6th National Conference on Earthquake Engineering & 2nd National Conference on Earthquake Engineering and Seismology .

Bucharest, June 14-16, 2017

The 2016-17 Seismic Sequence of Central Italy: Main Scientific Features and Technical Emergency Activities

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PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Introduction

AIMS:

- Providing information on the earthquake sequence and its effects
- Describing the emergency management with a special focus on the technical-scientific management in the emergency

SUMMARY

- ✓ Background information on seismic risk of Italy
- ✓ Description of the sequence
- ✓ General picture of the damage
- ✓ Organization of Italian Civil Protection and Emergency management
- ✓ Coordination of the technical-scientific activities within the emergency management
- ✓ Simulation scenarios and accelerometric data of soil and structures
- ✓ Surveys for damage and usability assessment of public and private buildings, cultural heritage, road network and provisions taken

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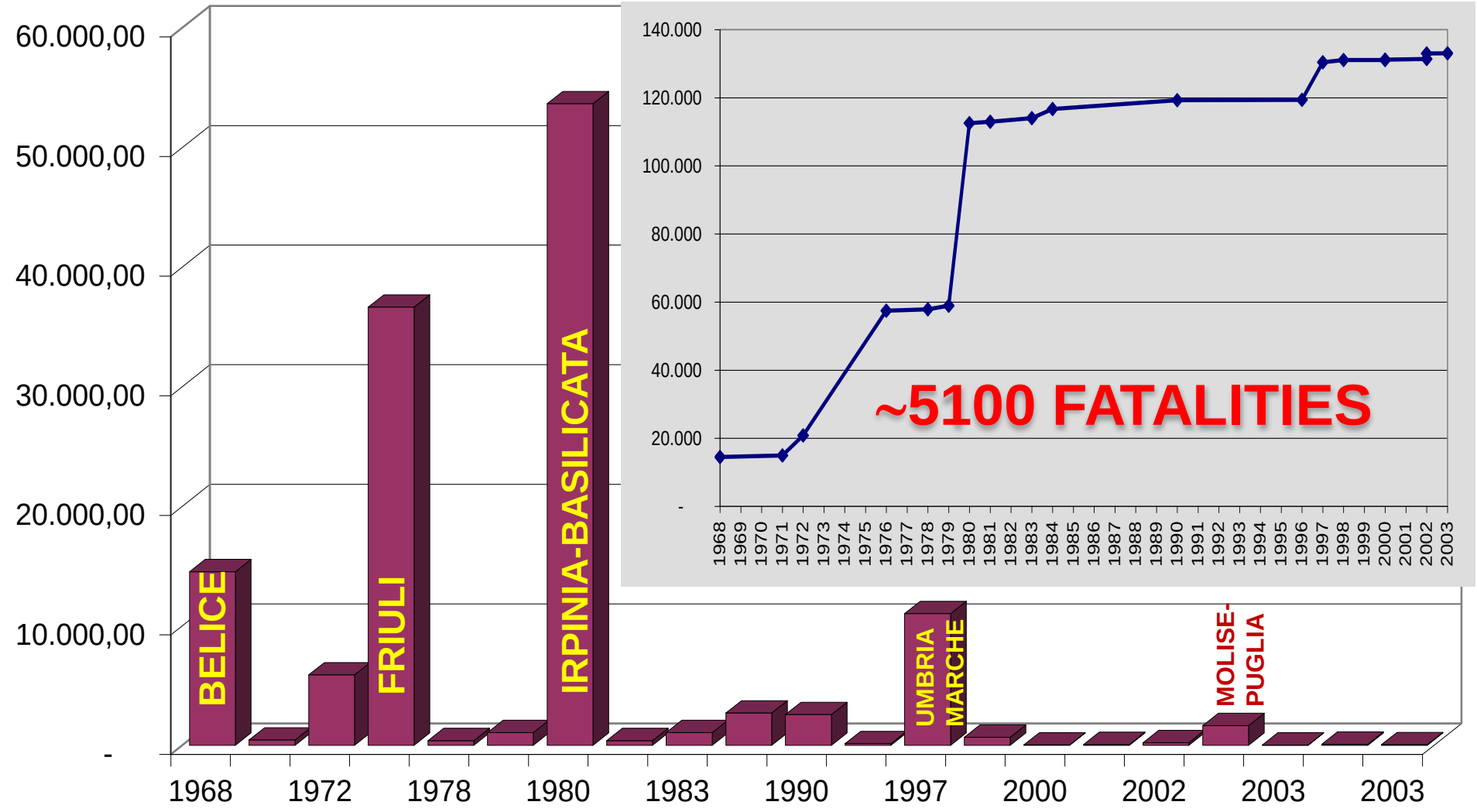
Losses due to Italian Earthquakes - last 50 yrs (m€-2005)



+ ABRUZZO 2009+EMILIA 2012+CENTR.ITALY 2016 (50B€?) → 3.5 B€/yr

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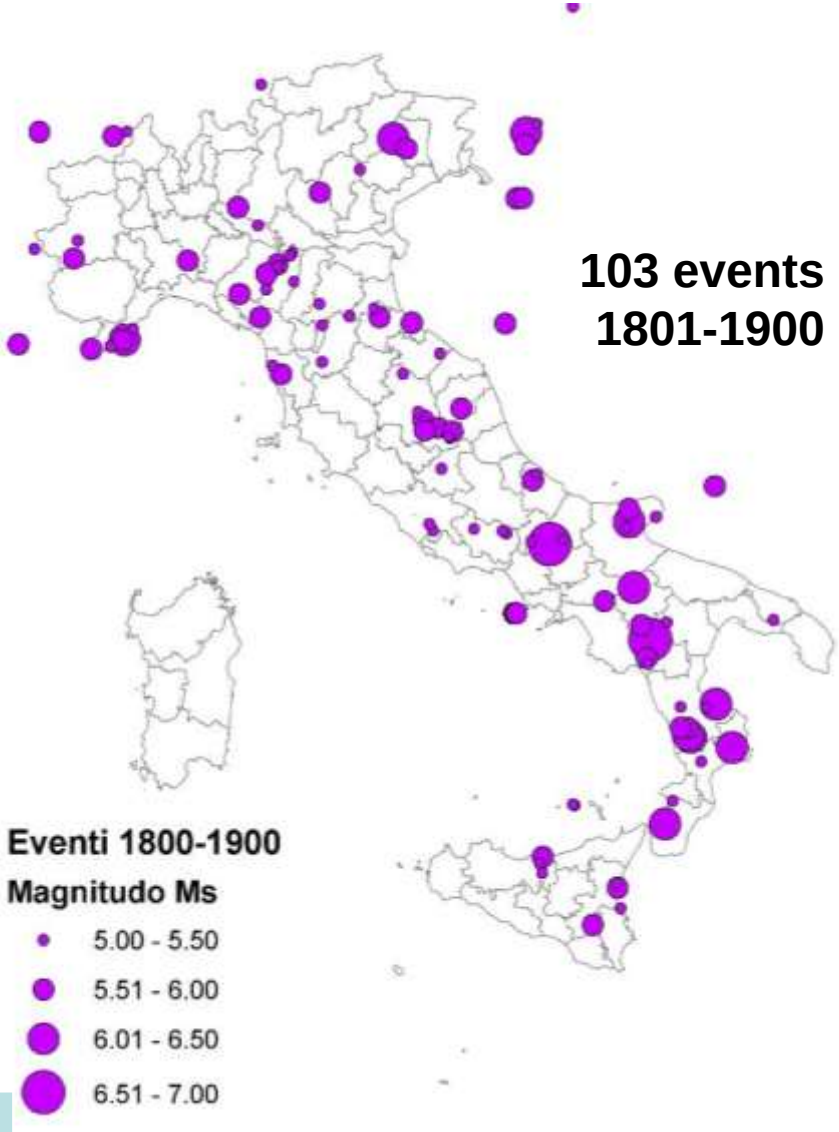
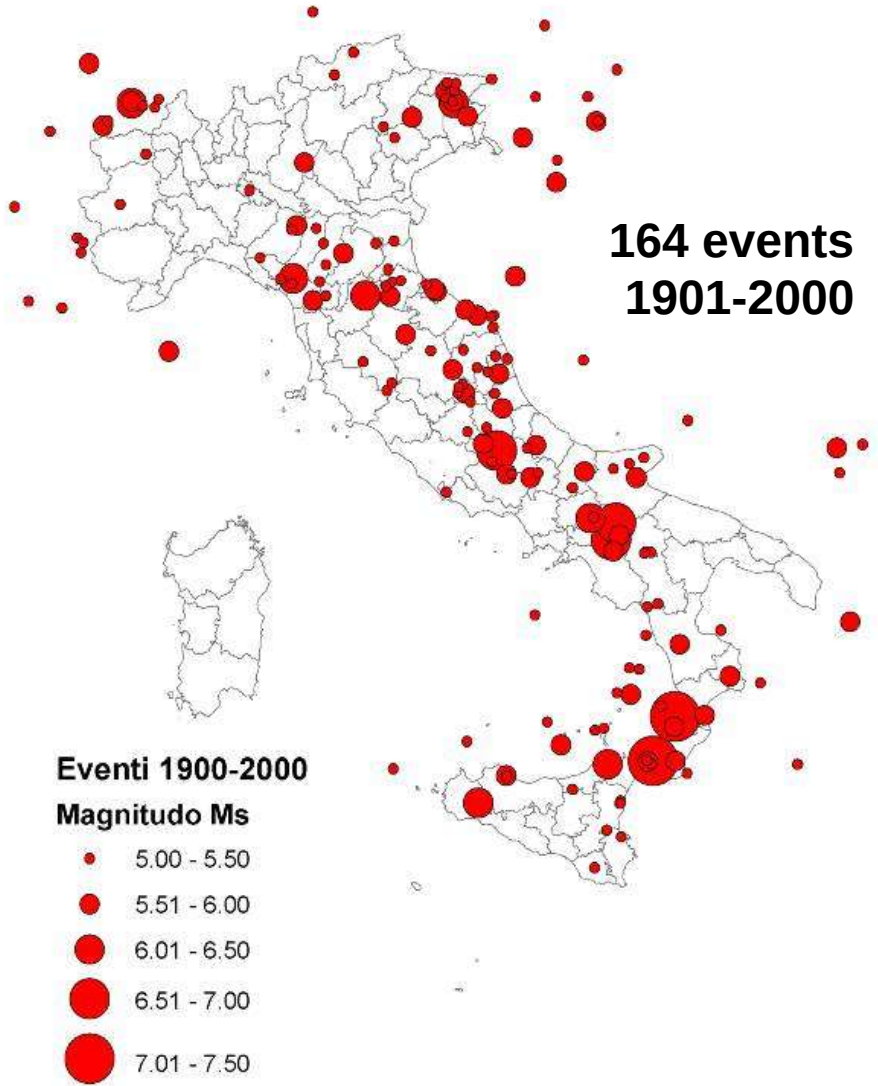
M5+ Earthquakes of XIX and XX Centuries





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SEISMIC RISK XXI CENTURY PROJECTIONS

Based on what happened in XIX and XX centuries, in the XXI century one could expect:

500 - 2000 casualties and injured / year

→50000-200000 casualties and injured 100 yrs

1 - 2 billions Euro / yr

→ 100-200 bln Euros in the XXI cen.

N.B.: this cost estimate is only relevant to apartment blds.

Total costs could increase by 50-100%.

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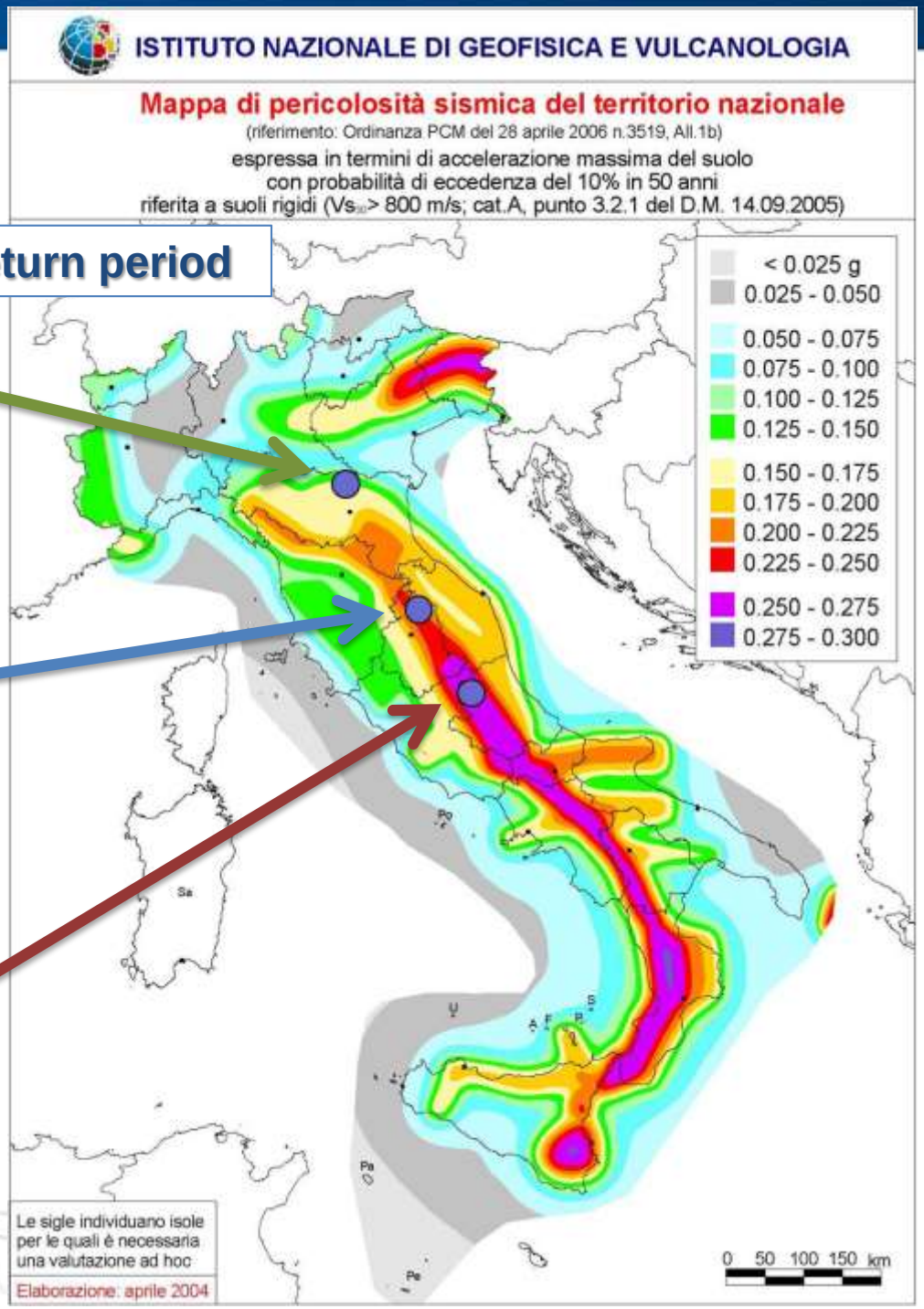

475 y return period

Emilia 2012

Umbria-Marche 1997

Abruzzo 2009

Major Earthquakes in the **last 30 yrs**:

1. Umbria-Marche
   Sept. 26, 1997,
   a_g=0.15-0.25g
2. Abruzzo
   April 6, 2009,
   a_g=0.20-0.275g
3. Emilia-Lombardia-Veneto
   May 20, 2012,
   a_g=0.125-0.175g

National Seismic Hazard Map of Italy (MPS Working Group, 2004). The epicenters of the three earthquakes analyzed in this paper are marked with blue dots.

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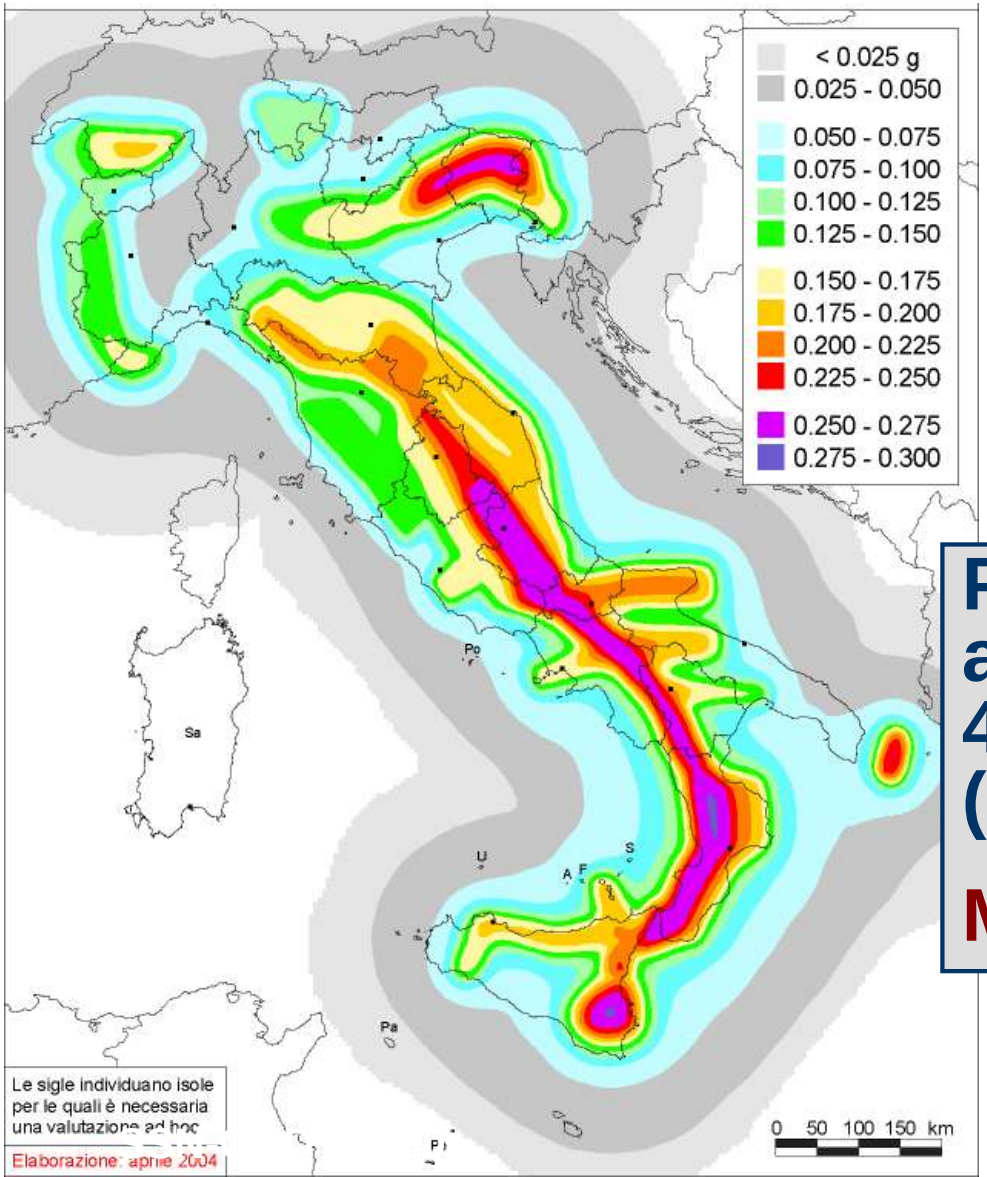
SEISMIC HAZARD IN ITALY



Peak ground acceleration (stiff soil) 475 yrs return period (Prob. 10% in 50 yrs)

Max PGA = 0.28g

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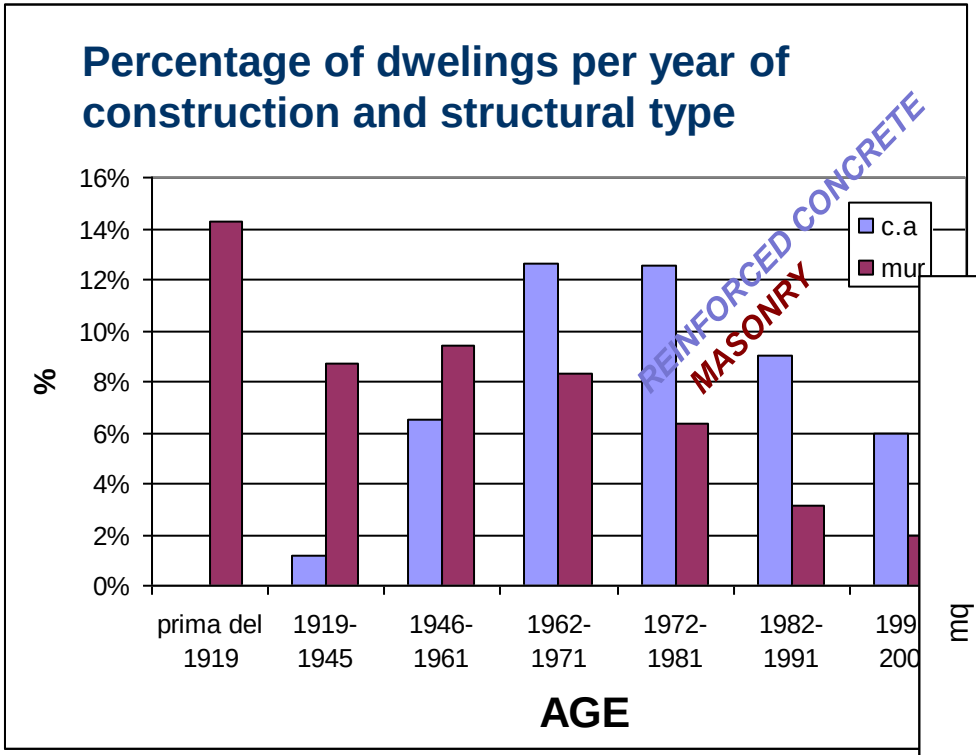
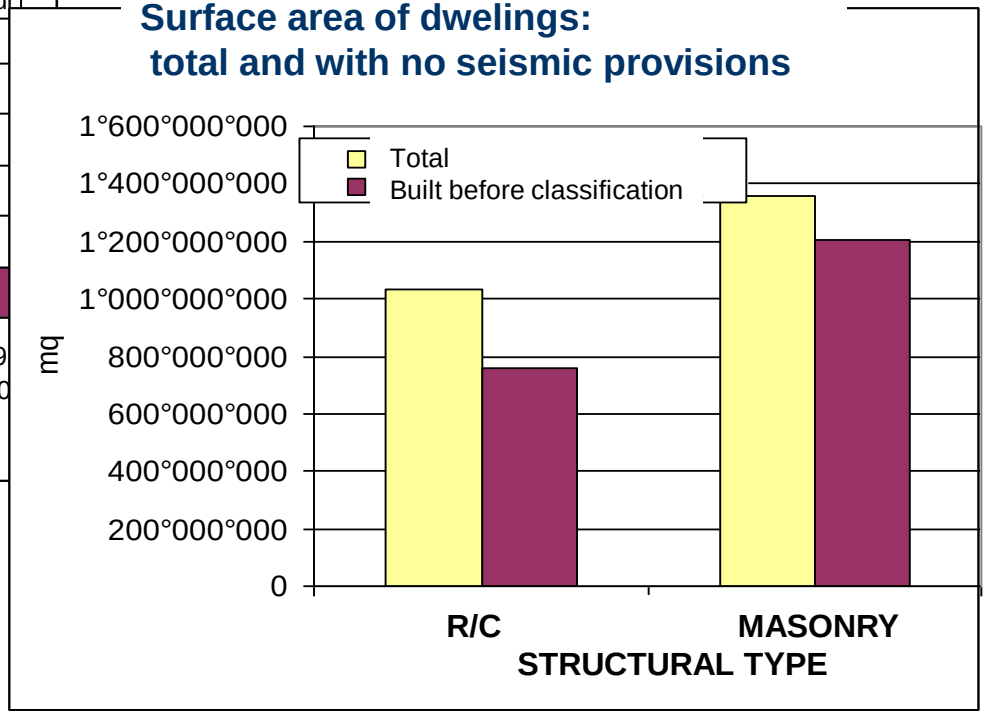
EXPOSURE AND VULNERABILITY

Dwellings – Census 2001





- 5% of masonry buildings
- 15% of R/C buildings

BUILT AFTER 1982

Most of the buildings are obsolete and designed with no seismic provision

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DESTRUCTIVENESS OF ITALIAN EARTHQUAKES

The high seismic risk has to be ascribed to the **high vulnerability of the Italian building stock**, mainly due to the several factors, among which:

- **Bad quality** of old constructions and **degradation** of large urban settlements
- **Inadequate past seismic classification** and **standards**
- Huge number of vulnerable **cultural heritage buildings** and old **historical centres**

The August 24th, 2016, Ml 6.0-Mw 6.0 Earthquake

- On August 24th, 2016, at 3:36 a.m., a strong earthquake (**Ml 6.0, Mw 6.0, depth 8 km**) occurred along the Apennines Chain, Central Italy.
- Disruption occurred in three small municipalities, **Amatrice, Accumoli and Arquata**.
- Observed intensities attained the degree **X-XI on the MCS scale** and X on the EMS scale (INGV).
- **299 fatalities**.
- **390 hospitalized injured** people.

The **emergency response is coordinated**, according to Law 225/1992, **by the Department of Civil Protection** (DPC), within the general framework of the **National Service of Civil Protection**.

The earthquake sequence until October 26th, 2016

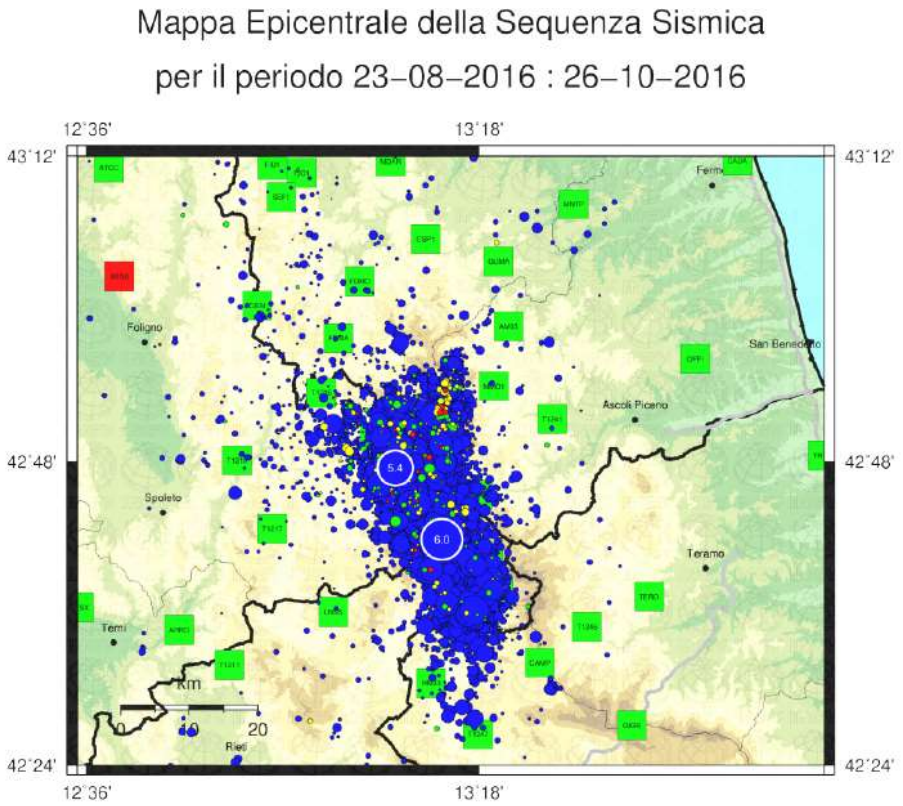
One aftershock, which occurred about 1 hour after the main shock, **12km northnorthwestward**, reaching Mw 5.3,

No foreshocks preceded the main shock.

On **October 26th, 2016, in the morning**, the seismic sequence was formed by more than **18,000 events**,

- 1 with Mw = 6.0
- 1 with 5.0 ≤ Mw < 6.0
- 15 with 4.0 ≤ Ml < 5.0
- 250 with 3.0 ≤ Ml < 4.0.

over a length of more than 50 km with a NNW-SSE strike.



Aggiornata al 2016–10–26,05:13:06 UTC, numero di eventi 18094

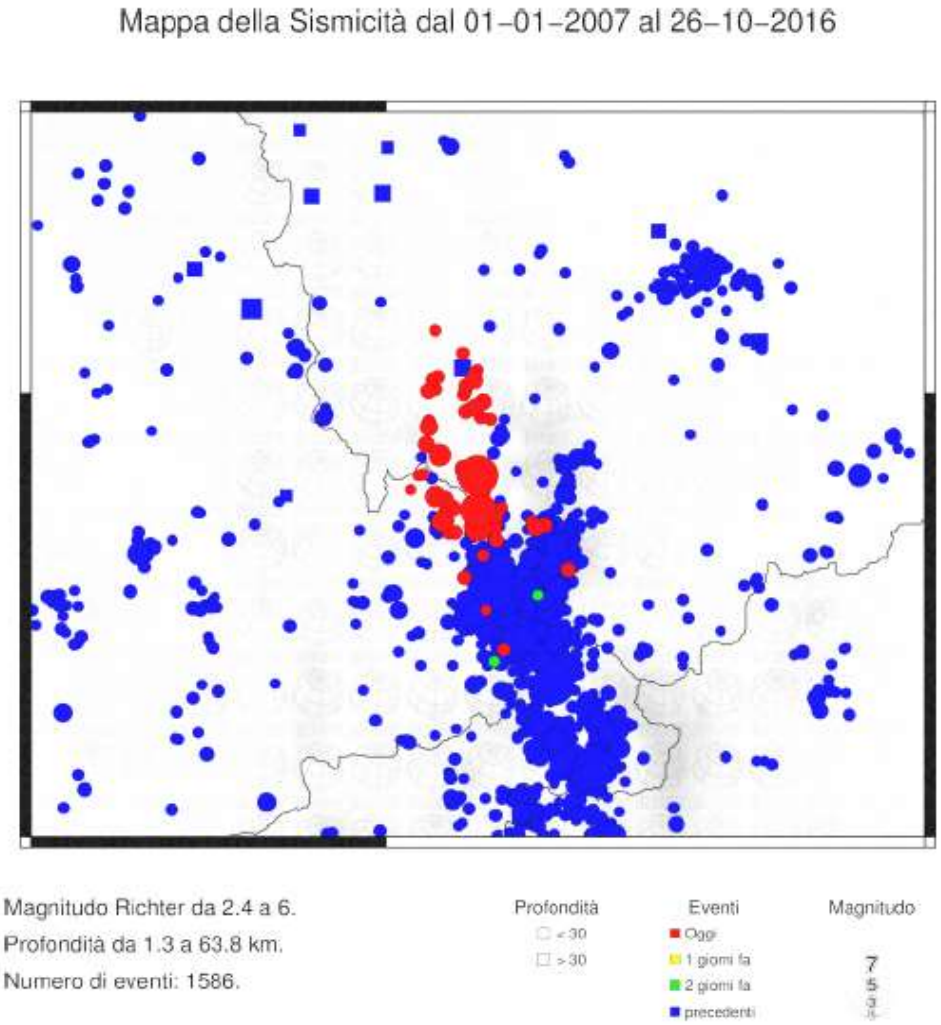
	Oggi	Ieri	2gg fa	Precedenti
Ml < 3.0	22	139	174	17492
3.0 <= Ml < 4.0	0	0	0	250
4.0 <= Ml < 5.0	0	0	0	15
Ml >= 5.0	0	0	0	2

The October 26th, 2016, Ml 5.9-Mw 5.9 Earthquake

On **October 26th** at 20.18 local time a **Mw 5.9** occurred, preceded at 19:10 local time by a **Mw 5.4** strong shock.

These events and the following seismic sequence occurred to the NNW of the previous seismic activity. The Mw 5.9 occurred **25km northnorthwestward** from the Mw 6.0 epicenter.

No casualty occurred



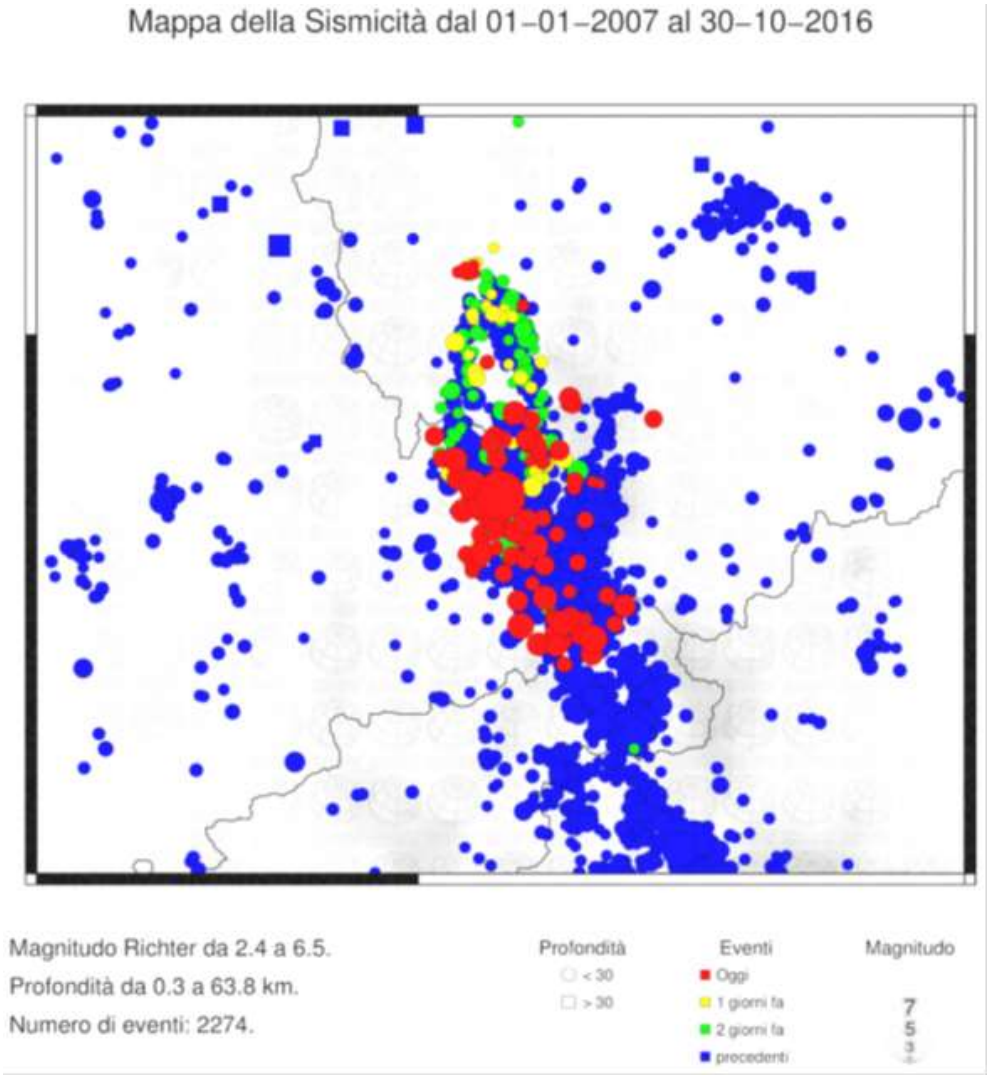
The October 30th, 2016, Ml 6.1-Mw 6.5 Earthquake

On **October 30**, at 7:40 local time, the strongest seismic event of the sequence occurred in an area located **between the two zones** previously hit.

The **Mw 6.5** occurred **18km northnorthwestward** from the first epicenter.

Highest magnitude observed in Italy since the Mw 6.8 **1980** Irpinia earthquake (I_0 X MCS).

No casualty occurred (28 people injured)

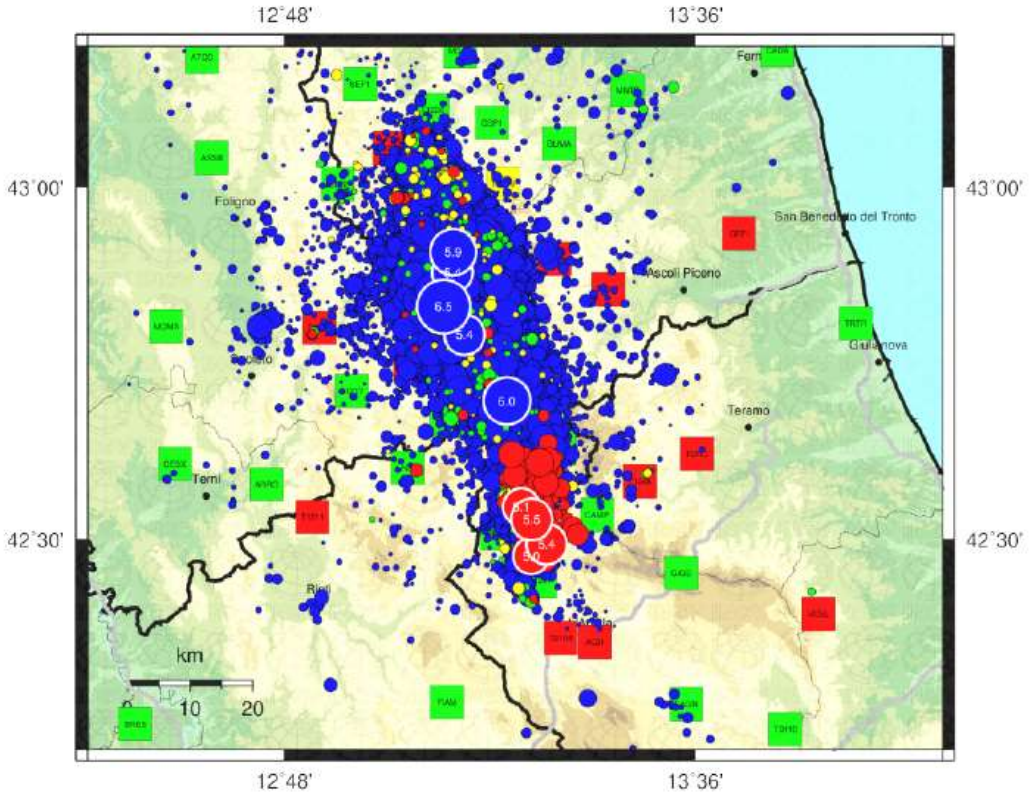


The January 18th, 2017 four events (Ml-Mw: 5.3-5.1, 5.4-5.5, 5.3-5.4, 5.1-5.0)

On January 18th, 2017, **four** seismic events Ml5+ hit the southernmost part of the area interested by the ongoing seismic sequence, **18-25km southward** the first epicenter.

The first three (Mw5.1, Mw5.5, Mw5.4) between 9:25 and 10:25 UTC, the fourth one (Mw 5.0) at 13:33 UTC.

No casualty occurred (34 fatalities due to the snowfall)



Aggiornata al 2017–01–18,18:01:05 UTC, numero di eventi 46884

	Oggi	Ieri	2gg fa	Precedenti
Ml < 3.0	208	119	181	45364
3.0 <= Ml < 4.0	45	0	0	905
4.0 <= Ml < 5.0	6	0	0	50
Ml >= 5.0	4	0	0	5

Stato della rete

Funzionante Parzialmente funzionante Guasta

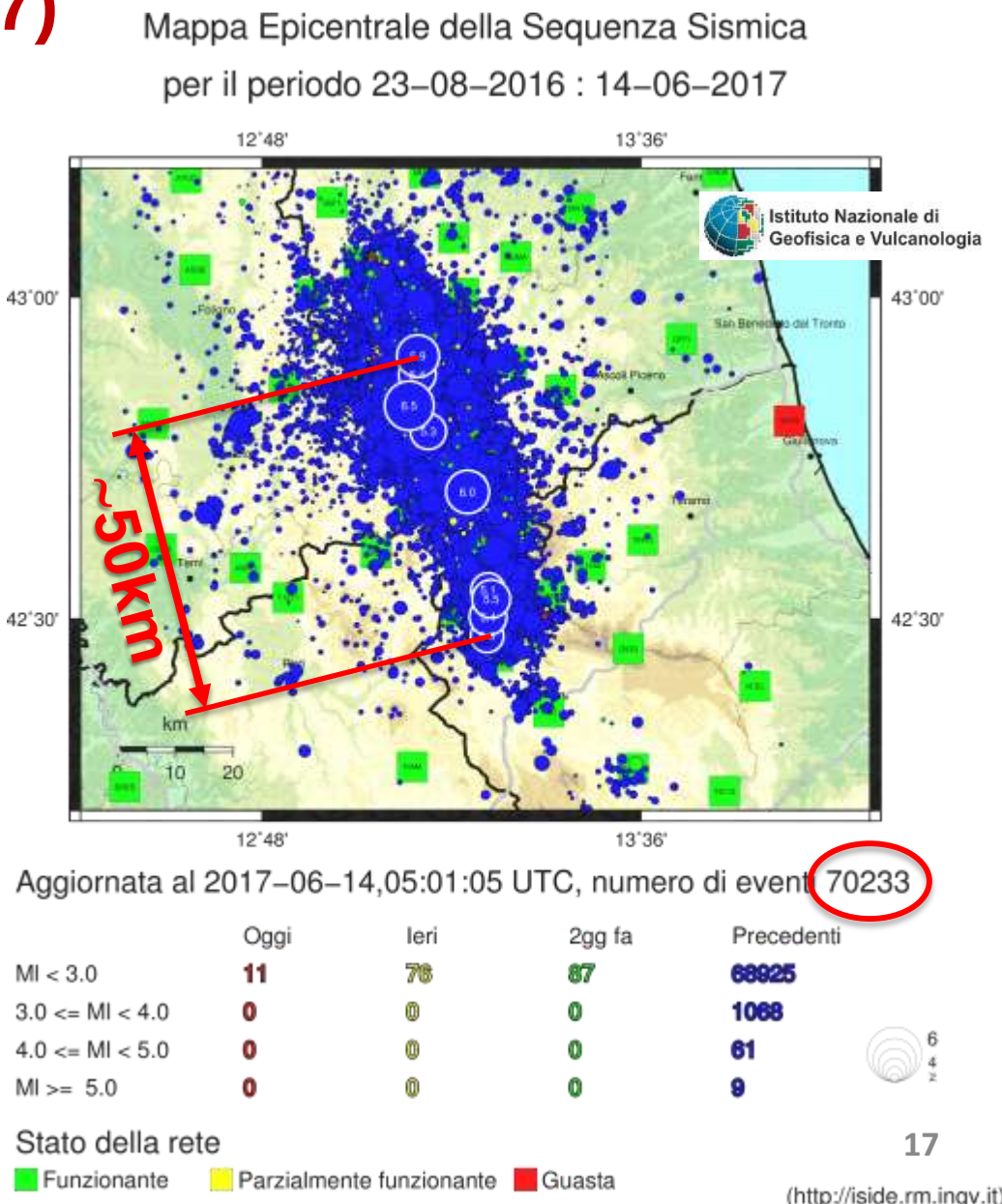
(http://iside.rm.ing

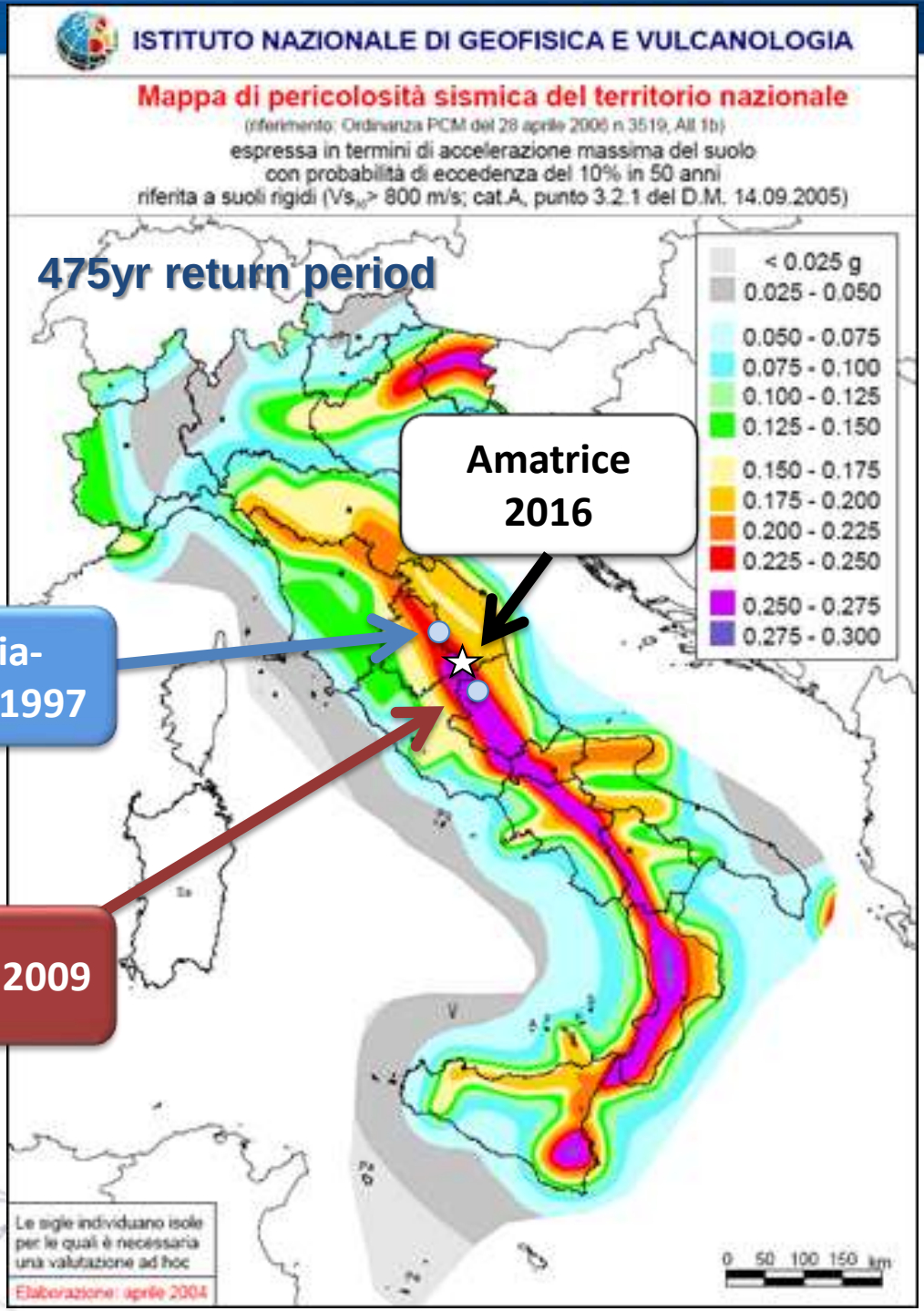
Present-day seismicity (13.06.2017)

On June 13th, 2017, the seismic sequence was formed by more than 70,000 events:

- 2 with Mw ≥ 6.0
- 7 with 5.0 ≤ Mw < 6.0
- 61 with 4.0 ≤ Ml < 5.0
- 1068 with 3.0 ≤ Ml < 4.0

Maximum distance between Mw 5+ events was about **50 km** along NNW-SSE strike.



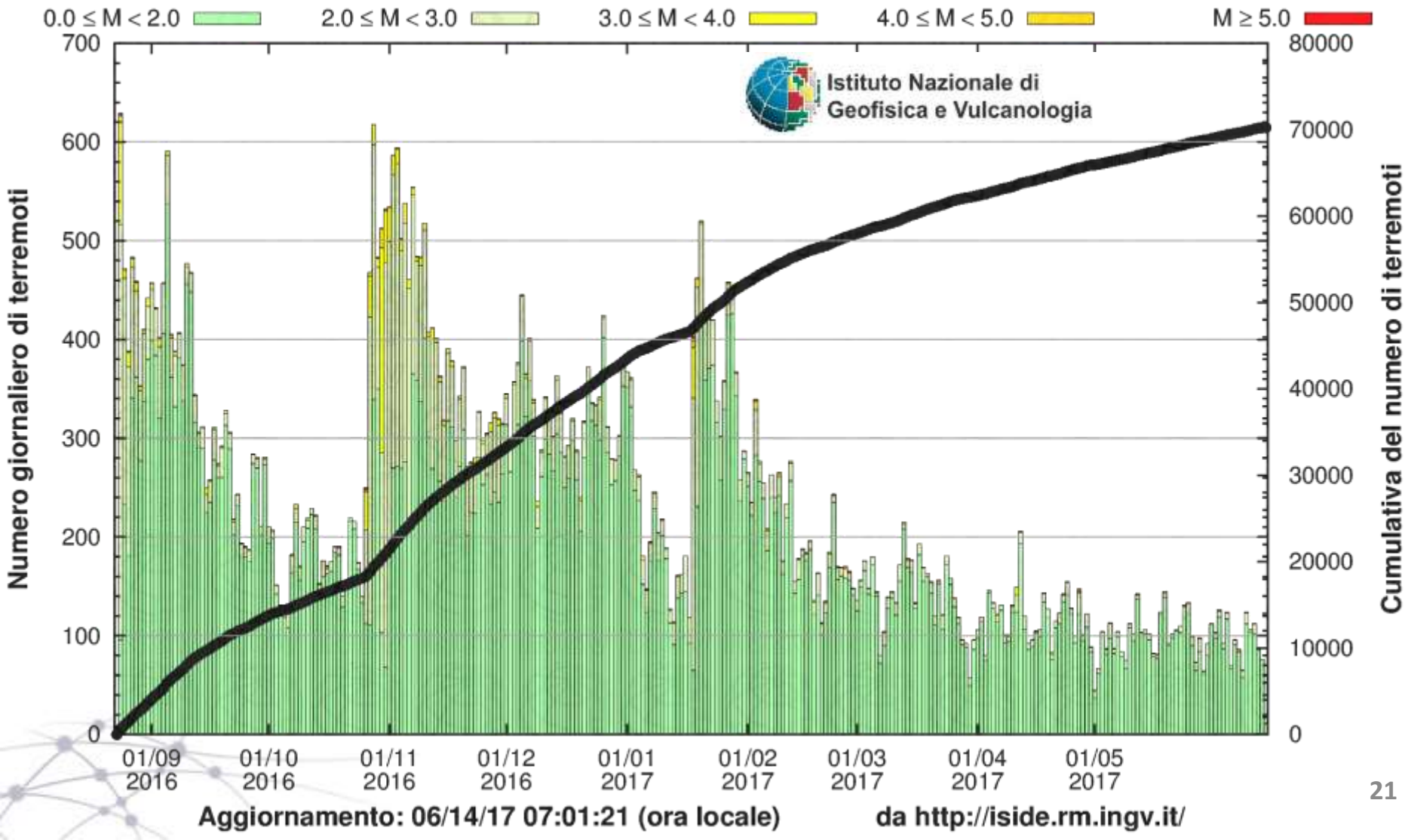


- 475 yrs return period acceleration is **0.26 g**
- the epicentral area is classified as seismic zone since **1915**.
- The affected area partially **overlaps** the **1997** and the **2009** earthquakes affected areas.
- The earthquake occurred at the **end of summer**.

National Seismic Hazard Map of Italy (MPS Working Group, 2004).

Seismicity (until 13.06.2017)

INGV report available after 1h and every 1h, 8h, 24h, 7d, 30d after the event



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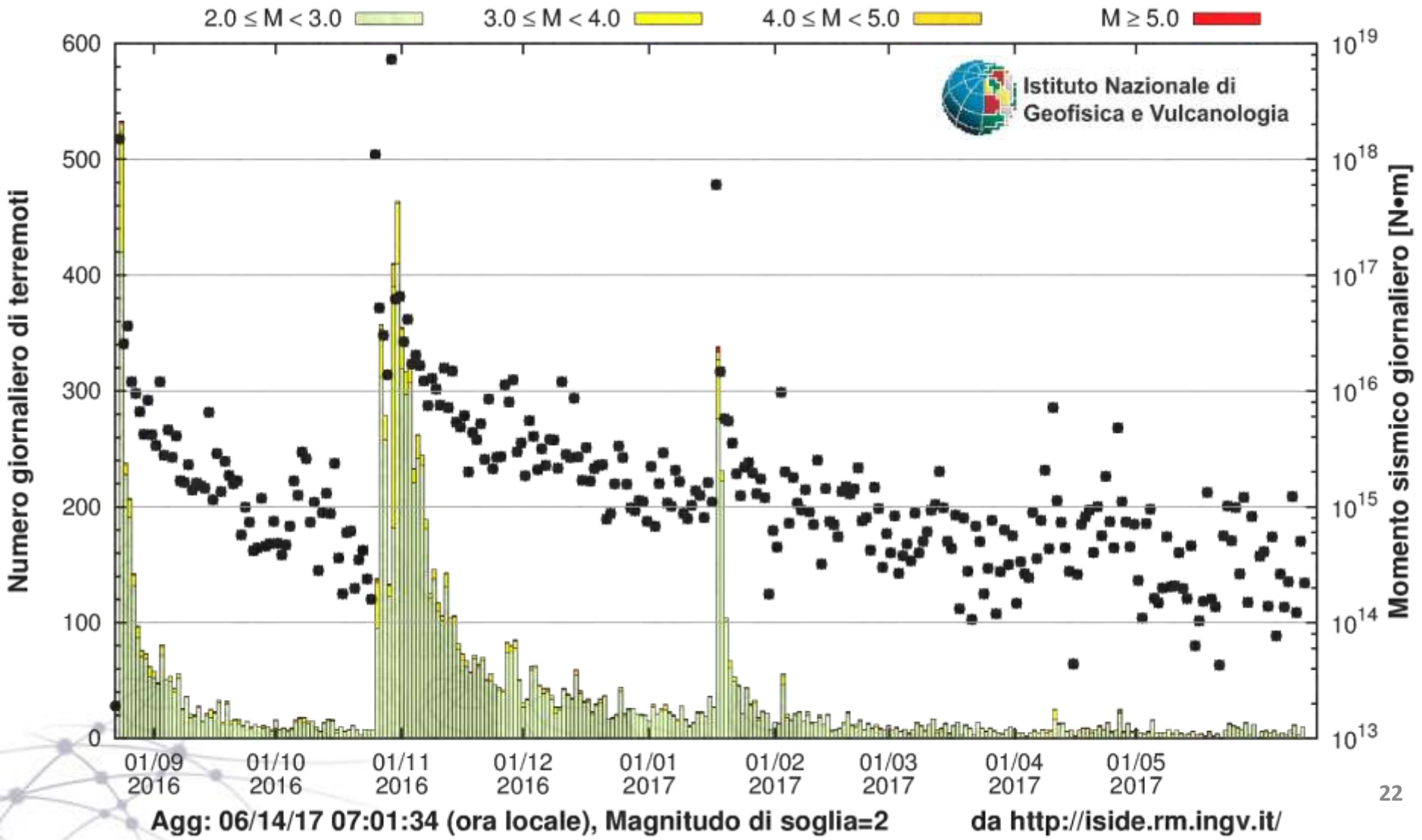


Geological/seismotectonic setting

From a tectonic point of view, the epicentral area is part of the **Apennines fold-and-thrust belt**, an orogenic chain which formed in **Meso-Cenozoic times** with a general NW-directed motion towards the Adriatic foreland.

This compressional tectonic phase was replaced by an **extensional tectonic phase**, which is still ongoing and currently affecting the region with a **SW-NE–striking extension**.

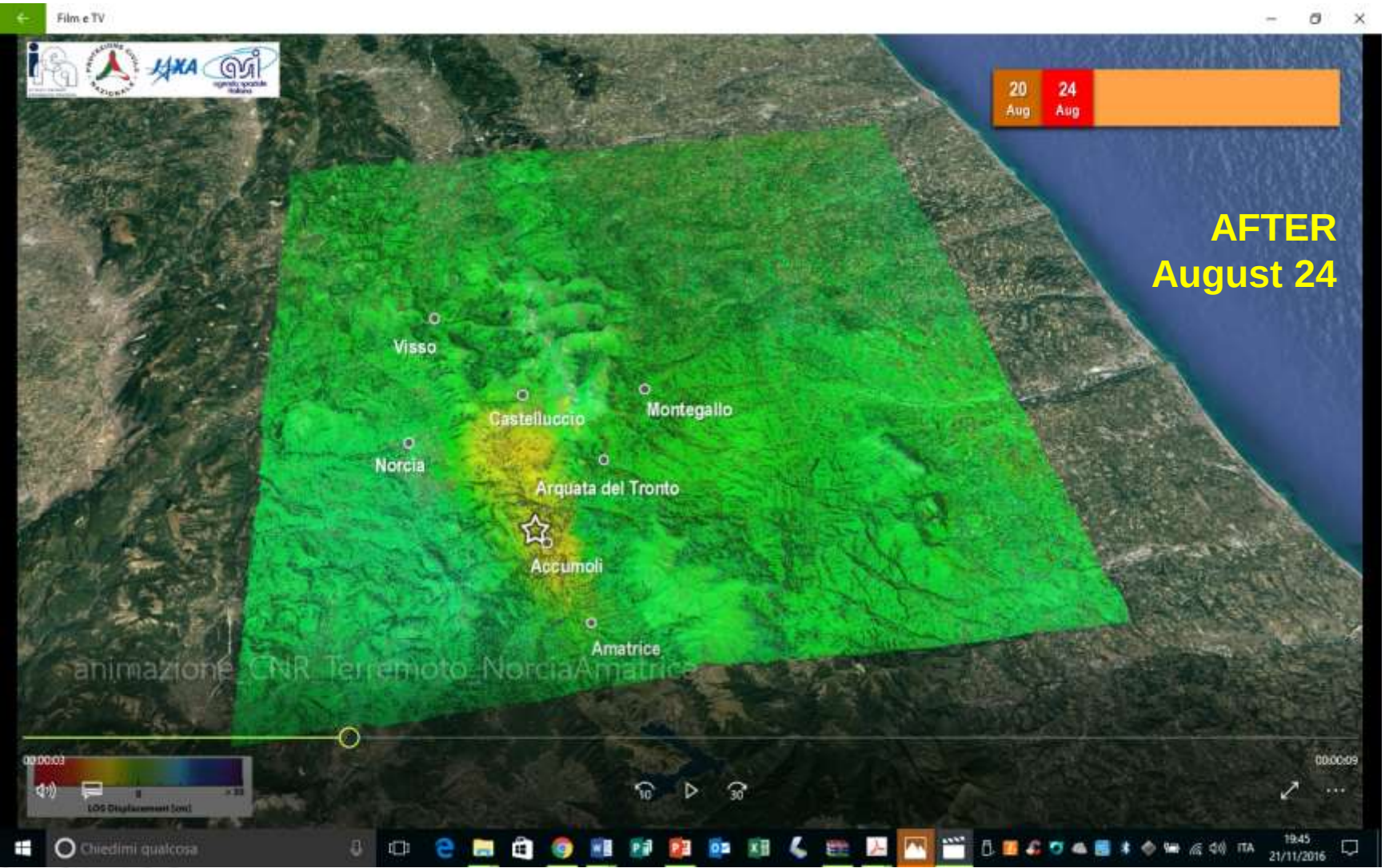
The **numerous active normal faults** present in that part of territory, as well as the seismicity, respond to this **extensional tectonic regime**.

The **seismogenic faults** responsible for the main shocks are coherent with this extensional stress field, being a **NNW-SSE-striking, WSW-dipping normal faults**, with **a length of 15-20 km** and a **dip angle in the order of 45°-50°**. Some antithetic or low dipping planes are also present.

Coseismic effects from satellites

M. Dolce

Coseismic surface deformation detected by CNR-IREA with the interferometric technique on radar data coming from ALOS2



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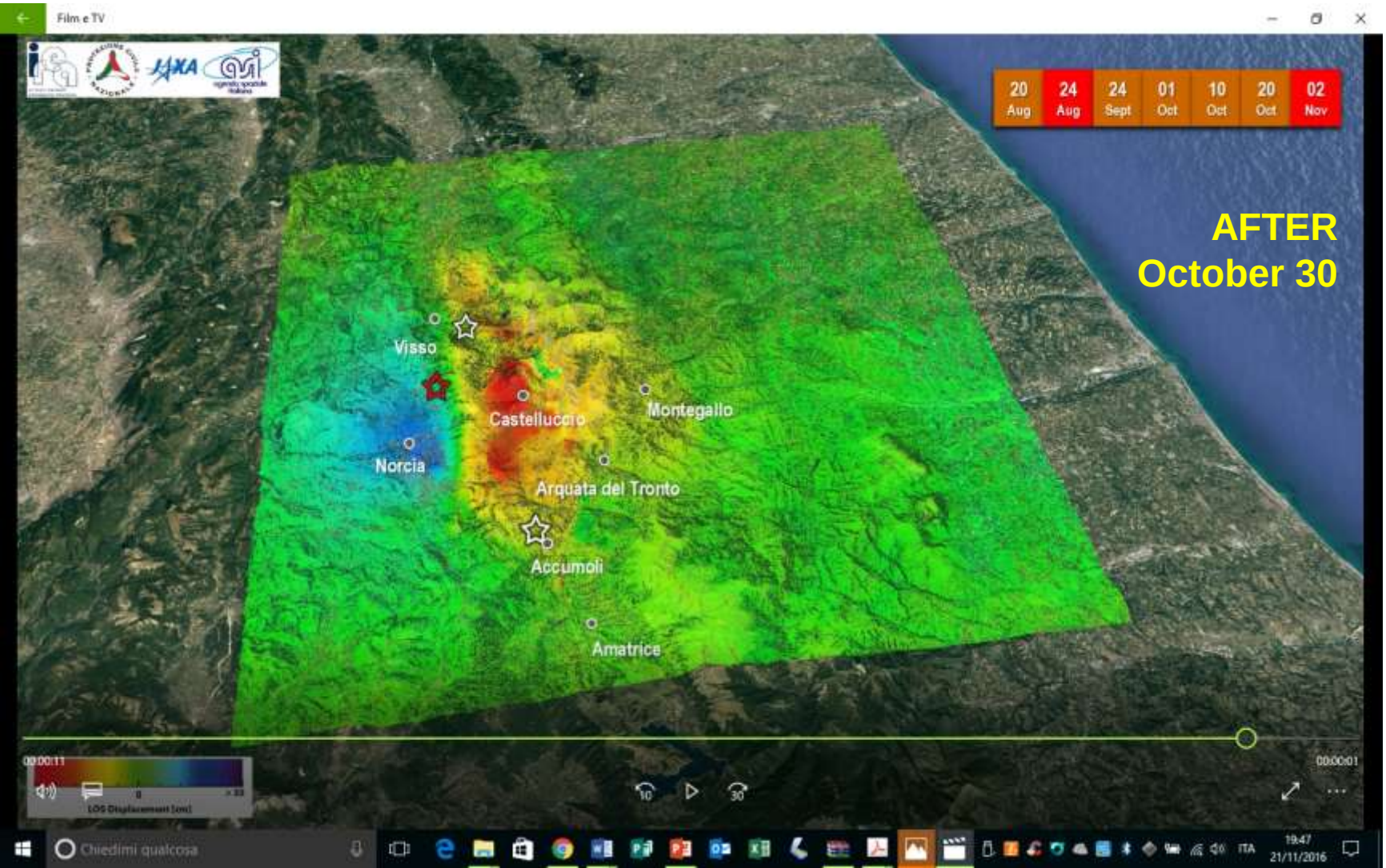


Socio-economic characteristics of the epicentral area

- The affected area is located in **Central Italy**, at the **boundaries among 4 Regions**, namely **Abruzzo**, **Lazio**, **Marche** and **Umbria**.
- Involved **provinces are 7**: **Ascoli Piceno, Fermo, Macerata** (Marche), **Perugia** (Umbria), **Rieti** (Lazio), **L'Aquila, Teramo** (Abruzzo).
- Territory is prevailingly **mountainous**, mostly exceeding **900** m elevation (**35**% vs. 19% national average, **64**% in Lazio).
- **Population** average **density is low** (**75** inhab./sqkm, vs. 200 national average, **41** in Umbria), distributed over **small municipalities** formed by a **large number of localities** (2600 people in the Amatrice municipality, distributed over 47 localities).
- The average **income** per person is less than national average.

Socio-economic characteristics of the epicentral area

- **Most of the population working in the same municipalities** where they live → existence of a local labor market, mainly based on agricultural economy.
- **High percentage of farms** (especially breeding farms) with respect to the resident people.
- **Tourism** is an important economic activity due to the nature of that territory, with great **environmental interest** and low urbanization.
- Availability of **accommodation higher** than the national mean, with a large number of B&B and holiday farms.
- Many **tourists are house-owners** living in the surrounding cities and spending their holidays in their houses, which are a relevant part of the damaged building stock.

AMATRICE – Before 24.08.16

AMATRICE – After 24.08.16
IMCS = X-XI

AMATRICE – After 30.10.16
IMCS = XI

AMATRICE – After 24.08.16
IMCS = X-XI

AMATRICE – After 24.08.16
IMCS = X-XI



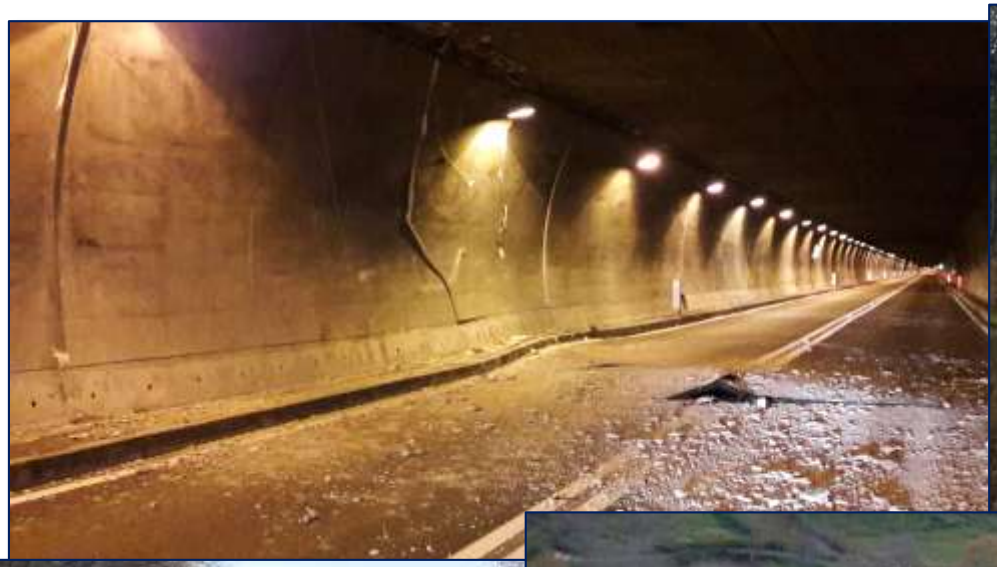


ACCUMOLI– After 24.08.16
IMCS = VIII-IX

ACCUMOLI– After 30.10.16
IMCS = XI

After October 30
Road Interruptions

After October 30
Road Interruptions



PESCARA DEL TRONTO– After 24.08.16 - IMCS = X-XI

www.protezionecivile.gov.it

THE ITALIAN NATIONAL SERVICE OF CIVIL PROTECTION

(Law n. 225 / 1992)

By "**Civil Protection**" it is meant

The ensemble of the activities put in place to protect life, goods, settlements and environments from damage and risk of damage due to calamities

In Italy «Civil Protection»
IS NOT a task assigned to a SINGLE ADMINISTRATION
BUT a function played by a COMPLEX SYSTEM

"NATIONAL SERVICE OF CIVIL PROTECTION" (SNPC)

Established by the Law n. 225 of 1992
and coordinated by the (National) **Department of Civil Protection**
of the Prime Minister Office

THE NATIONAL SERVICE OF CIVIL PROTECTION

Major Risk Commission

PRESIDENCY OF THE COUNCIL OF MINISTERS

Department of Civil Protection

Coordination activity

- Interior
  - National Fire-fighters Corps
  - Police
  - Prefectures
- Foreign Affairs
- Environment
  - ISPRA
- Health
  - 118
- Economy and Finance
  - Revenue Guard Corps
- Defence
  - Army
  - Navy
  - Air Force
  - Carabinieri
- Economic Development
- Infrastructures
  - TERNA
- Transportation
  - Costal Guard
  - ANAS
  - National Highway
  - National Railway
- Cultural Heritage
- University and Research
  - INGV
  - CNR
  - National Research Institutes
- Public Education
- Communications
- Agricultural Policy and Forestry
  - State Forest Corps
- Regions
- Provinces
- Municipalities

Citizens and any other public and private institution in the territory contribute to civil protection activities

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24 August h. 4.00 AM
Operational Committee meeting

National coordination for the first emergency response
The Operational Committee met permanently until 28 August 2016

Challenges of emergency management

- **FOUR** affected regions = **vast territory**
- Need for **coordinating 4 different civil protection regional systems**
- High number of **resources** mobilized to cover a wide affected area
- **Critical infrastructures** (roads and electricity network)
- **Access** and **logistics** in the area
- Removal and disposal of **debris**
- Local administrations **continuity**
- **Vulnerability** of the territory (buildings, agricultural areas, hydrogeological risk...)
- **Cultural** heritage
- **Media** attention
- Public and Private building/houses **damage assessment** (>200,000 requests)
- **Long** sequence of seismic (and other) events

→ **Repeated and recurring situations!**

Search & rescue

Medevac

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Sheltering people

25 camps set up by Regional and National Volunteers organizations
Now dismantled

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Sheltering people

After late october shocks

1296 people have been hosted in temporary shelters

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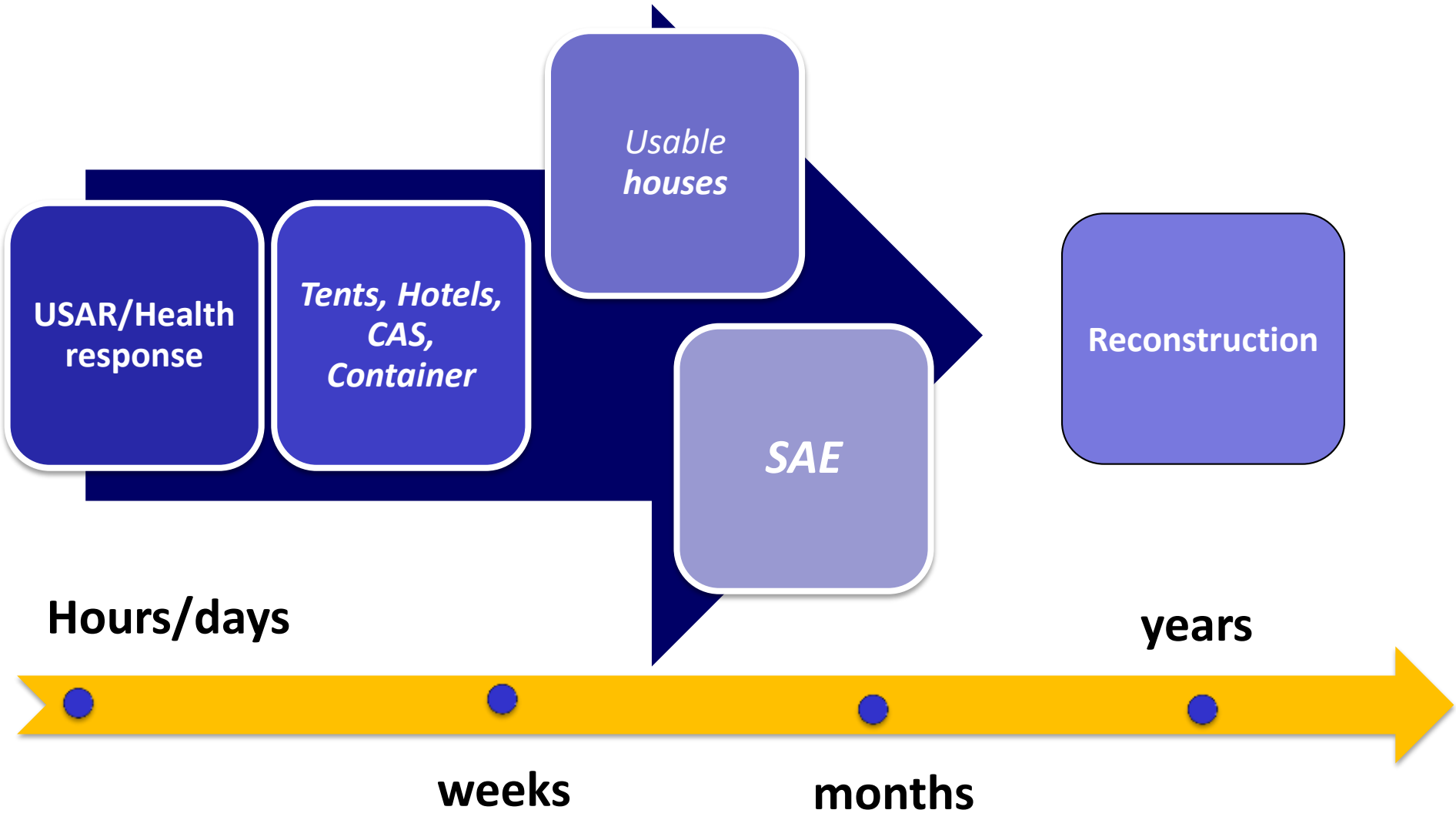
GENERAL STRATEGY FOR DWELLING NEEDS



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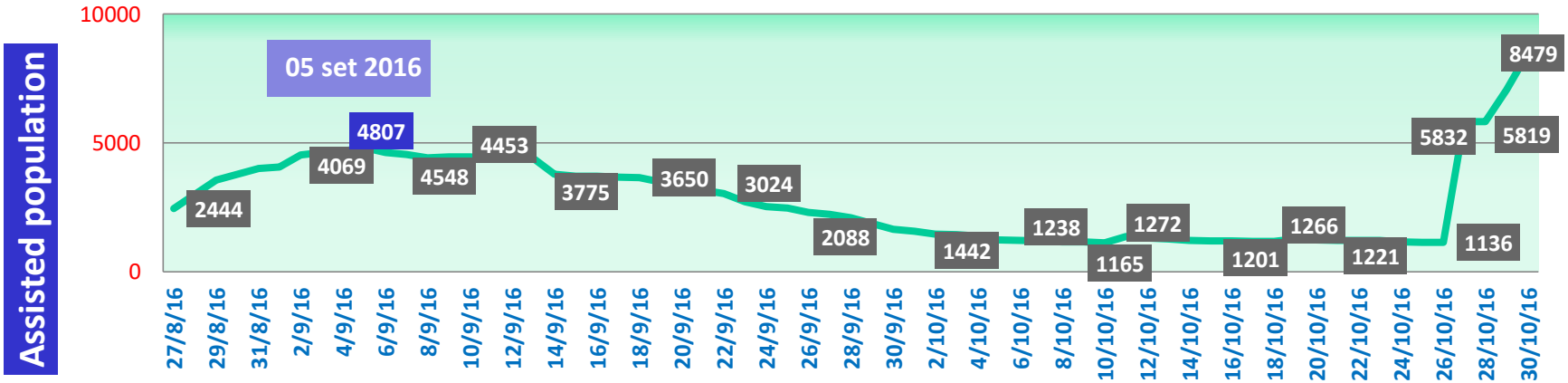
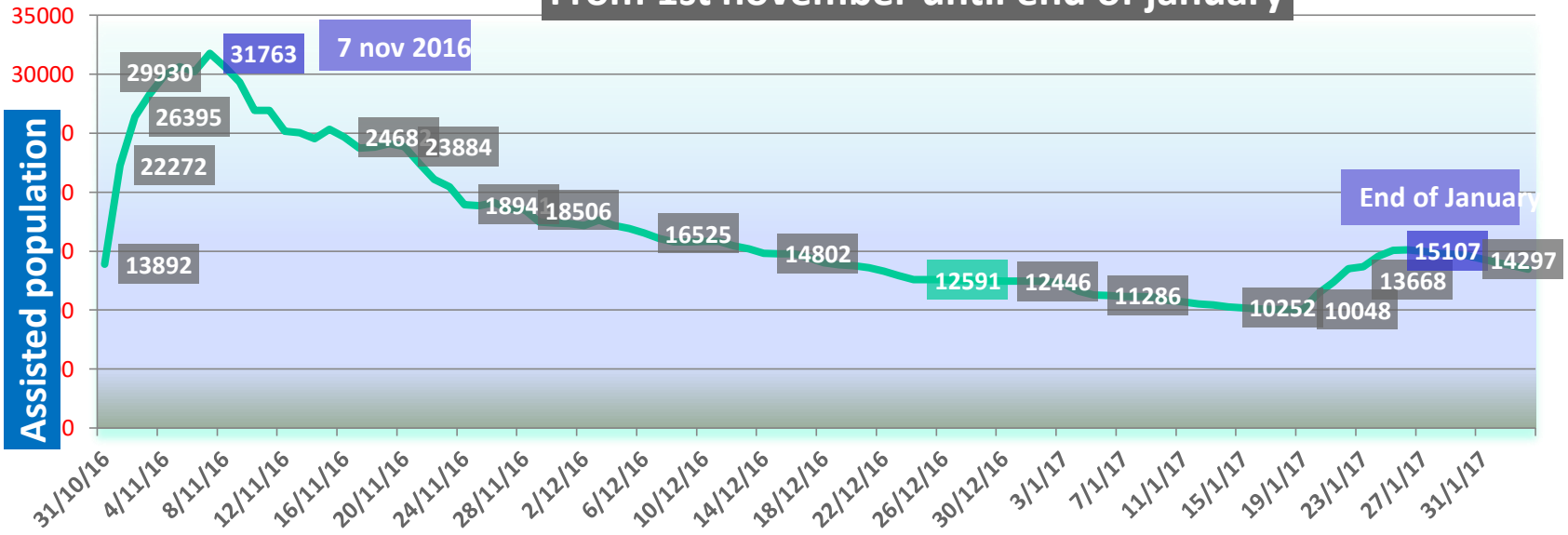
Assistance to the population needing accomodation

From 24th of august to 31st of october 2016



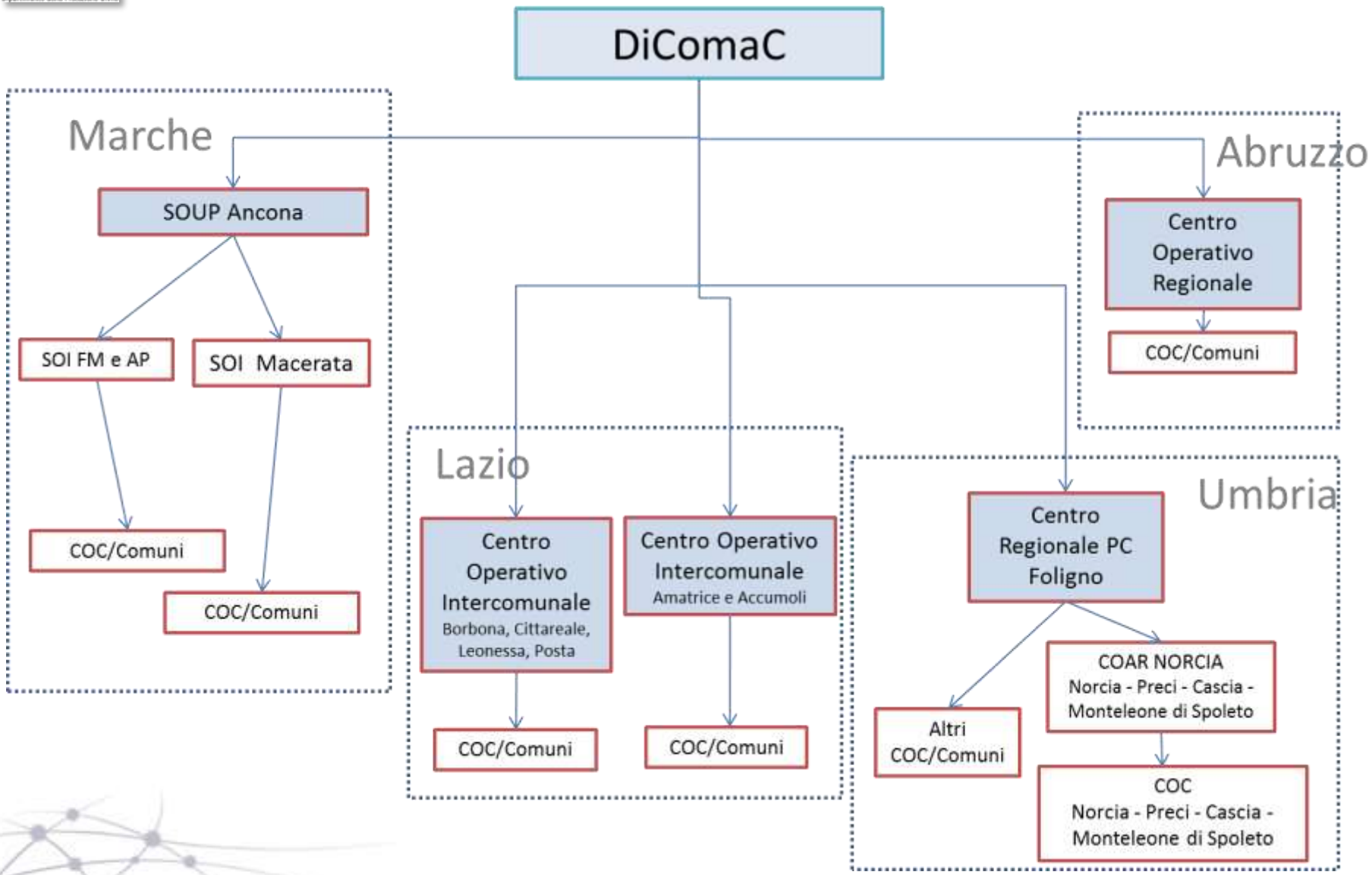
From 1st november until end of january



The National coordination system on site Direction of Comand and Control (Di.Coma.C.)

28 August 2016 Di.Coma.C. was established in Rieti at 12:00

TODAY'S MODEL (until April '17)



Direction of Command and Control (DiComaC)

DICOMAC OPERATIONAL FUNCTIONS

- *Coordination Unit*
- *Logistics and assistance to the population*
- *Planning and Technical Unit*
- *Volunteers*
- *Press and Communication*
- *Health*
- *Lifelines*
- *Road network management*
- *Emergency Telecommunications*
- *ICT*
- *Human Resources*
- *Admin, financial and legal support*
- *Post event damage assessment*
- *Air cell*
- *School*
- *Cultural Heritage*

Representatives of Fire Brigade, SSOO, Regions, ANCI, Parks Authorities, Miur, Mibact and Competences Centres

Technical activities

In addition to the **search and rescue** and to the **direct population assistance** activities, many **technical activities** are carried out to **support the civil protection management** of this first emergency phase.

Many of them are carried out by academy and research institutions, as **centres of competence**, to support civil protection needs under the **coordination of DPC at Dicomac**.

Coordination of technical and scientific activities - Competence Centres

In the general framework of the national warning system, the role of DPC Competence Centres is defined as follows:

"**Competence Centres**" (Centres for Technological and Scientific services, development and transfer) are institutions which provide **services, information, data, elaborations, technical and scientific contributions** for specific topics, to **share the best practices in risk assessment and management**. Competence Centres of for seismic risk are research institutes and academic consortia.

Competence Centres

- **INGV**

(Seismic surveillance, Seismological research projects; emergency scientific-technical support)

- **ReLUIS**

(Earthquake engineering research projects; emergency scientific-technical support)

- **EUCENTRE**

(Earthquake engineering research projects; emergency scientific-technical support)

Competence Centres

- **CNR (IGAG, IRPI, IREA)**
(microzonation, landslides surveys, satellite inteferometry; emergency scientific-technical support)

- **ISPRA**
(geological mapping, induced geological effects; emergency scientific-technical support)

- **ENEA**
(rubble management; emergency scientific-technical support)

- **ASI**
(satellite data provider)

POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

2' → 5'– 30'	***EPICENTER AND MAGNITUDE EVALUATION***	• ***Collecting and processing of seismometric network data by INGV***
10' →60'	***SIMULATED DAMAGE SCENARIOS AND DATA PROCESSING OF MONITORING SYSTEMS***	• ***Software simulation of the earthquake impact on constructions by DPC*** • ***Collecting and processing soil and building accelerometric data by DPC***
6h → 7-14d	***SITE SURVEYS FOR MACROSEISMIC AND COSEISMIC EFFECTS***	• ***Site evaluation of Mercalli Intensity,*** • ***Geological surveys for landslides, surface faulting and soil liquefaction***
6h → 6-12m	***TEMPORARY MONITORING OF SOIL AND STRUCTURES***	• ***Installing of temporary soil accelerometric stations and structure monitoring systems***
24h→ 6-12m	***POST – EARTHQUAKE DAMAGE AND SAFETY ASSESSMENT***	• ***Building inspections for damage and usability assessment.*** • ***Technical evaluations for temporary houses.***

POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

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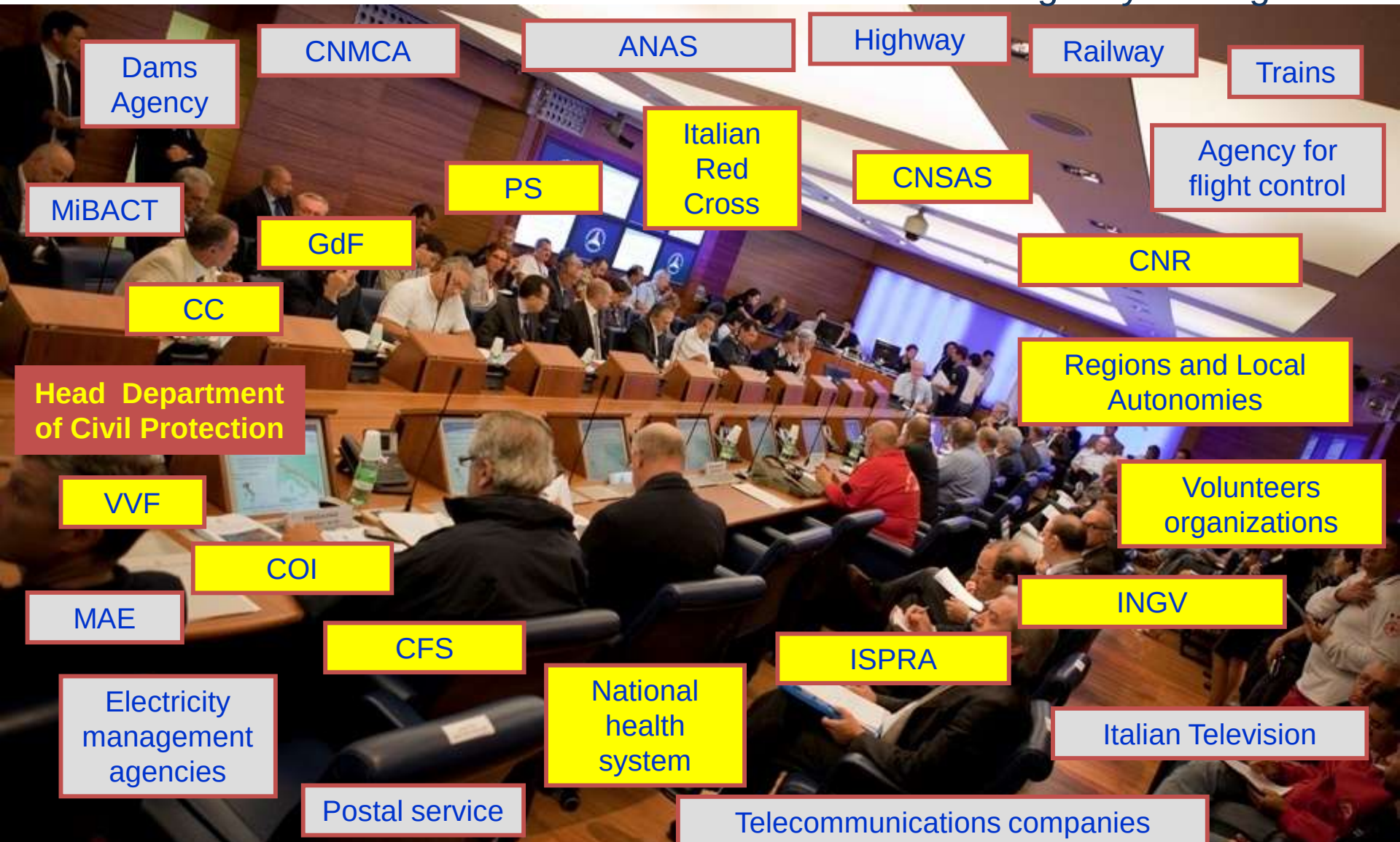
10' →60'	***SIMULATED DAMAGE SCENARIOS AND DATA PROCESSING OF MONITORING SYSTEMS***	• ***Software simulation of the earthquake impact on constructions by DPC*** • ***Collecting and processing soil and building accelerometric data by DPC***
6h → 7-14d	***SITE SURVEYS FOR MACROSEISMIC AND COSEISMIC EFFECTS***	• ***Site evaluation of Mercalli Intensity,*** • ***Geological surveys for landslides, surface faulting and soil liquefaction***
6h → 6-12m	***TEMPORARY MONITORING OF SOIL AND STRUCTURES***	• ***Installing of temporary soil accelerometric stations and structure monitoring systems***
24h→ 6-12m	***POST – EARTHQUAKE DAMAGE AND SAFETY ASSESSMENT***	• ***Building inspections for damage and usability assessment.*** • ***Technical evaluations for temporary houses.***

The Operational Committee

started its activities within DPC on August 24 at **4:00 a.m.**, until August 28, and ensured a unified direction and coordination of emergency management.



Impact scenario - August 24

Scenario available in 10-15' after the event

A first picture of the possible consequences was immediately obtained from the **epicentral coordinates and Richter magnitude that were made available to DPC by INGV**. Based on these parameters, a **damage scenario** immediately developed through the **DPC-SIGE** software returned an estimate of the earthquake consequences.

people in collapsed buildings:
38-1724
homeless:
6135-115,912
collapsed/unusable buildings:
5625-57,769
estimated epicentral intensity:
IX MCS

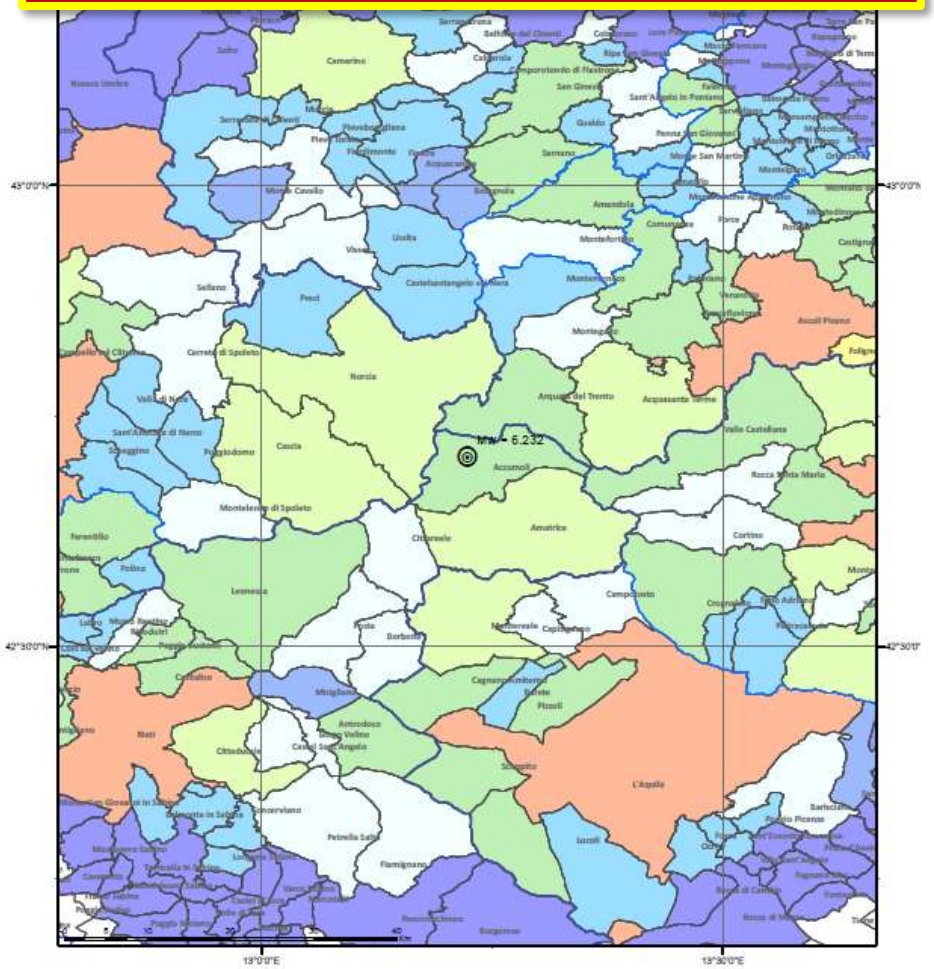


Fig.6 Scenario di danno T = T0: Popolazione Senza Tetto (valori medi stimati)

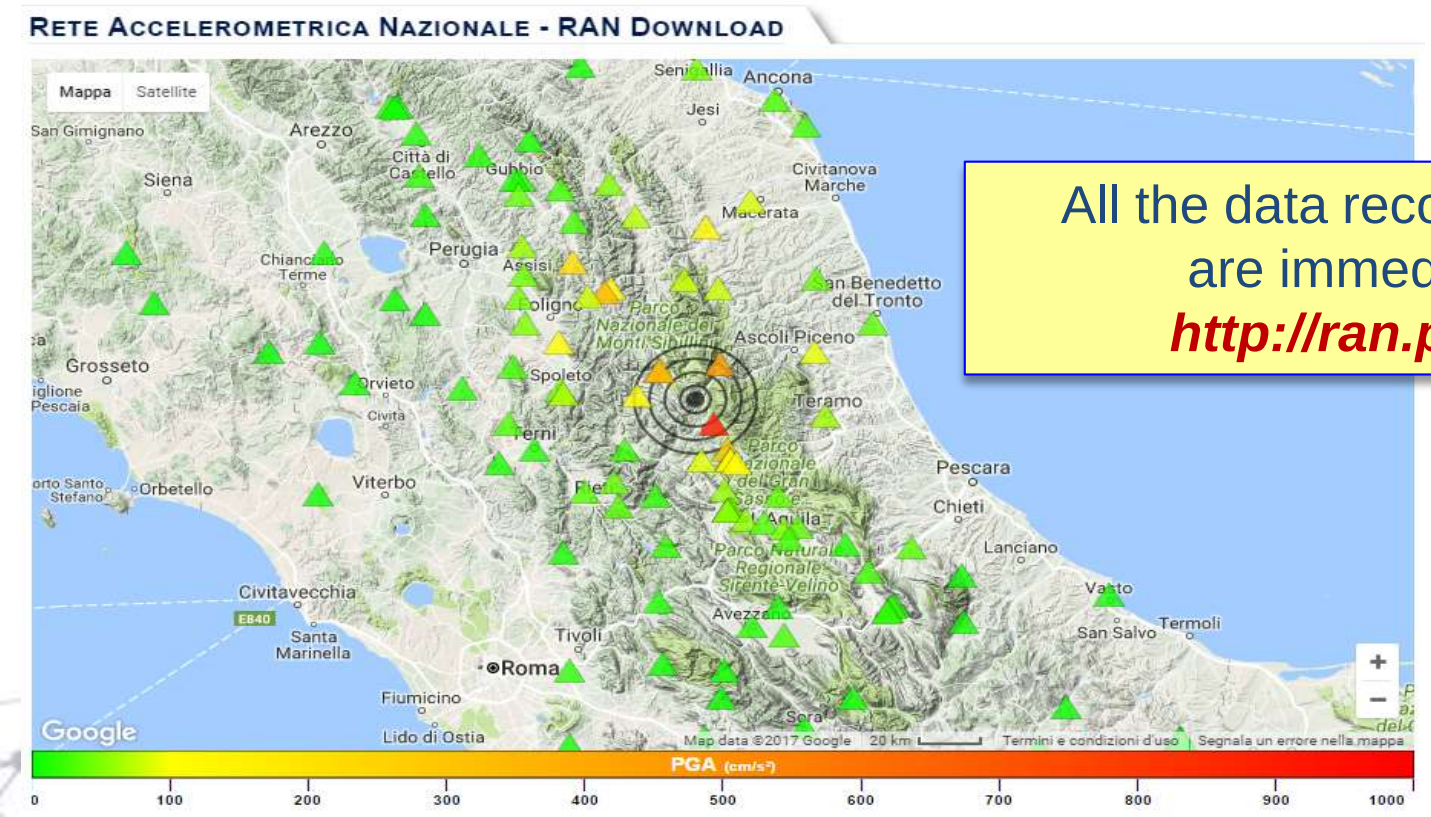
SIGE_epicentro
limiti regionali
limiti provinciali
limiti comunali

0
1 - 10
11 - 50
51 - 100
101 - 250
251 - 500
501 - 1000
1001 - 1500
1501 - 5000
> 5001

National Strong-Motion Network (RAN-DPC)

The RAN-DPC strong-motion network (code IT) is formed by more than **560 permanent digital stations**, whose data are tele-transmitted to the **DPC monitoring centre**.

RAN-DPC guarantees a dense cover of all high seismic hazard zones of the national territory, with instrumental density proportional to the hazard level.



All the data recorded by RAN-DPC are immediately published on ***http://ran.protezionecivile.it/***

National Strong-Motion Network (RAN-DPC) – August 24 (Mw=6.0)

M. Dolce

www.protezionecivile.gov.it

Event: Accumoli - Origin time: 2016/08/24 01:36:32 Lat:42.706 Lon:13.223 Ml = 6.0 Agency: INGV

Seismic moment: 7.520e+18 Nm - Mw = 6.3 Agency: DPC

sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	*Hz*	*cm/s*s*	*cm/s*s*	*cm/s*	*cm*	*cm/s*s*	*cm/s*s*	*cm/s*s*		
AMT	HGE	10	0.2-50.0	915.97	640.03	44.25	2.96	1786.88	199.93	20.85	B*	Amatrice
AMT	HGN	10	0.2-50.0	445.59	297.52	39.11	7.03	566.87	356.08	41.43	B*	Amatrice
AMT	HGZ	10	0.2-50.0	399.94	214.41	27.45	4.46	414.57	328.56	57.23	B*	Amatrice
RQT	HGE	14	0.2-50.0	447.87	294.03	13.85	2.05	938.23	75.56	21.78	B*	Arquata_Del_Tronto
RQT	HGZ	14	0.2-50.0	396.54	163.71	9.16	1.92	411.45	42.19	19.67	B*	Arquata_Del_Tronto
NOR	HGE	14	0.2-50.0	192.12	162.55	31.06	8.20	306.03	411.44	69.77	C*	Norcia
NOR	HGN	14	0.2-50.0	165.66	154.00	15.21	4.33	442.27	242.97	51.25	C*	Norcia
NOR	HGZ	14	0.2-50.0	258.33	143.12	14.68	2.82	279.99	120.86	18.62	C*	Norcia
NRC	HGE	14	0.2-50.0	331.61	320.42	29.20	6.25	711.12	237.14	51.36	B	Norcia
NRC	HGN	14	0.2-50.0	376.96	294.50	19.16	5.67	631.13	193.98	48.16	B	Norcia
NRC	HGZ	14	0.2-50.0	208.60	178.76	8.74	2.27	563.85	100.20	17.27	B	Norcia
CSC	HGE	17	0.2-50.0	104.40	79.75	5.46	0.90	196.47	74.73	7.50	B	Cascia
CSC	HGN	17	0.2-50.0	91.91	76.04	5.47	1.11	197.07	51.42	7.28	B	Cascia
CSC	HGZ	17	0.2-50.0	64.32	44.98	2.27	0.67	94.74	39.26	6.27	B	Cascia
PCB	HGE	19	0.2-50.0	190.70	133.78	10.64	1.33	372.79	110.44	13.82	B*	Poggio_Cancelli
PCB	HGN	19	0.2-50.0	287.02	173.62	10.67	1.73	528.22	148.39	19.45	B*	Poggio_Cancelli
PCB	HGZ	19	0.2-50.0	80.89	58.70	5.43	1.09	218.86	103.23	17.50	B*	Poggio_Cancelli
MSC	HGE	22	0.2-50.0	109.38	74.73	9.45	1.53	273.21	145.50	11.87	B*	Mascioni
MSC	HGN	22	0.2-50.0	83.51	56.69	6.30	1.70	130.50	91.81	18.29	B*	Mascioni
MSC	HGZ	22	0.2-50.0	54.94	50.00	5.60	1.89	156.47	93.57	20.10	B*	Mascioni
MSCT	HGE	22	0.2-50.0	114.01	77.58	9.78	1.58	283.85				
MSCT	HGN	22	0.2-50.0	86.36	58.32	6.46	1.74	132.82				
MSCT	HGZ	22	0.2-50.0	53.39	51.12	5.69	1.94	159.83				
SPD	HGE	24	0.2-50.0	56.80	53.48	5.17	0.77	113.04				
SPD	HGN	24	0.2-50.0	104.27	71.52	7.49	1.39	197.03				
SPD	HGZ	24	0.2-50.0	57.24	41.47	5.67	1.81	84.95				
LSS	HGE	27	0.2-50.0	23.24	20.58	1.79	0.65	62.02				
LSS	HGN	27	0.2-50.0	19.69	17.05	1.81	0.87	41.71				

MaxHor(PGA) = 0.91 g
MaxHor(PSA0.3s) = 1.78 g
MaxHor(PGD) = 8.2 cm
MaxVert.(PGA) = 0.39 g

Data available in 5-10' after the event

PGA,PGV,PGD = peak ground acceleration, velocity and displacement
EPA = effective ground acceleration (Kramer, 1996)
PSA03,PSA10,PSA30 = spectral acceleration (0.3, 1.0, 3.0 sec)

National Strong-Motion Network (RAN-DPC) October 26 (Mw=5.9)

M. Dolce

www.protezionecivile.gov.it

Event: Castelsa - Origin time: 2016/10/26 19:18:05 Lat:42.915 Lon:13.128 Ml = 5.9 Agency: INGV

Seismic moment: 3.750e+18 Nm - Mw = 6.1 Agency: DPC

sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	*Hz*	*cm/s*s*	*cm/s*s*	*cm/s*	*cm*	*cm/s*s*	*cm/s*s*	*cm/s*s*		
CNE	HGE	3	0.2-50.0	553.54	416.37	23.36	3.02	1288.22	232.33	18.38	na	Castel Santangelo sul Nera
CNE	HGN	3	0.2-50.0	420.07	348.16	30.53	5.28	865.69	373.01	30.07	na	Castel Santangelo sul Nera
CNE	HGZ	3	0.2-50.0	489.29	237.36	15.16	2.83	531.47	116.68	31.44	na	Castel Santangelo sul Nera
CMI	HGE	8	0.2-50.0	684.48	622.44	48.66	6.92	1778.56	507.98	40.49	na	Campi
CMI	HGN	8	0.2-50.0	349.39	299.29	23.51	2.95	798.03	224.95	31.53	na	Campi
CMI	HGZ	8	0.2-50.0	494.80	175.53	11.84	1.73	335.12	113.66	15.70	na	Campi
PRE	HGE	9	0.2-50.0	282.13	155.23	7.66	1.13	343.69	61.49	14.08	na	Preci
PRE	HGN	9	0.2-50.0	239.33	156.06	9.61	1.69	365.35	49.51	21.83	na	Preci
PRE	HGZ	9	0.2-50.0	174.52	75.23	5.22	1.40	188.20	51.47	12.81	na	Preci
CLO	HGE	11	0.2-50.0	81.89	75.02	6.55	0.70	167.02	73.43	6.02	na	Castelluccio
CLO	HGN	11	0.2-50.0	83.29	73.18	7.45	1.16	237.07	91.10	13.94	na	Castelluccio
CLO	HGZ	11	0.2-50.0	105.87	53.79	4.25	0.54	87.37	46.54	5.62	na	Castelluccio
MCV	HGE	14	0.2-50.0	408.58	240.04	11.22	1.29	390.40	74.56	13.46	na	Monte Cavallo
MCV	HGN	14	0.2-50.0	559.74	349.50	14.32	1.76	954.87	62.46	19.38	na	Monte Cavallo
MCV	HGZ	14	0.2-50.0	529.49	123.77	7.43	0.84	192.98	61.33	8.18	na	Monte Cavallo
NOR	HGE	14	0.2-50.0	222.45	164.99	16.47	2.58	425.23	248.26	13.64	C*	Norcia
NOR	HGN	14	0.2-50.0	137.55	115.47	9.92	2.58	235.95	154.52	40.19	C*	Norcia
NOR	HGZ	14	0.2-50.0	96.90	72.55	7.09	1.43	147.12	105.09	12.11	C*	Norcia
NRC	HGE	14	0.2-50.0	242.27	171.94	18.99	2.00	357.20	174.55	16.33	B	Norcia
NRC	HGN	14	0.2-50.0	346.67	269.76	19.95	1.74	397.90	105.77	30.83	B	Norcia
NRC	HGZ	14	0.2-50.0	211.33	134.51	8.74	1.09	275.35				
SLO	HGE	14	0.2-50.0	52.97	48.49	3.69	1.00	119.24				
SLO	HGN	14	0.2-50.0	67.65	50.63	3.50	0.96	166.78				
SLO	HGZ	14	0.2-50.0	53.25	39.45	2.73	0.71	87.67				
MMO	HGE	16	0.2-50.0	171.05	123.63	6.34	1.07	302.76				
MMO	HGN	16	0.2-50.0	170.99	131.62	11.57	1.89	306.01				
MMO	HGZ	16	0.2-50.0	93.51	81.93	4.93	0.84	161.71				
MNF	HGE	17	0.2-50.0	127.96	81.30	8.35	1.61	178.42	68.05	10.69	A*	Montefiegni-Piastra

MaxHor(PGA) = 0.68 g
MaxHor(PSA0.3s) = 1.77 g
MaxHor(PGD) = 6.9 cm
MaxVert.(PGA) = 0.52 g

Data available in 5-10' after the event

PGA,PGV,PGD = peak ground acceleration, velocity and displacement
EPA = effective ground acceleration (Kramer, 1996)
PSA03,PSA10,PSA30 = spectral acceleration (0.3, 1.0, 3.0 sec)

National Strong-Motion Network (RAN-DPC) – October 30 (Mw=6.5)

M. Dolce

www.protezionecivile.gov.it

Event: Norcia - Origin time: 2016/10/30 06:40:17 Lat:42.840 Lon:13.110 Ml = 6.1 Agency: INGV

Seismic moment: 1.930e+19 Nm - Mw = 6.5 Agency: DPC

sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	*Hz*	*cm/s*s*	*cm/s*s*	*cm/s*	*cm*	*cm/s*s*	*cm/s*s*	*cm/s*s*		
NOR	HGE	5	0.2-50.0	361.15	270.88	56.37	10.59	784.71	874.41	134.39	C*	Norcia
NOR	HGN	5	0.2-50.0	282.42	226.77	43.41	9.91	568.03	853.24	119.37	C*	Norcia
NOR	HGZ	5	0.2-50.0	275.50	239.63	17.34	4.60	473.40	200.35	29.12	C*	Norcia
NRC	HGE	5	0.2-50.0	477.19	495.99	47.05	10.22	1894.83	806.57	91.27	B	Norcia
NRC	HGN	5	0.2-50.0	326.71	374.85	38.81	8.40	1130.05	535.24	109.43	B	Norcia
NRC	HGZ	5	0.2-50.0	378.34	289.30	18.38	4.88	682.85	273.60	32.17	B	Norcia
CNE	HGE	7	0.2-50.0	454.66	378.82	39.54	5.28	1064.25	516.19	39.66	na	Castel Santangelo sul Nera
CNE	HGN	7	0.2-50.0	343.25	274.91	27.87	3.86	699.35	308.12	24.85	na	Castel Santangelo sul Nera
CNE	HGZ	7	0.2-50.0	595.87	292.87	16.83	3.09	985.74	186.41	27.79	na	Castel Santangelo sul Nera
PRE	HGE	8	0.2-50.0	260.91	191.33	10.89	1.83	478.65	122.67	9.76	na	Preci
PRE	HGN	8	0.2-50.0	315.42	194.62	14.05	2.42	421.45	128.12	27.31	na	Preci
PRE	HGZ	8	0.2-50.0	202.52	95.16	6.72	1.61	173.17	89.09	15.83	na	Preci
CLO	HGE	8	0.2-50.0	478.45	361.57	66.10	14.25	1126.09	862.01	102.28	na	Castelluccio
CLO	HGN	8	0.2-50.0	634.00	547.79	54.36	9.31	1568.22	1017.45	81.82	na	Castelluccio
CLO	HGZ	8	0.2-50.0	649.74	571.23	53.99	18.13	1452.43	607.55	187.23	na	Castelluccio
CSC	HGE	16	0.2-50.0	150.74	139.53	10.99	3.54	331.04	120.12	33.12	B	Cascia
CSC	HGN	16	0.2-50.0	172.34	148.79	12.37	3.16	303.00	124.69	29.90	B	Cascia
CSC	HGZ	16	0.2-50.0	168.53	102.46	5.64	1.74	196.90	62.42	29.67	B	Cascia
MMO	HGE	19	0.2-50.0	203.06	152.25	10.23	2.93	349.73	95.97	20.59	na	Montemonaco
MMO	HGN	19	0.2-50.0	191.65	166.48	12.06	3.32	620.74	105.87	27.38	na	Montemonaco
MMO	HGZ	19	0.2-50.0	144.28	124.64	7.66	2.32	383.03	83.66	14.28	na	Montemonaco
MCV	HGE	19	0.2-50.0	299.59	170.13	7.17	1.11	257.09				
MCV	HGN	19	0.2-50.0	388.57	217.95	12.46	0.99	551.77				
MCV	HGZ	19	0.2-50.0	451.72	123.93	5.71	1.07	171.28				
ACC	HGE	19	0.2-50.0	455.22	412.16	38.60	8.06	1326.12				
ACC	HGN	19	0.2-50.0	390.16	368.15	43.20	9.58	1124.70				
ACC	HGZ	19	0.2-50.0	538.94	257.55	19.21	5.68	590.67				
MNF	HGE	25	0.2-50.0	122.75	110.64	5.16	1.25	357.03				

MaxHor(PGA) = 0.63 g
MaxHor(PSA0.3s) = 1.89 g
MaxHor(PGD) = 18.1 cm
MaxVert.(PGA) = 0.64 g

dista = epicentral distance

PGA,PGV,PGD = peak ground acceleration, velocity and displacement
EPA = effective ground acceleration (Kramer, 1996)
PSA03,PSA10,PSA30 = spectral acceleration (0.3, 1.0, 3.0 sec)

Data available in 5-10' after the event

National Strong-Motion Network (RAN-DPC) – January 18, 2017 (Mw=5.5)

M. Dolce

www.protezionecivile.gov.it

Event: Capitign - Origin time: 2017/01/18 10:14:09 Lat:42.529 Lon:13.282 Ml = 5.4 Agency: INGV
Seismic moment: 1.610e+18 Nm - Mw = 5.8 Agency: DPC

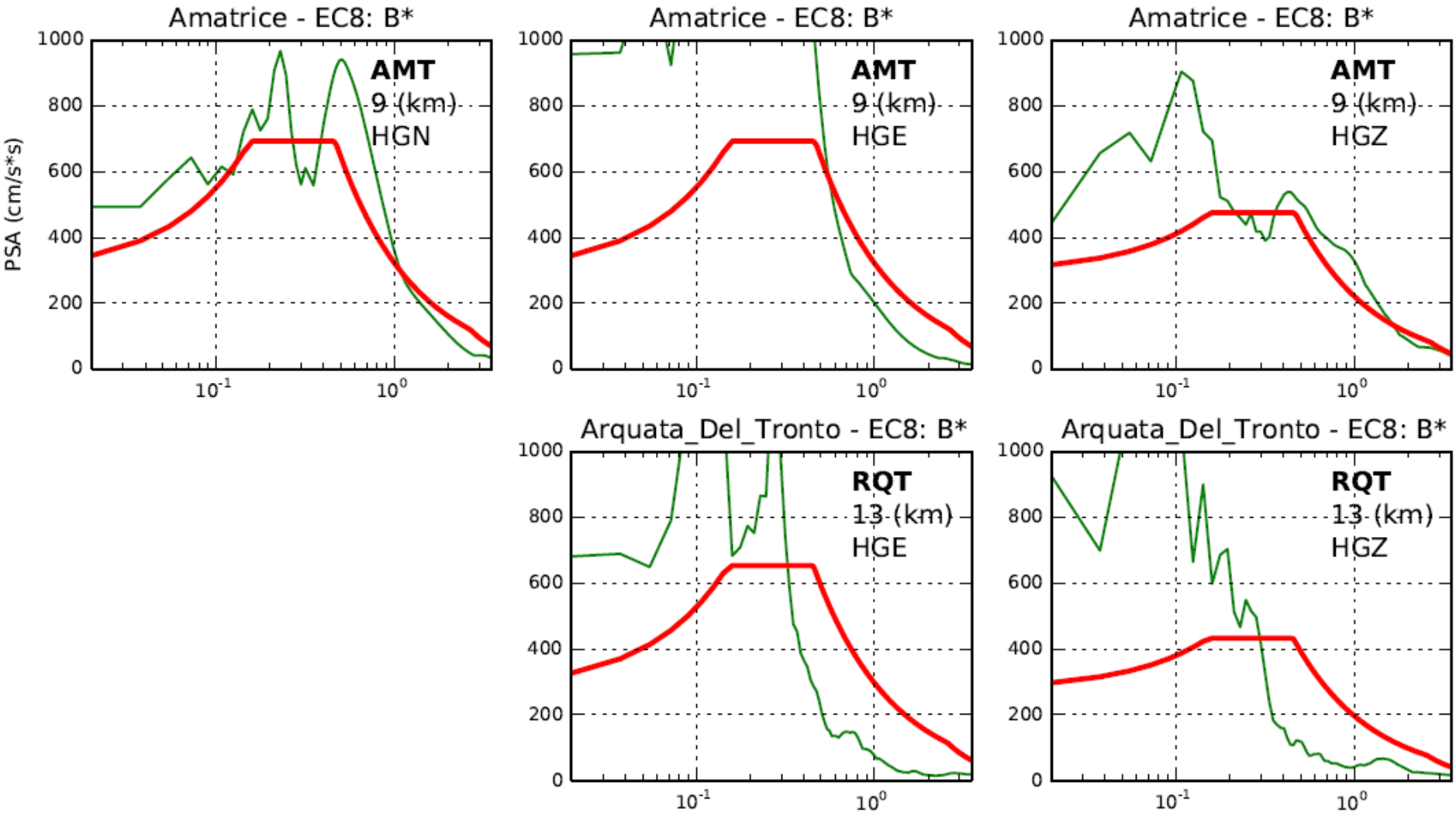
sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	*Hz*	*cm/s*s*	*cm/s*s*	*cm/s*	*cm*	*cm/s*s*	*cm/s*s*	*cm/s*s*		
PZI1	HGE	11	0.2-50.0	102.14	54.15	3.80	0.28	129.22	25.14	2.04	B*	Pizzoli
PZI1	HGN	11	0.2-50.0	98.65	72.75	4.20	0.48	161.06	51.27	2.64	B*	Pizzoli
PZI1	HGZ	11	0.2-50.0	47.39	24.01	1.70	0.17	40.63	17.10	0.91	B*	Pizzoli
AMT	HGE	12	0.2-50.0	317.72	244.14	14.34	1.67	615.66	67.02	14.99	B*	Amatrice
AMT	HGN	12	0.2-50.0	337.37	248.96	18.64	2.09	586.73	117.24	13.12	B*	Amatrice
AMT	HGZ	12	0.2-50.0	147.28	94.91	4.86	1.87	205.42	34.63	17.27	B*	Amatrice
AQF	HGE	18	0.2-50.0	66.48	44.51	1.73	0.13	93.18	9.77	1.05	B*	L_Aquila_Valle_Aterno_Ferri
AQF	HGN	18	0.2-50.0	46.23	36.18	1.31	0.16	104.74	8.38	1.11	B*	L_Aquila_Valle_Aterno_Ferri
AQF	HGZ	18	0.2-50.0	48.95	31.46	1.26	0.14	34.77	6.65	1.28	B*	L_Aquila_Valle_Aterno_Ferri
AQV	HGE	18	0.2-50.0	63.15	40.97	1.99	0.18	97.27	18.25	1.38	B	L_Aquila_Centro_Valle
AQV	HGN	18	0.2-50.0	62.49	41.86	1.59	0.18	53.51	10.98	1.06	B	L_Aquila_Centro_Valle
AQV	HGZ	18	0.2-50.0	24.43	16.43	0.92	0.15	51.03	12.26	1.58	B	L_Aquila_Centro_Valle
AQG	HGE	18	0.2-50.0	60.63	44.90	2.55	0.20	90.81	15.40	1.50	B	L_Aquila_Colle_dei_Grilli
AQG	HGN	18	0.2-50.0	42.07	35.95	1.71	0.16	62.64	12.18	1.03	B	L_Aquila_Colle_dei_Grilli
AQG	HGZ	18	0.2-50.0	20.00	11.87	0.66	0.16	26.20	9.59	1.19	B	L_Aquila_Colle_dei_Grilli
ACC	HGE	19	0.2-50.0	85.56	61.81	2.63	0.70	126.55	30.48	7.04	na	Accumoli
ACC	HGN	19	0.2-50.0	65.06	60.81	3.67	0.75	131.68	22.81	11.06	na	Accumoli
ACC	HGZ	19	0.2-50.0	55.42	35.12	2.42	0.71	62.27	20.18	9.59	na	Accumoli
ANT	HGE	21	0.2-50.0	10.06	11.09	0.77	0.18	32.63	10.91	1.13	A*	Antrodoco
ANT	HGN	21	0.2-50.0	10.96	11.94	1.12	0.26	30.95	28.52	2.11	A*	Antrodoco
ANT	HGZ	21	0.2-50.0	6.27	5.93	0.52	0.16	17.55				
AQK	HGE	23	0.2-50.0	21.37	17.47	1.34	0.32	38.36				
AQK	HGN	23	0.2-50.0	24.85	24.92	3.19	0.55	61.77				
AQK	HGZ	23	0.2-50.0	21.78	17.86	1.88	0.36	48.35				
LSS	HGE	26	0.2-50.0	16.12	11.11	0.75	0.14	24.71				
LSS	HGN	26	0.2-50.0	19.52	14.37	0.93	0.10	34.91				
LSS	HGZ	26	0.2-50.0	10.76	7.70	0.56	0.21	16.52				
BZZ	HGE	26	0.2-50.0	17.70	14.01	0.83	0.14	31.55	15.05	1.25	B	L_Aquila_Bazzano

MaxHor(PGA) = 0.33 g
MaxHor(PSA0.3s) = 0.61 g
MaxHor(PGD) = 2.1 cm
MaxVert.(PGA) = 0.14 g

Data available in 5-10' after the event

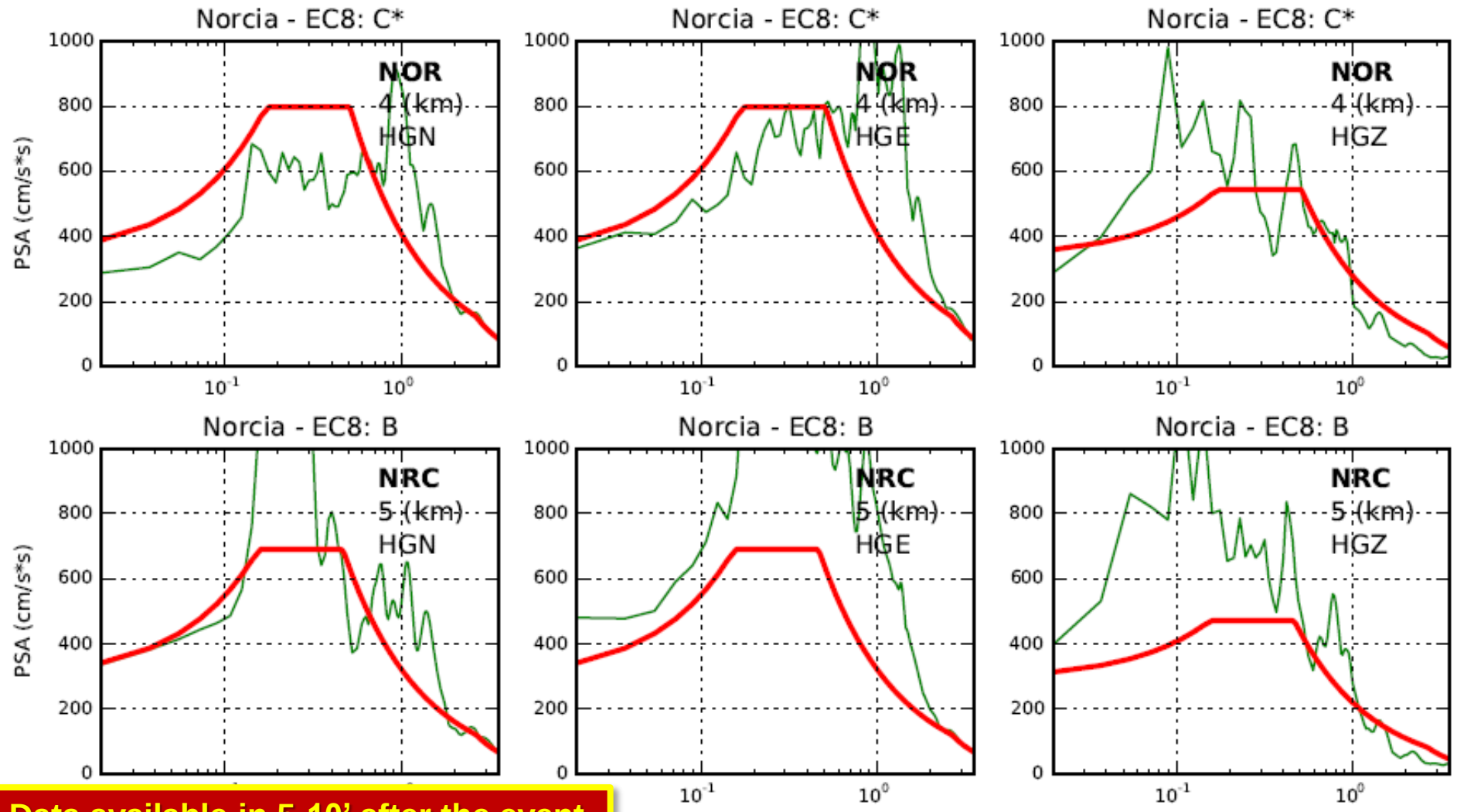
PGA,PGV,PGD = peak ground acceleration, velocity and displacement
EPA = effective ground acceleration (Kramer, 1996)
PSA03,PSA10,PSA30 = spectral acceleration (0.3, 1.0, 3.0 sec)
EC8 = Site classification (Eurocode from ITACA)

RESPONSE SPECTRA
August 24, 2016



Data available in 5-10' after the event

RESPONSE SPECTRA
October 30, 2016



Data available in 5-10' after the event

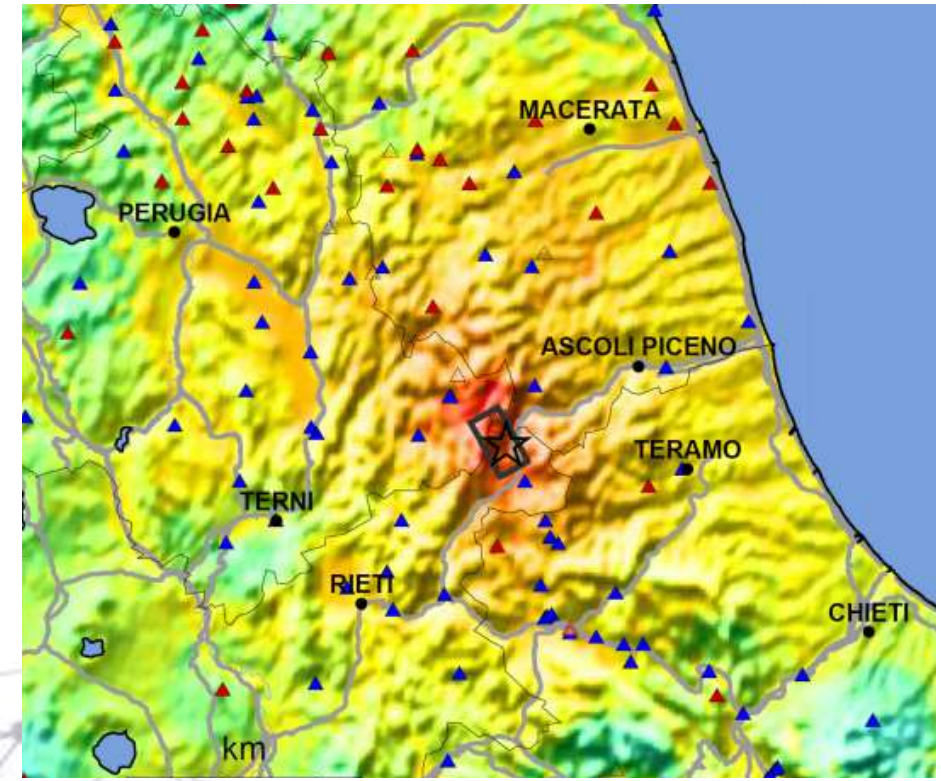
SHAKEMAP – August 24, 2016

Mappe di scuotimento INGV degli eventi del 24.08.16, 26.10.16 e 30.10.16 in termini di Intensità Strumentale

Map Version 19 Processed 2016-11-07 18:52:57 UTC

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	*<0.02*	*0.08*	*0.3*	*0.9*	*2.4*	*6.4*	*17*	*45*	*>120*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Faenza and Michelini, 2010, 2011



INGV ShakeMap : Rieti
24 Aug 2016 01:36:32 UTC M 6.0 N42.70 E13.24 Depth: 4.2km ID:7073641

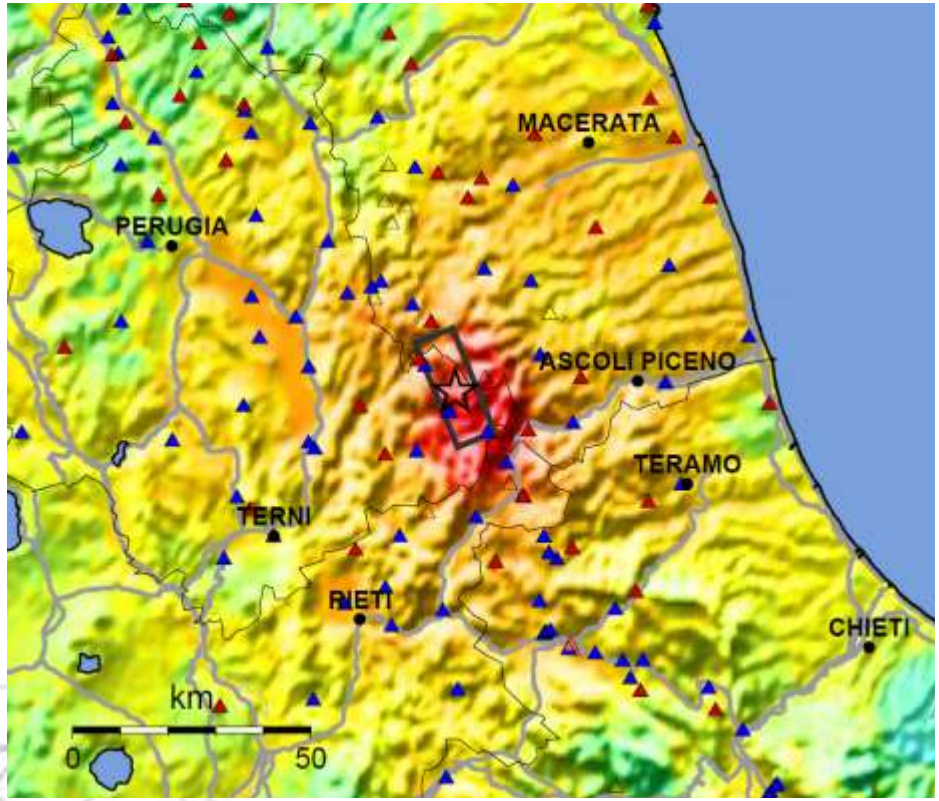
SHAKEMAP – October 30, 2016

Mappe di scuotimento INGV degli eventi del 24.08.16, 26.10.16 e 30.10.16 in termini di Intensità Strumentale

Map Version 19 Processed 2016-11-07 18:52:57 UTC

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	*<0.02*	*0.08*	*0.3*	*0.9*	*2.4*	*6.4*	*17*	*45*	*>120*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Faenza and Michelini, 2010, 2011



INGV ShakeMap : Perugia
30 Oct 2016 06:40:17 UTC M 6.5 N42.83 E13.11 Depth: 9.2km ID:8863681

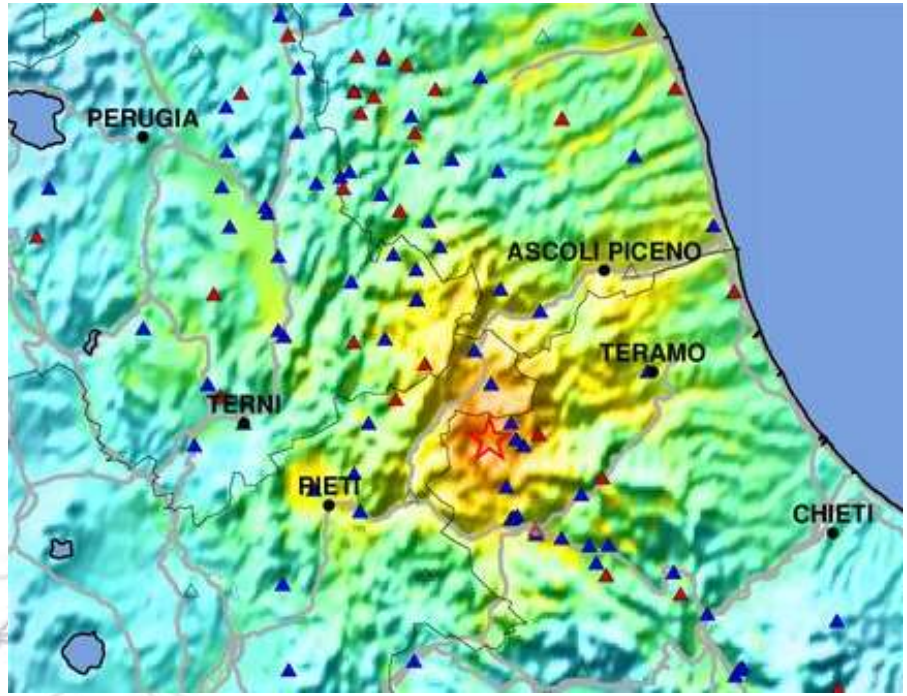
SHAKEMAP – January 18, 2016

Mappe di scuotimento INGV degli eventi del 24.08.16, 26.10.16 e 30.10.16 in termini di Intensità Strumentale

Map Version 19 Processed 2016-11-07 18:52:57 UTC

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	*<0.02*	*0.08*	*0.3*	*0.9*	*2.4*	*6.4*	*17*	*45*	*>120*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Faenza and Michelini, 2010, 2011



INGV ShakeMap : Perugia

30 Oct 2016 06:40:17 UTC M 6.5 N42.83 E13.11 Depth: 9.2km ID:8863681

Seismic Observatory of The Structures (OSS-DPC)

OSS-DPC is a national permanent network which monitors the seismic response of more than 150 structures, including schools, hospitals, town halls, bridges, and a dam. The OSS-DPC allows a remote estimation being made in few minutes of the damage suffered by the monitored structures after an earthquake and, by analogy, of the damage possibly suffered by similar structures in the same area.

The nearest monitored structure was a hospital at Norcia, 14 km far from the epicentre, while a total of 37 monitoring systems were triggered within 200 km distance from the epicentre.

Seismic Observatory of Structures (OSS-DPC) August 24

M. Dolce

www.protezionecivile.gov.it

EA080	Hospital	Norcia	R.C.	PGA=0.23g	Drift=0.04%
15SNO	School	Norcia	R.C.	PGA=0.29g	Drift=0.23%
BC037	School	Visso	masonry	PGA=0.33g	Drift=0.61%

Sigla	Data	Tempo tr-igger UTC	PGA_X (g)	PGA_Y (g)	PGA_Z (g)	PSA_X (g)	PSA_Y (g)	Dmax (x1000)	Danno Stimato
EA080	2016-08-24	01:36:36	0.1812	0.2312	0.2762	0.4054	0.5736	0.44	Nullo
15SNO	2016-08-24	01:36:12	0.2894	0.5224	0.3304	0.4322	0.8853	2.26	Nullo
BC037	2016-08-24	01:36:36	0.3265	0.3172	0.1347	1.0521	0.8044	6.1	Moderato
BC047	2016-08-24	01:36:40	0.0432	0.0579	0.0267	0.1669	0.1835	0.15	Nullo
EA083	2016-08-24	01:36:41	0.0534	0.0688	0.0314	0.1069	0.2359	0.3	Nullo
20IPI	2016-08-24	01:36:20	0.0139	0.0127	0.0081	0.0543	0.0748	0.48	Nullo
EA073	2016-08-24	01:36:44	0292	0.0385	0.0205	0.0676	0.1211	0.44	Nullo
BC046	2016-08-24	01:36:4	0194	0.0264	0.0217	0.0872	0.1067	0.11	Nullo
BC036	2016-08-24	01	0.0429	0.0401	0.0259	0.1254	0.1471	0.06	Nullo
EA067	2016-08-24		0.0262	0.0203	0.022	0.1212	0.1656	0.26	Nullo
BC053	2016-08-2	:36:45	0.0421	0.0541	0.0272	0.1155	0.2	0.34	Nullo
50OBR	201	01:36:42	0.0346	0.0455	0.0298	0.1828	0.1928	0.58	Nullo
EA077		01:36:53	0.0088	0.0093	0.0047	0.0311	0.0284	0.16	Nullo
16IPE	-08-24	01:37:15	0.0041	0.0047	0.0028	0.0224	0.0158	0.03	Nullo
B	2016-08-24	01:36:49	0.0192	0.0153	0.0076	0.0279	0.0284	1.46	Nullo

Data available in 10-15' after the event

Livelli di danno	Edifici in c.a.	Edifici in muratura
Nessun danno	0 <= Dmax < 5	0 <= Dmax < 2
Danno lieve	5 <= Dmax < 9	2 <= Dmax < 4.5
Danno moderato	9 <= Dmax < 15	4.5 <= Dmax < 8
Danno grave	15 < Dmax	8 < Dmax

Seismic Observatory of Structures (OSS-DPC) October 26

M. Dolce

EA080	Hospital	Norcia	R.C.	PGA=0.19g	Drift=0.37%
15SNO	School	Norcia	R.C.	PGA=0.48g	Drift=0.20%
BC037	School	Visso	masonry	PGA=0.48g	Drift=1.60%

Sigla	Data	Tempo trigger UTC	PGA_X (g)	PGA_Y (g)	PGA_Z (g)	PSA_X (g)	PSA_Y (g)	Dmax (x1000)	Danno Stimato
BC037	2016-10-26	19:18:04	0.3626	0.4751	0.3044	1.4019	1.3341	16.01	Grave
15SNO	2016-10-26	19:17:59	0.4317	0.4807	0.2733	0.5749	0.4343	1.99	Nullo
EA080	2016-10-26	19:18:11	0.1604	0.1925	0.1765	0.2805	0.4909	3.65	Nullo
59OCS	2016-10-26	19:19:08	0.0015	0.0013	0.0007	0.0053	0.003	0.04	Nullo
BC036	2016-10-26	19:18:12	0.0776	0.0964	0.0752	0.2744	0.3827	2.5	Nullo
EA073	2016-10-26	19:18:14	0.0254	0.0213	0.019	0.1539	0.0704	0.57	Nullo
EA083	2016-10-26	19:18:14	[illegible]91	0.0429	0.0227	0.1071	0.2433	0.32	Nullo
EA067	2016-10-26	19:18:15	[illegible]	0.0306	0.02	0.1338	0.2029	0.48	Nullo
BC053	2016-10-26	19:18:[illegible]	0.0826	0.087	0.078	0.2578	0.4431	1.27	Nullo
50OBR	2016-10-26	[illegible]	0.0282	0.0192	0.0158	0.0666	0.0591	0.36	Nullo
BC039	2016-10-26	[illegible]35	0.0216	0.0251	0.0159	0.0672	0.0662	0.27	Nullo
20IPI	2016-10-[illegible]	19:17:55	0.0065	0.0071	0.0052	0.0316	0.0355	0.4	Nullo
BC044	201[illegible]	19:18:18	0.0112	0.0123	0.0065	0.0548	0.0458	0.07	Nullo
EA116	[illegible]26	19:18:20	0.0092	0.0072	0.0067	0.0422	0.0564	0.11	Nullo
EA12[illegible]	[illegible]16-10-26	19:18:18	0.0171	0.0261	0.0174	0.1038	0.0883	0.32	Nullo
4[illegible]	2016-10-26	19:18:17	0.0118	0.0143	0.0051	0.0569	0.0281	0.21	Nullo
47C[illegible]Q	2016-10-26	19:18:17	0.0091	0.0139	0.0056	0.0412	0.0538	0.32	Nullo

Data available in 10-15' after the event

Seismic Observatory of Structures (OSS-DPC) October 30, 2016

EA080	Hospital	Norcia	R.C.	PGA=0.19g	Drift=0.08%
15SNO	School	Norcia	R.C.	PGA=0.57g	Drift=0.56%
BC037	School	Visso	masonry	PGA=0.48g	Drift=1.10%

Sigla	Data	Tempo tr-igger UTC	PGA_X (g)	PGA_Y (g)	PGA_Z (g)	PSA_X (g)	PSA_Y (g)	Dmax (x1000)	Danno Stimato
15SNO	2016-10-30	06:40:09	0.5732	0.5638	0.4528	0.8065	0.7484	5.62	Lieve
EA080	2016-10-30	06:40:20	0.3222	0.309	0.6595	0.4239	0.573	0.79	Nullo
BC037	2016-10-30	06:40:19	0.2913	0.3012	0.3302	1.3862	1.4727	10.98	Grave
EA083	2016-10-30	06:40:24	0.0863	0.0991	0.0511	0.2142	0.3774	0.46	Nullo
EA073	2016-10-30	06:40:26	0.0445	0.0538	0.0348	0.1478	0.125	0.8	Nullo
EA067	2016-10-30	06:40:27	0.0382	0.0397	0.0314	0.1877	0.1826	0.33	Nullo
BC039	2016-10-30	06:40:26	[illegible]	0.11	0.0609	0.2345	0.2777	2.21	Lieve
20IPI	2016-10-30	06:40:15	[illegible]	0.0214	0.0157	0.1047	0.1105	1.08	Nullo
BC044	2016-10-30	06[illegible]	0.0397	0.0468	0.0217	0.1709	0.2729	0.32	Nullo
BC045	2016-10-30	[illegible]	0.0435	0.0382	0.0264	0.171	0.2418	1.87	Nullo
EA116	2016-10-30	[illegible]:40:28	0.0405	0.0312	0.0223	0.1561	0.1759	0.36	Nullo
46CAQ	2016[illegible]	06:40:21	0.0358	0.0551	0.0224	0.1437	0.1757	0.75	Nullo
47CAQ	[illegible]	06:40:20	0.0368	0.0502	0.0308	0.0816	0.1569	1.6	Nullo
BC053	[illegible]-10-30	06:40:25	0.0543	0.039	0.0493	0.2167	0.2699	0.57	Nullo
BC[illegible]	2016-10-30	06:40:27	0.0803	0.1153	0.0495	0.3487	0.5289	0.5	Nullo
5[illegible]	2016-10-30	06:40:22	0.0498	0.0591	0.0442	0.1493	0.2456	0.59	Nullo
BC043	2016-10-30	06:40:28	0.0283	0.0223	0.0148	0.1167	0.1755	2.44	Nullo

Data available in 10-15' after the event

Seismic Observatory of The Structures (OSS-DPC)

M. Dolce

EA080	Hospital	Norcia	R.C.	15 Km

15SNO	School	Norcia	R.C.	15 Km

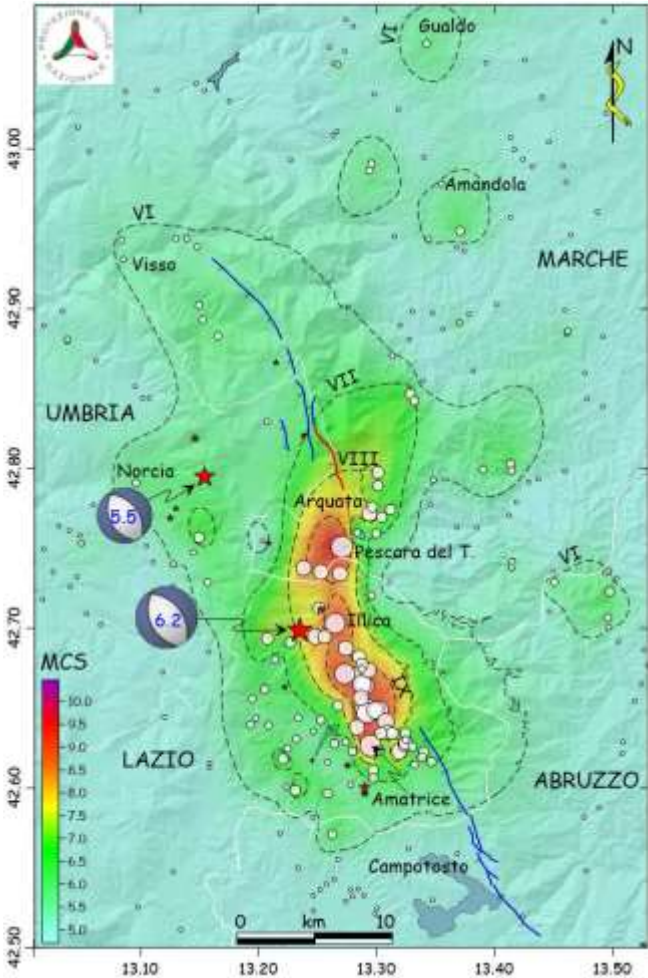
POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

2' → 5'– 30'	*EPICENTER AND MAGNITUDE EVALUATION*	• *Collecting and processing of seismometric network data by INGV*
10' →60'	*SIMULATED DAMAGE SCENARIOS AND DATA PROCESSING OF MONITORING SYSTEMS*	• *Software simulation of the earthquake impact on constructions by DPC* • *Collecting and processing soil and building accelerometric data by DPC*
6h → 7-14d	***SITE SURVEYS FOR MACROSEISMIC AND COSEISMIC EFFECTS***	• ***Site evaluation of Mercalli Intensity,*** • ***Geological surveys for landslides, surface faulting and soil liquefaction***
6h → 6-12m	*TEMPORARY MONITORING OF SOIL AND STRUCTURES*	• *Installing of temporary soil accelerometric stations and structure monitoring systems*
24h→ 6-12m	*POST – EARTHQUAKE DAMAGE AND SAFETY ASSESSMENT*	• *Building inspections for damage and usability assessment.* • *Technical evaluations for temporary houses.*

Macroseismic survey after August 24th, 2016

DPC officers and CNR-IGAG and INGV researchers have conducted field surveys to assign a macroseismic intensity MCS to each municipality and locality of the epicentral area.

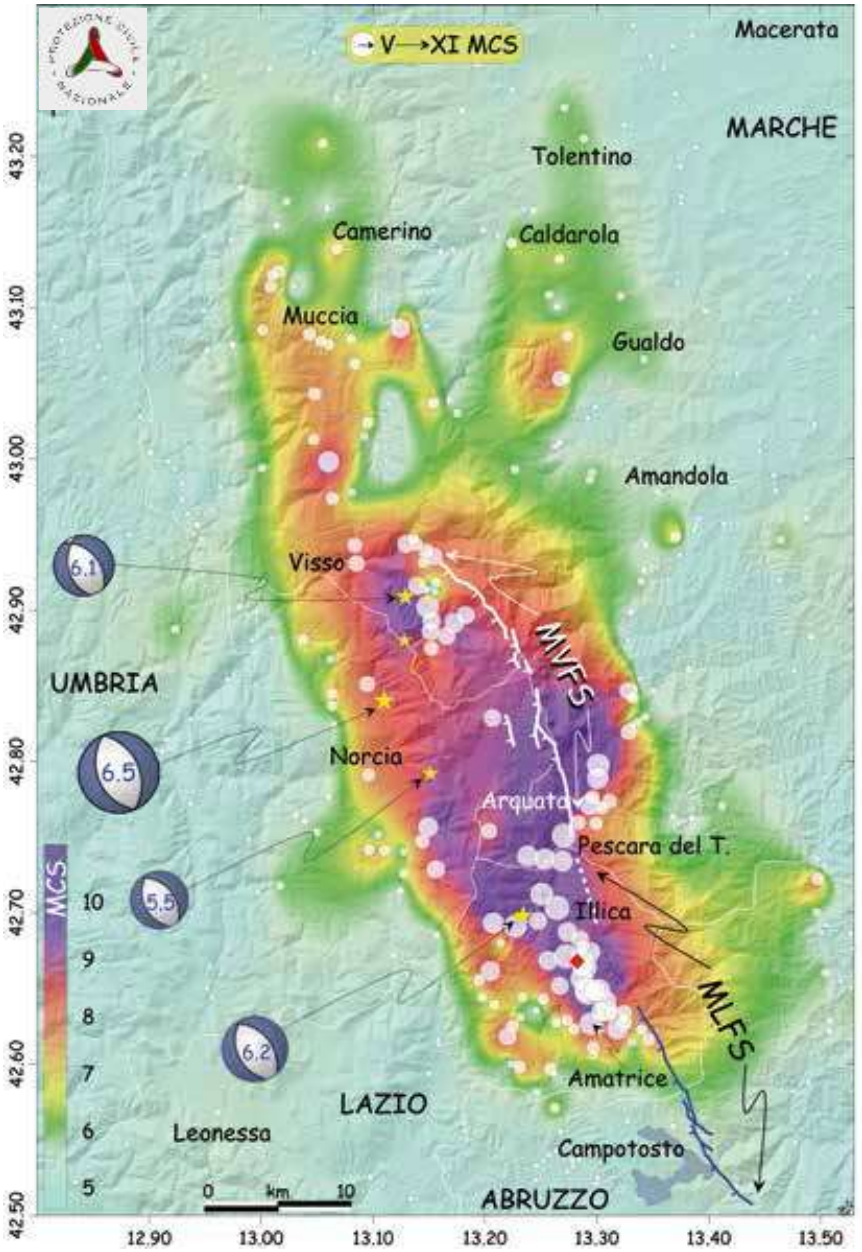
Values exceeding intensity X MCS have been found in and near the epicenter.



Macroseismic survey after October 30th, 2016

The **maximum** observed (**cumulated**) intensity is **XI** in the MCS scale.

The macroseismic field of cumulated intensities $I_{MCS} \geq 7$ is **70 km long and 30 km wide** (before January 18, 2017).



COSEISMIC EFFECTS

At a more local scale, many **rockfalls** and **landslides** were observed, as always happens when moderate-to-strong earthquakes hit the Apennines chain. These phenomena have been surveyed in particular by geologists from **ISPRA** and **CNR**, with special regard to those cases potentially or really affecting **transportation network and building stock**.

SLOPE INSTABILITIES

Pescara del Tronto, September 6th, 2016

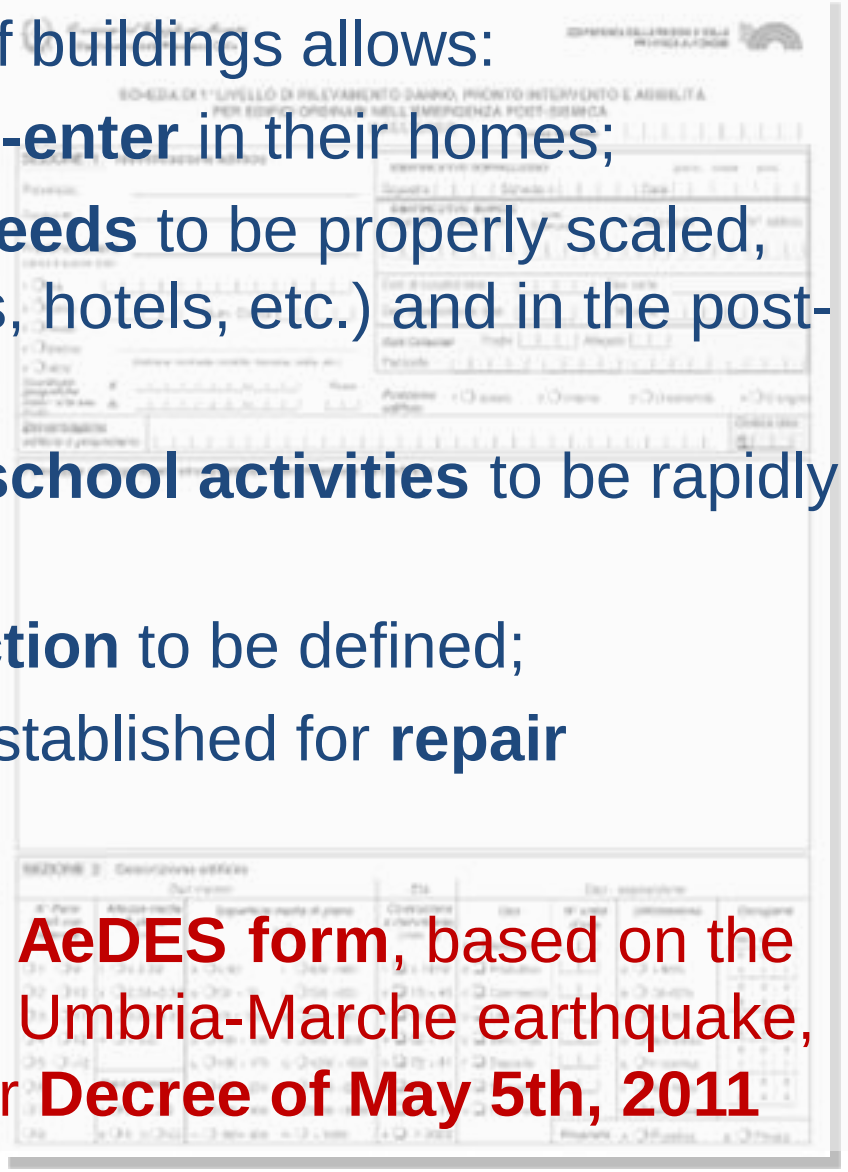
POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

2' → 5'– 30'	*EPICENTER AND MAGNITUDE EVALUATION*	• *Collecting and processing of seismometric network data by INGV*
10' →60'	*SIMULATED DAMAGE SCENARIOS AND DATA PROCESSING OF MONITORING SYSTEMS*	• *Software simulation of the earthquake impact on constructions by DPC* • *Collecting and processing soil and building accelerometric data by DPC*
6h → 7-14d	*SITE SURVEYS FOR MACROSEISMIC AND COSEISMIC EFFECTS*	• *Site evaluation of Mercalli Intensity,* • *Geological surveys for landslides, surface faulting and soil liquefaction*
6h → 6-12m	*TEMPORARY MONITORING OF SOIL AND STRUCTURES*	• *Installing of temporary soil accelerometric stations and structure monitoring systems*
24h→ 6-12m	***POST – EARTHQUAKE DAMAGE AND SAFETY ASSESSMENT***	• ***Building inspections for damage and usability assessment.*** • *Technical evaluations for temporary houses.*

Post-earthquake damage/usability assessment of ordinary buildings

Damage and usability assessment of buildings allows:

- the population to **safely stay or re-enter** in their homes;
- shelter and **temporary housing needs** to be properly scaled, both in the emergency (tent camps, hotels, etc.) and in the post-emergency (temporary housing);
- **productive, administration and school activities** to be rapidly reactivated;
- **funds needed for the reconstruction** to be defined;
- priority and funding criteria to be established for **repair interventions**.



Well-grounded procedures using the **AeDES form**, based on the experience acquired **since the 1997** Umbria-Marche earthquake, are established by the Prime Minister **Decree of May 5th, 2011**

Post-earthquake damage/usability assessment of ordinary buildings

M. Dolce

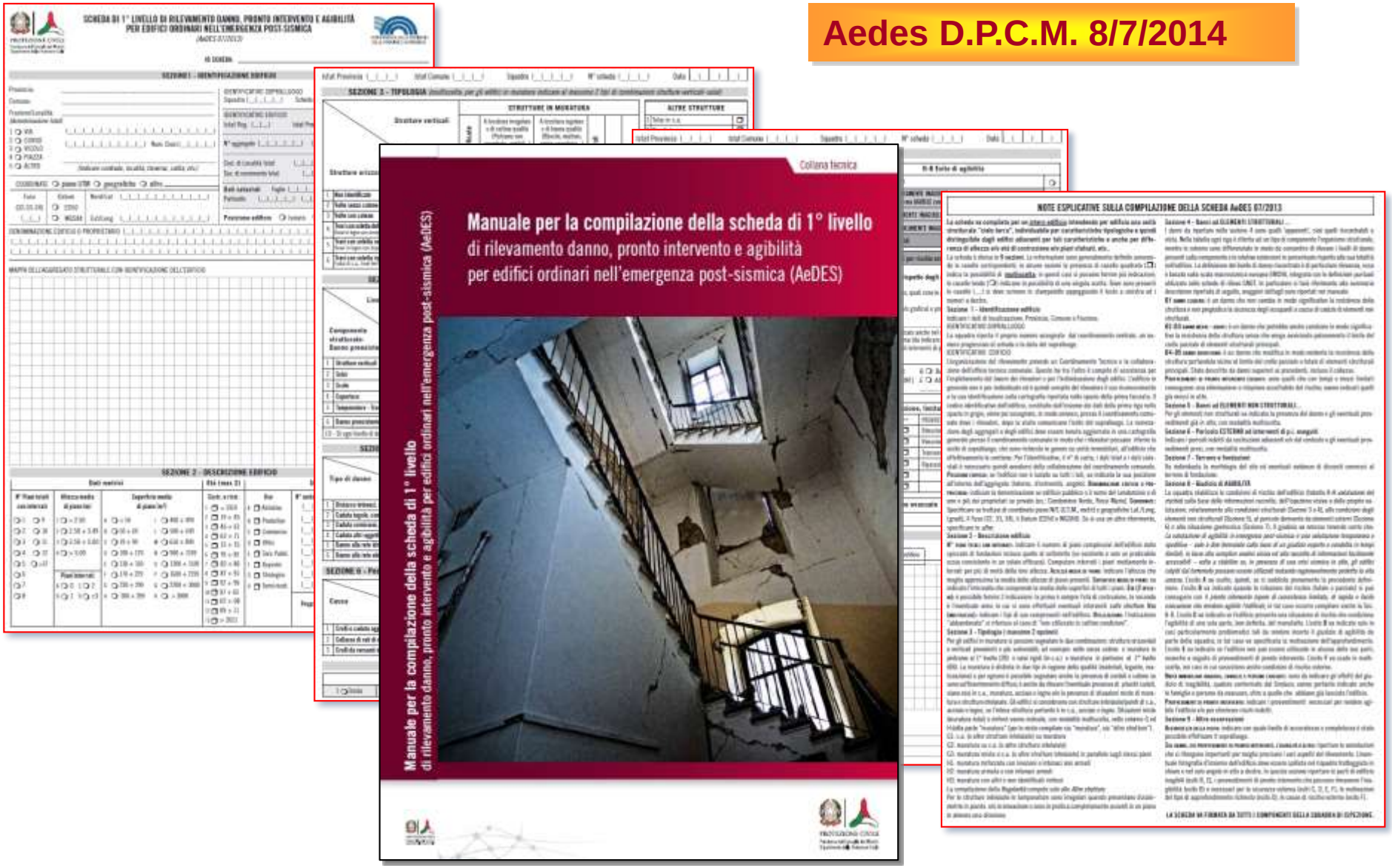
Post-earthquake usability evaluation is a **quick and temporarily limited assessment**, based on **expert judgement of specially trained technical teams**, on visual screening and on easily collected data, aimed to detect **if, during the current seismic crisis, damaged buildings can be used, being reasonably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

A) USABLE	**Building can be used without measures. Small damage, but negligible risk for human life.**
B) USABLE WITH COUNTERMEASURES	**Building is damaged, but can be used when short term countermeasures are taken.**
C) PARTIALLY USABLE	**Only a part of the building can be safely used .**
D) TEMPORARILY UNUSABLE	**Building to be re-inspected. Unusable until the new inspection.**
E) UNUSABLE	**Building can not be used due to high structural, non structural or geotechnical risk for human life. Not necessarily imminent risk of total collapse.**
F) UNUSABLE FOR EXTERNAL RISK	**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.).**

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

AeDES FORM AND MANUAL

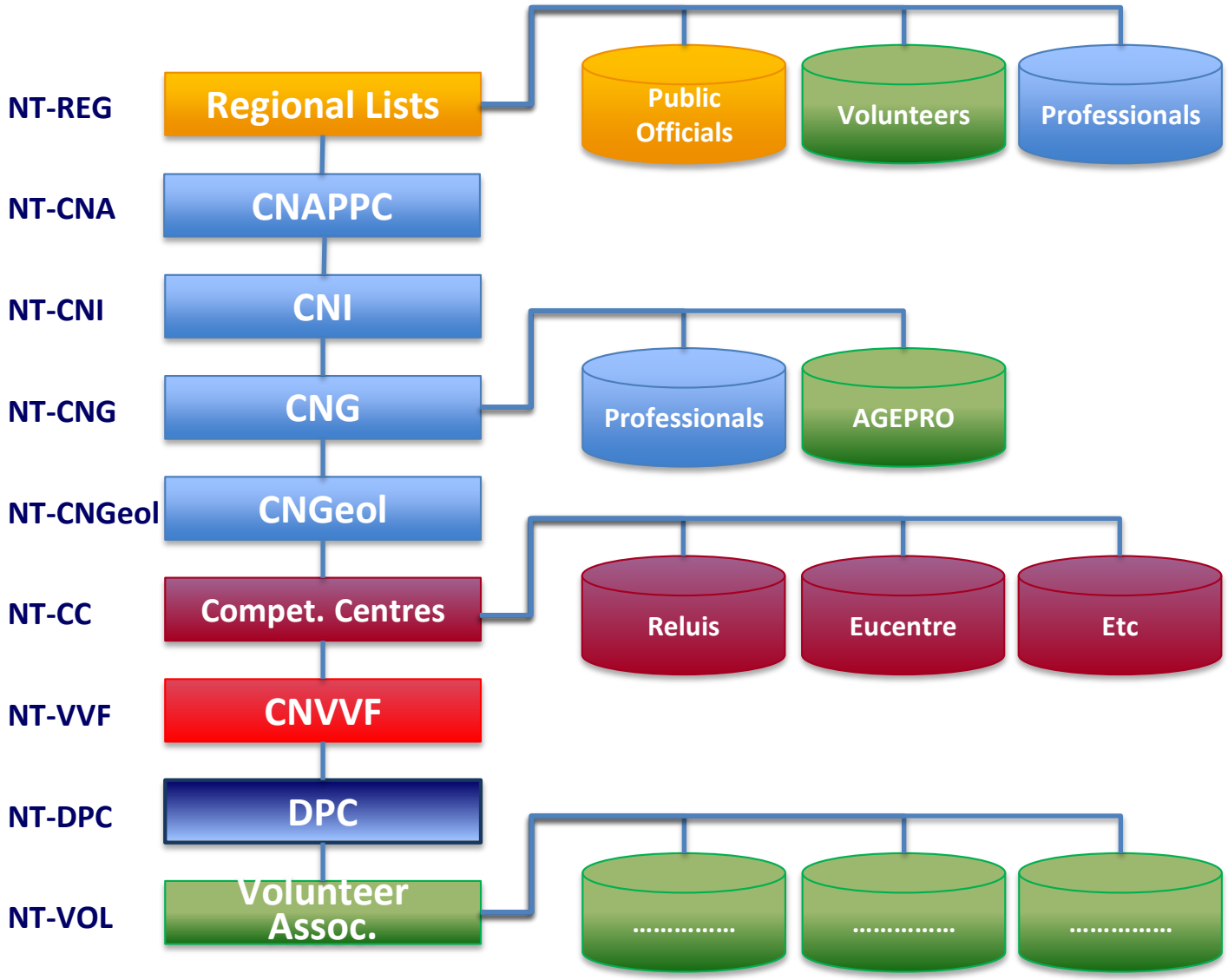
Aedes D.P.C.M. 8/7/2014



PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

ORGANIZATION OF INSPECTORS
THE NATIONAL TECHNICAL TEAM (NTN)

National technical Team (NTN)



PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

TRAINING OF INSPECTORS
THE NATIONAL TECHCNICAL TEAM (NTN)

- about 30-40 training courses per year are organized by DPC, regions, and Technical Chambers.
- Each course is attended by **40-50 people**
- Duration of courses is about **60 hrs**,
- Training includes virtual exercises and **final test**
- Until now about **6000 inspectors** have been trained in Italy and passed the **final test**

Damage and usability assessment of ordinary buildings

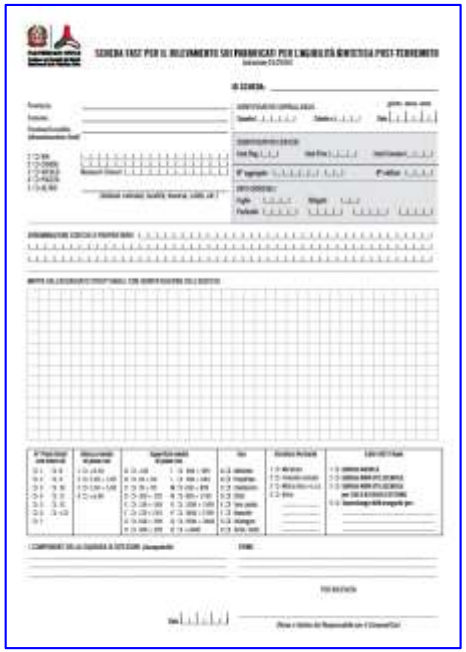
A huge effort has ben made to organize the damage and usability assessment survey. The assessment is performed by experts coming from different Regions, researchers of DPC Competence Centres (ReLUIS and EUCENTRE), and engineers, architects and surveyors coordinated through the relevant national professional Councils.

INSPECTIONS until 16.10.2016	
Total number	**28645 done - 77000 requested**
Schools	**677 done**
Public buildings	**202 done**

After October 30, the number of requests has increased significantly until a total of **~175,000** (13.01.17)

→ The new procedure **FAST** has been implemented in parallel with **AeDES**

Usability of private buildings after 30.10.16 – FAST

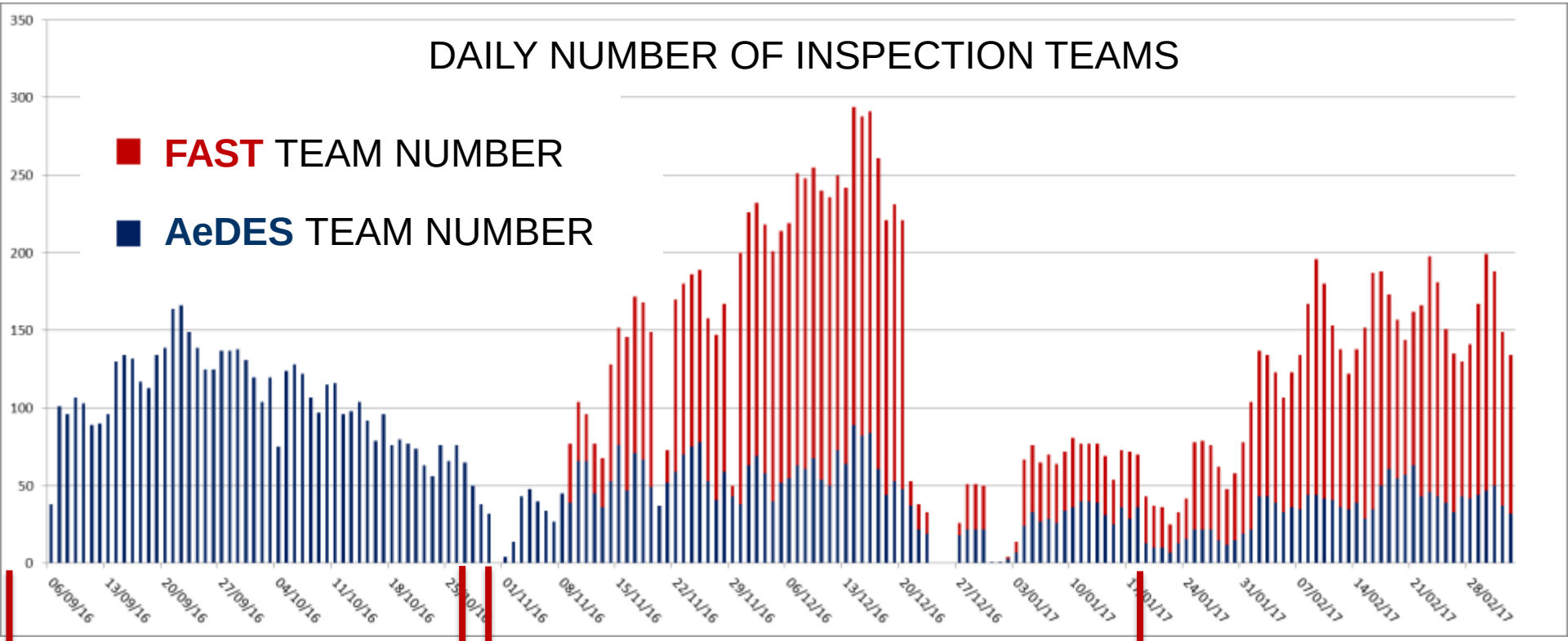


The **enlargement of the damaged area** produced by the Mw 6.5 earthquake required a **faster procedure** for the usability assessment of buildings, in order to rapidly define the demand of temporary dwelling solutions →

→ the **FAST procedure**.

HIGHLIGHTS:

- No long training course required → **new different teams involved**
- «**Usable**» or «**Not Usable**» are the outcomes of inspection of entire buildings (like AeDES)
- **No internal inspection** needed for the «not usable» outcome
- «**Usable**» outcome requires internal inspection but is the final outcome
- «**Not Usable**» outcome requires further AeDES inspection
- **~10** FAST insps./day/team vs. **~5** AeDES insps./day/team



Christmas

Snow

M6.0

M6.5

M5.4,M5.9

M5.0~5.5

Damage and usability assessment of ordinary buildings (June 12, 2017)

Total usability assessments: **184,686**

Total requests: **202,917**

with **AEDES forms** for public and private buildings: **66,910**

- **2,547** schools (**66% usable**, 6% unusable, 28% partly or temporarily unusable)
- **2,949** public buildings (**49% usable**, 20% unusable, 31% partly or temporarily unusable)
- **61,414** private buildings (**42% usable**, 6% unusable for external risk, 29% unusable, 21% partly or temporarily unusable, 2% not assessed)

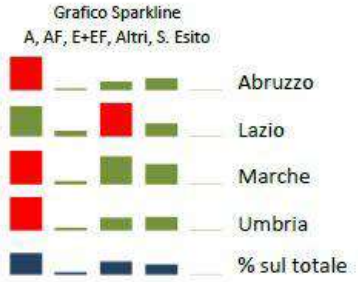
with **FAST forms** (since November 9, 2016): **117,776**

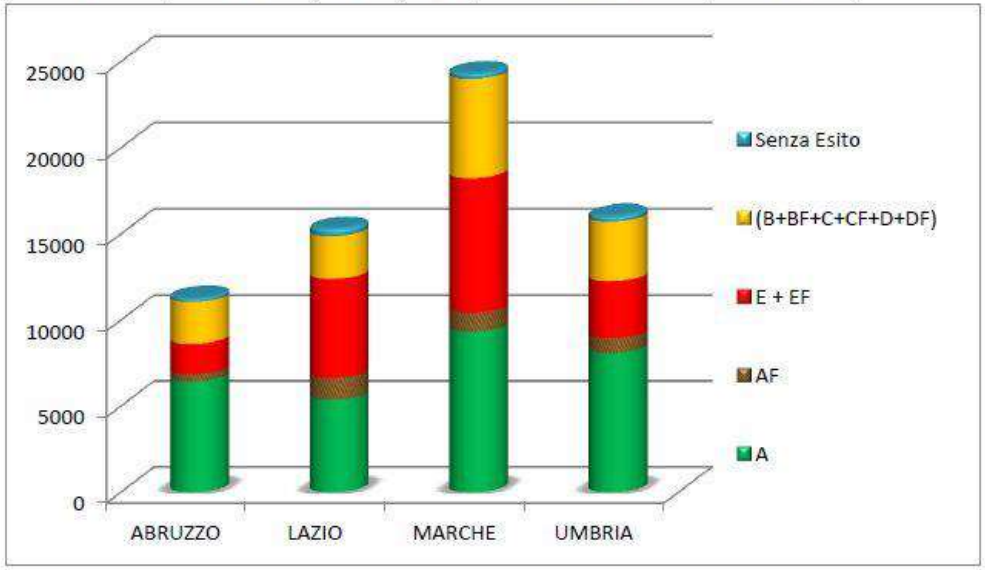
- **92,902** assessed (**56% usable**, 3% unusable for external risk, 40% partly, temporarily or totally unusable)
- **24, 827**not assessed (not accessible or needing further surveys)

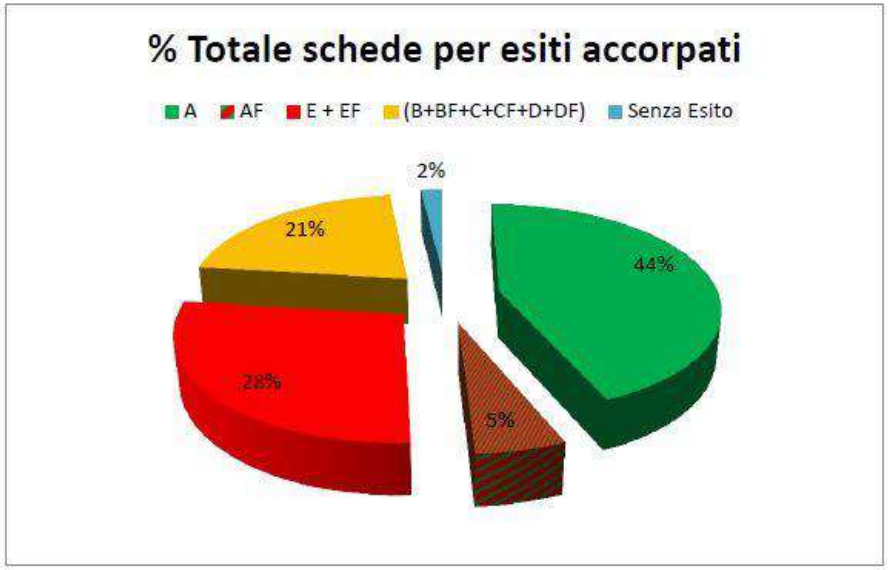
Usability of private buildings
AeDES inspections on 12.06.17

Esiti Sopralluoghi Totali AeDES + GL AeDES Cumulati per Regione e Aggregati per Esito

Regione	Schede Aedes + GL_Aedes					TOTALE Schede
	A	AF	E + EF	(B+BF+C+CF+D+DF)	Senza Esito	
ABRUZZO	6438	429	1748	2434	217	**11266**
LAZIO	5353	1271	5770	2495	411	**15300**
MARCHE	9311	1120	7819	5751	312	**24313**
UMBRIA	8080	872	3299	3469	311	**16031**
Totale	29182	3692	18636	14149	1251	**66910**
%	44%	6%	28%	21%	2%	





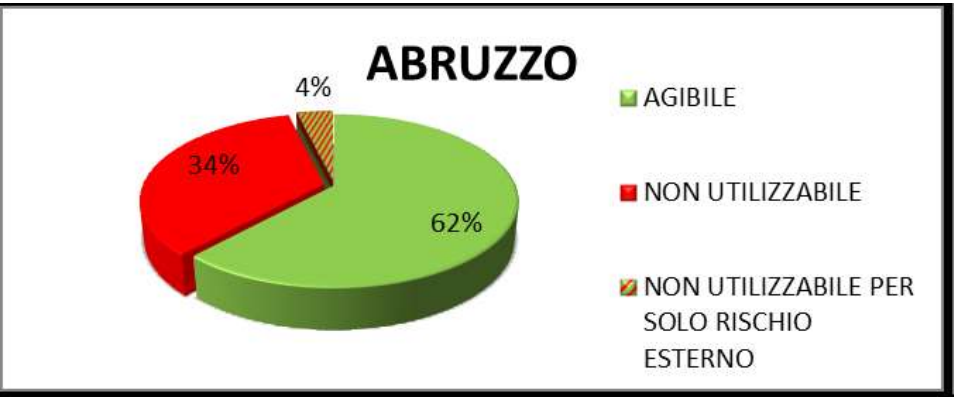


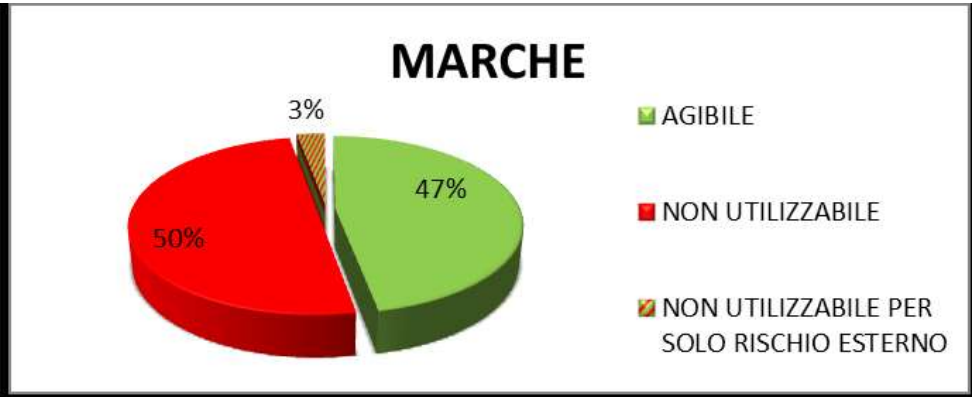
Usability of private buildings After 30.10.16 – FAST procedure

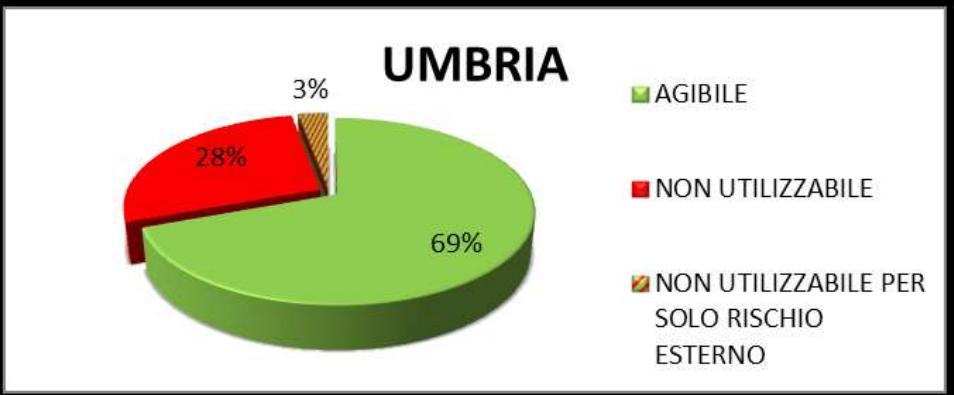
12.06.17 Situation

FAST forms (since November 9, 2016): **117,775**

- **92,902** assessed (57% usable, 3% unusable for external risk, 40% partly, temporarily or totally unusable)
- **24,827** not assessed (not accessible or needing further surveys)







SCHOOLS

Special attention is devoted to schools, whose activity in Italy starts at mid-September.
Restarting school regularly was meant as a restart of “normal” life, thus avoiding depopulation of the affected municipalities.

Head of Department of Civil Protection met in the DICOMAC Minister of Education, Universities and Research.

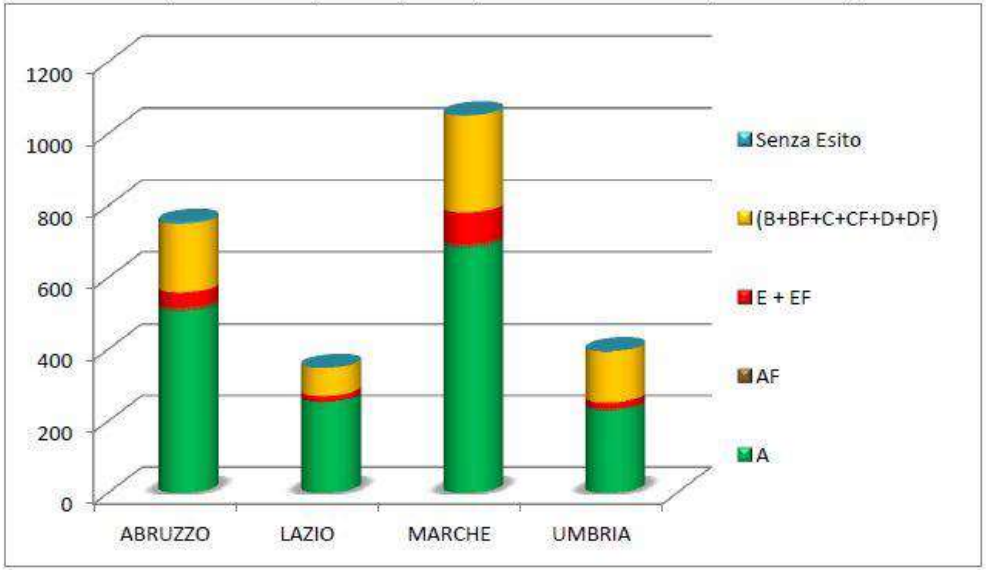
The temporary new school at Amatrice ready on September 12, 2016

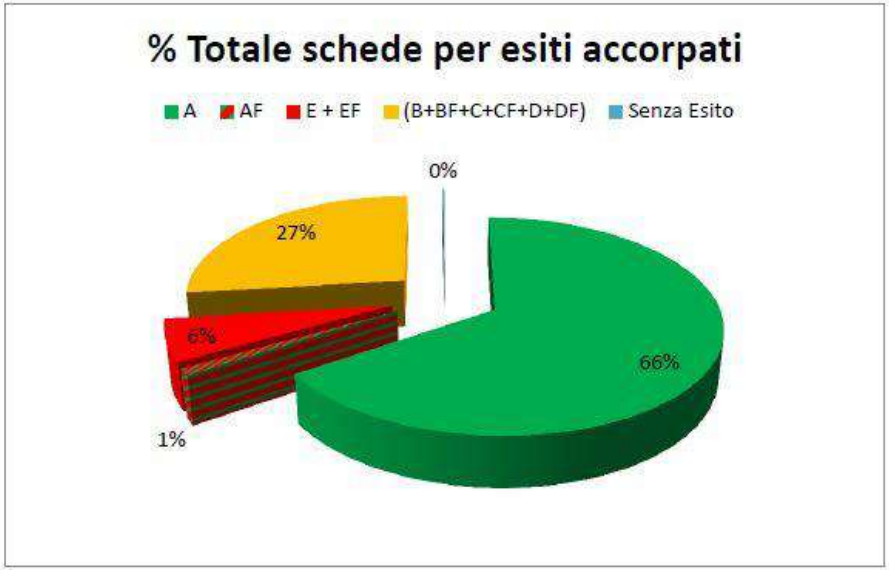
Usability of school buildings
AeDES inspections after 30.10.16

M. Dolce

Esiti Sopralluoghi Scuole AeDES + GL AeDES Cumulati per Regione e Aggregati per Esito

	Schede Aedes + GL_Aedes SCUOLE					TOTALE Schede
Regione	A	AF	E + EF	(B+BF+C+CF+D+DF)	Senza Esito	
ABRUZZO	506	11	41	191	5	**754**
LAZIO	254	0	16	78	0	**348**
MARCHE	683	10	88	269	1	**1051**
UMBRIA	229	6	17	142	0	**394**
Totale	1672	27	162	680	6	**2547**
%	66%	1%	6%	27%	0%	





9 schools in different municipalities in the four regions using donations

CULTURAL HERITAGE

Cultural heritage was heavily damaged by the 24.8 earthquake.

The October 26 and 30 Earthquakes have dramatically extended and increased the level of damage, up to the collapse of many churches. Faster procedure for safety countermeasures are being adopted

A strong collaboration was set up within the DICOMAC among the Ministry of Cultural Heritage, the operational structures, the Competence Centres and DPC officers to manage cultural heritage emergency operations, regarding **artworks and buildings** (churches, palaces, walls, etc.).

Cultural Heritage
Technical activities

The main activities on Cultural Heritage are:

1. **Assessment of damage and usability** of churches, historical palaces and other heritage manufacts;
2. Displacement and sheltering of **mobile heritage** at risk;
3. Evaluation of safety conditions and **execution of safety countermeasures**;
4. **Cost analyses of damage**;

Post-earthquake damage/usability assessment of cultural heritage - churches

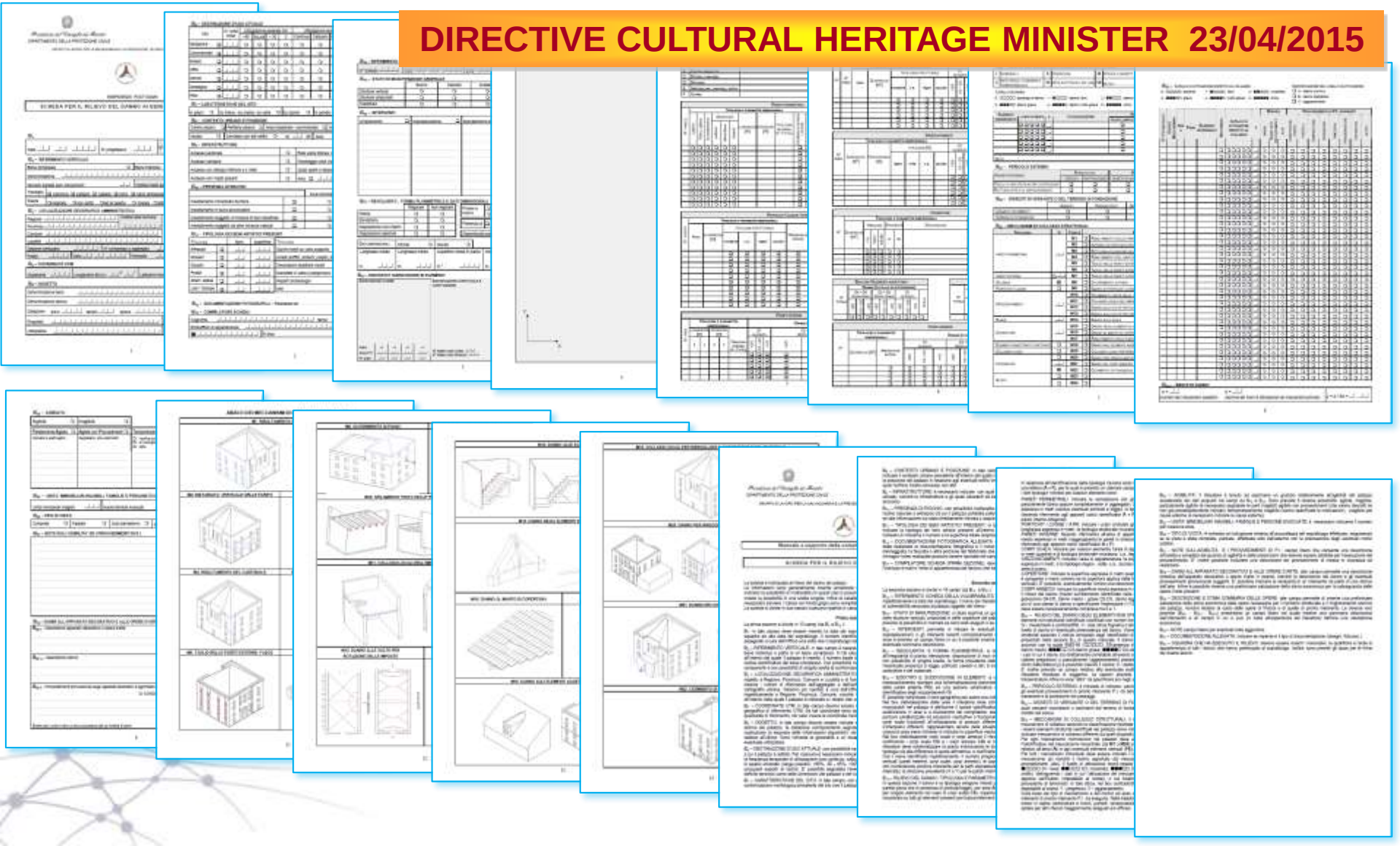
DPCM 23/02/2006
DIRECTIVE CULTURAL HERITAGE MINISTER 23/04/2015

DPCM 13/03/2013

Post-earthquake damage/usability assessment of cultural heritage - palaces

M. Dolce

DIRECTIVE CULTURAL HERITAGE MINISTER 23/04/2015



DAMAGE INSPECTIONS ON HISTORICAL BUILDINGS

4500 DAMAGE INSPECTIONS ON 3785 CHURCHES, HISTORICAL PALACES, OTHER… (52% DAMAGED BUILDINGS)

Cultural Heritage - Activities

The assessment of damage and usability of churches, historical palaces and other heritage was coordinated by **DiComaC and Heritage Ministry**, with the technical support of **ReLUIS**.
The survey had to be **restarted several times** due to the sequence evolution.

REGION	Damage (usability) inspections (05.03.17)			
	1st level inspections **before 30/10/16**	2nd level inspections **before 30/10/16**	2nd level inspections **after 30/10/16**	2nd level inspections **after 16/01/17**
ABRUZZO	166	327	62	399
MARCHE	243	250	101	1030
LAZIO	89	116	40	175
UMBRIA	162	302	250	702
TOTAL	**660**	**995**	**453**	**2786**

RECOVERY MOVABLE CULTURAL HERITAGE

13.000 RECOVERED PIECES FROM 329 BUILDINGS,
5.000 BOOKS,
2.600 m. ARCHIVES

RECOVERY MOVABLE CULTURAL HERITAGE

13.000 RECOVERED PIECES
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Cultural Heritage - Activities

Displacement and sheltering of **mobile heritage** at risk have been carried out with the involvement of **Firefighters, Carabinieri, Army, Volunteers**, besides **Heritage Ministry officers**.

REGION	Recovery of mobile heritage (05.03.17)		
	No. of involved buildings	No. of pieces recovered	No. of archival goods (meters)
ABRUZZO	8	141	0
MARCHE	145	5416	386
LAZIO	77	2286	530
UMBRIA	82	4233	1700
TOTAL	**312**	**12076**	**2616**

SAFETY COUNTERMEASURES ON HERITAGE BUILDINGS

450 RELEVANT SAFETY COUNTERMEASURES ON HISTORICAL BUILDINGS (CHURCHES, HISTORICAL PALACES, MUSEUMS..)

SAFETY COUNTERMEASURES ON HERITAGE BUILDINGS

Cultural Heritage - Activities

Evaluation of safety conditions and **execution of safety countermeasures** have been carried out by Firefighters and directly by private owners, under the supervision of the heritage Superintendent

REGION	Safety countermeasures (05.03.17)					
	Cultural heritage Ministry + Firefighter Corps					Art.6 DL 205/2016
	Concluded	In progress	Starting	Under decision	TOTAL	
ABRUZZO	12	4	3	0	19	14
MARCHE	71	24	7	2	104	189
LAZIO	10	4	8	0	22	2
UMBRIA	22	5	5	1	33	22
TOTAL	**115**	**37**	**23**	**3**	**178**	**227**

The situation of roads network after the late shocks was quite critical. The extension of the network (**15.300 km**) and damages required a sistemic approach in the evaluation of damages and identification of proper recovery neasures.

Implementing partner for road safety

3.000 km assessed

622 sites visited

574 critical points identified

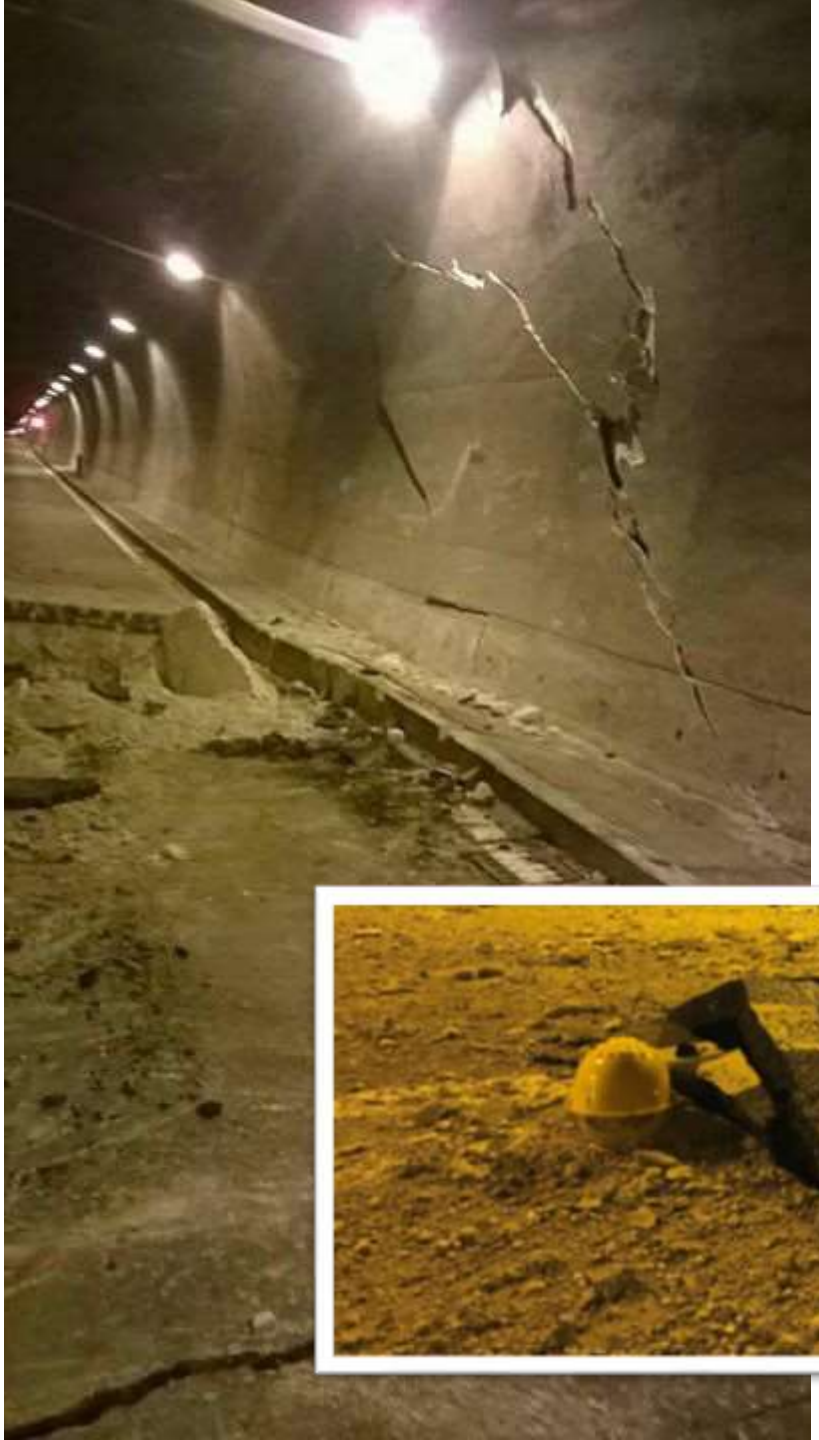
517 actions proposed

PROGRAM FOR ROADS RECOVERY

408 projects

389 mln €


16/12/2016

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Conclusion

- **Scientific and technical activities** are fundamental for the **emergency management** after a strong earthquake and during a seismic sequence like the one under way
- Many coordination activities carried out by the Italian Department of Civil Protection are based on the scientific and technical information provided by its **technical offices** and by the **centres of competence**
- Technical activities are **coordinated**, within **DiComaC**, by some specific **functions** (**Technical**, **Damage and Usability Assessment**, **Cultural Heritage**)

Further details on the Central Italy Earthquake emergency can be found in :
http://www.protezionecivile.gov.it/

6th National Conference on Earthquake Engineering & 2nd National Conference on Earthquake Engineering and Seismology .

Bucharest, June 14-16, 2017

The 2016-17 Seismic Sequence of Central Italy: Main Scientific Features and Technical Emergency Activities

Prof. Mauro Dolce
Italian Department of Civil Protection &
University of Naples, Federico II

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile