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English summary

The EU project ELITE (*Elicit to learn crucial post-crisis lessons*) was a Coordination and Support action project, completed in the period of January 2013 to June 2014. The project received funding from the EU's Seventh Framework Programme for research, technological development and demonstration from the grant agreement no. 312497 and had a budget of 940, 434 Euros.

This report is the second of four publicly available deliverables in the ELITE project that study lessons learned from respectively forest fires, earthquakes and floods. The purpose of this report is to identify what are the most relevant problems related to the crisis management of earthquakes, and to systematize and analyze any lessons learned regarding preparation, response and recovery from earthquakes.

The report contains a state of the art description of earthquakes illustrated with recent examples. Lessons learned are identified and clustered in common problem areas (categories) related to the crisis management of earthquakes. Secondly, there is an identification of possible solutions or suggestions on how to best improve the common problems areas defined. Finally, the lessons learned and best practices from earthquakes are systematized, based on findings from a workshop on earthquakes, in-depth interviews with experts, and primary and secondary literature review of the crisis management literature on earthquakes.

The results are mainly based on a participative workshop with experts from the ELITE Community of Practice (CoP) which took place in Weeze, Germany, in June 2013. The CoP consists of the project's end users; a heterogeneous group of first responders, researchers, civil protection officers, representatives from NGOs etc. from various European countries. By using problem structuring methods, such as the post-it method, it was possible to gather and categorize a large numbers of experiences and lessons learned from different earthquake disasters, as well as extracting tangible lessons learned from crises and identify challenges related to the different phases of an crisis. The findings were grouped in so-called *problem categories*, i.e. the most common problems faced pre-, during and after a crisis.

The main finding is that lessons learned from earthquakes are mainly focused on (i) communication (both inter-agency communication and crisis communication), knowledge and training experience in the pre-crisis phase, (ii) logistics and risk assessment in the crisis phase, and (iii) lack of debrief and problems related to the recovery stage for the local population in the post-crisis phase. In the workshops the experts stressed the importance of not forgetting the recovery phase, as well as creating a vibrant environment for learning from crises (i.e. from lessons identified to lessons learned).

Through the group discussions it became apparent there are three groups of actors that researchers must take into account when studying earthquakes; (1) the population on the site affected by an earthquake, (2) the rescue teams, and (3) national authorities. Therefore, a chapter is dedicated to tangible lessons learned and best practices categorized after the *main actors* involved.

Sammendrag

EU-prosjektet ELITE (*Elicit to learn crucial post-crisis lessons*) er et 'Coordination and Support action' prosjekt som ble gjennomført i perioden januar 2013-juni 2014. Prosjektet fikk støtte fra EUs syvende rammeprogram for forskning, teknologisk utvikling og demonstrasjon etter tilskuddsavtale nr. 312497 og hadde et budsjett på rundt 8 millioner kroner.

Denne rapporten er den andre av i alt fire offentlig tilgjengelige rapporter i ELITE-prosjektet som omhandler erfaringer, eller «lessons learned», fra henholdsvis skogbranner, jordskjelv og flom. Hensikten med denne rapporten er (i) å samle kunnskap, (ii) kategorisere og (iii) analysere både empirisk og teoretisk informasjon om hvordan en best skal forberede seg, håndtere og lære av jordskjelvkatastrofer. Rapporten inneholder en 'State of the art' beskrivelse av jordskjelv med eksempler fra nylige jordskjelv. Erfaringer og læringspunkter fra krisehåndtering av jordskjelv har blitt identifisert og samlet i felles problemområder (kategorier) og videre har mulige forslag til løsninger, såkalte «best practices», relatert til disse problemområdene blitt identifisert og drøftet. Avslutningsvis blir disse læringspunktene og løsningene systematisert i en tabell, basert på funn fra en workshop, dybdeintervjuer med eksperter og gjennomgang av primær- og sekundærlitteratur om krisehåndtering og jordskjelv.

For å samle konkrete erfaringer fra kriser og identifisere utfordringer knyttet til de ulike fasene i en jordskjelvkatastrofe, ble det arrangert en workshop med medlemmer av prosjektets sluttbrukergruppe, det såkalte Community of Practise (CoP), i Weeze, Tyskland, i juni 2013. CoP består av en heterogen gruppe av responspersonell, forskere, sivilforsvarspersonell, representanter fra frivillige organisasjoner etc., fra en rekke ulike europeiske land. Ved å bruke problemstrukturerende metode, slik som post-it-metoden, var vi i stand til å samle inn og kategorisere et stort antall erfaringer og lærdommer fra ulike jordskjelvkatastrofer. Funnene ble gruppert i såkalte "problemkategorier", dvs. de vanligste problemene som oppstår før, under og etter en krise. Informasjonen som ble samlet inn under workshopen ble supplert med intervjuer og en litteraturgjennomgang.

Hovedfunnene er at de innsamlede erfaringspunktene fra jordskjelvkatastrofer er i hovedsak knyttet til (i) kommunikasjon (både kommunikasjon på tvers av etater og krisekommunikasjon), (ii) kunnskap og opplæring av redningspersonell før krisen, (iii) logistikk og risikovurdering under selve krisen, og (iv) mangel på gjennomganger samt gjenoppbygging av lokalsamfunnet etter krisen har funnet sted. I workshopen understreket ekspertene viktigheten av å huske restitusjonsfasen, samt å skape et levende miljø for læring av kriser.

Et annet viktig resultat som ble tydelig etter gruppediskusjoner var at det er tre grupper av aktører som forskere må ta hensyn til når en skal studere jordskjelv; (1) befolkningen som er rammet av et jordskjelv, (2) redningsmannskap, og (3) nasjonale myndigheter. Ett kapittel i rapporten er derfor dedikert til konkrete erfaringer og «best practices» kategorisert etter hvilken *hovedaktør* som er involvert.

Contents

Preface

The report was written by Maren Maal and Tonje Grunnan from FFI, except chapter 4 concerning the state of the art description on earthquakes, which was written by Maria Rosaria Gallipoli and Sabatino Piscitelli (IMAA-CNR[1], Italy), Angelo Masi (Basilicata University, Italy) and Marco Mucciarelli (OGS-CRS[2], Italy).

We would like to thank the participants in the *ELITE Workshop on Earthquakes* which took place in Weeze, Germany, 25-26 June, 2013, and the respondents from the in-depth interviews, for their valuable inputs. We also thank Gert Lang (Research Institute of the Red Cross (FRK), Austria) for revising the report.

[1] IMAA-CNR: Institute of Methodologies for Environmental Research of the National Council of Research.
[2] OGS-CRS: National Institute of Oceanography and Experimental Geophysics – Seismological Research Center.

1 Introduction to the ELITE project

The EU project ELITE (*Elicit to learn crucial post-crisis lessons*) was a Coordination and Support action project, completed in the period of January 2013 to June 2014. The project received funding from the EU's Seventh Framework Programme for research, technological development and demonstration from the grant agreement no. 312497 and had a budget of 940, 434 Euros.

ELITE was coordinated by Tecnun – Faculty of Engineering at the University of Navarra in Spain, by Dr. José Mari Sarriegi. The Norwegian Defense Research Establishment (FFI), represented by Tonje Grunnan, was the scientific lead of the ELITE project. The other consortium partners included: Gjøvik University College (Norway), International Search and Rescue Germany (ISAR) (Germany), Research Institute of the Red Cross (Austria), Main School of Fire Service (Poland), Thales Research and Technology (France) , Institute of Methodologies for Environmental Research of the National Council of Research (IMAA-CNR) (Italy) and the National Association of Italian Municipalities (ANCI) - Umbria (Italy). Tonje Grunnan and Maren Maal from the BAS7-project (Protection of society 7) conducted the work on behalf of the FFI. Grunnan was the work package leader for WP4. FFI also participated actively in three other work packages.

The ELITE project has developed a prototype of a web-solution (wiki) - *a living document* - which contains information about experiences and lessons learned from natural disasters, primarily in Europe. Much of our knowledge of learning from disasters is fragmented, and the goal of the ELITE project was to collect, categorize and analyze common problem areas in all phases of a crisis, so-called *lessons learned*. The web solution is assumed to help the various actors in crisis management by creating a platform to transfer and share relevant knowledge among users, best practices and guidelines. Due to restricted time, the project focused on natural disasters such as *forest fires, earthquakes and floods*. For this reason the wiki contains mostly reports and documents related to these types of natural disasters, but it is possible to share lessons learned from other types of natural disasters.

ELITE had six work packages (WPs). *WP1* was the coordination and management of the project. *WP2* had the responsibility for arranging the workshops for the ELITE CoP. *WP3* developed the web based platform (the ELITE living document). *WP4* gathered, categorized and analyzed common problem areas and lessons learned in four reports and developed a framework for lessons learned reporting in crisis management. *WP5* mapped the learning process and developed a scientific model of learning. *WP6* disseminated the results from the ELITE project and created a handbook with lessons learned and best practices.

2 The ELITE Community of Practice (CoP)

The project was linked to an extensive group of end users from a total of 16 nations that together formed a Community of Practice (CoP). The end users consisted of a number of actors, such as operational firefighters, police and health professionals, civil protection, emergency and contingency planners at local, regional and national levels, and representatives from NGOs. The aim was to involve stakeholders who were interested in mutual learning and exchanging information, and to help establishing, validating and maintaining the living document.

The ELITE CoP will be continued through the establishment of the Society of Crisis Management Community of Practice (SeCriMaCoP). The aim is to keep the living document alive by getting more crisis managers to share their experiences through this platform. The consortium partners will play a leading role in gathering more end users and donations for the continuation of the Society. Initially, TECNUN will have the presidency in the SeCriMaCoP, while FFI will have the role as vice president. FFI will work to gather more active end users in Norway.

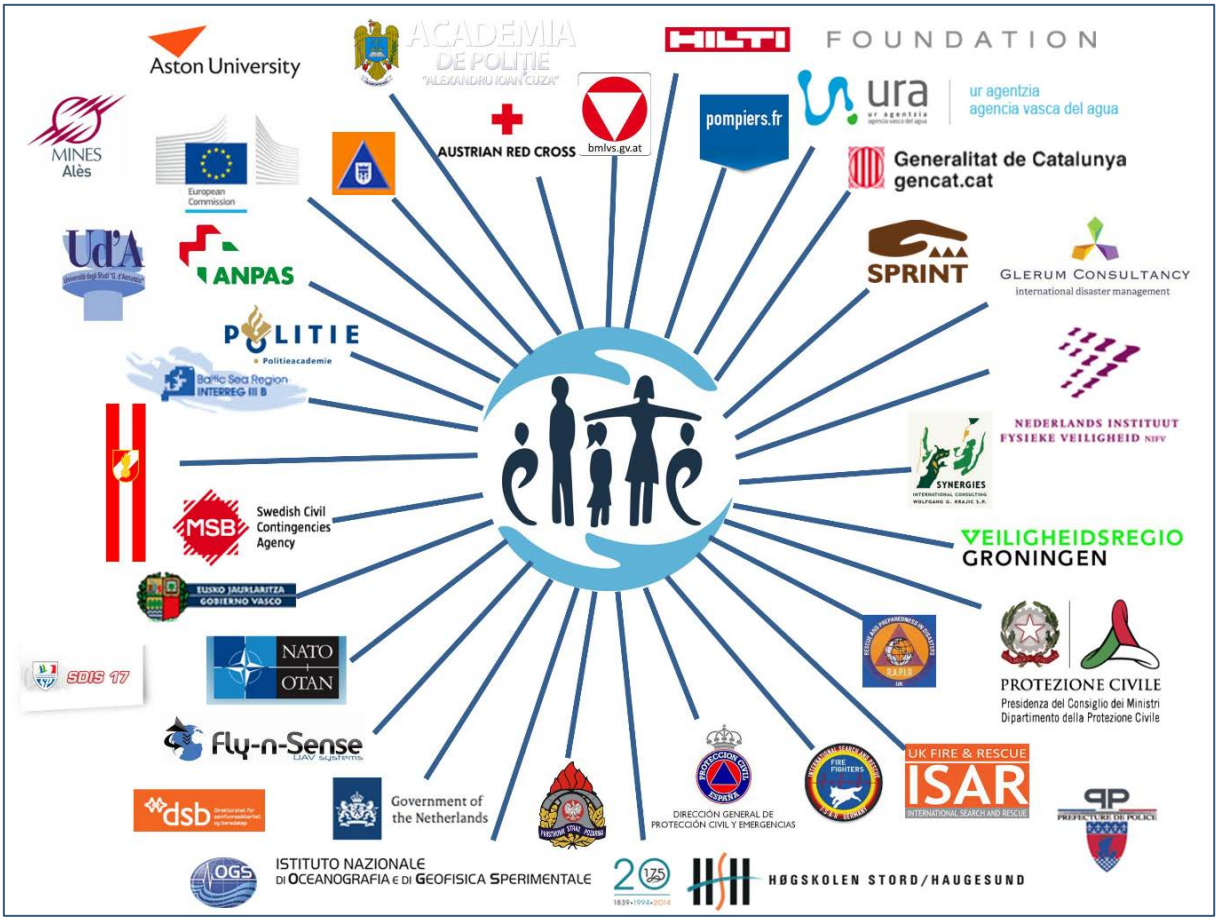

Figure 2.1 The ELITE Community of Practice (CoP).

3 Knowledge gathering, categorization and analysis of lessons learned

The aim of work package 4 was to gather knowledge, categorize and analyze experiences of each of the three natural disasters; forest fires, earthquakes and floods. A comprehensive literature review was conducted with the purpose of identifying the most relevant experiences and lessons learned within each disaster type. Most of the empirical data, however, was collected in four two-day workshops and one table-top/reporting exercise that the project organized for the end users. Findings from these workshops were continued and validated through questionnaires and semi-structured interviews with selected participants.

Five deliverables were produced in the work package. The first report[3] was prepared by Thales Research and Technology (TRT) and was a methodological report describing the development of categories in the ELITE web solution. The report is exempt from public dissemination. Three lessons learned reports were produced from each of the following disaster types; forest fires[4], earthquakes[5] and floods[6]. The goal of these reports was to identify common problem areas and challenges (*lessons learned*) in each type of emergency and describe possible solutions to the problems identified (*best practices*). Furthermore, these findings were used to create a framework or guidelines, to identify the key learning points in the aftermath of large, severe crises. This framework is presented in the fifth report[7]. The final report has a holistic perspective and attempts to transfer findings across the different disaster types and draw knowledge from the previous deliverables.

As responsible for work package 4, FFI is publishing the four publicly available deliverables. This is done in order to disseminate the results and have a wider distribution, nationally and internationally. This report presents the second lessons learned report; *Earthquakes lessons learned report*, see Appendix A.

[3] Goujon, B. (2013). *Methodological report on categorisation*. Deliverable 4.1 ELITE project. FP7-SEC. Contract no. 312497. Restricted.
[4] Maal, M. and Grunnan, T. (2014a). *Forest fires lessons learned report*. Deliverable D4.2. ELITE project. FP7-SEC. Contract no. 312497.
Maal, M. and Grunnan, T. (2014b). *Floods Lessons Learned Report*. Deliverable 4.4. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.
[5] Maal, M., Grunnan, T., Gallipoli, M.R., Piscitelli, S., Masi, A. and Mucciarelli, M. (2014). *Earthquake lessons learned report*. Deliverable D4.3 in the ELITE project FP7 SEC Contract No. 312497.
[6] Maal, M. and Grunnan, T. (2014b). *Floods Lessons Learned Report*. Deliverable 4.4. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.
[7] Grunnan, T. and Maal, M. (2014). *Holistic analysis of lessons learned*. Deliverable 4.5. EU FP7 ELITE (Elicit to learn crucial post-crisis lessons). Contract No: 312497.

Appendix A Earthquakes lessons learned report

ELITE

Elicit to Learn Crucial Post-Crisis Lessons

DELIVERABLE **D4.3**

Earthquake Lessons Learned Report

Contract number :	*312497*
Project acronym :	ELITE
Project title :	Elicit to Learn Crucial Post-Crisis Lessons

Deliverable number :	**D4.3**
Nature :	Report
Dissemination level :	PU (Public)
Report date :	23rd of June 2014

Authors:	Maren Maal, Tonje Grunnan, Maria Rosaria Gallipoli, Sabatino Piscitelli, Angelo Masi, Marco Mucciarelli
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Coordinator: TECNUN

VERSION CONTROL

Version	Date	Contributors	Sections Affected
1	**30.09.2013**	**FFI**	**Deliverable D4.3 submitted to the EU**
2	**30.06.2014**	**FFI**	**Modified deliverable D4.3 submitted to the EU**

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EXECUTIVE SUMMARY

The aim of Deliverable 4.3 is to gather knowledge, categorize and analyze both primary and secondary data regarding preparing, responding and recovering from *earthquakes*. This report constitutes the second of three reports in work package four (WP4) in the ELITE project, dedicated to lessons learned from respectively forest fires, earthquakes and floods.
The report contains:

- A state of the art description of earthquakes illustrated with recent examples.
- Identification of lessons learned are clustered in *common problem areas* (categories) related to the crisis management of *earthquakes.* This is based on a participative workshop with experts from the ELITE Community of Practice (CoP), using problem structuring methods.
- Identification of possible *solutions* or suggestions on how to best improve the common problems areas defined.
- Systemization of lessons learned and best practices from earthquakes based on findings from the ELITE workshop on earthquakes, in-depth interviews with experts, and primary and secondary literature review of the crisis management literature on earthquakes.

In order to extract tangible lessons learned from crises and identify challenges related to the different phases of an earthquake disaster, a workshop with members of the CoP took place in Weeze, Germany, in June 2013. The CoP consists of the project's end-users; a heterogeneous group of first responders, researchers, civil protection officers, representatives from NGOs etc., from various European countries. By using problem structuring methods, such as the post-it method, we were able to gather and categorize a large numbers of experiences and lessons learned from different earthquake disasters. The findings were grouped in so-called "problem categories", i.e. the most common problems faced pre-, during and after a crisis. The information gathered in the workshop was complemented by interviews and a literature review.

We found that the lessons learned from earthquakes mainly focused on communication (Inter-agency communication and crisis communication), knowledge and training experience in the pre-crisis phase, logistics and risk assessment in the crisis phase, and lack of debrief and problems related to the recovery stage for the local population in the post-crisis phase. In the workshops the experts stressed the importance of not forgetting the recovery phase, as well as creating a vibrant environment for learning from crises (lessons identified to lessons learned).

Through the group discussions it became apparent there are three groups of actors that researchers must take into account when studying earthquakes; (1) the population on the site affected by an earthquake, (2) the rescue teams, and (3) national authorities. Therefore, a chapter is dedicated to tangible lessons learned and best practices categorized after the main actors involved.

The report was written by Maren Maal and Tonje Grunnan from FFI. Chapter 4 concerning the a state of the art description on earthquakes was written by Maria Rosaria Gallipoli and Sabatino Piscitelli (IMAA-CNR[1], Italy), Angelo Masi (Basilicata University, Italy) and Marco Mucciarelli (OGS-CRS[2], Italy). Revisions were received from Gert Lang (Research Institute of the Red Cross (FRK), Austria). We thank the participants in the *ELITE workshop on earthquakes* and the respondents from the in-depth interviews for their valuable inputs.

[1] IMAA-CNR: Institute of Methodologies for Environmental Analysis – National Research Council of Italy.
[2] OGS-CRS: National Institute of Oceanography and Experimental Geophysics – Centre of Seismological Research.

1. INTRODUCTION

Of all large natural disasters, earthquakes and their secondary hazards have claimed the largest number of lives in recent years (IFRC[3] 2012). IFRC (2012) calculated that between 2000 and 2008, an average of 50,184 people in the world was killed every year due to seismic events. In the recent years one has witnessed a series of catastrophic seismic events across the world. Yet, the most devastating impacts conveying the destructive force of earthquakes was witnessed in Haiti (2010) which claimed about a quarter million fatalities, and the massive earthquake, tsunami and nuclear emergency in Japan (2011) where nearly 24,000 persons perished or went missing (Lo and Wang 2012:1).

Earthquakes are considered to be unique within the natural disaster management domain. This is because they remain "largely unpredictable and have very rapid onsets" (IFRC 2012:5). One must approach earthquakes in a different manner than other natural disasters. This is because one of the major factors determining the impact of the earthquake is "the level of human development itself – as earthquakes themselves don't kill people but the collapse of buildings do" (IFRC 2012:5). One must therefore address the underlying causes of vulnerability to earthquakes. Preparation, raising awareness in the population, advocacy concerning the importance of safe building codes and better coordinated response efforts are important in this regard.

1.1 About the ELITE project

The Elicit to Learn Crucial Post-Crisis Lessons (ELITE) project will create a living document containing lessons learned from disasters such as forest fires, earthquakes and floods, and lessons learned that are common across these disaster types. The ELITE living document will be a publicly available web solution which comprises a "living" repository of best practices and guidelines as well as social media features. This "living document" will be continuously updated and nurtured by a Community of Practice (CoP) [4] for mutual learning and information sharing. The ELITE CoP consists of the main stakeholders in crisis management, in addition to a large group of end‐users. However, before the living document is launched an iterative process of gathering and categorizing has taken place.

The output of the analysis process in WP4 is three lessons learned reports on forest fires (D4.2), earthquakes (D4.3), floods (D4.4) as well as a holistic report where all tangible lessons learned are integrated using an all phases-all hazard approach(D4.4). In addition, a report on categorization for the living document (D4.1) will be produced. This deliverable constitutes the second in a series of three lessons learned reports in the project.

1.2 Research question and objective of the report

The objective of this report is to gather knowledge, categorize and analyze both primary and secondary data regarding *preparing, responding and recovering from earthquakes*.

[3] IFRC: International Federation of Red Cross and Red Crescent Societies.

[4] CoPs are groups of people who share a common interest and concerns, and who expand their knowledge and expertise in this area by sharing ideas, experiences, insights, tools and best practices (Ruffner 2010; Snyder 2003; Wenger 2002). For more information about the CoP, see Maal and Grunnan (2013).

This report poses the **research question** *what are the most relevant problems and are there any lessons learned relating to earthquakes?*

In order to do this, various qualitative methods such as a workshop with experts and a literature review have been used to gather current knowledge on earthquakes. The literature reviewed includes reports from humanitarian agencies who have field experience (IFRC and ALNAP[5]), as well as in-depth interviews with experts from different levels within the crisis management. Also information from REAKT[6] (2014), an on-going EU project aiming to improve the efficiency of real time earthquake risk mitigation methods, has been used. In order to capture the newest and most relevant lessons learned and best practices, information from the earthquake workshop was used.

1.3 Plan for the report

The report is structured as follows:

In **chapter 2** the terms in this report will be defined and conceptualized. What makes earthquake different than other natural disasters will be discussed. An outline of who are the actors in the crisis management and the different phases of a crisis will also be explored.

Chapter 3 includes methodological reflections concerning this report's research process which consists of a literature review, use of the post-it method in the ELITE workshop and semi-structured interviews with key informants.

Chapter 4 contains a state of the art description of earthquakes. Recent earthquakes in Italy, L'Aquila (2009) and Emilia (2012) are described and certain problem areas are identified.

In **chapter 5** different lessons learned from earthquake crisis management will be identified based on information from the ELITE workshop. The relevant lessons learned are structured into problem areas; (5.1) in the pre-crisis phase, (5.2) during the crisis, and (5.3) in the post-crisis phase.

Chapter 6 identifies possible solutions to the problem areas. The solutions are divided into the main problem areas; (6.1) Communication, (6.2) Training, (6.3) Logistics & Equipment, (6.4) Risk assessment and Early Warning Systems, (6.5) Debrief and (6.6) Recovery.

Chapter 7 systematizes the lessons learned and best practices from the crisis management literature and draws some best practices based on interviews. It also includes a compilation table of the problems and solutions identified by the ELITE workshop participants.

Chapter 8 sums up the main findings in this report.

5 ALNAP: Active Learning Network for Accountability and Performance in Humanitarian Action.

6 REAKT: Strategies and Tools for Real Time Earthquake Risk Reduction.

2. BACKGROUND

This chapter will conceptualize and define the most relevant terms used in the report and describe in short what makes earthquakes different than other types of disasters.

2.1 Conceptualization and definitions

2.1.1. Definition of lesson learned

The ELITE project has used the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) definition of **lessons learned**. Lessons learned are defined as:

"Knowledge or understanding gained through experience. A lesson must be significant in that it has a real or assumed impact on operations; valid in that is actually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result".

"Learning" can be difficult to describe and measure. Boin, t'Hart and Sundelius (2005:117), introduce three different types of learning: (i) *Experiential learning* is when one has experienced direct exposure to a crisis and has subsequently developed insight about what caused the crisis and how the crisis management worked, (ii) *Explanation based learning* is when one has "rational-scientific search for the causes of failure and the effect of response, (iii) *competence or skill based learning* which implies that during and after the crisis new expertise and technology is created to handle a similar future crisis in a better manner (Boin et al. 2005:117)[7].

2.1.1. Phases of a crisis and the actors involved in crisis management

A general definition of crisis or a disaster is when: *"[…] policymakers experience a serious threat to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstances necessitates making vital decisions"* (Rosenthal, Charles and t'Hart 1989:10, cited in Boin et al. 2005:2).

Natural disasters can be defined according to the extent of their impacts. The perception of the term crisis depends on the context, the ability of the involved actors to assess the situation. There are many actors involved in managing and responding to natural disasters. The key services are the police, fire and rescue services, ambulances, emergency call centres, hospitals and the municipality crisis management organizations. In addition, civil protection units, military units (such as the Home Guard), and non-governmental organizations (NGOs) may be called upon. Regional and national authorities can become involved depending on the severity of the crises and the need for coordination.

There is also an international aspect when it comes to natural disasters as they may affect several countries. The *EU mechanism* is a good example of cooperation across borders. The EU mechanism was established to support the mobilisation of emergency assistance from European Participating States in the event of major emergencies.

Often there are different actors involved the various stages of a crisis. One can outline three general phases related to a crisis. These phases are not clear-cut but transcends into each

[7] The different types of learning are further elaborated in Maal and Grunnan (2013).

other. *(1) Pre-crisis* (*mitigation, prevention* and *preparation), (2) The Implementation phase (during the crisis),* and *(3) The post crisis phase:* This involves a *recovery* from the crisis situation where one ensures a transition back to business-as-usual.

2.2 What makes earthquakes different than other disasters?

Earthquakes are considered to be unique within the natural disaster management domain (IFRC 2012:5, ALNAP 2008). This is because earthquakes in themselves are rarely responsible for any deaths. The high mortality and large scale destruction is due to collapsed structures and the secondary hazards that the earthquake triggers (i.e. fires, tsunamis, landslides, rock falls, floods due to bursting of dams etc.). For example, when there is an earthquake in urban areas it often leads to major fires. It has been observed that large numbers of people have been killed by fire after an earthquake (in 1906 San Francisco Earthquake, and the 1923 Kanto (Tokyo) Earthquake). In Kobe in Japan (2011) the "mortar or plaster cover protecting timber construction fell off during a severe vibration, and the exposed timber structure caught fire after the earthquake motion" (Otani ND:15)[8].

ALNAP (2008) has mapped out some additional factors that make earthquakes different than other disasters.

Photographs from the earthquake in Chile in 2010 (*Photograph by Victor Ruiz Caballero (Reuters) and David Lillo (AP) in National Geographic*).

- Earthquakes may trigger landslides which destruct roads, bridges and other type of infrastructure. This makes it very difficult for the search and rescue teams to access the danger zones and for victims to get away.

- Earthquakes have aftershocks. Aftershocks are smaller earthquakes that happen in the same area as the main shock. Aftershocks are the *"seismic activity representing the earth's readjustment along a fault line after a mainshock event*" (wise geek 2013). These earthquakes may pose a threat to the SAR teams and crisis management staff. It may disrupt the ongoing operation and can cause collapse of buildings that were damaged in the main earthquake.

- Earthquakes claim the highest mortality rate compared to other natural disasters. This is due to collapsing buildings that may kill large numbers of people (ALNAP 2008).

- The likelihood of injuries is high. Especially fractures and crush injuries.

[8] ND stands for No Date and is used for reports/articles/web sites that have no date.

- Because earthquakes occur rarely compared to other natural disasters, it becomes 'harder to sell' for risk-reduction measures than more frequent disasters.

- Earthquakes create large amounts of rubble from collapsed buildings. This rubble must be cleared before reconstruction can start.

- There is no gap between relief and recovery in earthquakes. Households begin their recovery at once.

- Secondary hazards triggered by earthquakes make the crisis complex (i.e. fires, tsunamis, landslides, rock falls, floods due to bursting of dams etc.).

3. METHODOLOGICAL APPROACH

The research methods used in the report include participative group discussions during the earthquake workshop, semi-structured interviews and a review of secondary and primary literature.

3.1 Group discussions and the post-it method

In the ELITE project there will be separate workshops for each of the three topics; forest fires, earthquakes and floods, and a fourth, holistic workshop. The second workshop, on earthquakes, took place the 25th and 26th of June 2013 in Weeze, Germany[9].

The earthquake workshop was designed to first *identify lessons learned*. A post-it exercise was conducted. All experts wrote down lessons learned within problem areas that they had experienced in various phases of a crisis on different post-its. Later the experts presented their post-its and stuck them onto the whiteboard. This would often cause discussions as the expert would often provide an example where they experienced this problem, other experts would also share similar experiences.

Post-its with similar lessons learned were grouped under larger problem areas and it was also noted in which of the phases in a crisis this problem would occur (see photographs from workshop).

It was a participative process and all the group members got to share their views, this triggered interesting discussions as the experts came from different countries and had different backgrounds.

Photographs from post-it exercise in ELITE Earthquake workshop in Weeze 2013 *(Photographs by T. Grunnan 2013 and M. Maal 2013)*

[9] See van Santen and Illing (2013). The first workshop took place in Weeze, Germany, the 15th-16th of April 2013.

The next day the same groups had to *identify possible solutions* to the problems. The problems had been plotted into a Word-table and could therefore be projected on a screen. All the problems were dealt with and each time a solution was proposed by the experts. Afterwards attempts were made to find possible hinders to solve the problem.

Finding solutions are much more difficult than findings problems. It was also interesting to note that during the first day when identifying problems all members participated actively. The second day, older and more experienced experts would attempt to promote solutions. This was also a question of mastering the language, as proposing complex solutions required a good vocabulary. Language barriers are difficult to overcome and very relevant in the context of EU projects.

Through the workshop exercises and the following discussion the consortium managed to disseminate and collect procedures, best practices; lessons learned and establish a common understanding of the possibilities for interoperability. Many of the participants from the ELITE CoP told us that this was a great platform to meet relevant actors involved in civil protection interventions, as well an opportunity to share lessons learned and best practices.

3.2 Interviews with key informants

The interviews conducted were semi-structured. Bryman (2004:321) defines semi-structured interviews as a flexible process where the researcher follows an interview guide, but can ask follow-up questions and pursue topics that may be of particular interest to the respondents. The interview guide was created after the workshop and the literature review. Statements from the workshop were used in the interview guide to focus the interview.

The interviews were conducted with two experts including the head of the Emergency Response Department in the Norwegian Refugee Council and a Brigade Commander at the Agency for Fire and Rescue Services in the City of Oslo, Norway. The interviews were used to supply and verify the primary data gathered through the workshop. The information gathered through interviews will not be referred to explicitly. However, the findings are incorporated into the text.

3.3 Literature review

On the topic of earthquakes there is a great deal of evaluation reports conducted by humanitarian agencies related to how one can better deal with large-scale earthquakes. These reports base their findings on previous incidents like Haiti (2010) and Japan (2011). The lessons identified and the lessons learned from IFRC, IRIN[10] and ALNAP are therefore a type of experiential learning. The on-going EU project REAKT has been useful for background information and for studying lessons learned regarding strategies and tools for real time earthquake risk reduction (REAKT 2014).

[10] IRIN is a service of the UN Office for the Coordination of Humanitarian Affairs which provides humanitarian news and analysis.

4. STATE OF THE ART – EARTHQUAKES[11]

Natural earthquakes are caused by the fracturing of brittle rock when it is deformed under stress load beyond its breaking strength. Sudden rupture will occur, either along pre-existing **faults** or by breaking up a new fault (**seismic source**) (Bormann, P. 2012). The location below the earth's surface where the earthquake starts is called the **hypocenter**, and the location directly above it on the surface of the earth is called the **epicenter**.

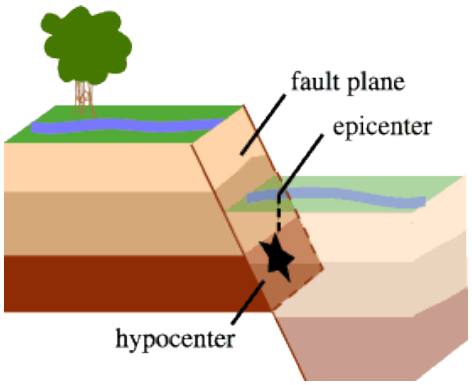

Figure 1: Cartoon reporting some features of an earthquake *(from http://earthquake.usgs.gov/learn/kids/eqscience.php)*

Most earthquakes occur along the main plate boundaries. These boundaries constitute either zones of extension (e.g., in the up-welling zones of the mid-oceanic ridges or intra-plate rifts), transcurrent shear zones (e.g., the San Andreas fault in the west coast of North America or the North Anatolian fault in Turkey), or zones of plate collision (e.g., the Himalayan thrust front) or zones of subduction (mostly along deep sea trenches). Accordingly, tectonic earthquakes may be associated with many different faulting types (*strike-slip, normal, reverse, thrust faulting or mixed*) (**focal mechanisms**) (Bormann, P., 2012) (Fig. 5).

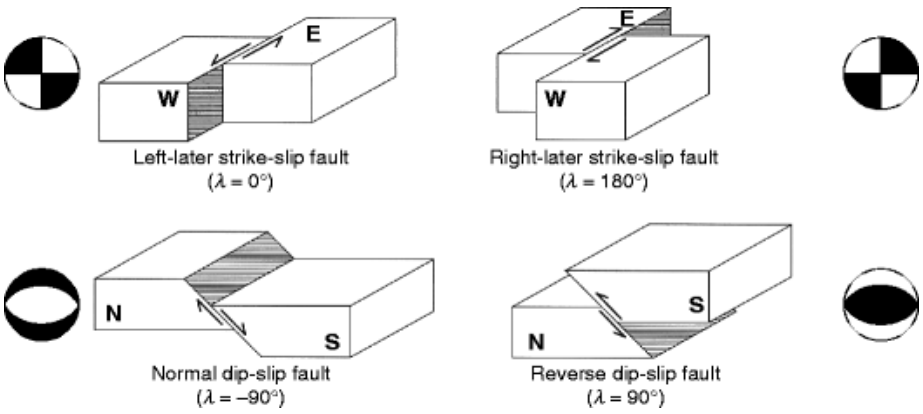

Figure 2: Cartoons of the related motions of crustal blocks and "Beach-ball" representations of basic types of faulting *(from Encyclopedia of Solid Earth Geophysics, 2011).*

[11] Chapter 4 is written by Maria Rosaria Gallipoli and Sabatino Piscitelli (IMAA-CNR), Angelo Masi (Basilicata University) and Marco Mucciarelli (OGS-CRS).

The outgoing waves are influenced by the strain distribution near the source. This leads to the concept of radiation pattern, which is a geometric description of the amplitude, specifically, the motion on the fault plane causes the body wave radiation patterns. The attenuation of wave patterns depends on elastic/anelastic attenuation and scattering phenomena, and the site effects on the geological/geotechnical characteristics of superficial soils. Thus, the seismic waves amplitude at the surface is not corresponding to the popular sketch of circular, concentric waves like a stone in a pond. On the contrary, there are sharp variations from site to site. There are several parameters devised to measure the severity of a quake at a given site.

4.1 Macroseismic intensity

The size of a seismic source may be characterised via its macroseismic intensity **I**. The latter describes the strength of the resulting shaking in terms of human perceptions, damages to buildings and other structures as well as changes in the surrounding environment. **I** depends on the distance from the source and the underground conditions and is mostly classified according to scales of 12 degrees. From an analysis of the areal distribution of perceptions and damages one can estimate the intensity **Io** in the (*epicentral*) source area as well as the source depth **h**. There exist correlation relationships between *Io* and other instrumentally determined measures of the earthquake size such as the *magnitude* as well as between *I* and *ground acceleration*.

Intensity is basically a descriptive measure of the severity of the ground shaking on the basis of observed effects in a limited area on: *Living things* (people and animals): as intensity increases, a greater proportion of people or animals notice the shaking, and are frightened by it; *Objects:* as intensity increases, greater numbers of ordinary domestic items (crockery, books, etc.) begin to shake and then be upset or thrown down; *Buildings*: as intensity increases, buildings become progressively more severely damaged; *The natural environment*: as intensity increases, there is an increasing likelihood of effects such as cracks in embankments, rockfalls, and so on. In Europe the most widely used scale is the EMS98 (European Macroseismic Scale), that substituted the MSK scale (Medvedev-Sponheuer-Karnik). In some countries with long historical record is still widely popular the MCS scale (Mercalli-Cancani-Sieberg), that does not take into account the vulnerability of buildings and is sometime assigned for single, monumental structure (which is not allowed by EMS).

4.2 Magnitude and seismic energy

The magnitude **M** is a logarithmic measure of the size of an earthquake or explosion based on instrumental measurements. The magnitude concept was first proposed by Richter (1935) to provide an objective instrumental measure of the size of earthquakes. Magnitudes are derived from instrumental recordings of ground motion amplitudes and periods or from signal duration. There are different types of magnitude scale depending on which phase amplitude are considered (Lay and Wallace 1995).

4.3 Instrumental peak parameters

Seismic recordings at a given point are a measure of acceleration or velocity of ground motion observed as a function of time. The most common measure of ground motion severity is the absolute peak value recorded of acceleration (PGA), velocity (PGV) or displacement (PGD). PGA is the most used for historical reasons, but is not very well correlated with damage and can be varying abruptly even in nearby sites. PGV is much better correlated with earthquake damage.

4.4 Integral parameters

Among the integral intensity measures, those ones mainly used and that are able to effectively represent the damage potential of a ground motion (Masi et al., 2011), are:

- Arias Intensity $$I_A = \frac{\pi}{2g} \cdot \int_0^t a^2(t)dt$$
- Housner Intensity $$I_H = \int_{0.1}^{2.5} S_v(T, \xi = 0.05)dT$$

where g is the acceleration gravity, $a(t)$ is the time history in acceleration, S_v is the pseudo-velocity spectrum, T is the vibration period, and ξ is the equivalent viscous damping coefficient.

4.5 Seismic risk

One of the primary motivations for studying earthquakes is the destructions caused by large earthquakes. In many part of world, seismic risks are significant, whether they are popularly recognised or not. In assessing the potential danger posed by earthquakes or other natural disasters, it is useful to distinguish between *hazard* and *risk*.
The ***hazard*** is the intrinsic natural occurrence of the earthquakes and the resulting ground motion due to the convolution of seismic source, radiation/attenuation pattern and site effects.

*Hazard = seismic source*attenuation pattern*site effects*

The ***risk*** is the danger the hazard poses to life and property.

*Risk = hazard*vulnerability*exposure*

The ***vulnerability*** of a construction (building, bridge, etc.) can be defined as its proneness to be damaged by an earthquake. Based on a quantitative assessment of seismic vulnerability, the probability of damage to given structural types caused by earthquakes of various intensities can be predicted. This is a key step in the evaluation of seismic risk, as economic losses (direct, repair costs, indirect, interruption of economic activities) and casualties are strongly correlated to structural types and their expected damage (Dolce et al., 2003). Seismic vulnerability can be assessed by making use of different techniques: Direct, Indirect and Conventional (Dolce, 1996). The choice depends mainly on the level of information available and on the extension of the area under examination.

The ***exposure*** represents the global value of elements at risk (human beings, structures, properties, environment, etc.) in a territory.

4.6 Earthquake Hazard in Europe and Neighbouring countries

The most recent effort to update the seismic hazard studies with uniform methodology in Europe was undertaken by the EU-funded project SHARE (http://www.share-eu.org/).
The following map is one of the outcomes of the project (Fig. 6).

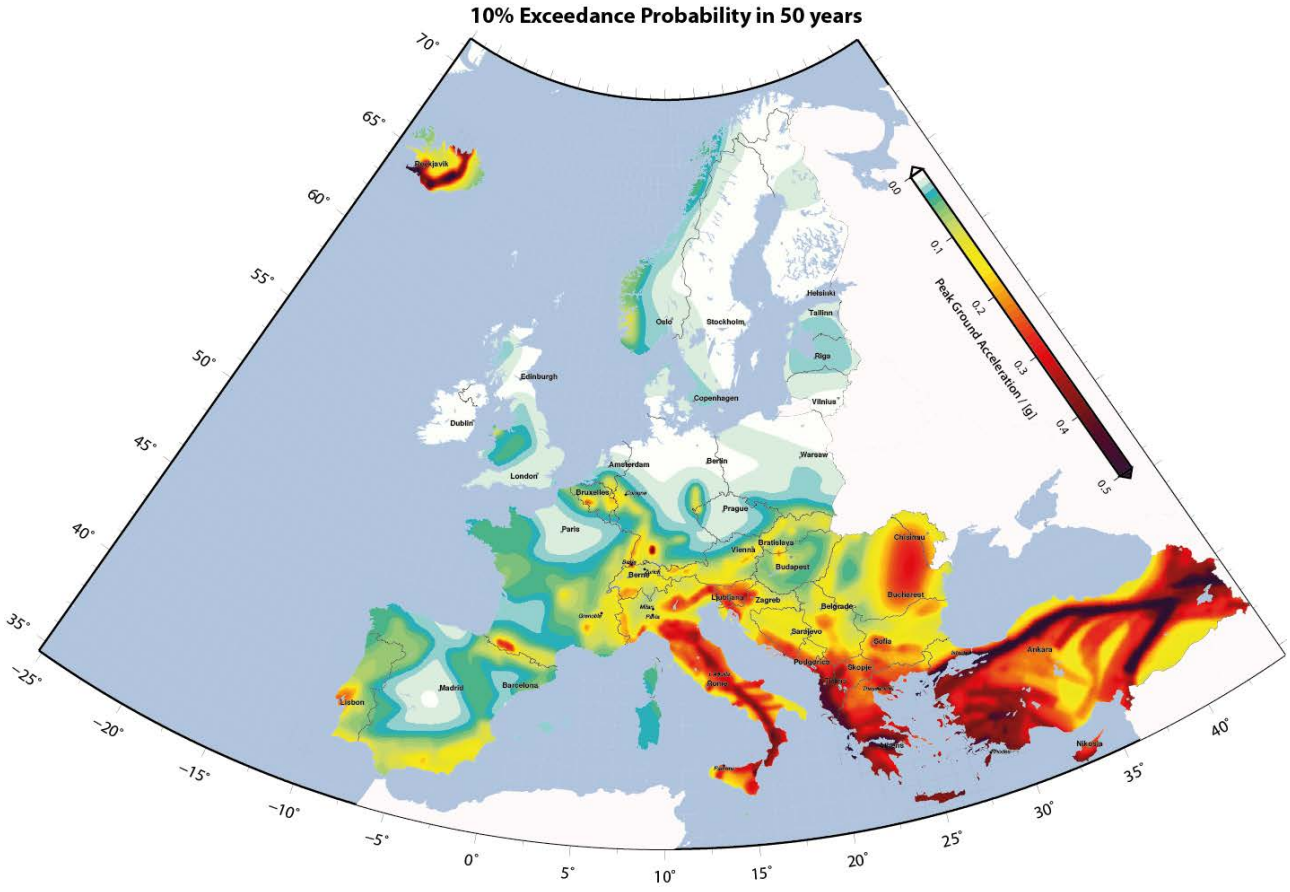

Figure 3: Euro-Mediterranean Seismic Hazard Maps *(from http://www.efehr.org:8080/jetspeed/portal/hazard.psml).*

This map depicts the 10% exceedance probability that a peak ground acceleration of a certain fraction of the gravitational acceleration *g* is observed within the next 50 years. The colours code ranges from 0-0.5g and is saturated. The map shows that lower ground motions are expected to be observed in regions with colder colours (green to yellow) compared to regions with warmer colours (orange to dark red). The maps show, for example, that the highest ground motions are expected along major plate boundaries such as the North Anatolian Fault zone. It is possible to see that the most hazardous areas are Iceland, the Balkans, Turkey and Italy. Other earthquake prone areas can be found in Portugal, Spain, France, the Rhine valley and the coast of Norway.

4.7 Recent Examples from Italy; The L'Aquila and Emilia earthquakes

The 2009 central Apennine earthquake (Mw 6.3; see photographs) devastated the old downtown areas of L'Aquila on the night of April 6, 2009. Its social impact has been very high, both in terms of human loss and from an economical point of view. The death toll reached 308, with 1,568 injured and 67,500 temporary left homeless (Amato et al. 2011).

Photographs: Many buildings were destroyed in L'Aquila, including the Palazzo del Governo (left). View of the ruins of Tempera (IX MCS) at dawn of April 6, 2009 (right); the church clock indicates the time of the earthquake that the night before razed to the ground the entire village *(Photographs by P. Galli).*

On May 20 and 29, 2012, two major earthquakes (Mw 6.1 and Mw 6.0, respectively) (quick Regional Centroid Moment Tensor [RCMT] at http://autorcmt.bo.ingv.it/quicks.html) struck the Pianura Padana Emiliana region (northern Italy), causing 27 dead, at least 400 injured and up to 45,000 homeless in total (Fig. 7).

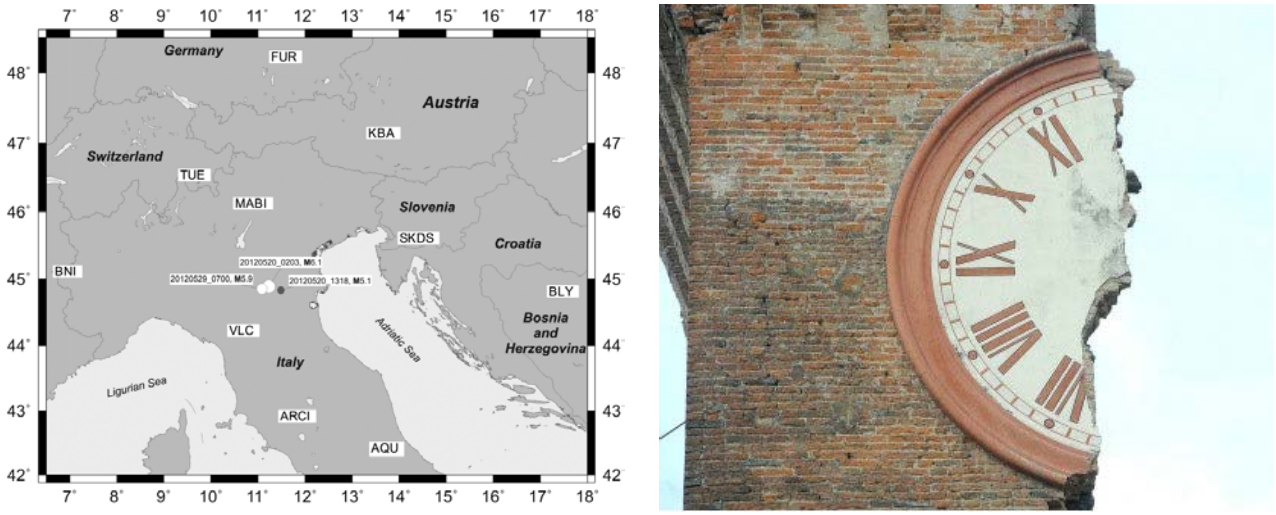

Figure 4: Regional map showing the locations of the epicenters of the May 20, 2012, Mw 6.1 earthquake and the May 29, 2012, Mw 6.0 event *(from Ganas et al., 2012).*

Both earthquakes showed a prompt response from Civil Protection. Search and rescue, also thank to international cooperation in L'Aquila was completed in 72 hours after the event. The set-up of shelter camps, thanks to the volunteers' organisation, started in few hours and all the people in need had a temporary accommodation in 36 hours (In Emilia the time was less, due to the lesser number of casualties and homeless).

Those two recent earthquakes draw attention to other issues listed in the following.

L'Aquila 2009 earthquake: damage to Reinforced Concrete buildings

Reinforced Concrete (RC) buildings designed either with outdated or non anti–seismic criteria have often displayed unsatisfactory seismic behaviour during past earthquakes (e.g. Southern Italy 1980, Turkey 1999). Besides, RC buildings currently represent a large proportion of the building stock in many countries all over the world, including Italy and other Mediterranean earthquake-prone countries.

During the recent L'Aquila earthquake several existing RC buildings suffered heavy structural damage and in a few cases collapsed (see photographs). On the contrary, non-structural damage both in private and public buildings was extensive, varying from small cracks to collapse along with minor or no damage to structural elements (Braga et al., 2011). Such extensive damage on non-structural elements (NSE) was not found in past Italian earthquakes, mainly because of the limited amount of RC structures in the building stock of the affected zones. In fact, in the 1980 Irpinia earthquake (M_l = 6.9) only a small share of the damaged buildings, around 13%, had RC framed structure.

Therefore, L'Aquila earthquake provided interesting hints on the seismic vulnerability of existing non-ductile RC buildings showing that their performances can be quite poor thus leading to dramatic consequences to human beings (most of casualties in L'Aquila town were caused by RC buildings' collapses) and significant disruption of the affected community (e.g. temporary or permanent closure of public buildings).

Photographs: Structural and non-structural damage examples on RC buildings after the L'Aquila 2009 earthquake *(Photographs by Braga et al., 2011).*

Hospitals

The strongest shocks of the Emilia sequence, mainly because of damage to non-structural components, caused the evacuation of three hospitals in the epicentral area forcing health authorities to transfer patients and deviate injured people to other hospitals (Masi et al., 2013).
This is an important issue to discuss taking into account that health facilities are complex systems having a fundamental role in emergency management and, above all, in saving lives during a seismic crisis (Lupoi et al., 2008). In fact, past earthquakes showed the awful

consequences coming from the occurrence of damage to hospitals that cannot satisfy the increased demand of healthcare just when it is more needed like in the post-earthquake condition (Price et al., 2012). As well known, first hours from the seismic event are a key time for rescue activities and saving lives.

When dealing with the vulnerability of hospitals, a peculiar condition needs to be recognized: hospitals, more than other public or private buildings, do require great caution in the judgement on their safety condition after seismic events (Masi et al., 2013) (see photographs). On one hand, they have to be carefully inspected and assessed applying a precautionary principle in consideration of the particular nature and state of their occupants. On the other hand, depriving the community of a strategic building whose importance greatly increases during an emergency can be very impacting. Further, experience demonstrates that whether the decision to close a hospital can be rather easily made, reopening partially or totally it can be far more complex requiring a large number of technical and administrative steps, as the case of the San Salvatore Hospital after L'Aquila 2009 earthquake shows (Price et al., 2012). This is particularly true in countries with a complicated network of administrative rules and authorities involved in their application like Italy.

Photographs: External and internal damage examples on Hospital buildings after the Emilia 2012 earthquake *(photographs by Masi et al., 2013)*

Points of reflection

Other issues arise from the two earthquakes:

1) The importance of side effects in aggravating locally the consequences of an earthquake (see below the liquefaction in Emilia) and thus the need to implement a thorough microzonation campaign prior to future events to know in advance the most hazardous area.

2) The important role of timing of the quake in determining casualties. In L'Aquila, private houses were more vulnerable than workplaces and the fact that the earthquake occurred at night times causes more victims. In Emilia the night times occurrence saved lives given that the industrial facilities suffered widespread collapses.

3) The high vulnerability of historical and religious buildings, besides the losses to cultural heritage, proved to be a powerful force of disruption of social cohesion. People felt deprived of cultural symbols and aggregation places.

4) There were issues about communication to the population, with serious problems related to the definition of acceptable damage vs. safety perception, the meaning of hazard maps and the (un)predictability of earthquakes.

5) The damages connected to business interruption proved to be difficult to estimate beforehand. The most striking example was the fact that a substantial fraction of disposable filter for kidney dialysis was produced in the Emilia area affected by the 2012 quake, forcing to find emergency solution in a limited time to restore production, in order to avoid a global crisis due to shortage with possible serious consequences for people in treatment worldwide.

5. IDENTIFICATION OF LESSONS LEARNED IN CRISIS MANAGEMENT OF EARTHQUAKES

This chapter will identify the main lessons learned related to crisis management in earthquakes which were collected through the post-it exercise with the ELITE CoP at the ELITE workshop in Weeze, June 2013. The CoP participants were divided into smaller groups and were asked to write down problems on post-it's that were clustered around the three phases of a crisis (for more information see section 3.3). The findings in this report are therefore presented according to the different phases of a crisis (see figure 5 illustrating the outline of this chapter). Furthermore, the lessons learned were clustered in problem areas within each phase. Communication was considered one of the most important problem areas and is split into two sections; inter-agency communication and crisis communication.

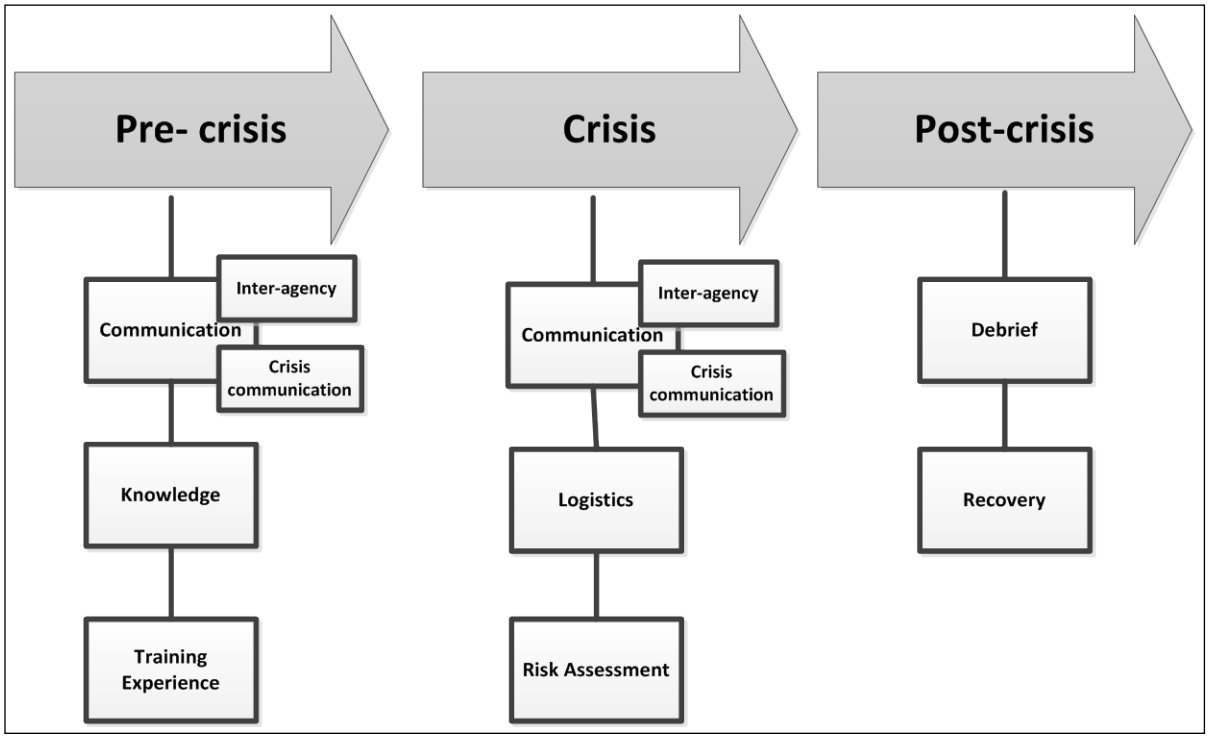

Figure 5: Outline of problem areas in the different phases of a crisis

5.1 Pre-crisis

5.1.1. Communication

Inter-agency communication

Horizontal communication - between teams

A lack of common terminology between different actors in the rescue operations is a major problem before and during international rescue operations. Due to language barriers it becomes difficult to foster cooperation between the rescue teams from various countries in Europe. Being able to communicate effectively is crucial during a crisis. Even in large scale exercises the experts noted that language barriers hindered effective and clear communication. A

complicating feature is that the different teams taking part in the rescue efforts use dissimilar protocols, different technologies and tools. This causes interoperability problems.

Hierarchical communication - between levels
Another problem area mentioned by the experts was related to the lack of communication between different levels within the crisis management. It was noted that the Search and Rescue teams (SAR) need the most updated technical information available before the teams can enter the earthquake areas. This includes information on what has happened and predictions on what may happen; i.e. technical information on the earthquake, like aftershocks and possible secondary hazards, as well as logistics. This is essential when preparing for an operation. The experts also wanted to receive information whether the given information was standardized and sent out to all teams participating.

Designing strategies
The people who are designing strategies for the SAR teams may not have knowledge or familiarity with the field and terrain where the earthquake has occurred. This can result in strategies and plans that are not suited to the terrain affected. This may cause inter-agency communication problems. When designing strategies one must also prepare for domino effects, and/or cascading effects (earthquake, then floods, then power cut off etc.). Isolated plans on one disaster can be correct and suitable, but when several disasters occur in the same time period the original plan is not enough. Experts noted that one must accept that it is not possible to access all the emergency areas in a large scale earthquake. One can only assist from the outside. Deciding what is the limit of access and help provided is not an easy task.

Crisis communication

Communication to population
Informing the population about the location of waiting/emergency areas must be done in the pre-crisis stage. Often the population affected lack this type of information. Effective risk communication can be argued to be a balancing act. The crisis managers cannot give the population too much information because it can lead to information overload. However, crisis managers must give them enough information to be able to know how to respond after an earthquake.

5.1.2. Knowledge

The ELITE CoP experts underlined the importance of knowledge regarding prevention and preparedness before the crisis takes place. This was a common problem in the local population.

Lack of knowledge in the population
Several experts argued that a major problem area was related to the lack of knowledge on prevention in the population. Some experts used the term “wrong culture”. One example explained by the experts was that some groups in the population believed that an earthquake was ‘God’s plan’ and therefore there was no need or purpose to prepare for an earthquake. This was related to vulnerability of historical buildings in Italy where little was done to strengthen the building structure. These buildings are often visited by a lot of people and are therefore important to strengthen.

In the workshop it was mentioned by experts that the older and historical buildings are often vulnerable in earthquakes. The earthquake in Spain in 2011 (Terremoto de Lorca, 11th of May 2011) 60 buildings regarded as cultural heritage were damaged. The damages cost more than 40 million euros (Sáenz de San Pedro Alba 2013).



Photographs from Terremoto de Lorca, 11th of May 2011 *(Photographs from Luis Sáenz de San Pedro Alba 2013)*.

Little focus on prevention and lack of self-protection in the population
It was critically highlighted by the experts that many people do not understand the 'value added' by prevention. Therefore national governments may have problems when allocating money for prevention. However, what happens in a crisis (the actions by the population, SAR teams and other actors) are dependent on what you have prepared in advance. The problem is that plans and preparations are not implemented within the population before a crisis. The population does not know how to react during an earthquake and how to follow instructions from crisis managers. The plan becomes just a piece of paper which has not been implemented in practice. The experts noted that this also relates to self-protection behavior, where people (especially those from small villages), do not know if their houses are safe, or what to do in the case of an earthquake. There is a lack of communication on what people and local societies can do themselves. Often self-protection behaviors are explained to school children, but not to adults.

Prevention - technical challenges implementing risk assessment
Another aspect is how building codes are formulated as it may be difficult to transform elements in the risk analysis into implemented laws or regulations. A problem that may arise is: What can one do when the performed risk assessment indicates that some buildings are in a risk zone? Should the authorities force owners to strengthen the buildings or should the authorities make the inhabitants move to buildings that are not in the risk zone? This is the same for zones in risk of floods or fires. Another aspect is that the building codes may be up to date and correct on paper, but the implementation may be difficult. Implementing building codes may be costly because it usually requires expensive building elements (solid steel).

5.1.3. Training experience

First responders lack experience with earthquakes
Several experts noted that there was a lack of training and experience with earthquakes among the first responders. One example was the Dutch responders who have not experienced any earthquakes as there have not been any previous earthquakes in the Netherlands. Unfortunately, responders who have firsthand experience and training are often moved to other jobs within the crisis management system. This means that the "current" professionals have little experience.

Lack of training and inside knowledge- population collaboration with SAR teams
Lack of preparation in the pre-crisis stage can result in shocked local "experts" and volunteers who hinder the SAR teams from acting effectively. Responders who come from another area (or another country) lack the inside- knowledge about the "terrain and field". Therefore the first

responders who come from “abroad” need to be rapidly integrated into the broader crisis management.

5.2 Crisis

5.2.1. Communication

The experts in the workshop focused on inter-agency communication as the main problem during the crisis. This is because the experts to a large extent were crisis managers with an operational focus/ hands-on approach. This section conveys some of the communication challenges the responders face during a crisis.

Inter-agency communication

Liaison communication
During a large scale crisis involving earthquakes one must often cooperate with the national military through a liaison. This can often become a challenge as the military have their own protocols and ways of doing things. Between European countries the type of cooperation between the civil (SAR) and military units varies. In some countries the rescue operations are claimed to be very good because of their tight cooperation with the military. The response force in France is an example where the SAR teams trained and worked closely together with the military. Many first responders had civil protection background. Some experts argued that working with the military improved the work discipline in the SAR team. In other countries the military was assigned one area in the disaster zone, while the civil entities worked independently in another area. In other words, there was little cooperation.

Inter-agency communication; media
The experts noted that a factor which complicates rescue operations can be the media. The media often gives a wrong image of how the rescue efforts are conducted. For example, the media are not allowed to go into the most dangerous areas where the rescue teams are at work. Therefore the affected areas accessible to journalists are not being helped by the response teams, because it is not the areas that are worst hit. In the media this is often angled as “little is being done”. Thus, the media may give a distorted image of what is happening which is spread to the broader population. Therefore people within the crisis management must use time and resources on focusing on pleasing the media instead of dealing with the crisis.

Inter-agency communication; government
During a crisis situation there is often a problem with the information flow between the different actors. The first responders in the ELITE workshop argued that it was especially complicated to communicate with the government (FEMA [12]) and the population. Some experts argued “politicians are not taking the right decisions at the right time, often they wait too long”. The experts believed that political leaders are often inexperienced when it comes to crisis and are not used to delegate issues to more experienced and trained people. Often it can become a political issue about *who* is actually responsible for the rescue operation. If the rescue operations goes well there are many people who wants to be responsible, however if the operation had weaknesses various blame games between actors can occur.

Inter-agency communication; researchers

[12] FEMA: Federal Emergency Management Agency.

Sharing of information concerning the earthquake, what it means to the population and the SAR teams working in the area, is necessary when assessing the situation. The experts noted however, that there are problems in the cooperation between researchers and the civil protection actors. The Civil protection agencies rely on information and details about the earthquake provided by researchers. This communication should be very efficient to avoid delays.

Inter-agency communication; responders' teams
As mentioned earlier there are language barriers between responders' teams. This becomes especially poignant in a crisis situation. This can be exemplified with technical gadgets that have different names. When tools needed to communicate with other agents are not available, it makes it even harder to cooperate efficiently.

Response plans must be physically available
In a crisis the power is often cut and computers may be damaged. If the response plans only are stored in computers and these are not available physically or digitally, then the external responders in the rescue teams do not have the information to act in a coordinated and planned manner. The experts argued that this was often the case.

Crisis communication

Inter-agency communication; population, reliance on new technology, smart phones
The experts argued that crisis communication to the population in the affected areas is important. It must be concise and not too much information as people are often stressed and therefore not able to follow long and complicated instructions. For example if people are moved to designated emergency areas there must be clear signs, and volunteers to aid them. Nowadays a lot of information is provided though social media like Facebook, twitter and webpages. This is a good way to spread information, however relying only on smartphones and internet may be dangerous. This is because in a crisis these tools can easily break down. Therefore many experts were skeptical towards heavy reliance on modern equipment that needs electricity and an internet connection.

Media support
One should also let journalists and representatives from the media take pictures and inform the journalists on the situation. The journalists should not have access to the zones where rescue work is done as they may pose a security risk.

5.2.2. Logistics

Cartography
The experts noted that in a crisis situation there is a lack of cartography on paper. This cartography is needed when people are being sent from the teams to observe and assess the impacts of the earthquake as well as accessing areas and finding alternative routes to the emergency area.

Reliance on internet and computers
If the internet connection breaks down the rescue teams often lack relevant documents, like the national emergency plans. If the documents are available digitally one often lacks printers to print and distribute the documents that are needed during the response.

Special radio channels

Good and constant communication is needed in a crisis. Cell phones, email might not work, therefore special radio channels are needed.

Transportation of equipment
The experts argued that when transporting equipment one often experience bureaucracy problems. In most cases one need planes in order to arrange for expertise, material and man power to arrive at the right spot. For example the polish responders were sent to Haiti, but their equipment stayed in Poland. Some of the experts argued that transporting equipment is more difficult than transporting people.

5.2.3. Risk Assessment

Welfare/safety for responders
One must have movement control and information regarding the status of tunnels, bridges and railways. This should be known before sending any rescue team to the worst hit areas. The security of the rescue teams is the main priority. The population might not understand that responders will not be sent until their safety is guaranteed. It would help if a risk assessment plan was made in advance. In other words, good and early risk assessments are needed.

Priority
In a crisis situation one must define the priorities of a mission. The experts argued that the question becomes "What are the most urgent tasks?" It also becomes a question of who should make these priorities and define the urgent needs. During a crisis one often lacks the information about who needs the most urgent help. Helicopters are usually needed for this purpose. After the first wave of first response has been sent a supply chain should be established, to go on sending what is needed for an effective response. This is difficult to plan as the earthquake and its secondary hazards may develop differently.

5.3 Post-crisis

In the post-crisis stage the main problem areas related to the responders and the local population. The topic of recovery for the local population will be discussed further in section 6.6.

5.3.1. Debrief

Few evaluations
Several experts noted that there is little focus on the recovery stage. When a crisis is over, many responders feel that their work is done. Many experts focus on the preparation phase, but one expert argued that one must focus on proper evaluations as lessons learned can be fed into changes that can be incorporated in the preparation. Lack of proper evaluations is a result of sensitivity. Admitting that something could have been done differently implies that someone could have done it better or did a mistake. Thus, many responders believe that owning mistakes and sharing lessons learned from an incident may become a career-ending decision. This is not a good environment to share experiences.

No debriefs
The responders often do not receive a debrief. Therefore lessons learned are not gathered nor implemented for the next time.

5.3.2. Recovery

A common problem area is the recovery from an earthquake for the local population. One of the CoP experts termed this "the forgotten phase". These are some of the main problems that the local population faces in the aftermath of a crisis.

Lack of continuity
After a crisis one must attempt to *recover* from the crisis situation and ensure a smooth and fast transition back to business-as-usual for the local population. The authorities must rebuild the infrastructure, but someone must identify the most critical infrastructure that is needed in the recovery phase. In many cases there are significant delays until economic help is received by the affected people. This is often due to bureaucracy. It is also within this context that organizations need funding in order to continue rebuilding critical infrastructure and help people. Budgetary restraints results in lack of continuity in the response and recovery efforts.

Stress management in population
The affected population has been through a stressful experience therefore Critical Incident Stress Management (CISM) must be used. Psychological support and debriefs are needed for those who have been in stressful places and environments. This is essential when attempting to go back to business as usual.

Involvement of local population
Several experts argued that response teams and the authorities must involve the local population in the pre-crisis phase and during the crisis. This will make it easier for the local population to participate in their own recovery. It creates a greater continuity as the local population can continue and rebuild critical infrastructure, as well as being kept busy and making the local population feel in charge of their own environment. Many argued that being able to recreate and rebuild one's own community after a crisis can become empowering for the people involved.

Emergency areas
The site where the emergency areas are located may have an impact on the recovery. In Italy the emergency areas was located in the football stadiums. This meant that it was difficult to go back to business as usual as the youth did not have any spaces where they could play football.

6. IDENTIFICATION OF POSSIBLE SOLUTIONS AND COMPILATION OF FINDINGS

The experts in the ELITE workshop identified possible solutions to the lessons learned addressed in chapter 5. The possible solutions are suggestions on how best to improve crisis management for the various challenges revealed in chapter 5. The possible solutions are divided into the major problem areas, rather than solutions in each phase of the crisis. This was done because the solutions to the problems often overlap the different phases of a crisis.

6.1 Communication

Inter-agency communication

Overcoming language barriers
Experts argued that the best way for responders and the crisis management to overcome challenges related to terminology is through practice and exercises. Through training one can increase cooperation, use model exercises and create a handbook with pictures of the equipment used. In a worst case scenario, responders who do not share any common language can use a handbook to convey what type of equipment is needed etc. The handbook will also explain different technical terms which will be illustrated with pictures. These tools should be created to overcome language barriers in situations where time is of essence.

English as an emergency language
Experts argued that one must find and use a common language within the emergency response community. English was considered to be the best option. It was argued that people within the crisis management must be able to speak English fluently or else this may damage the effectiveness of the operation. At least one person in the response team must be able to speak English, is not necessary that all members speaks English as the specific tasks in a search and rescue operation will always be the same even though it is in different countries.

Promoting a common understanding/approach
The experts noted how one must promote a common understanding relating to behaviour of actors within the crisis management; there are for example cultural differences in regards to leadership between countries. Also titles, like the position of a Liaison officer may entail different things between the European countries. One needs to have common guidelines and descriptions of what this position entails in practice. At the moment the United Nations Disaster Assessment and Coordination (UNDAC) handbook has some common guidelines.

Promoting a common approach
The experts argued that agreeing on common objectives between different teams in a crisis can be rather vague, it is better to agree on a common approach/tool in the operations. This is much more practical and useful for the teams.

Communication plans
In order to overcome inter-agency communication difficulties the experts argued that one should have a previously defined communication plan. This plan should have clearly defined communication flows. Each flow should have a specific topic/content. One person should be responsible for each communication flow and level. One must also identify the best channel for each information flow; radio, web etc. It is of outmost importance to speak as simple, understandable and as short as possible. These “communication protocols” should be

established in advance to be effective during the crisis. Through training and exercises the responders can improve the protocols and language.

Local knowledge needed when localizing waiting/emergency areas
One must have planned beforehand where the emergency areas are to be located. Territorial knowledge and awareness of secondary risks is required. For example, an emergency waiting area should not be located in an area prone to landslides etc. One must take into account the culture of the population (the habits of the population- for example using football stadiums for waiting areas can have a negative impact in the recovery phase).

Communication technology
During operations and in a crisis the experts noted that one must use advanced radio technology. Devices like zeppelins could provide the needed infrastructure to maintain communication, even in the absence of internet or mobile phones. Several experts expressed that they were worried because of the increasing dependence on smartphones. Smartphones are based on a fragile system. Therefore the experts wanted to have some physical and less fragile systems; like metal signs for meeting points for families and victims in emergency situations. In other words, one must balance technical solutions and solutions in an alternative system if the system breaks down. Other experts noted that one should to a greater extent use the local networks and communication channels in the affected population; they communicate better and easier.

National authorities are always responsible and in charge
One must remember that national authorities in country hit by a disaster are always responsible. The MIC[13] in Brussels must obtain technical information from the affected country, as well as information concerning what they need from the European community.

Crisis communication

Communication to the population
One should establish three groups in the crisis management that specifically deal with communication: (1) actors who communicate with first responders, (2) actors who communicate and informs the affected community, and (3) actors who deal specifically with the media. In the pre-crisis stage one must provide information to the community. This will improve the overall knowledge in the population. Especially informing and involving children in schools can be helpful. If awareness campaigns take place before a crisis, the children may somehow be better prepared for a crisis. Activating children has been a useful approach in Italy. Children at all ages work with earthquake related problems. One example is information campaigns on waiting areas[14]. Through this practical approach, putting the children in charge, children will learn and understand how to behave and where to go after an earthquake. This information will be spread to their families. This will be explored further in section 7.1. Some experts argued that one must not only focus on children, general information campaigns are also necessary.

Organization of communication to the population
First responders should first provide help and then provide information to the habitants. The affected area can be divided in zones and each zone is assigned to one volunteer who is responsible to provide information to population.

[13] MIC: Monitoring and Information Centre.

[14] A summary of the project can be accessed through this link: http://cms.provincia.terni.it/online/Home/Areetematiche/Protezionecivile/articolo7824.html.

6.2 Training

Training of volunteers using Web Geographical Information Systems (GIS)
It is important to train the local volunteers about what they should do and where to go in case of an earthquake by using WebGIS solutions. This solution is also used during the crisis to inform the population about the current status of the crisis. Social media can also be effective for this purpose.

Team competitions
In order to motivate the volunteers and responders one can develop competitions that challenge teams to improve their performance. At the same time this is a great training opportunity. Training related to earthquakes is also useful in the case of a fire. An example is coordinating evacuation plans.

Field training and international exercises
More field training is needed, especially in the case of European countries close to borders (Italy-Austria-Slovenia). These countries should take part in international exercises. Therefore international and field exercises must be developed for this purpose.

Training through multimedia
Through multimedia features one can use visual training tools, such as videos on YouTube. For example a video about "how to evacuate a building", "how to…", (see link http://www.youtube.com/watch?v=UuTowptYlrM).

Self-protection
Train and educate intervention teams and volunteers on self-protection measures.

Debrief
Improve the debriefing, or lessons learned from the implementation process. This is essential to improve the methods and approach for the next rescue effort. All actors who took part in the response team should be included and encouraged to share their story and views on the operation.

Exchanging lessons learned and best practices
Rescue teams should exchange information in order to improve their performance. F.ex methods of how firefighters could get access into buildings if the buildings were collapsed due to an earthquake (or a fire).

6.3 Logistics & Equipment

Excess communication lines
One should have excess/redundant communication lines in order to guarantee free communication lines during the crisis.

Creating a minimum standard on equipment
One should create minimum standards on the equipment used in operations. This is to improve the cooperation. Teams in the same countries, but from different towns, have equipment that may be incompatible.

Self-sufficiency
The teams should improve their self-sufficiency. For example the NORSAR teams bring 10 days of water and food.

Standardized agreements
In order to overcome bureaucracy and use time efficiently one should develop standardization agreements, similar to the Standardization Agreements (STANAG) developed by NATO for cross border assistance.

Training for logistics
It is important to improve training and have more exercises for logistics staff.

Updated contact lists
The experts noted that one should have an updated contact list of trucks and drivers in the response team. In an emergency one can therefore call directly to the drivers so they can be alerted very rapidly. If they receive a call at midnight they are forced to help, but they know they will be paid for this.

Improve transport procedures
In order to reduce the bureaucracy and time in an emergency situation one must improve the procedures related to transport. For example one should avoid paying taxes on equipment entering a country hit by a disaster or that sniffer dogs that are needed in the operations are forced to be in quarantine before being accepted in a country.

6.4 Risk assessment and Early Warning Systems

Improve the building codes and control
Risk assessments need to be frequently overviewed in order to be up to date if a crisis is to occur. If one identifies risks one should translate it into implemented measures. However, there are certain challenges. Regarding building vulnerability there are already, in most places, rules for construction. Yet, it must be controlled by the authorities during the construction. In some instances steel is not used in the constructions because it costs money. Therefore one must improve the regulation (seismic code) and the control of its application, this is especially important for buildings in seismic zones. Yet, there is a great uncertainty as the earthquake can affect two similar neighbor buildings in a very different way. Therefore experts should analyze what happened with the infrastructures after the earthquake and take this into account for the next event. Developing Earthquake early warning systems is necessary as researchers can rapidly detect an ongoing earthquake and broadcast a warning in the target area, before the arrival of the destructive waves (Zollo et al. 2014 in the REAKT project). REAKT is an ongoing EU project that works with this topic, and aims to define strategies and tools for real time earthquake risk reduction (REAKT 2014).

Private buildings in risk zones should be reinforced/strengthened
Some of the private buildings in risk zones should be reinforced to be resilient to an earthquake. Unfortunately, people are not aware of the risk and therefore invest in other things such as new cars, or solar panels to generate electricity. Awareness campaigns are therefore needed.

6.5 Debrief

Plan debrief procedures beforehand
One should have a standardized debrief plan before the event occurs. Several experts noted that debriefs after an operation is often lacking. This must be conducted more systematically in order to improve the implementation of lessons learned. After a crisis one should revise the risk analysis.

6.6 Recovery

Improve rebuilding management
In order for the population to rapidly return to business as usual one need to rebuild critical infrastructure. One should improve the rebuilding management by having previously identified who should take part in the recovery phase. The actors involved in this work are civil engineers, or companies (for example electric companies).

Recovery plans
One should develop recovery plans beforehand that can be followed in the recovery phase. The plan should include rebuilding infrastructure such as electricity, motorways, health clinics and schools (etc.).

No building in risk zones
Government and local authorities are responsible in any crisis, but can get help from the international community. In the recovery phase the authorities should avoid rebuilding official buildings (especially spaces where people gather) in risky places. This cautionary approach should also be promoted for private buildings.

Critical incident stress management (CISM)
CISM must be conducted in the population after an incident has occurred. CISM is a short-term psychological helping-process for the affected population. The purpose of CISM is to enable people to return to their daily routine more quickly. This aids the recovery process. By conducting CISM one can attempt to decrease the likelihood for members of the population to experience post-traumatic stress disorder.

6.7 Compilation of results

A compilation table with the main lessons learned (categorized in problem areas) for each crisis phase and potential solutions have been created on the basis of primary data gathered from the ELITE CoP workshop (table 1).

Problem areas	(1) Pre-crisis	(2) during a crisis	(3) post-crisis	Solutions
Communication ***Inter-agency communication***	→ Lack of common terminology and language barriers between teams → Lack of communication on technical details on the earthquake between levels within the crisis management → Strategies and plans are not suited to the terrain affected by an earthquake due to little local knowledge of the terrain among the strategists.	→ Liaison communication is difficult due to different protocols and methods → Politicians are not taking the right decisions at the right time →The media often distort the image of what is happening during a crisis → Little information sharing between researchers and the civil protection actors → Language barriers between teams → National response plans are often not physically available for SAR teams		→Create a handbook with pictures of the equipment used →English as an emergency language →More international training exercises → Common guidelines and descriptions of what titles and positions entail →Local knowledge used when localizing waiting areas →Robust technology- metal signs etc. → Previously defined communication plans →Promote a common approach and focus on the tools rather than vague goals →National authorities are always in charge
Communication ***Crisis communication***	→Risk communication on waiting areas for the population must be done effectively	→Reliance on new information technology based on a fragile system (i.e. smart phones etc.). →The media can pose a security risk		→Coherent and effective communication to population (f. ex through information campaigns) →Volunteers organized to give information to population
Knowledge	→Little knowledge in the population due to "wrong culture" → Technical challenges implementing risk assessment, like building codes →Lack of knowledge on self-protection in the population → Parts of the population do not understand the 'value added' by prevention →Lack of knowledge in population and have not learned how to be "guided"			
Training	→ First responders have little experience with earthquakes →Lack of training and inside knowledge among the volunteers collaborating with SAR			→Training of volunteers using WebGIS →Team competitions for rescue teams →Field training and international exercises →Training through multimedia →Self-protection among responding teams →Debrief →Exchanging lessons learned and best practices

Problem areas	(1) Pre-crisis	(2) during a crisis	(3) post-crisis	Solutions
Logistics		→Lack of cartography on paper → Heavy reliance on internet and computers in the SAR teams →Special radio channels are needed by the SAR teams →Bureaucracy problem in transporting equipment		→Excess communication lines →Creating a minimum standard on equipment →Self-sufficiency for SAR teams →Standardized agreements →Training for logistics →Updated contact lists in the rescue teams →Improve transport procedures
Risk Assessment		→Welfare/safety for responders →Difficulties with prioritization in the SAR teams, who make the shots?		→Improve and adhere to safe building codes →Recovery plans →Private buildings in risk zones should be reinforced →Improve rebuilding management →No building in risky zones
Debrief			→Few evaluations of response efforts →No debriefs within the teams	→Plan debrief procedures beforehand
Recovery			→Lack of continuity → Less funding in recovery stage → Media attention can shape the priorities →Emergency areas must be located in such a way that one can get back to business as usual fast →Stress management in population needed → Involvement of local population in recovery	→Stress management (CISM) in the population

Table 1: Compilation table of lessons learned divided in the three phases of a crisis

7. LESSONS LEARNED AND BEST PRACTISES RELATED TO ACTORS

Findings from chapter 5 and 6 are compiled in this chapter. The compilation includes primary data gathered from the ELITE CoP workshop. The secondary literature includes lessons learned reports from humanitarian organizations as well as best practices from local communities who have experienced earthquakes. In order to find best practices semi-structured interviews were conducted with two experts[15] (first responder/fire fighter and a representative from a NGO) to supply and verify the primary data gathered through the workshop. The information gathered through interviews will not be referred to explicitly. However, the findings are incorporated into the text.

After the workshop and interviews it became apparent that there are some main actors who play a major role in a crisis situation like an earthquake; (1) the population, (2) the rescue teams, and (3) national authorities. Therefore, tangible lessons learned and best practices are in this chapter categorized after the main actors involved. The two last sections include topics that are crosscutting and contain *Recovery-'the forgotten stage'* and the *importance of learning and creating lessons learned*.

7.1 The local population: Safety measures and help to self-help

Earthquakes are sudden onset disasters; therefore in the affected areas the first people there will be the local population. The affected communities will therefore play a paramount role as first responders after an earthquake. "The majority of life-saving work in any disaster is done by populations themselves" (IRIN ND). Earthquake-preparedness in the local population is needed in order to improve "awareness, mitigation and strengthening capacities for first response at the community level" (IFRC 2012). Involving and aiding the population to "help themselves" is vital in this context. During the recovery phase a strong and active community can become empowered building up their own local communities. A community-led response keeps the community active which means that people can work though their hardship. Training and creating awareness of risks among the local population is therefore necessary and vital. However, the experts argued that a lot of the equipment used by SAR teams is technical and "using just a shovel will not help". Therefore one must build up the countries' resources and increase the general knowledge in the population.

A best practice regarding awareness campaigns targeting children and their families is found in Italy. School children create informational campaigns regarding earthquakes (a brochure and a TV commercial that will air on local stations). In the process the school children are becoming aware of the secondary risks triggered by earthquakes, and the children can further inform their families. This exercise can therefore create awareness of risks which the local community is exposed to. Another example of a best practice regarding crisis communication is the new web-page made by ANCI Umbria targeting children under 10. This page can be accessed here: http://www.allalargadaipericoli.it/.

7.2 Rescue teams: Communication and coordination

In a large natural disaster there will be several humanitarian and emergency actors that will arrive at the same time in the country affected. There is often tension between humanitarian

[15] The experts include the head of the Emergency Response Department in the Norwegian Refugee Council and a Brigade Commander at the Agency for Fire and Rescue Services in the City of Oslo, Norway.

actors versus the emergency SAR teams as they have to fight for the same limited resources (like trucks from the airport to the accident site). The humanitarian and emergency actors often have different priorities; the humanitarian actors want to provide food and water to the population, while the SAR teams wants to use all the resources to be able to save as many as possible from the ruins.

Effective coordination of the rescue efforts is dependent on having a professional coordinating team at the airport in the affected country. The first team that arrives often takes the coordinating role until a professional EU or UN team arrives at the scene. The faster a professional coordinating team arrives, and the other teams follow the professional team's instructions, the better the rescue efforts will be.

Establishing tighter coordination in the pre-crisis stage
NRC, IOM (international Organization of Migration) and UNHCR (UN High Commissioner for Refugees) worked together in Haiti, NRC assisted in locating safe places where emergency tent camps could be set up. These three organizations worked effectively together and after the experience of Haiti, they developed tighter cooperation. This conveys how better coordination and communication between international organizations can ensure a better response.

Special agreements made before crisis
Countries prone to natural disasters should make specialized agreements with international humanitarian organizations before a crisis takes place. This must be done to overcome bureaucracy relating to customs etc. International organizations should also have specialized teams beforehand that are suited for the tasks.

Overcoming the language barrier
NRC only sends people abroad who master the local languages. For example, most of the NRC people who were sent to Syria speak Arabic and Persian.

7.2.1. Emergency actors must be aware of the local context

Some actors argued that it would be easier if FEMA would not interfere as much in the rescue efforts as the emergency actors speak the same language, use the same terms and think alike. However, FEMA's in various countries act differently. It became clear that the emergency actors wanted to be briefed concerning the country and the context in which the crisis has happened. This is to be prepared on how FEMA may handle the crisis.

Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP 2008) underlines that one must be aware that an earthquake will affect the groups of the population differently. The rich often have reserves that enable them to recover more quickly, and the poor have far more limited reserves (ALNAP 2008). According to Tearfund (2005 cited in ALNAP 2008) **"**Every disaster widens the gap between rich and poor (in setting policies, reconstruction and restoring services all lead to asset erosion". ALNAP argues that "given this tendency of disasters to increase inequalities, it is vital that agencies pay attention to issues of social protection and economic recovery".

IRIN notes that responders must remember that recovery operations are not neutral; "They will reinforce or reduce existing inequalities and must be actively designed to do the latter". When responders' listens to the recipients in order to make sure the assistance is appropriate one must also ensure that the recipients present must reflect the broader community, and not just the elite. One should give voice to women who often represent the interests of their children and the old. Social awareness of cultural codes among international rescue teams is important.

In the post-crisis on must remember that livelihoods are key to recovery. One must therefore listen to affected populations about their priorities for livelihood recovery (IRIN ND). Also one should give cash and buy locally wherever possible.

A lessons learned by IRIN (ND) is that authorities should not overstate the risk of disease as this leads to misallocation of resources. According to research "Only three out of 600 geophysical disasters led to disease epidemics" (published in the Emerging Infectious Diseases Journal). How to handle the dead after the earthquake is important as the real risk posed by dead bodies after natural disasters is mental illness caused by shock and grief among the survivors. Restoring family bonds is essential in order to recover and return to normalcy. Psychosocial problems must be dealt with and several teams have people working focusing especially on this.

7.2.2. The importance of partnering with local actors

In any disaster the initial golden period of 72-hours must be used effectively in order to have an effective rescue operation. The authorities should therefore prior to the occurrence of earthquake pre-arrange mutual-aid plans both locally and internationally. Local partners are especially important as they are on site. In the pre-crisis phase one should engage and strengthen partnerships "with all actors who could be part of future earthquake response or recovery operations" (IFRC 2012:18). Relevant actors include non-governmental organizations (NGOs), representatives from government ministries at different levels, representatives of United Nations agencies, companies from the private sector and academic institutions.

7.3 National authorities: Responsibility and coordination

It is the national authorities in the affected country that is responsible for informing the international community of what is needed of assistance in case of an earthquake. However, sometimes the affected country is overwhelmed by the disaster. The country may lack information from the affected area and is therefore not able to formulate clear requests of assistance or whether assistance is needed at all. Countries may also lack knowledge of the available international capacity and not be aware of the procedures to coordinate international assets, tools and procedures.

The role of the Office for the Coordination of Humanitarian Affairs (OCHA) is to prepare countries to improve the speed and quality of request for international assistance in major disasters, as well as to make optimal use of internationally available assets. OCHA also assists disaster-prone countries in assessing and evaluating the extent of their preparedness to cope with major disasters that require international assistance (Peter 2005).

7.3.1. The importance of building codes

It is also the responsibility of the national authorities to control that buildings follow the building codes. The building code in every country can be regarded as a living document. This implies that one must have periodical reviews and update the codes to best reflect current regional and local site seismicity, structural earthquake performance and the latest design and technology (Lo and Wang 2012).

Therefore one must as soon as possible incorporate new findings regarding f. ex. the seismic hazard in a specific area into the building codes. This should be implemented and controlled, yet there is flexibility of whether existing buildings must be demolished and then rebuilt. However, buildings like hospitals, schools and emergency-response facilities which are located

in risky areas (i.e. weak subsoils prone to liquefaction, tsunami vulnerable zone, or site subject to geologic hazard such as landslides, rock falls, etc.), “should be relocated or retrofitted to meet the requirement of maintaining their function after an earthquake” (Lo and Wang 2012).

Other buildings that can be regarded as ‘critical facilities’, i.e. factories containing hazardous materials, or facilities with high occupancies, or power generation/distribution and telecommunication facilities, should be designed and maintained at a higher seismic level.

7.3.2. Smoother interaction between international actors and FEMA

Interlocutors between the national government and international organizations
NRC (Norwegian Refugee Council) sends out interlocutors when the national government is in need of advice and guidance when a natural disaster has occurred. Interlocutors are someone who informally explains the views of a government and also can relay messages back to the government. This is done to overcome the challenge of coordination between the national authorities and the international community. With informal assistance the national authorities can take decisions faster in situations where time is essential. The interlocutors help the national decision makers to prioritize.

The importance of training national assessment teams
Assessing the extent of the crisis and what areas and activities should be prioritized is vital in an earthquake. NRC has been training continuously national assessment teams. An example is from Bangladesh where the NRC noted that policymakers with help from the national assessment teams took faster and smarter decisions. The policy makers’ prioritization matched the international experts’ opinion. This made it easier for all actors to begin tackling the crisis, instead of discussing what one should prioritize. This was used as an example by the respondent of the importance of training national assessment teams that can provide the essential information needed to overcome leadership problems and lack of knowledge.

7.3.3. Mapping of risks and early warning systems

Plans for mitigation and risk-reduction efforts for earthquakes must be coupled with preparedness and early warning for secondary hazards such as tsunamis and large scale fires. The complexity and chaotic nature of earthquakes requires planning and preparedness.

Therefore one should in the pre-crisis stage map zones at risk of earthquakes at the national level. This should include fault lines and settlements situated on or near these areas. This preventative exercise helps to increase awareness in the settlements in risk zones, as well as governments and other stakeholders. However, one must also map possible secondary hazards that may be triggered by the earthquake. For example if a settlement localized on a fault line along the coast a tsunami can be a secondary hazard. If the settlement is close to a dam, the earthquake may burst the dam construction causing floods. Or if the settlement is located in a valley a landslide can be triggered by an earthquake. These secondary hazards should also be mapped and the local population should be aware and prepared for different emergency scenarios.

7.4 Recovery: The forgotten phase

Through the workshop exercise it became clear that most problems were associated with the pre-crisis stage and during the crisis. One expert noted that this is a general problem; one tends to forget the recovery stage. International rescue teams focus on relief, but forget the recovery. Recovery takes time and when the media attention from the international community wears off this can affect the continuity of the projects. This is often tightly linked with budgetary restraints

among the rescue teams and humanitarian organizations. Several experts noted that responders forgot the vital role that the local population plays in the recovery phase. Several reports highlight the importance of involving the local population, helping them to help themselves. Local communities participating in their own recovery can experience empowerment in a situation where people often experience apprehension and powerlessness.

Long term recovery
NRC underlines the importance of having long term strategies in countries that are prone to natural disasters. NRC sends experts who work with the government and other relevant sectors to prepare for potential disasters. For example, in Ethiopia one has managed to include disaster modules into the curriculum at universities. The result is that students who may gain important leadership positions have knowledge of how to handle disasters. The long term strategy includes the involvement of stakeholders and feedback on what it is useful etc. The importance of a continuous dialogue is stressed by NRC.

Short term solutions should be transitional solutions
Response teams who are building emergency shelters must not neglect the importance of permanent shelter for the population. The reason is that many short term solutions become permanent (especially in developing countries). IRIN (ND) argued that a lesson learned is to build "transitional shelters" that can be turned into permanent dwellings.

7.5 The importance of learning and creating lessons learned

Learning is not something that only happens after a crisis. Experts noted that when one is deployed and in the field one will always talk together in the teams on challenges, lessons learned and how one can do things better the next day.

After each exercise or natural disaster the team leader involved in the mission or exercise, must write a report that will be sent to MIC. The problem is whether these reports which include lessons learned and best practices are being used and incorporated into regulations and guidelines made by MIC. After each incident/exercise MIC will receive reports from all the teams involved. This can be over 20 teams, in other words over 20 reports.

Yet, one must be careful when one is evaluating the international exercises. FEMA's in different countries can behave differently to critical comments. Some experts noted therefore that one was not able to be frank and state the various weaknesses in the exercise. This defeats the purpose of evaluating and the ability to learn if one must withhold critical comments.

Revising the manual after each crisis
After each crisis the NRC field personnel sends lessons learned to the NRC headquarter. The lessons learned and best practices are incorporated into the manual. After each crisis the manual gets revised and includes new important and practical information. It was noted that most manuals and guidelines are too detailed and is not very useful in the field because you can only do 60% of everything is noted in the elaborate guidelines. Therefore practical manuals that are continuously being updated after each crisis can be regarded as a best practice.
Experts noted the need for international exercises. Several, big international exercises should be a requirement before emergency actors are sent into the field. This should also include lessons learned seminars. The expert argued that the representatives in the coordination teams in EU and UNDAC was able to cooperate better because of the courses they had taken together.

8. SUMMARY AND CONCLUSIONS

This report has *gathered and systematized knowledge on earthquakes* based on information from experts in the ELITE CoP, through literature reviews and interviews. Different key terms related to earthquakes were described, and seismic risk and earthquake hazards in Europe were explored. Recent earthquakes in Italy, L'Aquila (2009) and Emilia (2012) were referred to and certain problem areas were identified.

The most *relevant lessons learned related to earthquakes* were identified through the ELITE workshop in June 2013, and they were categorized according to the different phases of a crisis and in the most significant problem areas:

Pre-crisis; Communication (Inter-agency communication and Crisis communication), Knowledge and Training experience.

Crisis; Communication (Inter-agency Communication and Crisis communication), Logistics and Risk assessment.

Post-crisis; Lack of debrief and problems related to the recovery stage for the local population.

Through the workshops and interviews possible solutions to the lessons learned were also identified. These solutions related to the bigger problem areas; *Solutions to inter-agency communication problems*, *Risk assessment and Early Warning Systems*, *Training, Logistics & Equipment*, *Debrief* and *Recovery.* Finally, lessons learned and best practices from the ELITE CoP workshop, interviews and primary/secondary literature were systematized into categories related to actors. A compilation table of the main problem areas for each crisis phase with solutions to the problems was presented.

Some of the main lessons learned, best practices, possible solutions or suggestions for improvement are selected and summarized in the lessons learned table below (table 2).

Problem areas for lessons learned	Lesson learned	Source
Communication; Communication to the population	To improve the communication to the population the crisis managers should establish three groups that specifically deal with communication: (i) actors who communicate with first responders, (ii) actors who communicate and informs the affected community, and (iii) actors who deal specifically with the media. It is of outmost importance to speak as simple, understandable and as short as possible.	COP
Communication; Communication to the population	In the pre-crisis stage emergency and preparedness organizations must provide information to the community which will improve the overall knowledge in the population. Also informing/involving school children in awareness raising campaigns is useful.	COP
Communication; Inter-agency	Crisis managers and the response teams must overcome the language barriers through (i) practice and exercises which increases cooperation, (ii) use model exercises and create a handbook with pictures of the equipment used and different technical terms which will be illustrated with pictures, and (iii) using English as an emergency	COP

	language (at least one person in the response team must be able to speak English).	
Communication; Inter-agency	Promoting a common understanding/approach by using common guidelines and descriptions of what different positions (especially leader positions) entail in practice.	COP
Communication; Inter-agency	International emergency organizations should establish tighter coordination in the pre-crisis stage which will ensure a better response.	Interview 2013
Communication; Strategic level	Countries prone to natural disasters should make specialized agreements with international humanitarian organizations before a crisis takes place. This must be done to overcome bureaucracy relating to customs etc. International organizations should also have specialized teams beforehand that are suited for the tasks.	Interview 2013
Communication; Inter-agency	To overcome inter-agency communication challenges crisis managers should have a previously defined communication plans. This plan should include; (i) clearly defined communication flows with specific topic/content, (ii) one person should be responsible for each communication flow and level, (iii) identification of the best channel for each information flow; radio, web etc.	COP
Communication	Response plans must be physically available and not only stored in computers, because in earthquakes the power is often cut and computers may be damaged.	COP
Communication; media	The crisis managers should inform the journalists on the situation; however, journalists should not have access to the zones where rescue work is done as they may pose a security risk.	COP
Communication; local knowledge	Local knowledge needed when localizing waiting/emergency areas.	COP
Training; volunteers	Local volunteers must be trained to use Web Geographical Information Systems (GIS).	COP
Training; volunteers	Team competitions can be used to motivate volunteers and responders and to improve their performance.	COP
Training	More field training and international exercises are needed.	COP
Training	Through multimedia features responders can train by watching informative videos on YouTube about “how to evacuate a building” etc.	COP
Training	Train and educate intervention teams and volunteers on self-protection measures.	COP
Training	Improve the debriefing, or lessons learned from the implementation process. This is essential to improve the methods and approach for the next rescue effort.	COP
Training	Rescue teams should exchange information on lessons learned and best practices in order to improve their performance.	COP
Knowledge	The local population must obtain more knowledge regarding the ‘value added’ by prevention and preparedness before the crisis takes place. This can be done through awareness raising campaigns on self-protection behaviour.	COP
Logistics	Having excess communication lines to guarantee free communication lines during the crisis	COP
Logistics	Creating a minimum standard on equipment and making the	COP

	equipment compatible between countries used in operations is important to improve cooperation.	
Logistics	The responding teams should improve their self-sufficiency. For example the NORSAR teams bring 10 days of water and food.	Interview 2013
Logistics	Develop standardization agreements, similar to the Standardization Agreements (STANAG) in NATO for cross border assistance to increase the effectiveness for the operation.	COP
Logistics	It is important to improve training and have more exercises for logistics staff.	COP
Logistics	Updated contact list of trucks and drivers in the response team so that the responders can call/alert the drivers.	COP
Logistics	Improve transport procedures to avoid paying taxes on equipment or having sniffer dogs in quarantine.	COP
Logistics	The teams must have (i) cartography on paper, (ii) access to national emergency plans on paper, (iii) special radio channels for communication, (iv) proper transportation of equipment.	COP
Logistics	Developing Earthquake early warning systems is necessary as researchers can rapidly detect an on-going earthquake and broadcast a warning in the target area, before the arrival of the destructive waves	REAKT 2014; Zollo et al.
Risk assessment	Risk assessments and building codes need to be frequently overviewed and controlled in order to be up to date and implemented in practice.	COP
Risk assessment	Private buildings in risk zones should be reinforced to be resilient to an earthquake- awareness campaigns are needed to convince the local population to invest more money in prevention.	COP
Risk assessment	Movement control and information regarding the status of tunnels, bridges and railways is important to know before sending any rescue team to the worst hit area (Welfare/safety for responders)	COP
Debrief	Have a standardized debrief plan before the event occurs.	COP
Debrief	Have evaluations where lessons learned can be fed into changes the preparation and emergency plans.	COP
Recovery	Improve rebuilding management of critical infrastructure by identifying who should take part in the recovery phase in a 'recovery plan' before the crisis has taken place.	COP
Recovery	In the recovery phase the authorities should avoid rebuilding official buildings (especially spaces where people gather) in risky places. This cautionary approach should also be promoted for private buildings.	COP
Recovery	*Critical incident stress management (CISM) in the population.* Psychosocial problems must be dealt with and several teams have people working focusing especially on this.	IRIN (ND)
Recovery	Do not overstate the risk of disease from dead bodies after an earthquake as this leads to misallocation of resources. The real risk posed by dead bodies after natural disasters are mental illness caused by shock and grief among the survivors.	IRIN (ND)
Recovery	Restoring family bonds is essential in order to recover and return to normalcy.	IRIN (ND)
Recovery	Involve the local population in rebuilding critical infrastructures as it promotes greater continuity, the local population will be kept busy	IRIN (ND)

	and feel in charge of their own environment.	
Recovery; partnering with local actors	Pre-arrange mutual-aid plans locally as local partners are on site and could be part of future earthquake response or recovery operations	IFRC 2012

Table 2: Summary of relevant lessons learned gathered from the ELITE CoP

BIBLIOGRAPHY

ALNAP (2008). *Responding to earthquakes 2008- Learning from earthquake relief and recovery operations*. Last visited 16.09.2013

www.alnap.org/pool/files/ALNAPLessons**Earthquakes**.pdf

Amato A., Galli P. and M. Mucciarelli (2011). *Introducing the special issue on the 2009 L'Aquila earthquake*. Bollettino di Geofisica Teorica ed Applicata, Vol. 52, n.3, pp. 357-365, DOI 10.4430/bgta0033.

Boin, Arjen, Paul `t Hart, Eric Stern and Bengt Sundelius (2005). *The Politics of Crisis Management. Public Leadership under Pressure*. Cambridge: Cambridge University Press

Bormann, P. (Ed.) (2012). *New Manual of Seismological Observatory Practice* (NMSOP-2), IASPEI, GFZ German Research Centre for Geosciences, Potsdam; http://nmsop.gfz-potsdam.de; DOI: 10.2312/GFZ.NMSOP-2, urn:nbn:de:kobv:b103-NMSOP-2.

Braga F., Manfredi V., Masi A., Salvatori A., Vona M. (2011). *Performance of non-structural elements in RC buildings during the L'Aquila, 2009 earthquake,* Bulletin of Earthquake Engineering, Vol. 9, N. 1, 307-324.

Bryman, Allan (2004). *Social Research Methods*. Oxford: Oxford University Press.

Dolce, M. (1996). *Seismic Vulnerability Evaluation and Damage Scenarios*. US – Italian Workshop Seismic Evaluation and Retrofit. Columbia University, New York City.

Dolce M., Kappos A.J., Masi A., Penelis G., Vona M., 2006. *Vulnerability assessment and earthquake scenarios of the building stock of Potenza (Southern Italy) using the Italian and Greek methodologies,* Engineering Structures, Vol. 28, pp. 357-371, 2006.

Encyclopedia of Solid Earth Geophysics (2011). Gupta, Harsh K. (Ed.), 2011, XXXVIII, 1539 p. 821 illus., 399 illus. in color. ISBN 978-90-481-8701-0.

EU (2012). *The European civil protection training programme.* Last visited 07.06.2013
http://ssai.interno.it/download/allegati1/training_brochure.pdf

FLASH (2013). *Storm struck a tale of two houses*. Last visited 15.08.2013
http://www.stormstruck.org/

Ganas A., Roumelioti Z. and Chousianitis K. (2012). *Static stress transfer from the May 20, 2012, M 6.1 Emilia-Romagna (northern Italy) earthquake using a co-seismic slip distribution model*. Annals of Geophysics, 55, 4, 2012; doi: 10.4401/ag-6176.

Hellevik, Ottar (2002). *Forskningsmetode i sosiologi og statsvitenskap*. Oslo: Universitetsforlaget (in Norwegian).

Hernantes, Josune (2013). *Community of Practises*. Presentation at 1st ELITE Workshop, Weeze, Germany, April 16th.

International federation of Red Cross and Red Crescent societies (2012). *Earthquakes: Guidelines on preparing responding and recovery*. Published by IFRC.

IPCC (2012). Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. 582 pp. Cambridge: Cambridge University Press.

Irin (ND). *DISASTERS: 30 earthquakes, 28 lessons learned*. Last visited 31.07.2013
http://www.irinnews.org/report/87825/disasters-30-earthquakes-28-lessons-learned

Kepka, Pawel (2013). *Operation Rudy*. Presentation at 1st ELITE Workshop, Weeze, Germany, April 16th.

Lay T. and T.C. Wallace. (1995) *Modern Global Seismology*, Academic Press, pp. 521.

Lo, Robert C. and Wang, Yumei (2012). *Lessons Learned from Recent Earthquakes – Geoscience and Geotechnical Perspectives*. Last visited 31.07.2013
http://cdn.intechopen.com/pdfs/28211/InTech-Lessons_learned_from_recent_earthquakes_geoscience_and_geotechnical_perspectives.pdf

Lupoi G., Franchin P., Lupoi A., Pinto P.E., Calvi G.M. (2008). *Probabilistic Seismic Assessment for Hospitals and Complex-Social Systems*. Research Report Rose 2008/02.

Maal, Maren and Grunnan, Tonje (2013). *Forest fires lessons learned report*. Deliverable D4.2. ELITE project. FP7-SEC. Contract no. 312497.

Masi A., Vona M. and Mucciarelli M. (2011). *Selection of natural and synthetic accelerograms for seismic vulnerability studies on RC frames*. Journal of Structural Engineering, 137(3): 367-378.

Masi A., Santarsiero G., Gallipoli M.R., Mucciarelli M., Manfredi V., Dusi A., Stabile T.A. (2013). *Performance of the health facilities during the 2012 Emilia (Italy) earthquake and analysis of the Mirandola Hospital case study*, Bulletin of Earthquake Engineering (accepted for publication).

Otani, Shunsuke (ND). *Lessons Learned From Past Earthquakes*. Last visited 31.07.2013
<http://www.rcs.arch.t.u-tokyo.ac.jp/otani/Turk_EE97.pdf>

Politiet (2011*). PBS I POLITIETS Beredskapssystem DEL I - Retningslinjer for politiets beredskap*. Last visited 16.09.2013.

https://www.politi.no/vedlegg/rapport/Vedlegg_1660.pdf

Peter, Thomas (2005). *Capacity Building for Disaster Response - OCHA Perspective*. Last visited 15.08.2013
http://www.unisdr.org/2005/wcdr/thematic-sessions/presentations/session5-3/ocha.pdf

Price, H.J., De Sortis, A., Schotanus M., 2012. *Performance of the San Salvatore Regional Hospital in the 2009 L'Aquila Earthquake*. Earthquake Spectra, Vol. 28, pp. 239-256.

RAND (no date). *A broad definition of Interoperability*. Last visited 21.05.2013
http://www.rand.org/content/dam/rand/pubs/monograph_reports/MR1235/MR1235.chap2.pdf

REAKT (2014). *Strategies and tools for Real Time EArthquake RisK ReducTion*. Last visited 05.05.2014.

http://www.reaktproject.eu/

Richter, C. F. (1935). *An instrumental earthquake magnitude scale*. Bull. Seism. Soc. Am., 25, 1-32.

Ruffner, J. W., Brodie, A. C., Holiday, C. L., and Isenberg, T. H. (2010), "Selecting and Utilizing Metrics for an Internet-Based Community of Practice" in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, pp. 1254-1258.
Sáenz de San Pedro Alba, Luis (2013). *The Spanish Model of Civil Protection.* Powerpoint presentation in the ELITE Earthquake workshop in Weeze in 2013.

Snyder, W. M. and de Souza Briggs, X. (2003). *Communities of Practice: A New Tool for Government Managers.* IBM Center for the Business of Government.

Stein S. and M. Wysession (2003). *An introduction to seismology, Earthquake, and Earth Structure*, Blackwell Publishing.

Støldal, Morten (2013). “Hvordan lære leksa” in *Brannmannen* Nr. 3-2013 (in Norwegian). Last visited 16.09.2013.
http://www.brannmannen.no/arkiv.aspx?M=NewsV2&PID=17&NewsID=4758

van Santen, Rikus and Illing, Mareike (2013). Earthquakes Lessons Learned Workshop Report. Deliverable D2.2. ELITE project. FP7-SEC. Contract no. 312497

Wenger, E. C., McDermott, R., and Snyder, W. M., (2002). *Communities of practice: A guide to managing knowledge*. Cambridge, MA: Harvard Business School.

Wisegeek (ND). *What is an aftershock*. Last visited 15.08.2013
http://www.wisegeek.com/what-is-an-aftershock.htm

Wildfirelessons.net (2013). *Facilitated Learning Analysis - Implementation guide*. Last visited 26.06.2013
http://wildfirelessons.net/documents/FLA_Guide.pdf

Working group on experiential learning in the Norwegian Fire and Rescue Services (2013). *Experiential Learning model*. Meeting at Gardermoen, 21st of August 2013.

Zollo, A, S. Colombelli, L. Elia, A. Emolo, G. Festa, G. Iannaccone, C. Martino, P. Gasparini (2014). “An integrated regional and on-site Earthquake Early Warning System for Southern Italy: concepts, methodologies and performances” In: Wenzel, F., Zschau, J. (Eds.) (2014*): Early Warning for Geological Disasters: Scientific Methods and Current Practice*, Springer, 117-137. DOI: 10.1007/978-3-642-12233-0

ANNEX A INTERVIEWS

20th of August 2013, Oslo: Benedicte Giæver is the head of the Emergency Response Department in the Norwegian Refugee Council that operates NORCAP (Norwegian Capacity) and the thematic rosters in international emergencies.

27th of August 2013, Kjeller: Ståle Lindhardt is Brigade Commander (brigadesjef) at the Agency for Fire and Rescue Services in the City of Oslo, Norway.

ANNEX B ABBREVIATIONS

ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
CISM	Critical incident stress management
CoP	Community of Practice
ELITE	Elicit to Learn Crucial Post-Crisis Lessons
ESA	European Space Agency
FEMA	Federal Emergency Management Agency
FFI	Norwegian Defence Research Establishment
FLA	Facilitated Learning Analysis Process
IFRC	International Federation of Red Cross and Red Crescent Societies
IMAA-CNR	Institute of Methodologies for Environmental Analysis – National Research Council of Italy
IOM	International Organization of Migration
IPCC	Intergovernmental Panel on Climate Change
MIC	Monitoring and Information Centre (in Brussels)
NASA	National Aeronautics and Space Administration
NGO	non-governmental organizations
NORSAR	Norwegian search and rescue team
NRC	Norwegian Refugee Council
OCHA	Office for the Coordination of Humanitarian Affairs
OGS-CRS	National Institute of Oceanography and Experimental Geophysics – Centre of Seismological Research (in Italy)
REAKT	Real Time Earthquake Risk Reduction
SAR	Search and Rescue
SOPs	Standard Operating Procedures
STANAG	Standardization Agreements

UNDAC	United Nations Disaster Assessment and Coordination
UNHCR	UN High Commissioner for Refugees
WebGIS	Web Geographical Information Systems