



Swedish Civil  
Contingencies  
Agency

Disaster Prevention Workshop  
Stockholm, Hasselbacken,  
27-29th of July, 2009



# The Abruzzo Earthquake: Effects and Mitigation Measures

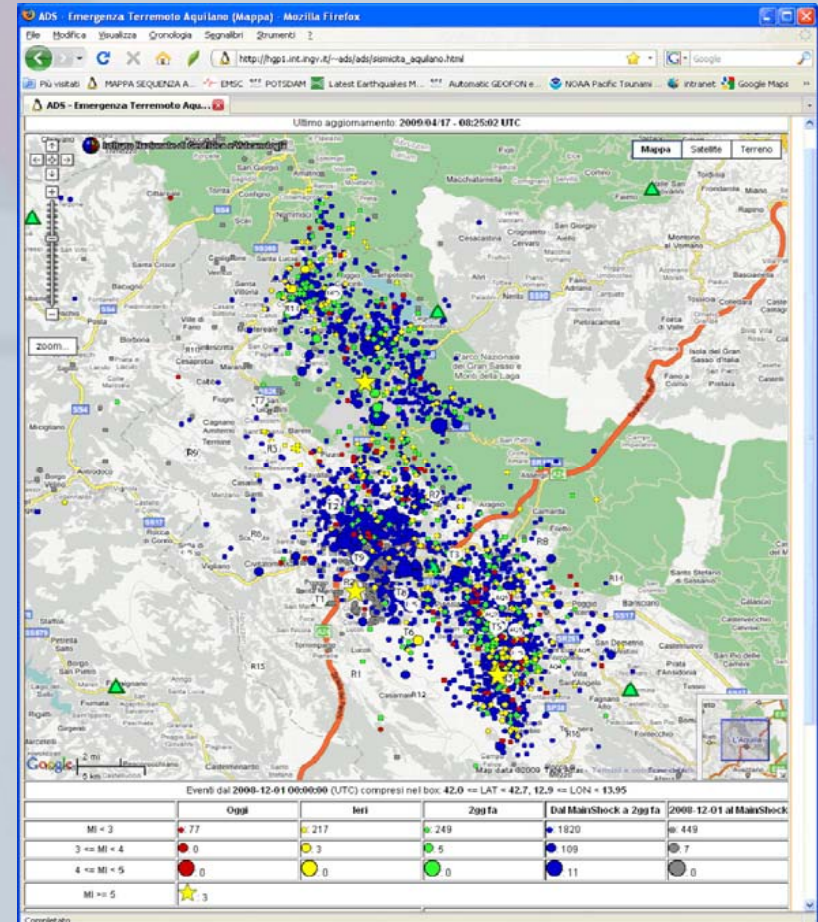
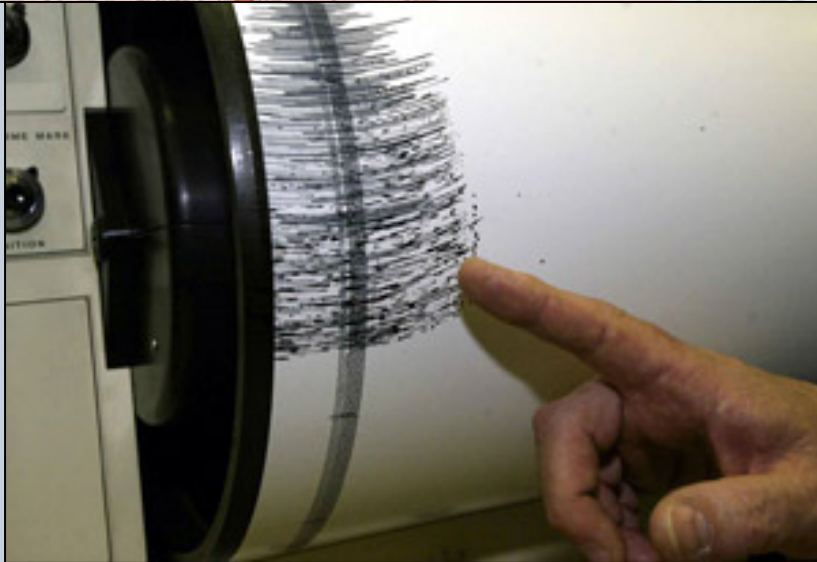
**Mauro Dolce**

Director - Seismic Risk Office,  
Italian Civil Protection Department,  
Professor of Earthquake Engineering,  
University of Naples, Federico II

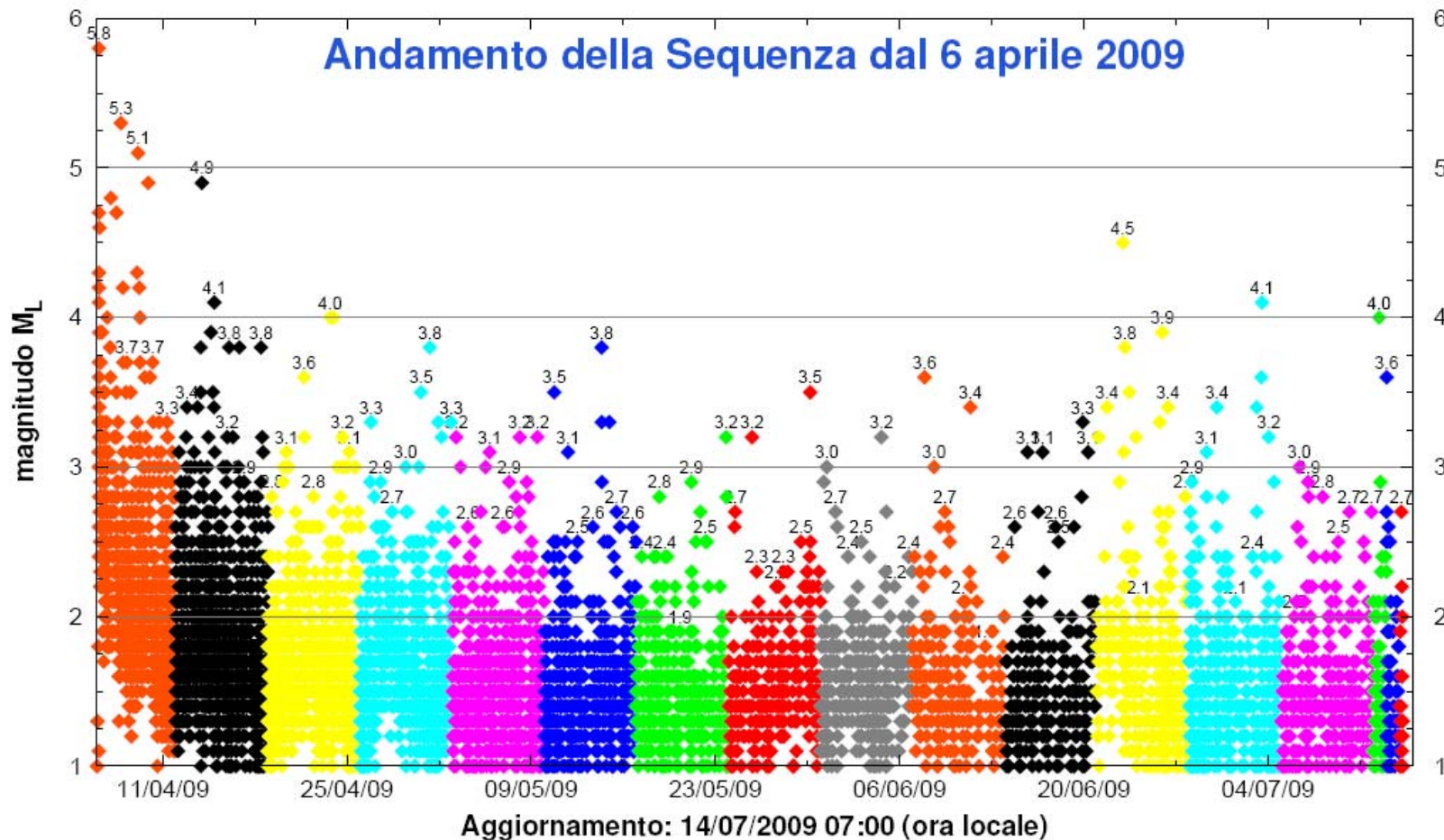
6 April 2009 H. 3.32 a.m.



MI 5.8 – Richter  
Mw 6.3



## Andamento della Sequenza dal 6 aprile 2009



# TOTAL NUMBER OF EARTHQUAKES IN L'AQUILA AREA IN ONE MONTH

From 06.04.2009 to 06.05.2009:

- 148 earthquakes  $3.0 \leq M_I < 4.0$
- 13 earthquakes  $4.0 \leq M_I < 5.0$
- 3 earthquakes  $M_I \geq 5.0$

<b>Totale scosse dal 6 aprile 2009</b>	<b>9532</b>
2.0 ≤ M < 3.0	1700
3.0 ≤ M < 4.0	190
4.0 ≤ M < 5.0	19
M ≥ 5.0	3



### Sequenza sismica aggiornata al giorno 14 luglio ore 07:00

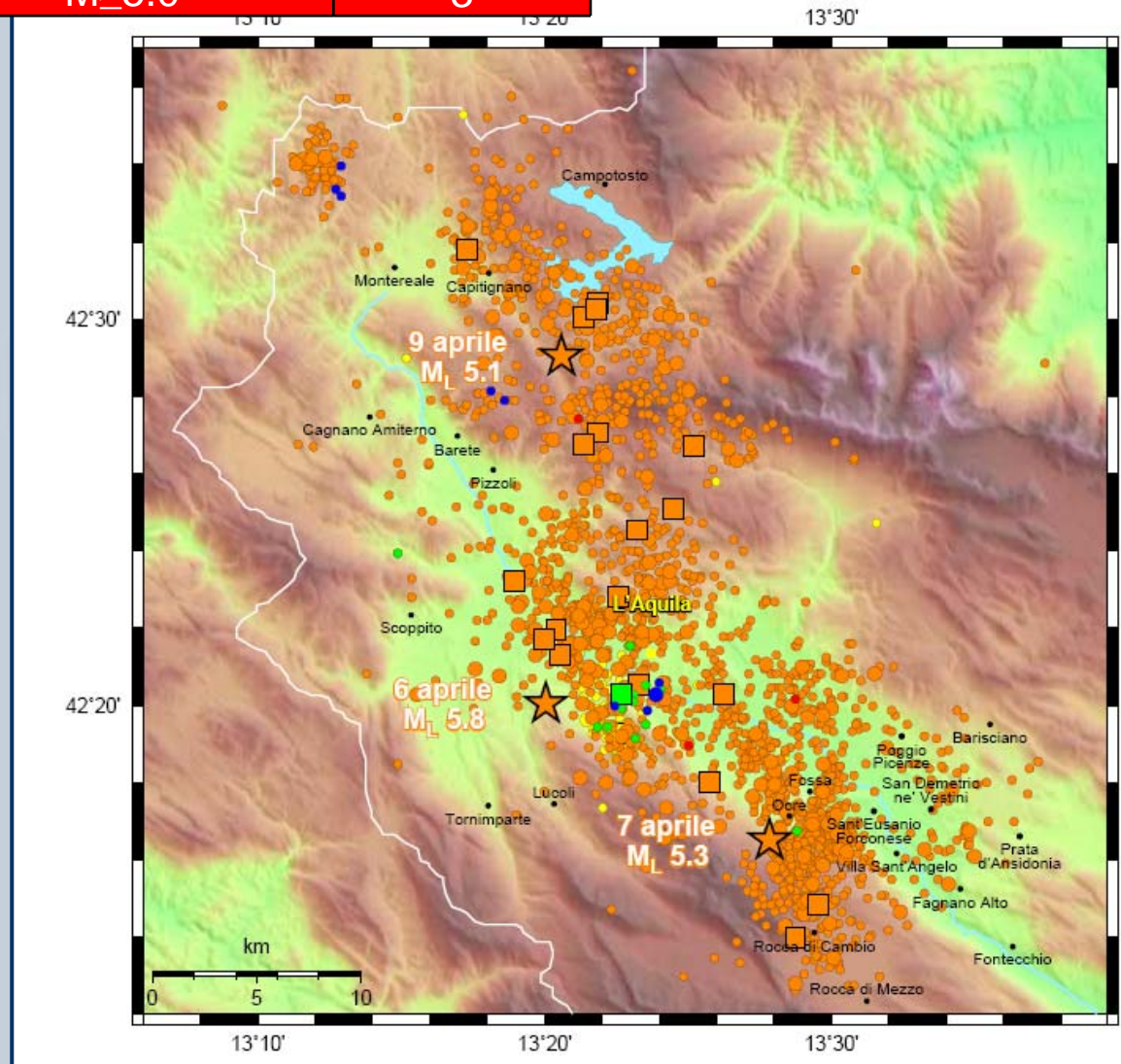
Le localizzazioni sono aggiornate alle ore 05:00 UTC

#### Classificazione in base alla magnitudo M<sub>L</sub>

- 2.0 ≤ M<sub>L</sub> < 3.0
- 3.0 ≤ M<sub>L</sub> < 4.0
- 4.0 ≤ M<sub>L</sub> < 5.0
- ☆ M<sub>L</sub> ≥ 5.0

#### Andamento della sequenza

- dal 01/12/2008 al 06/04/2009
- dal 06/04/2009 al 11/07/2009
- 12 luglio
- 13 luglio
- 14 luglio



# OUTLINE



## 1. Organization of the Italian CP System

## 2. Seismic Risk in Italy and the Abruzzo Eq

## 3. Civil Protection rescue and technical activities

## 4. Conclusion

# THE NATIONAL CIVIL PROTECTION SYSTEM

PRESIDENCY  
OF THE  
COUNCIL  
OF  
MINISTERS

Department  
of Civil  
Protection

Interior

Foreign Affairs

Environment

Health

Economy and Finance

Defence

Economic Development

Infrastructures

Transportation

Cultural Heritage

University and Research

Public Education

Communications

Agricultural Policy and Forestry

Regions

Provinces

Municipalities

National Fire-  
fighters Corp  
Police  
Prefectures

ISPRA

118

Revenue Guard

Army  
Navy  
Air Force  
Carabinieri

TERNA

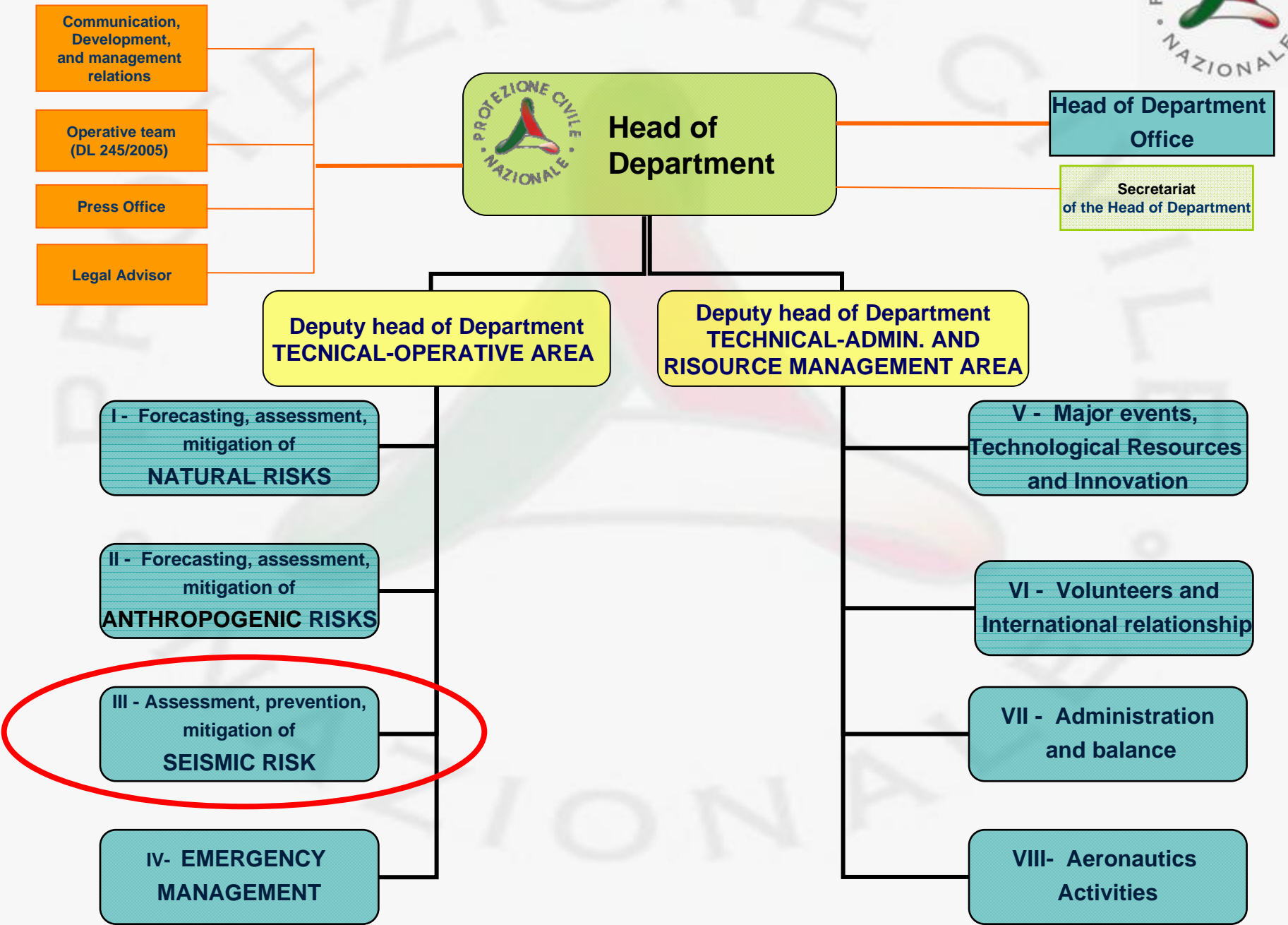
Coastal Guard  
ANAS  
National Highway  
National Railway

I.N.G.V.  
C.N.R.  
National  
Institutes

State Forest Corps



# Organization of the Civil Protection Dept.





# Organization of the Seismic Risk Office

## Office III – Evaluation, Prevention and Mitigation of Seismic Risk

Seismic Risk Assessment

Vulnerability, Technical Regulations and post-Emergency management

Emergency management Training and Education

Monitoring systems

Functional Centre - SRS

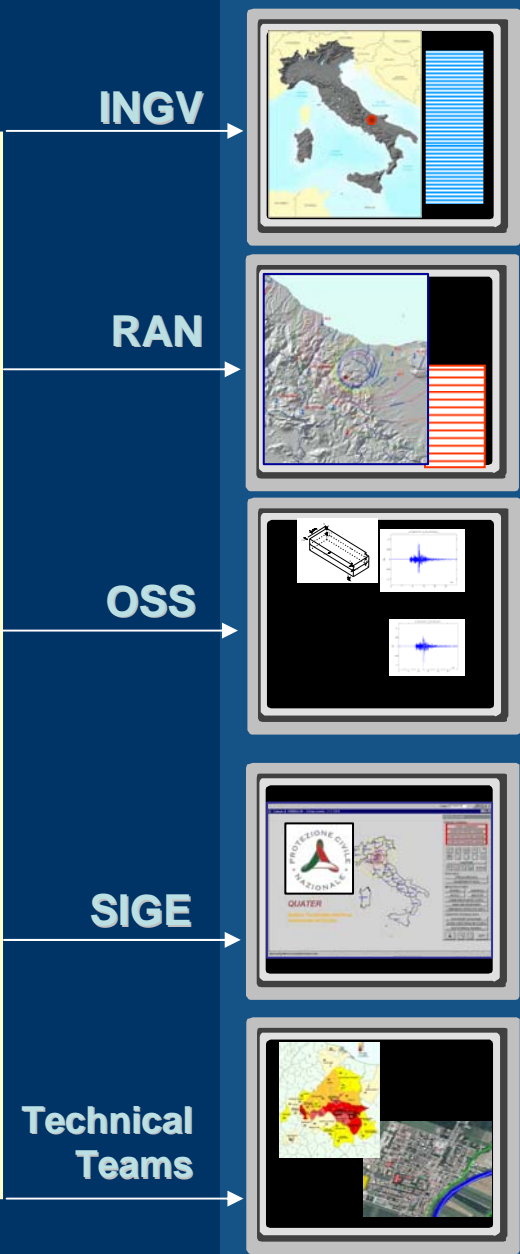
Competence Centres for Seismic Risk:

RELUIS  
EUCENTRE  
INGV



## Functional Centre

THE MAIN ACTIVITIES OF THE OFFICE AND OF THE RELATED COMPETENCE CENTRES ARE MONITORED AND SYNTHESISED IN THE FUNCTIONAL CENTRE TO SUPPORT DECISIONS AFTER AN EVENT



**Seismometric network** ground motion parameters (event localization, magnitudo) to start **SIGE**

**Strong motion network**  
Strong motion data to produce shake maps

**Structure monitoring system**  
network for damage evaluation

**Expected structural damage**  
Expected number of casualties  
Economic loss evaluation

**Macroseismic survey**

**Damage survey and safety assessment**



# COMPETENCE CENTRES OF DPC

- **INGV**



(Seismic surveillance, Seismological research projects, Emergency technical support)

- **ReLUIS**



(Earthquake engineering research projects, Emergency technical support)

- **EUCENTRE**



(Earthquake engineering research projects, Emergency technical support)

# OUTLINE



1. Organization of the Italian CP System

**2. Seismic Risk in Italy and the Abruzzo Eq**

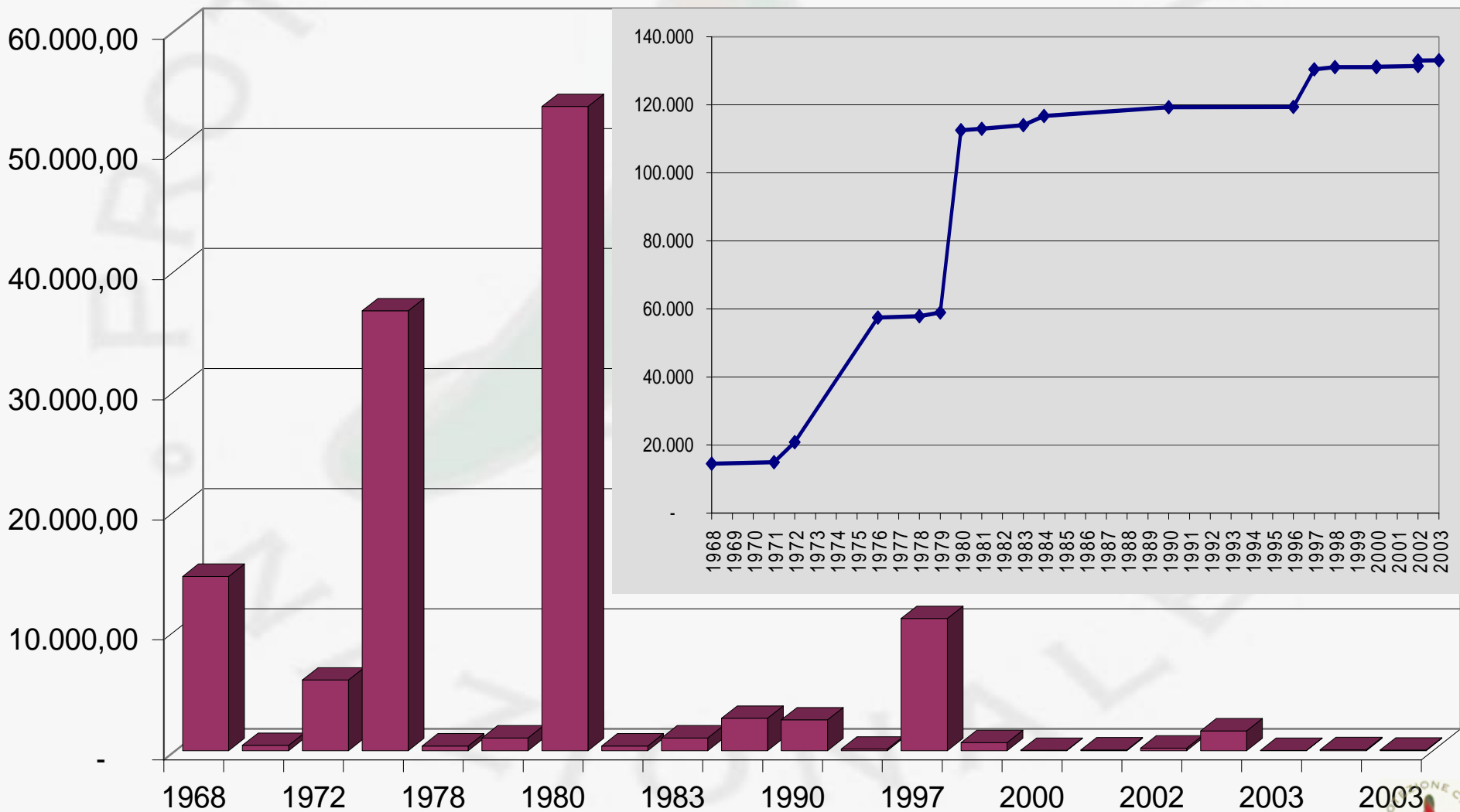
3. Civil Protection rescue and technical activities

4. Conclusion

# COST OF LAST 40 YEARS ITALIAN EARTHQUAKES (M€-2005)



Costo dei terremoti in Italia tra il 1968 ed il 2003 (€2005)



# SEISMIC RISK XXI CENTURY PROJECTIONS



Based on last two century history, the following numbers can be expected:

**500 - 2000 dead or injured people / year**

**→ 50000-200000 in the XXI century**

**€1 - 2 billions / year**

**→ €100-200 billions in the XXI century**

N.B.: The cost estimation is relevant to houses only. Overall costs should include also public and office buildings, monumental buildings, factories and infrastructure. Possible increases are of the order of 50-100%

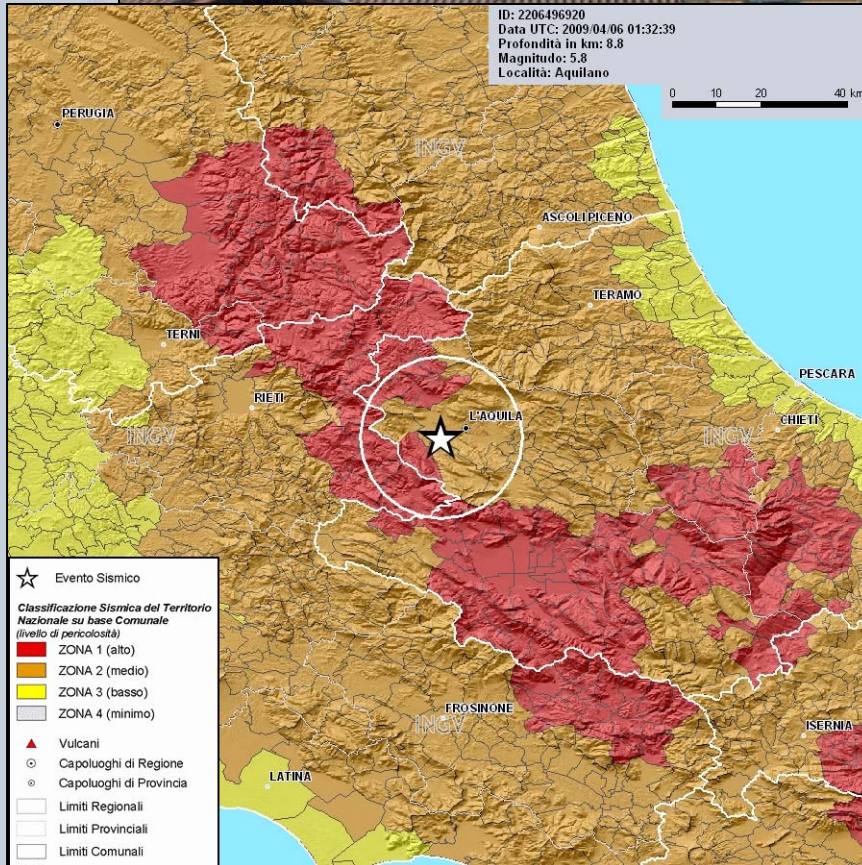


# L'AQUILA 06.04.09: A PECULIAR EARTHQUAKE

The administrative capital of the Region has been hit, the political world has devoted a great attention to the event and post-event consequences:

- The mass media attention is spasmodic,
- The amount of scientific data is enormous,
- A new different model for the emergency and post-emergency management is being operated
- **Special socio-economical problems**
- **Special emergency and post-emergency management**
- **Special scientific aspects related to both seismology and engineering**

# High hazard & high vulnerability → high risk





# Onna



# Tempera



 DI.COMA.C	 REGIONE AUTONOMA FRIULI VENEZIA GIULIA Protezione civile della Regione	 protezione.civile@regione.fvg.it www.protezionecivile.fvg.it I - 33053 Palmanova, via Nazionale 43
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Tempera



# OUTLINE



1. Organization of the Italian CP System
2. Seismic Risk in Italy and the Abruzzo Eq
- 3. Civil Protection rescue and technical activities**
4. Conclusion

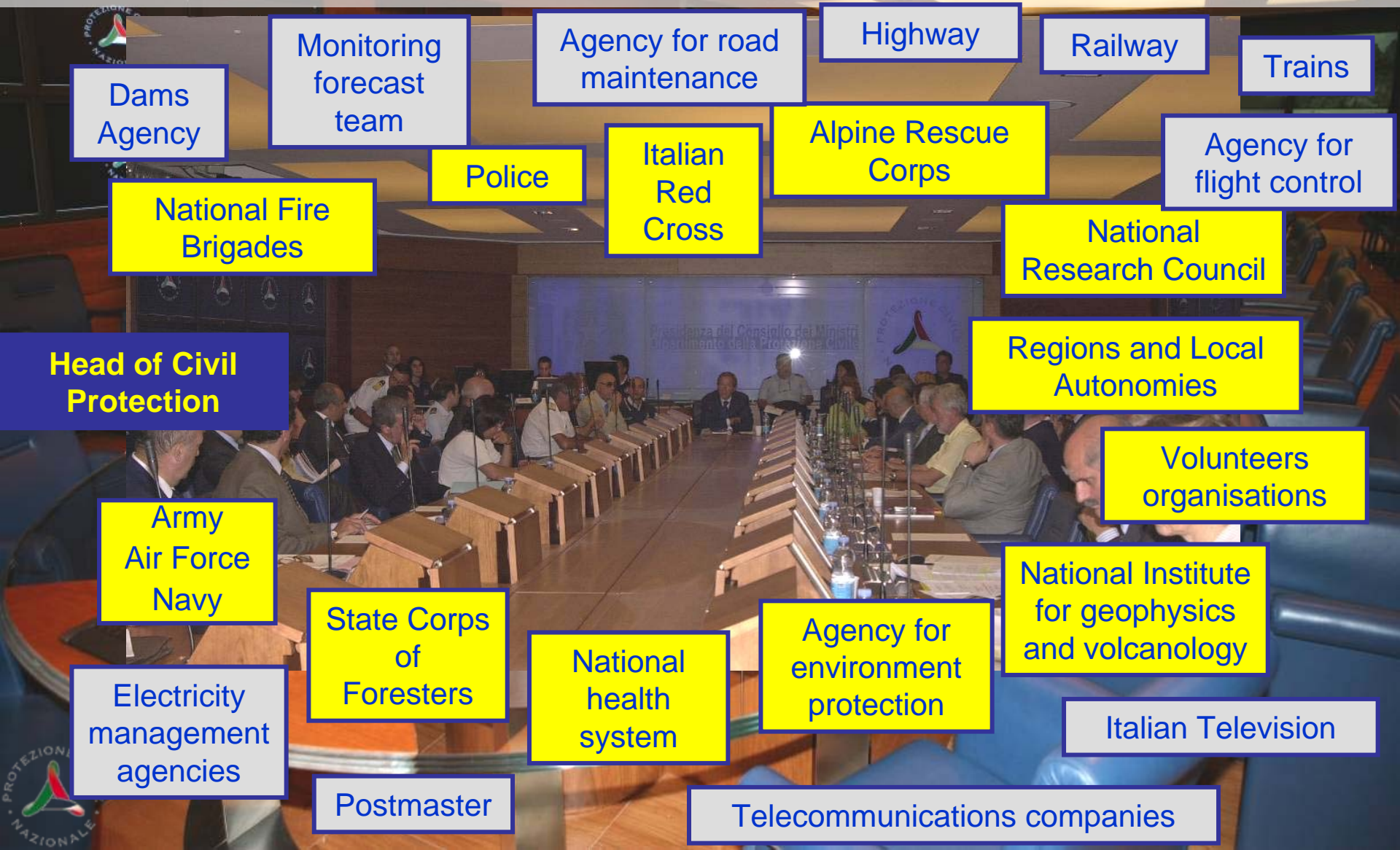
# The first response of CP System



# CO-ORDINATION

## An Operational Committee

is set up within the Department of Civil Protection to ensure a unified direction and coordination of emergency management





**COMITATO OPERATIVO NAZIONALE**

**COMITATO OPERATIVO IN LOCO**

**Commissione  
Grandi Rischi**

**DICOMAC**

**COM 1**  
L'Aquila

**COM 2**  
San Demetrio

**COM 3**  
Pizzoli

**COM 4**  
Pianola

**COM 5**  
Paganica

**COM 6**  
Navelli

**COM 7**  
Sulmona

**COM 8**  
Montorio al  
Vomano

**1**  
Comune

**12**  
Comuni

**9**  
Comuni

**8**  
Comuni

**10**  
frazioni

**14**  
Comuni

**20**  
Comuni

**15**  
Comuni

# AUXILIARY FUNCTIONS



Technical and  
Scientific Support



Lifelines



Health Assistance



Damage Survey



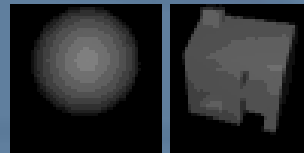
Mass media and  
Information  
Management



Search and Rescue  
activities



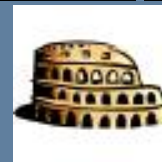
Volunteers



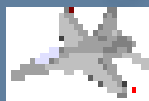
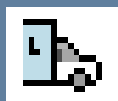
Local Government



Resources  
Management



Cultural Heritage



Transport and  
Viability Control



Assistance to  
people



Telecommunications



Operational  
Co-ordination

**Personnel deployed:**

**MORE THAN**

**12 000**

**PEOPLE INVOLVED IN  
THE EMERGENCY  
ACTIVITIES**

*Last Update - 16.04.2009*

<b>Organization</b>	<b>Units</b>
VVF	2245
VVF - CAPI	10
Forze Armate	1487
Corpo Forestale dello Stato	138
Polizia di Stato	647
Arma dei Carabinieri	214
Guardia di Finanza	286
EI SMOM	10
CRI	500
Colonne mobili regionali	3367
organizzazioni nazionali volontariato	2.296
CISOM	80
CNSAS	2
ISPRA	10
CNR	15
ENEA	7
INGV	36
ENAV	4
H3G	10
TERNA	11
AUTOSTRAD	10
AISCAT	167
ANAS	50
POSTE ITALIANE	49
GRUPPO FERROVIE DELLO STATO	10
ENEL	235
PROVINCIA AQ	252
DPC	120
<b>Total</b>	<b>12268</b>





**Search and Rescue activities**





L'Aquila  
6/7 aprile



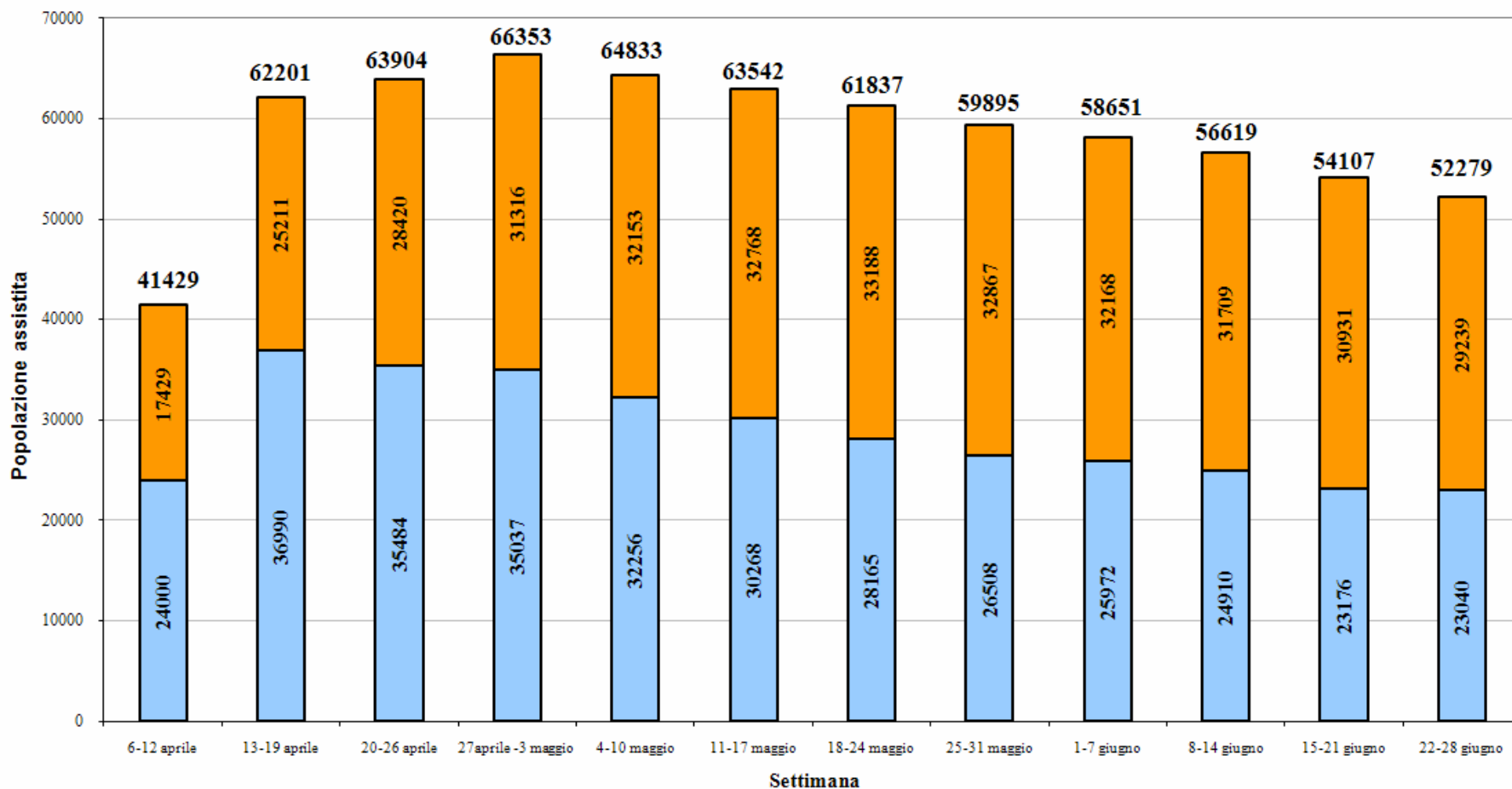
# About 66 000 people assisted



## Media settimanale tipo alloggio popolazione

aggiornamento ore 8.00 del 28.06.2009

- Popolazione assistita in strutture
- Popolazione assistita in tendopoli



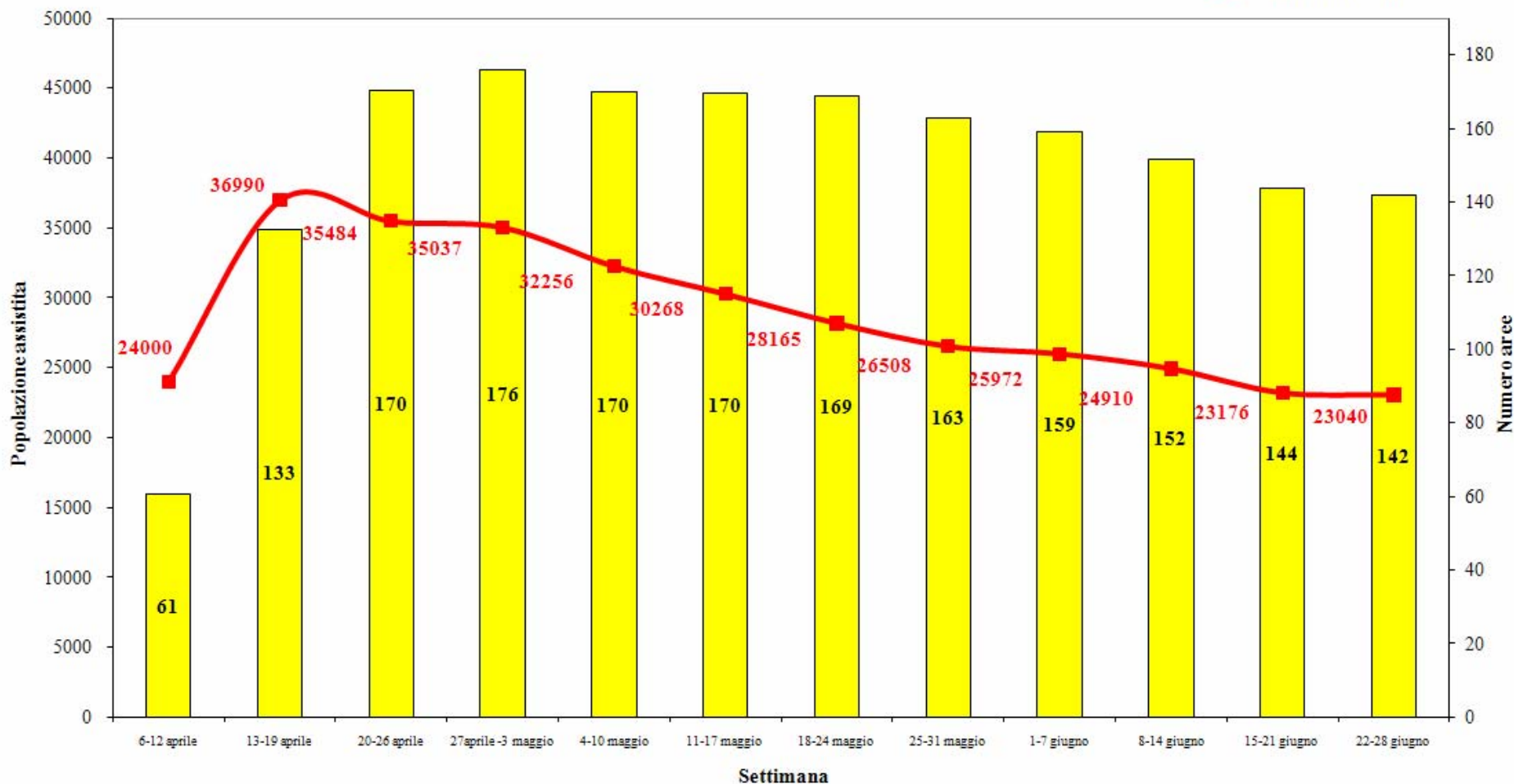
# People assisted - Tents



## Media settimanale popolazione assistita - aree di ricovero

aggiornamento ore 08.00 del 28.06.2009

■ Aree di ricovero  
■ Popolazione assistita

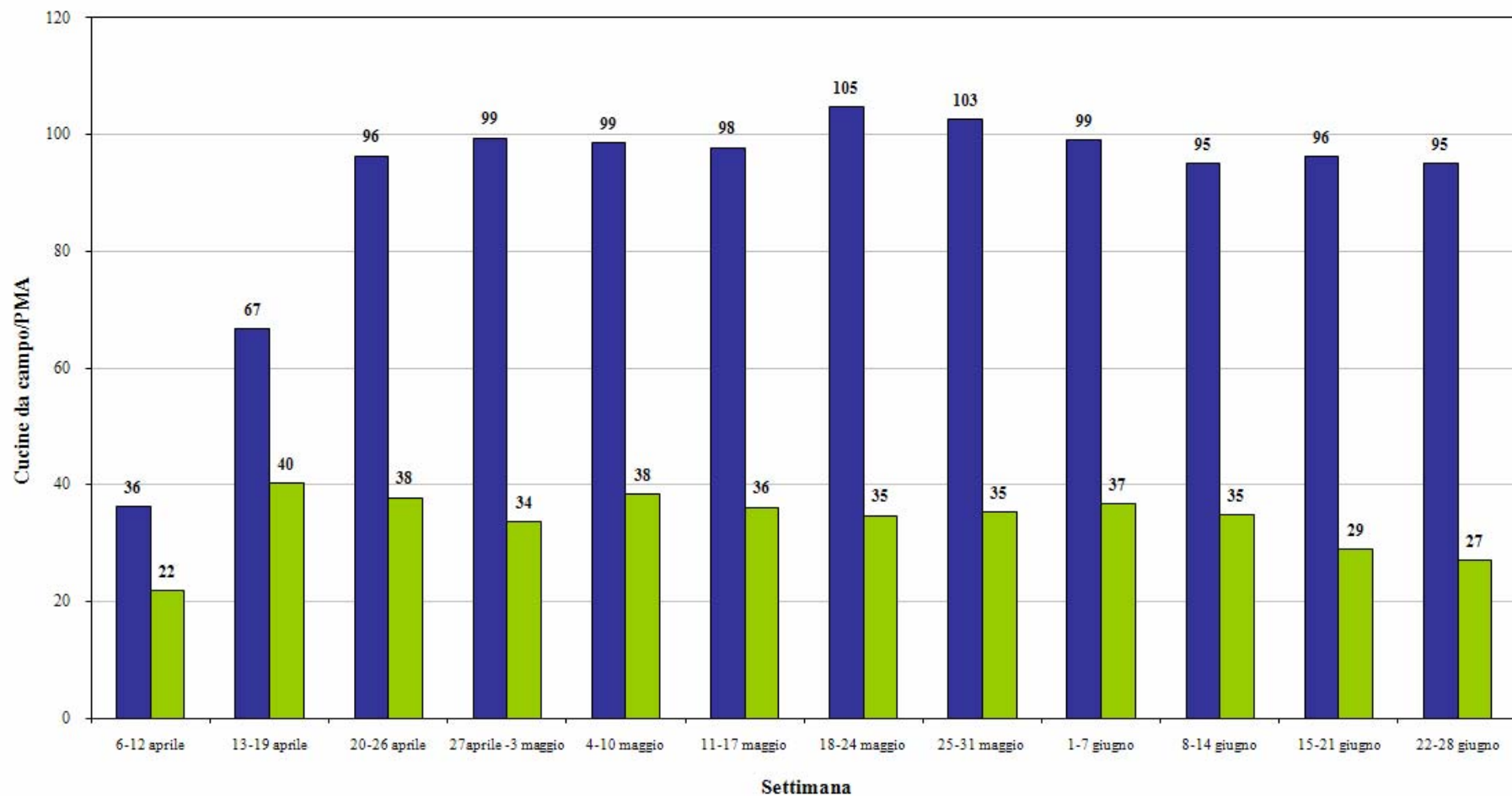


### Media settimanale cucine da campo - PMA

aggiornamento ore 08.00 del 28.06.2009

■ Cucine da campo

■ PMA/presidi sanitari



## PHASES 2-3: POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

2' → 5'	<b><i>EPICENTER AND MAGNITUDE EVALUATION</i></b>	<b><i>Collecting and processing of seismometric network data by INGV</i></b>
15' →60'	<b><i>SIMULATED DAMAGE SCENARIOS AND DATA PROCESSING OF MONITORING SYSTEMS</i></b>	<b><i>Software simulation of the earthquake impact on constructions, Collecting and processing of soil and strategic building accelerometric data</i></b>
6 h → 150 h	<b><i>SITE SURVEYS FOR MACROSEISMIC AND COSEISMIC EFFECTS</i></b>	<b><i>Site evaluation of Mercalli Intensity, Geological surveys for landslides, surface faulting and soil liquefaction</i></b>
6 h → 3 m	<b><i>TEMPORARY MONITORING OF SOIL AND STRUCTURES</i></b>	<b><i>Installing of temporary soil accelerometric stations and structure monitoring systems</i></b>
24 h →6 m	<b><i>POST – EARTHQUAKE DAMAGE AND SAFETY ASSESSMENT</i></b>	<b><i>Building inspections for damage and usability assessment. Provisional works. Temporary housing.</i></b>

Event ID = 1193569040 Del : 21/10/2006 Ore : 07:04:10.84

Non siete connessi al sistema automatico !!!\Tokyo\D\$

Ora GMT : 19:08:55 Ora Locale : 20:08:55  
 Pulisci mappa >> Visualizza un punto >>  
 Lat. 43.641 Long. 13.03

Mappe Sismicità Mini GIS Log Visualizza Eventi Controlla Acquisizione Stampa

Lista eventi sismici Evento : 0704

Tokyo Kyoto

sabato 21 ottobre 2006

EV\_0704\_A\_04.txt  
 EV\_0704\_A\_05.txt  
 EV\_0704\_A\_06.txt  
 EV\_0704\_A\_07.txt  
 EV\_0704\_A\_08.txt  
 EV\_0704\_A\_09.txt  
 EV\_0704\_A\_10.txt  
 EV\_0704\_A\_11.txt  
 EV\_0704\_A\_M1.txt  
 EV\_0704\_A\_M2.txt  
 EV\_0704\_A\_WW.txt  
 EV\_0704\_A\_XX.txt  
 EV\_0758\_A\_01.txt

19 : Eventi def. XX  
 EV\_0156\_A\_XX.txt  
 EV\_0348\_A\_XX.txt  
 EV\_0633\_A\_XX.txt

Opzioni di visualizzazione  
 Visualizza localizzazioni temporanee  
 Visualizza stazioni non triggerate  
 Visualizzare più eventi alla volta  
 Visualizza etichetta dell'evento  
 Visualizzare solo le riviste WW

Scegli un operazione :

Visualizza dettagli Rilocalizza Evento Evento su Mappa AGENDA Comunicati Pro. Civ.

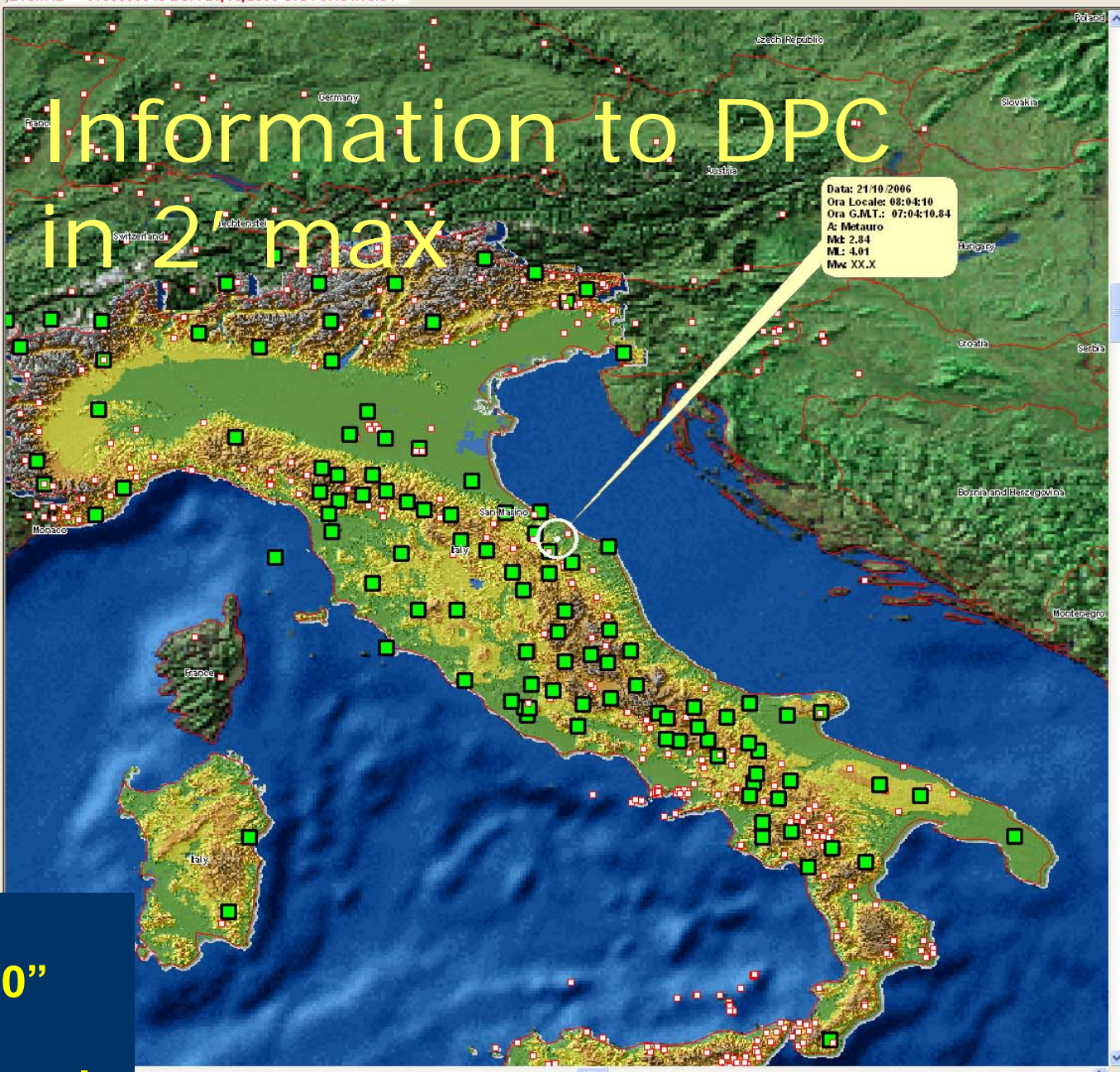
Zona **Metauro**

Dati Dell'evento selezionato

Tipo Loca. **XX** Qualità Loca. **BA** Md **2.84** MI **4.01**  
 Profondità **38.4 Km.** BUONA Ms **XXX** Mw **XXX**  
 Data **21/10/2006**  
 Ora **07:04:10.84 GMT**  
 Lat./Long. **43.641 13.03** Numero Stazioni **0128**

Num	Nome	Peso	Distanza in (	Rete
1	FSSB	81	19	IV
2	CING	99	29	IV
3	PESA	98	33	IV
4	BADI	23	58	IV
5	ADI	100	42	IV
6	MURB	86	53	IV
7	RSM	95	51	IV
8	CDCA	91	61	IV
9	SNTG	34	39	IV
10	ASS	88	64	IV

Calcolo Magnitudo Durata  
 Durata in mm Magnitudo Intensità



# Information to DPC in 2' max

**Example M 4.0**  
**First locations after 30"**  
**Final after 120-200"**  
**ML based on 159 channels**



# RAPPORTO E.S.

## Rapporto Emergenza Sismica



Scala  
di  
emergenza  
sismica

- Scenario average estimates: about**
- 1200 people involved in building collapse
  - 26000 homeless
  - 18000 unusable dwellings
  - 135000 damaged dwellings

### Evento sismico

Comune epicentrale L'Aquila (L'Aquila)

Data 06-04-09 Longitudine 13.33

Ora 03.32 Latitudine 42.33 Magnitudo MI 5.8

### Stime complessive (Attenzione: scenario calcolato su una profondità media ipocentrale di 10 km)

Probabili persone coinvolte in crolli (min-max)	200	2200
Probabili persone senza tetto (min-max)	8700	54000
Probabili abitazioni crollate o inagibili (min-max)	6700	38000
Probabili abitazioni danneggiate (min-max)	61000	207000
Probabile Intensità (MCS) massima raggiunta		VIII-IX
Probabili COM/Prefetture da allertare	16 (+ 46 con ES = 0 )	
Comuni afferenti ai COM		284 (+ 244 )





# Real data

- **300 victims**

22 bambini (*età inferiore ai 16 anni*)

173 femmine

119 maschi

- **1500 injured**

- **65.579 assisted people**

- **44.533 buildings (population 130.008) to be inspected in the area of Intensity VI (MCS scale). From the first 60000 surveys about 25% of the buildings inspected results severely damaged**

## DPC – STRONG MOTION NETWORK (RAN)

▲ 213 digital stations connected via GPRS/GSM

▲ 11 remote digital stations

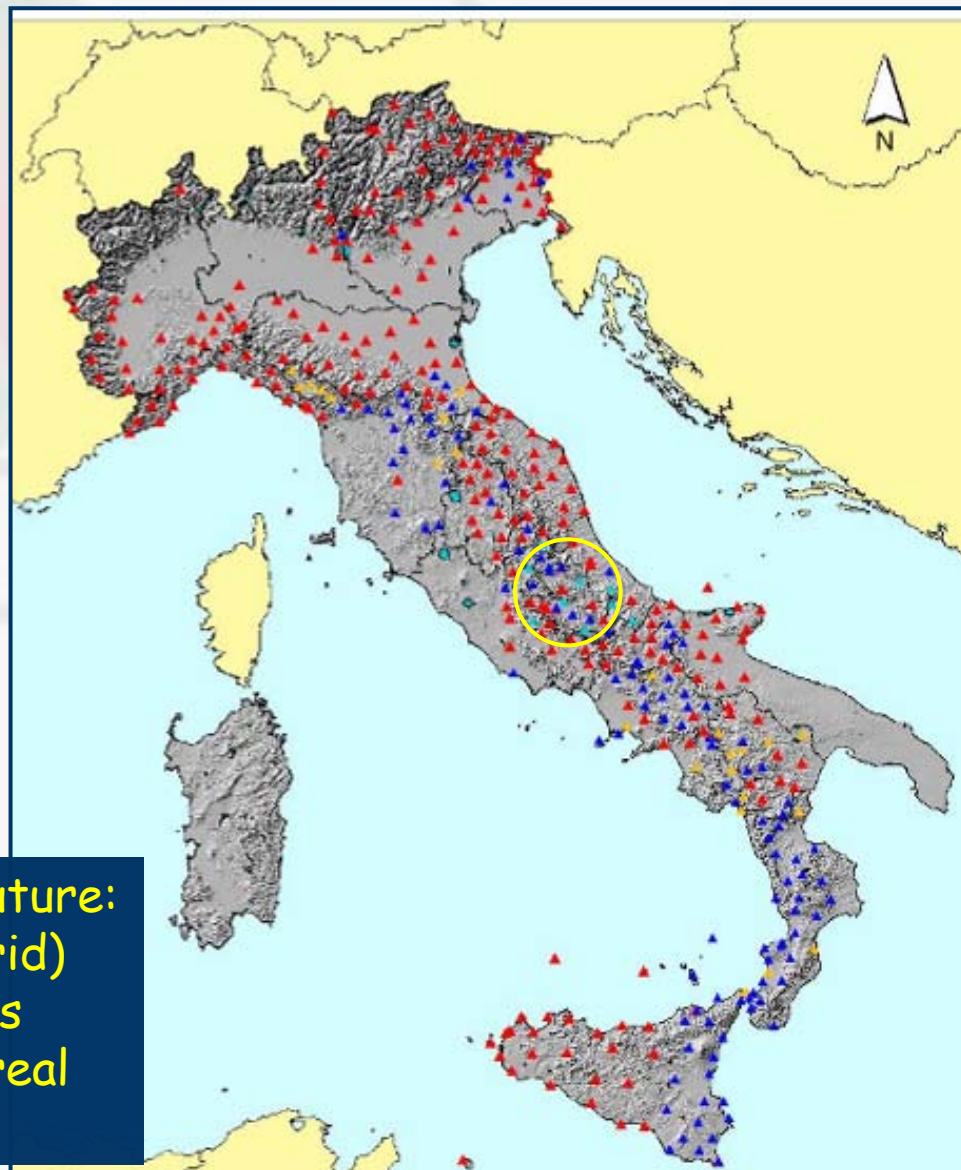
▲ 130 scheduled digital stations  
(within 2008)

119 analogic stations are not included  
in the map



typical  
arrangement  
of a station

In the near future:  
570 (20 km grid)  
digital stations  
connected in real  
time



# RAN - RETE ACCELEROMETRICA NAZIONALE

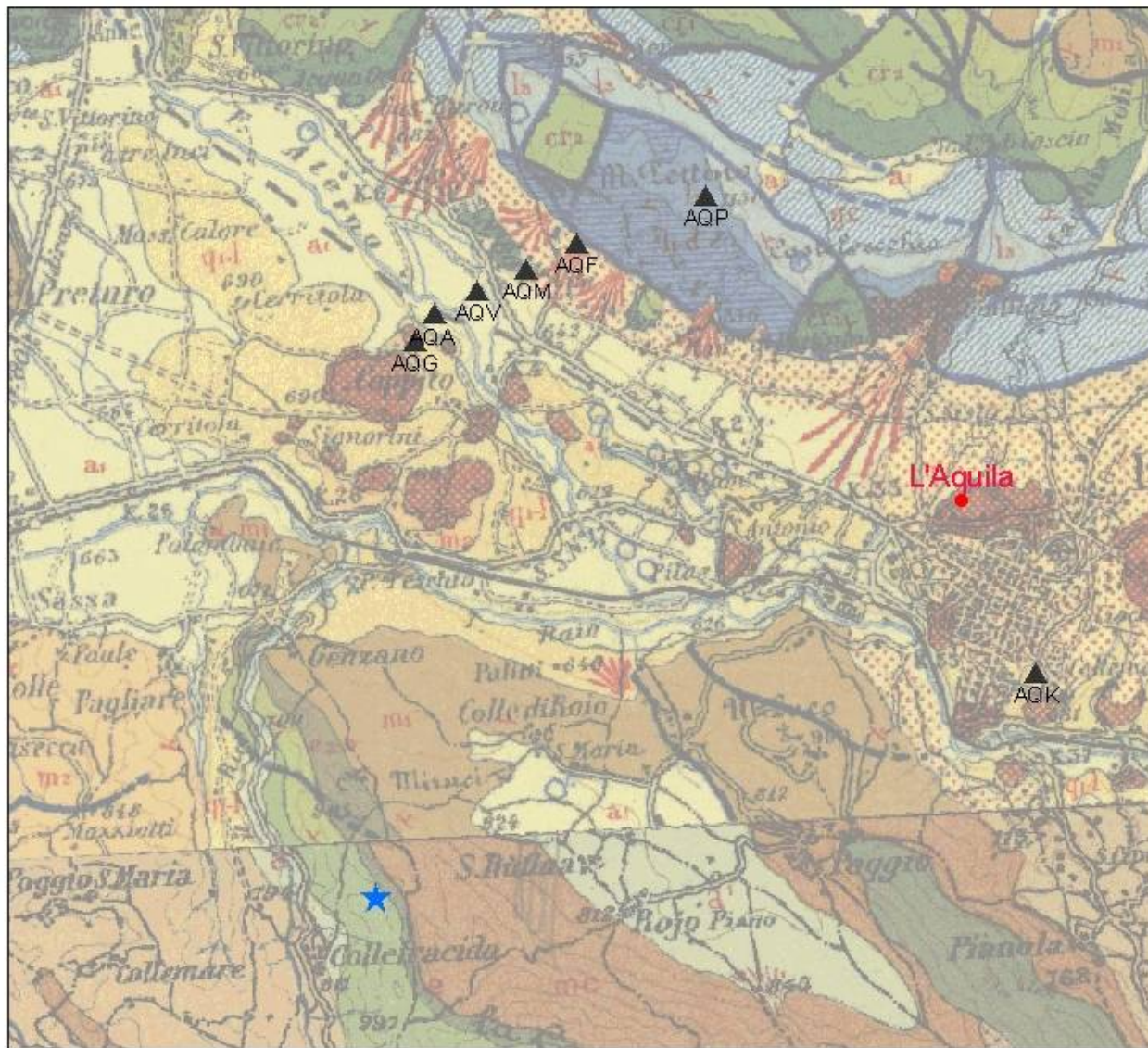
TERREMOTO DEL 6 APRILE 2009 - ore 01:32 (UTC) - AQUILANO - M = 5.8

N.	Codice record	Codice stazione acc.	Località	Provincia	Regione	Lat N	Long E	PGA (cm/s <sup>2</sup> )	Distanza epicentrale (km)
1	GX066	aqv	L'Aquila - V. Aterno - Centro Valle	L'Aquila	ABRUZZO	42,377	13,344	662,599	4,80
2	FA030	aqg	L'Aquila - V. Aterno - Colle Grilli	L'Aquila	ABRUZZO	42,373	13,337	504,921	4,30
3	CU104	aqa	L'Aquila - V. Aterno - F. Aterno	L'Aquila	ABRUZZO	42,376	13,339	478,000	5,80
4	AM043	aqk	Aquil PARK ing.	L'Aquila	ABRUZZO	42,345	13,401	366,285	5,60
5	EF021	gsa	GRAN SASSO (Assergi)	L'Aquila	ABRUZZO	42,421	13,519	148,862	18,00
6	TK033	cln	CELANO	L'Aquila	ABRUZZO	42,085	13,521	89,381	31,60
7	BI106	avz	AVEZZANO	L'Aquila	ABRUZZO	42,027	13,426	67,687	34,90
8	CR008	orc	ORTUCCHIO	L'Aquila	ABRUZZO	41,954	13,642	64,399	49,40
9	BY048	mtr	MONTEREALE	L'Aquila	ABRUZZO	42,524	13,245	62,233	22,40
10	CR003	sul	SULMONA	L'Aquila	ABRUZZO	42,089	13,934	33,656	56,50
11	EK007	cht	CHIETI	Chieti	ABRUZZO	42,370	14,148	29,411	67,10
12	GE1463	gsq	GRAN SASSO (Lab. INFN galleria)	L'Aquila	ABRUZZO	42,460	13,550	29,165	22,60
13	BX007	fmg	FIAMIGNANO	Rieti	LAZIO	42,268	13,117	26,352	19,30
14	DF006	ant	ANTRODOCO	Rieti	LAZIO	42,418	13,079	25,939	23,10
15	BY003	cso1	CARSOLI 1	L'Aquila	ABRUZZO	42,101	13,088	18,295	33,00
16	EI160	boj	BOJANO	Campobasso	MOLISE	41,484	14,472	14,171	133,50
17	BH003	cds	CASTEL DI SANGRO	L'Aquila	ABRUZZO	41,787	14,112	9,956	88,50
18	BN048	tmo	TERMOLI	Campobasso	MOLISE	41,989	14,975	9,843	140,90
19	ZC002	lss	LEONESSA	Rieti	LAZIO	42,558	12,969	9,625	39,10
20	HB060	spo	SPOLETO	Perugia	UMBRIA	42,734	12,741	9,585	65,90
21	BS029	css	CASSINO	Latina	LAZIO	41,486	13,823	9,436	102,70
22	CU008	mmp1	MOMPEO 1	Rieti	LAZIO	42,249	12,748	8,855	49,20
23	BW024	spc	SPOLETO (cantina)	Perugia	UMBRIA	42,743	12,740	7,572	66,70
24	BC018	isr	ISERNIA	Isernia	MOLISE	41,611	14,236	7,186	109,70
25	AL104	ptf	PETRELLA TIFERNINA	Campobasso	MOLISE	41,696	14,702	6,855	133,70
26	CQ001	sbc	SUBIACO	Roma	LAZIO	41,913	13,106	6,680	50,50
27	CB004	ass	ASSISI	Perugia	UMBRIA	43,075	12,604	6,050	101,70
28	AY026	scp	SERRACAPRIOLA	Foggia	PUGLIA	41,807	15,165	5,621	162,40
29	IY045	ssr	S. SEVERO	Foggia	PUGLIA	41,691	15,374	5,349	183,40

N.	Codice record	Codice stazione acc.	Località	Provincia	Regione	Lat N	Long E	PGA (cm/s <sup>2</sup> )	Distanza epicentrale (Km)
30	AU056	cmr	CASTELMAURO	Campobasso	MOLISE	41,833	14,712	5,286	126,90
31	AY081	ctl	CATTOLICA	Rimini	EMILIA R.	43,955	12,736	4,371	186,60
32	BD004	scm	S. CROCE DI MAGLIANO	Campobasso	MOLISE	41,711	14,984	4,230	153,20
33	CA056	sns	SANSEPOLCRO	Arezzo	TOSCANA	43,567	12,143	3,828	168,00
34	QX001	vrp	VAIRANO PATENORA	Caserta	CAMPANIA	41,333	14,132	3,531	129,40
35	BB007	sep	S. ELIA A PIANISI	Campobasso	MOLISE	41,625	14,880	3,514	150,40
36	GK004	cmb	CAMPOBASSO	Campobasso	MOLISE	41,563	14,652	2,905	138,90
37	BM444	nap	NAPOLI Ovest	Napoli	CAMPANIA	40,799	14,180	2,609	184,50
38	FO003	tls	TELESE TERME	Benevento	CAMPANIA	41,222	14,530	2,602	158,50
39	AY017	ric	RICCIA	Campobasso	MOLISE	41,483	14,838	2,515	156,50
40	QI081	mnn	MANFREDONIA	Foggia	PUGLIA	41,634	15,911	2,366	227,30
41	DF032	snm	SAN MARINO		EMILIA R.	43,934	12,449	2,322	191,80
42	BU012	mng	MONTE S. ANGELO	Foggia	PUGLIA	41,704	15,958	2,315	228,40
43	AR042	gnl	GENZANO DI LUCANIA	Potenza	BASILICATA	40,843	16,033	2,210	279,40
44	DM033	vie	VIESTE	Foggia	PUGLIA	41,877	16,165	2,205	239,70
45	BX001	bne	BENEVENTO	Benevento	CAMPANIA	41,128	14,785	2,040	180,40
46	EC009	can	CANDELA	Foggia	PUGLIA	41,203	15,475	2,025	218,00
47	AV122	bdt	BADIA TEDALDA	Arezzo	TOSCANA	43,707	12,188	1,991	178,80
48	BS035	sdq	S. GIOVANNI ROTONDO	Foggia	PUGLIA	41,709	15,733	1,985	192,00
49	BQ056	cnm	CASALNUOVO MONTEROTARO	Foggia	PUGLIA	41,618	15,105	1,877	166,90
50	EB150	cer	CERIGNOLA	Foggia	PUGLIA	41,260	15,910	1,750	245,20
51	AT182	for	FORLI'	Forli - Cesena	EMILIA R.	44,199	12,042	1,615	232,30
52	AR006	pdm	PIEDIMONTE MATESE	Caserta	CAMPANIA	41,355	14,385	1,509	139,40
53	BG067	stn	STURNO	Avellino	CAMPANIA	41,018	15,112	1,376	208,00
54	BA125	avl	AVELLINO	Avellino	CAMPANIA	40,923	14,787	1,278	198,10
55	BM130	pic	PIANCASTAGNAIO	Siena	TOSCANA	42,850	11,685	1,244	147,10
56	AO008	bbn	BIBBIENA	Arezzo	TOSCANA	43,748	11,821	1,002	199,60
57	EH008	stl	SATRIANO DI LUCANIA	Potenza	BASILICATA	40,541	15,642	0,948	277,40

- I files con codice alfanumerico (es.: AX006) si riferiscono a registrazioni accelerometriche di strumenti digitali e sono dati in formato ascii.
- Le registrazioni digitali, in unità di (cm/s<sup>2</sup>), sono suddivise per le tre componenti del moto; Longitudinale (YLN), Trasversale (XTE), Verticale (ZUP) più un header (HDR) e sono tutte campionate a 200 campioni al secondo (sps).
- Gli strumenti digitali della RAN sono dotati di ricevitore GPS e quindi hanno un riferimento temporale che ne consente l'associazione univoca all'evento sismico.

**Distribution of the RAN stations nearest to the epicentre of the main shock**



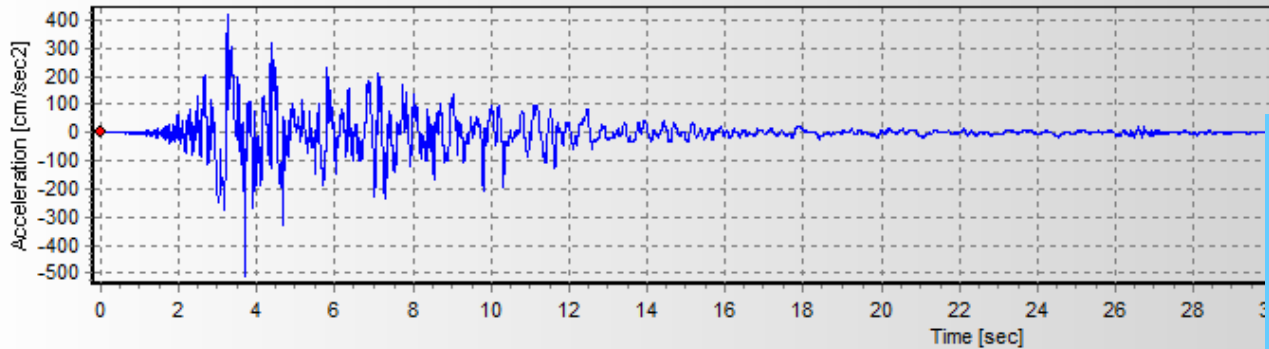
### Legend

★ Epicentro main shock

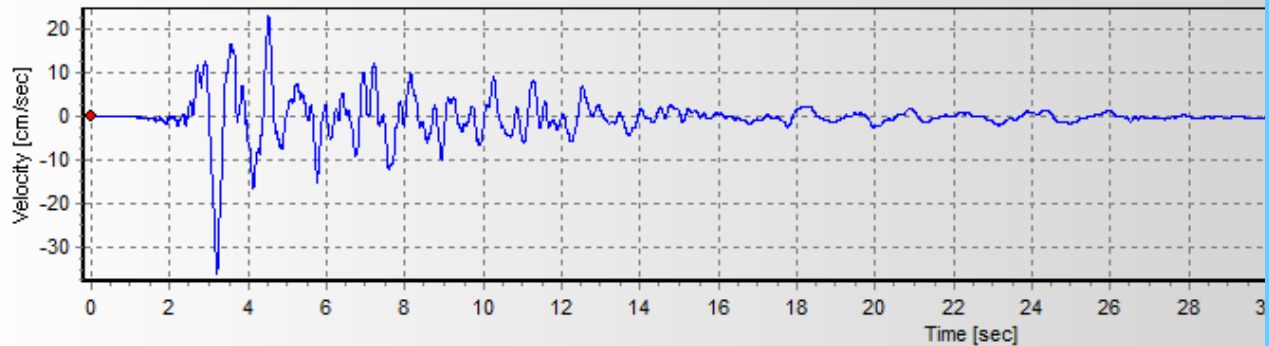
▲ Stazioni RAN



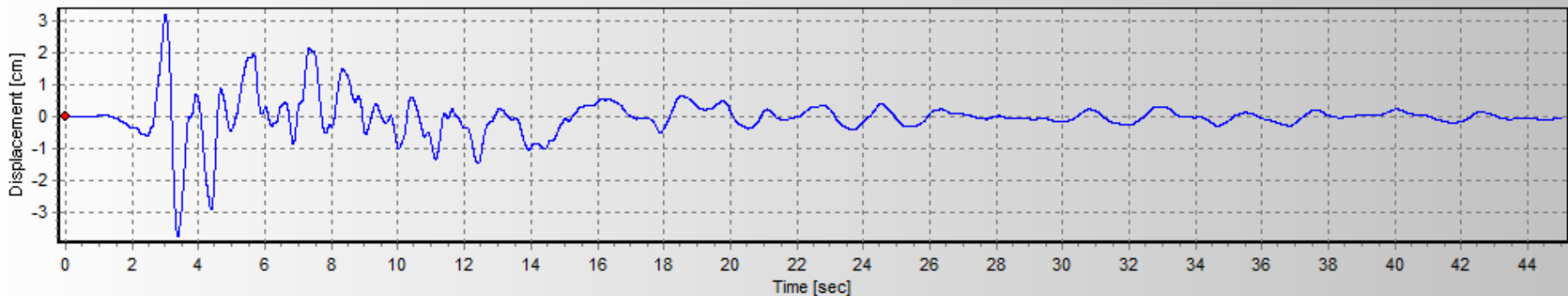
6 aprile **AQg**  $M_I=5.8$   $R_{epi}=4.3$  km comp EW



**Maximum Acceleration:**  
**510.83843994cm/sec<sup>2</sup>**  
**at time t=3.68sec**



**Maximum Velocity:**  
**35.95829093cm/sec**  
**at time t=3.205sec**

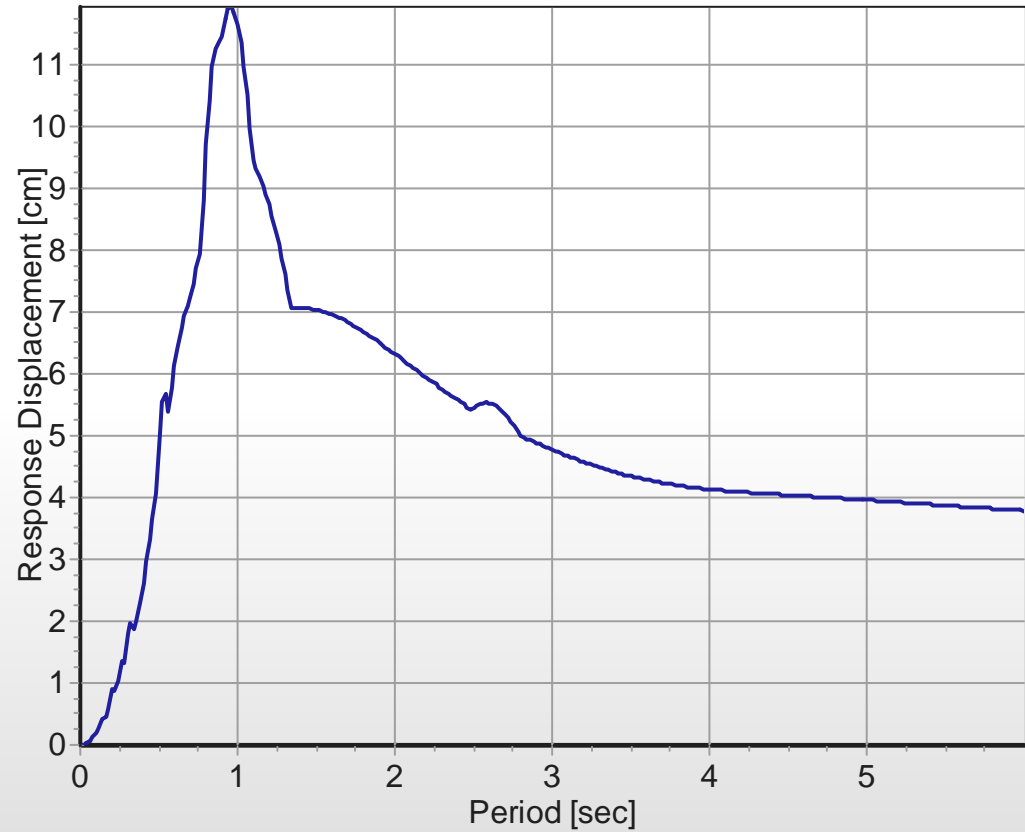
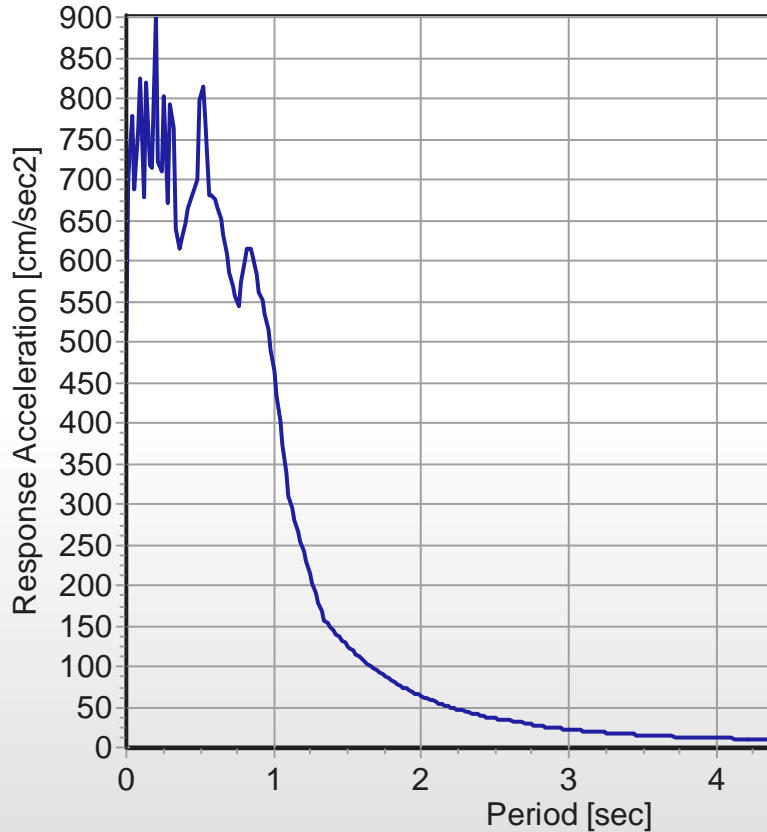


**Maximum Displacement:**  
**3.75762048cm**  
**at time t=3.37sec**

6 aprile **AQg**  $M_l=5.8$   $R_{epi}=4.3$  km comp **EW**

Spettri di accelerazione e spostamento al 5%

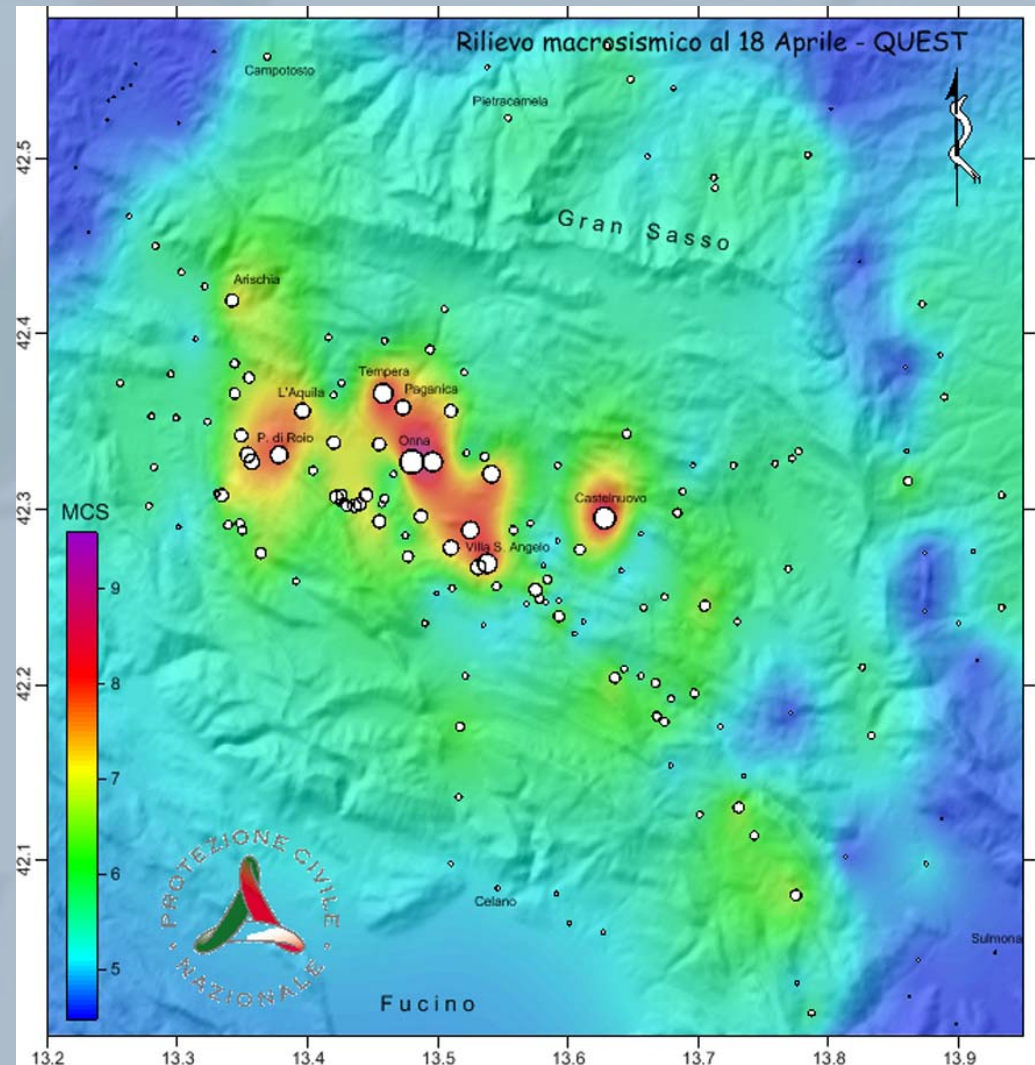
Stazione Aquila –Colle dei Grilli all'estremità SW della valle dell'Aterno con  $PGA=0.5$  g



## MACROSEISMIC SURVEY (QUEST)

Technical teams carry out a quick damage survey to produce a macroseismic map of the territory and identify the most affected areas

## ABRUZZO EQ MACROSEISMIC SURVEY





# GEOLOGICAL SURVEY

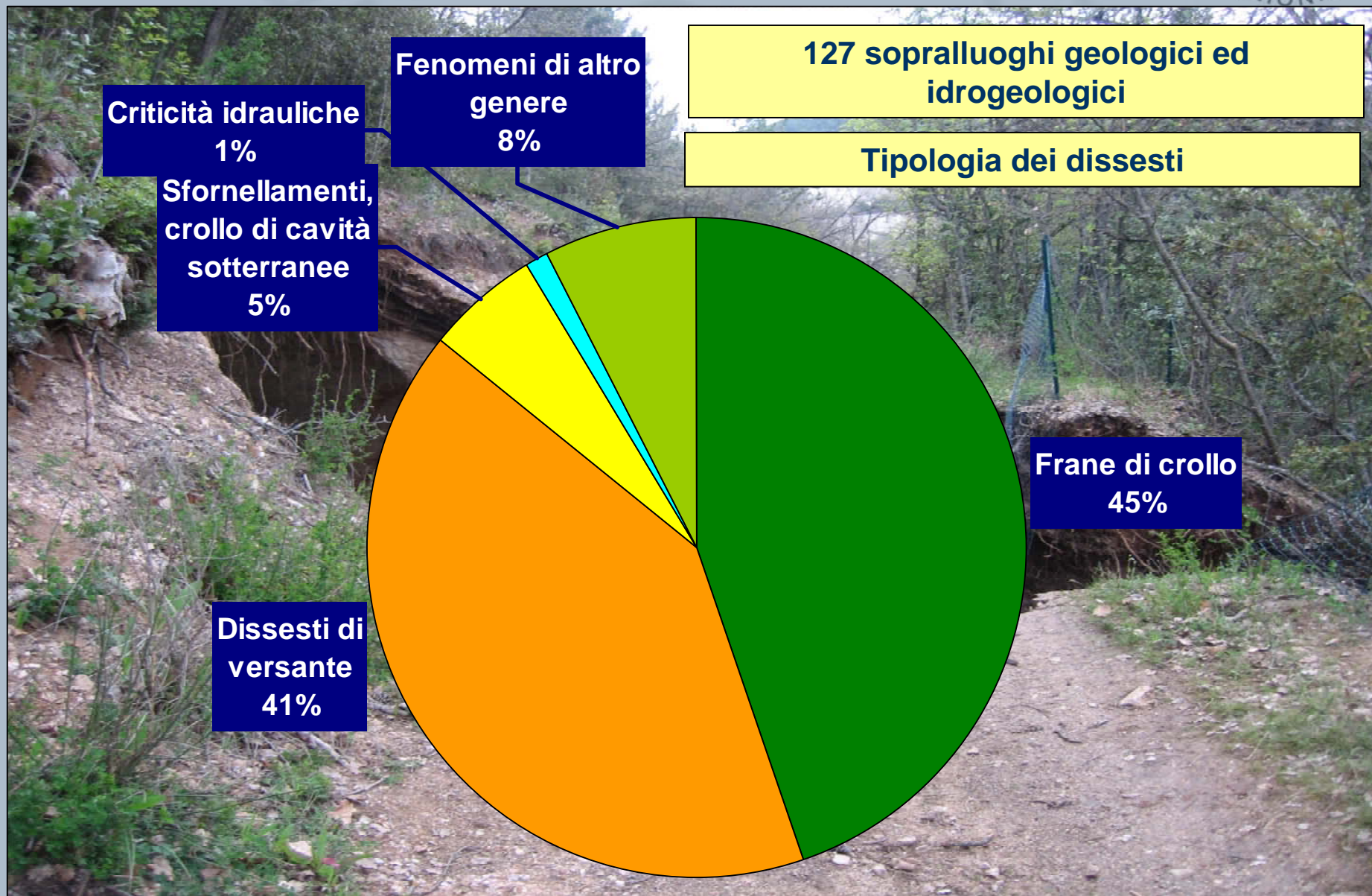


Technical teams carry out surveys aimed at recognising, mapping and evaluating earthquake effects on the natural environment:

- landslides
- surface faulting and fracturing
- soil liquefactions



# Hydrogeological phenomena



## San Demetrio nei Vestini

(coordinate- . 42,2909 -13,5765)

Tipo effetto: Frane spondali

Descrizione: Crepacci e fenditure nel terreno con parziale franamento delle sponde del lago, probabile variazione livello acqua



ISP - AQ10



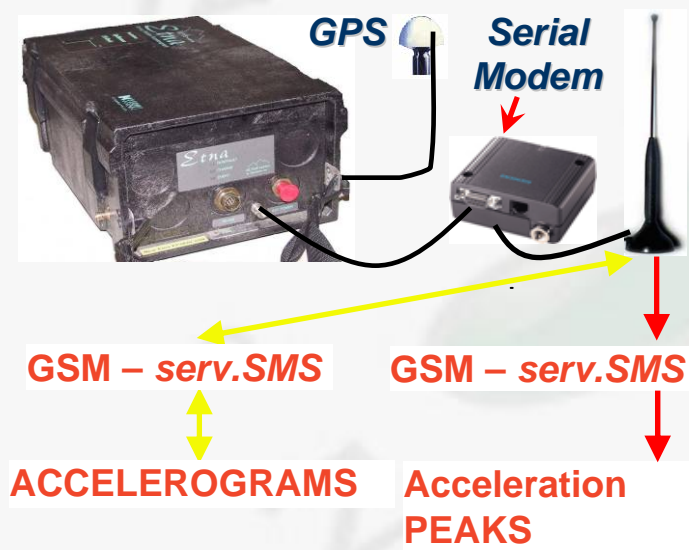
ISP - AQ10



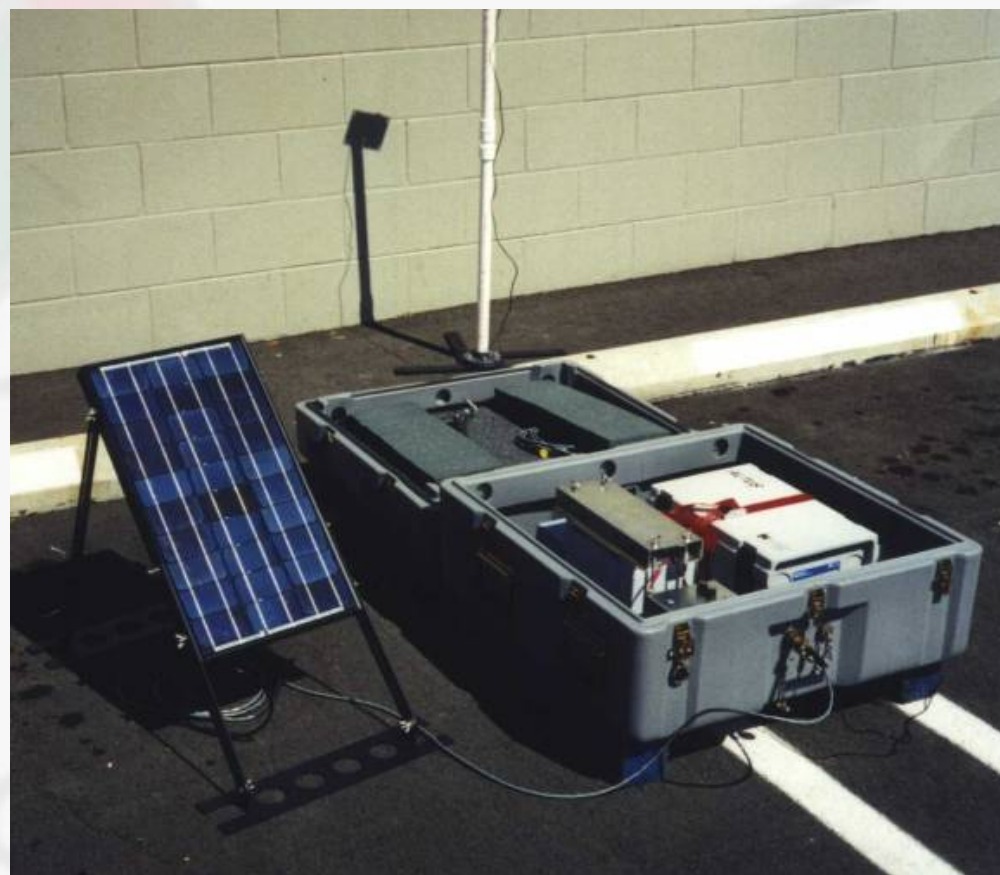
ISP - AQ10

# TEMPORARY STRONG MOTION MONITORING NETWORK

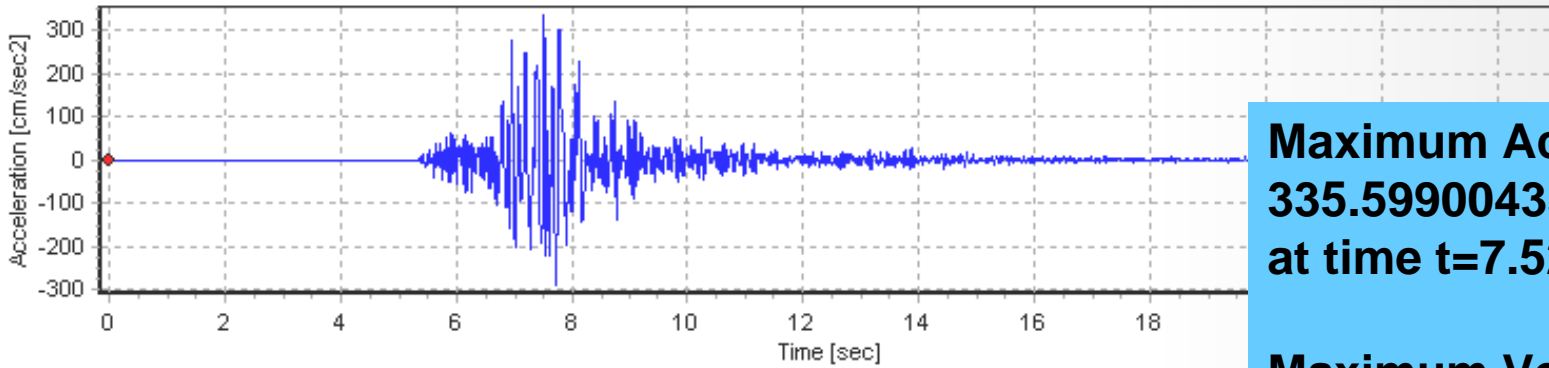
In order to increase the amount of strong motion data during the aftershocks, a mobile strong motion network is installed in the epicentral area



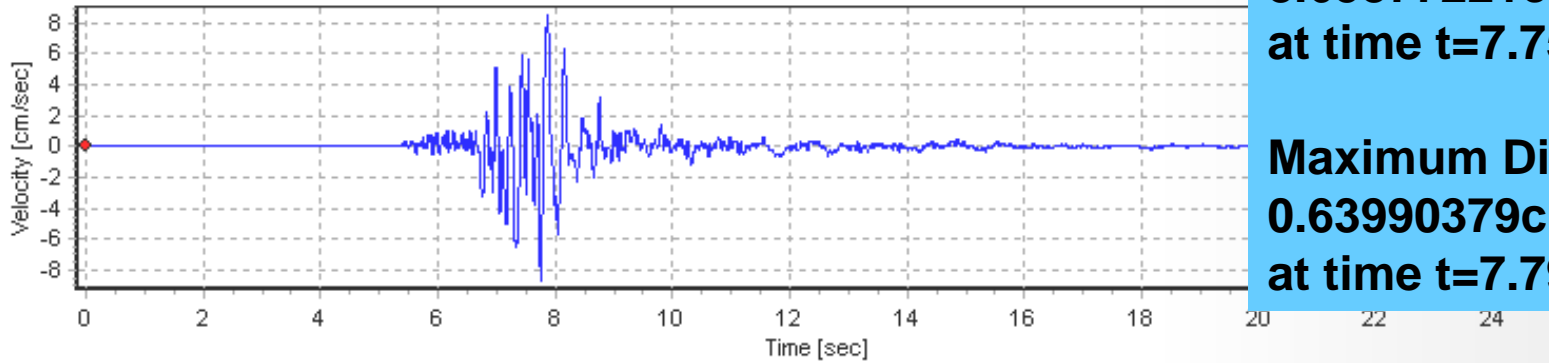
**Portable instrument  
(mobile network)**



# Poggio Cancelli DAM 09/04 21.38 MI=4.9 Repi =7.1 km comp

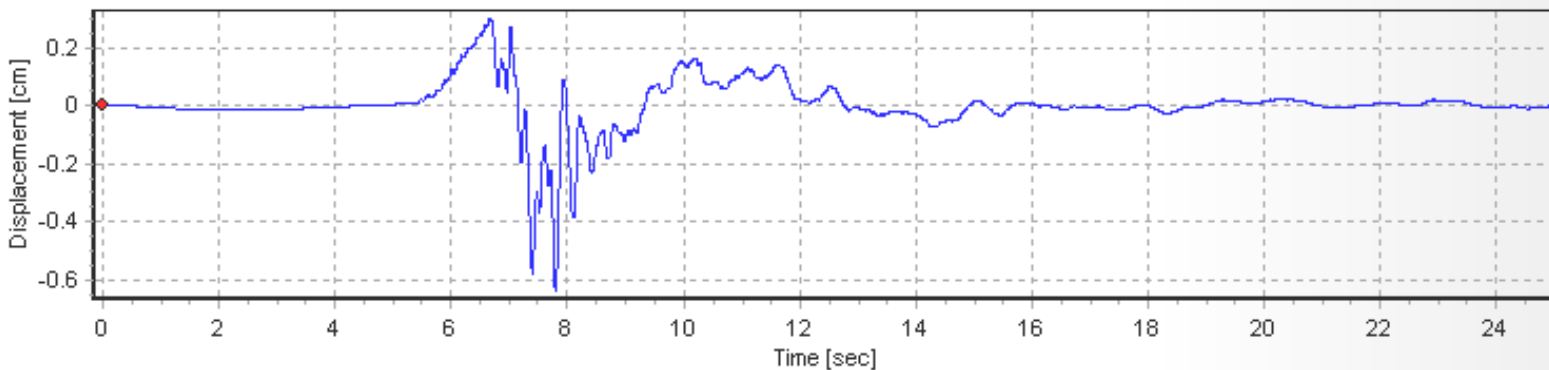


**Maximum Acceleration:**  
**335.59900435cm/sec<sup>2</sup>**  
**at time t=7.52sec**



**Maximum Velocity:**  
**8.65877221cm/sec**  
**at time t=7.75sec**

**Maximum Displacement:**  
**0.63990379cm**  
**at time t=7.79sec**

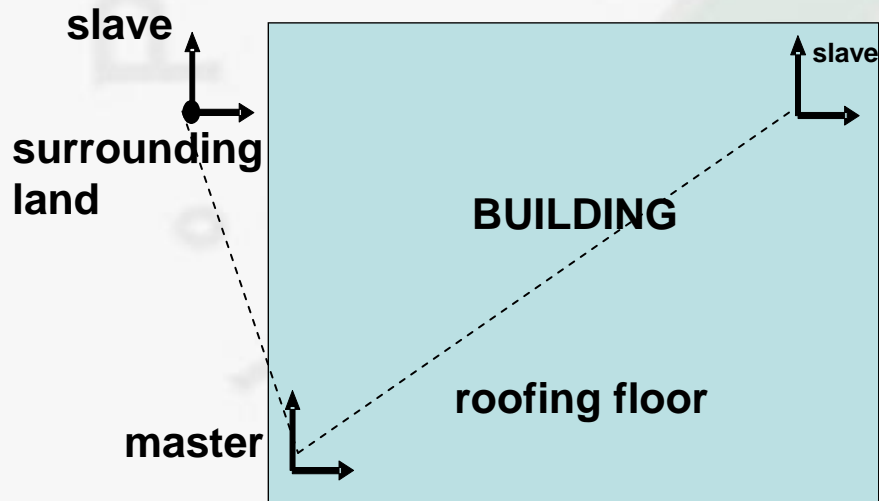


Current number of DPC-RAN fixed and temporary (strong motion) stations in Abruzzo:

- **21** RAN teletransmitting temporary stations activated after the *mainshock* ■
- **17** RAN teletransmitting fixed stations
- **38** total number RAN stations in Abruzzo (+ additional stations by other institutions)

# TEMPORARY MONITORING OF STRUCTURES

To keep under control some fundamental strategic buildings in the affected area (hospitals, etc.) and detect any damage due to aftershocks, 15 monitoring systems have been installed after the earthquake



The upper floor is monitored with two radio-linked biaxial sensors. A triaxial is added in the surrounding land.

Elaborations are made in local mode and immediately transmitted.

visual contact

*Typical sensor layout for temporary monitoring of buildings*

<b>PRESIDENZA DEL CONSIGLIO DEI MINISTRI DIPARTIMENTO DELLA PROTEZIONE CIVILE</b>	<b>OSSERVATORIO SISMICO DELLE STRUTTURE MONITORAGGIO STRUTTURALE NELLE REPLICHE SISMICHE</b>
<b>UFFICIO VALUTAZIONE PREVENZIONE E MITIGAZIONE DEL RISCHIO SISMICO SERVIZIO MONITORAGGIO DEL TERRITORIO E GESTIONE DELLE BANCHE DATI</b>	<b>PARAMETRI MODALI DEGLI EDIFICI MONITORATI</b>

			<b>Freq. 1 [Hz]</b>	<b>Freq. 2 [Hz]</b>	<b>Smorz. 1 [%]</b>	<b>Smorz. 2 [%]</b>
1	Municipio di Pizzoli (AQ) (COM 3)	23-4-2009	4.48 (Long.)	6.47 (Trasv.)	3.9	3.5
2	Scuola materna Via Scarfoglio L'AQUILA (COM 1)					
3	Istituto Comprensivo di San Demetrio Ne' Vestini (AQ) (COM 2)	23-4-2009	5.76 (Long.)	6.41 (Trasv.)	3.6	3.0
4	Corpo centr. Pal.Comando Sc.Guardia Finanza all'Aquila (DICOMAC)	22-4-2009	2.46 (Long.)	4.54 (Trasv.)	4.3	3.1
5	Istituto comprensivo capoluogo di Montereale					
6	Corpo lat.SUD Pal.Comando Sc.Guardia Finanza all'Aquila (DICOMAC)	22-4-2009	2.46 (Long.)	4.52 (Trasv.)	4.5	3.3
7	Corpo lat.NORD Pal.Comando Sc.Guardia Finanza all'Aquila (DICOMAC)	22-4-2009	2.45 (Long.)	4.51 (Trasv.)	4.5	3.1



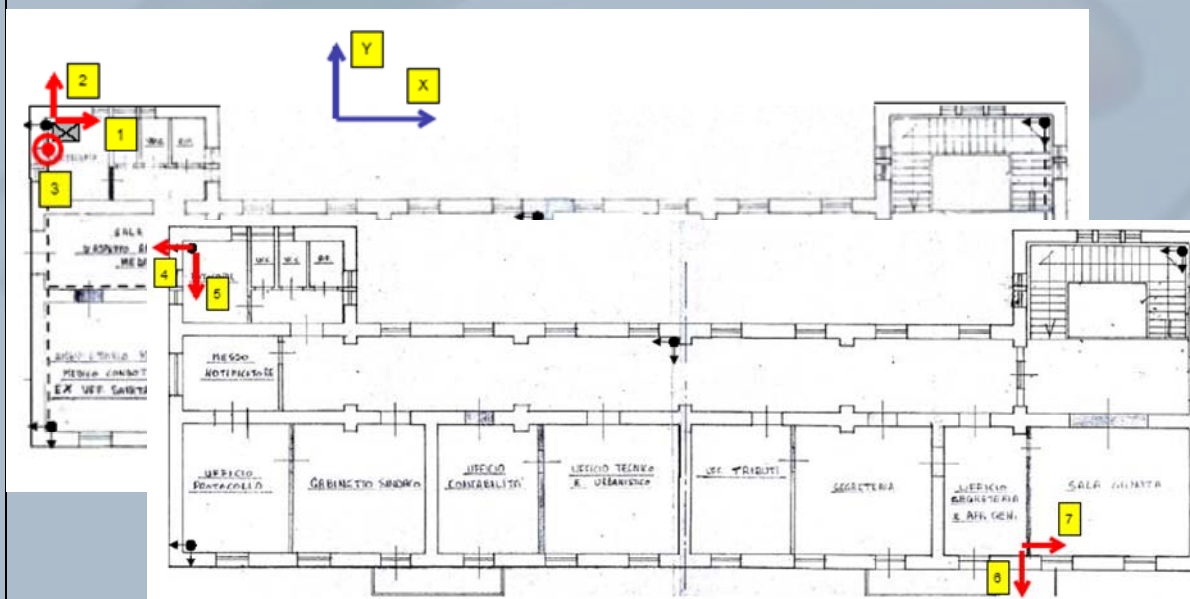
## Struttura

Comune e Provincia	Pizzoli (AQ)
Indirizzo	Piazza Municipio, 13 – 67017 Pizzoli (AQ)
Latitudine; Longitudine	42,4361 N; 13,3017 E
Morfologia	Edificio con piano rialzato e piano primo
Sistema costruttivo	Muratura
Ingombro massimo in pianta	40.90 m x 13.50 m
Altezza alla gronda	10.00 m

Foto



Piante con sensori





<b>Evento</b>	<b>PGA [g] (3)</b>	<b>PSA [g] (4)</b>	<b>Fa=PSA(i)/PGA(i) (5)</b>	<b>Dmax [mm] (6)</b>	<b>DRIFT max [%] (7)</b>
06-04-2009 23:15 UTC M=4.8	0.082 0.073	0.22 A4 (X)	2.68	5.09 A5-A2 (Y)	0.59
07-04-2009 09:26 UTC M=4.7	0.026 0.034	0.11 A7 (X)	4.30	3.00 A7-A1 (X)	0.35
07-04-2009 17:47 UTC M=5.3	0.047 0.069	0.18 A7 (X)	3.76	7.05 A5-A2 (Y)	0.82
07-04-2009 21:34 UTC M=4.2	0.030 0.040	0.10 A7 (X)	3.33	2.36 A7-A1 (X)	0.27
08-04-2009 22:56 UTC M=4.3	0.023 0.019	0.082 A6 (Y)	4.32	1.85 A6-A2 (Y)	0.21
09-04-2009 00:53 UTC M=5.1	0.15 0.14	0.54 A4 (X)	3.60	14.50 A7-A1 (X)	1.69
09-04-2009 03:14 UTC M=4.2	0.011 0.011	0.042 A5 (Y)	3.81	0.99 A5-A2 (Y)	0.12
09-04-2009 04:32 UTC M=4.0	0.011 0.010	0.030 A4 (X)	2.73	0.71 A5-A2 (Y)	0.08
09-04-2009 19:38 UTC M=4.9	0.073 0.065	0.26 A6 (Y)	3.98	6.95 A7-A1 (X)	0.81
13-04-2009 21:14 UTC M=4.9	0.094 0.068	0.22 A6 (Y)	3.22	4.61 A5-A2 (Y)	0.54

# POST-EARTHQUAKE DAMAGE/USABILITY ASSESSMENT

## USABILITY

*Post-earthquake usability evaluation is a quick and temporarily limited assessment, based on expert judgement of specially trained technical teams, on visual screening and on easily collected data, aimed to detect if, during the current seismic crisis, damaged buildings can be used, being reasonably safeguarded the human life.*

<b>A) USABLE</b>	<b>Building can be used without measures. Small damage, but negligible risk for human life.</b>
<b>B) USABLE WITH COUNTERMEASURES</b>	<b>Building is damaged, but can be used when short term countermeasures are taken</b>
<b>C) PARTIALLY USABLE</b>	<b>Only a part of the building can be safely used</b>
<b>D) TEMPORARILY UNUSABLE</b>	<b>Building to be re-inspected. Unusable until the new inspection.</b>
<b>E) UNUSABLE</b>	<b>Building can not be used due to high structural, non structural or geotechnical risk for human life. Not necessarily imminent risk of total collapse.</b>
<b>F) UNUSABLE FOR EXTERNAL RISK</b>	<b>Building could be used, but it cannot due the high risk caused by external factors (heavy damaged adjacent or facing buildings, possible rock falls, etc.)</b>

# Damage and usability assessment

No. of inspections carried out until 18.05.09

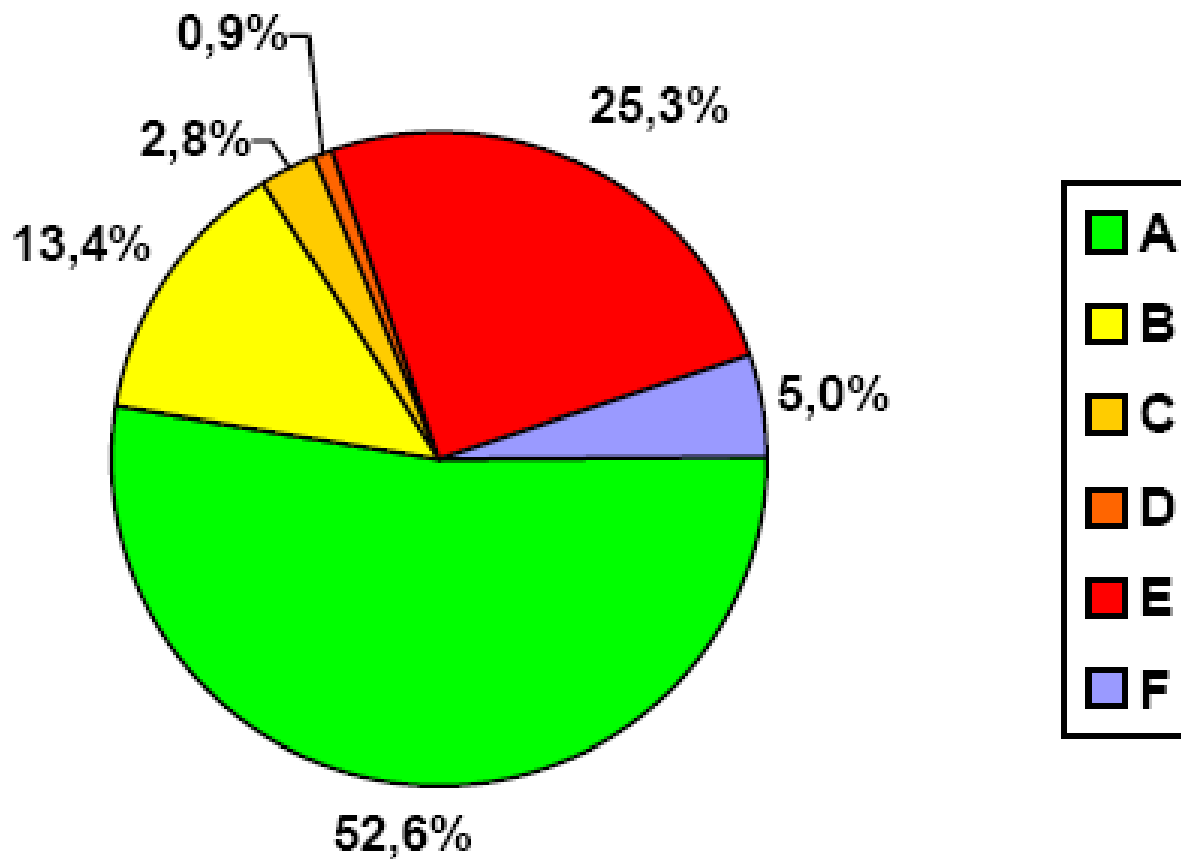
62 258

7 April

06 July

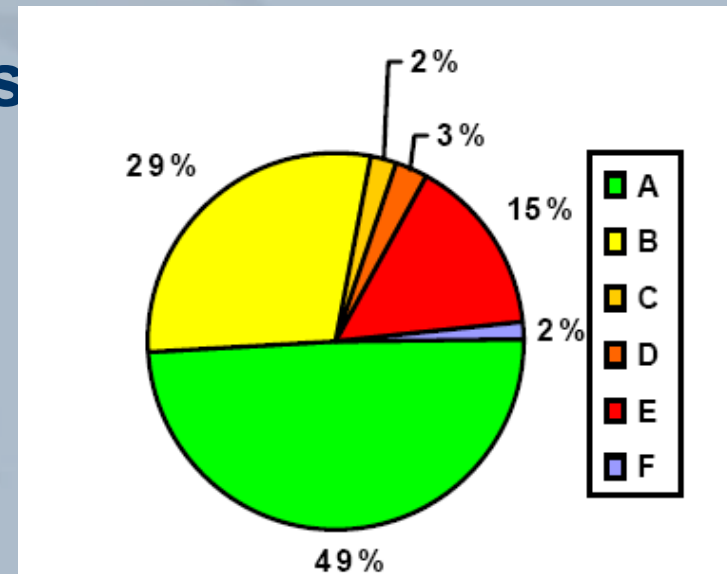


# Statistics

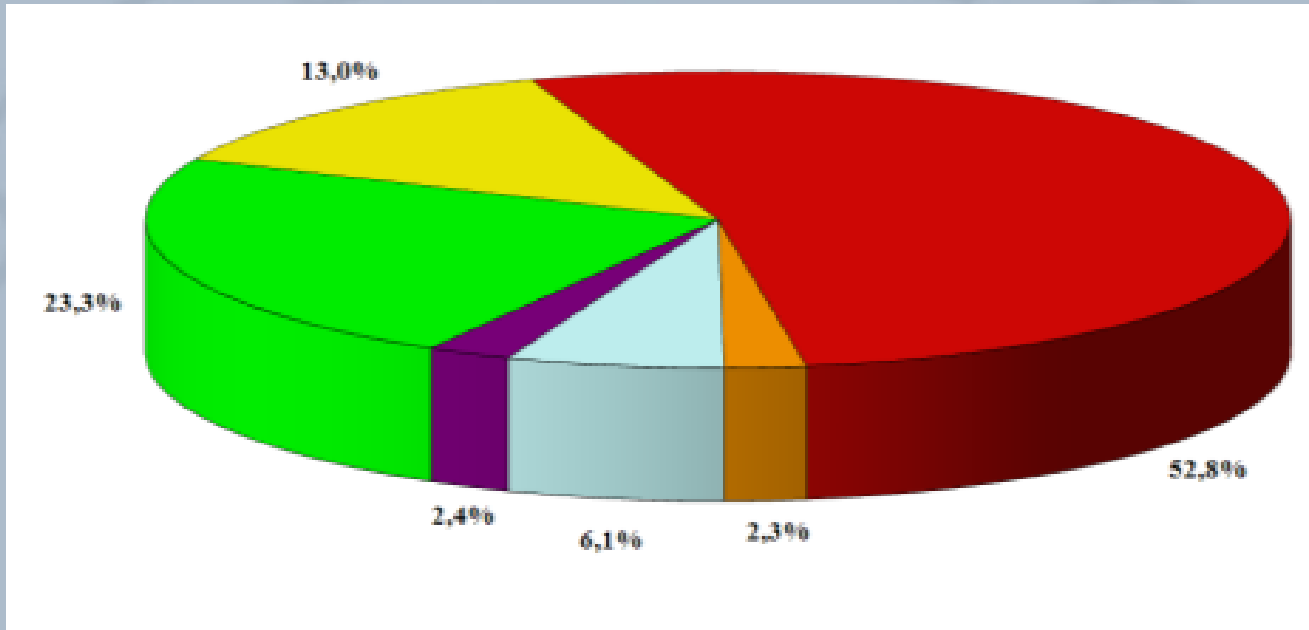


# DAMAGE AND USABILITY OF SCHOOLS

- Schools had priority in the damage assessment activities and most of them were inspected in the first days after the earthquake
- In l'Aquila municipality 106 school buildings have been inspected
- In the Province of L'Aquila, inspections in 64 municipalities have been carried out: 309 buildings were inspected



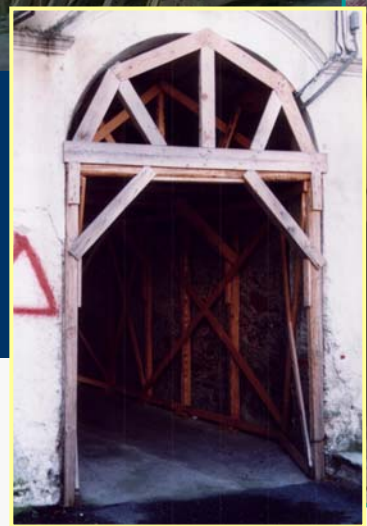
# Cultural heritage



Inspections	Percentage	Outcome
324	23,3%	Edifici AGIBILI
181	13,0%	Edifici AGIBILI CON PROVVEDIMENTI
733	52,8%	Edifici INAGIBILI
32	2,3%	Edifici PARZIALMENTE AGIBILI
85	6,1%	Edifici TEMPORANEAMENTE INAGIBILI
33	2,4%	Edifici INAGIBILI per cause esterne

**No. Inspections  
1373**

# POST-EARTHQUAKE PROVISIONAL WORKS







# POST-EMERGENCY ACTIVITIES – TEMPORARY HOUSES

## S. GIULIANO DI PUGLIA - 2002

### INSTALLATION OF TEMPORARY PREFABRICATED TIMBER HOUSES



# Il Decreto Abruzzo del 28 aprile 2009 n.39

## I PUNTI PRINCIPALI

- Il piano C.A.S.E.
- Contributi per la ricostruzione e riparazione di edifici pubblici e privati
- Imprese, lavoro e famiglia: le agevolazioni
- Sospensioni e dilazioni di termini di legge e scadenze
- Riduzione del rischio a livello nazionale

# Objectives and design philosophy

## STRATEGIA TRADIZIONALE

IMMEDIATO  
tende



PROVVISORIO  
baracche prefabbricate



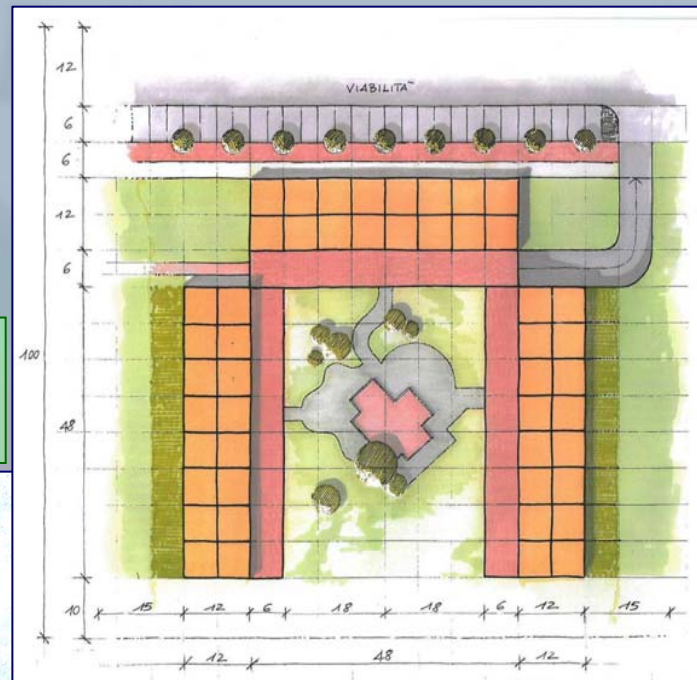
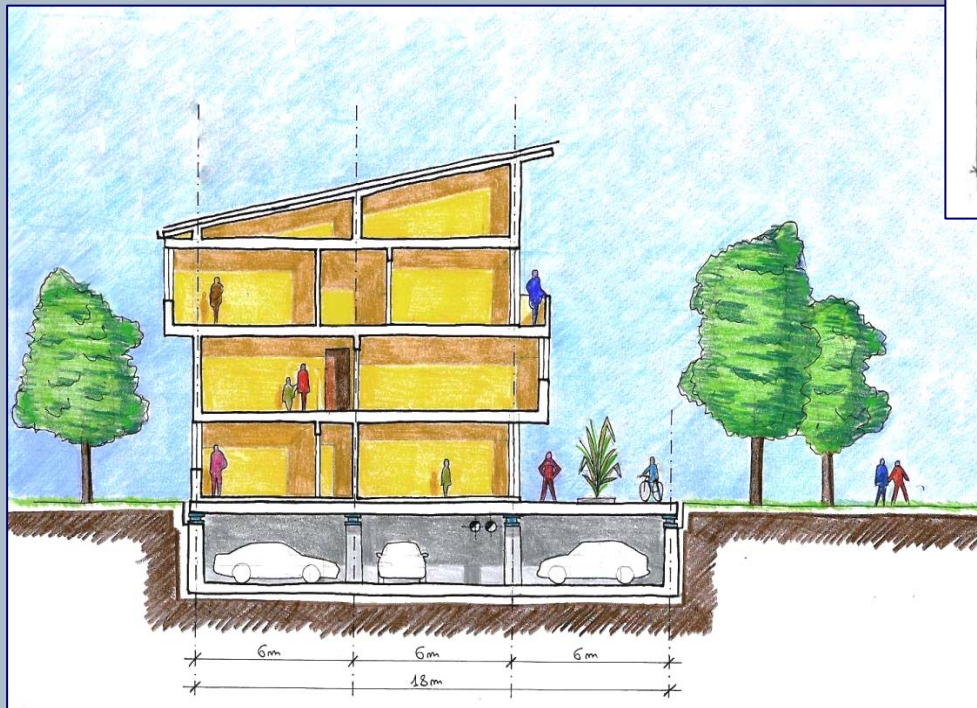
DEFINITIVO  
nuove abitazioni

## STRATEGIA ALTERNATIVA

IMMEDIATO  
tende



PROVVISORIO  
Abitazioni ad elevati  
standard qualitativi



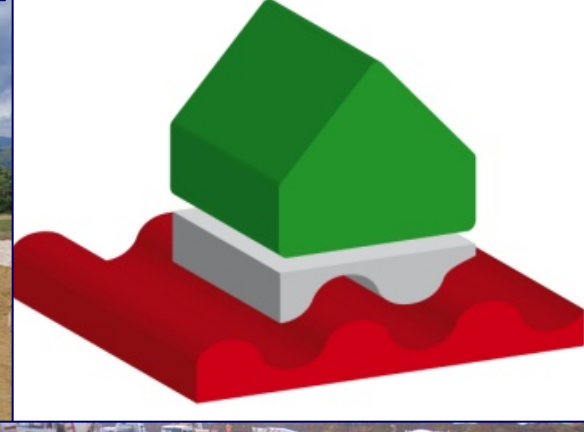
## Project C.A.S.E.

### OBJECTIVE:

- 150 buildings
- 4000 apartments for
- 12-14000 homeless
- IN 6 MONTHS



- Abitazioni e quartieri disponibili in cinque/sei mesi
- Sicurezza antisismica di "isolato urbano"
- Elevato livello dello standard abitativo
- Elevato livello tecnologico orientato all'autosufficienza impiantistica
- Sostenibilità ambientale e bioedilizia





# MICROZONATION

The reconstruction activities cannot reach full effectiveness without an improvement of the knowledge of local site effects.

CP has started a microzonation study in  $MCS \geq 7$  areas, to be completed within september 2009, according to the recently published guidelines for microzonation.

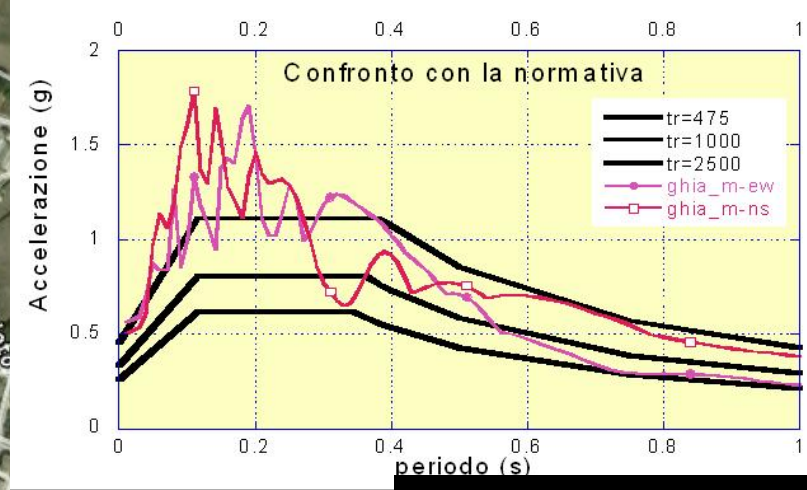
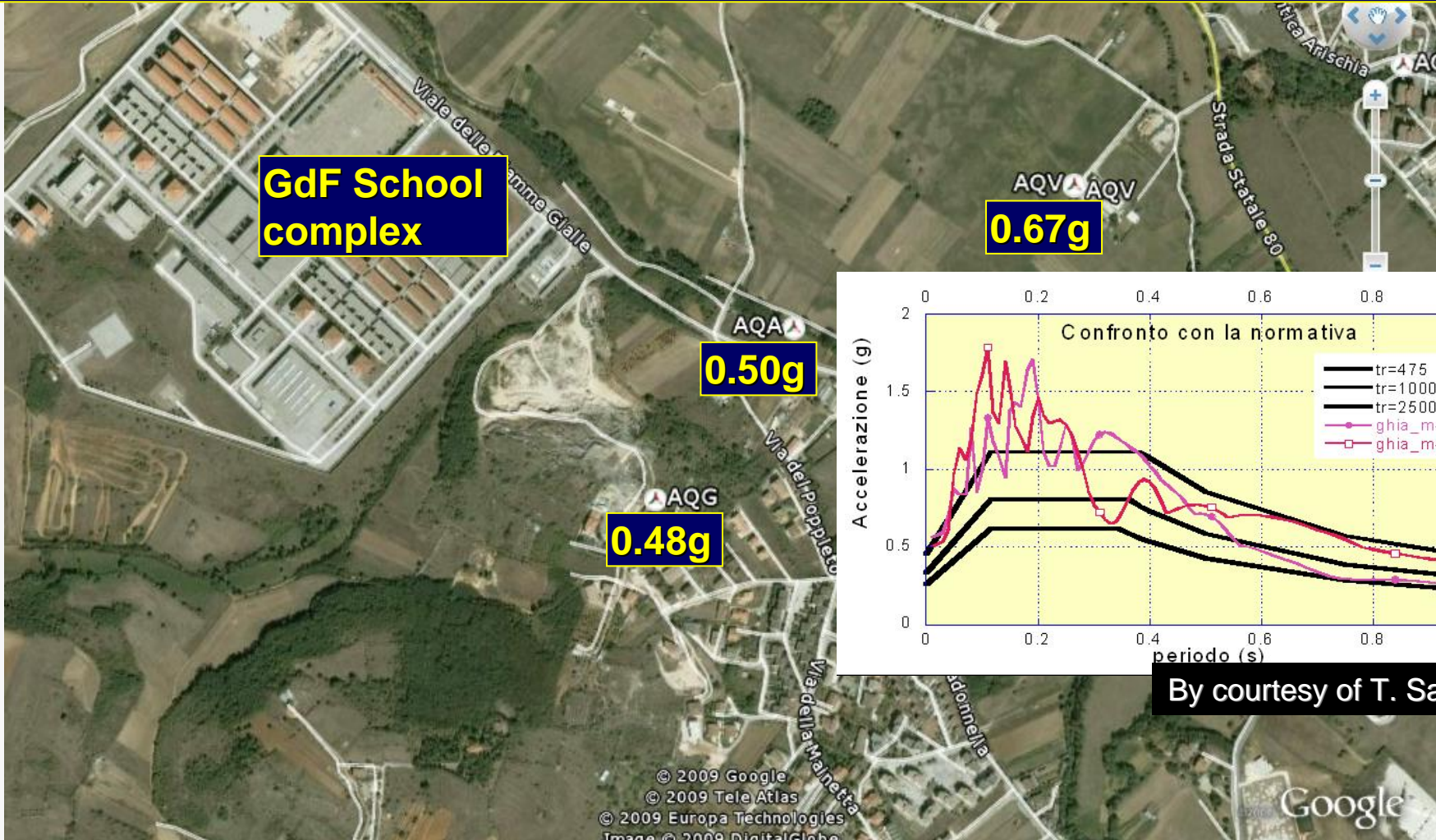


# **G8 MEETINGS IN L'AQUILA**

## **SEISMIC SAFETY**

# Strong motion records (RAN)

**Buildings hosting G8 experienced stronger earthquake than current code design earthquake requires**



By courtesy of T. Sanò





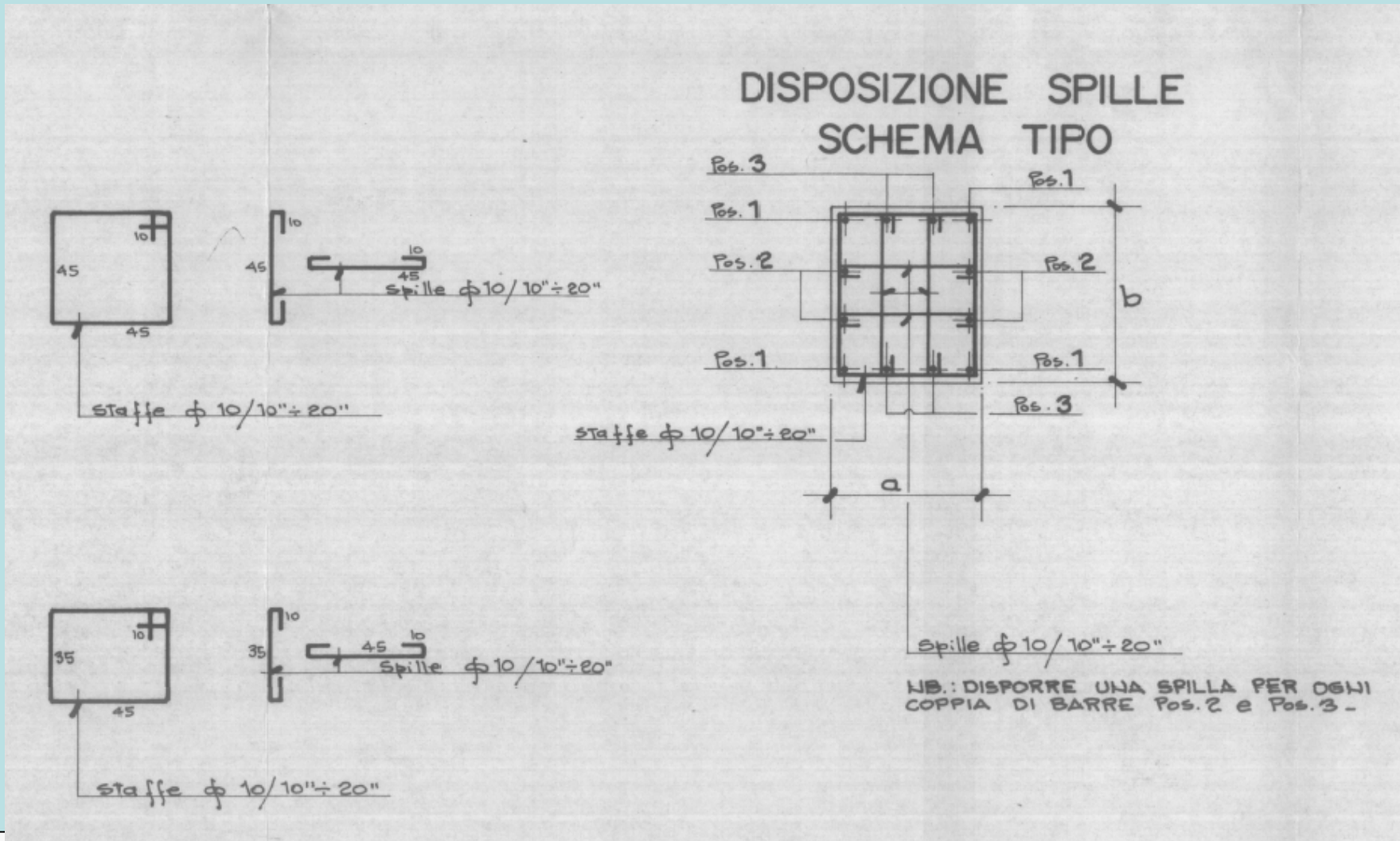
# Seismic safety of the buildings of the School of “Guardia di finanza” – L’Aquila

## INVESTIGATIONS AFTER THE QUAKE

- 1. Visual inspection for damage and post-earthquake safety assessment**
  - Slight damage to non structural elements
  - NO structural damage
- 2. Re-evaluation of the design documents**
  - Compliance with modern seismic code detailing
- 3. Material (concrete) testing**
  - Compliance with design requirements
- 4. Dynamic identification**
- 5. Permanent dynamic monitoring**
  - 6 buildings now → 16 buildings during G8
- 6. Re-analysis for seismic safety assessment**
  - in progress → positive preliminary results

# Investigation on buildings

## Re-examination of the structural design documents



# Summary of investigations carried out until now



	Type of investigation	quantità
Material (Concrete) testing	Non-destructive tests (SonReb type)	500
	Tests on drilled cores	80
Dynamic characterisation of structures	Dynamic characterisation of structures (No. of buildings)	50
	Continuous monitoring	6
Modellazione strutturale	Numerical analysis of seismic risk (VC)	16
	Finite element numerical analysis	20

Competence Centre of Civil Protection	University	No. of operators
	University of Basilicata	10
	University of Naples - Federico II	6
	University of Perugia	6
	University of Molise	4
	University of Pavia	20
	<b>TOTAL OPERATORS</b>	<b>46</b>

# COMPETENCE CENTRES OF DPC

- **INGV**



(Seismic surveillance, Emergency technical support, Seismological research projects)

- **RELUIS**



(Emergency technical support, Earthquake engineering research projects)

- **EUCENTRE**



(Emergency technical support, Earthquake engineering research projects)

In the past three years,  
PC research funds amounted to about 10 M€ / year



# CONCLUSION

The effectiveness of the response of Civil Protection to the seismic event of Abruzzo can be ascribed to the full involvement and cooperation of the different components of the Civil Protections system, including the volunteer organisation.

Rescue operations and technical evaluations could therefore fully exploit the great potential of all of them.

As far as the scientific components are concerned, their support to technical evaluations has come out to be precious in many activities due to their structured involvement through the competence centers, to:

- *Monitor soil and structures with mobile instrumentation, to evaluate aftershock effects,*
- *survey earthquake effects on natural (landslides, liquefactions, soil fractures, etc.) and built environment (macroseismic survey, damage assessment, etc.).*

Also in post-event activities important synergies are established between research and CP:

**EARTHQUAKES REPRESENT FULL SCALE EXPERIMENTS THAT PROVIDE SIGNIFICANT AND STIMULATING HINTS FOR SCIENTISTS.**



**THANKS  
FOR YOUR  
ATTENTION**