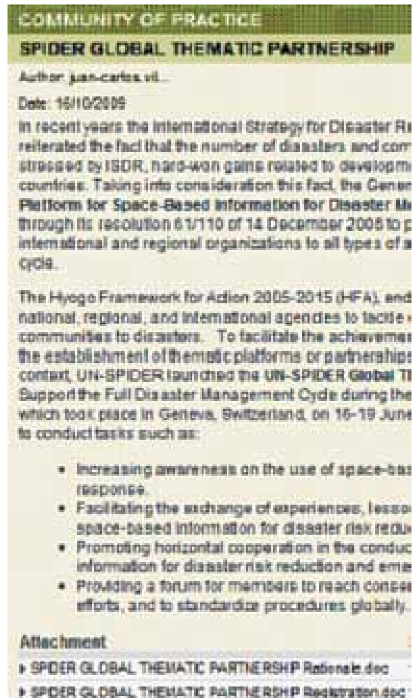


Figure 8: Community of the Practice on the Knowledge Portal

How is UN-SPIDER organized? Structure and Funding

The organizational framework of UN-SPIDER has three cornerstones: the UN-SPIDER staff, the network of Regional Support Offices and the National Focal Points.

The Director of the **Office for Outer Space Affairs** is the supervisor of the UN-SPIDER Programme and is responsible for its overall implementation. The Director is assisted by a Programme Coordinator to help plan and coordinate all activities, including coordination with the Regional Support Offices. The Programme Coordinator works closely with the Heads of the **Bonn Office** and the future **Beijing Office** as well as with the Programme Officer who leads the Outreach Activities and Capacity Building, in the implementation of all programme activities.

Regional Support Offices are regional and national Centres of Expertise in the use of space technology in disaster management which agree to form a network for implementing the activities of the programme in their respective regions in a coordinated manner. A Regional Support Office should be a leading national or regional institution with notable expertise in the use of space technology for disaster management. It has to be nominated by its government or governing body.

Cooperation Agreements have been signed with Regional Support Offices in Algeria, the I. R. Iran, Nigeria, Pakistan, Romania, Ukraine, and the Asian Disaster Reduction Center in Japan. UN-SPIDER has also received formal offers from the Philippines, South Africa, the University of the West Indies, and the Water Center for the Humid Tropics of Latin America and The Caribbean (CATHALAC), and has informed the respective regional groups of these offers (as of 8 March 2010).

National Focal Points are the national institutions representing the disaster management and/or space application communities. They are nominated by their respective government to work with UN-SPIDER to strengthen national disaster management planning and policies and in the implementation of specific national activities that incorporate space-based technology solutions to support disaster management.

As of March 2010, the following 40 United Nations Member States had nominated a UN-SPIDER National Focal Point: Austria, Belarus, Belize, Bolivia, Bosnia & Herzegovina, Burkina Faso, Burundi, China, Cote d'Ivoire, Croatia, Egypt, El Salvador, Ethiopia, India, Iraq, Jordan, Kenya, Malawi, Malta, Mauritania, Mauritius, Morocco, Myanmar, New Zealand, Nigeria, Philippines, Qatar, Republic of Korea, Senegal, Singapore, Spain, Syria, Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Ukraine, and the United Arab Emirates. The National Focal Points in these countries represent a wide range of organizations such as disaster management authorities, civil protection units, disaster risk reduction platforms, space agencies and mapping organizations.

The activities of UN-SPIDER are being implemented successfully with the support and the voluntary contributions (cash and in-kind) received from a number of Member States as well as from private companies, which is gratefully acknowledged.

Figure 9: *UN-Spider Team*

Figure 10: Network of Regional Support Offices, National Focal Points

An exemplary case: The African Sub-Sahara Flood/Disease SensorWeb Pilot Project

The following outline demonstrates how various UN-SPIDER activities may translate into concrete projects.

Disaster management agencies in the Southern African Region have to adapt to an increasing number of natural disasters mainly caused by floods and drought. The effects of global climate change will most probably aggravate this situation and substantially increase the economic impact, threatening the livelihoods of an increasing number of people. In addition, vector borne diseases and epidemics of weather- and climate-sensitive infectious diseases, including malaria, meningitis, and cholera, cause massive disruption to societies and put a heavy burden on national and local health systems.

During the floods in Namibia in March 2008, the UN-SPIDER team was instrumental in ensuring access to the International Charter Space and Major Disasters and other opportunities to support the Namibian government with satellite data. A severe flood had started at the end of January and reached its peak around mid-March. The Namibian government declared the state of emergency on 5 March. A request to provide satellite imagery for the northern and north-eastern regions of Namibia reached UNOOSA from the Department of Water Affairs, Ministry of Agriculture Water and Forestry (MAWF), and the country office of the United Nations Development Program (UNDP) in Namibia, asking for international support to obtain high resolution, cloud free satellite imagery on a priority basis. Subsequently, on March 14, UNOOSA activated the International Charter to help Namibia to manage the impacts of the floods including the outbreak of cholera. UN-SPIDER provided support and followed-up closely with both UNDP and the Department of Water Affairs of Namibia, helping the country to take full advantage of international support.

In January 2009 the Government of Namibia requested a Technical Advisory Mission of UN-SPIDER to assess the existing use of space-based technology and information for disaster management and emergency response in Namibia. Specifically, the mission was requested to identify potential areas where space-based technology and information could play a greater role, and to propose recommendations on how to improve Namibia's access to and use of space-based technology and information. Following a meeting during the International UN-SPIDER Workshop in October 2008 in Bonn, with the governmental focal point for the mission, the Department of Water Affairs, Ministry of Agriculture Water and Forestry, three experts from UN-SPIDER and the German Aerospace Center's crisis information team (DLR/ZKI) were fielded to Windhoek, Namibia from 27 January to 2 February 2009 to provide technical advice and train local experts in remote sensing techniques for flood mapping. A two day kick-off workshop on 29 and 30 January 2009 brought together relevant disaster management stakeholders to evaluate past experiences and formulate lessons learnt.

A field visit to the flood-prone region with hands-on training on GPS applications for disaster managers followed by training for technical experts to improve end-user adapted geospatial emergency response products and services completed the mission. The workshop and training were funded by the German Technical Cooperation (GTZ).

Again in late February and March 2009, severe flooding affected Northern Namibia due to heavy local rains and an inflow of water from northern regions. On 27 February 2009, UNOOSA again activated the International Charter.

Whereas the first call was extended in time to specific regions in Northern Namibia, a second call followed for the affected areas bordering the Okavango and the Zambesi Rivers in North/North Eastern Namibia. In addition to the Charter activation, UN-SPIDER was involved in a range of activities to provide supplemental information, data and imagery.

Finally, the community that was brought together by this approach decided not only to support Namibia during the relief situation but to implement a pilot project with more far reaching goals.

The idea was to collect weekly high resolution imagery from satellites such as EO-1, Formosat and Radarsat and to validate the satellite data against ground measurements so that the satellite data can be used for better forecasting of floods and for improved situational awareness for in-country emergency workers. A technical workshop was held at the UN-SPIDER Bonn Office in August 2009 with representatives from UN-SPIDER, NASA, NOAA, DLR, the Namibia Department of Hydrology and Ukraine Space Research Institute to begin planning ahead.

Figure 11:
UN-SPIDER activities in Namibia 2008-2010

The pilot project is envisaged to combine high resolution satellite imagery with in-situ data and modelling approaches in order to derive a scientifically sound, operational trans-boundary flood management system for the Southern African region, and to provide useful flood and water-borne disease forecasting tools for local decision makers.

Some personnel at NASA Goddard Space Flight Center are already engaged in studying Malaria Early Warning Systems and other vector-borne diseases related to floods. Additionally, UN-SPIDER addressed this issue to the community attending the Second United Nations International UN-SPIDER Bonn Workshop in October 2008. Recommendations from the respective institutions in Namibia such as the Ministry of Health and Social Services are prerequisite to successfully integrating any outcomes from this project into the National Health Emergency Preparedness and Response Plan.

Finally, in January 2010 the Department of Water Affairs, Ministry of Agriculture, Water and Forestry in Namibia together with UN-SPIDER organized a regional follow-up activity for a *Flood Management Pilot Project* in Namibia in order to promote the access and use of space-based technologies and solutions for disaster management and emergency response within relevant communities. The activities in Windhoek were preceded by a visit to the northern regions Caprivi and Oshana that were affected by the flood in 2009. Additionally, meetings with representatives of the Northern Regional Councils were arranged.

Subsequently, a technical meeting with stakeholders in Windhoek was arranged with the mayor to provide information, feedback and lessons learnt from the Namibian disaster management institutions, as well as national and regional relief practitioners, and to provide technical expert knowledge on the use of space technology to better facilitate international collaboration in the future. Following the field mission communications were finalised to include the technical solutions provided by the international expert team and the user needs in the different regions. Substantial output regarding user requirements, data and information structure, capacity development, and necessary steps for developing support for national policy planning were generated by six working groups. Finally, the mission team reported at a high-level debriefing committee, including the Minister for Agriculture, Water and Forestry, who explicitly appreciated the international support to Namibia and the set of technical solutions, and announced the political commitment of the Government of Namibia to support further activities of the pilot project.

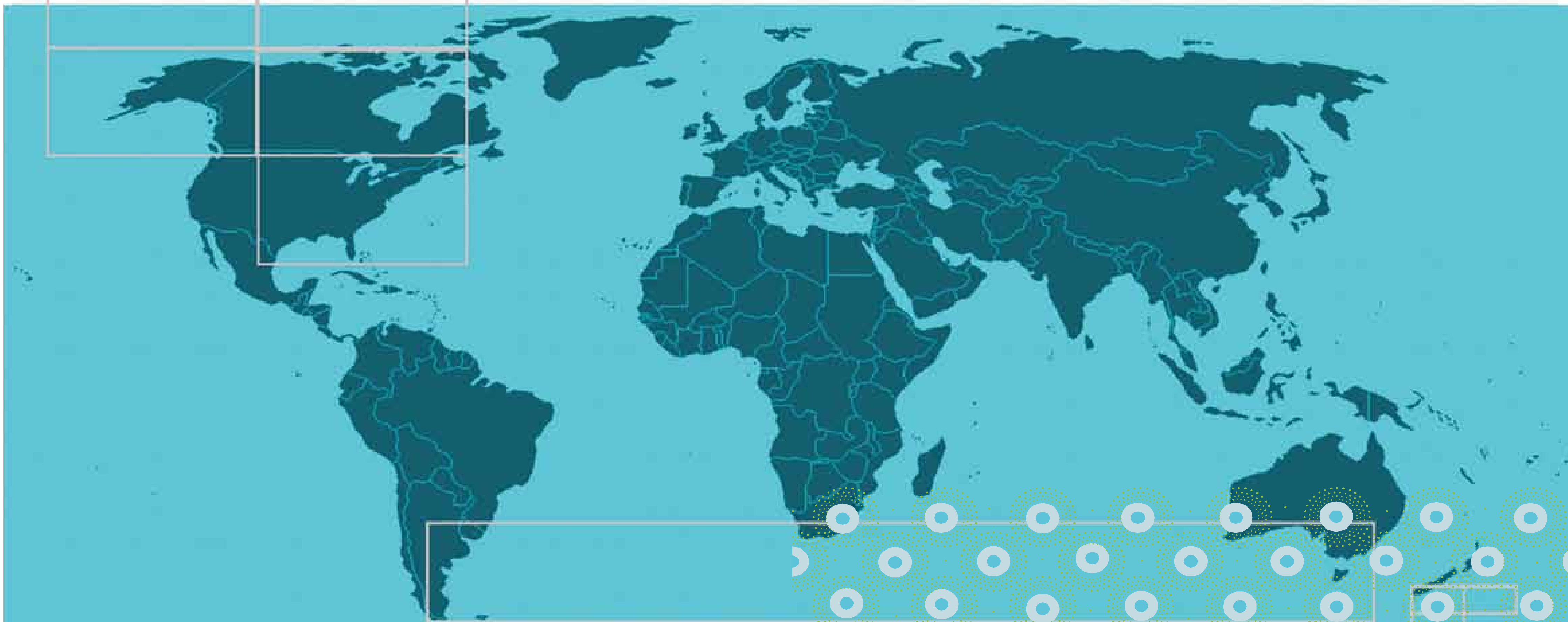
Global Spatial Data Infrastructure Association (GSDI)

GSDI Association

What are Spatial Data Infrastructures?

Spatial data infrastructures (**SDIs**) are the fundamental spatial datasets, the standards that enable integration, the distribution networks that provide access, the policies and administrative principles that ensure compatibility, the people including users, providers, and value adders, at each level; local through to state, national, regional and global.

Spatial data is vital to making sound decisions at all levels. **Disaster management, response and recovery** is one example of an area in which decision-makers are benefiting from spatial information, together with the associated spatial data infrastructures that support information discovery, access, and use of this information in the decision-making process.



GSDI Association

The Global Spatial Data Infrastructure Association (GSDI) is an inclusive organization of organizations, agencies, firms, and individuals from around the world promoting international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations and their citizens to better address social, economic, and environmental issues of pressing importance.

Mission of the GSDI Association

The mission of the GSDI Association is to

- ✓ Serve as a point of contact and effective voice for those in the global community involved in developing, implementing and advancing spatial data infrastructure concepts.
- ✓ Foster spatial data infrastructures that support sustainable social, economic, and environmental systems integrated from local to global scales.
- ✓ Promote the informed and responsible use of geographic information and spatial technologies for the benefit of society.

Goals of the GSDI Association

The primary activities of the GSDI Association

- ✓ support the establishment and expansion of local, national, and regional (multi-nation) spatial data infrastructures that are globally compatible.
- ✓ provide an organization to foster international communication and collaborative efforts for advancing spatial data infrastructure innovations.
- ✓ support interdisciplinary research and education activities that advance spatial data infrastructure concepts, theories and methods.
- ✓ enable better public policy and scientific decision-making through spatial data infrastructure advancements.
- ✓ promote the ethical use of and access to geographic information.
- ✓ foster spatial data infrastructure developments in support of important worldwide needs such as improving local to national economic competitiveness, addressing local to global environmental quality and change, increasing efficiency, effectiveness, and equity in all levels of government, and advancing the health, safety and social wellbeing of humankind in all nations.

The Scientific and Technical Program of the GSDI Association

Much of the work of the GSDI Association is planned and accomplished through standing committees whose memberships are made up from individuals from full member organizations and members of the International Geospatial Society. The standing committees include:

- ✓ Technical Committee
- ✓ Legal and Socioeconomic Committee
- ✓ Outreach and Membership Committee
- ✓ Societal Impacts Committee.

GSDI Aspirations

The GSDI Association by concentrating on specific strategic tasks aspires to:

- ✓ more closely align its organizational activities by addressing member needs and societal needs identified and prioritized by its organizational and individual members
- ✓ provide more effective communication mechanisms to better enable its members to work collaboratively
- ✓ achieve visible and measurable outcomes in furtherance of the core missions and goals of the organization.

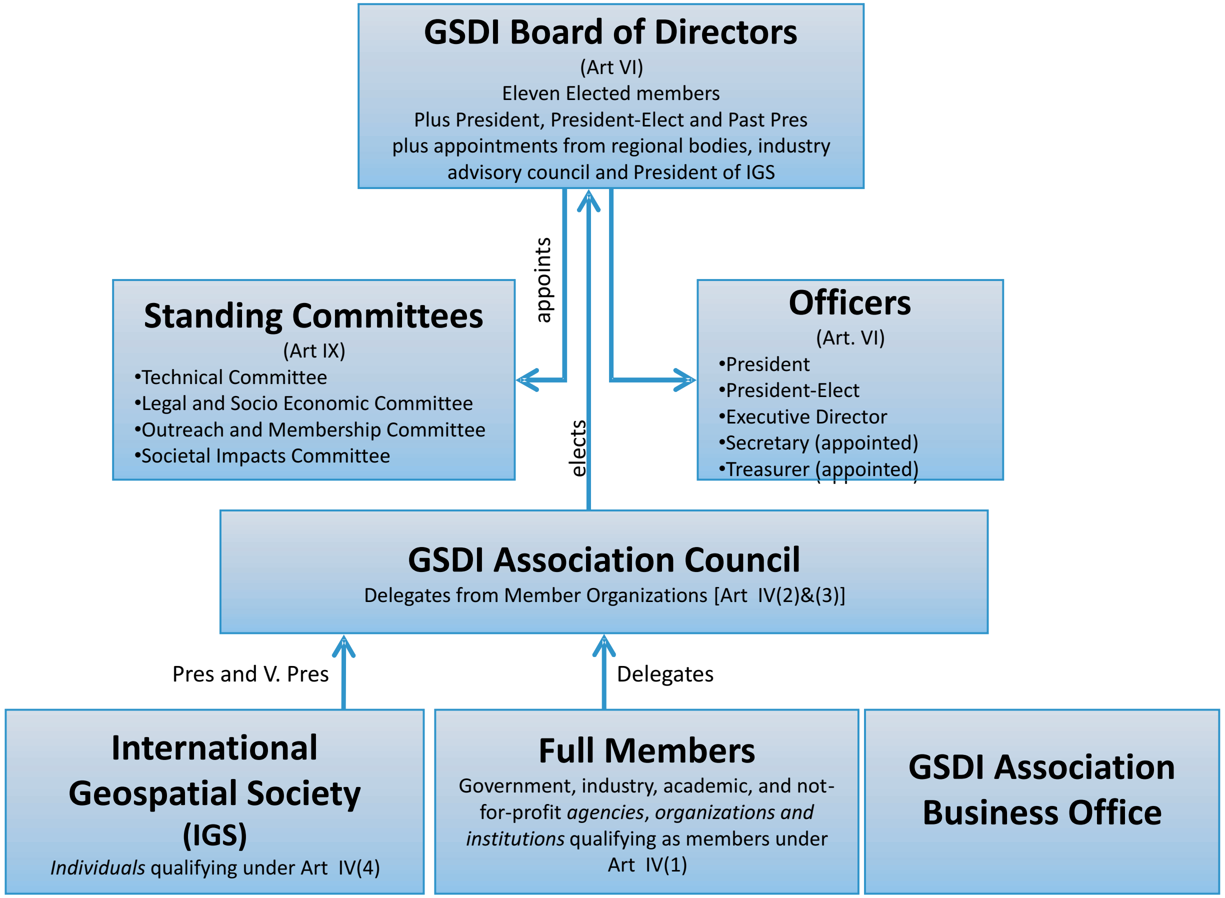
Additionally, the GSDI Association through the provisioning of significantly expanded services and products aspires to be the global organization of choice for:

- ✓ local to global agencies, private companies, academic institutions and non-profit organizations engaged in advancing the uses of SDIs and improving decision-making through the use of SDIs
- ✓ individual geospatial specialists interested in solving local to global societal problems.

Organizational Structure

The GSDI Association consists of a Council comprised of the delegates from the Full Member organizations and two representatives from the International Geospatial Society , the Board of Directors which is the main administrative body of the Council and the Standing Committees.

The GSDI Association has two classes of membership: full members and individual members. Full members include organizations such as government agencies and organizations, private companies, industry organizations, academic institutions, not-for-profit organizations, and similar organizations that influence the development of spatial data infrastructures at national, regional, and international levels. Individual members are those individuals that are members of the International Geospatial Society (IGS).



Activities of GSDI Association in support of global disaster management initiatives

Emergency Response and Recovery Readiness

Even in large wealthy nations, local communities are told that they should not expect substantial direct delivery of goods and services from national or international relief agencies for at least 72 hours after a major widespread disaster. Thus local communities must be prepared to rely on their own public and private emergency response and management systems in that most critical of time periods immediately after a disaster occurs.

If the components of a spatial data infrastructure are in place and are in use on a daily basis by local users for accomplishing mapping, vehicle routing, asset management, service delivery and similar tasks, then the information infrastructure is much more likely to be available and useful for accomplishing similar tasks during a calamity. Learning how to use geospatial and affiliated communication technologies doesn't occur overnight. Nor will data needed to respond to emergencies appear out of thin air. For these reasons, the GSDI Association encourages the building of long-term SDI from local to global scales within and among all nations of the world.

GSDI Conferences

One of the principal activities of the association is to provide a GSDI Conference for SDI-related professionals, scientists, and applications, on a regular basis to share and exchange ideas. Since 1996, experts in SDI and spatial data management matters have come together to share their experiences in advancing SDI platforms from local to international levels. A continuing theme of GSDI is *realizing spatially enabled societies*. The pressing needs of societies are a particular emphasis of GSDI conferences and include a focus on disaster prevention, warning, management, response, and recovery.

Small Grants Program

Nations with the few economic resources are the hardest hit in the event of a natural or human made disaster. Many more lives may be lost and recovery will typically take much longer. The GSDI Association supports an annual small grants program to support national or sub-national activities that foster partnerships, develop in-country technical capacity, improve data compatibility and access, and increase political support for spatial data infrastructure and earth observations application development. Priority is given to projects in developing nations and countries with economies in transition.

Global Spatial Data Infrastructure GSDI

Developing Partnerships and Spreading Knowledge

GSDI provides a global venue for networking, communicating and learning among its members. Through the Geographic Information Knowledge Networks (GIK Network) GSDI enhances communications and sharing among geospatial specialists and organizations from all nations and for the global geographic information community at large (http://giknetwork.org).

Open Access to Data, Tools and Learning Materials

The GSDI Association and its members promote open access to the greatest extent possible to spatial data as well as to educational materials in how to use geospatial technologies and establish SDI. If those affected by a disaster can't gain access to the detailed geospatial data and technologies they need when they need it, the data and technologies have no value and might as well not exist. In order to support learning, all past books developed by the GSDI Association have been published using open access licenses, the articles in all the proceedings from the past world conferences are openly published on the web and its web pages are all posted using creative commons licenses. Thus, legal and economic barriers to sharing among those interested in pursuing knowledge on topics such as emergency response and recovery are reduced greatly.

The International Association of Geodesy

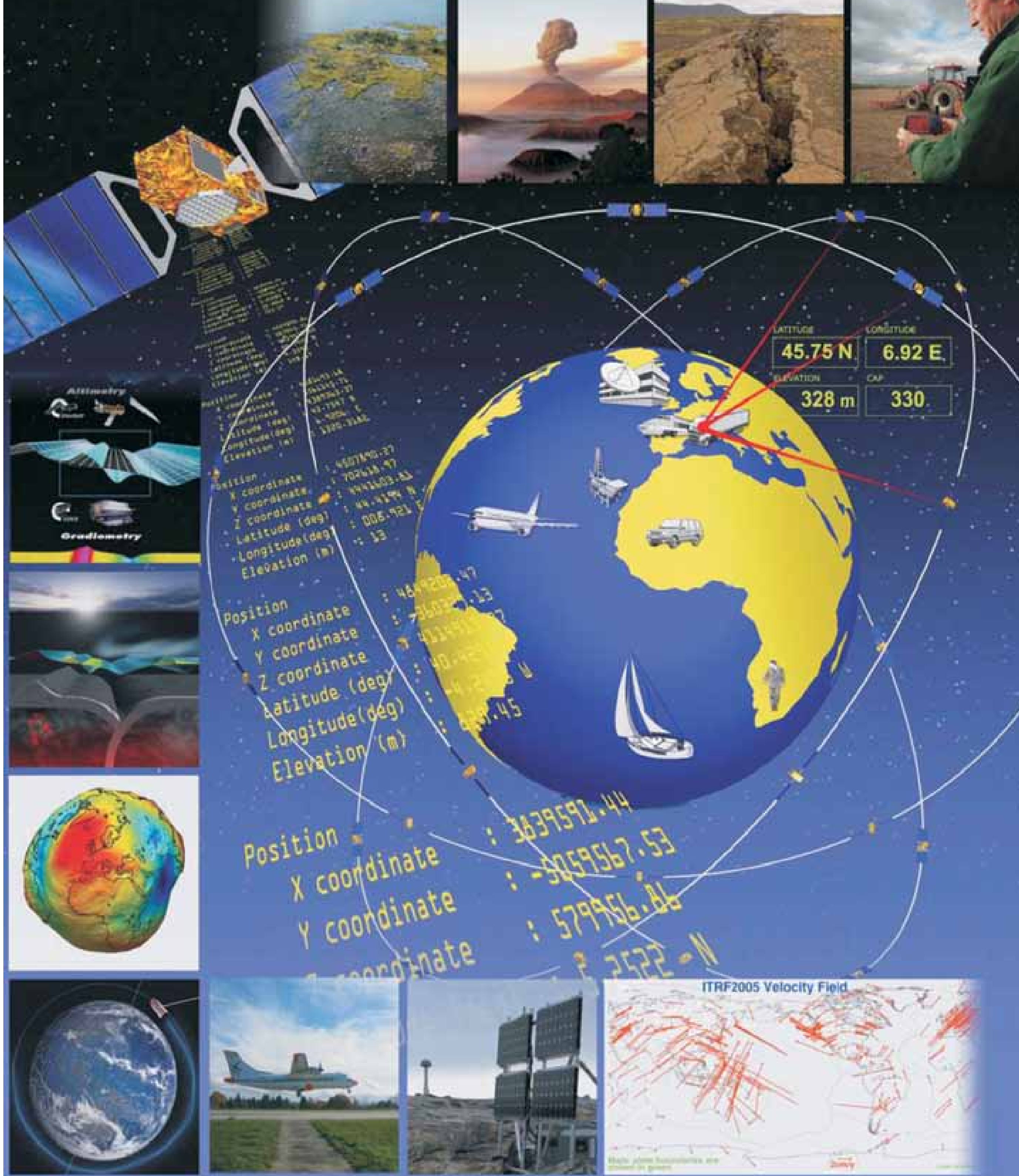
What is Geodesy?

The classical definition of Geodesy is the science concerned with the Shape, Size, and the Gravity Field of the Earth. Geodesy today is much more than that. It is a geo-science that treats the Earth as a complex dynamic system, a body consisting of many layers, surrounded by the atmosphere and the oceans. Geodesy deals with:

- ✓ the monitoring of the solid Earth (e.g. tectonic andnon-tectonic displacements);
- ✓ the monitoring of variations in the liquid Earth (sea level rise, ice sheets);
- ✓ monitoring variations in the Earth's rotation (polar motion, the length of the day);
- ✓ determining orbits for scientific satellites (including Earth Observation Satellites);
- ✓ monitoring the atmosphere with satellite geodetic techniques (ionosphere, troposphere);
- ✓ monitoring the temporal variations in the gravity field of the Earth;
- ✓ determining positions, and their changes with time, of points on or above the surface of the Earth with the utmost precision.

Geodesy continues to provide the scientific basis of Navigation by the exploitation of the existing and planned Global Navigation Satellite Systems (GNSS), such as GPS, GLONASS, GALILEO, COMPASS. Its activities have a link to fundamental Astronomy via the global terrestrial reference system.

Geodesy is experiencing spectacular growth and each year new frontiers of Earth science knowledge are being explored, such as temporal variations of positions and gravity (land deformations, post glacial rebound, sea level rise, etc.). It is contributing to both everyday mapping and navigation purposes, and to the deeper understanding of our living planet, the Earth.



The Association

The International Association of Geodesy (IAG) is the scientific organization responsible for the field of Geodesy. The origin of IAG goes back to 1862, the year, in which the "Mitteleuropäische Gradmessung", predecessor of IAG, was established. It promotes scientific cooperation and geodetic research on a global scale, and contributes to it through its various research bodies. It is an active member Association of the International Union of Geodesy and Geophysics (IUGG), which itself is a member of the International Council for Science (ICSU).The scientific work of the Association is performed within a component structure consisting of:

- ✓ Commissions,
- ✓ Inter-commission Committees,
- ✓ Services,
- ✓ the Communication and Outreach Branch (COB), and
- ✓ the Global Geodetic Observing System.

IAG's Mission

The mission of the Association is the advancement of Geodesy. IAG implements its mission by:

- ✓ advancing geodetic theory through research and teaching,
- ✓ collecting, analysing and modelling observational data,
- ✓ stimulating technological development, and
- ✓ providing a consistent representation of the figure,
- ✓ rotation and gravity field of the Earth and planets, and their temporal variations.

The official IAG Website:

http://www.iag-aig.org

The website of the IAG Office:

http://iag.dgfi.badw.de

AG objectives

- ✓ To foster geodetic research and development,
- ✓ to support and maintain geodetic reference systems,
- ✓ to provide observational and processed data, standards,
- ✓ methodologies and models,
- ✓ to stimulate development of space techniques to increase the resolution of geodetic data,
- ✓ to initiate, coordinate and promote international cooperations, and
- ✓ to promote the development of geodetic activities accross the globe, especially in developing countries.

IAG Meetings

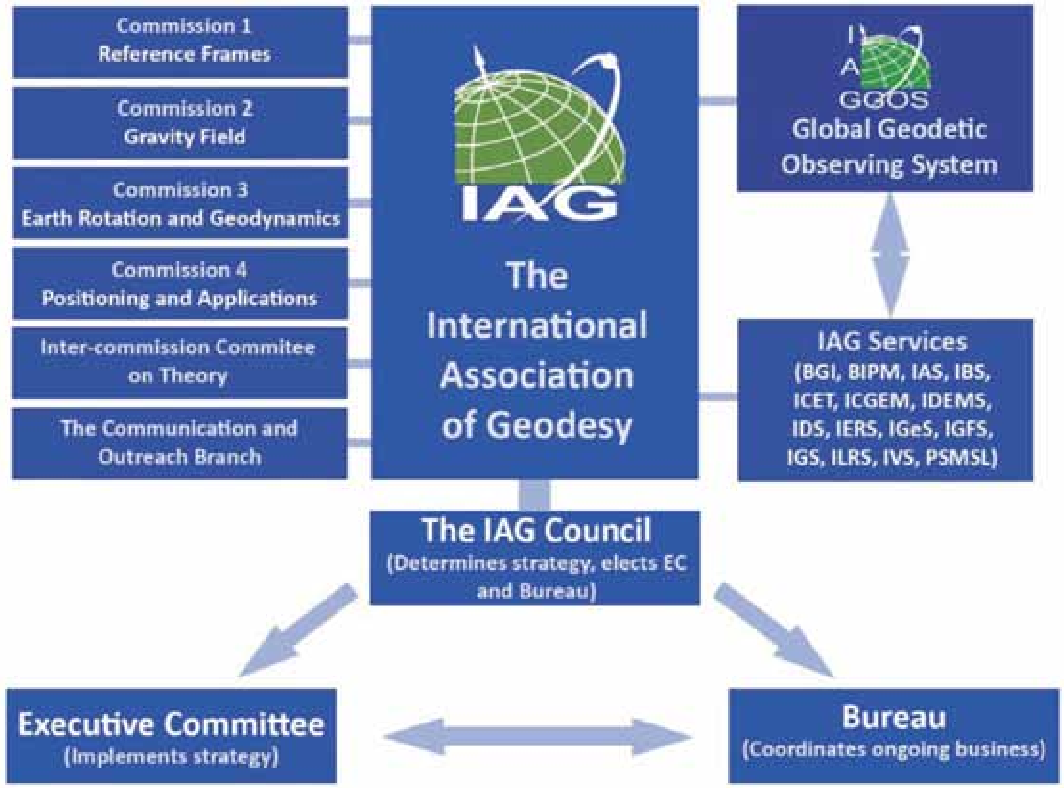
The IAG holds its own "General Assembly" every four years in conjuction with the General Assembly of the IUGG, at the same time and the same place. In addition, the Association organizes "Scientific Assemblies", independently from the IUGG, generally in the mid-term between General Assemblies. Other meetings that the IAG sponsors or supports include numerous international symposia and workshops covering broad fields of Geodesy and closely associated sciences and engineering.

IAG Publications

The IAG publications include:

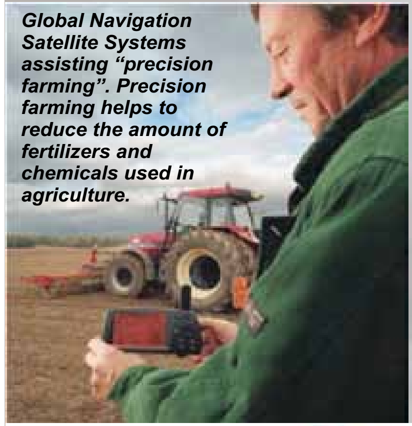
- ✓ the Journal of Geodesy,
- ✓ the IAG Symposia series,
- ✓ the Geodesist's Handbook,
- ✓ the "Travaux de l'Association Internationale de Géodésie",
- ✓ the IAG special publications,
- ✓ the IAG Newsletter.

The structure of IAG



Why is Geodesy fundamental to Society?

Traditionally, Geodesy has been viewed as a service science, providing important utility to other geosciences, and supporting many applications. In the past, the main “customers” of Geodesy came from the surveying and mapping profession, while today Geodesy serves all Earth sciences, including the geophysical, oceanographic, atmospheric, hydrological and environmental science communities.



Global Navigation Satellite Systems assisting “precision farming”. Precision farming helps to reduce the amount of fertilizers and chemicals used in agriculture.

Moreover Geodesy has served society by providing reference frames for a wide range of practical applications, such as navigation on land, sea and in the air, and from construction of infrastructure to the determination of reliable boundaries of real estate properties. In the past these reference frames were created on a national or regional level.

Today, GNSS provides access to precise point coordinates in a global reference frame anytime and anywhere on the Earth’s surface with centimetre-level accuracy.

A deeper understanding of the Earth is not possible without sufficient observations of a large set of parameters characteristic for various Earth system processes. Earth observations are not only necessary for a scientific understanding of the Earth, but they are also fundamental for many societal benefit areas, ranging from disaster prevention and mitigation to the protection of the biosphere, the environment and human health. Thus this science contributes to a prosperous global society.

Geodesy is fundamental in meeting these global challenges. It provides the foundation in which all Earth observation systems are ultimately built. But Modern Geodesy does more: with its “three pillars” of geokinematics, Earth gravity field, and Earth rotation, it also provides comprehensive observations of changes in the Earth’s shape, gravity field and rotation. These fundamental geodetic quantities are intimately related to mass transport in the fluid envelope of the solid Earth and its interior, as well asto the dynamics of the Earth System.

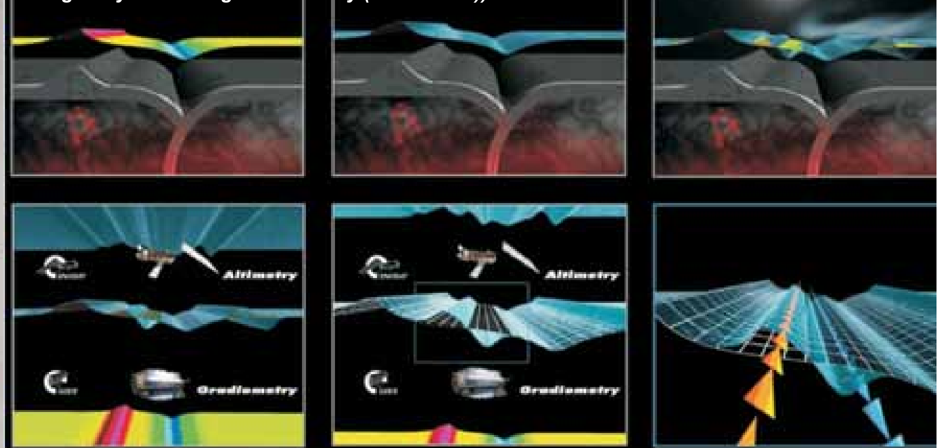
New geodetic techniques are leading to fundamental changes not only in all areas of navigation and transport, but also for applications in process control (e.g. farming, construction, mining, resource management), construction and monitoring of infrastructure (e.g., offshore platforms, reservoirs, dams, bridges and other large engineering structures), surveying and mapping, and Earth observation.

Geodetic techniques are crucial in the assessment of geohazards and anthropogenic hazards, and they play a pivotal role in early warning systems helping to mitigate the consequences of such disasters. Geodesy therefore contributes to increased security, to a better use of resources, and in general to the progress towards the sustainable development.

The Kvarken Archipelago (below). In western Finland is an oustanding example of post glacial uplift. The ground is still rising about 8mm a year, thus new land is emerging from the water.

IAG is one of the member Associations of the IUGG

Geodesy helps to understand ocean currents by mapping the sea surface topography using Altimetry and modelling the gravity field using Gradiometry (Photo:ESA))



IAG Services

The IAG is the home of a number of scientific services whose goals are to provide the user community with various geodetic products and/or information and to foster international cooperation:

BGI (Bureau Gravimetrique International)

URL: http://bgi.cnes.fr

BGI collects existing gravity measurement on a worldwide basis.

BIPM - Section Time, Frequency and Gravimetry

URL: http://www.bipm.org/en/scientific/tfg/

BIPM is responsible for the maintenance of the International Atomic Time (TAI) and the Coordinated Universal Time (UTC).

IAS (International Altimetry Service)

URL: http://ias.dgfi.badw.de

The IAS provides a point of contact for general information on satellite altimetry.

IBS (IAG Bibliographic Service)

URL: http://www.bkg.bund.de

BS maintains a literature database for geodesy, photogrammetry and cartography (GEOPHOKA).

ICET (International Centre for Earth Tides)

URL: htt://www.astro.oma.be/ICET

ICET collects and analyses measurements on Earth Tides.

ICGEM (International Centre for Global Gravity Field Models)

URL: http://icgem.gfz-potsdam.de/ICGEM

ICGEM collects existing gravity field models and provides services to utilize these models.

IDEMS (International Digital Elevation Model Service)

URL: http://www.cse.dmu.ac.uk/EAPRS/iag

IDEMS collects and validates digital models of the global topography.

IDS (International DORIS Service)

URL: http://ids.cls.fr

IDS provides DORIS data and data products for a wide range of scientific and practical applications.

IERS (International Earth Rotation and Reference Systems Service)

URL: http://www.iers.org

IERS provides and maintains the International Celestial Reference System and Frame, the Int. Terrestrial Reference System and Frame, and it provides Earth orientation parameters, standards, and models.

IGeS (International Geoid Service)

URL: http://www.iges.polimi.it

IGeS collects software and data referring to the geoid.

IGFS (Int. Gravity Field Service)

URL: http://www.igfs.net

IGFS is responsible for the collection, validation, archiving and dissemination of gravity data.

IGS (International GNSS Service)

URL: http://www.igs.org

IGS provides important data and products for the use of GNSS for Earth science, as well as many societal applications.

ILRS (Int. Laser Ranging Service)

URL: http://ilrs.gsfc.nasa.gov

ILRS collects, analyses and distributes Satellite and Lunar Laser Ranging data.

IVS (Int. VLBI Service for Geodesy and Astrometry)

URL: http://ivscc.gsfc.nasa.gov

IVS coordinates Very Long Baseline Interferometry (VLBI) observing programmes, sets standards, develops conventions for VLBI observations.

PSMSL (Permanent Service for Mean Sea Level)

URL: http://www.pol.ac.uk/psmsl

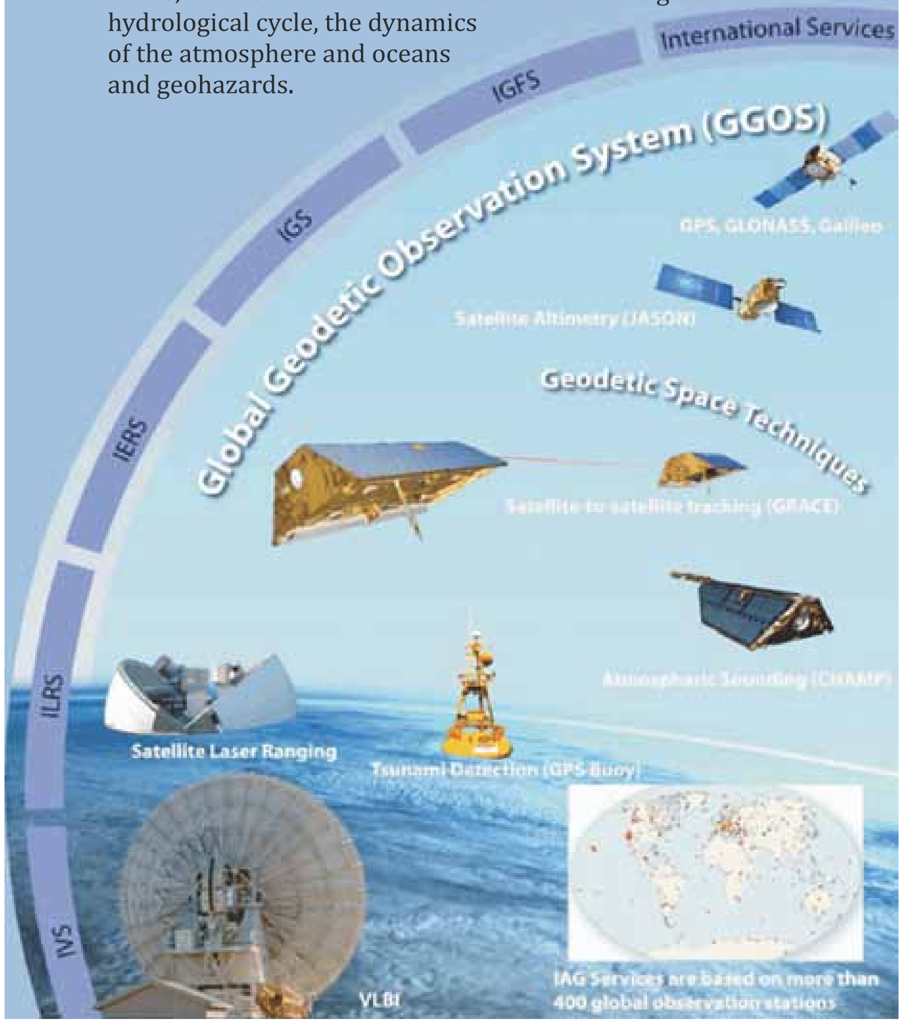
PSMSL is responsible for the collection, analysis and interpretation of sea level data from a global network of tide gauges.

The Global Geodetic Observing System (GGOS)

URL: http://www.ggos.org

GGOS is an official component of IAG as well as a participating organization of the Group on Earth Observations (GEO).

GGOS provides observations of the three fundamental geodetic observables and their variations, that is the Earth's shape, the Earth's gravity field, and the Earth's rotational motion. Thus GGOS ensures the basis to maintain a stable, accurate and global reference frame, which is crucial for all Earth observation. GGOS contributes to the Global Earth Observing System of Systems (GEOSS) not only with the global reference frame, but also with observations related to the global hydrological cycle, the dynamics of the atmosphere and oceans and geohazards.



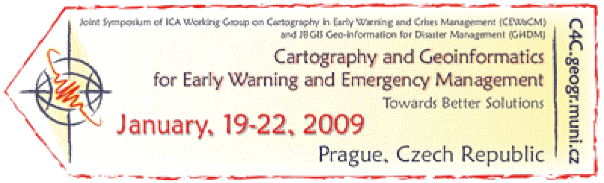
The International Cartographic Association (ICA)

What is Cartography and geographic Information?

A map is a symbolised image of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance.

Maps and geographic information (GI) have special power through their ability to connect and integrate data sets by the inherent geographical location, and present the information contents in a user-friendly and understandable visual and tactual way. Such ability has long been recognized as an intrinsic property of the map artefact, as well as contemporary geodatabases. The power of maps and geographic data handling has been recently recognized in many real world applications and strategic decision making situations related to current topics like crisis management, early warning systems, efforts for supporting sustainability and decreasing global poverty.

(From the ICA Research Agenda)



The International Cartographic Association

International Cartographic Association (ICA) is the world authoritative body for cartography, the discipline dealing with the conception, production, dissemination and study of maps

The ICA was founded on June 9, 1959, in Bern, Switzerland. The first General Assembly was held in Paris in 1961. The first President was Professor Eduard Imhof, of ETH Zurich, Switzerland, who held this position between 1961 and 1964.

The activities of the ICA are important for promoting and advancing the theory and praxis of cartography. Throughout its 50-year history, ICA has brought together researchers, government mapping agencies, commercial cartographic publishers, software developers, educators, earth and environmental scientists, and those with a passion for maps.

The mission of the International Cartographic Association is to promote the discipline and profession of cartography in an international context.

The International Cartographic Association exists:

- To contribute to the understanding and solution of worldwide problems through the use of cartography in decision-making processes.
- To foster the international dissemination of environmental, economic, social and spatial information through mapping.
- To provide a global forum for discussion of the role and status of cartography.
- To facilitate the transfer of new cartographic technology and knowledge between nations, especially to the developing nations.
- To carry out or to promote multi-national cartographic research in order to solve scientific and applied problems.
- To enhance cartographic education in the broadest sense through publications, seminars and conferences.
- To promote the use of professional and technical standards in cartography.

The Association works with national and international governmental and commercial bodies and with other international scientific societies to achieve these aims.

Adopted by the 10th General Assembly of the International Cartographic Association, Barcelona, Spain, 3 September 1995.

Research Agenda

The ICA Research Agenda specifies the areas of research activities that the Association will address, namely:

- Geographic Information;
- Metadata and SDIs;
- Geospatial Analysis and Modelling;
- Usability;
- Geovisualization, Visual Analytics;
- Map production;
- Cartographic Theory;
- History of Cartography and GI Science;
- Education; and
- Society.

Commissions and Working Groups

To achieve its aims, including the implementation of the Research Agenda, the ICA operates through a number of Commissions and Working Groups. It works with national and international governmental and commercial bodies and with other international scientific societies. Commissions and Working Groups carry out the general operations of the ICA. These organisations have addressed the full range of scientific, technical and social research that is the mark of ICA activity.

The ICA promotes the generation of extensive publications, generally through its Commissions and Working Groups. This activity provides a focus for Commissions and Working Groups and allows for knowledge about advances in contemporary thinking and research to be disseminated. The publications include books, journals and the ICA Newsletter.

ICA Working Group on Early Warning and Crisis Management

For a number of years the ICA has developed a focus on Early Warning and Crisis/Disaster/Risk management. The ICA Working Group on Early Warning and Crisis Management chair, immediate past-President Milan Konečný, first elaborated on the need for cartography and GIScience to be actively involved in this area at the Second International Conference on Early Warning (EWC II) in 2003. He was concerned that professionals involved in early warning and crises management, whilst experts in their own particular fields, had a poor understanding of how maps, metadata, standards, geographical visualization tools could better support their endeavours.

Prior to the formal formation of the Working Group, the ICA actively participated in the Early Warning conference in Bonn in 2002 and at the *Cartographic Cutting-Edge Technology for Natural Hazard Management* conference, held in Dresden, Germany in 2004.

The topic of Early Warning and Crises Management was incorporated into the 2005 Memorandum of

Understanding between the United Nations Office for Outer Space Affairs and the International Cartographic Association, It was agreed "to utilize, when appropriate, the scientific, technological, expertise of ICA through the reviews, evaluations or recommendations on matters relating to the use and applications of GNNS, early warning and disaster management, and management of natural resources".

The formal proposal to form a Working Group on Early Warning and Crisis Management was made at the 13th ICA General Assembly, held in conjunction with the International Cartographic Conference, in La Coruna, Spain in 2005. The initial Chair of the Working Group was Dr Wilber from Kenya.

The Working Group on Early Warning and Crisis Management is now an active contributor the work of the International Cartographic Association and its outreach and training activities. The endeavours of the Working Group are focussed on contributing to promoting the importance of geospatial information and tools to inform in early warning and how access to appropriate geospatial tools can assist in times of emergency. As well, the Working Group actively disseminates the knowledge about the use of maps and geospatial information to the wider international emergency mitigation and management community.

The aims of the Working Group

- To provide leadership in the development of concepts, ontologisation and standardization of early warning for hazard, risk and vulnerability mapping and cartographic modelling.
- To promote the cartographic use of remotely sensed and other geospatial data and various analysis techniques for early warning and crisis management by organizing conferences, seminar and workshops.
- To investigate psychological condition of end user given by their personal character and situation and psychological condition of rescued persons.
- To promote capacity building and quality mapping, and cartographic modelling including modern technology for early warning and crisis management through topic related publications.
- To participate and contribute to global initiatives in early warning and crisis management for instance through the maintenance of a website.
- To promote hazard, risk and vulnerability mapping for crisis management and communication.
- To develop mechanisms and networks for exchange of information among stakeholders on crisis management and early warning.

Activities of the ICA Working Group on Early Warning and Crisis Management

In 2005, at the XVIII General Assembly of the Pan-American Institute for Geography and History in Venezuela, the ICA Working Group promoted the need to develop cartography and GIS applications for early warning prevention and management of disasters to the Latin American community.

The 2005 ICA conference in La Coruna, Spain ICA included a special seminar *Cartography in the SDI Changing World, The Role of SDI and Cartography in our contemporary World for monitoring and disaster alleviation.*

In 2006 a poster was prepared by the Working Group - "Cartography and Geoinformatics for Early Warning". The poster was widely disseminated within the cartography and GIScience international community. It was aimed at the promotion of the work of the Working Group within the community and to illustrate to the general public the need to ensure that essential geospatial information was available during times of crises. The poster was launched at the *Third International Conference on Early Warning*, organized by the United Nations and the International Strategy for Disaster Reduction (ISDR), held in Bonn, Germany in 2006.

In 2007 the work of the ICA Working Group on Early Warning and Crises Management was promoted in the Asia-pacific region. The Working Group was actively involved in the *Workshop on Disaster Management*, associated with the *2nd Indonesian Geospatial Technology Exhibition* (IGTE) in Jakarta, Indonesia.

The start of 2008 saw the beginning of a number of seminars organized by or with direct contributions from the ICA Working Group. The first was the *Early Warning and disaster/crises management* conference was held in Borovets, Bulgaria. The second was the *Workshop on Cartography in Early Warning and Crises Management and Round Table,* held at *AutoCarto 8*, Shepherdstown, West Virginia, USA. This event addressed natural anthropogenic disasters; current global, regional and local initiatives in early warning and crises management; paradigms of action; exchange of best practices for activities in the field; avoidance of shortcuts in crises situations; sharing and standardizing of data on material reserves and potential human provisions;

the interconnection between current OGC/ISO activities and crises management.

The main activity of the Working Group in 2009 was conducting a Joint Symposium with the JBGIS Gi4DM - *Cartography and Geoinformatics for Early Warning and Emergency Management* - held in January 2009 in Prague, Czech Republic. The symposium topics were organized under the themes of: frameworks and tools; technologies and infrastructures; citizens in early warning and emergency management; e-government and e –governance; and cartographic and Geoinformatics applications. A 'Round Table' on Spatially Enabled Early Warning and Emergency Management was held at the Symposium.

In early April 2009, the Working Group promoted its activities at a seminar on the *Potentials in Early Warning and Emergency Management* at the international GeoSiberia conference in Novosibirsk. Following the success of the sessions it was decided to include meetings of the WG as part of future GeoSiberia conferences.

At the *International Cartographic Conference*, held in Santiago, Chile in November 2009 the Working Group met and a number of papers related to cartography and Geoinformatics for Early Warning were presented. Two sessions in the ICC program were devoted to problems of Emergency Management. As well, as part of an outreach activity the Working Group conducted an excursion to the Chilean Military Center for Crises Management and the Chilean Civilian Emergency Management Office both located in Santiago de Chile.

In April 2010 in Novosibirsk, Russia, a seminar was held on *Early Warning and Crises/Disaster Management.* This was a joint event between the ICA, the International Society on Digital Earth-ISDE and SSGA, with the participation of colleagues from the ISPRS and FIG.

A number of events are in preparation for 2010. These are: Nessebar, Bulgaria, June 2010 - *Digital Earth Summit and 3rd Conference on Cartography and GIS* - a seminar on *Early Warning and Disaster/Crises Management: European Concepts for Crises Management and Early Warning*; and Orlando, USA, November 2010 - a workshop on Crises Management and Early Warning at *AutoCarto 2010*.

The 25th International Cartography Conference and the 15th General Assembly of the International Cartographic Association will take place between 3–8 July 2011, in Paris, France. The Working Group on Early Warning and Crisis Management will hold a focused meeting in Paris in conjunction with the conference. (See the Web site at: http://www.icc2011.fr/ for further information about the conference).

Summary

In summary, the International Cartographic Association began to be active in Early Warning and Crises Management in 2003. This followed with a number of activities that have now become part of the Working Group's activities - seminars at Borovets and Nessebar in Bulgaria, seminars in Novosibirsk, Russia, at *AutoCarto* USA and at International Cartographic Conferneces. The working Group continues to address the issues of Crises Management and Early Warning in collaboration with members of the JBGIS.

Professor Dr. Milan Konecný, Immediate past-President, International Cartographic Association and Chair ICA Working Group on Early Warning and Crisis Management

Professor Dr. Dr. William Cartwright, President, International Cartographic Association

The International Federation of Surveyors (FIG)

Stig Enemark,
FIG president, Professor in Land Management, Aalborg University, Denmark

What is a surveyor ?

A surveyor is a professional person with the academic qualifications and technical expertise to practise the science of measurement and mapping; to assemble and manage geographic related information; to use that information for efficient administration of land and properties and the and the natural and built environment; and to instigate the advancement and development of such practices.

Practice of the surveyor's profession may involve one or more of the following activities which may be carried out in association with other professionals: positioning and mapping; land and engineering surveying; spatial information management; boundary surveying and land registration; land administration and land-use planning; land valuation and real estate management; and construction economics and management.

In the application of these activities surveyors take into account the relevant legal, economic, environmental and social aspects affecting each project.

What is FIG?

FIG is the premier international organization representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards.

FIG was founded in 1878 in Paris and was known as the Fèdèration Internationale des Gèometres. This has become anglicized to the International Federation of Surveyors. It is a UN-recognized non-government organization (NGO), representing more than 100 countries throughout the world, and its aim is to ensure that the disciplines of surveying and all who practise them meet the needs of the markets and communities that they serve.

In general, FIG will strive to enhance the global standing of the surveying profession through both education and practice, increase political relations both at national and international level, help eradicating poverty, promote democratisation, and facilitate economic, social and environmental sustainability.

FIG's activities are governed by a work plan, which is regularly reviewed against a longer-term strategic plan. The current work plan 2007-2010 is entitled “Building the Capacity”. FIG recognises the particular needs of capacity building in developing countries to meet the challenges of fighting poverty and developing a basis for a sustainable future.

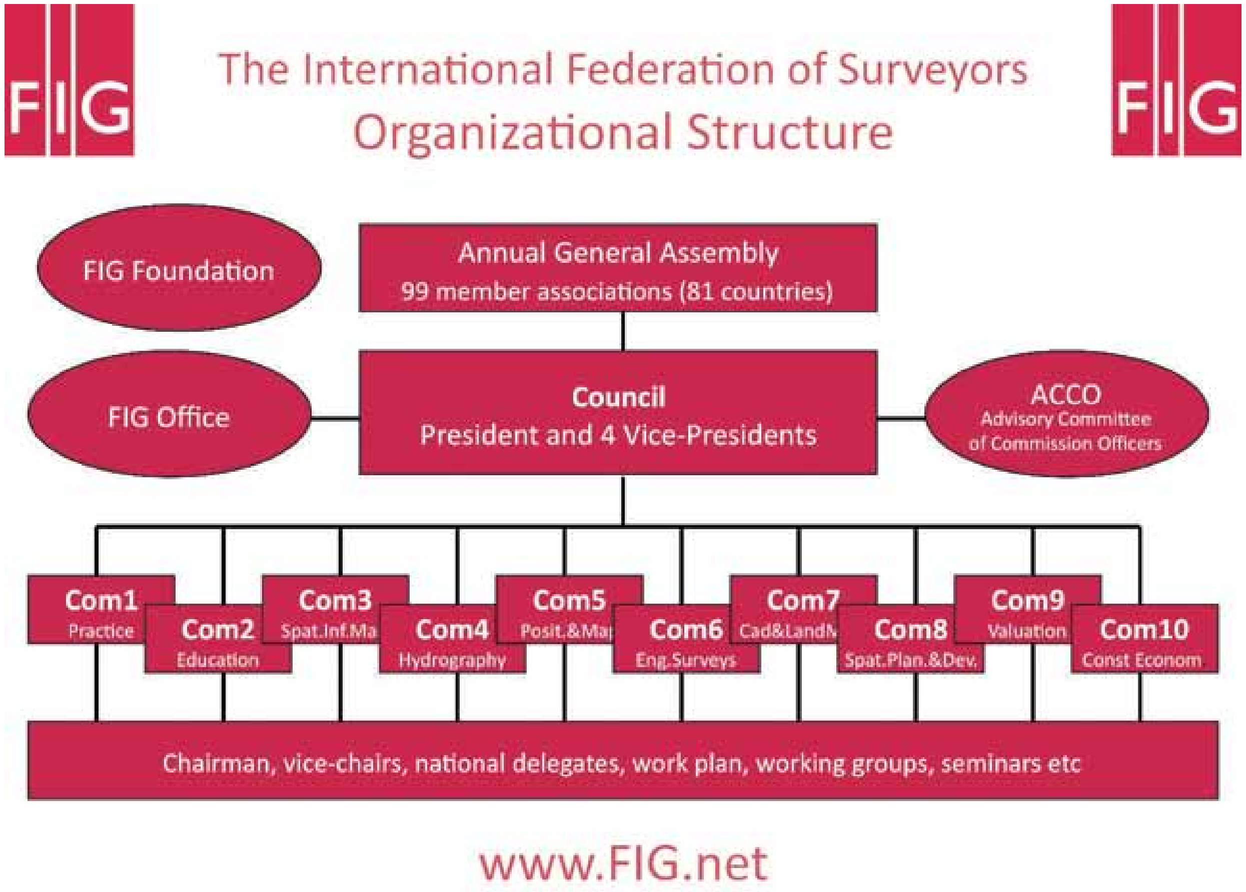


FIG also recognises that markets for surveyors' services are constantly changing. The plan therefore lays emphasis on strengthening professional institutions; promoting professional development; and encouraging surveyors to acquire new skills and techniques for meeting the needs of society and the environment.

Ten commissions lead FIG's technical and professional work. Each member association appoints a delegate to each of the commissions. Detailed information on the work of the commissions, their work plans, working groups, seminars, newsletters and publications can be found at the FIG website: www.FIG.net

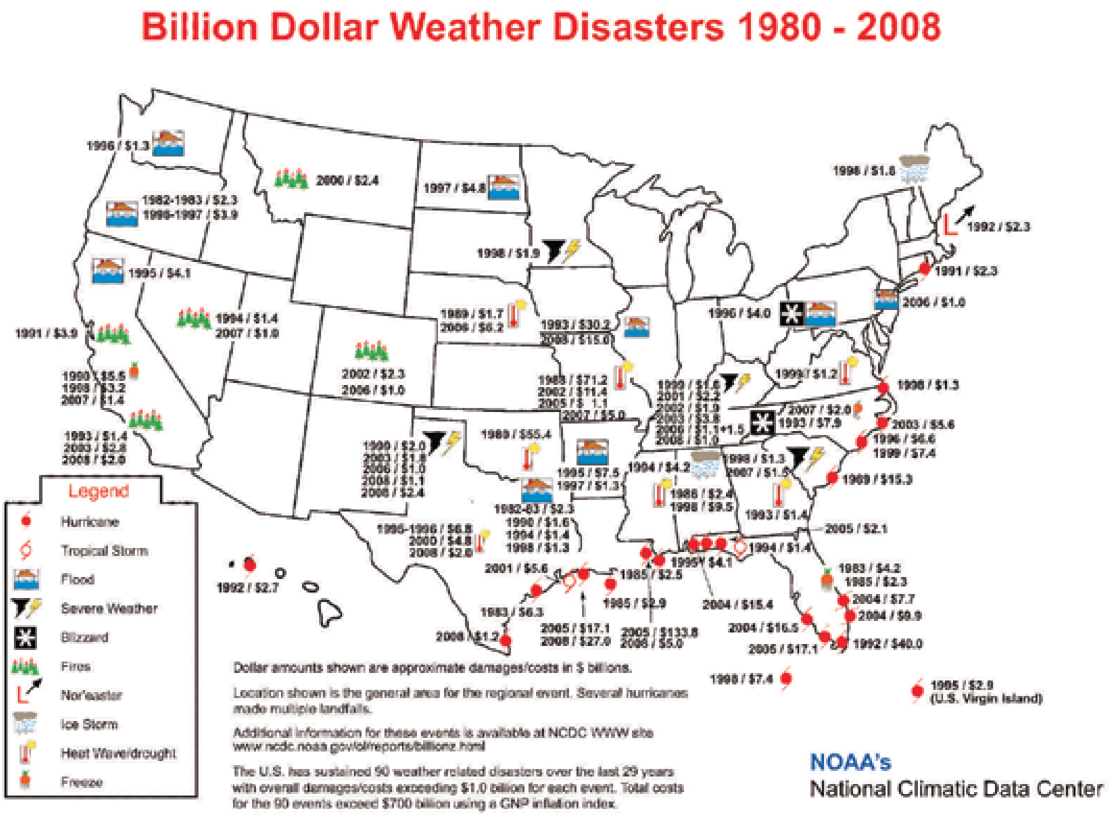
FIG approach to natural disaster prevention and management

Due to the increasing frequency of disasters worldwide and their humanitarian and economic consequences, a lot of international organizations, and NGOs are looking at developing techniques and tools for disaster risk management, such as UN/ISDR (2004), FIG (2006) and RICS (2009).

The process of disaster risk management forms an ongoing circle of activities related to the situation *before* (risk identification, prevention, preparedness), *during* (emergency relief) and *after* a disaster (recovery, reconstruction) where the latter should then feed back into improving the resilience of vulnerable communities and reduce future risks leading towards sustainable development.

The contribution of surveyors relate mainly to the situation before and after a disaster while emergency relief during the disaster in undertaken mainly by the humanitarian organistaions.

The FIG publication no 38: The Contribution of the Surveying Profession to Disaster Risk Management (2006) clearly outlines the wide scope of surveyor's abilities including land management, geodetic engineering, geo-informatics, satellite technology, and remote sensing that can make an important contribution to improve, simplify and to shorten the disaster management process.



Billion dollar whether disaster in the USA 1980-2008. (Source: NOAA)

The total number of disasters (such as drought, earthquake, flood, slide, volcanic eruption, hurricane, etc.) has increased from about 150 in 1980 to more than 400 in 2000. In the USA, for example, more than 90 weather disasters have occurred the last 30 years with the total costs exceeding 700 billion USD.

There is wisdom in the statement of Kofi Annan, the former UN Secretary General: "While many people are aware of the terrible impact of disasters throughout the world, few realise this is a problem that we can do something about."

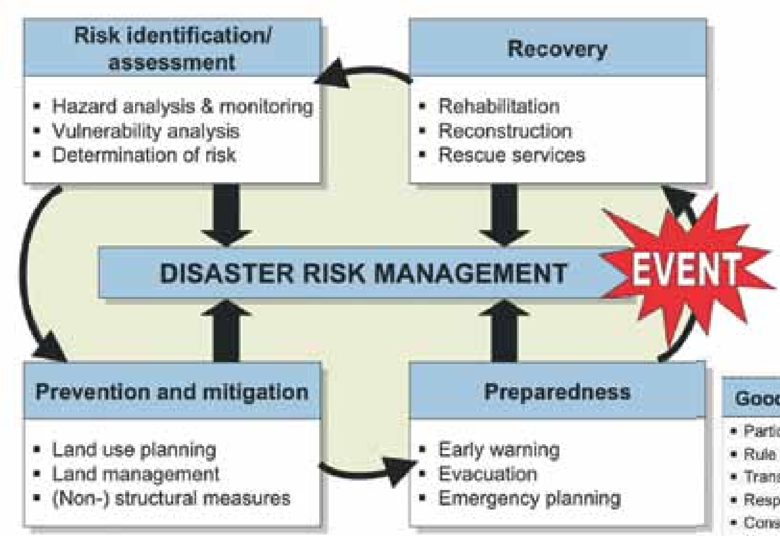
Land administration systems in support of natural disaster risk management

Sustainable land administration systems provide clear identification of the individual land parcels and land rights attached to these parcels. This information on the people to land relationship is crucial in the immediate post disaster situation. Following the relief and early recovery transition period where focus is on the overriding humanitarian efforts of saving lives and providing immediate relief the recovery and reconstruction phase will to a large extent relate to re-establishing the situation of legal rights to land and properties and the reconstruction of buildings and infrastructure. Sustainable land administration systems provide the basis for managing these processes.

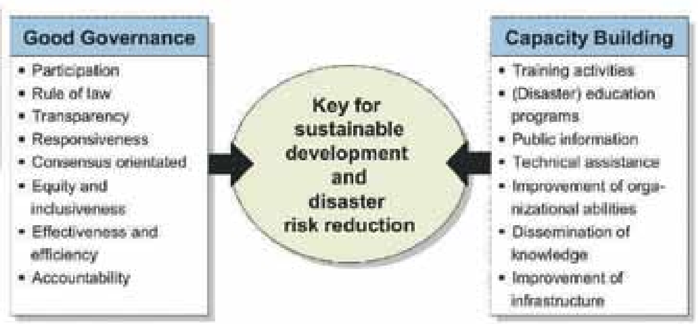
Disaster risks should be identified as area zones in the land use plans and land information systems with the relevant risk assessments and information attached. Such disaster risk zones may relate to sea level rise, earthquakes, volcano eruption, flooding, draught, hurricanes, etc, and the information should relate to the predicted risks as known through statistics and positioning measurement systems.

By combining the disaster risk information with the relevant information on land tenure, land value, and land use the necessary risk prevention and mitigation measures can be identified and assessed in relation to legal, economic, physical, and social consequences.

In disaster zones relevant measures should be taken to build the preparedness for managing any disaster events. Land is necessary for emergency shelter and for restoration of livelihoods. Land grabbing is a key risk in this process. Humanitarian actors are therefore confronted with the land issue as they undertake emergency shelter and protection activity.



Left: Key elements of disaster risk management (FIG, 2006)



Right: Good governance and capacity building for disaster risk reduction and sustainable development (FIG 2006).

Building the capacity for disaster prevention and management

Good governance and capacity building are central components in the process and implementation of disaster risk management and sustainable development.

The capacity to be prepared for and manage natural disasters will of course include the use of early warning systems that provide timely and effective information in due time for taking the necessary actions and preparing for an efficient response.

Another key issue is to establish the necessary political commitment for integrating mitigating measures and disaster risk reduction into the land administration systems, and to implement these policies through organisational structures and regulatory frameworks.

FIG (2006): The Contribution of the Surveying Profession to Disaster Risk Management. FIG Publication No. 38. FIG Office, Copenhagen, Denmark.

RICS (2009): The Built Environment Professions in Disaster Risk Reduction and Response. RICS, London.

UN-ISDR (2004): Living with Risks: A Global Review of Disaster Reduction Initiatives. United Nations.

The Map Trade Association (IMTA)

Why are maps and geographic information important to risk and disaster management?

By Mark Cygan, IMTA (Americas) director and Sandy Hill, IMTA, executive director

The International Map Trade Association (IMTA) is a worldwide organization in the mapping, geospatial and geographic information industry. A truly global organization, IMTA's mission is to connect the business of maps worldwide. IMTA welcomes members from every corner of the world and the association is made up of three regions: Europe, Africa, and the Middle East; Asia and the Pacific; and the Americas. Each region organizes it own local activities ensuring wherever based, IMTA is both relevant and accessible.

New technologies, cartography techniques, and mapping products are emerging all the time and keeping up-to-date with industry developments can be a real challenge. IMTA organizes global conferences, committees, discussion groups and newsletters to facilitate the exchange of information. The large community is accessible via *www.maptrade.org* and provides a community for sharing ideas.

Maps are the products of cartography, art, science and technology, and graphically communicate and represent the world we live in and the events that occur in it, helping us gain understanding.

July 2008 Fires in Northern and Central California

During the summer of 2008, more than 2,780 individual fires burned large portions of forests and chaparral in California. A majority of the fires were started by lightning from dry thunderstorms, a storm producing thunder and lightning but no rain.

The fires broke out after three years of below normal rainfall, and that spring was recorded as the driest on record for many regions in the area. More than 800,000 acres burned, making these the greatest in California history by burned area. Aid from around the world, including workers from Greece, Chile, Argentina, Brazil, Australia, Canada, Mexico and New Zealand was present to help fight the fires. More than 20,000 personnel were committed to combat the flames, including 467 hand crews, 1,503 engines, 423 water tenders, 291 bulldozers, 142 helicopters, 400 soldiers and numerous air tankers. The loss of life was high, with 23 fatalities.

During the fire, agencies used digitally mapped data, spatial analysis, and modeling to better plan and carry out fire suppression operations. GIS was used to assist in the deployment and tracking of California state assets fighting the hundreds of fires taking place.

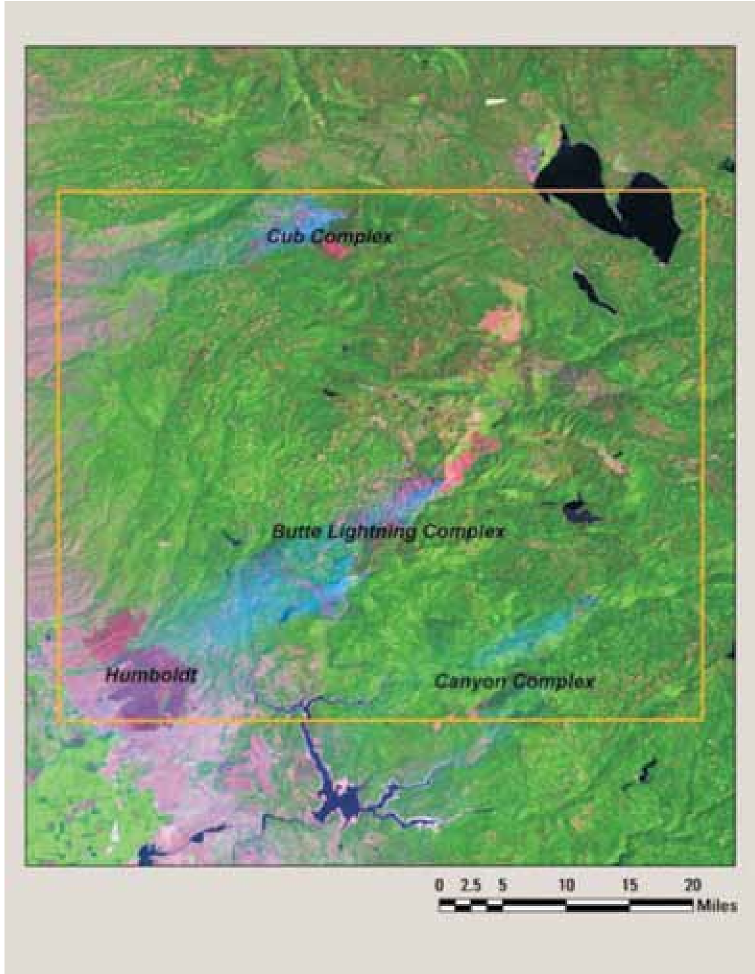
GIS experts deployed during previous fires again worked with California State fire fighters and federal and local agencies for tactical planning as part of the overall response. Incident management teams used

GIS to map active fire perimeters, hot spots, burned areas, and affected communities. Protection priorities were established with the assistance of GIS by assessing highly flammable accumulations of vegetation combined with steep terrain that threatened homes, infrastructure, and natural resource values. GIS-generated maps were also used for public information sharing, including fire locations, road closures, damaged properties, evacuations, shelter locations, and Red Cross assistance.

Imagery was very important during the active fire stage. Fourteen Landsat images acquired between 5 July 2008, and 8 July 8 2008, were mosaicked to provide a continuous 30-meter resolution overview of active and contained wildfires in northern California.

As wildfires were contained, additional Landsat 5 and 7 imagery was used to map post fire soil burn severity and vegetation mortality, refine and verify fire perimeters, and serve as input to models predicting post fire debris flow hazards. The data were processed by the USGS Earth Resources Observation and Science Center.

The mosaic was used by state and local fire management staff as a graphic to support various fire status briefings.



This image is a partial Landsat 5 scene of the Humboldt fire region (outlined as well on the mosaic.) The light blue tone represents smoke from active fires and the dark red area near Humboldt indicates a scar from a previous fire.

Hurricane Katrina

Hurricane Katrina hit the Atlantic coastline in the United States in 2005 and left disaster in its wake. Forming over the Bahamas, it crossed southern Florida causing deaths and flooding before rapidly gaining strength in the Gulf of Mexico. When it made its second landfall in southeast Louisiana, it had caused severe destruction along the Gulf Coast from central Florida to Texas. The most costly in terms of damage, estimates for rebuilding are well in excess of $100 billion. Close to 2,000 people lost their lives.

These Landsat 7 satellite images show damage from Hurricane Katrina along the Mississippi Gulf coast from Biloxi, Mississippi to the edge of Mobile, Alabama. The bottom image, acquired on September 8, 2005, in comparison to the same area in 2003 (top image), reveals how the brunt force of the hurricane not only affected the coastline, but also reached the inland areas of the Pascagoula River.

Data comparisons show the nature, magnitude, and spatial variability of coastal changes such as beach erosion, overwash deposition, and island breaching. These data will also be used to further refine predictive models of coastal impacts from severe storms. The data are being made available to local, state, and federal agencies for purposes of disaster recovery and erosion mitigation.

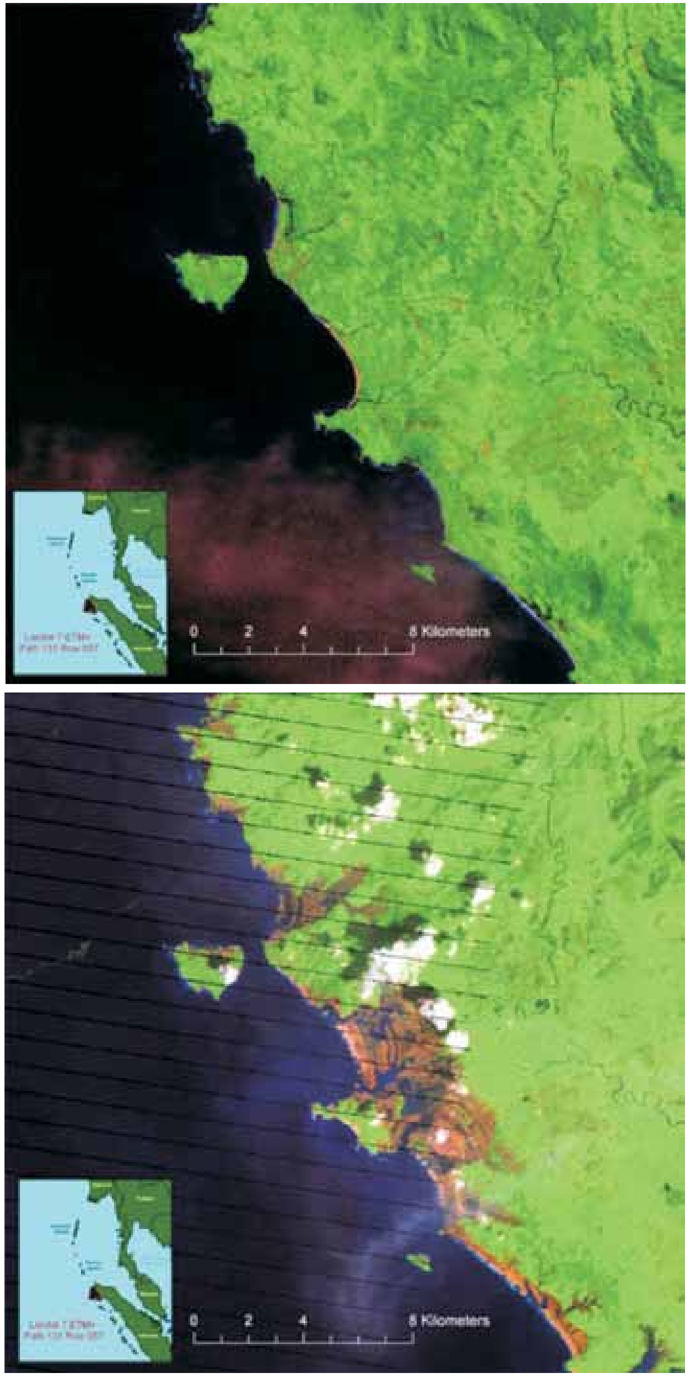
Above: *Landsat 7 satellite data acquired 11/08/2004 Bands 5,4,3 with pan merge.*
Below: *Landsat 7 satellite data acquired 9/08/2005 Bands 5,4,3 with pan merge*

Indian Ocean Tsunami Impact on Northwest Sumatra Coast

The tsunami generated by the great Sumatra earthquake of 26 December 2004 devastated 200 kilometers of Sumatra coast from Kuede on the north end of the island to south of Meulaboh on the west coast. Of the roughly 223,000 lives lost during this event, 72% of the casualties were caused by the near-field tsunami that struck northern Sumatra; the remaining deaths were due to the far-field tsunami that impacted coasts around much of the Indian Ocean. Post-tsunami reconnaissance surveys of the northwest coast of Sumatra indicate tsunami flow depths of five to 12 meters along the north coast and seven to 20 meters along the west coast; peak run-up was as high as 39 meters west of Aceh Province near Lhoknga.

The image pair below illustrates a small portion of the Landsat scene which has experienced extensive destruction along coastlines, river channels, and estuaries. The large affected area, toward the center of the scene on the right, shows inland intrusion by the tsunami of greater than 3 kilometers. Upland areas, above 15-20 meters, were largely unaffected.

Studying these flow depths and run-up heights show that the tsunami may have had alternate sources, such as secondary intraplate faults, contributing to the tsunami in addition to interpolate slip on the Sumatra megathrust. Understanding this means that tsunami warning times for inhabitants are reduced and there is an increased likelihood of devastation by inundation.



Landsat Comparison of Pre/Post Tsunami Acquisitions for the Northwest Sumatra Coast

The International Society for Photogrammetry and Remote Sensing (ISPRS)

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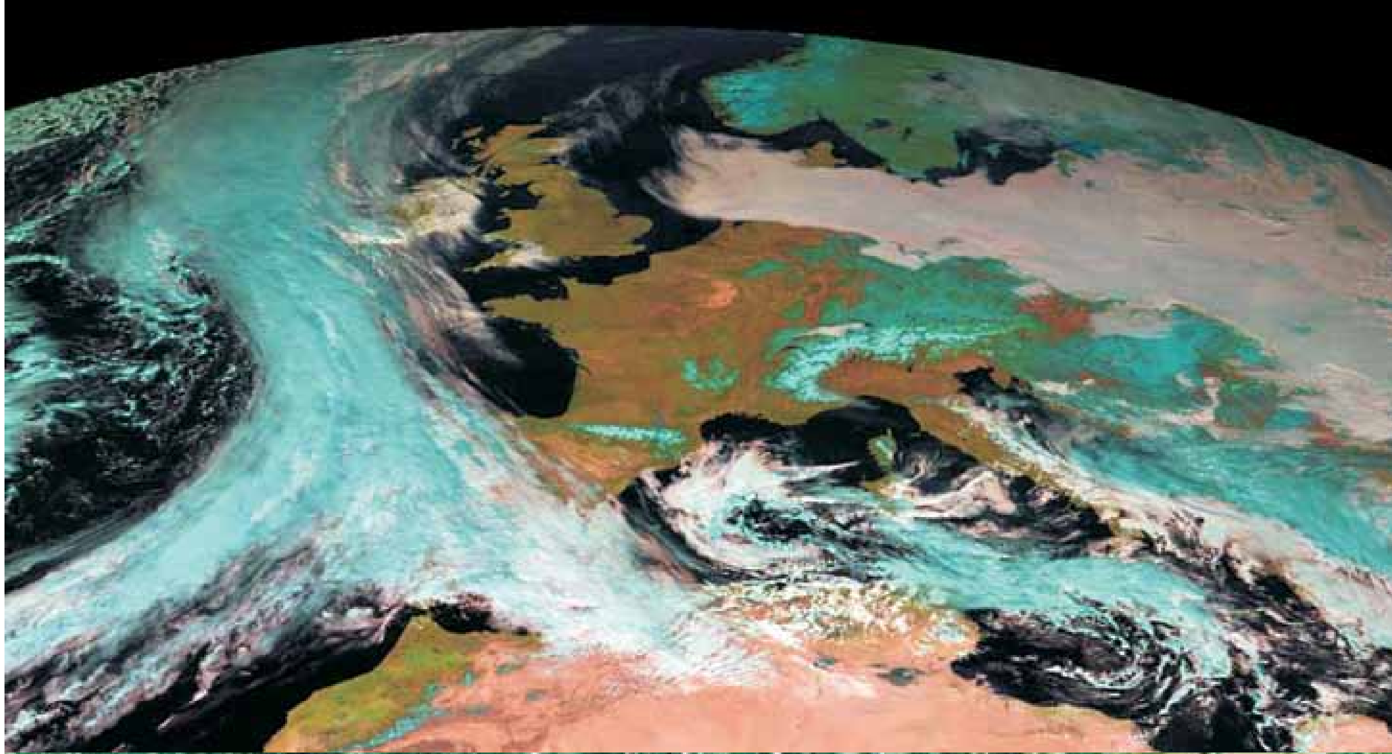
What are Photogrammetry, Remote Sensing and the Spatial Information Sciences?

Photogrammetry and Remote Sensing is the art, science, and technology of obtaining reliable information, from noncontact imaging and other sensor systems, about the Earth and its environment, and other physical objects and processes through recording, measuring, analyzing and representation.

Spatial Information Science is the art, science, and technology of obtaining reliable spatial, spectral and temporal relationships between physical objects, and of processes for integration with other data for analysis, portrayal and representation, independently of scale.



Mission of ISPRS?

The International Society for Photogrammetry and Remote Sensing is a non-governmental organisation devoted to the development of international cooperation for the advancement of photogrammetry, remote sensing and spatial information sciences and their applications. The Society operates without any discrimination on grounds of race, religion, nationality, or political philosophy. Established in 1910 by Professor Dolezal from the Technical University of Vienna, Austria, ISPRS is the oldest international umbrella organisation in its fields, which may be summarized as addressing “information from imagery.”

Role of ISPRS

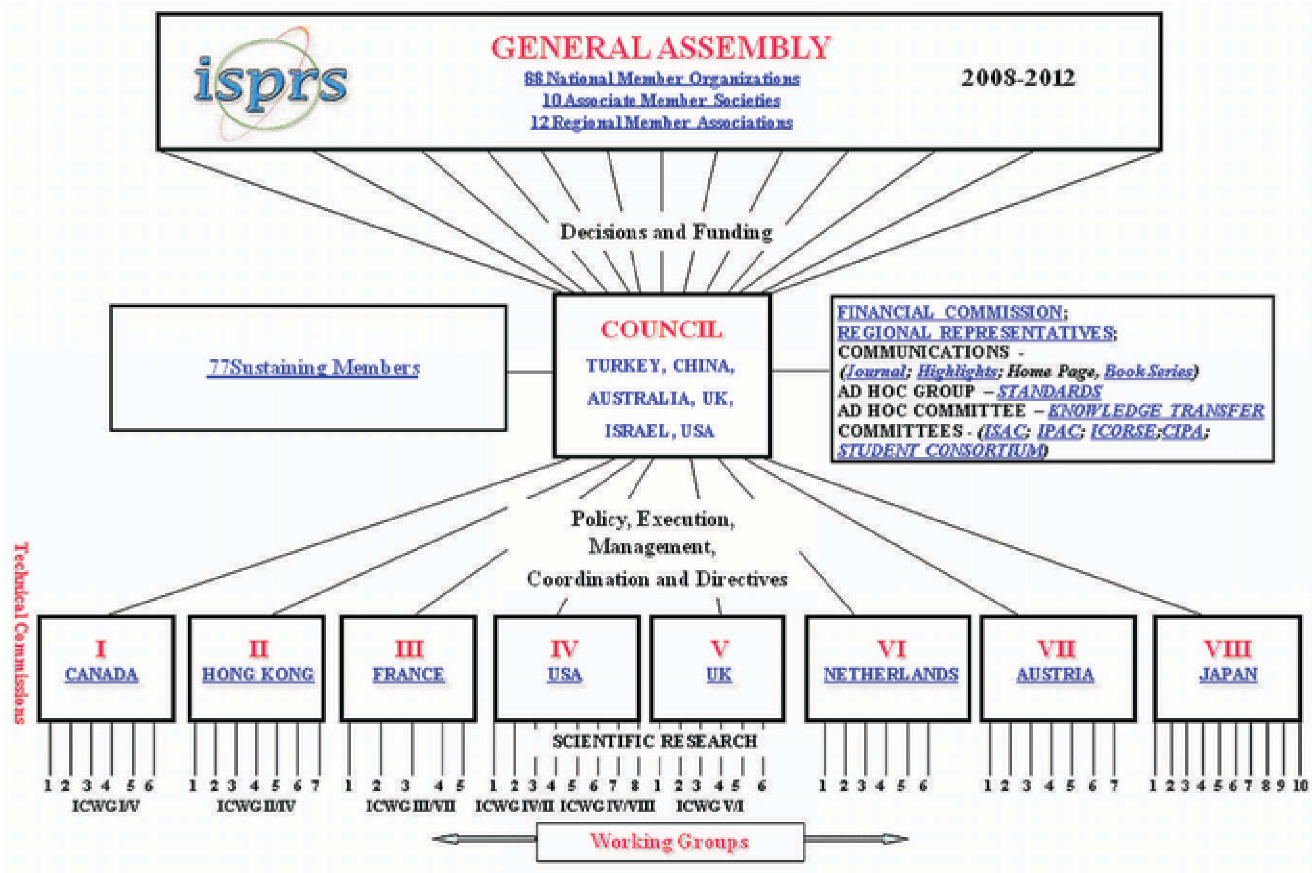
The principal activities of ISPRS are:

1. Stimulating the formation of national or regional Societies of Photogrammetry and Remote Sensing.
2. Initiating and coordinating research in photogrammetry and remote sensing and spatial information sciences.
3. Holding international Symposia and Congresses at regular intervals.
4. Ensuring worldwide circulation of the records of discussion and the results of research by publication of the International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences.
5. Encouraging the publication and exchange of scientific papers and journals dealing with photogrammetry and remote sensing.

Figure 1: ISPRS is a Society of National Societies and Organisations

The scientific and technical programme of ISPRS

The scientific and technical programme ISPRS is organized by eight Technical Commissions. Each Commission is comprised of a number of Working Groups which are responsible for particular topics within the Commissions' areas of responsibility. The ISPRS conference programme includes a quadrennial Congress, Technical Commission Symposia held in the even numbered year between the Congresses and workshops organized by the Working Groups at regular intervals.



Activities of the ISPRS WG IV/8: 3D Spatial Data Integration for Disaster Management and Environmental Monitoring

This working group is a continuation of the WG IV/8 'Spatial data integration for emergency response' which worked during the period 2004 to 2008. The group was formed to address the urgent demands for better, more sophisticated and appropriate means for managing the consequences of man-made and natural risks. The focus was on interoperability of emergency services, harmonisation of data and provision of appropriate information to ensure that needs of citizens receive high-quality attention. The most demanding Response Phase was studied explicitly by investigating user needs and requirements for provision of tools for an efficient collaboration and understanding between different rescue teams such as the Health Sector, Police, Fire Brigade and civil protection.

Figure 2: Indoor 3D visualisation and analysis

What is the current status? Many international activities (projects) have taken place to ensure timely supply of harmonized data as soon as practicable after a disaster to aid in the provision of appropriate services. Geoportals and web access points have been developed worldwide to provide easy search and access 24 hours per day. Early warning centres have been established in several countries. Many bottlenecks in the provision of spatial data have been resolved by ensuring the most appropriate data is provided, supported by an integrated systems approach.

However, most of the operational systems use two-dimensional data sets. Systems capable of seamless integration of 3D topographic (GIS), geological, meteorological, BIM models are not yet available. There has been insufficient research on 3D indoor modelling for safe evacuation and navigation in urban environments. Appropriate models for 3D analysis and simulations, e.g. prediction of plume movement, have received little attention. It is our firm understanding that 3D technology can better aid disaster management and environmental monitoring.

Figure 3: Outdoor 3D visualisation and analysis

◆The goal of this Working Group is to contribute to the investigation of user requirements, research, development, and testing new technologies for intelligent use of spatial information in the Response Phase of risk and disaster management. The work of the WG in the period 2008-2012 concentrates on the following topics:

- Integration of 3D GIS and intelligent image analysis systems for emergency management in urban environments;
- Application of low-cost and real-time digital imaging and mobile mapping technologies for emergency response;
- 3D data structures, algorithms, and standards for emergency data management and exchange;
- Geo-ontology and semantics for emergency response;
- Innovative knowledge-based systems for browsing and analysis in distributed environments;
- 3D visualization of scenes and situations (including indoor) on different mobile front-ends;
- Analysis of emergency management needs for production and updating of spatial information.

Activities of the ISPRS WG VIII/1 - Disaster Management

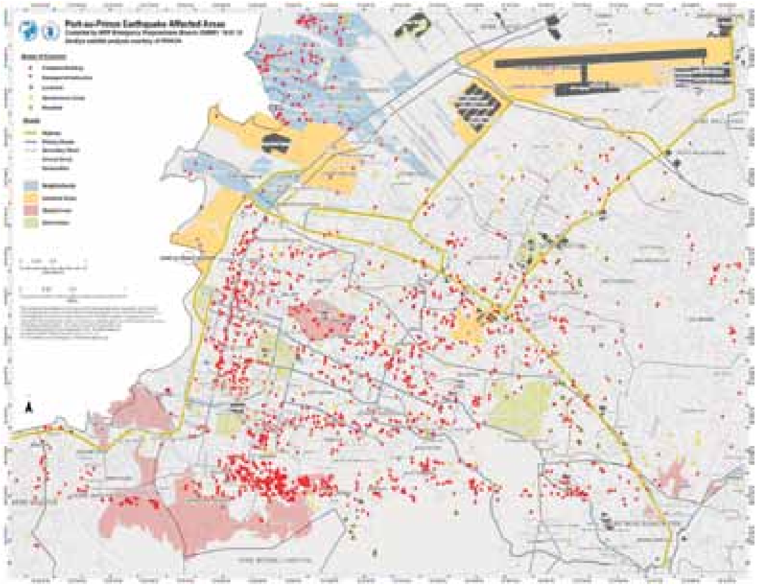
This working group was formed to investigate, from a scientific and technical point of view, the role of remote sensing in managing the consequences of natural and man-made disasters and aims at informing and activating people involved in disaster monitoring, mitigation and damage assessment from both from public institutions and private companies.

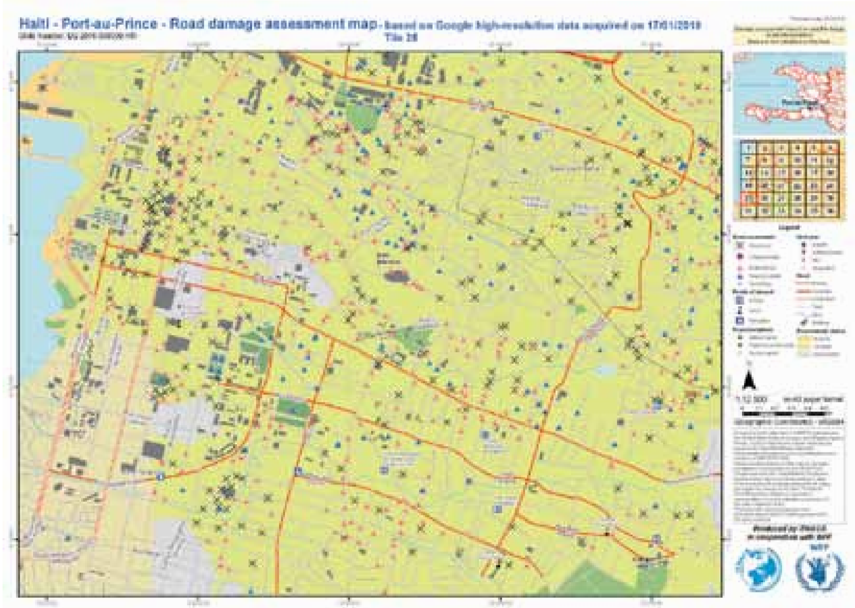
The main goals are:

1. The development of appropriate tools and methodologies for disaster management using remote sensing connected to GIS technologies;
2. In collaboration with Commission I, define an integrated system of observation comprising space, aerial, and in-situ measurements for disaster early warning, monitoring, damage assessment, and mitigation;
3. To enhance the cooperation with various partners such as CEOS, the International Global Observing Strategy (IGOS), UN Agencies and all Private/Institutional Organizations involved in the Disaster Management cycle..

The focus is on: generation of vulnerability and hazard zone maps for different types of disasters, such as forest fires, cyclones, floods, drought, volcano eruptions, earthquakes, landslides etc.; identification and assessment of potential risk zones; integration of remotely sensed observations and communication strategies with enhanced predictive modeling capabilities for disaster detection, early warning, monitoring, and damage assessment; development of disaster management plans for pre-, during and post-disaster situations and enhanced support for early warning systems, emergency events mitigation and decision making; collaborating with International Associations when appropriate.

This emergency represents a milestone for the whole scientific community, individual volunteer groups, as well as the key players in the major satellite providers and internet geo-providers (Google and Microsoft) who have contributed an enormous amount and variety of data towards this emergency response. Now, it is time to develop solutions for effective processing, analysis and application of the spatial data, taking into account the lesson learnt from the latest experiences.





Currently, tremendous efforts are being made by the international community to respond to and assist people affected by the earthquake in Haiti.

Figure 4-5:
Above: Port-au-Prince affected areas
Left: Port-au-Prince road damage assessment map

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FIG

IMTA®
INTERNATIONAL
MAP TRADE
ASSOCIATION

isprs
information from imagery

GSDI
Association

WFP
wfp.org

SiTI
Istituto Superiore sui
Sistemi Territoriali per l'Innovazione

UNITED NATIONS
Office for Outer Space Affairs

ESRI

Compagnia
di San Paolo

ITHACA
INFORMATION TECHNOLOGY FOR HUMANITARIAN ASSISTANCE, COOPERATION AND ACTION

WFP'S EMERGENCY PREPAREDNESS AND RESPONSE BRANCH.

Emergency Preparedness is a key policy for the World Food Programme the world's largest humanitarian agency. Investing in disaster preparedness and mitigation measures is the second of WFP's five strategic objectives - the core of its vision and operation.

Preparedness means having the information, technology, planning and thinking in place to anticipate an emergency so as to respond to it more rapidly and efficiently. It means monitoring man-made and natural hazards closely, analyzing this information carefully and

methodically and making it easily accessible to key decision makers and the wider staff of WFP. It means using the newest and most innovative technologies to make WFP's work faster, leaner and smarter.

EARLY WARNING

The Early Warning team at the Emergency Preparedness and Response Branch provides a comprehensive monitoring service - watching droughts, floods, tropical storms, volcanic activity, earthquakes - alongside the social and economic hazards which can turn a crisis into an emergency. Its analytical expertise allows WFP to react when it can see a disaster in the making.

The team combs the international media and uses both internal and external humanitarian sources to provide forecasts, warnings and alerts - both to WFP staff and to those of other agencies. It produces daily news headlines and early warning developments, provides key dates on a weekly and three-monthly basis and produces WFP's contribution to the Early Warning Early Action Report. This is a key inter-agency resource - every quarter it is presented to key UN humanitarian agencies at the Inter-Agency Sub-Committee, which the Chief of Emergency Preparedness and Response Branch co-chairs.

The Emergency Preparedness and Response Branch is now in the process of further extending its social and economic early warning capacity. It has brought on board important technical, academic and commercial partners and is leading the development of a web-based system to better gather and manage information, as well as to mine data. New areas - such as social networking - are being explored to ensure that the warning signs which can save lives are picked up. These new tools are vital when our changing climate is provoking more competition for natural resources.

WFP

wfp.org

World Food Programme
Fighting Hunger Worldwide

INFORMATION MANAGEMENT

Today's world is abuzz with information - it's hard to easily and efficiently access what is most important and useful. Alongside its Early Warning information service, the Emergency Preparedness and Response Branch manages WFP's large resource of geographical and geo-spatial information. It is working to bring it all together, in one place to promote easy access and to avoid duplication.

EPweb - the dedicated Emergency Preparedness website complements this mission. Constantly updated and expanded, EPweb now holds nearly 3,000 maps, information on food prices, on where WFP's offices and stocks are worldwide, alongside in-depth information about individual countries and areas of concern. EPweb allows decision-makers and field staff straightforward and rapid access to information - helping them to mitigate the effects of an emergency. When a disaster such as an earthquake or hurricane strikes special Crisis pages are immediately activated to help speed up and streamline WFP's response, with information gathered together for easy access in one place.

IMPORTANT EXTERNAL PARTNERSHIPS

The partnerships which the Emergency Preparedness and Response Branch has formed are impressive. It is co-operating with leading academic institutions - such as Columbia University in the United States - and with several national space agencies. The Emergency Preparedness and Response Branch's relationship with ITHACA (International Technology for Humanitarian Assistance Cooperation and Action) a specialist research institute at Italy's prestigious Politecnico of Turin is especially vibrant. The closeness of this relationship allows WFP's Emergency Preparedness and Response Branch to deliver satellite imagery of an area hit by a natural disaster to field staff and key decision-makers within 24 to 48 hours. Additional information is then mapped on to show clearly on one page how many people may be affected and where they are. Known as Rapid Impact Analysis, this type of analytical mapping is invaluable in helping WFP know where help is most needed.

TECHNOLOGY AND PREPAREDNESS

WFP is further building on this and other technological partnerships. With ITHACA and the Dartmouth Flood Observatory in the United States, sophisticated flood modelling and forecasting is being developed. Two decades of historical data are combined with new information on rainfall from remote sensors, so as to predict what may happen next. As we adapt to the more severe weather patterns brought on by climate change - and to the additional stresses brought by rapid urbanisation - we're working with our partners to better forecast drought and to tailor our work more accurately in the world's growing cities.

HAZARD MAPPING

In the first hours and days of any emergency, for WFP having the right information is critical. But, forewarned is forearmed - if there's a picture of what has happened in the past and who are the people affected, it is even better. So the Emergency Preparedness and Response Branch is pushing the frontiers of mapping natural hazards to produce better preparedness planning. In areas most at risk of severe weather, it is integrating huge amounts of data onto multi-layered maps to produce a single page image of a potential emergency. For cyclone-prone Madagascar, slopes, watersheds and areas of deforestation were mapped together with population density information, for a picture of where help will most be needed. For Haiti, which suffers hurricanes more frequently than it does earthquakes, food insecurity has been added to the process. In Niger and Afghanistan, livelihoods vulnerable to flooding were mapped. This level of preparedness lets WFP know where it may have to go to help people, and importantly, where it may not have to. It makes our response faster and lets us use our resources sensibly and efficiently.

PLANNING AHEAD FOR A POSSIBLE GLOBAL CRISIS

If we use all our preparedness skills and resources wisely, we can prepare for and mitigate crises which in the past have hit the world much harder. In 2009, an influenza pandemic was declared the first for over 40 years. But WFP's Pandemic Response Unit (within the Emergency Preparedness and Response Branch) had already been thinking ahead. It has built up valuable experience which can now be transferred for use in other situations. Staff have been trained in how to stay safe, medical supplies have been pre-positioned, pandemic preparedness plans have been tested on the ground and specialised computer simulators have been developed. This shouldensure that WFP can continue with its job of feeding hungry people.

A Foundation for the Advancement of Society

The Compagnia di San Paolo is one of the largest private foundations in Europe. It was founded in 1563 as a private brotherhood and later evolved into a banking institute and charitable institution. The new charter was adopted in March 2000.

The Foundation is actively involved in civil society and pursues aims of public interest and social use, in order to foster the civil, cultural and economic development of the community in which it operates.

These institutional activities are funded with the earnings on the financial assets accumulated over the centuries, that the Compagnia is committed to preserve for the generations to come.

The Compagnia di San Paolo is actively engaged in the following sectors: scientific, economic and legal research; education; art; conservation and promotion of the cultural heritage; cultural activities and the performing arts; health; assistance to socially deprived categories.

The Compagnia pursues its objectives according to annual and multi-annual plans, by awarding grants to public and non-profit entities and through direct involvement in programmes and the participation of specialised "operational bodies" created and supported by the Compagnia, also in cooperation with other institutions, in relevant fields of interest.

The Compagnia is a member of the European Foundation Centre in Brussels and of ACRI the Italian Association of Foundations of Banking Origin.