Technologies and community mechanism for civil protection assistance and cultural heritage conservation

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1 ABSTRACT

The project was intended to help ensure better protection, primarily of people but also of the environment and property, including cultural heritage in the event of major emergencies, i.e natural, technological or environmental accidents occurring inside or outside the community. This project also explores the potentiality of a prototype for a dynamic GIS and real-time local tactical communications system specifically oriented to the activities of the forecast and the prevention of the volcanic risk. Actions foreseen for the Department of the Civil protection are: Set up a training programme including joint courses, an exchange program and exercises; stimulate and encourage the introduction of new technologies; take measures to facilitate strategies for assistance intervention and other intervention support for the conservation of cultural heritage. In particular the EuroSot Event 2005 had the objective to reinforce co-operation between the community and the member states in civil protection assistance intervention in the event of major emergencies, or the imminent threat thereof, which may require urgent response action.

2 INTRODUCTION

The Plans of Civil Protection are important instruments for the management of all possible risks and events of emergency related to a territory. This project takes into account the important guidelines of the AUGUSTUS method produced by the Department of Civil Protection. The project also concerns the realization of a database and the implementation of the appropriate technological support for the conservation of cultural heritage specifically oriented to the activities of the forecast and prevention of the volcanic risk. This study analyses the territory of Nicolosi1 and represents the test-field for all possible events related to volcanic danger and risk in Mount Etna volcano for which the geodatabase has been already implemented. The first phase of the job concernes the accurate knowledge of the territory and research related to the definition and the simulation of the most common risk models such as the seismic risk, volcanic risk (lava flow, volcanic cinders) forest fires, meteorological risk, etc.

In this phase we take into account the more important guidelines (already available or in itinere2), in order to analyse the modality of the geographic database related to the implementation of the Civil Protection (L.225/92), the AUGUSTUS method, the Regional Programme HORUS

and the documentation produced by the INSPIRE Programme3. This project takes into account the important guidelines for the Conservation of the Cultural Heritage (L. 137/2002 and L.R. nr. 14/1998)4. Furthermore, in this phase we analyses the more important guidelines in order to define the modality of the geographic database related to the implementation of the Cadastre of Roads (DM 1.6.2001) and the documentation produced by the "Intesa Stato-Regioni- Enti Locali" for the realization of the Geographic Information System. General use of risk assessment can provide a basis for preventing and limiting the consequences of accidents, thus enabling the risks to be dealt with in a coherent way (DCDEP, 2000). This is also supported by the United Nations Environment Program APELL (Awareness and Preparedness for Emergencies at the Local Level), which lists the identification of risks that can pose a potential threat as one of its main goals. Similarly, FEMA (FEMA, 2001) has its PROJECT IMPACT, aimed at building disaster-resistant communities. In order to gain better preparedness for disasters, possible risks must be identified. Visualization may here provide a valuable tool for both identifying, exploring and communicating risks.

In this paper we describe methodologies for the implementation of a specialised GIS, for the production of thematic cartography and for the management of the risk assessment (such as post-event analysis). The project also concerns the realization of a GIS (geographic information systems) and the implementation of the appropriate technological support. The project makes it possible for those who deal with the management of emergency situations to take more efficient decisions thanks to the interconnection of national contact points and the sharing and exchange of information. For this purpose the radio-transmission technologies has been implemented for the Plan of Civil Protection in Nicolosi. In particular the EuroSot Event 2005 involves authorities responsible for protecting citizens from natural and man-made risks, for testing new tecnologies and for training programme including joint courses.

3 GIS TECHNOLOGIES FOR THE HAZARD ASSESSMENT

The planning and the realization of a prototype for a dynamic GIS is specifically oriented to the activities of the forecast and the prevention of the risk related to danger events. This prototype can also support the management of possible events of emergency not only in Nicolosi but in the Mount Etna volcano.

The GIS Technologies implements models of simulation for the risk phenomena both with natural or man-made features and with specific required conditions. They also apply to the Nicolosi Plan and define both the immediate definition of pre and post-event analysis (such as the seismic events, earthquakes), and the slow evolution of the time-scale event (such as lava flow, woodland fires, etc). On the use of GIS to assess natural hazards we note visualization as important not only in the development of GIS generally, but also as a tool to improve reliability of hazard assessment, thus decision support, and also to improve the ability of non-experts to take

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[1] www.protezionecivilenicolosi.it., link of the Civil Protection Centre in Nicolosi.

[6] DL 31/3/1998 n° 112, art. 108 related to the Sanitary Risk, "Circolare Sirchia" 1/7/2004, and the guidelines of the DPC 6/7/2001.

[3] The INSPIRE – Infrastructure for Spatial Information in Europe is a large current initiative of the European Commission to promote the multipurpose availability of feasible geographic information. Smith et al (2002)

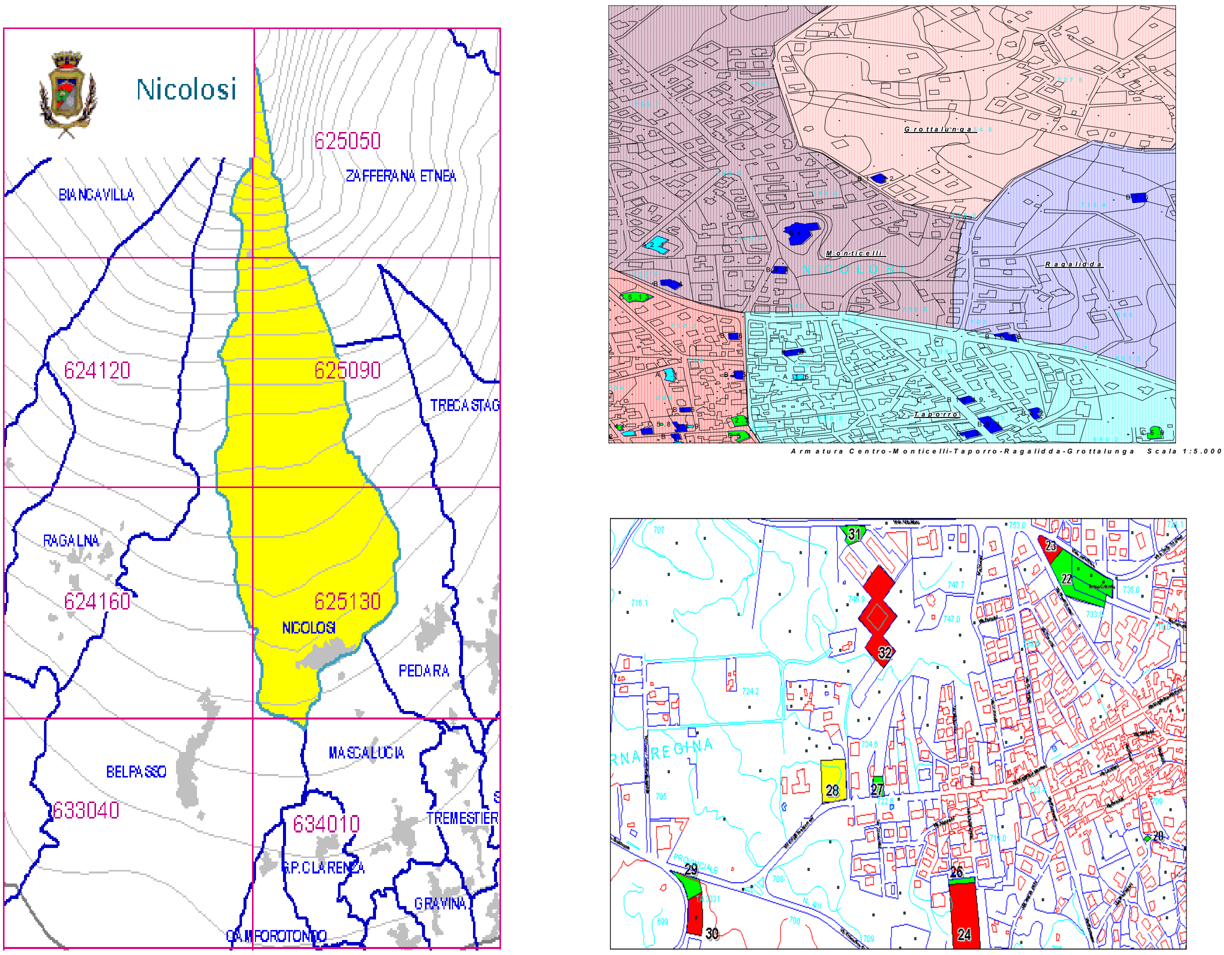
[4] Other guidelines are: The NOPPCEC (D.Lgs.490/99) for the implementation of Operative Stations in Provinces and the SORIS emergency strategies (deliberation 304/2000).

advantage of the information presented5. A statement on the need to improve the representation of risk and vulnerability is also found in Radke et al. (2000), noting that the average GIS is not able to represent the depth and richness of the dynamic nature of risk and vulnerability.

The primary issues of this study are also related to the definition and implementation of methodologies and models. Within the study of those models and their implementation on the GIS platform, the project included the detailed definition of the features of the cartographic data (available or in phase of acquisition) and all the necessary elements (both topological and informative) for the specialised GIS. The prototype GIS tool was created using different softwares such as MapInfo 7.0 SCP and AutoCAd Map technology. In order to facilitate the ever-expansion of new data, thematic layers were developed for all data input into the database.

Cartographic research6 explores the use of thematic maps for civil protection with the emphasis on extracting specific pieces of information such as:

1. volcanic risk: historical series for volcanic events; maps of hazard assessment related to lava flow; census of the population; survey of the vulnerability related to building and public service; data related to volcanic cinders.
2. seismic risk. map of the hazard assessment related to the seismic risk; vulnerability maps building (public and private buildings) and in particular vulnerability maps for cultural heritage; inventories of areas sensitive to volcanic risk and volcanic risk inventory; inventory of densely populated areas and road network. Life lines (electrical network, water-works, gas-pipes, etc.), areas of emergency;
3. woodland fires: land use maps (extension of the woodland heritage), climatic map of the territory; map of the historic woodland fires and strategic places; hidrography and remotely sensed data (vegetation, soil moisture);
4. estimation of population density related to districts and ISTAT (Italian Statistic Institute) data;
5. and use and existence of such risk to be taken into account in land-use planning
6. meteorological risk**:** climatic variability and the temporal variability of disaster risks, climatic data network spread across the territory;
7. sanitary risk;



Graph 1: Models of the seismic risk and emergency areas in the territory

5 Coppock (1995) for further study.

6 Readers are referred Kraak, M J and Ormeling F.J (1996) for further study.

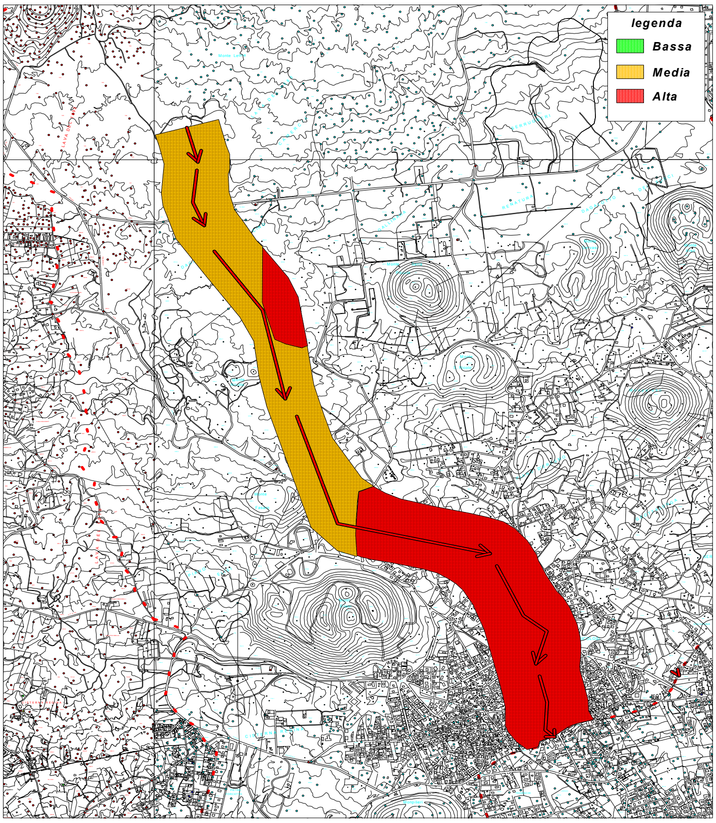
4 VULNERABILITY IN CULTURAL HERITAGE ANALYSIS

The central idea upon the "Risk Map" is based on the development of systems and metodologies enabling maintenance and conservation strategies for cultural heritage with regard to their conditions and the environment where they are situated related to the risk phernomena. The objective is to predict, and thus to decide in advance, wich measures has to be taken most urgently, with regard to the time necessary for execution in order to avoid losses and damage. In the particular case of the volcanic emergency “Etna 2001”, the Superintendence BB.CC.AA. of Catania produced a specific plan for the conservation of the “movable” cultural heritage (paintings, sculptures, etc). This plan also involves a detailed listing of the cultural heritage in the urban centre related to ICR standards.

In general the first line of defence against volcanic risk and earthquakes has historically been the construction of buildings that can withstand severe shaking. Nicolosi relies on the seismic design provisions in building codes related to cultural heritage to ensure that structures can resist earthquakes. The variations in the seismic threat across the country are depicted on maps in building codes as zones of different risk levels. These building-code maps are based on more detailed shaking-hazard maps. The geological survey shaking-hazard maps for the Catania province are based on current information about the rate at which earthquakes occur in different areas and on how far strong shaking extends from quake sources. Shaking-hazard maps can be combined with data about the strength of existing historic buildings (churches, monasteries, etc.) and traditional architecture, to estimate expected earthquake damage in an area over a given period of time. Although strong earthquakes are frequent in Nicolosi and in the Mount Etna in general, damage in those areas could be catastrophic in a powerful temblor. This is because most buildings and other structures there have not been constructed to withstand severe earthquake shaking.

For this reasons it will be possible to update the SIT throught the transmission of useful information for post event analysis. In particular will be possible the delimitation of the lava flow areas and the location of the damaged buildings and cultural heritage in general to the Central Operative station (COS). In the same way, it will be possible to fill a short inventory of the survey of the damaged buildings or of the road network with the radio-transmission technologies related to the DB and to send the data to the GIS in real time. In fact natural factors and small-scale man-made can deeply modify the morphology of the land use and the characteristics of urban areas and natural environments. It is well known that the updating of a reliable cartography, both for its metric quality and its contents, represents an indispensable tool for the realization of a specialised GIS.

The primary objective of this phase of analysis was the updating of the cartographic data, and of the informative contents (presented in the database) which are strictly connected to each other. The main purpose was to avoid useless duplications and redundancies (on one side and informative errors and incompleteness, on the other) and to stimulate the implementation of multi-scale and multi purposes systems.



Graph 1: Risk Map

In the mid-term phase of the Plan for Civil Protection in Nicolosi, vulnerabilità data partially derived from ISTAT 1991 census, coming from a study published in 2001 by the Italian National Sesmic Survey and by Regional data. Still statistical derived data are not enough reliable and complete, such they have been analised for other purpouses. To update these data a deeper analysis of vulnerability distribution on the territory a specific investigation campain will be performed in many seismically exposed towns in the Etna volcano, by means of a method named “Guided Interviwe Protocol”[7]. Vulberability of built environment and population’e exposure data have been implemented in the GIS of Risk-Exposed Building of Nicolosi, together with damage probability analysis.

The purpose of this study is to test how well a particular GIS algorithm would be able to delineate areas around Nicolosi that would be safe from lava flows from any event that could open around the Etna volcano. The accuracy of the algorithm calculations will be tested against physical models and correlated well. In populated areas around volcanoes that produce effusive lava flows, it is important to know the areas that are and are not in danger of being damaged by these lava flows. Assumptions made in the study were that eruptions were most likely to occur within or adjacent to known vent source areas, and that basaltic lavas flow downhill following the path of maximum gradient. Hazard maps were produced using these assumptions that highlighted areas with highest probabilities of being reached by flows. Calculation buffers were then designed for the neighborhood analysis operations. The buffers ware applied only to areas where eruption probability was highest, mostly the areas with the highest vent concentrations. The buffer was then able to identify “safe areas” on the terrotory that statistically should not be in the path of future lava flows. The outcomes of this study can be used to prepare emergency response and evacuation plans before the next eruption on Etna occurs. Historically, eruptions in this area have been shown to produce pyroclastic flows and surge eruptions. GIS was used to delineate the areas most likely to suffer the largest loss of human lives in the event of eruptions of varying magnitudes. Volcanic risk assessment in the study area is also complex because there are various regions of vent complexes, rather than one central vent. Maps were generated of the zones of highest probability of being hit by pyroclastic flows relative to the total number of simulations. The maps produced showed that topography will tend to control the emplacement of pyroclastic flows, with areas of low elevation having the highest hazard probabilities. A map of relative volcanic risk was then generated by combining the hazard probability maps with population density data.

5 RADIOCOMMUNICATION TECHNOLOGIES AND POSITIONING SYSTEM

The danger events stimulate the implementation of reliable technological support in the field of innovative positioning systems via satellite and telecommunication technologies related to the management of emergency and the evacuations or danger events. For this purpose the Radiocommunication technologies have been implemented for the Plan of Civil Protection in Nicolosi and in general in the Etna Mount. In the field of the plan for emergencies, the Italian Amateur Radio (A.R.I.) implemented the installation of the radio-communication network as a multi-user data network for the Central Operative Stations (COS). In particular, the Civil Protection Department displays system for emergencies with a relay installed in a protected area. Furthermore technological equipment also concerns an other relay for the ARI. This is installed in a private house in Vetore Mount. Those places will be properly tested in order to verify the communication technologies with the Civil protection equipments in the emergencies areas, shunting station and massing areas. This technology will connect the Central Operative Station and the Vittorio Emanuele Hospital. The Center is equipped with communication systems and it is directly connected with the competent services all over the territory. The Disaster Management Agencies and the Operative Central Station are organised with client server system, radio station and radio localization (27 MHz and 43 MHz) related to different equipment such as a digital network and APRS, a real-time tactical digital communicatons protocol for exchanging information between the stations covering the Mount Etna and the eastern slope of Sicily. The technologies also concern the APRS (Automatic Position Reporting System) for the integration of maps and other data and display data by using a one-to-many protocol to update everyone in real time. With this technological equipment the Central Operative Station (COS) will be able to easily identify the location of the emergency team in real time and to deploy them to that destination through the more direct channels. The modem GPS technologies and the packet radio guide emergency and operative team into a real-time tactical communications and display system for emergencies and public service applications. The installation of Voip systems and WI-FI guarantee the optimal communication and management of the emergency strategies between the Operative Central Station and the team involved in the site of emergency. The use of the Standard 802.11ib (WI-FI) technology is also implemented for the transmission of files and images via e.mail and for the suitable internet network. This always maintains efficiency, reliability and security of the telecommunication system. Viewing the complex radio-communication technologies at the highest level of implementation, it will have an important advantage in the field of the strategic operations in emergency: the bi-directional informative flow between the COS and the team involved in the site of emergency will always guarantee the updating of the data in real time. For this reason the GIS could be implemented with the realization of a client/server system related to the management of an emergency post event equipment (connected to the Central Operative Station). This will interface with the computer and remote controllers (or remote palm systems). Also it will be possible to share and to update the useful information in real time. This also guarantees the optimal management of the emergency strategies between the Operative Central Station and the team involved in the site of emergency.

6 EUROSOT EVENT 2005

The Event uses the opportunities offered by information and communication technologies to encourage and support the delivery of cross-border public sector services to citizens in Europe, to improve efficiency and collaboration between Italian and European public administrations and to contribute to making Europe an attractive place to test civil protection strategies. In particular the EuroSot Event 2005 had the objective to reinforce co-operation between the community and the member states in civil protection assistance intervention in the event of major emergencies, or the imminent threat thereof, which may require urgent response action.

The objectives of the event were:

- to support and supplement disaster prevention efforts at the national, regional and local levels, including the preparedness of those responsible for civil protection and intervention in the event of a disaster;

[7] Dolce, M. (1996)

- to contribute to informing the public about a disaster;
- to establish a framework for effective and rapid cooperation between european civil protection services when mutual assistance is needed;
- to enhance the coherence of actions undertaken at international level in the field of civil protection.
- to Coordinate the response and recovery actions in emergencies.
- to organize and promote the volunteer organizations work in the field of Civil Protection.

The EuroSot Event 2005 adopted all the available technologies on reinforcing the civil protection capacity of the EU, which focused on how to pool intervention teams and resources during a major disaster related to the sismic risk in the most effective way. The telecommunication identified a number of information gaps. It also highlighted the need for more training and interoperability and the need to improve communication and coordination.

7 CONCLUSIONS

This information will be in real time loaded by the GIS system and database software and immediately made available for all the final users involved in the emergency.

The need for the development of methodologies in the implementation of the network of permanent GPS station and specialised GIS has pushed the research groups to achieve experimentations and applications in this field of studies. As Molak (1997) points out, earlier forms of risk analysis and risk communication tended to overemphasize the role of the expert in "proving that something is not dangerous". However, as he states further, the most important issue is to always make risk assessment transparent to the public with all the assumptions and parameters clearly stated. The thought process that goes into evaluating a particular hazard is more important than the application of some sophisticated mathematical technique or formula, which often may be based on erroneous assumptions or models of the world. Visualization is an excellent tool to overcome these limitations, because it stimulates thought and because it can be used to display uncertainties and the variability of the parameters that influence risk. What lacks most is the interoperability of systems for scientific visualization, image processing, GIS, database engineering, statistical analysis and other methodology. In the search for relevant applications of new techniques for risk analysis, it was discovered that most literature, with a few notable exceptions, only employs static 2D techniques, maybe covering a few variations of risk factors with 3D techniques and DTM. Risk analysis seems preoccupied with numbers rather than figures, more concerned with modelling risk accurately than allowing room for uncertainty and exploration. Unfortunately, this seems to be the nature of risk analysis; in the end, the public wants certainty whether there exists a risk or not, vagueness does not seem to be an option here. Risk analysis is a crucial element in emergency preparedness. Visualization is one methodology that should be part of risk analysis. Visualization is closely linked to GIS. The number of limitations, challenges and possible improvements in GIS with respect to using it in emergency preparedness, as highlighted by Radke et al. (2000), can serve not only as a guideline for future GIS research for emergency preparedness, but also point to rewarding research avenues for visualization of risk and vulnerability.

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