16TH EUROPEAN CONFERENCE ON
EARTHQUAKE ENGINEERING
THESSALONIKI
18 - 21 JUNE 2018

The 2016–2017 Central Apennines Seismic Sequence: Analogies and Differences with Recent Italian Earthquakes

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Dipartimento della Protezione Civile

OBJECT

Main **scientific features** and **technical emergency activities** of the **2016-2017 Central Italy seismic sequence**

compared to the recent strongest Italian earthquake sequences:

- **1997 Umbria-Marche (Max Ml 5.9, Mw 6.0)**
- **2009 Abruzzo (Max Ml 5.9, Mw 6.1)**
- **2012 Emilia (Max Ml 5.9, Mw 5.9)**

pointing out **analogies and differences**

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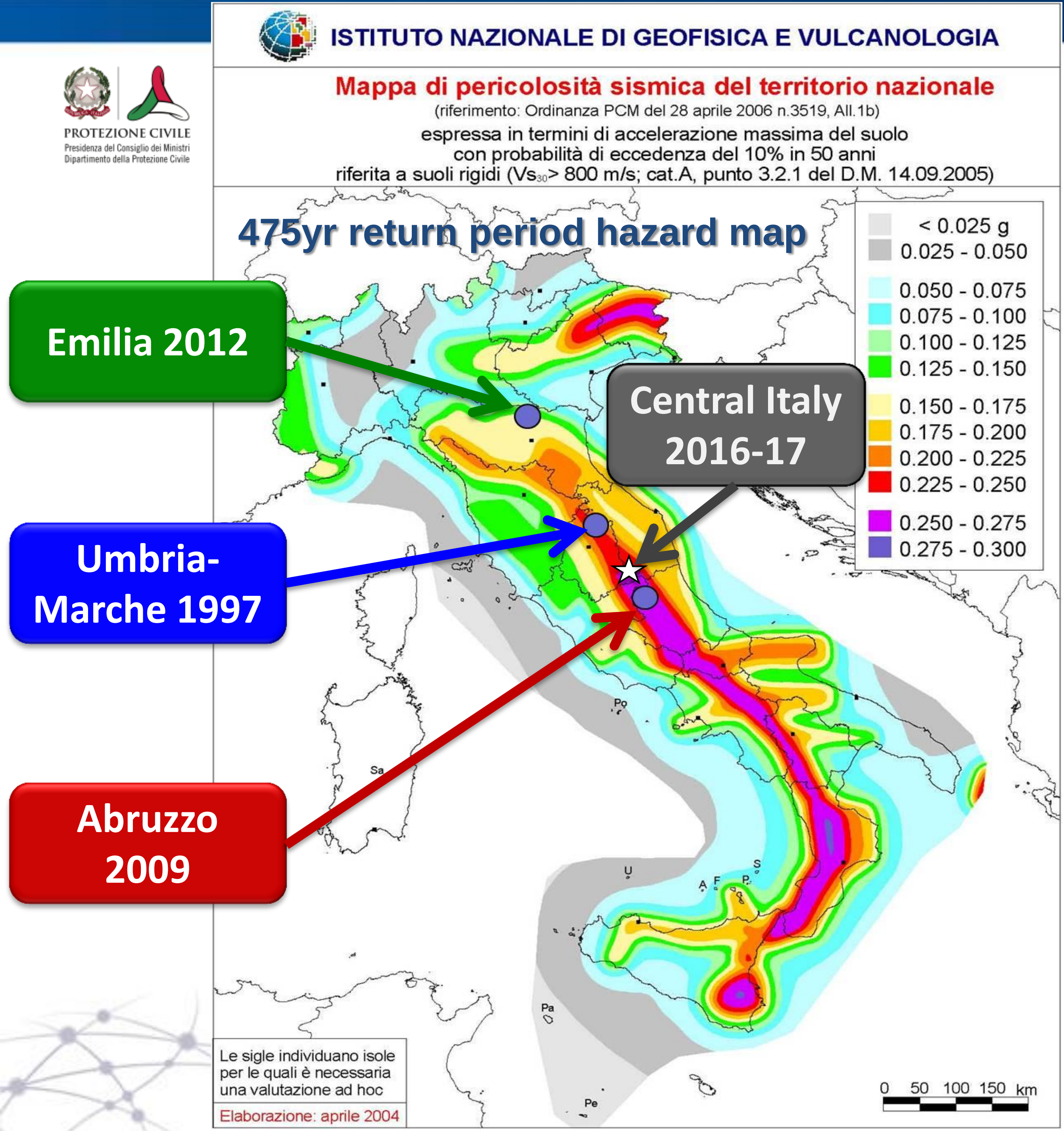

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1. Umbria-Marche
   Sept. 26, 1997,
   a_g=0.15-0.25g
2. Abruzzo
   April 6, 2009,
   a_g=0.20-0.275g
3. Emilia-Lombardia-Veneto
   May 20, 2012,
   a_g=0.125-0.175g
4. Central Italy
   August 24, 2016,
   a_g=0.15-0.275g

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

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**.

The **emergency response was coordinated**, according to Law 225/92, **by the Department of Civil Protection** (DPC), within the general framework of the **National Service of Civil Protection**.

SEISMICITY (until 13.06.2017)

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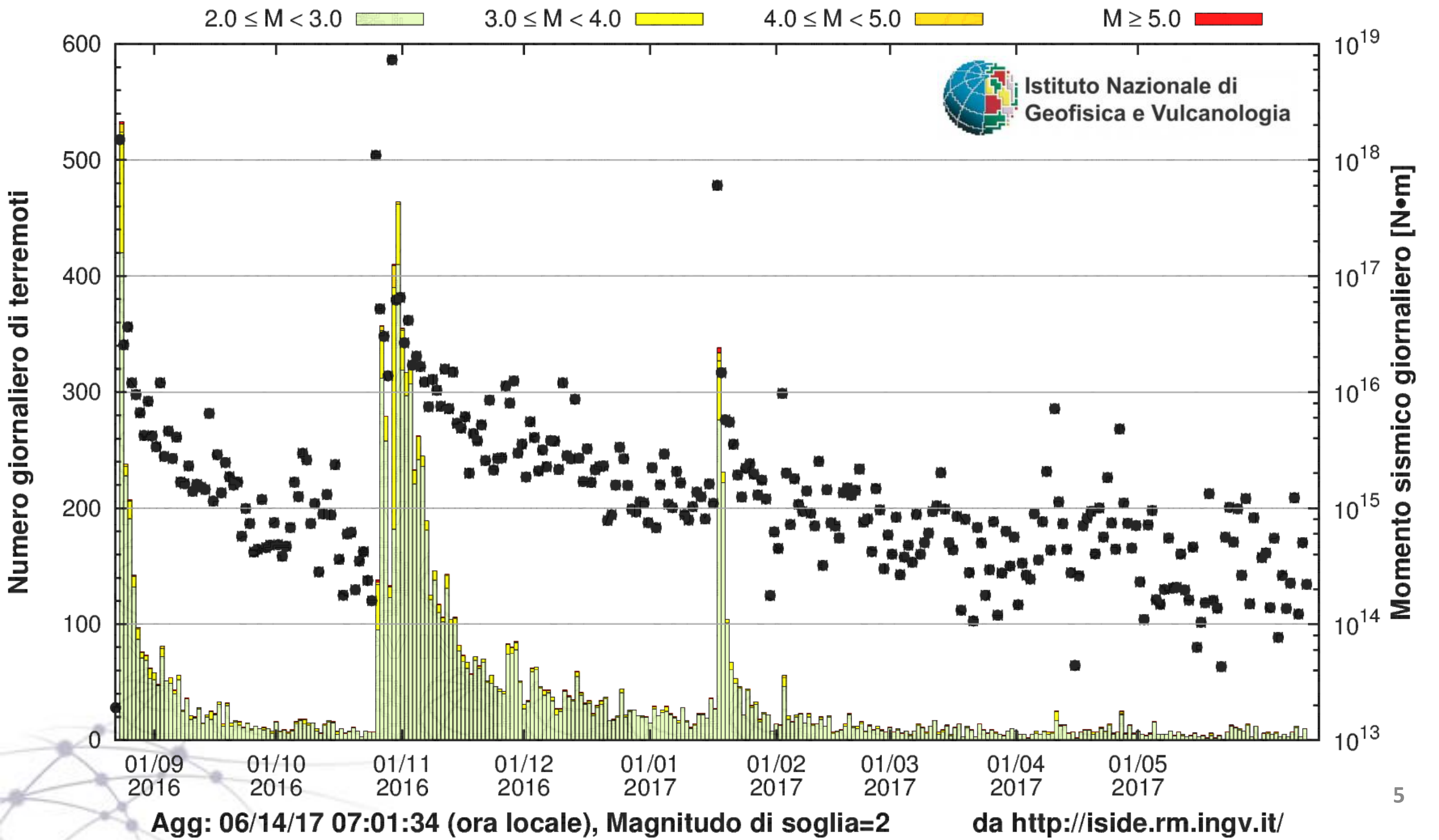

SEISMICITY UNTIL 13.06.2017

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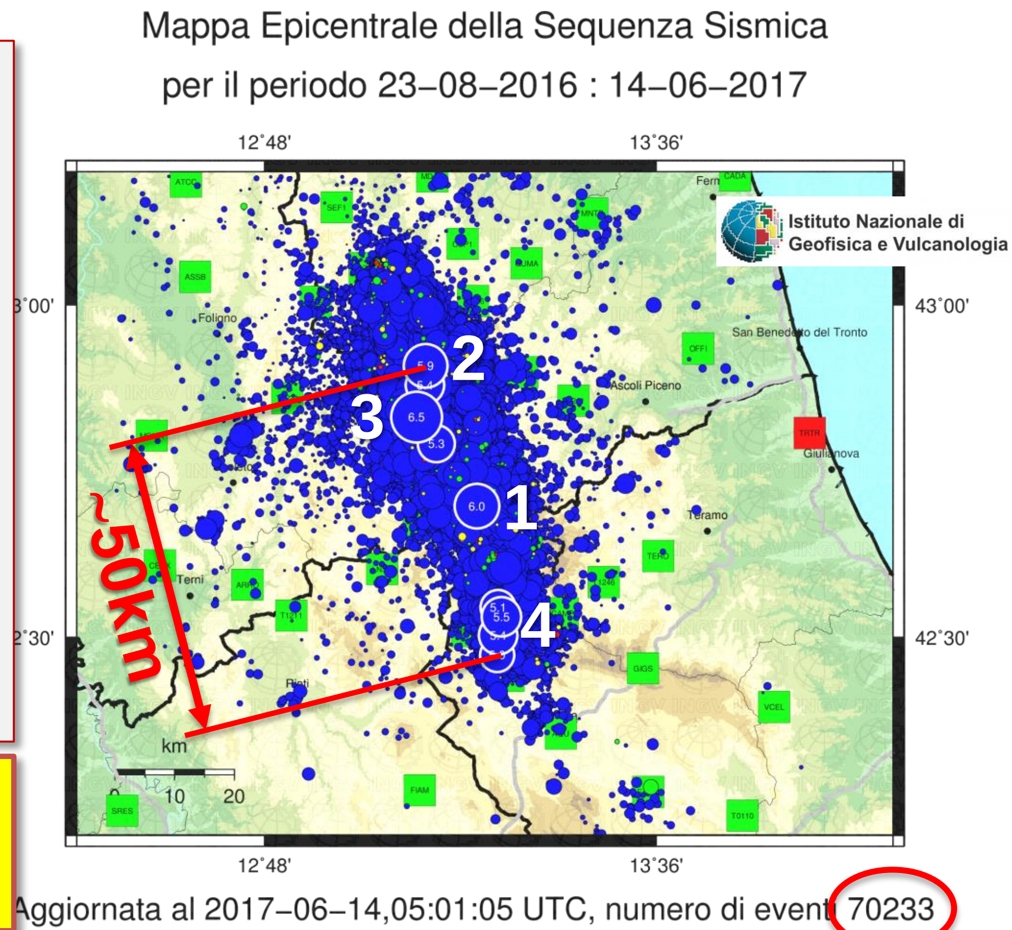
Until June 13, 2017
→ **70,000 events**:

- **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 → **50 km**

No more fatalities after the first event



1 - 24 August 2016, Accumoli Mw 6.0 ←

2 - 26 October 2016, Visso Mw 5.9

3 - 30 October 2016, Norcia Mw 6.5 ←

4 - 18 January 2017, Campotosto, 4 shocks Mw 5+

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

No. of fatalities:

- 1997 Umbria-Marche → 11
- 2009 Abruzzo → 309
- 2012 Emilia → 26
- 2016-17 Central Italy → 299

SEISMOTECTONIC SETTING

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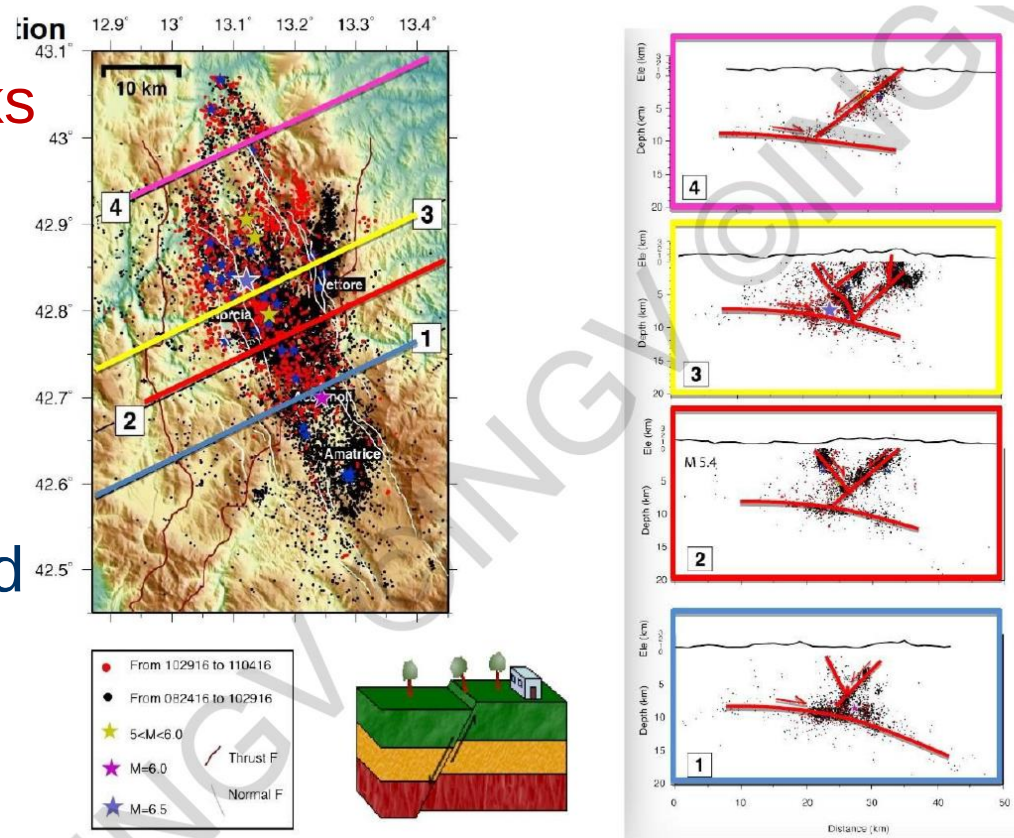
The epicentral area is part of the **Apennines fold-and-thrust belt**, an orogenic chain which formed in **Meso-Cenozoic times** with a general NW-directed motion towards the Adriatic foreland.

The **seismogenic faults** responsible for the main shocks are coherent with the current **extensional stress field**.

They are **NNW-SSE-striking, WSW-dipping normal faults**, with **a length of 15-20 km** and a **dip angle of 45°-50°**. Some **antithetic** or **low dipping** planes are also present.



SOCIO-ECONOMIC FEATURES of the epicentral area

- The affected area is located in **Central Italy**, at the **boundaries of four Regions**, namely **Abruzzo, Lazio, Marche and Umbria.**
- Involved **provinces are 7**: **Ascoli Piceno, Fermo, Macerata** (Marche), **Perugia** (Umbria), **Rieti** (Lazio), **L'Aquila, Teramo** (Abruzzo).
- Epicentral area is **mountainous**, mostly exceeding **900**m elevation.
- **Population** average **density is low** (**75** inhab./sqkm, vs. 200 nat. av.).
- The average **income** per person is lower than national average.
- local labor market mainly based on agricultural economy → **High percentage of farms** (especially **breeding farms**)
- **Tourism** is an important economic activity due to the great **environmental interest** and low urbanization.
  - Availability of **accommodation higher** than the national average.
  - Many **tourists are house-owners** living in the surrounding cities.

AMATRICE – Before 24.08.16

AMATRICE – After 24.08.16
I_{MCS} = X-XI

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AMATRICE – After 30.10.16
IMCS = XI

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AMATRICE – After 24.08.16
I_{MCS} = X-XI

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AMATRICE – After 24.08.16
I_{MCS} = X-XI

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ROAD DISRUPTIONS
After October 30

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After October 30
Road Interruptions

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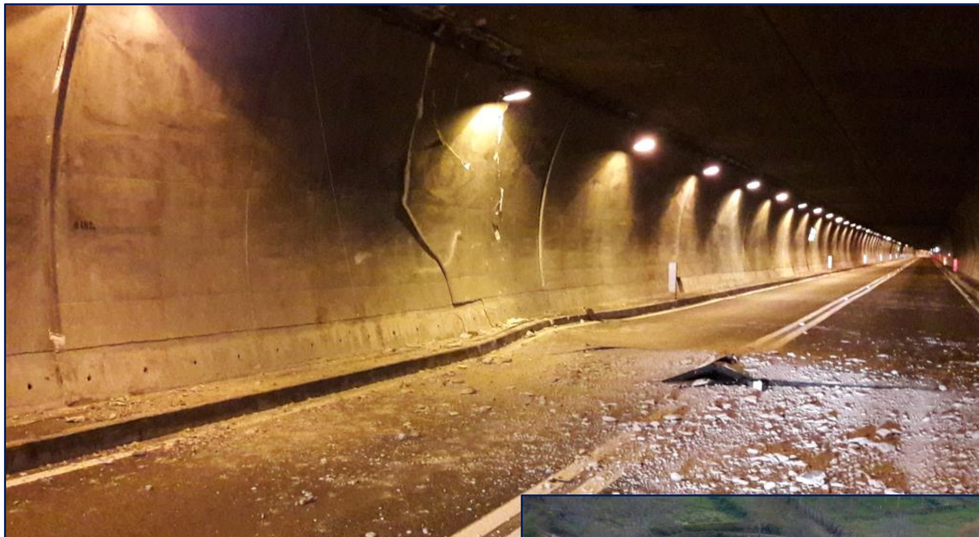

THE ITALIAN
NATIONAL SERVICE OF CIVIL PROTECTION

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(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

MANDATE

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The National Service of Civil Protection of Italy (Law 225/1992) aims at safeguarding human life and health, goods, national heritage, human settlements and the environment from all natural or man-made disasters.

It deals with:

- Forecasting and Warning
- Prevention and Mitigation
- Rescue and Assistance
- Emergency overcoming

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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

RESCUE

Search & rescue

Medevac

ASSISTANCE

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Sheltering people

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

ASSISTANCE

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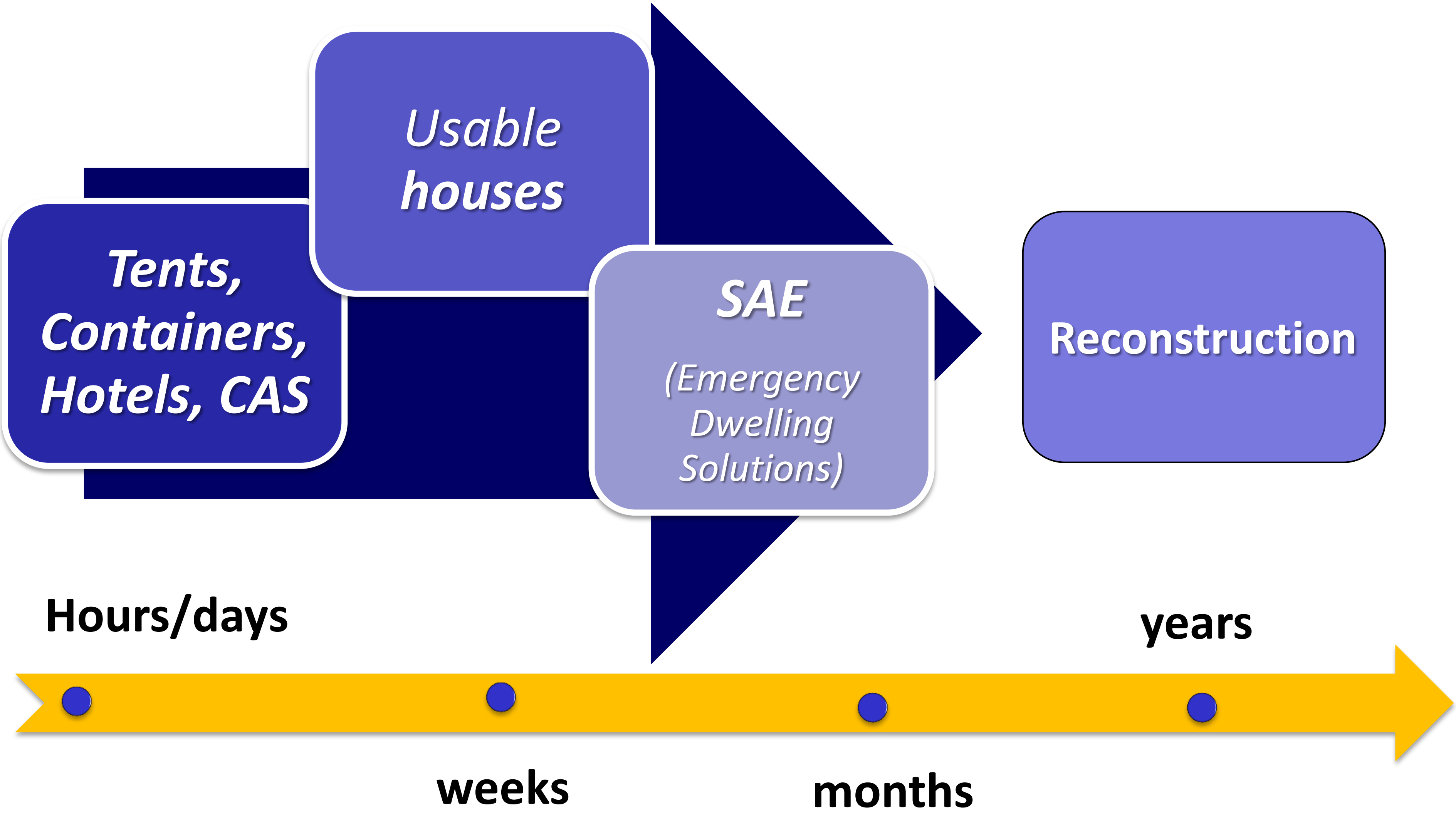
Sheltering people

***After** late october shocks*

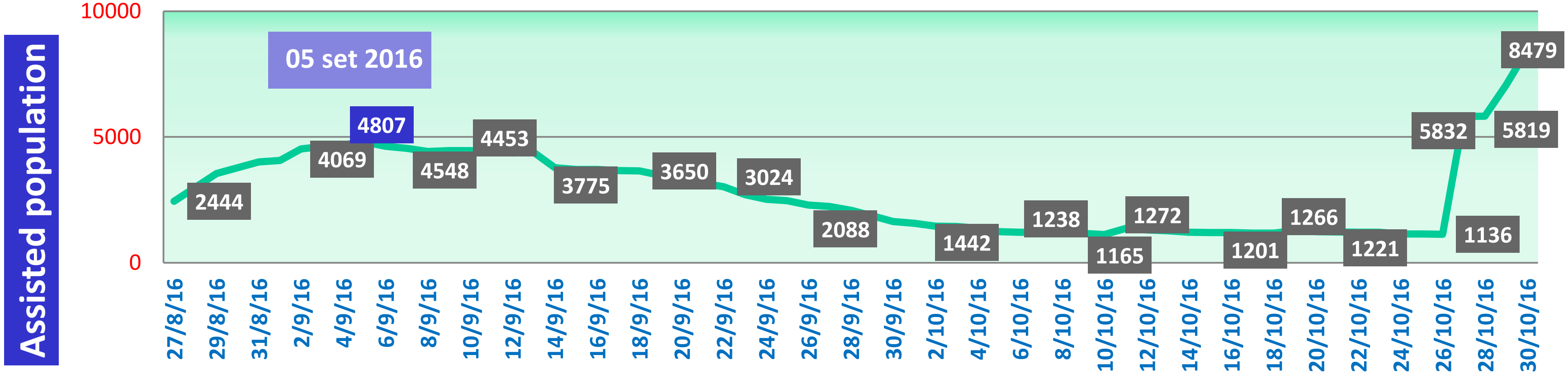
1296 people have been hosted in temporary shelters

GENERAL STRATEGY FOR DWELLING NEEDS

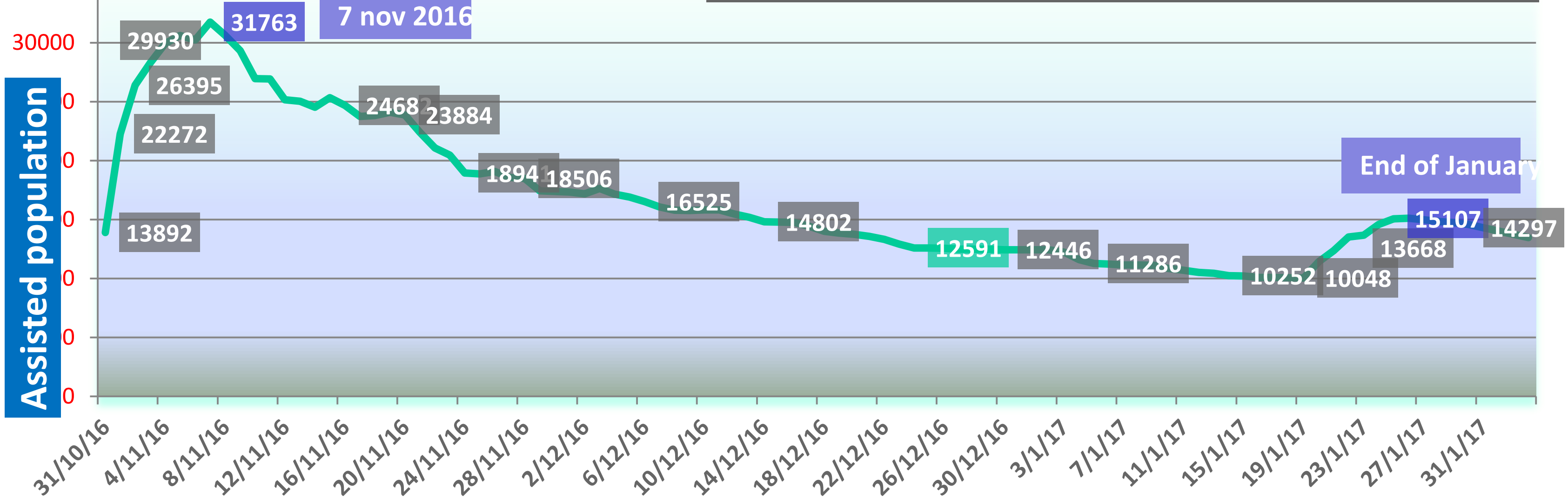


ASSISTANCE TO THE POPULATION NEEDING ACCOMODATION

From 24th of august to 31st of october 2016



From 1st november until end of january



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ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

Previous earthquakes had **different numbers of assisted people**, consistently with the

- **higher population density** of their epicentral area
- **earthquakes' characteristics**.

Max n. of people needing assistance soon after:

- **2009 Abruzzo earthquake** → ca. **67,000**
  (epicenter in the L'Aquila city with >70,000 inhabitants)
- **2012 Emilia earthquake** → ca. **16,000**
- **2016-17 Central Italy (30.10)** → ca. **32,000**

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

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**.

COMPETENCE CENTRES

- **INGV**
(Seismic surveillance, Seismological research; emergency scientific support)
- **ReLUIS**
(Earthquake engineering research; emergency scientific-technical support)
- **EUCENTRE**
(Earthquake engineering research; emergency scientific-technical support)
- **CNR (IGAG, IRPI, IREA)**
(microzonation, geological effects, satellite inteferometry; emergency scientific-technical support)
- **ISPRA**
(geological mapping, geological effects; emergency scientific-technical support)
- **ENEA**
(rubble management; emergency scientific-technical support)
- **ASI**
(satellite data provider)

POST-EVENT TIMETABLE OF TECHNICAL ACTIVITIES

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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.*

THE OPERATIONAL COMMITTEE

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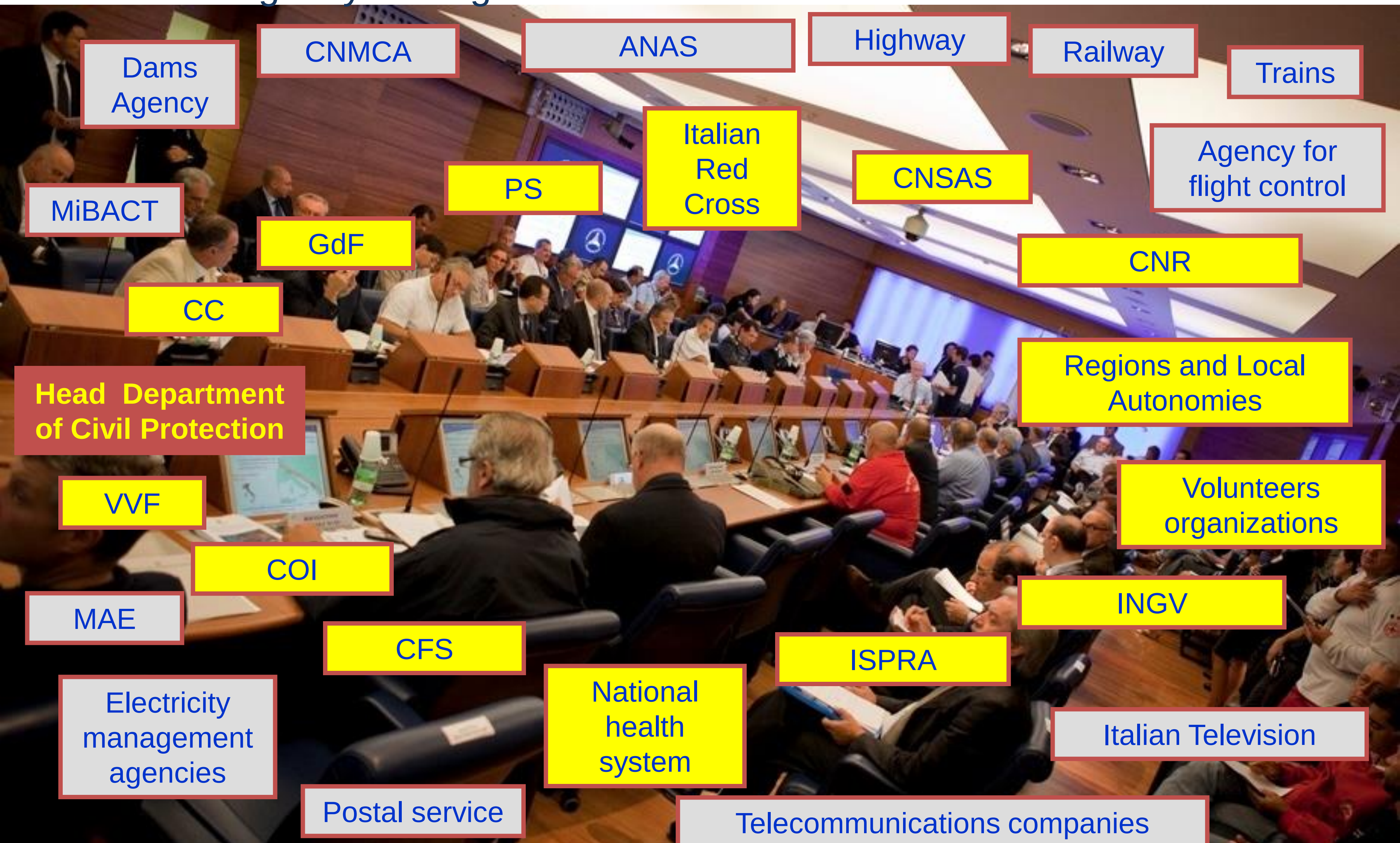
started its activities on August 24 at **4:00 a.m.**, to coordinate the emergency management based on the first information available



IMPACT SCENARIO - AUGUST 24

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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

Scenario available in 10-15’ after the event

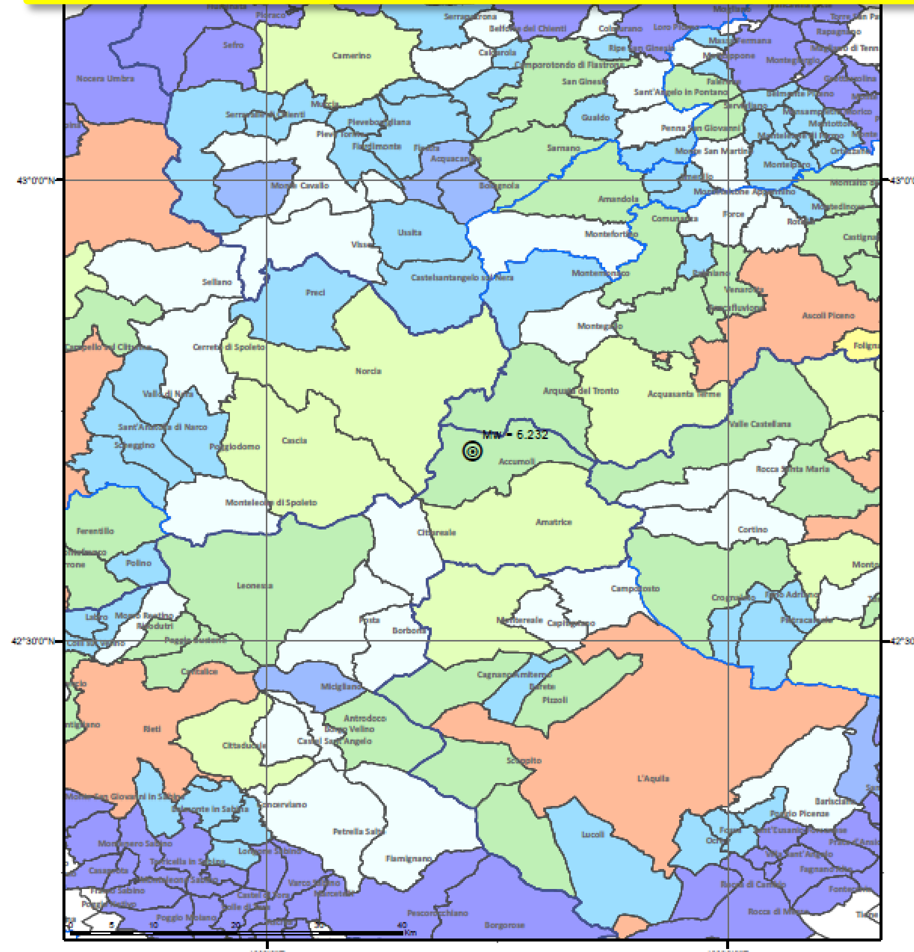

Fig.6 Scenario di danno T = T0: Popolazione Senza Tetto (valori medi stimati)

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

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

SIGE OUTCOMES

2009 Abruzzo earthquake →
SIGE outcomes **quite consistent with real figures** in terms of fatalities, injured people, homeless and unusable buildings

2012 Emilia earthquake →
SIGE outcomes largely **overestimated**:
estimated VIII-IX degree MCS epicentral intensity vs. VII-VIII MCS actual intensity
(probably due to the **kinematics of the seismogenic faults** and to the **subsurface geological setting** of the Po Plain)

NATIONAL STRONG-MOTION NETWORK (RAN-DPC)

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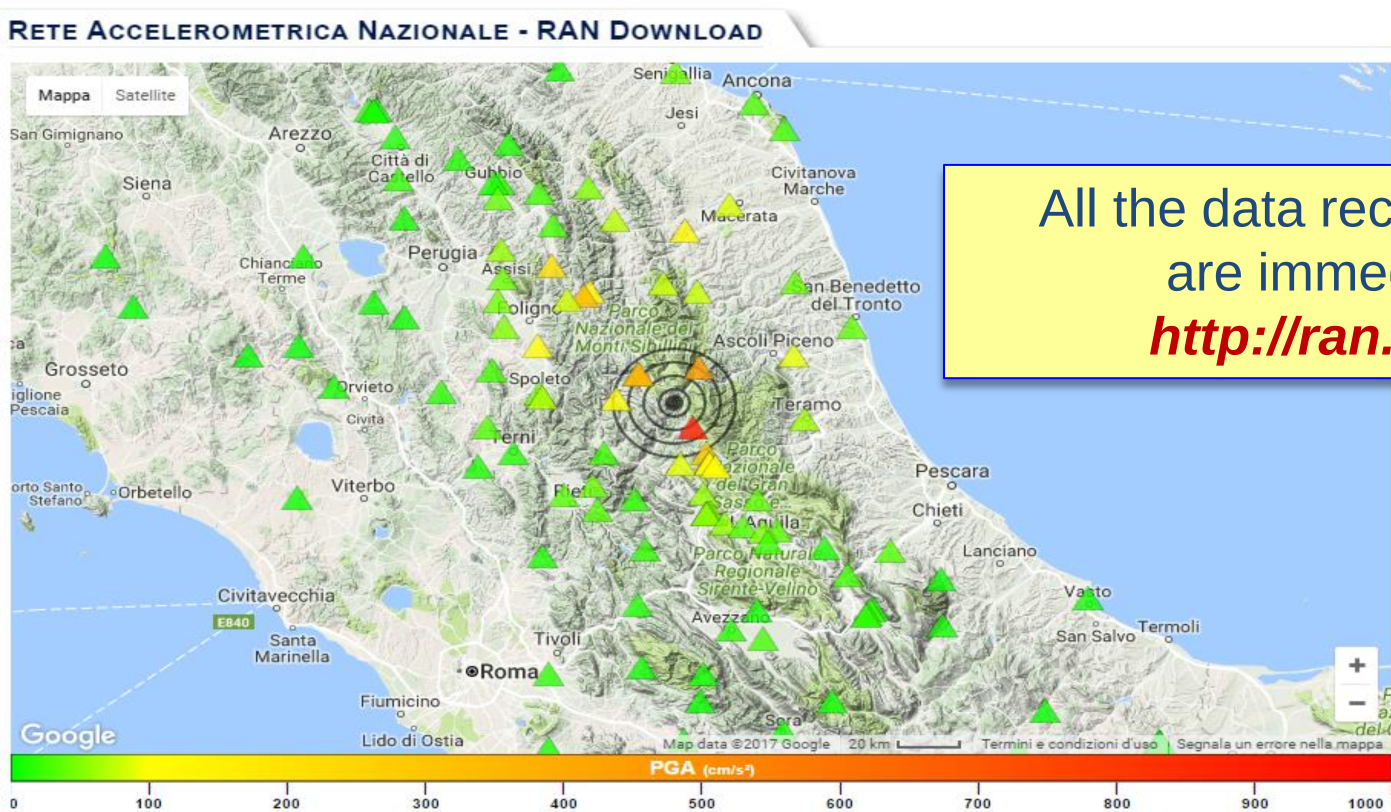
The RAN-DPC strong-motion network (code IT) is formed by more than **560 permanent digital stations**, whose data are tele-transmitted to the **DPC monitoring centre**.

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)

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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

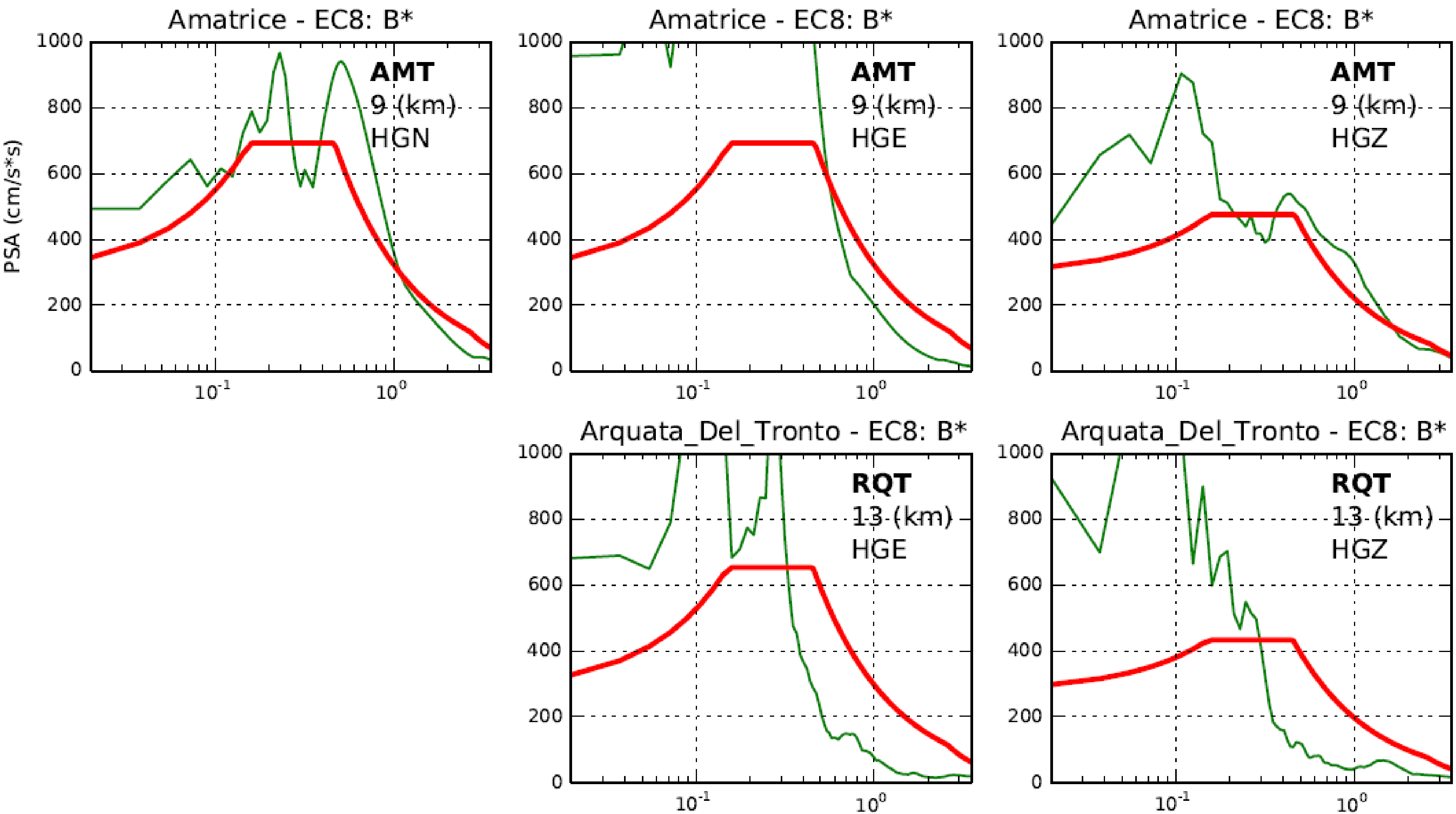
sta	chan	dista	filter	PGA	EPA	PGV	PGD	PSA03	PSA10	PSA30	EC8	location
		km	Hz	cm/s*s	cm/s*s	cm/s	cm	cm/s*s	cm/s*s	cm/s*s		
AMT	HGE	10	0.2-50.0	915.97	640.03	44.25	2.96	1786.88	199.93	20.85	B*	Amatrice
AMT	HGN	10	0.2-50.0	445.59	297.52	39.11	7.03	566.87	356.08	41.43	B*	Amatrice
AMT	HGZ	10	0.2-50.0	399.94	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	[illegible]	[illegible]	[illegible]	[illegible]
MSCT	HGN	22	0.2-50.0	86.36	58.32	6.46	1.74	132.82	[illegible]	[illegible]	[illegible]	[illegible]
MSCT	HGZ	22	0.2-50.0	53.39	51.12	5.69	1.94	159.83	[illegible]	[illegible]	[illegible]	[illegible]
SPD	HGE	24	0.2-50.0	56.80	53.48	5.17	0.77	113.04	[illegible]	[illegible]	[illegible]	[illegible]
SPD	HGN	24	0.2-50.0	104.27	71.52	7.49	1.39	197.03	[illegible]	[illegible]	[illegible]	[illegible]
SPD	HGZ	24	0.2-50.0	57.24	41.47	5.67	1.81	84.95	[illegible]	[illegible]	[illegible]	[illegible]
LSS	HGE	27	0.2-50.0	23.24	20.58	1.79	0.65	62.02	[illegible]	[illegible]	[illegible]	[illegible]
LSS	HGN	27	0.2-50.0	19.69	17.05	1.81	0.87	41.71	[illegible]	[illegible]	[illegible]	[illegible]

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

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

RESPONSE SPECTRA
August 24, 2016



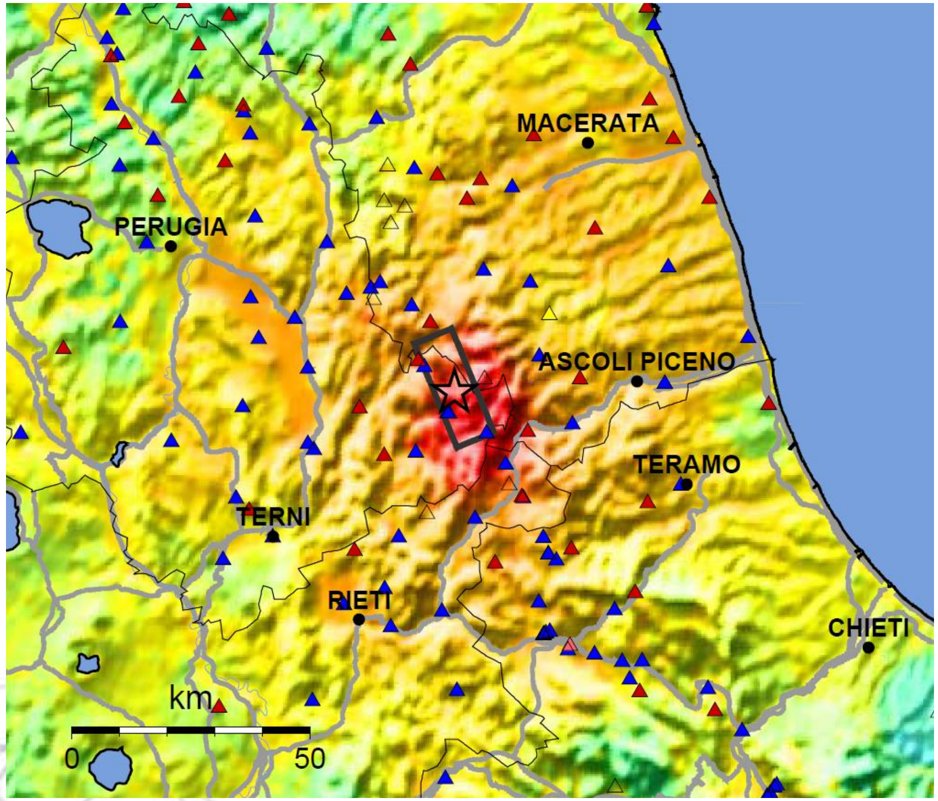
Data available in 5-10' after the event

SHAKEMAP – October 30, 2016

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

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

Much **higher values** of PGA and of other intensity quantities

2009 Abruzzo:
- Max PGA → 664 cm/s^2
- Max PGV → 38.6 cm/s
- Max PGD → 11.9 cm

2012 Emilia:
- Max PGA → 290 cm/s^2
- Max PGV → 57 cm/s
- Max PGD → 18 cm

2016-17 Central Italy:
- Max PGA → 910 cm/s^2
- Max PGV → 66.1 cm/s
- Max PGD → 18.1 cm

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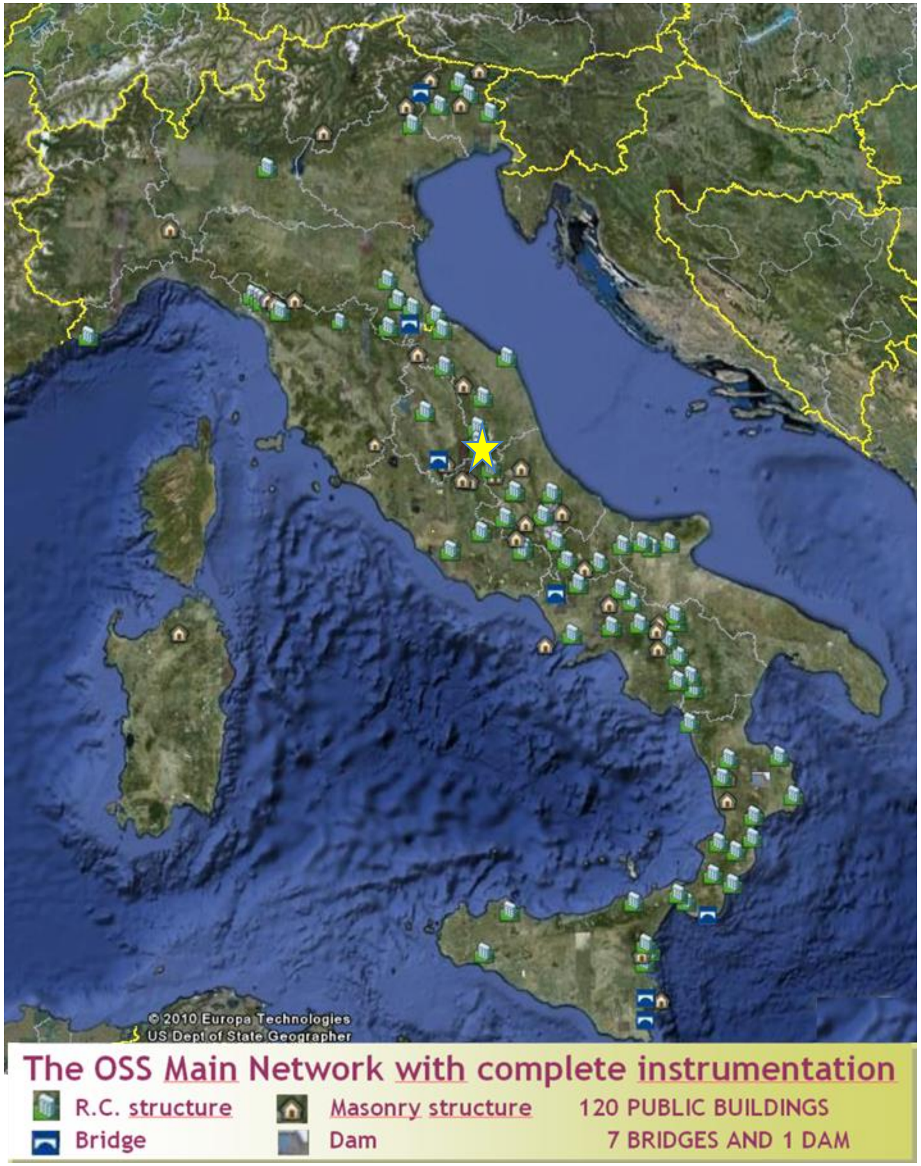
SEISMIC OBSERVATORY OF STRUCTURES (OSS-DPC)

OSS-DPC is a national permanent network which monitors the seismic response of **more than 150 structures**, including schools, hospitals, town halls, bridges. The OSS-DPC allows a remote estimation being made 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) – 24.08.16

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EA080	Hospital	Norcia	R.C.	PGA=0.23g	Drift=0.04%
15SNO	School	Norcia	R.C.+Diss.Braces	PGA=0.52g	Drift=0.23%
BC037	School	Visso	masonry	PGA=0.33g	Drift=0.61%

Sigla	Data	Tempo trigger 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	[illegible]0292	0.0385	0.0205	0.0676	0.1211	0.44	Nullo
BC046	2016-08-24	01:36:4[illegible]	[illegible].0194	0.0264	0.0217	0.0872	0.1067	0.11	Nullo
BC036	2016-08-24	[illegible]	0.0429	0.0401	0.0259	0.1254	0.1471	0.06	Nullo
EA067	2016-08-24	[illegible]	0.0262	0.0203	0.022	0.1212	0.1656	0.26	Nullo
BC053	2016-08-2[illegible]	[illegible]:36:45	0.0421	0.0541	0.0272	0.1155	0.2	0.34	Nullo
50OBR	201[illegible]	01:36:42	0.0346	0.0455	0.0298	0.1828	0.1928	0.58	Nullo
EA077	[illegible]24	01:36:53	0.0088	0.0093	0.0047	0.0311	0.0284	0.16	Nullo
16IPE	[illegible]-08-24	01:37:15	0.0041	0.0047	0.0028	0.0224	0.0158	0.03	Nullo
R[illegible]	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

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Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

SEISMIC OBSERVATORY OF STRUCTURES (OSS-DPC) – 30.10.16

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EA080	Hospital	Norcia	R.C.	PGA=0.32g	Drift=0.08%
15SNO	School	Norcia	R.C.+Diss.Braces	PGA=0.57g	Drift=0.56%
BC037	School	Visso	masonry	PGA=0.30g	Drift=1.10%

Sigla	Data	Tempo trigger 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	[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	06:40:28	0.0405	0.0312	0.0223	0.1561	0.1759	0.36	Nullo
46CAQ	[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]	06:40:25	0.0543	0.039	0.0493	0.2167	0.2699	0.57	Nullo
[illegible]	2016-10-30	06:40:27	0.0803	0.1153	0.0495	0.3487	0.5289	0.5	Nullo
[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

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Dipartimento della Protezione Civile

SEISMIC OBSERVATORY OF STRUCTURES (OSS-DPC)

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BC037	School	Visso	Mas.	15 Km

15SNO	School	Norcia	R.C.	15 Km

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

With respect to the previous recent earthquake sequences in 2009 and 2012, a larger number, better quality, of records has been obtained by OSS

- **First time, in Italy**, that some complete instrumental **records** on buildings subjected to **strong motions** reaching **near collapse or significant damage conditions**.
- Their exploitation in **scientific studies** can provide important contributions to the **understanding of the seismic behavior** of masonry and R.C. buildings.

MACROSEISMIC SURVEY after August 24, 2016

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

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

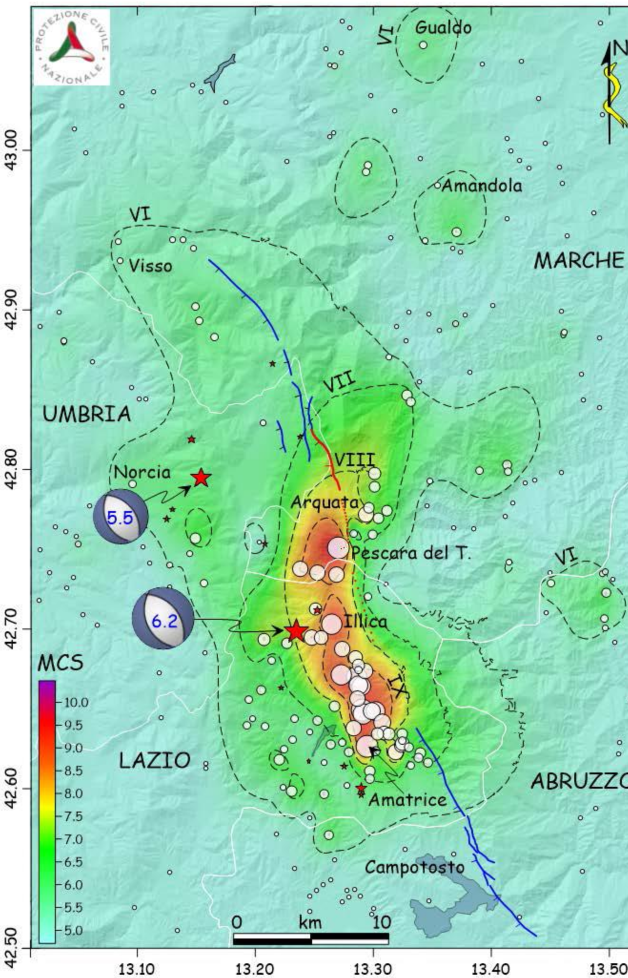
PROTEZIONE CIVILE NAZIONALE

INGV

IGAG

Rapporto preliminare sugli effetti macrosismici del terremoto del 24 Agosto 2016 di Amatrice in scala MCS

Coordinamento del rilievo macrosismico MCS a cura di P. Galli[1] e A. Tertulliani[2]



MACROSEISMIC SURVEY after August 30, 2016

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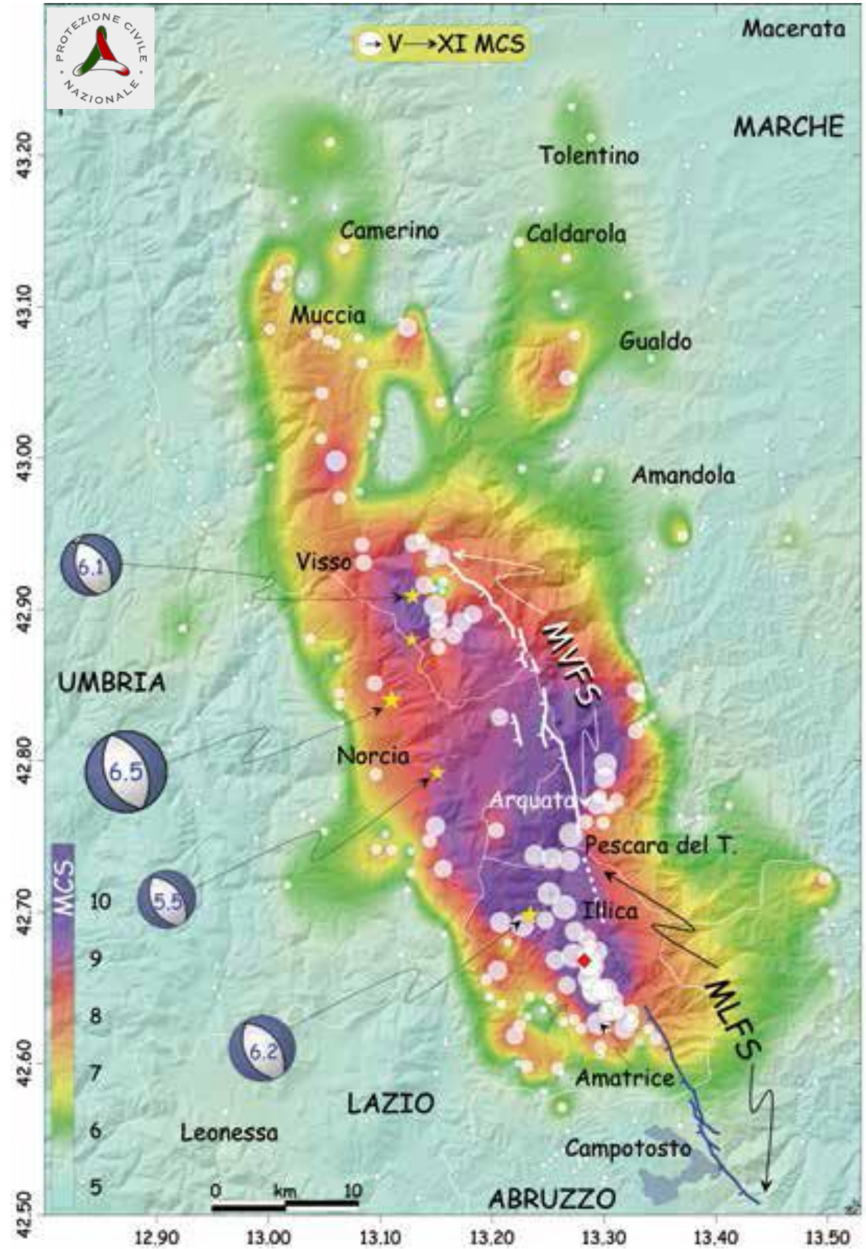
Maximum observed (**cumulated**) intensity is **XI** in the **MCS** scale.

The macroseismic field of cumulated intensities **I_{MCS}≥7** is **70 km long and 30 km wide**



ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

2016-17 sequence **MCS macroseismic field** vs. 1997 Umbria-Marche, 2009 Abruzzo 2009 and 2012 Emilia 2012 ones, all displaying Ml 5.9 (more than one main shock in each of them)

Difference in the **max intensity** and size of **damaged areas**:

- **1997 Umbria-M. → Max(I)=IX–X I≥VII area: ~45x20km**
- **2009 Abruzzo → Max(I)=IX–X I≥VII area: ~55x15km**
- **2012 Emilia → Max(I)=VII-VIII I≥VII area: ~20x10km**
- **2016–17 C.Italy → Max(I)=XI I≥VII area: ~70x30km**

The 2016–2017 Central Italy seismic sequence has been **much more energetic (and destructive)** than the previous ones

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**, especially those cases potentially or really affecting **transportation network and building stock**.

COSEISMIC EFFECTS

M. Dolce
www.protezionecivile.gov.it

Pescara del Tronto, September 6th, 2016

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

Same geographic and seismotectonic location for **2016-17 Central Italy**, **1997 Umbria-Marche** and **2009 Abruzzo**, i.e., the core of the Apennines
→ **rock-falls are distinctive coseismic effect**

Same extensional tectonic regime: normal kinematics
→ the overall surface deformation corresponds to a **general subsidence** and **surface faults / fractures**

The 2012 Emilia seismic sequence occurred in the largest alluvial plain of Italy in a compressional tectonic regime:
→ **widespread liquefaction phenomena**
→ **no surface faulting**

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Post-event 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-eevent damage/usability assessment of ordinary buildings

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.).**

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)

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

Damage and usability assessment of ordinary buildings (until 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)

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

Differences with respect to the 1997, 2009 and 2012 earthquake sequences:

1. **space**, **time** and **intensity** characteristics of each sequence: in the previous sequences the main shocks occurred within 10-20 days maximum
   → the time lapse between the main shocks of this sequence required the **restart of the inspection activities** and a change of procedure (**FAST** in parallel with **AeDES**)

2. **administrative complexity**: the area affected by the 2016–2017 sequence involves four regions

4. No. of **building inspections:**
- **2009** → ca. **80,000**
- **2012** → ca. **40,000**
- **2016-17** → ca. **220,000**

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

5. **Road infrastructure conditions** and **areal distribution of damage** determined **logistic difficulties** for inspection teams

6. **Season** affects **urgency** to complete inspections, **commuting** of teams and **daylight working hours**:
   - **2009 → Spring-Summer**
   - **2012 → Spring-Summer**
   - **2016–2017 → Autumn-Winter**

7. **Preparedness**:
   - **1997 → no** trained inspectors
   - **2009 → few** trained inspectors (half-day training courses)
   - **2012 → limited number** of trained inspectors (same)
   - **2016-17 →** new **rules** limited the recruitment of AeDES teams only among already trained experts
     → **inadequate number** of inspectors available

SCHOOLS

Special attention has been 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.

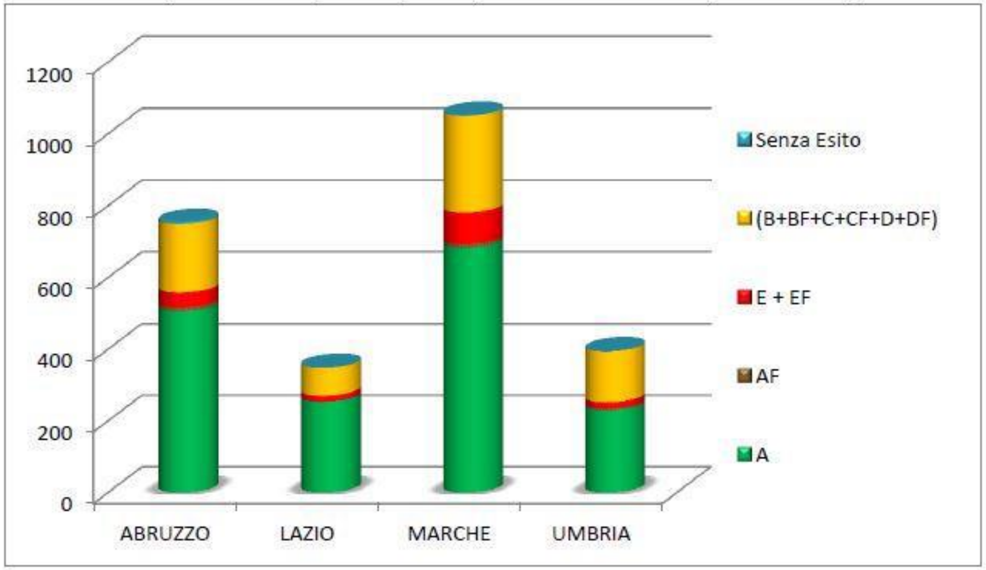
Head of Department of Civil Protection met in the DICOMAC Minister of Education, Universities and Research.

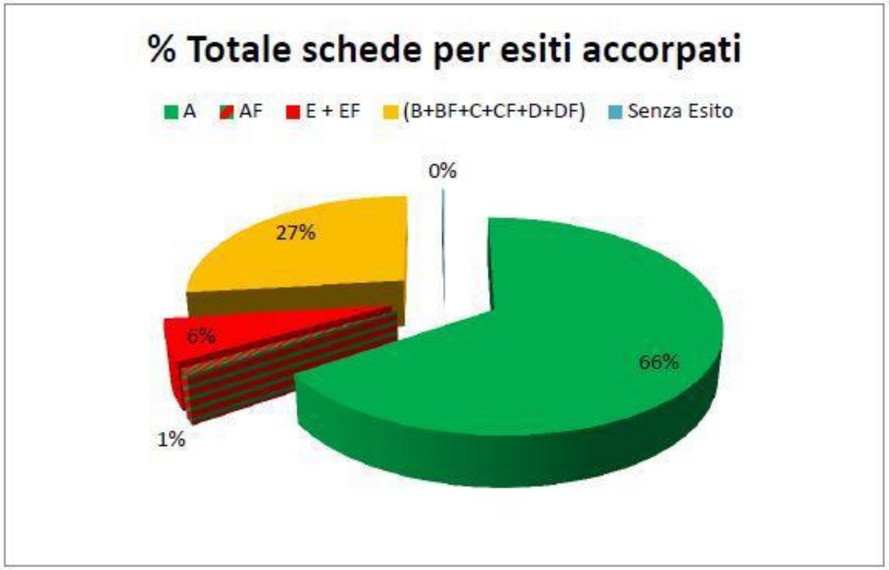
The temporary new school at Amatrice ready on September 12, 2016

USABILITY OF SCHOOL BLDS AeDES inspections after 30.10.16

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

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

School emergency management was **similar** to what experienced in **2009** and **2012**: first mainshocks occurred during the **night**, resulting in **no casualties** in school buildings

Common feature
→ **big effort to allow students to continue their scholastic activities** at the best.

Differences with respect to **2009** and **2012** earthquakes
→ **season of occurrence** and, then, possibility of benefiting from **favorable climatic conditions** and **summer holidays** for school management in the **short-medium term**

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 were 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.).

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Cultural Heritage Emergency management

1. **Assessment of damage and usability** of churches, historical palaces and other heritage manufacts;
2. Displacement and sheltering of **mobile heritage (artworks)** at risk;
3. Evaluation of safety conditions and **execution of safety countermeasures**;
4. **Protection of mobile heritage** using temporary coverage;
5. **Securing «architectural elements»** (selection, displacement and sheltering);
6. Making **cost analyses of damage**.

DAMAGE INSPECTIONS ON HISTORICAL BUILDINGS

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

RECOVERY OF MOVABLE CULTURAL HERITAGE

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

SAFETY COUNTERMEASURES ON HERITAGE BUILDINGS

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

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

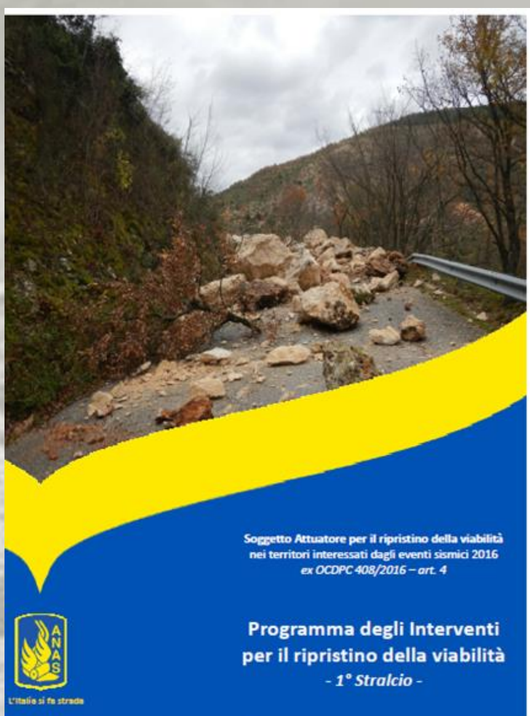
In the **2016-17** seismic sequence, the **size of the damage area** referred to **built heritage** (especially churches) is much wider than that referred to ordinary buildings (even more than 100km from main shock epicenters).

There is a **considerable overlap** of the area affected by this seismic sequence and those affected by the **1997** and **2009** earthquakes:

- → **increase of previous damage**, of not yet repaired and strengthened buildings after the previous earthquakes
- → **re-occurrence of the damage**, even worse than before, of simply repaired and weakly strengthened buildings

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

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 M€**

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CONCLUSION

Challenges of the 2016-17 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...)
- **Huge damaged cultural heritage**
- **Media** attention
- Public and Private building/houses **damage assessment** (>200,000 requests)
- **Long** sequence of seismic (and other - snowfall) events

→ **Repeated and recurring situations!**

ANALOGIES AND DIFFERENCES with Recent Italian Earthquakes

The **2016-17 Central Italy seismic sequence** determined a **seismic emergency** somewhat **different from the emergencies managed** by the Italian **National Service of Civil Protection (SNPC)** in the past 30 years.

Unexpected complexities had to be dealt with by **balancing well-established procedures** with a **sufficient flexibility** to adapt them to the specific case.

16TH EUROPEAN CONFERENCE ON
EARTHQUAKE ENGINEERING
THESSALONIKI
18 - 21 JUNE 2018

The 2016–2017 Central Apennines Seismic Sequence: Analogies and Differences with Recent Italian Earthquakes

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

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