Spatial Information for Disaster Management
Using Examples from Istanbul

Orhan Altan and Gerhard Kemper

Abstract

With the passing of each day, the catastrophe risk for urban regions of the world is increasing. Recent events in Northridge USA (1994), Kobe Japan (1995), Marmara Sea, Turkey (1999) and more recently in Sumatra (2004) and Yogyakarta, Indonesia in 2006 are typical examples of what can happen when a major earthquake strikes directly under a densely populated area. Massive human casualties and loss of resources have occurred as a result of the tsunami in South-East Asia. Mega cities created by the rapid urbanization and development in unsafe areas have led to far greater losses than have been experienced in the past. Rapid response in gaining reliable and quick data in these cases is most important for aid management. The Anatolian peninsula is one of the well-known areas endangered by earthquakes. During history many dramatic examples have occurred. In these earthquakes, many people either died or were injured and a lot of damage occurred. In the Sea of Marmara, these earthquakes have also initiated tsunamis which hit the coastline and caused secondary damage. Modern technologies in combination with remotely sensed data in the GIS environment open a wide field for assisting in crisis management. The most important component of any crisis-management system is a crisis preparedness plan where especially our disciplines of photogrammetry, remote sensing, and spatial information science can contribute in many ways. Crisis preparedness plays a key role in protecting the population against disasters. All crisis-management efforts need interdisciplinary cooperation to provide sustainable help for all citizens. We aim to highlight possible contributions by examples of earthquake- and tsunami-risk for Istanbul. Some elements are referred to existing applications already installed or under construction, others are part of our own studies in Istanbul. Crisis-management systems, e.g., can be founded on three columns, the Crisis Preparedness Plan, the Early Warning

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System, and Rescue and Management Action. International efforts are established to combine and integrate all available data obtained during and after disasters. International cooperation has led to the newly established entity called DMISCO (Disaster Management International Space Coordination), which will be explained in this chapter.

1 Risk-level

Big events like earthquakes and tsunamis do not necessarily cause a high risk potential. Risk for human life depends on the natural conditions in combination with the activities of the population and their society (Heitner, 1969). There are many places where we meet high activity and rapid changes of the environment due to earthquakes, volcanism, tsunamis, weather disasters, and many more. Natural disasters often occur unrecognized in areas apart from the population. Other places bear a high risk to human life. Population growth and the need for agricultural or urban use force populations to make use of these areas. The coastlines are places where fisherman work and live, even though a high risk for tsunamis might exist. Today mainly the urban sprawl has raised the risk level. In the middle ages, Istanbul was situated on the European side of the Bosporus, which is safer than the south-eastern part. Today the city covers the coastline along the Sea of Marmara for a few dozen kilometers and is situated now much closer to the North Anatolian fault. In addition, the densities of urban fabric with houses of several layers enhance the risk level. Strong earthquakes and tsunamis do not appear very frequently. In our fast lifestyle, we forget or ignore such risks. Balancing a risk level is an interdisciplinary task. In the case of earthquakes and tsunamis, we have to cooperate with specialists such as geologists and hydrologists and bring them into contact with city planners and decision makers.

2 Earthquakes near Istanbul

The reason for earthquakes and tsunamis are the movement of geological plates. The North Anatolian fault is one of the biggest and most active tectonic lines. Monitoring of the earthquake history along this fault shows that the epicenters moved from east to west towards the Sea of Marmara. The last strong shock hit Turkey on August 17, 1999 and caused a dramatic disaster. Measured at 7.4 on the Richter scale the tremor was centered between Izmit and Bursa, about 80 km east of Istanbul. This was the most powerful earthquake to ever hit Turkey. More than 15,000 people died, 23,000 were injured, and finally 500,000 were made homeless. Izmit is situated on the North Anatolian fault in the Izmit Bay. This fault leads through the Sea of Marmara just 50 km south of Istanbul’s center. The main shockwaves shook and destroyed buildings especially those that were built ignoring rules for safe construction. Most buildings were damaged or destroyed by the S-waves coming a few seconds after the primary ones. The combination of heavy load, big slope, undercut
basis of the hills, e.g., by roads and sometimes liquid in the sediments, can lead to landslides as a secondary disaster. A similar effect is liquifaction of the ground that can happen even in flat terrain. A tsunami flew after the earthquake into Izmit bay. With a maximum run-up of 2.5 m along the northern coast of the bay and 1–2 m on the southern coast, it was a small one and just flooded the area. However, the Sea of Marmara bids a high potential for creating small-and medium-sized tsunamis. Besides the above mentioned, the following usually aggravate the situation. Broken gas-pipelines causing fires that spread quickly in a destroyed city. Industry can initiate environmental disasters like burning oil tanks and petrol leakage. Besides that, criminal activities might begin (see Fig. 1).

**Fig. 1.** Damage from the earthquake 1999, tectonic subsidence, ground liquification and the tsunami. The ship in the foreground thrown onshore by tsunami wave action. (Kandilli Observatory and Research Institute, www.drgeorgepc.com/Tsunami1999Turkey.html, accessed on 14.04.08)

Sometimes the secondary effects are more destructive than the primary ones. Inside the city of Istanbul many buildings have been destroyed and 3,000 people killed, mainly in the southern part of the mega city and mainly in so-called Gececondo–Districts. Within the last 50 years, Istanbul has grown to a mega city with more than 16 million inhabitants. Rough terrain, forests, and the Black Sea limit the sprawl to the north, so Istanbul expanded to the south on both sides along the coastline of the Marmara Sea. The strongest urban sprawl vector leads to the southeast and already has met the Izmit bay (Altan, and Kemper, 2008). The terrain of Istanbul is hilly and especially along the
Bosporus there are big slopes, a high risk for hang slide as a secondary disaster. The geological survey intensively observes the fault to detect potentially vertical movements. Only strong vertical acceleration might initiate a tsunami wave that grows by approaching the beach. The initial amplitude depends on the shock-intensity, the vertical movement, and the water column over the fault. The path then defines where, at which height, and when a tsunami runs up the coastline. The situation along the Bosporus is critical since the wave can grow by entering this narrow “canyon”. The situation as a funnel might increase the height of the waterfront by a factor of 2–3. Reports about tsunamis in Istanbul demonstrate the risk throughout the history (Alpar et al. 2004).

3 Crisis preparedness

A good crisis preparedness plan is the turnkey for any operational crisis-management system and needs highly interdisciplinary work. Usually an inventory of natural and artificial structures and their potential for risk is obligatory and builds its basis. To be effective, they must be part of the city planning in order to take natural risks into account. Like that, it is an important input for the administration. Figure 2. shows a potential run-up analysis of an estimated big tsunami and the population affected. Areas detected as risky have to be treated primarily since we must expect the biggest hit of an earthquake or tsunami there. Organizations that are going to help after the disaster (first aid, fire-fighters, technical Teams…) should be organized without being endangered themselves. GIS data help to detect paths and roads to enter these areas or to evacuate the people. Important for the city and the risk managers is information about the stability of the buildings. To develop a crisis preparedness plan for Istanbul means to cooperate with many disciplines with the assistance of foreign specialists. The integration of all data into a geo-server is essential and must be prepared in a way that decision makers can easily access them for the safety of the society. In a crisis management system, this preparedness plan needs a large amount of data. A good database is the most important criteria for sustainable city planning with respect to risk management as well as the foundation for strategies and management of disasters. Only a complete data collection enables us to set up an early warning system and to organize disaster management. It is important to find acceptance at the population level and to practice behavior in case of earthquake and/or tsunami events.

4 Geo-scientific research

The natural disaster potential must be evaluated by geological and hydrological research. Beside the determination of the potential earthquake centers, the path of the wave-energy must be modeled. In case of an earthquake, the geological structure transports the various waves. In the event of a tsunami, the bathymetric conditions, the vertical water column and the run-up-path are of interest. Geological and
hydrological data build the basic layers in a geo-database. Remotely sensed data can assist in detecting significant changes from the air or orbit. Radar data can monitor even very small changes in the terrain that indicate stress in the geological structures. Hyper spectral sensors can assist in detecting anomalies in the environment, e.g. the emission of thermal heat, gas, or other indicators. This information can also be part of an early warning system. For modeling tsunamis, terrain models of the seafloor, the shore and the coastline must be established. Beside classical hydrological methods e.g. via echo sounder, LIDAR technologies, using water penetrating laser, assist in the off-shore areas for bathymetric measurements. DTM (digital terrain models) and DSM (digital surface models) which include artificial structures are important to compute reliable hydrodynamic run-up simulations. This is very important for tsunami modeling. Aerial surveys use airborne cameras and/or airborne LIDAR sensors and are able to deliver a high-density DTM and DSM. In combination with land use data, risk estimations and generalization of the city into certain risk-levels can be done. Tsunamis cannot be compared with “normal” waves since their energy is extremely high even though the amplitude might be small from the beginning. On the open sea you might not recognize them but their energy shows up when approaching the beach. A typical indicator for a tsunami is the sudden and sustainable falling of the water level where a high front of the tsunami follows. Water can transport material that is then used as “weapons” and increases the destructive force of the wave. Run-up simulation becomes complex when objects or the terrain presses the water into specific directions. The Bosporus builds a funnel within which the water-level can increase several times. The water then runs in a direction not perpendicular to that is the beach; it runs along the shore and hits the objects from the side or even the back. The better the input data the more precise the final model and the results it produces.

5 Risk mapping

Data from the geoscientific survey and research, hydrological models and land use data must be combined with the 3D data in order to achieve spatial risk estimation. The combination of demographic data with urban structural analysis gives a good approximation of a tsunami risk level as shown in Fig. 2. This map was generated using data of the MOLAND Project (Monitoring Land Use/Cover Dynamics) combined with demographic data and terrain models classified for tsunami run-up simulations (Kemper et al. 2005). Even though these estimations are simple, they highlight the risk level. The shown area of Büyükçekmece is covered by residential areas on low terrain 30,000 people can be affect by a tsunami. Such risk maps help city planners and are the basis defining rules for constructing objects in these areas. Those maps support the Crisis Management Team to detect sensitive parts of the city and assist in defining paths for helping the people. Many scientists use GIS combined with remotely sensed data and/or aerial photos to extract the land use map, commonly in combination with spatial or non-spatial ancillary data. Terrain models have various possibilities to contribute to risk mapping. Risk maps help the
decision makers to understand the needs for sustainable planning and support an integrated crisis management. Crisis management and the need to redefine city structures more easily can find more acceptance in the population by presenting these risk maps than any other arguments can do. Like that, these maps are of major importance for conveying political decisions needed for a successful crisis management.

![Fig. 2. Areas of a certain run-up risk for Tsunamis overlaid with land-use data and population density of residential areas (Kemper et al. 2005)](image)

### 6 Engineering and architecture

Istanbul has to deal with a difficult “heritage,” the so-called Gecekondu areas. These Gecekondu’s are illegally built-up areas of residences that were not constructed by engineering rules. Depending on the political situation, they were legalized and then often enlarged by additional stories. These buildings typically are not stable against earthquake shocks and sometimes collapse anyway. Also the foundation anyway is weak especially if the building was enlarged. The technology to construct shockproof buildings is well known in Turkey but only rarely applied. To validate all buildings in Istanbul is an enormous work. The overplanning of the former Gecekondu areas takes place, a good chance for planning new residential areas that consider the risk and make live more safety. There is a need to obtain data of buildings static-stability, their use and their infrastructure. It is good
to know how many people remain inside the building at different times of the day. Are emergency exits available and do they really lead to a safer place? Field mapping is very limited for collecting these data. Oblique imaging technologies can assist in the same way as they do for home security analysis. Those images can help engineers and other specialists to validate the building since they enable one to view typical constructive elements of it.

### 7 City planning and data processing

All information must be integrated in sustainable planning. City planners, administration and decision makers must validate the natural and artificial facts to design a sustainable and long-lasting safer city. City planners deal with various information and must build the interface between geoscientists and the decision makers. They have the knowledge and right feeling about: what can be modified, what is possible in the legal frame and what the right way is to motivate politicians for investing in a “city for tomorrow.” As part of the crisis-management system, they are dependent on data other disciplines produce. These data are heterogenic and not ready for easy decision making. Besides traditional development and planning, an entire risk-analysis must be part of enhanced master plans. Other disciplines must be deeply integrated, e.g., geographers, computer scientists and others. Photogrammetry and remote sensing contribute to the GIS application; 3D data and animation in a virtual reality environment contribute to understanding sustainable city development. To simulate different scenarios in 3D helps all involved getting a better understanding of the need for changing existing structures to procedure a safer city. Infrastructural objects such as roads, bridges, pipelines, and dams must be part of a master plan that aims to reduce the risk and show ways to access areas in case of a disaster. Dealing with such amounts of various data needs a powerful server or a server farm with a spatial database. A centralized data server is needed for modeling data and for managing crises. Spatial information sciences use geo-data servers to store these data and to give access to specialists for analyzing, modeling, and to produce new data sets. A geo-data warehouse with a geo-portal manages the access of administrative, scientific, and public parties. GIS and computer scientists continuously optimize the data handling of big data volumes and a large variety of data types via geo-data warehouses. Such data collection enables one to set up an early warning system and to organize a disaster management plan.

### 8 Decision making and organization

A weak point in all activities is rendering the developed concepts and ideas into real activities and master plans. Good ideas and concepts are lost due to changes of political leadership or through lack of money in the related budget. However, it is easier for decision makers to begin new activities, if the concept is transparent, understandable and meets all aspects in a well-balanced way. Scientists are not good presenters even
though they have nice tools to build scenarios and simulations. Too often, we believe that simulations and animations are tools only to attract non-scientists. This technology is able to open doors to the administration and by that; it also hands over a key for accessing the public. If the population is aware of the needs for planning and reorganization of the city, rendering of the plans becomes easier and becomes apart from political competition. This is really sustainable! However, funding is an issue that is on a basis that the scientist can hardly influence.

9 Rescue plans

The Crisis Preparedness Plan must contribute to the rescue planning. Crisis preparedness means to simulate the disaster and to adjust the rescue plans. The geo-scientific data deliver models e.g. estimation of possible destroyed infrastructure by shock waves. Other simulations might deliver run-up simulations and their efficiency on the urban structure. Results are maps that points out where help is needed. The geo-database can then assist in planning the best access to these areas. Where are the roads to access these places, which hospital is the closest, how to get machines and other material there? Where will people go when in panic? What infrastructures can create additional disasters? This extremely interdisciplinary cooperation might result in a “rescue plan” which also can be used to manipulate input variables to improve the city planning and to define rules. A good rescue plan must include the population. They need guidelines on how to behave in a disaster situation and must get training. How should they behave, where should they go and can they assist the rescue teams? Warning must be simple and easily understandable for foreign people. People must be rescued but can become part of the rescue system. Knowing what to do and knowing how to help people reduces panic and makes the rescue easier. Part of this training is the sensitization and information of the citizens. Interactive maps, oblique images and 3D city models with virtual reality simulations assist in learning. Part of the training is to understand natural signatures like pre-earthquake tremors and vibrations or the water run-off at the shore. In addition, there must be a common alarm system.

10 Prediction and early warning

On the basis of the crisis preparedness system described above, prediction and early warning systems need additional information derived from measurements, monitoring or automated sensors. Perfect communication plays the key role. An operational communication, e.g., special channels in the GSM or satellite phones, are essential since wire-based communication technologies frequently are destroyed. Pre-designed data are needed to give in the right alerts at the right time on the right place. Sensors have to communicate with a central organization, but in some cases
direct access to the warning is more efficient, e.g., in Japan, fast trains are stopped automatically by an alarm sign and gas pipelines are closed immediately. A prepared alarm-chain has to be activated by the sensors. We have to be aware that these things have to be tested and trained by the crisis-management teams and by the population to know what must be done if a disaster happens. In 2005, the tsunami disaster at Bandah Aceh had neither a sufficient alarm system nor did the population know how to behave. A big problem of this tsunami disaster was the transport of “weapons” by the water. The transported wooden boards, cars, and many other things made even a 2-m flood extremely dangerous and destroyed more buildings than expected by water only. It must be part of an early warning system to fix such “weapons”, e.g., group can it to road blocks, close shops, remove dangerous things inside... An early warning or forecast system must be based on a good preparedness plan. Early warning is a difficult task for earthquake shocks since the reaction time is extremely short and the activity must be designed as an automatic procedure. For Istanbul also the tsunami warning needs an automated workflow since the wave can hit the beach already after 10–30 minutes. Early warning surely has limits by these short timeframes, a good preparedness however can give at least a chance to save lives and prepare for a rapid rescue. Forecast is difficult but can assist to set a first alarm level.

11 Prediction

Earthquake prediction by existing ground-based facilities are unreliable and the earthquakes in recent years point to the need for scientific progress in solving this problem and in employing additional evidence for earthquake prediction. Geodetic science plays an important role in earthquake research (Aksoy 1995). By means of long-term measurements, deformations caused by deformations in the Earth’s crust caused by the movement of tectonic plates can be examined. In a recent study Murai and Araki (2005) used data from GPS stations to study the daily change ratio and sudden changes of signs over triangular networks. The big Sumatra earthquake could have been detected and predicted from this data. The evidence of the likelihood of the earthquake was found in the daily change ratio of the triangular area (Singapore–Lhasa–Kunming) in the northing and height coordinates lane 8 days before the earthquake and on the (Indonesia–Singapore–Lhasa) in easting and height coordinates plane 2 and 5 days respectively before the earthquake. Sergey and Kirill (2003) have proposed a concept for a geo-space system to predict and monitor earthquakes and other natural disasters, which is based on monitoring the ionosphere and magnetosphere of the Earth for short-term forecasting of earthquakes. It involves the investigation of the interaction between the ionosphere’s F layer variations and variations occurring in the circum-terrestrial environment associated with seismic activity detected by means of ground-based and satellite monitoring. Remote sensing tools can assist too and support geologists to detect stress in the rocks. Radar-sensors in airborne or space-borne platforms can detect even small changes in the surface and indicate stress by using interferometer
Early warning

Real-time observation needs mechanic or electronic devices. Various innovative sensors, already applied in many areas are seismographs, which detect small rumors and vibrations that might indicate an upcoming shock. They are useful to set a pre-alarm but must be handled carefully. Even if the population is trained; every warning creates fear and panic. The main shock must be detected immediately and the alarm chain started automatically. Sensors based on acoustic, accelerative, or other detectors can clearly identify these shocks and validate their strength. In case of an earthquake 100 km south of Istanbul, the P-wave might arrive within 15 seconds, while the S-wave would approach 10 seconds later. A real-time communication is essential in combination with an automated reaction system. Tsunami waves run slower and hit the beach 15–30 Minutes after the shock. Sensors in the Sea of Marmara are just under installation. They provide warning via wireless communication. 15 minutes is a short time, but enables one to start the alarm-chain (see Fig. 4).

Fig. 3. This interferogram was created from two sets of radar data: The first was obtained before the Izmit earthquake, and the second 35 days after (comet.nerc.ac.uk/images, Accessed on 11.04.2008)
Automated actions are needed to deal with the short time frame. In 25 seconds is difficult to estimate as it is a relatively short time frame, e.g., to stop trains and to close pipelines to limit fire disasters. Such actions must be prepared by using the crisis preparedness plan. They must be well tested. The robustness of the alarm communication is extremely important. Public alarms can consist of sirens, radio information, warning SMS, and many others. All citizens must be educated to recognize these signs and must be trained in reacting in the right way. Relatively small things can save hundreds of lives. A key issue is communication. Beside communication between sensors and the Crisis Center with its servers, communication is needed to set the alarm and to maintain contact with the rescue teams. Radio transceivers, GSM and satellite phones keep the communication for the crisis management going. Using cellular networks data communication can be possible as long as the transmitters are powered. The power supply at the transmitter and repeater stations are critical factors in case of major earthquakes.

Fig. 4. Tsunami Sensors installed close to tectonic fault zones for detecting Tsunami waves when they start, (http://www.forschung.bmbf.de/de/4879.php accessed on 18.04.08)
14 Disaster management

Noting the capabilities of space technologies for providing assistance in times of disasters, the UN Office of Outer Space Affairs included in the report of the Committee on the Peaceful Uses of Outer Space on its 5-year review of the implementation of the recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), submitted to the General Assembly at its 59th session, the implementation of an international space coordination body for disaster management (now referred to as DMISCO). At that session the General Assembly agreed “that a study should be conducted on the possibility of creating an international entity to provide for coordination and the means of realistically optimizing the effectiveness of space-based services for use in disaster management and that the study should be prepared by an ad hoc expert group, with experts to be provided by interested Member States and relevant international organizations.” It is expected that the resources for the core of the work for the establishment of DMISCO will be undertaken at the United Nations Vienna office (three staff), with contributions in cash from Member States (for facilities, operational costs, and staff), together with in-kind contribution (such as facilities provided by a hosting Member State) and secondments of experts. Additionally, funds will be needed to support the implementation of projects identified in conjunction with National Focal Points (NFPs) and will be defined and secured on a case-by-case basis. DMISCO has been operational since 1st January 2007, and hopefully it will contribute to considerably reducing the impacts of future disasters.

15 Importance of digital archives and space data

With the vast experience gained through operational use of space data, the concept of a space based observation and communication system for disaster management is evolving in different applications. The most important need is to assess the overall requirements of users at various levels and the delivery mechanisms that could effectively provide the services for monitoring, forecasting, warning, assessment, prediction and reduction of natural disasters. The information required by disaster managers in each of the critical phases of disaster management, which includes mitigation and preparedness, response and recovery/relief, consist of

1. database design
2. near real time monitoring/ mapping
3. modeling framework
4. networking solutions
5. multiagency interface.

The success of disaster management largely depends on availability, dissemination and effective use of information. The information needs to include current information on weather, infrastructure (roads, hospital, and administration boundaries), demography etc. to assess the disasters. Currently such data are being
generated by multiple users and stored in multiple formats and media, making it difficult to bring the data together to support disaster-management activities. In addition, there is a need to assess the disaster in terms of location, extent and likely impact, so as to plan relief and recovery actions. An integrated system adequately equipped with necessary infrastructure and expertise to constantly monitor the risk profiles on all possible disasters, and maintain a national database, will become relevant. In this context, the GIS technique offers a tool to analyze multiple layers. A pilot study was carried out by the Indian Space Research Organization in 1998–2001, to design a prototype system that will integrate space inputs with conventional data. The study area selected was the Brahmaputra floods in Assam. The system consisted of comprehensive database design, space based near-real-time monitoring tools, modeling framework, networking, and a user interface. With appropriate synthesis of these core elements, flood monitoring and damage assessment was carried out. Through the use of networking, the space-based inputs were disseminated to the users. The study has led to a realistic assessment of the gaps in the current system and conceptual framework for a disaster-management system. Earth observation satellites have demonstrated their utility in providing data for a wide range of applications in disaster management. Pre-disaster uses include risk analysis and mapping; disaster warning, such as cyclone tracking, drought monitoring, the extent of damage due to volcanic eruptions, oil spills, forest fires, and the spread of desertification; and disaster assessment, including flood monitoring and assessment, estimation of crop and forestry damage, and monitoring of land use/change in the aftermath of disasters. Remotely sensed data also provide a historical database from which hazard maps can be compiled, indicating which areas are potentially vulnerable. Information from satellites is often combined with other relevant data in geographic information systems (GIS) in order to carry out risk analysis and assessment. GIS can be used to model various hazard and risk scenarios for planning the future development of an area (UN 2004) as demonstrated by the following:

1. Disasters such as floods, earthquakes, forest fires, oil spills, drought, and volcanic eruptions affect large parts of the globe and coordinated international efforts are required to minimize their impacts. Disaster relief requires timely and updated geo-social databases and situational analysis for the various phases of the disaster.
2. Space technology such as remote sensing and meteorological satellites, as well as communications and navigation and positioning systems, can play a vital role in supporting disaster management by providing accurate and timely information and communication support.
3. The utilization of space assets in support of disaster management continues to lag significantly in most parts of the globe and remain as a major challenge; however, there are several international efforts aiming to address the developmental needs and achieve effective utilization of space technology.
4. A considerable gap, however, exists and is likely to remain in all areas of space technology applications for disaster management, including technical, operational, education/training, and organizational areas, unless a global, integrated, coordinated approach is taken. In virtually all countries, there is a
lack of understanding of the benefits of the use of space technologies to support risk reduction and disaster-management activities, especially by the disaster managers and civil protection agencies.

Getting the latest information on the affected area is crucial for managing the rescue teams. Today push broom scanners but also small, medium, and large format digital cameras are combined with precise GPS/IMU orientation systems that allow rapid and fully automated data extraction. These techniques are nowadays small and easy to install and can be adjusted to many aircraft. Any aircraft is able to carry such a system to capture images which are more than documentation only. These data are as precise as aero triangulated images but enable rapid updating of the database. Many automated tools, mainly designed for remotely sensed data, can extract changes automatically. With only small personal assistance, they can indicate where e.g. destroyed buildings are. Within a few hours, taken imagery and their analysis can be integrated in the data server and become accessible to the rescue and managing teams. Using space-borne data is limited by the repetition rate of the satellite platforms. Airborne hyperspectral sensors can assist perfectly in getting relevant data since they enable a huge combination of spectral bands that can indicate much more than an image alone can do. LIDAR data of the destroyed areas can deliver very dense DSMs, which easily can be validated with the existing DSM data on the server to produce a change map. It is important to produce data as fast but not as accurate as possible. The resolution should meet the requirements only.

16 Conclusions

To be successful in managing disasters, good crisis preparedness, an optimal prediction and early warning and a well-defined management must be established. All efforts must be well distributed over the three columns “preparedness, prediction and disaster management”. Most effective however is the preparedness. If this first and key aspect is not worked out at an early stage all other efforts will not work. Spatial data and their proper handling in geo-data servers provides the chance to combine interdisciplinary work. Today still the various kinds of data sources, the different needs and the various points of view hamper an optimal progress in disaster management. We have many possibilities to achieve data, to store them and to process results. We must take this chance to build up strategies in science as well as in practice in order to address the policy and the decision makers. To solve existing problems is not a technical job, it is a political task. Good early warning systems have strong linkages between different elements. The major players concerned with these elements meet regularly to ensure they understand all of the other components and what other parties need from them. The main element of this chain is information (especially the spatial information) on the disaster area. In former disasters the importance of the need of accurate, timely and information over wide areas has been understood afterwards. A helpful application of geo information technologies requires a solid base of political support, legal frameworks,
administrative regulations, institutional responsibility and capacity, and technical training. Early warning systems have to be part of disaster management plans and policies. Preparedness to respond is to be engrained into public awareness.

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