# Earthquake scenario in Western Liguria, Italy, and strategies for the preservation of historic centres

Scientific Coordinator: Prof. Sergio Lagomarsino

#### Introduction

The project intends to compare and integrate different methods, considering both the well-established and original ones, for the development of scenarios of earthquake ground shaking, vulnerability and damage, in regions of medium extension (about 2000 km<sup>2</sup>), which are characterised by a complex geomorphology and with different urban tissues. The application is focused on the Western Liguria, a region of great interest from the point of view of seismic history and vulnerability, due to a wide variety of the potential site effects and the characteristics of the built environment. The Research Units (RU) of the project are the following:

RU	Responsible	Affiliation
1	EVA Claudio	DIPTERIS, University of Genoa
2	GUIDOBONI Emanuela	SGA - History, Geophysics and Environment
3	FACCIOLI Ezio	DIS, Technical University of Milan
4	BINDA Luigia	DIS, Technical University of Milan
5	BAGGIO Carlo	DiPSA, III University of Rome
6	MAGENES Guido	DIPMEC, University of Pavia
7	LAGOMARSINO Sergio	DISEG, University of Genoa
8	DALAI Maria Luisa EMILIANI	Department of Art History, Univ. La Sapienza of Rome

#### 1. Seismicity and source characterisation

Responsible: Claudio Eva

The scope of this section is to achieve new information on seismicity of the Western Liguria and the surrounding regions, in order to define the scenario earthquakes. To do this, the following items have been considered: 1) a review of the main historical earthquakes, with a deepening of archive researches; 2) a revision of the instrumental seismicity, as recorded by local French and Italian networks, with a revaluation of focal parameters (magnitude, seismic moment, source mechanisms); 3) seismicity-structure correlation and determination of lateral heterogeneities in the crust, through tomographic inversion.

#### a) Results obtained at the end of the first-year activities

In the first year the following activities have been performed:

- The 1818, 1819, 1831, 1854 and 1887 earthquakes have been studied from the macroseismic point of view and properly relocated. (RU2)
- All information of local earthquakes, occurred in the period 1988 to 2001, have been performed creating wave's shapes from data collection. (RU1)
- Reflection and refraction of seismic profiles, crossing in the region and the Ligurian Sea border, have been collected. (RU1)

• All collected data have been used to define correlation between crustal structure and seismic activity and to plan a new zonation for seismic hazard evaluation. (RU1)

b) Second-year activities

- In order to better determine the seismogenetic area of the 1887 earthquake, it has been examined the earthquake which took place on 19th July 1963, for which an instrumental epicentre was known and a PQ with 70 locations, only Italian ones (NT and DOM, 1997). The study has led to evaluate 463 locations, allowing to have a highly detailed picture of the propagation, in relation to the instrumental epicentre in the sea (87 km from the coast). (RU2)
- Continuation of the historical research, by examining the documentation preserved at the Turin State Archives and at the Imperia State Archives, San Remo office. It has been improved the understanding of the administrative scenario after the earthquakes, characterised by a bureaucratic and fragmentary decision-making reconstruction process. One affected location (Poggio) has been added. (RU2)
- On the base of data collected in the first year of activity, the RU1 has performed:
  - a) a tomographic analysis of the crust of Western Liguria and Ligurian Sea; this analysis emphasises the presence of strong lateral heterogeneities, that have been used also to model the 1887 earthquake (the strongest one in the last millennium);
  - b) a ri-parametrization of the magnitude of all recorded earthquakes with a new Mwe;
  - c) a new attenuation law, based on velocimetric data, has been carried out;
  - d) a complete revision of the focal mechanisms for the most energetic earthquakes, occurred in the last twenty years, has supplied the stress field of the region.
- c) <u>Results obtained</u>
  - The studies performed in the last two years has permitted to obtain a coherent view of the seismogenetic sources inland and along the border of the Ligurian Sea. As consequence, it was possible to constrain the focal parameters of the genetic source of the 1887 earthquake and to model the fracture-propagation process, considering both point and extended sources. The results are in good agreement with the macroseismic field and they allow us to utilize the event as scenario earthquake. It is outlining that modelling has taken into account the crustal heterogeneities, derived from tomographic inversion of local earthquakes time arrivals. Seismicity revisions, seismotectonic correlations and the stress field have been used to perform an alternative zoning for the hazard evaluation.

# d) Activities to be carried out in the third year

• Calibration of the highest values of intensity scale (1887 earthquake), by specifying if they are due to the vulnerability or to local topography. For this purpose, local building information will be thoroughly examined by analysing the outlying villages with different degrees of effects (up to two degrees in

difference). (RU2)

- Knowledge of the effects suffered, with reference to the characteristics of the residential network (distribution and demographic scale) in 1887 and in 1963. (RU2)
- Archive (in GIS environment) of the historical sources (administrative and scientific), damage to the monuments, cartography and iconography. (RU2)
- Seismotectonic analysis to determine a second scenario earthquake, considering the seismicity in the Saorge–Taggia neotectonic line, responsible of minor events occurred in the last two centuries. This structure might be considered as source of a 5 magnitude event, very close to the most populated area of the region. (RU1)

## 2. Earthquake ground motion, site effects and interaction

Responsible: Ezio Faccioli

In order to analyse the structural response and evaluate building damages, the seismic ground motion analysis is developed at two different scales: sub-regional scale (Province of Imperia), urban scale (Taggia). At sub-regional scale the deterministic motion representation (intensity and PGA) will be associated with an evaluation based on probabilistic methods. At urban scale, a more detailed seismic motion simulation study of the scenario will be carried out taking advantage also of the local records of small earthquakes.

a) <u>Results obtained at the end of the first-year activities</u>

- An event such as that occurring in Western Liguria on February 1887 has been selected as the main (but not unique) scenario earthquake. The assumed seismic source is a reverse fault, located about 20 km offshore, and oriented parallel to the coast. A magnitude 6.3 was at first assigned to the earthquake, and a deterministic ground shaking scenario was generated via GIS at a regional scale; the peak ground acceleration values obtained were low compared with to observed intensities. (RU3)
- Probabilistic hazard analyses were carried out for the Taggia–Argentina Valley area, as an example of the proposed method. (RU1, Geodeco Spa)
- Local amplification effects were ascertained and quantified for hilltop sites. (RU3)
- The measurement and analysis of seismic background noise in Argentina Valley, and in particular the H/V spectral ratio interpretation, allowed us to generate a preliminary map of dominant frequencies. (RU1)

b) <u>Second-year activities</u>

- Two hypotheses proposed for the 1887 seismic source were tested: a fault segment perpendicular to the coast, and a segment parallel to the coast. In both cases, good agreement between the GIS-generated, deterministic scenarios and observed intensities has been found; however, for the fault located 20 km offshore M 6.5-6.7 values should be used (RU3).
- Hybrid synthetic accelerograms were calculated as the sum of a deterministic signal (generated through HISADA method for a crustal profile from literature)

low pass filtered at 2Hz, and a stochastic signal, generated with a method based on empirical Green functions, high pass filtered at 2 Hz. These analyses indicate as preferable source of the 1887 event the offshore fault system parallel to the coast, with M > 6.5 (RU3). The stochastic accelerograms are generated from weak motion earthquake recordings available for the year 2001, received from RU1.

- The seismic records of RSNI (North-Western Italy Seismic Network) and RSLG (Seismic Network of Lunigiana and Garfagnana) networks allowed us to define site amplification effects at some stations. A M<sub>WA</sub> scale (Wood-Anderson equivalent) was defined. Then a peak ground attenuation law has been developed for low energy earthquakes. (RU1)
- Morphological and geological maps at the 1:10000 scale obtained from Liguria Region (acquired through RU7) have been introduced into a GIS environment (RU3), and a simplified classification into general geotechnical units performed. (RU3)
- A geotechnical and geophysical survey was made in the Taggia Argentina Valley area, consisting of two boreholes with the down-hole measurement of the S e P seismic velocities. The surveying phases were attended by RU1 e RU3.
- The collection of geotechnical and geophysical data from past surveys in the Argentina Valley area has been completed. A geotechnical profile on a cross-section of the valley has been constructed, and amplification functions were computed and compared with the dominant frequencies obtained in the seismic noise survey.
- Amplification functions were estimated at the Down Hole survey sites in order to introduce the local amplification effect into the probabilistic hazard analysis (RU1).

c) <u>Results obtained</u>

- On the basis of different studies, the most probable seismic source for the 1887 earthquake has been identified, and used to obtain the main ground shaking regional scenario.
- The local seismic response in Taggia Argentina Valley was studied.

d) Activities to be carried out in the third year

- A deterministic scenario for a moderate (onshore) earthquake is to be developed, the event being identified is a replica of the may 1831 M 5.5 event.
- Scenarios are to be generated in terms of both macroseismic intensity and peak ground acceleration.
- Site conditions will be taken into account for the *Imperia province* using the geological map available at a 1:10000 scale.
- The scenarios are to be upgraded by assessing the topographic amplification.

# 3. Assessment at sub-regional scale and vulnerability analysis

Responsible: Sergio Lagomarsino

In a risk or scenario analysis, the inventory of the exposed vulnerable elements (current buildings, monuments, assets of artistic and historical value) represents a critical aspect. In fact, it should be desirable to take advantage of the existing databases, but the vulnerability models are usually linked to a specific survey form, so that *ad hoc* surveys are needed, with relevant costs. The project intends to collect the existing data (Civil Services, Monuments and Fine Arts Office, bibliography), in order to create a suitable database with records georeferred in GIS environment (Task 7); moreover, different vulnerability models already available are considered. The final goal is the definition of an integrated methodology, able to consider various vulnerable objects in an homogenous way. Obviously, the new models should be applicable b other territory, not only to the Western Liguria. In particular, in Task 3 macroseismic vulnerability models are developed to carry out analyses at subregional scale; in Task 5, instead, mechanical models have been considered for the urban scale. Nevertheless, both models can be used at the two scales. With analogous criteria, it is possible to carry out a vulnerability analysis of the monumental heritage, with reference to structures and assets.

a) Results obtained at the end of the first-year activities

- Collection of the available data on the Western Liguria, with reference to the exposed vulnerable elements (ordinary buildings, resident population): administrative borders, census sections (Liguria Region); consistency of the buildings through ISTAT data (provided by Vincenzo Petrini). (RU7)
- Collection of the available data on the monumental heritage: list of the preserved monuments and assets (Monuments and Fine Arts Office); *Territorial Plan of Landscape Coordination*, with location of the urban centres of historic value and other isolated structures (Liguria Region); bibliographical research. (RU7)
- Critical analysis of the existing methodologies to evaluate building vulnerability; development of a new macroseismic vulnerability model. (RU7)
- Surveying of the churches of Taggia, by the GNDT form, which has been defined after Umbria-Marche earthquake. (RU7)
- Mapping of works of art catalogued by the Monuments and Fine Arts Office. Rational analysis of the bibliography of cultural heritage in the test area. (RU8)
- Survey form for vulnerability analysis of cultural heritage. (RU8)
- Database containing information about altars, frescoes, paintings, stuccoworks, bells, statues and furnishings from cataloguing on sub-regional scale of 30 churches, 2 palaces, 6 sacristies, 2 monasteries, in the area of Taggia, Badalucco, Castellaro and Bussana Vecchia. Altogether, the following assets have been filed: 51 altars, about 1196 m<sup>2</sup> of frescoes, about 569 m<sup>2</sup> of stuccoworks, 93 furnitures, 23 bells, 8 organs, 62 sculptures, 231 paintings, 502 furnishings, 137 statues, 124 pieces of furniture. (RU8)

b) <u>Second-year activities</u>

• Definition of a new methodology for the vulnerability analysis, through a macroseismic approach, starting from the EMS 98 (*European Macroseismic* 

*Scale*). This scale implicitly includes a vulnerability model, which is defined in a vague and incomplete way. The methodology has been obtained using the fuzzy sets theory and a new discrete probability distribution (derived from the beta distribution), more adequate than the binomial one. The vulnerability model can be used at different scales, with any database, taking into account the role of the uncertainties. (RU7)

- Processing of data relative to the monumental heritage at the sub-regional scale, through: collection of other available data (ICR – Central Institute for Restoration, Rome) and link to the list of the preserved monuments and assets (Monuments and Fine Arts Office), which have been developed during the first year; georeferentiation in GIS environment using the available cartography and bibliography. (RU7)
- Improvement and check of survey form for vulnerability analysis. Revision of typologies of artistic assets. Definition of parameters for the damage levels in each typology. Definition of standard procedures for digital photographic survey. (RU8)
- Creation of a new relational database (*Historical and artistic assets*) integrating all collected data (catalogued works of art, bibliography references, documentary photos, results of survey and vulnerability analysis). (RU8)

c) <u>Results obtained</u>

- Macroseismic methodology for the vulnerability analysis of the current buildings, which can applied at the sub-regional scale using existing data.
- Georeferentiation of the monumental heritage; creation of a database containing the information collected by the Ministry of Culture (ICR).
- New survey module for vulnerability analysis.
- Database *Historical and artistic assets*, with digital images archive.
- d) Activities to be carried out in the third year
  - To check the reliability of the ISTAT data for buildings on the Imperia Province, in a systematic and sampling way. Definition of building typologies (starting from ISTAT data) and evaluation of their vulnerability parameters (vulnerability index, vulnerability factors) through the methodology developed in the second year.
  - Vulnerability analysis and damage scenarios at the sub-regional scale.
  - Vulnerability analysis of monumental heritage, using a two level approach: I level sub-regional scale (model from the Traiano project); II level churches in Taggia area (macroelements model, from the SAVE project).
  - Definition of value parameters for the architectural heritage. (RU7-8)
  - Research concerning the integration of the two forms, for the structural vulnerability and for vulnerability analysis of historical and artistic assets. (RU7-8)

## 4. Typological classification and survey of the buildings

Responsible: Luigia Binda

The vulnerability models, derived from a macroseismic approach (Task 3) or based on simplified mechanical models (Task 5), are both characterised by the need of a typological classification. A classification, although detailed, contains buildings with a very different seismic behaviour, if the peculiar aspects of the built environment on that particular region are not considered. Task 4 aims at individualizing recurrent kinds, characterising their vulnerability thanks to detailed survey of the constructive techniques and with on site and laboratory tests. Survey is greatly important for the masonry buildings on the historic centre, where materials and techniques frequently change even in close centres, but it is also addressed to the pre-code r.c. buildings.

a) Results obtained at the end of the first-year activities

- Classification of the masonry typologies (materials and texture), in the historic centres of Taggia (RU4-5), Baiardo (RU4) and Bussana Vecchia. (RU5)
- Survey and historical analysis of the Suore della Visitazione Convent. (RU4)
- Mechanical characterisation of masonry walls and materials in Taggia and Baiardo, by on site tests: flat-jacks, sonic and section survey. (RU4)
- Typological analysis of the masonry buildings and transformation of the urban tissue in Bussana Vecchia. (RU5)
- Collection of detailed information (structural drawings) on single reinforced concrete representative buildings in the test area of Arma di Taggia and the province of Imperia, built in different periods. (RU6)
- Historical analysis on damages suffered by different churches in Taggia and Castellaro, on the basis of the archive research. Comparison between damages caused by 1831 and 1887 earthquake in the historic centre of Taggia. (RU2)
- Identification of artistic assets qualifying the urban centres in Western Liguria, such as fountains, portals, shrines. Choice of Taggia as test area. (RU8)

b) <u>Second-year activities</u>

- In order to better understand the distribution of the effects regarding the highest degree of intensity due to the 1887 earthquake, elements of building vulnerability at that time have been examined. A large number of technical and scientific reports indicate the poor state of the built environment before the earthquake. These reports enlighten some specific elements, like: loss of connection between the walls, excessive dead load of roofs, weakness of vaults, very heavy floors up to the top, the weakness of materials, etc. (RU2)
- *City of Taggia.* The survey of façades and sections of the walls have been completed; through archive data and on site survey of details, the collection of technological information on the historic centre has been completed. The survey and historical analysis of the *Suore della Visitazione* convent and of the Santa Teresa church was also completed, so that the evolution from the first core was clarified and the most vulnerable parts were enlighten. Sonic and flat-jack tests on points of the building have been done and the materials sampled in the same points were characterised in laboratory from a chemical, physical and mechanical point of view. (RU4)

- *City of Baiardo*. The archive documents have been collected and the oldest part of the historic centre, damaged by the 1887 earthquake, have been surveyed (monumental church and castle, building agglomerates). Being one of them under restoration, the access to the site allowed us to survey also interiors and details (vaults, openings, columns, etc.). The design drawings for the interventions have been collected and it will be possible to study the effectiveness of this restoration. On three buildings (Church, Castle and the agglomerate under restoration) on site tests æ flat-jacks, sonic and section survey have been carried out. (RU4)
- Comparison between the results collected in Taggia and Baiardo, in order to improve the knowledge on the construction techniques and materials properties (the mortar used in Baiardo is based on putty lime and not made with row soil). (RU4)
- Analysis of the historical communication ways: most important Roman centres, Roman roads (among them the Julia Augusta), bridges, the morphology of the territory and the medieval roads along the Roja and Argentina river valleys; antique mountain roads and the local communication ways around the city of Taggia and its bridge have been hypothesised. (RU5)
- The historical maps of Taggia (Vinzoni 1758, cadastre 1879) were collected and the evolution of the centre from the X to the XX century has been drawn. (RU5)
- Typological analysis of the urban roads, with an identification of three types of urban tissue: non planned tissue along annular roads (Tages way), planned built tissue along linear roads (Lercari street-Spagnuoli street); transformation of medieval court buildings over a probable Roman tissue (Lotti street-Anfossi street). (RU5)
- Direct surveys of some building units were carried out and some plans, sections and prospects of the buildings (scale 1:2000 1:500) were found, for a wide part of the historic centre. On the basis of the knowledge of the masonry constructions (height of the buildings, the thickness of the walls and the external prospects), a plan-volumetric representation of the city has been produced. (RU5)
- Collection of detailed information (structural drawings) on single reinforced concrete representative buildings in the test area of Arma di Taggia and the province of Imperia, built in different periods. (RU6)
- Definition of a new module for the urban assets of Taggia. (RU8)

# d) Activities to be carried out in the third year

- Typological classification of masonry, singling out some useful parameters for a quick on site identification. Evaluation of the mechanical properties for different kind of masonry, by *in situ* non-destructive test and comparison with the results obtained in Umbria, within another GNDT Project. (RU4)
- Classification of building typologies, by considering the growth and transformation phases; statement of useful parameters for a quick identification.
- Cataloguing of Taggia urban assets and photographic digital survey. Updating of the data base of Historical and artistic assets. (RU8)

# 5. Vulnerability models and damage scenarios

Responsible: Guido Magenes

In order to carry out homogeneous vulnerability analysis and compare damage scenarios, vulnerability models have to be based on a same conceptual approach for all kind of structures (masonry buildings, r.c. buildings, monuments). Macroseismic vulnerability models, which are developed and applied on Task 3, are very simple for the use and available for the analysis at sub-regional scale. A set of mechanical vulnerability models is defined on Task 5, differently expressed for each building typology and for the analysis at different scales. An advantage of a mechanical approach is the possibility to consider seismic effects in spectral terms, so that damage evaluation can take into account the interaction between dynamic properties of buildings and geodynamic characteristics of the site.

a) <u>Results obtained at the end of the first-year activities</u>

- Application of a preliminary "displacement-based" simplified seismic assessment procedure (Calvi, 1999) for existing r.c. buildings, to produce damage scenarios, using ISTAT data. (RU6)
- Development of a numerical model for the nonlinear dynamic analysis of multistorey r.c. frames, taking into account joint failure. Preliminary nonlinear dynamic analyses on multistorey r.c. frames,modelling joint failure (Calvi, Magenes and Pampanin 2001 & 2002). (RU6)

b) <u>Second-year activities</u>

- Formulation of a new deformation-based simplified assessment procedure to be used in the scenario analyses (Glaister & Pinho, 2003). Calibration of a nonlinear model for the simulation of infills, through comparison with experimental data. (RU6)
- Nonlinear analyses on multistorey r.c. frames, with the simulation of weak joints and the presence of infills. The models were developed using the code "Ruaumoko" (Carr, 2001). (RU6)
- Development of a mechanical based vulnerability method for masonry buildings, based on the *capacity-spectrum* approach (Hazus, 1999): definition of capacity curves, joined to each typology (materials, height), and intersection with the earthquake spectral demand, properly reduced as the displacement increases (performance point). Comparison with the results of the macroseismic method. (RU7)
- Survey of the entire historical centre of Taggia, by means of a quick form (which doesn't require to go into the building), containing information on the geometry, the egularity, the position in the building aggregate, the presence of traditional aseismic devices (tie rods, buttresses, foil arches, etc.). The collected data, together with a photographic documentation, have been implemented in GIS environment; they will be used both for macroseismic and mechanical based vulnerability analyses. (RU7)

c) <u>Results obtained</u>

• The relevance of joint damage and frame-infill interaction in the seismic response of multistorey buildings has been evaluated for a series of structural

configurations of interest. The refined modelling criteria which were developed for nonlinear time history or pushover analyses are being used as a reference for simplified deformation/displacement based assessment criteria. The newly formulated deformation-based assessment procedure represents an improvement with respect to similar, previously proposed procedures (Calvi 1999) by considering the mutual dependence of the displacement capacity and effective period of the structure. (RU6)

#### d) Activities to be carried out in the third year

- Completion of the survey of r.c. buildings in Arma di Taggia. Detailed analyses of a few real representative buildings. Application of the new deformationbased procedure to the test area, evaluation of damage scenarios and comparison with DPM-based method.
- Vulnerability analysis and damage scenarios for masonry buildings at the subregional and urban scale (historic centre of Taggia), using the method based on the *capacity-spectrum* approach. Comparison with the results of Task 3.

# 6. Traditional and innovative interventions for the damage mitigation

Responsible: Carlo Baggio

This task addresses to the definition of intervention for the seismic improvement, characterised by effectiveness and compatibility with the requirements of preservation, easily realisable also considering the constructive techniques of the buildings of Western Liguria. The result will be a *code of practice* organized by cards, that beyond describing with accuracy the design and operative aspects, will clearly bring to light the mechanical principles from which the improvement comes down.

Assuming various strategies of intervention in the two test-sites (for example through the systematic adoption in the buildings of the tie rods as a light intervention) it will be possible to upgrade with the new vulnerability models the damage scenario, verifying therefore in a direct way the result in terms of mitigation of the risk.

a) Results obtained at the end of the first-year activities

• Task 6 started at the beginning of the second year.

b) <u>Second-year activities</u>

- The research in the historical archives has put forward the finding of a technical code, issued with a Royal Decree on November 13, 1887, containing rules for the rebuilt and the repair of the damaged buildings; among the many recommendations, we mention: new buildings must be built on stable sites; public buildings (schools, hospitals, town halls) should be lower then 4 storey; in the churches, the basilica plan has to be preferred (vaults in the nave are forbidden); masonry vaults are allowed only in the basements; doors and windows should be far from the corners for, at least, 1.5 meters; the cuts in the masonry bearing walls (pipes, chimneys, etc.) should be made in such a way that doesn't compromise the stability. (RU2)
- Vulnerability analysis of a complex arrangement of building units resting on the hill slope in its full 3D reality, focusing on wall connections and on height of facades. Numerical analyses via ANSYS package were performed on

masonry assemblages, using "gap elements", which are able to model a 3D texture of blocks. First results show that collapse depends mainly on force orientation; angle interlocking of the two intersecting walls plays a minor role. (RU5)

- c) <u>Results obtained</u>
  - The 1887 seismic code, which collects the information about damages caused by the earthquake on Ligurian buildings, represents a starting point in order to develop a *code of practice* of interventions for the seismic improvement.
- d) Activities to be carried out in the third year
  - Individuation of traditional and innovative solutions for the seismic improvement, both with reference to the masonry buildings on the historic centres and to the churches. Development of models that verify the effectiveness of the above-mentioned interventions. (RU2-4-5-6-7)
  - Execution of experimental tests (shaking table) on reduced scale for some masonry assemblages. Experimental results will lead to propose methods for the vulnerability mitigation, by favouring the traditional ones. (RU5)
  - Development of a *code of practice* for interventions on Ligurian buildings. (RU4-5)
  - Development of virtual damage scenarios at the two scales (sub-regional and urban scale), by adopting different prevention strategies for the buildings (programmed maintenance, slight improvement for buildings of a given typology, interventions on the more vulnerable structures, etc.). Comparison between the damage scenarios and the present situation; cost-benefit analysis. (RU7)
  - Research concerning the compatibility of structural works with preservation of artistic assets. (RU8)
  - Definition of standard procedures to protect works of art after earthquake concerning: individuation of adapted places to collect mobile artistic assets from damaged buildings; protection of frescoes and stucco – works; compatibility of structural first works with conservation of works of art. (RU8)

#### 7. Automatic data management

Responsible: Vera Pessina

#### a) <u>Results obtained at the end of the first-year activities</u>

- The data available were collected and assembled in a GIS. They consist of the Liguria Region cartographic data, the ISTAT data of the 1991 population census, the regional 1:500.000 geologic map and the 1:10.000 map of Taggia, the offshore faults localization and the DEM (Digital Elevation Model) at 200x200m and 40x40m resolution. (RU3-7)
- It was checked the GIS availability, and it was proceeded in the standardisation of procedures for exchanging data between the two adopted GIS (ArcInfo and MapInfo). (RU3)

b) <u>Second-year activities</u>

• Two main purposes have introduced introduced a kind of methodological

progress in the information data management in a risk project: on one side, the need of upgrading the level of the available information and of promoting the knowledge reached in each task had lead to the creation of a CD containing homogenous and corrected data, that have to be sheared among the RU (data are accessible also from those RU that have no GIS skill, thanks to the ArcExplorer (freeware) software). On the other side, the structure of the GIS has been designed in order to satisfy the visibility requirements of the Liguria Project and its future dissemination. For these purposes, the activity dealt with the:

- upgrading of the organic collection of the layers (they were converted and formatted according to shapefile ArcView, ArcInfo and MapInfo format; the data were verified and metadata files were provided for each layer, after a carefully evaluation of the informative contents);
- designing the ArcView project structure; it has been designed in order to be directly accessible by CD and, in future, to be available for a larger group of users. Indeed, it was (1) customised as "kiosk application"; (2) the structure of the project was designed on the base of the available data, and (3) a friendly-user interface was created;
- collecting the data on a CD and decide, with the Project coordinator, the different level of distribution of the data (among the RU and/or to external users);
- defining the metadata contents (the level of precision, reliability and quality of the data layers) and to create the form for their collection. (RU3)
- c) <u>Results obtained</u>
  - Design of the CD containing all layers which are collected and elaborated. (RU3)
- d) <u>Activities to be carried out in the third year</u>
  - Distribution of the data CD to the RU, the collection of their opinions, critics and suggestions, and their involvement in the GIS structure design.
  - To ultimate the collection of the contents and the layers produced by the RU in the last phase of the project.
  - Assemblage of the metadata files, above all for those information that have to be widely distributed.
  - Exportation of the GIS structure in ArcIMS environment, for the Internet distribution of the data by a browser.

# Conclusions

The project is going on in accordance with the phases originally indicated, except for some unavoidable changes, which became necessary during the development of the work. The research wasn't limited to the application of well-established tools, but led, in some cases, to the statement of new methodologies and theoretical models, of scientific relevance.

In the third year a complete integration among the different tasks will be made, with the elaboration of the damage scenarios. The results of the project will be published on Internet and in a wide report; moreover, some short thematic reports are planned: hazard, vulnerability, code of practise for the interventions on the historical buildings, manual for the emergency management of the cultural heritage (monuments, artistic assets).

Finally, some events are foreseen, with the aim of presenting the results to the Civil Services and the people. In particular, we will organize a conference, with a popular tone, and a photographic exhibition on the historic, artistic and environmental heritage of the Western Liguria.



**Figure 1.** Examination of the data of the Western Liguria Project, with links to the views "Exposure", "Hazard" and "Damage", for the analyses at sub-regional and urban (Taggia) scales.



Figure 2. "Hazard" at urban scale (Taggia) and examination of some information on bore holes and geoelectric sections.