GRUPPO NAZIONALE PER LA DIFESA DAI TERREMOTI
FRAMEWORK PROGRAM 1999-2001
COORDINATED PROJECT PROPOSAL

1. RESEARCH AREA
THEME1 - EVALUATION OF THE SEISMIC RISK OF THE RESIDENTIAL PATRIMONY AT A NATIONAL SCALE **(Subthemes 1.1, 1.2, 1.3, 1.4, 1.5, 1.6)**

2. PROJECT TITLE
REVISION OF THE THEORETICAL AND OBSERVATIONAL GROUNDS OF THE SEISMIC HAZARD ESTIMATES AT A NATIONAL SCALE

3. PROJECT DURATION
3 YEARS

4. GENERAL INFORMATION ABOUT THE PROPONENT

4.1 SCIENTIFIC COORDINATOR OF THE PROJECT (Name, position, affiliation, address, telephone, fax, e-mail)

Gasperini Paolo
Position: Associate Professor
Affiliation: Dipartimento di Fisica, Università di Bologna
Address: Via Irnerio, 46, 40127 Bologna
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4.2 CURRICULUM VITAE OF THE COORDINATOR including the most relevant publications pertaining to the project (max 10; reprints must not be included) and his/her participation to other projects.

Curriculum Vitae of Paolo Gasperini

Born in Bologna on September, 2, 1954. He began his scientific activity on year 1973 as undergraduate collaborator of the Geodesy and Geophysics Institute of the University of Bologna.
On March, 26, 1982 he received his "Laurea" degree in Physics with a thesis on "Sinthetic seismograms generation for SH component and its use for the calculation of focal parameters".
On October, 1, 1982 he was hired as researcher at the Istituto Nazionale di Geofisica of Rome.
On November, 1, 1992 he was appointed as Associate Professor of Solid Earth Physics at the University of Florence (Italy), and put in charge of the course of Earth Physics for Geology students.
Since November, 1, 1995 he is Associate Professor of Solid Earth Physics at the University of Bologna, and is in charge of the course of Seismology for Geology and Physics students.
During the Academic Years 1993/94 e 1994/95 he held the course of Marine Geophysics for Environmental Sciences students of the Bologna University (subsidiary site of Ravenna).

Scientific Activity

He is author of more than 100 scientific papers, about a half of which on international journals. He has been or is holder of research contracts with the italian Ministry of Scientific and Technological Research (MURST), the italian National Research Council (CNR), and the Italian Space Agency (ASI). In the year 1997 he was coordinator of a project of the italian National Group for the Defence from Earthquakes (GNDT) for the unification of the historical catalogs and databases and in the 1998 for the reorganization of the instrumental catalog.

The main subjects of the scientific activity of Paolo Gasperini are:

Elaboration and interpretation of geodetic, topographic and photogrammetric observations.
Statistical analysis of seismicity and seismic precursors.
Statistical analysis and forecasting of volcanic eruptions.
Rheology of the Earth mantle and post-glacial rebound.
Numerical modeling of active tectonic processes.
Quantitative analysis of macroseismic data.

Participation to other projects

Italian Ministry of Scientific and Technological Research (Murst) year 1998
Italian National Research Council (GNDT) year 1998
Italian Space Agency year 1998

Most relevant publications pertaining to the project

Boschi E., Morelli A. and Gasperini P., A network of multi-sensor stations for continuous monitoring of ground motion and deformation, Phys. Earth Plan. Int., 84, 289-298, 1994.

Mulargia F. and Gasperini P., Evaluation of the applicability of the time- and slip-predictable earthquake recurrence models to Italian seismicity, Geophys. J. Int., 120, 453-473, 1994.

E. Boschi, G. Ferrari, P. Gasperini, E. Guidoboni, G. Smriglio and G. Valensise, Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980, I.N.G.-S.G.A, pp. 973, 1995.

CPTI Working Group (ING: E. Boschi, P. Gasperini, G. Valensise; GNDT: R. Camassi, V. Castelli, M. Stucchi, A. Rebez, G. Monachesi, M. S. Barbano, P. Albini; SGA: E. Guidoboni, G. Ferrari, D. Mariotti, A. Comastri; SSN: D. Molin), Catalogo Parametrico dei Terremoti Italiani, ING GNDT SGA SSN, Ed. Compositori, Bologna, pp. 92, 1999.

Ferrari G., Gasperini P. and Guidoboni E., Macroseismic intensity evaluation with the ``Fuzzy Sets Logic", Annali di Geofisica, 38, 811-826, 1995.

Boschi E., Gasperini P. and Mulargia F., Forecasting where larger crustal earthquakes are likely to occur in Italy in the near future, Bull. Seism. Soc. Am., 85, 1475-1482, 1995.

E. Boschi, E. Guidoboni, G. Ferrari, G. Valensise e P. Gasperini, Catalogo dei forti terremoti in Italia dal 461 a.C. al 1990 (2), I.N.G.-S.G.A, pp. 644, 1997.

Cianetti S., Gasperini P., Boccaletti M. and Giunchi C., Reproducing the velocity and stress fields in the Aegean region, Geophys. Res. Lett., 24, 2087-2090, 1997.

Gasperini P., Bernardini F., Valensise G. and Boschi E., Defining seismogenic sources from historical felt reports, Bull. Seism Soc. Am., 89, 94-110, 1999.

Vannucci G., Gasperini P., Ferrari G. and Guidoboni E., Encoding and computer analysis of macroseismic effects, Phys. and Chem. of the Earth, 24, 505-510, 1999.

4.3 LIST OF THE RESEARCH UNITS: Scientist Responsible, position, affiliation, total man/months dedicated to the Project by the personnel of each Research Unit.

Research unit UNIBO1

Scientist Responsible: Baldi Paolo
Position: Professore Ordinario
Affiliation: Università di Bologna
Total man months: 204

Research unit UNIBO2

Scientist Responsible: Bitelli Gabriele
Position: Professore Associato
Affiliation: Università di Bologna
Total man months: 83

Research unit ING1

Scientist Responsible: Valensise Gianluca
Position: Dirigente di Ricerca
Affiliation: Istituto Nazionale di Geofisica
Total man months: 110

Research unit ING2

Scientist Responsible: Riguzzi Federica
Position: Ricercatore
Affiliation: Istituto Nazionale di Geofisica
Total man months: 87

Research unit SGA

Scientist Responsible: Emanuela Guidoboni
Position: Ricercatore
Affiliation: SGA Storia Geofisica Ambiente
Total man months: 35

Research unit OGSM
Scientist Responsible: Monachesi Giancarlo
Position: Researcher
Affiliation: Osservatorio Geofisico Sperimentale di Macerata
Total man months: 69

The total man month amounts are inteded for the entire duration of the project (3 years)

4.4 INFORMATION ON INDIVIDUAL RESEARCH UNITS: Scientist Responsible, Institution, address, telephone, fax, e-mail, curriculum of the scientist responsible, name, position and affiliation of the participants, participation to other projects, man/months dedicated to the project, most relevant publications of the participants pertaining to the project (max 10 for each Research Unit; reprints must not be included).

Research unit UNIBO1

Scientific Responsible: Baldi Paolo
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Curriculum of Prof. Paolo Baldi

Paolo Baldi was born in Faenza (Italy) on July, 29, 1947. He received his degree in Physics at the University of Bologna; since 1987 he is Chair Professor of Geophysics.
The scientific career of Paolo Baldi has been focused on two main fields: Geodesy and Geophysics. In particular he is now involved in GPS measurements and data elaboration, analisys of crustal deformations in seismic areas, use of digital photogrammetry for monitoring at high spatial resolution the deformation processes of volcanic areas, gravimetric studies, tidal data analysis.

Name	**Position**	**Affiliation**	**Man month**
Achilli Vladimiro	Full Professor	Univ. Padova	3
Bacchetti Massimo	Technician	Univ. Bologna	3
Baldi Paolo	Full Professor	Univ. Bologna	9
Belardinelli Maria Elina	Researcher	Univ. Bologna	2
Bonafede Maurizio	Full Professor	Univ. Bologna	2
Carletti Francesca	Grant holder	Univ. Bologna	27
Casula Giuseppe	Researcher	ING	12
Castellaro Silvia	Phd Student	Univ. Bologna	3
Ciccotti Matteo	Phd Student	Univ. Bologna	3
Cianetti Spina	Phd Student	Univ. Parma	12
Dragoni Michele	Full Professor	Univ. Bologna	2
Gasperini Paolo	Associate Professor	Univ. Bologna	24
Gonzato Guido	Phd Student	Univ. Bologna	3
Guidi Cristiano	Technician	Univ. Bologna	3
Loddo Fabiana	Grant holder	ING	30
Marzocchi Warner	Associate Professor	Oss. Vesuviano	3
Menin Andrea	Technician	Univ. Padova	2
Mora Paolo	Technician	Univ. Bologna	3
Mulargia Francesco	Full Professor	Univ. Bologna	6
Pesci Arianna	Grant holder	ING	12
Rebez Alessandro	Researcher	OGS	6
Renner Gianfranco	Researcher	OGS	3
Salemi Giuseppe	Researcher	Univ. Udine	3
Serpelloni Enrico	Phd Student	Univ. Bologna	12
Targa Gabriele	Researcher	Univ. Padova	2
Vannucci Gianfranco	Phd Student	Univ. Camerino	12
Vettore Antonio	Associate Professor	Univ. Padova	2

The man month amounts are inteded for the entire duration of the project (3 years)

Most relevant publications of the participants pertaining to the project

Mulargia F., Achilli V., Broccio F., Baldi P., 1991. Is a destructive earthquake imminent in southeastern Sicily?. Tectonophysics, 188, 399-402.

Achilli V., Anzidei M., Baldi P., Marsella M.,Salemi G., 1993. The TYRGEONET Project. Proceedings of the Symposium on "Permanent Satellite Tracking Networks For Geodesy And Geodynamics", IAG Vienna Aug 16, 1991., Springer Verlag.

Mulargia F. and Gasperini P., Evaluation of the applicability of the time- and slip-predictable earthquake recurrence models to Italian seismicity, Geophys. J. Int., 120, 453-473, 1994.

Boschi E., Gasperini P. and Mulargia F., Forecasting where larger crustal earthquakes are likely to occur in Italy in the near future, Bull. Seism. Soc. Am., 85, 1475-1482, 1995.

Anzidei M., Baldi P., Bonini C., Casula G., Gandolfi S., Riguzzi F., 1997. GPS surveys across the Messina Straits (Southern Italy) and comparison with terrestrial geodetic data. Journal of Geodynamics, Vol.25, 2,85-97.

Anzidei M., Baldi P., Casula G., Galvani A., Kahlouche S., Pesci A., Riguzzi F., Saadi N., Touam S., Zanutta A. (1999) : First GPS measurements across the Central - Western Mediterranean area. Annali di Geofisica, Vol.42, 1, 115-121.

Ciccotti M., Negri N., Sasi L., Gonzato G. e Mulargia F., Elastic and fracture parameters of Etna, Stromboli and Vulcano lava rocks, in corso di stampa su J. Volc. Geoth. Res., 1999.

Gasperini P., Bernardini F., Valensise G. and Boschi E., Defining seismogenic sources from historical felt reports, Bull. Seism Soc. Am., 89, 94-110, 1999.

CPTI Working Group (ING: E. Boschi, P. Gasperini, G. Valensise; GNDT: R. Camassi, V. Castelli, M. Stucchi, A. Rebez, G. Monachesi, M. S. Barbano, P. Albini; SGA: E. Guidoboni, G. Ferrari, D. Mariotti, A. Comastri; SSN: D. Molin), Catalogo Parametrico dei Terremoti Italiani, ING GNDT SGA SSN, Ed. Compositori, Bologna, pp. 92, 1999.

Belardinelli M. E., Cocco M., Coutant F. and Cotton M., Redistribution of dynamic stress during coseismic ruptures: Evidence for fault interaction and earthquake triggering, J. Geophys. Res., 104, 14,925-14,945, 1999.

Scientist responsible of the Research Unit **Director of the Institution**

Research unit UNIBO2

Scientific Responsible: Bitelli Gabriele
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Curriculum Vitae of Gabriele Bitelli

Born in Bologna, April 14, 1957, he got a degree in Electronics Engineering from Bologna University. Currently Associate Professor in Photogrammetry at Bologna University, DISTART Department, Engineering Faculty.
The research activity is related to several fields of Geomatica: GPS, topographic surveying, aerial and close-range photogrammetry surveying, Geographical Information Systems for environmental applications.
He developed and realized a large number of surveying activities, in particular GPS and leveling networks for deformation monitoring (e.g. subsidence in Emilia Romagna region or in Ravenna area).
He is author or co-author of about 75 publications and presentations in national and international Symposia.

Name	**Position**	**Affiliation**	**Man month**
Bitelli Gabriele	Associate Professor	Univ. Bologna	9
Camassi Romano	Researcher	Univ. Bologna(GNDT)	12
Ercolani Emanuela	Grant holder	Univ. Bologna(GNDT)	27
Gandolfi Stefano	Grant holder	ING	6
Sarti Pierguido	Phd student	Univ. Bologna	6
Unguendoli Marco	Full Professor	Univ. Bologna	8
Vittuari Luca	Technician	Univ. Bologna	9
Zanutta Antonio	Phd student	Univ. Bologna	6

The man month amounts are inteded for the entire duration of the project (3 years)

Participation to other projects

GNDT PE98 Progetti 6.a.2 e 5.1.1
Progetto Finalizzato CNR Beni Culturali
Progetto di ricerca MURST ex40% 1998
PNRA - Progetto Nazionale di Ricerche in Antartide

Most relevant publications of the participants pertaining to the project

Unguendoli M.: “A rational approach to the use of a large number of GPS receivers”. Bulletin Geodesique, 64, 1990.

Bitelli G., A. Capra, D. Dominici, G. Folloni, F. Radicioni, M. Unguendoli, L. Vittuari: "GPS measurements for ground subsidence monitoring and geoid computation in the Ravenna area". Proceedings XX FIG Congress, Melbourne, pp. 30-39, 1994.

D. Dominici, F. Radicioni, A. Stoppini e M. Unguendoli: “Precision and Reliability versus surplus measurements in GPS networks”, Bollettino di Geodesia e Scienze Affini, 4, 1995.

Bitelli G., Camassi R.: "GIS data management and analysis in historical seismology". Reports on Surveying and Geodesy, M. Unguendoli ed., Nautilus, Bologna, pp. 146-158, 1996.

Bitelli G., Bonsignore F., Unguendoli M.: "Progetto di una rete per il controllo della subsidenza nella Regione Emilia Romagna ". Atti 1a Conferenza Nazionale ASITA, pp. 117-130, Parma, 1997.

O. Al-Bayari, M. Unguendoli: “Experiences in GPS control networks computation”. Proceedings 5th Bilateral Meeting Poland-Italy, Monselice, 1997.

Camassi R. e Stucchi M.: “NT4.1: un catalogo parametrico di terremoti di area italiana al di sopra della soglia del danno”. Milano, 93 pp., 1997.

Bitelli G., Camassi R., Cova E.: "Virtual Reality and GIS applications for earthquake damage representation: the case of the Earthquakes of September and October 1997 in Umbria-Marche (Central Italy)". Proceedings International Conference on GIS for Earth Science Applications, Ljubljana, 1998.

Camassi R., Castelli V., Molin D., Monachesi G. e Stucchi M.: “Principali terremoti storici dell'area umbro-marchigiana maggiormente interessata dagli eventi sismici di settembre-ottobre 1997”. Ingegneria Sismica, XV, 1, 45-48, 1998.

CPTI Working Group (ING: E. Boschi, P. Gasperini, G. Valensise; GNDT: R. Camassi, V. Castelli, M. Stucchi, A. Rebez, G. Monachesi, M. S. Barbano, P. Albini; SGA: E. Guidoboni, G. Ferrari, D. Mariotti, A. Comastri; SSN: D. Molin), Catalogo Parametrico dei Terremoti Italiani, ING GNDT SGA SSN, Ed. Compositori, Bologna, pp. 92, 1999.

Scientist responsible of the Research Unit **Director of the Institution**

Research unit ING2

Scientific Responsible: Valensise Gianluca
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Curriculum of Dr. Gianluca Valensise

Gianluca Valensise was born in Rome on 27 December 1958. First degree in Geological Sciences at University of Rome, La Sapienza (7.20.1982). Doctorate in Earth Sciences/Geophisics at University of Rome, La Sapienza (9.1.1987). Presently "Dirigente di Ricerca" (Senior Scientist) and member of the Board of Directors at Istituto Nazionale di Geofisica of Rome, branch of Seismology and Physics of the Earth Interior.
His research activity deals essentially with the investigation of large seismogenic sources using historical and geological information. Since 1996 has been in charge of coordinating ING research efforts in historical seismology. Co-author of the Catalogo dei Forti Terremoti in Italia and of the Catalogo Parametrico dei Terremoti Italiani. He is in charge of an ING project aimed at the creation of a "*Database of potential sources for earthquakes larger than magnitude 5.5 in Italy*", the first version of which will be published in the year 2000. Since February 1997 he has been in charge of coordinating the section "Active Tectonics and Paleoseismicity" of the ING. Coauthor of the National Seismic Risk Maps of Italy commissioned by the Department for Civil Defence in 1996. Has been a member of the "Group of Experts for the Compilation of the National Seismic Codes" installed by the Department for Civil Defence in 1997. Finally, he coordinates the ING participation in an EC project named "Faust" and devoted (1) to the compilation of a homogeneous database of European seismogenic sources, and (2) to the assessment of the impact of innovative strategies for the estimation of seismic hazard.

Name	**Position**	**Affiliation**	**Man month**
Basili Roberto	Grant holder	ING	18
Bordoni Paola	Grant holder	ING	18
Burrato Pierfrancesco	Researcher	ING	6
Casale Paolo	Technician	ING	6
D'Addezio Giuliana	Researcher	ING	6
Di Stefano Giuseppe	Researcher	ING	3
Di Giovambattista Rita	Researcher	ING	3
Ekström Goran	Full-Professor	Harvard University	2
Giunchi Carlo	Researcher	ING	3
Mazza Salvatore	First Researcher	ING	3
Mele Giuliana	Researcher	ING	6
Morelli Andrea	Research Director	ING	6
Pondrelli Silvia	Researcher	ING	6
Piromallo Claudia	Researcher	ING	6
Romeo Giovanni	Research Director	ING	3
Taccetti Quintilio	Research Director	ING	3
Valensise Gianluca	Research Director	ING	12

The man month amounts are inteded for the entire duration of the project (3 years)

Most relevant publications of the participants pertaining to the project

Basili, R., V. Bosi, F. Galadini, P. Galli, M. Meghraoui, P. Messina, M. Moro, and A. Sposato. The Colfiorito earthquake sequence of September-October 1997: surface breaks and seismotectonic implications for the central Apennines (Italy). J. Earthquake Eng., 2, 291-302, 1998

CPTI Working Group (ING: E. Boschi, P. Gasperini, G. Valensise; GNDT: R. Camassi, V. Castelli, M. Stucchi, A. Rebez, G. Monachesi, M. S. Barbano, P. Albini; SGA: E. Guidoboni, G. Ferrari, D. Mariotti, A. Comastri; SSN: D. Molin), Catalogo Parametrico dei Terremoti Italiani, ING GNDT SGA SSN, Ed. Compositori, Bologna, pp. 92, 1999.

Di Giovambattista, R., e Yu. S. Tyupkin. The fine structure of the dynamics of seismicity before m>= 4.5 earthquakes in the area of Reggio Emilia (Northern Italy). Annali di Geofisica, 42, 1999.

Ekström, G., A. Morelli, E. Boschi e A. M. Dziewonski. Moment tensor analysis of the central Italy earthquake sequence of September-October 1997. Geophys. Res. Lett. Vol. 25 , No. 11 , 1971-1974, 1998.

Gasperini, P., F. Bernardini, G. Valensise e E. Boschi (1999). Defining seismogenic sources from historical earthquake felt reports, Bull. Seism. Soc. Am., 89, 94-110.

Gruppo di Lavoro Riclassificazione Sismica del territorio nazionale (UniRM1: C. Gavarini, P. Pinto, L. Decanini; SSN: G. Di Pasquale, A. Pugliese, R. Romeo, F. Sabetta, F. Bramerini; UniPz: M. Dolce; PoliMi: V. Petrini, A. Castellani; ANPA: T. Sanò; OGS: D. Slejko; ING: G. Valensise. Proposta di riclassificazione sismica del territorio nazionale. Ingegneria Sismica, 1, 5-14, 1999.

Pantosti, D., D. P. Schwartz e G. Valensise (1993). Paleoseismology along the 1980 Irpinia earthquake fault and implications for earthquake recurrence in the southern Apennines, J. Geophys. Res., 98, 6561-6577.

Peruzza, L., D. Pantosti, D. Slejko e G. Valensise. Testing a new hybrid approach to seismic hazard assessment: an application to the Calabrian Arc (southern Italy). Natural Hazards, 14, 113-126, 1997.

Piromallo, C., and A. Morelli. Imaging the Mediterranean upper mantle by P-wave travel time tomography. Annali di Geofisica, XL, 963-979, 1997.

Piromallo, C., and A. Morelli. P-wave propagation heterogeneity and earthquake location in the Mediterranean region. Geophys. J. Int., 135, 232-254, 1998.

Scientist responsible of the Research Unit **Director of the Institution**

Research unit ING2

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Curriculum of Dr. Federica Riguzzi

Federica Riguzzi was born in Rome (Italy) on June 12, 1958. She received her degree in Physics at the University La Sapienza of Rome. Since 1987 she is researcher at Istituto Nazionale di Geofisica of Rome.
The scientific activity of Federica Riguzzi is twofold, both in Geophysics and in Geodesy. In particular she cooperated with many Italian and foreign Institutions and Agencies to develop and analyze GPS networks devoted to geodynamical and geodetic researches. At present she is involved in GPS measurements and analysis, displacement field and strain tensor estimation in tectonically active areas. Since 1997 she is a member of the Scientific Council of the International Geoid Service (IAG).

Name	Position	Affiliation	Man month
Anzidei Marco	First Researcher	ING	9
Borgstrom Sven	Technician	Oss. Vesuviano	6
Del Mese Sergio	Technician	ING	6
Del Gaudio Carlo	Researcher	Oss. Vesuviano	6
De Martino Prospero	Technician	Oss. Vesuviano	6
Galvani Alessandro	Grant holder	ING	9
Massucci Angelo	Technician	ING	6
Ricciardi Giovanni	Researcher	Oss. Vesuviano	6
Ricco Ciro	Researcher	Oss. Vesuviano	6
Riguzzi Federica	Researcher	ING	6
Sepe Enzo	Technician	Oss. Vesuviano	6
Tertulliani Andrea	Researcher	ING	9
Vecchi Maurizio	Technician	ING	6

The man month amounts are inteded for the entire duration of the project (3 years)

Most relevant publications of the participants pertaining to the project

Anzidei M., P. Baldi, G. Casula, M. Crespi, F. Riguzzi (1996). Repeated GPS Surveys across the Ionian sea: evidence of crustal deformations, Geophys. J. Int., 127, pp. 257-267.

Anzidei M., P. Baldi, G. Casula, S. Pondrelli, F. Riguzzi, A. Zanutta (1997). Geodetic and seismological investigation in the Ionian area, Annali di Geofisica, XL, 5, pp. 1007-1017B.

Anzidei M., P. Baldi, G. Casula, A. Galvani, F. Riguzzi, A. Zanutta (1998). Evidence of active crustal deformation of the Colli Albani volcanic area (central Italy) by GPS surveys, J. of Volc. and Geoth. Research, 80, 1-2, pp. 55-65.

Betti B., L. Biagi, M. Crespi and F. Riguzzi (1999). GPS sensitivity analysis applied to non permanant GPS control networks. Journal of Geodesy, 73, 158-167.

Crespi M., F. Riguzzi (1998). Software Package Available for Analyzing GPS Deformation Part II, EOS Electronic Supplement, June 3, http://www.agu.org/eos_elec/98059e.html.

De Rubeis V., C. Gasparini, A. Maramai, M. Murru, A. Tertulliani (1992). The uncertainty and ambiguity of isoseismal maps, Earthquake Engineering and Structural Dynamics, 21, 509-523.

Hunstad I., M. Anzidei, M. Cocco, P. Baldi, A. Galvani, A. Pesci(1999). Modelling coseismic displacements during the 1997 Umbria - Marche earthquake (Central Italy), Geophysical Journal International, (in corso di stampa).

Riguzzi F., A. Zanutta (1998). Displacement field for the Italian area from GPS permanent stations. Annali di Geofisica, vol. 41, 2, pp. 233-240.

Stramondo S., M. Tesauro, P. Briole, E. Sansosti, S. Salvi, R. Lanari, M. Anzidei, P. Baldi, G. Fornaro, A. Avallone, M.F. Buongiorno, G. Franceschetti, E. Boschi (1999). The September 26,1997 Central Italy earthquakes: coseismic surface displacement detected by SAR interferometry and GPS, and fault modeling. Geophysical Research Letters, 26, 883-886.

Tertulliani A. (1999). Site effects as inferred from damage severity observation. Geophysical Research Letters, 26, 1989-1992.

Scientist responsible of the Research Unit **Director of the Institution**

Research unit SGA

Scientific Responsibile: Emanuela Guidoboni
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Curriculum of the scientific responsible

Emanuela Guidoboni trained as a medieval historian ("laurea"degree *cum laude* at Bologna University) and initially carried out research in medieval economic history in the Department of Economic History at Bologna (1973-77). Her research career in historical seismology began in 1979, her particular contribution lying in the systematic and specific application of historical data to seismological knowledge, in order to establish both the seismic characteristics of particular areas and regions, and the effects of earthquakes on ancient buildings. The application of this new method led to publications and technical reports which have helped to improve our understanding of the seismicity of Italy and the Mediterranean area.
Since 1983 she has been responsible for numerous research projects at a national level concerning the analysis of historical seismic activity, firstly for ENEA (a study of major seismic events in northern Italy), later for ENEL (the planning and co-ordination of a macroseismic analysis of six nuclear sites), since 1988 for the Istituto Nazionale di Geofisica (*I Terremoti prima del Mille* [Earthquakes before the year 1000], and the *Catalogo dei Forti Terremoti* [Catalogue of Strong Earthquakes]), and since 1997 for the Servizio Sismico Nazionale (the Arianna project). She is also an adviser to the *International Atomic Energy Agency, ONU* (Morocco and Armenia), and has conducted courses in historical seismology at the Universities of Bologna and Reggio Calabria, as well as giving lectures and holding seminars at various research centres and universities outside Italy. She has published 87 scholarly articles and some books.
She is also President of the SGA in Bologna - a research body specialising in the study of historical earthquakes and environmental disasters of natural origin.

Participations to other projects

ING Analisi temporale delle principali sequenze sismiche storiche in Italia 70.000.000
ING Indagini storiche in aree con gaps sismici (Valtiberina) 80.000.000
ING Catalogo dei Forti Terremoti in Italia, 3 Aggiornamento e integrazione dei dati della precedente versione 2.1 del 1998 30.000.000

Name	**Position**	**Affiliation**	**Man month**
Guidoboni Emanuela	Research Director	SGA	4
Ferrari Graziano	Research Director	SGA	3
Mariotti Dante	Researcher	SGA	6
Comastri Alberto	Researcher	SGA	6
Ciuccarelli Cecilia	Researcher	SGA	6
Righini Claudio	Technician	SGA	6
Bianchi M.Giovanna	Technician	SGA	4

The man month amounts are inteded for the entire duration of the project (3 years)

Most relevant publications of the participants pertaining to the project

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Scientist responsible of the Research Unit **Director of the Institution**

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Curriculum of Dr. Giancarlo Monachesi

Born in Macerata (MC), 21/02/1955, University degree (BA, Geology) from Camerino University, 1979. Researcher at Osservatorio Geofisico Sperimentale of Macerata (OGSM) from 1979. Scientist Responsible of the OGSM "Seismology" Research Area from 1984. As a partner in the research programmes run jointly by GNDT/CNR and Regione Marche for the mitigation of seismic hazard on a regional scale, carried out studies on historical seismicity and the macroseismic surveys of relevant Umbro-Marchesan earthquakes occurred from 1979 onwards. Scientist responsible of research projects funded by GNDT and by the regional administrations of the Marches and Abruzzo. In the frame of the GNDT triennial plans has participated to the development of the NT and CPTI99 national seismic catalogues and been co-author of the macroseismic observations database DOM4.1.
Current responsibilities: co-responsible of the GNDT Sub-project 5.1.3 "Instrumental earthquake catalogue 1981-1996"; coordinator of the Marchesan Sismometric Network, which monitors the regional territory through 16 digital stations. Author or co-author of many scientific publications printed in international and national magazines. Main research interests:
historical and recent earthquake data collection;
problems of the organization and interpretation of earthquake data in terms of macroseismic intensity assessment;
collection and interpretation of RSM seismometric data for the seismogenic characterization of the regional territory;
measurement of local amplification effects;
multimedial informative campaigns on seismic hazard mitigation.

Name	**Position**	**Affiliation**	**Man month**
Castelli Viviana	Researcher	OGSM (Art 23 GNDT)	15
Coppari Henry	Technician	OGSM (Art 23 GNDT)	15
Frapiccini Massimo	Technician	OGSM	9
Monachesi Giancarlo	Researcher	OGSM	12
Parolai Stefano	Researcher	OGSM	18

The man month amounts are inteded for the entire duration of the project (3 years)

Participations to other projects

The OGSM is now participating, on the basis of an agreemen between GNDT/CNR and Marche Region administration, to activities of detailed seismic microzoning of four marchesan localities.
In the framework of an agreement with the italian National Seismic Service and Marche Region it is also managing the seismic monitoring of the regional territory.
Aside from the present project, OGSM participate to the following proposals
Theme 1 “Probabilistic and deterministic seismic hazard estimates and their calibration with macroseismic and instrumental data”
Theme 4: “EDU-RISK Earthquake education: a journey for seismic Risk reduction”

Most relevant publications of the participants pertaining to the project

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Scientist responsible of the Research Unit **Director of the Institution**

5. DESCRIPTION OF THE PROJECT

5.1 OBJECTIVE OF THE PROJECT (max 20 rows)

This project aims at re-assessing the seismic hazard at national scale through the systematic revision of the input data and using innovative methodolgies. We will reconsider all the data used in previous efforts in view of recent results showing that such data may not be suitable for reliable hazard assessment due to a combination of inaccuracies in their determination, systematic errors, and methodological flaws in their original definition. We will derive information on the stress and strain field from the analysis of earthquakes focal mechanisms and from specifically planned GPS campaigns. Special emphasis will be devoted to i) the definition of a homogeneous criterion for re-assessing the magnitude of all the earthquakes of the historical and instrumental catalogues; ii) the 3-D location of the main seismogenic sources; iii) the 2-D definition (3-D when possible) of the attenuation of earthquake intensity and of the spectral amplitude of seismic acceleration, velocity and displacement; and iv) the definition of the stress and strain fields for the whole country. We will also devise innovative strategies for the assessment of seismic hazard. The new approach will take advantage of all available data concerning the tectonic and geodynamic framework, the stress and strain fields, the location, expected dynamic behavior, and statistical properties of all seismogenic sources. The hazard models will be designed to incorporate the results of numerical models of the tectonic evolution of the area. Finally, we will integrate the resulting hazard estimates with comparative studies of earthquake damage in relation with the mechanical and geometrical properties of the site.

5.2 STATE OF THE ART (max 2 pages)

The assessment of seismic hazard in Italy has been traditionally approached both by standard statistical methods (Cornell, 1968) and by an hybrid approach (Grandori et al. 1984) which includes time-dependent estimates. Since its first formulation, however, the latter has not generated an adequate consensus within the national and international scientific community and has not been used for the computations that led to the most recent seismic hazard maps of Italy (Slejko, 1996; Romeo and Pugliese, 1997). A third scheme, which was referred to as “deterministic” by its authors (Panza et al., 1999), does not return true hazard estimates since it involves the computation of the maximum expected ground motion without taking into account the effective probability of earthquakes in the different areas.

Among the various approaches to the assessment of seismic hazard developed in the rest of the world in recent years, the ones designed by the Working Group of California Earthquakes Probabilities (WGCEP; 1988, 1990, 1992, 1995), by Ward (1994) and by Frankel et al. (1996) appear to us to be the most complete and receptive to the strong increase of geophysical knowledge that was recorded during the past decade. These are multidisciplinary models that consistently combine all the available observations from seismology, geodesy and geology for a certain area to evaluate time-dependent probabilities of a fixed level of ground shaking to be exceeded. Geological and paleoseismological data are used by these models respectively to locate surface-breaking seismogenic sources and constrain their rate of slip, while geodesy supplies global strain rates in areas characterized by blind faulting or distributed deformation. It should be recalled that Italy is characterized by several areas of this kind, such as the Po Plain, the Adriatic margin of the Apennines and most of the Calabrian Arc, as demonstrated by the difficulty of detecting seismogenic sources in these regions.

In contrast with California, where different types of space-based geodetic measurements have performed for at least a decade to monitor well-identified faults (Feigl et al., 1993), the availability of such data in Italy is limited. In particular it has been already demonstrated (Achilli et al., 1994) that the repetition of measurements along the national Italian trilateration network established in the late 1800s cannot supply a reliable estimate of the strain field, due to the combination of inherent uncertainties with the limited expected strain rates (1 to 10 mm/y on the basis of historical seismic release rates). More recent data from GPS measurements on networks located in seismic areas (Mulargia et al., 1991; Anzidei et al., 1995, 1997, 1998; Stramondo et al, 1999) or at regional scale with relatively large meshes (station spacing >100 km) are indeed available, but unfortunately such networks were not specifically designed for earthquake hazard studies (Achilli et al, 1993, 1995; Anzidei et al., 1996, 1999). Paleoseismological investigations of Italian faults are also rather limited: reliable recurrence parameters exist for not more than ten faults, mainly located in the central and southern Apennines.

Nevertheless these estimates, and particularly the average slip rate, can be certainly extrapolated to neighboring sources. The present capacity of identification of seismogenic sources from geological and geomorphological data is also limited due to the combination of relatively slow tectonic deformation and complexity of the geologic fabric and a landscape, which is still dominated by the Miocene-Pliocene compressional events.

Fortunately, Italy can count on much more abundant and accurate information on historical seismicity than, for example, the United States or Greece. The wealth of homogeneously collected historical earthquake data encouraged several workers to derive tectonic information from intensity data alone. In particular Gasperini et al. (1999) developed a method for deriving intensity-based seismogenic sources than can then be compared with their geologic counterparts and subsequently incorporated into hazard assessment schemes. This technique provided a very coherent image of the spatial distribution of the main seismogenic sources of Italy, which appear to concentrate in a relatively narrow (30-50 km) band along the Apennines and along a few other well-identified trends, and effectively balances out the lack for direct evidence of active faulting that characterizes Italy with respect to other tectonically active countries.

The state-of-the-art in historical seismicity is the recently published "Parametric Catalogue of Italian Earthquakes" (hereinafter referred to as CPTI: compiled by CPTI Working Group, 1999), which represents the first step in a process of integration of the historical databases produced by ING and SGA (Boschi et al., 1995b, 1997, 1999) and by GNDT (Camassi and Stucchi, 1997, 1998; Monachesi and Stucchi, 1997). Due to the nature of the Italian territory and seismicity both these databases used the traditional MCS scale to estimate earthquake intensities, but for the purpose of accurate hazard assessment it would be appropriate to proceed to their re-evaluation using modern international scales such as the EMS (Grünthal et al., 1998) or by innovative approaches such as those recently developed by Ferrari et al. (1995) and Vannucci et al. (1999).

The high quality and completeness of macroseismic studies in Italy also allowed the assessment of seismic hazard to be approached by analyzing statistically the occurrence of intensity felt reports at specific sites (Magri et al., 1994; Guidoboni e Ferrari, 1995), which normally correspond with large cities or cultural centers where large archives are located. Although only in very few cases the research was specifically designed to obtain statistically complete information (for example for Florence, Bologna, Siena and Fabriano), significant developments can be expected in this area of research from carefully targeted historical studies.

Before applying time-dependent seismic hazard models on well characterized areas (for example Type A or B on the WGCEP classification) it is important to consider recent works (Mulargia e Gasperini, 1995, Boschi et al., 1995a) which have shown that the observed earthquake distribution in most of the Italian seismogenic areas is not compatible with standard slip- and time-predictable models. In contrast, in these areas the seismicity appears to follow simpler statistical distributions of inter-event times like the gaussian (characteristic) and poissonian models. In areas for which information on earthquake recurrence and strain rates cannot be easily obtained (Type C of WGCEP classification) the only way of assessing seismic hazard is by a statistical approach whose "ingredients" are a seismic catalog, a seismogenic zonation and a set of attenuation laws.

Aside from the already mentioned CPTI, important results have been recently achieved in the area of earthquake catalogues, particularly concerning the exact location and the magnitude estimation for earthquakes recorded instrumentally in the past two decades. A complete reorganization of these data for the period 1981-1996 was performed in the framework of a joint project ING/GNDT (Monachesi e Gasperini, 1999). The operation returned a catalogue of substantially higher quality with respect to that previously available. The reorganization effort included: i) integration and homogenization into the catalogue of seismic arrivals at the Italian National Seismic Network (RSN) of ING, at the most important regional networks (Friuli, Umbria-Marche and Calabria networks plus the Genoa University network, which covers Liguria and part of Piedmont), ii) the computation of a set of one-dimensional velocity models for different areas, iii) the relocation of earthquakes with up-to-date software, iv) a more homogeneous and consistent magnitude estimate obtained by fitting new duration and amplitude magnitude relations using available Wood-Anderson (WA) and Synthetic Wood-Anderson (SWA) data. Deviations in the order of 0.5-1.0 units with respect to original magnitudes were found in the process, yet the new estimates are still not fully satisfying due to the lack of a sufficiently reliable and homogeneous reference magnitude dataset.

The problem of the inconsistency of magnitude estimates also concerns the time interval prior to 1980, for which the reference study is the work by Margottini et al. (1993). Comparisons based on the CPTI catalogue showed that the Ms magnitudes reported by Margottini et al. (1993) are not homogeneous with time. In particular there exists a bias of about 0.4-0.5 units (average) among Ms magnitudes

computed before 1964 (presumably based on recordings from mechanical instruments: Wiechert, Milne or others) and after 1964 (based on recordings of long-period instruments of the WWSSN network) which is clearly stressed by the comparison with epicentral intensity. This is in agreement with the recent results of Perez (1998), who showed an abrupt decrease of the slope of the cumulative plot of the number of world earthquakes in the Ms interval 6-7 after 1964 that can simply be interpreted as due to systematic underestimation by 0.5 magnitude units after that date (which corresponds to the inception of the WWSSN network). It is indeed of fundamental importance to find out the reasons of such discrepancy and correct it, also because it may have induced a systematic bias in the attenuation laws commonly used for the Italian territory (Sabetta e Pugliese, 1987), which in turn would then require a new calibration in terms of homogeneous magnitude (Heaton et al., 1986).
Concerning the seismic zonation, it should be recalled that the most recent elaboration by the GNDT (ZS.4 by Scandone et al., 1996) still lacks an adequate scientific justification and documentation and therefore its use for hazard estimates is arguable. The recent developments in the field of the definition of seismogenic sources from intensity data (Gasperini et al., 1999), detection of individual seismogenic structures using geological methods (Valensise e Pantosti, 1999), analysis of the stress field from focal mechanisms (Ekström et al., 1998), relocation of instrumental earthquakes (Monachesi e Gasperini, 1999), and numerical modeling of the kinematic and dynamic field of the Italian area will soon make it possible to describe the main earthquake sources and derive a new model of seismic zonation more tightly constrained by geological, seismological and geodetic observations.

5.3 DESCRIPTION OF THE RESEARCH (max 3 pages)

In the community of research on *seismic risk* in Italy, *seismic hazard* is considered by some to be only a propaedeutical stage to the estimation of risk. This point of view is hardly shared by scientists of many other earthquake-prone countries (as for example the United States), where the assessment of seismic hazard is the fundamental objective upon which planning and legislative decisions can be based. As demonstrated also by the recent experience of the Italian Working Group for Seismic Classification (Gavarini et al., 1999), the only data that can be taken into account to this end are the various forms and representations of the hazard maps.
To concentrate the efforts and the activities of the present working group on the problems of assessing the seismic hazard we therefore decided that our project will not cover the subthemes of the Framework Program which refer to the definition of building vulnerability and expected losses at national scale. We believe that these important parameters will be better estimated at a later stage by the qualified technical bodies (e.g., National Seismic Agency) based on the results of the present project and on the available statistical data.
Our project aims at improving the available basic data and the relevant schemes of analysis in a number of areas of research that contribute to the assessment of seismic hazard at the national scale. Each of these areas will form the ground for the activity of a specific group of experts gathered in a *Task* and led by a *Task Coordinator*. We anticipate that the interaction among scientists grouped in different tasks will benefit from a network of linked Web pages that will be managed by each group and by the *Project Coordinator*. These pages will make available on-line to selected groups of potential users the most recent version of the data, the scientific reports, the intermediate accomplishments, such that the results of each group will be promptly transferred to all project partners. The project Web-site will also be used to disseminate selected previews of the results that will be considered of interest for a wider scientific audience.
The essential philosophy of the project is to blend selected expertise from distant disciplines with the aim of (1) defining more accurately the information upon which traditional hazard estimates are based (space-time characteristics of seismicity, attenuation of seismic energy), (2) defining new datasets and implementing new strategies for obtaining innovative hazard estimates (location of seismogenic sources, geodetically and geologically determined deformation rates), and (3) developing innovative hazard models at national scale.
Following is a brief description of the main goals of each of the project tasks. The reader may refer to Section 5.4 for an in-depth description of the various aspects of the project and for organization details.

Task 1A - HISTORICAL EARTHQUAKE CATALOGUE

The goal of this task is to develop a set of methodologies for the investigation and for the analysis of historical data to be shared by the various groups. The new methodologies should help improving the Parametric Catalogue of Italian Earthquakes (CPTIWG, 1999) by testing strategies aimed at merging

more effectively the two databases on which this catalogue is based. We will update the CPTI 1999 by analyzing about ten earthquakes selected among those (1) with epicentral intensity ≥ IX, (2) that in both databases appear at a preliminary level of investigation, and (3) for which the two databases propose divergent parameters. We will then re-examine the relevant historical data, with special emphasis on open questions due the limited quality of the historical dataset or to divergent interpretations of the same historical information. New investigations will be performed only if consensus arises about the need for acquiring additional elements for the interpretation. In this framework we will test the effectiveness of the EMS 98 scale on historical earthquakes. New investigations will be planned only for poorly known destructive earthquakes or for events that are crucial for the assessment of regional seismic hazard, and only when the additional effort will definitely improved the understanding of the distribution of the effects of the given event.

Task 1B -TEST OF THE HIGHEST REPORTED LOCAL INTENSITIES

The goal of this task is to develop an efficient tool for reducing the possibility of significant over- or under-estimations in the assessment of intensity at the highest shaking levels and for understanding the reasons for important discrepancies that still exist between the two databases (CFT and DOM). Such over- and under-estimations may have a substantial impact in the assessment of hazard at the local scale. The intensity level selected as the lower threshold for this cross-check is VIII-IX because we believe that at this stage it is necessary to improve at least this portion of the whole available dataset. Close-up analyses of real urban structures and well understood earthquake damage scenarios highlight the complexity of such estimates. The extensive presence of monuments, important historical buildings and valuable civil buildings, which is common in Italian cities, stresses the need for well calibrated schemes of analysis of destructive earthquake effects shared by the all the operators involved.

Task 1C - SITE TIME HISTORIES

Historical investigations of variable depth will be carried out to improve and omogenise from the quantitative and qualitative viewpoints the historical series of earthquake effects available for a sample of sites comprising around 20 localities chosen for their demographic, economic, artistic or cultural relevance. Types of investigation will range from the expedite re-examination of existing studies and investigated sources, aiming to the production of omogeneous studies for each test-site, to new systematic researches aiming to the finding out of new, still untapped sources of earthquake information on each test-site. A similar experiment will be carried out for the 5 "silent" areas identified in Italy by ING, through the creation of a thicker-meshed network of test-sites on a sub-regional scale.

Task 2A - INSTRUMENTAL SEISMIC CATALOG

Some of the points that were not completed by the previous projects will be faced up. In particular: i) the integration of the data, partially not yes available on computer media, coming from some other important local networks (Osservatorio Vesuviano, Istituto Internazionale di Vulcanologia, ENEL, ENEA etc.), ii) the determination of three-dimensional velocity models and their use for the precise localization of earthquakes, iii) the control, through the teleseismic phases of the correct polarity, the amplification and the synchronization of the seismic stations, iv) the homogenization of the magnitude estimates on the basis of the results of the specific task 2B, v) will be approached the problem of the reorganization of the phases database for years before 1981 which also shows defects similar to the folowing period.

Task 2B - MAGNITUDE

The reasons of the observed bias among the Ms estimates before and after the installation of the WWSSN network will be analyzed. A program of systhematic analysis of broadband recordings since 1988 up to now will be set up in order to compute the synthetic Wood-Anderson magnitude for most events with Ml>3.5. The readings of the amplitudes of the still available original Wood-Anderson recordings for stations RMP and TRI, relative to the period 1972-1988, will be redone. In the sites TRI and RMP (or in another of the MEDNET network) the original Wood-Anderson instruments, which are now abandoned but still working, will be reinstalled. Strong motion recordings will be analyzed to compute the local magnitude in the near field with the Kanamori and Jackson (1978) method. The simultaneous inversion of the magnitude values, of station residuals and of the attenuation function will be performed. The resulting database of consistent magnitude will be compared with the data of duration and amplitude of the instrumental catalog in order to compute empirical magnitude relations. If necessary we will proceed to new readings of these duration and amplitudes from waveforms for a set of stations. We will continue the studies for the improvement of empirical relations to estimate of the magnitude from macroseismic fields.

Task 3 - SEISMOGENIC MODEL

The research will follow two distinct but complementary courses. Within the first course we will make available to the project partners the "*Database of potential sources for earthquakes larger than*

magnitude 5.5 in Italy", which is presently being compiled and the first version of which should be published at the beginning of the year 2000. The database contains about 200 of such sources and in the next 3 years will be progressively expanded with results from other national or international projects. The technique used for deriving seismogenic sources from earthquake intensity data will be modified to improve stability and reliability of the solutions. Special emphasis will be given to the identification of "potential seismic gaps", based both on historical seismicity and on surface and subsurface geology data. The essential parameters for characterizing individual sources (e.g. slip rate, average repeat time), currently available for a limited number of sources, will be extrapolated to adjacent, less known sources or hypothesized based on modeling of landscape features or on constraints from global deformation detected geodetically.
Within the second course of activity we will derive a new scheme of seismogenic zoning constrained by evidence for global tectonic strain derived from geodetic and field observations and by numerical modeling of geodynamic evolution. The main goal of this part of the project is to separate more objectively and effectively portions of the peninsula that are characterized by potential for destructive seismicity from those characterized by little or no earthquake potential.

Task 4 - DYNAMICS OF THE SEISMIC SOURCE

We will investigate the interaction between a recently activated seismogenic structure and the surrounding active structures. We will try to separate the coseismic and postseismic components in order to characterize the state of stationary (or interseismic) deformation that acts on a region and then determines its seismicity. Finally, we will focus on the source model of earthquakes that occurred on nearby structures to highlight possible heterogeneity of the response properties of a given structure to the stress perturbation. The identification of such heterogeneity may be useful characterize the space-time distribution of future earthquakes in the same area.

Task 5 - STATISTICS OF SEISMIC SOURCES AND CATALOGS COMPLETENESS

The slip- and time-predictable recurrence relation will be studied in the light of the new historical and instrumental catalogs in order to evalute their applicability to the italian area. The new catalogs will also be analyzed in order to infer the space-time clustering properties and the existence of migration. The statistical completeness will be evaluated by the various available methods, taking into account even the indications of the historical research.

Task 6A - SEISMIC TOMOGRAPHY

The new instrumental seismic catalog will be used to study the three-dimensional structure of the crust and lithosphere of the Italian region. The inclusion of data recorded by local networks into a homogenous catalog will increase the achievable resolution. Two important innovations will be implemented: current knowledge of crustal structure, obtained by short-scale, detailed investigations focused on specific areas — accurate but fragmentary — will be gathered and a national-scale synthesis model will be compiled, to be used as *a priori* estimate for the tomographic inversion. Also, the inclusion and joint inversion of local, regional, and teleseismic distance data — characterized by different sensitivity and trade-offs — will be crucial in minimizing the ambiguities of the inversion.

Task 6B - SEISMIC ATTENUATION TOMOGRAPHY

We will carry out a study of seismic attenuation in the Earth crust and upper mantle using classic methodologies and inversion techniques. First attenuation curves will be computed through a regionalization of the Italian territory. The attenuation in the upper mantle will be estimated by comparison of recordings of regional earthquakes at nearby stations. A tomographic inversion will then be planned to evaluate the spatial variations of the quality factor Q. 3D models of the quality factor will be derived using local seismic events on sample areas. Finally, we will explore the possibility of extending the scale of the study

Task 6C - SEISMIC INTENSITY TOMOGRAPHY AND SITE EFFECTS

We will proceed with a tomographic study, already in course at the Bologna University, using different forms of the attenuation function. A comparison with the result of the attenuation of instrumentally measured parameters will also be carried out. This study will give a compilation of the average residuals for each locality which will be correlated with the geological, geotechnical an topographical characteristics of each site. The definition of these parameters will allow to filter the intensity data from the propagation and site effects then to improve the analysis of such data in order to infer the seismic source parameters of historical seismogenic sources. A comparison among the different ground motion simulation methods and a validation of them on the basis of instrumental and macroseismic data will be carried out.

Task 7 - FOCAL MECHANISMS

We will analyze Italian earthquakes of the last 10 years with magnitude above 4-4.5 by inverting surface waveforms following the Centroid Moment Tensor (CMT) algorithm. CMTs have shown to be

the most accurate and reliable focal mechanisms for large, but also intermediate magnitude earthquakes. Consistency with the Harvard global catalog — which only includes events with magnitude above 5.5 also for the Italian region — will allow to compute seismic deformation and the principal directions of the stress tensor more reliably. The new CMT national catalog will also yield scalar seismic moments (and therefore moment magnitude), to be used to improve calibration of magnitude scales.

Task 8 - LABORATORY MEASUREMENTS

We propose to characterize the process of generating the earthquakes, by reproducing in the Rocks Mechanics Laboratory of Bologna University the seismicity of a portion of the crust. In particular, a series of microevents will be generated in rock samples or in similar materials. The fracture microevents will be recorded by a network of 4 microaccelerometers and the signals will be analized to compute the "magnitude" of the microevents. The time series of microevents will be statistically analyzed in order to identify the type of the process (with or without memory) that generate them and at the same time to study the validity of semi-deterministic models.

Task 9A - GEODETIC MEASUREMENTS

A semi-permanent geodetic network with sides of about 40-50 km will be set up along the apenninic chain ridge from Umbria to Calabria to monitor the interseismic deformation. This network will be designed by taking into account all of the vertices (about 20) that have been already monumented and measured during previous campaigns (TYRGEONET and GEOMODAP); we will also include the permanent stations managed by ASI that will also allow to adopt a very high accuracy reference system periodically updated by the International GPS service for Geodynamics (IGS). We do not think to include vertices of the old triangulation network of the Italian Geographic Military Institute (IGMI) due to the inadequate vertex settlements (often damaged or even lost) and also because the comparison with the historical measures, due to the high errors (semi-major axes of the order of 50 cm in the compensation of the most recent measures done in years 1950-1960), cannot be useful in computing the interseismic strain rates.

For "semi-permanent" station we mean a point located at a geologically stable site with a sound monumentation and with an easy access so that it is possible to make periodic measurements of long duration (10-15 days at least) at low costs. To do that the instrumentation already owned by the institutions involved in the research, will be implemented with transmission and remote-control equipments. As the experiences of the proposers showed and the statistics of the series of observations carried out on permanent stations in the last years confirmed, the above measure period will allow to define the coordinates (planimetric) with millimetric accuracy.

The processing of the GPS data will be carried out by scientific software (i.e. BERNESE, GIPSY, etc.), and tested by standard statistical approaches.

Task 9B - STRAIN FIELD

The strain tensor inside the meshes of the network will be computed from the comparison of repeated campaigns; the approach we will use is based on the principles of integrated geodesy, simultaneously using geodetic data of different origin and accuracy. This will allow to analyze the results of the GPS campaigns carried out in the last decade in the area, repeted precise levelling, and also gravity variation data. A particular attention will be payed to the evaluation of the reliability of the results.

Task 10 - MODELING OF THE STRAIN AND STRESS FIELDS

The lithosphere deformation in the Tyrrhenian basin and in the peri-Tyrrhenian chains will be simulated by numerical models that allow to solve the stress equilibrium and the mass conservation equations by the finite elements technique. Simple approaches based on continuous elastic or viscoelastic plates are not suitable to represent in detail the complexity of the deformation of the italian region. We propose instead a thermomechanical model based on the thin plate approximation that is able study the anelastic strain due to the principal deformation mechanisms (frictional sliding and dislocation creep).

Task 11 - HAZARD ANALYSIS

The results of the researches in the fields of historical and instrumental seismology, seismic attenuation, and seismogenetic model will be used to improve the probabilistic evaluations by the methods used until now in Italy (SEISRISK III, EQRISK etc.). This will be done in terms of ground motion parameters, derived parameters (Arias and Housner intensity) and macroseismic intensity. The possibility of defyning the hazard for the spectral ordinates of the ground motion parameters, of using bi- and tri-dimensional attenuation functions, and of introducing linear sources for the best defined segments of the apenninic chain will be also tested. At the same time the hazard analysis on the basis of the models used in California will be stated and carried out. The estimates on the basis of the various methods will be integrated with the results of the study on site effects and compared, also with

the results of the analysis of seismic site histories. Approaches of the "Montecarlo" type will be also tested. On the basis of decision making support techniques we will approach the search for the model representing the "least questionable" choice among different alternatives.

5.4 MANAGEMENT AND ORGANIZATION STRUCTURE OF THE PROJECT (max 5 pages)
The project should be divided in tasks, each entrusted to a scientist responsible. The description of each task must include final objectives and milestones. Moreover, the contribution of each Research Unit and the coordination among the Units must be highlighted.

Task 1A, HISTORICAL SEISMIC CATALOG (Resp: Guidoboni)
Participants: Bianchi, Camassi, Castelli, Coppari, De Simone, Ercolani, Ferrari, Furlan, Guidoboni, Monachesi, Tertulliani, Vannucci.
This research will be carried out jointly by SGA, OGSM, UNIBO and ING2. Two seminars will be held to develop and subsequently update a common approach to the assessment of macroseismic intensity. The first seminar will be devoted to specific aspects of research in historical seismology, while the second will also deal with the multidisciplinary analysis of research problems. The second seminar will therefore be open to a wider public of end-users of data concerning earthquake effects (engineers, geologists, seismologists). For post-1992 earthquakes (presently not included in the CPTI catalog) we will retrieve and georeference intensity data from the ING Macroseismic Bulletin, then proceed to homgeneization and parameterization according to the criteria set forth in the compilation of the CPTI 1999.
Task 1B -TEST OF THE HIGHEST REPORTED LOCAL INTENSITIES (Resp. Ferrari)
Participants: Ferrari, Guidoboni, Mariotti, Righini, Ciuccarelli, Furlan, De Simone
The activities under this task will be accomplished by SGA.
In order to reduce the number of data to be analyzed, we will first generate a subset of the full database by discarding all intensities that refer to small localities (population < 5,000). We will then analyze this countrywide dataset, find out the reasons for all the existing discrepancies and highlight the elemnts that may be crucial for the re-evaluation of the effects. The results of this analysis will be discussed jointly by the participants to the group "Historical Seismic Catalog" (Task 1A), who will then take responsibility for the necessary corrections.
Task 1C, SEISMIC SITE HISTORIES (Resp: Monachesi)
Participants: Camassi, Castelli, Coppari, Ercolani, Frapiccini, Monachesi, Vannucci.
This objective will be pursued by the Research Units UNIBO2 and OGSM. Some test-sites will be selected, their total number being a mediation between its having to have a nationwide relevance and the available resources. Original data already available for each test-site will be inventoried and collected, and their informative potential will be assessed with regard both to the completeness of past researches and the potential availability of still uninvestigated informative depositories. If necessary, that is if definite gaps in seismic histories are detected, new ad hoc researches will be carried out. The collected data sets will be re-assessed in terms of macroseismic intensity, according to the European Macroseismic Scale (Gruntal et al., 1998) and the Mercalli Cancani Sieberg scale (Sieberg, 1932), and used for testing the stability of hazard evaluations with traditional and innovative methodologies. The same methodology will be applied, on a sub-regional scale, to some test-areas, using a comparatively larger sample of sites than the one selected on the national scale.
Task 2A, INSTRUMENTAL SEISMIC CATALOG (Resp:Monachesi)
Participants: Monachesi, Parolai, Gasperini, Morelli, Piromallo
The research will be carried out mainly by the OGSM, ING (1) e UNIBO (1) research units. The result of this task will be particularly important for tasks 6B, 6C and 7.
Subtask 2A.1 - Merging of other networks
By activation of subcontracts the contribution of some local network will be solicited to the completion of the seismic phase arrivals database. In some cases it could be necessary to carry out the manual entry of the data not already available on computer media. For this operation, external service contracts could be activated.
Subtask 2A.2 - 2D and 3D modelling and relocation
In close cooperation with task 6A, a velocity model for the italian area with lateral variation of wavelength of 50-100 km will be estimated. The relocation will be carried out by *ad hoc* computer codes.
Subtask 2A.3 - Reorganization of database before year 1980

Similarly to what was already carried out, in the 1998 Project, for the database after 1980, a quality control of the seismic phase readings will be done. The correct link to the events and the presence of inconsistencies of the arrival times (for earthquakes spanning over hours, days, months, years, or S phases times before P ones) and of the station codes.

Subtask 2A.4 - Checks using teleseismic events

On a sample basis, and in case with the new readings of the seismograms of some teleseismic events for each period, the synchronization of the local networks, the polarity and the amplification of the stations will be checked.

Task 2B, MAGNITUDE (Resp: Gasperini)

Participants: Gasperini, Romeo, Di Stefano, Taccetti, Mazza, Casale, Rebez, Renner

Subtask 2B.1 - Wood-Anderson amplitudes

The collaboration to the Project of the Osservatorio Geofisico Sperimentale (OGS) of Trieste will be endowed by a subcontract concerning the readings of the amplitudes of WA seismograms of TRI. The same operation will be carried out by ING personel for RMP station. Since, both the original WA instrument of TRI and at least one of RMP are still working (even if not operating presently), they will be reinstalled in the original sites. While for TRI station this is certainly possible as the site still is occupied by a broadband station, for RMP the possibility to use the original site is to be verified since it is presently dismissed. In case this not possible another station will be chosen among the ones where a broadband station is in operation (for example AQU). If possible the second WA seismometer of RMP will be repaired and installed in the same site. The reading will be carried out with the optical digitizer equipment already developed at ING (Romeo, 1995). The measurement campaign, in principle limited to the duration of this project, should verify the coincidence among the original instruments amplitudes and the synthetic ones derived from the broadbands.

Subtask 2B.2 - Extensive analysis of broadband data

The broadband recordings from 1988 to present time will be systematically analyzed. The association of the recordings with the considered events and the presence of a signal suitable for the amplitude measure shall be verified. The uncertainity of the measure will be estimated on the basis of amplitude, the noise and the coherence of the two components. This job will be done by ING and UNIBO personel.

Subtask 2B.3 - Catalog of the magnitude estimates from international organizations

The ISC, EMSC and NEIC data will be examinated and evaluated in relation to the source and the number of simultaneous observations. Each estimate of Ms mB and Mw will be linked to the earthquakes of the instrumental catalog. This work will be done at UNIBO and will require the activation of a contract for one year.

Subtask 2B.4 - WA magnitudes, residuals and attenuation function evaluation

The attenuation function for epicentral distances closer than 100 km will be evaluated by the analysis of the accelerometric data with the Kanamori and Jenkins (1978) method. The result will be used to constrain the simultaneaous inversion of the attenuation function for WA and SWA data. This operation will also give the values of magnitude and the station residuals for the set of earthquakes having more than one measure. At a second time the magnitude will be computed even for single measures.

Subtask 2B.5 - Duration and amplitude relations for instrumental database data

If it will not be possible to get satisfying correlations of WA and SWA magnitudes with the duration and amplitudes in the database, these will be read again with uniform criteria for a tens of stations chosen among the ones that operated with more continuity in the last 20 years. This task will take place in case at ING starting from the second year and will require the activation of a contract.

Subtask 2B.6 - Verification of Ms estimated before the WWSSN network set up

The problem will be analyzed at UNIBO by the search of original sources of these estimates (catalog and bulletins). We will carry out a comparison with other types of magnitude. We will consider also earthquakes in others european countries where the instrumentation used in the different periods was similar to the italian one.

Task 3, SEISMOGENIC MODEL (Resp: Valensise)

Participants: Basili, Bordoni, Burrato, D'Addezio,Valensise

The "*Database of potential sources for earthquakes larger than magnitude 5.5 in Italy*" will be made available to the project partners, along with a scheme for assessing the statistical significance of the data and for extrapolating information from the best to the least known sources. All new data acquired from the international literature or from ongoing Italian and international project not directly related with GNDT will be examined and included in the database. The location and geometry of sources obtained from intensity data alone will be refined through improved algorithms and cross-

checks. The general theme of identification of "potential seismic gaps" will be actively pursued by promoting cooperation among the project partners and by direct field investigations (including modeling of selected landscape features and trenching). The activity will take place essentially within the ING. The task will require a computer technician to be hired for the duration of the project and short contracts to external consultants for implementing new features of the GIS on which the model is based.

Task 4, DYNAMICS OF THE SEISMIC SOURCE (Resp.: Bonafede)

Participants: Bonafede, Dragoni, Belardinelli

No significant resources will be requested for the completion of this task. The project will greatly benefit from the interaction with the scientists involved in this task, all of which are based in UNIBO, particularly in the fields of macroseismic and instrumental characterization of seismic sources, evaluation of the post seismic component of the strain, and others.

Task 5, STATISTICS OF SEISMIC SOURCES AND CATALOGS COMPLETENESS (Resp.: Mulargia)

Participants: Mulargia, Marzocchi, Di Giovambattista

Also in this case no significant resources are asked for since most of the methods of analysis ave already been developed and are currently used in other research projects at ING and UNIBO. The scientists involved will participate with their scientific expertise and will perform applications to datasets of interest of the project.

Task 6A, SEISMIC TOMOGRAPHY (Resp.: Morelli)

Operators: Morelli, Piromallo

Execution of this task will benefit from methodologies and computing tools implemented at the ING by us during previous research in tomography and three-dimensional earthquake location on a wider scale. Computing tools will be adapted to the smaller geometry and tuned to optimal resolution. We will activate a fellowship to retrieve and compile a synthetic *a priori* model of the Italian crust (thickness, velocity) to be used as a constraint for the tomographic inversion. In collaboration with Task 2A, all catalog earthquakes will be relocated.

Task 6B, SEISMIC ATTENUATION TOMOGRAPHY (Resp.: Mele)

Participants: Parolai, Mele, Monachesi.

The concerned investigations are mainly of an innovative kind, at least insofar as they concern the development of threedimensional models of the Q quality factor. This section of the work will be carried out only if enough data will be available on the national territory. No special resources will be requested, always excepting those related to the needful interaction between the involved researchers and the international experts of the topic. The involved institutions will be ING and OGSM.

Task 6C - SEISMIC INTENSITY TOMOGRAPHY AND SITE EFFECTS (Resp: Gasperini)

Participants: Gasperini, Carletti, Loddo, Vannucci

Subtask 6C.1 - Tomography of seismic intensity

These researches were recently started at UNIBO and are not otherwise endowed. They concerns the developement of the classical tomographic methodology to the problem of seismic intensity attenuation. Their relapse on the project is very important since it permits inferences even on the anisotropy of the attenuation of other ground motion parameters and the estimate of effects of anomalous amplification on very important sites like big towns and culturally remarkable centers.

Subtask 6C.2 - Site effects in terms of intensity

With methods similar to above ones it should be possible to evaluate differential macroseismic responses inside big towns like Florence, Bologna, Rome etc. Moreover the "cleaning" of the intensity data from the propagation and site effects would allow to refine the evaluations of the source characteristics of historical earthquakes by the inversion of synthetic models for the computation of intensity. During the project iwould be necessary the activation of a research grant.

Subtask 6C.3 - Site effects in terms of ground motion parameters

In this case the aim is a critical analysis of the various tehniques available in literature for the simulation of the ground motion and their application to the local correction of the hazard estimates. The research will be carried out at UNIBO and the required resources will include, besides the common research costs, a two years research grant and/or the activation of subcontracts with others researchers.

Task 8, LABORATORY MEASUREMENTS (Resp: Mulargia)

Participants: Mulargia, Castellaro, Gonzato, Ciccotti

These ar studies already in course at UNIBO on other research projects. Even in this case the collaboration with the involved researchers is an added value to this project, pratically a no costs, in the fields of the understanding of the fracture events occurrence and of the propagation of seismic waves

in crustal rocks. In particular the results of these researches will give answers on the characteristics of the statistical distribution of seismic events which will be used in the formulation of hazard models.

Task 7, FOCAL MECHANISMS (Resp: Morelli)

Operators: Morelli, Olivieri, Pondrelli, Ekstrom

Tools for the calculation of focal mechanisms by extending the Centroid Moment Tensor algorithm to analysis of smaller magnitude earthquakes by inversion of fundamental mode surface waves recorded at local and regional distance have been implemented at the ING in collaboration with Harvard University. We propose to apply it backward in time to analyze events of the last decade for which broadband seismograms have been recorded by the MEDNET network. CMT focal mechanisms will be compared with those obtained by fitting first motion polarities. Moment tensor sums will be computed to quantify seismic deformation in macroareas. Teleseismic broadband seismograms will be inverted to reconstruct source time functions and to compute hypocentral depths by fitting body waveforms. Additional resources needed to achieve these objectives are marginal, because the activity will be based on computer techniques and resources available.

Tasks 9A, GEODETIC MEASUREMENTS (Resp. Riguzzi)

Participants: Riguzzi, Anzidei, Galvani, Baldi, Casula, Pesci, Salemi, Achilli, Vettore, Targa, Menin, Ricciardi, Del Gaudio, Ricco, Sepe, Borgstrom, De Martino Unguendoli, Gandolfi, Sarti, Vittuari, Zanutta, Bitelli, Ercolani

This task requires the participation of the research units ING2, UNIBO1 and UNIBO2.A research grant or a service contract of at least 2 years will be required

Subtask 9A.1 - Materialization of the vertices of the apenninic network

This will be preceded by an accurate field recognition in order to detect geologically stable areas; for the choice of sites what is already existent concerning local and regional network and active permanent stations will be taken into account. The monumentation will be carried out used forced centering systems for the GPS antenna, in order to evoid ripositioning mistakes.

Subtask 9A.2 - Execution of two measurement campaigns at least

The need of stay on the points for a period of the order of 10 days and the high number of vertices do not allow to measure all the network simultaneusly.Thus we will proceed to the surveying of series of sessions covering only a part of the network, but granting their integration by partial overlapping and the use of permanent stations.

Subtask 9A.3 - Data-bank

Due to large amount of the data and in order to fix a certain landmark for next years activities, a complete and easy to use data bank will be created and mantained.

Subtask 9A.4 - Processing

The processing of GPS data will be carried out by standard procedures implemented in the scientific software available to proponents.

Task 9B, DEFORMATION FIELD (Resp. Baldi)

Participants: Achilli, Baldi, Casula, Pesci, Serpelloni.

The computation, on the basis of the measurements done in task 9A, of the deformation field and the evaluation of the reliability of the results, will be carried out. A particular attention will be payed to the *a posteriori* estimation of the accuracy of the used data, by the detection of outlier, and the possible modification of the observations weight. This procedure is mandatory since often the accuracy of a geodetic campaign by usual statistics (i.e. from the variance-covariance matrix of the network compensation) is overestimated. This work will be carried out mainly at UNIBO1.

Task 10 - MODELING OF THE STRAIN AND STRESS FIELDS (Resp: Giunchi)

Operatori: Giunchi, Cianetti, Gasperini

These methos will be developed mainly at ING and will give a interpretative framework of the tectonic evolution of the italian area which will support both the definition of the seismogenic zonation (task 3) and the definition of deformation rates useful for the hazard estimates (task 11) in areas which for various reasons other information are scarce or ambiguous.

Task 11, HAZARD ANALYSIS (Resp: Gasperini)

Participants: Mulargia, Gasperini, Serpelloni, Marzocchi

This task will be pursued mainly at UNIBO1. It will be the receiver of all the new data and information produced by the other tasks. By the classic methodology the probability matrices for given levels og ground shacking will be determined in terms of PGA, intensity and derived parameters. Initially the attenuation relation found in literature will be adopted, then the anisotropic relations derived by the results of tasks 6A an 6B will be used. The seismogenic zonation developed in task 3 will be used. On a second stage the multidisciplinary models that make use of the geodetic strain data will and of the seismotectonic model derived form the catalog odf seismogenic sources will be faced out.

We will investigate the differences among various hazard models both in terms of the expected probability of a certain level of ground shaking to be exceeded and in terms of probability for the same level of not being exceeded for different return periods. We will then define an "optimal model" by weighing different models according to their associated uncertainty and using a *fuzzy* approach for decision support. The "optimal model" will represent the least subjective choice among the various alternative models.

5.5 TABLE OF THE RESEARCH OBJECTIVES AND ANNUAL MILESTONES

It is intended that each task will deliver a report on the status of the activities every six months. The report will be signed by the task coordinator in collaboration with all the scientists involved. The coordinator will be free to arrange with his/her collaborators the dissemination of any significant results through scientific journals and Internet. The table describes only products that represent a permanent patrimony of information that can be used directly by the scientific community.

FIRST YEAR

Task	**Research objective**	**Deliverables**
1A	Development of methodologies for the investigation of historical earthquake data	First preliminary update of the CPTI
	Progress of integration between the CFTI and DOM databases	
	Geo-referencing data from the ING Macroseismic Bulletin	
1B	Selection of intensity data according to population of felt locality	List of significant departures in intensity assessment between the two databases
1C	Selection of sample localities at national and sub-regional level	Dataset of available information on sample localities
	Inventory and collection of available information	
2A	Incorporation of data from local networks	Updated catalog of the seismic phases after 1980
	Evaluation of problems of the phases database before 1981	
2B	Construction and calibration of optical reading and digitization devices of WA seismometers	Optical reading and digitization devices
	Preliminary evaluation of bias of Ms after 1964	New magnitude-felt area relations
	Reading of historical WA seismograms	Catalog of WA amplitudes 1972-1988
	Analysis of SWA amplitudes from broadband data for 200 earthquakes	Preliminary catalog of SWA amplitudes
	Preliminary evaluation of WA,/SWA magnitudes, residuals and attenuation function	Preliminary catalog o WA/SWA magnitudes
	Correlation and regression of WA/SWA magnitudes with durations and amplitudes in database of seismic phases (after 1980)	Preliminary empirical relations for duration and amplitude magnitude
3	Set up of a database of about 200 principal seismic sources	Database of potential sources for earthquakes larger than magnitude 5.5 in Italy: first version
	Improved understanding of release mechanisms for minor seismicity	Preliminary scheme of seismogenic zoning
	First identification of “seismic gaps”	Map of priority intervention zones for successive tasks
4	Improved understanding of seismic source phenomena	
5	First evaluation of the validity of recurrence models and of statistical completeness	
6A	Retrieval and synthesis of existing information on crustal structure	
	Construction of a database of time phases for the tomographic inversion	
6B	Retrieval and organization of basic data	Creation and implementation of the database required by the research plan
	Calculation of attenuation curves begins	
6C	-	
7	Calculation of CMT focal mechanisms	
8	Laboratory measurements and data analysis	

9A	Selection of vertices of the geodetic network Semi-permanent monumentation of the network	Monumented network Preliminary monographs of the vertices
9B	-	-
10	Preliminary numerical model	
11	Preliminary comparison of different hazard assessment methods	

SECOND YEAR

Task	Research objective	Deliverables
1A	Beginning of tightly focused studies	
	Progress in the integration of CFTI and DOM	Second version of CPTI with full integration of the ING macroseismic Bulletin
	Further studies on the assessment of intensity	
1B		
1C	Evaluation of the completeness of the available material and of the potential for improvement of the dataset	Dataset update
	Beginning of focused historical investigations	
2A	Computation of 3D models and preliminary locations	Relocated preliminary catalog with re-evaluated magnitudes
	Association and merging of new magnitude values	
2B	Recording of digital WA (DWA) in parallel to broadbands	Catalog of DWA and corresponding SWA amplitudes
	Final evaluation of the Ms bias prior to 1964	New magnitude-felt area relations
	Analysis of SWA amplitudes from broadband data for further 200 earthquakes	Final catalog of SWA amplitudes
	Final magnitude, residual and attenuation functions	Final WA /SWA magnitude catalog
	Possible re-reading of duration and amplitude for about 10 stations	Final empirical relations
3	Improved identification of sources previously identified from intensity data alone	Incorporation of new records in the database
	Direct characterization of a limited number of sources	Update of existing database records
4	Improved understanding of seismic source phenomena	
5	Final evaluation of the validity of recurrence models and of statistical completeness	
6A	Synthesis of the *a priori* model for the Italian crust	
	Tomographic inversion	Preliminary tomographic model
6B	Calculation of the final model of 2D variations of attenuation at national scale	
6C	-	-
7	Calculation of CMT focal mechanisms	Catalog of focal mechanisms
8	Laboratory measurements and data analysis	
9A	First campaign of GPS measurements	Final monographs of the vertices
	Integration and comparison with data from other networks	Coordinates of network vertices
9B	-	-
10	Final numerical model	
11	Preliminary hazard estimates with traditional methods using the updated dataset	Preliminary hazard maps at national scale
	Development and test of innovative methodologies	

THIRD YEAR

Task	Research objective	Deliverables
1A	Investigation of discrepant earthquakes Multidisciplinary evaluation of current problems Update of poorly known earthquakes	 Final version of CPTI
1B	Assessment of correction criteria	List of corrections to be made
1C	Homogenization of retrieved information in terms of EMS and MCS intensity Definition of completeness Calculation of site-specific hazard using different methodologies	 Site-specific hazard estimates
2A	Re-organization of pre-1980 database (if needed) Polarity checks using teleseismic arrivals (if needed)	Pre-1980 database (if needed)
2B	Comparison of SWA vs. DWA Regional WA attenuation functions	 Catalog of Ml and Ms magnitudes
3	Declaration of "potential seismic gaps" Database is extended to include all newly identified sources	New information layer of the database Database of potential sources for earthquakes larger than magnitude 5.5 in Italy: final version Final scheme of seismogenic zoning
4	Improved understanding of seismic source phenomena	
5	-	-
6A	Constrained tomographic inversion	Tomographic model of Italian crust and lithosphere
6B	2D attenuation model is obtained through inversion Feasibility of a 3D model and possible implementation	2D attenuation model and possible 3D extension
6C	-	
7	Summation of moment tensors for selected areas	Seismic deformation for selected areas
8	Evaluation of recurrence models	Recurrence model
9A	Second campaign of GPS measurements Integration and comparison with data from other networks	Coordinates of vertices Displacement vectors
9B	Calculation of strain tensors	
10	Update of the numerical model	
11	Final estimate of seismic hazard using traditional methods Estimates using multidisciplinary methods Estimates using innovative methods (if applicable) Comparison of different techniques and final selection	Hazard maps at national and local scale