Bollettino di Geofisica Teorica ed Applicata Vol. 57, n. 2, pp. 161-182; June 2016
DOI 10.4430/bgta0171

The Short-Term Countermeasures System of the Italian National Fire Service for post-earthquake response

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(Received: November 12, 2015; accepted: January 23, 2016)

ABSTRACT After a major earthquake, the system for emergency management is activated. As part of a bigger effort involving other organizations, the Italian National Fire Service sets up a system for the management of the short-term countermeasures, called Short-Term Countermeasures System (STCS). The STCS contributes to coping with the emergency, providing a quick characterization of the emergency scenario and realizing short-term countermeasures to secure hazardous situations. This paper illustrates the background and the processes that led to the creation of the STCS, and delineates the procedures and methodologies adopted for the STCS operations. Finally, the paper shows the results obtained by STCS upon applying the procedures to a full-scale exercise and to national and international seismic emergencies.

Key words: seismic emergency, short-term countermeasures, decision-making support, fire service.

1. Introduction

The Italian National Fire Service (in Italian "Corpo Nazionale dei Vigili del Fuoco", hereafter CNVVF) is a component of the Italian National Civil Protection system. It is governed by the Ministry of the Interior, and its professional and volunteer branches are located throughout the national territory. The CNVVF is responsible for fire prevention and protection, and it ensures the public safety, providing rescue and technical assistance after accidents. One of the tasks of CNVVF is the intervention in case of sudden or threatening structural collapse, with the purpose of protecting the safety of people, as well as the integrity of the goods and/or structures. After a devastating earthquake, CNVVF immediately activates the Urban Search and Rescue team to rescue people, as well as specific units to provide other assistance to the population. Simultaneously, the Short-Term Countermeasures System (STCS) is activated and contributes to coping with the emergency by providing a quick characterization of the situation and by realizing short-term countermeasures to restore the practicability of roads, as well as to protect strategic buildings and historical and artistic heritage. In this context, the shoring of buildings (to stop the progression of the damage) is a complex activity requiring specialized technical skills. Indeed, the activity is carried out in hazardous conditions, sometimes implying work on damaged structures during an ongoing seismic sequence. CNVVF specially trains firefighters to deal with these situations. Despite the importance of these tasks during an emergency, the

STCS was established only recently. The purpose of this paper is to delineate the background and the steps that led to the establishment of the STCS, and to illustrate the foundation of STCS procedures and methodologies and its tools. Finally, some applications of the methodologies are illustrated, discussing both the results of a real-scale exercise and the utilization during national and international seismic emergencies.

2. Historical background

Documents from the earthquakes of Messina (1908, southern Italy), Avezzano (1915, central Italy) and Belice (1968, southern Italy) prove that firefighters have a long history of securing damaged buildings [see Grimaz *et al*. (2010a), for some examples of pictures]. During those times, the shoring interventions usually consisted of wooden supports, while steel ties and other approaches were used mainly for the final consolidation of the buildings. Some innovations in shoring techniques started after the 1976 Friuli earthquake (north-eastern Italy), when teams of firefighters with highly developed skills in carpentry secured the damaged buildings through the massive utilization of metal ropes and wood beams (Grimaz *et al*., 2010a). At that time, neither specific safety procedures nor technical evaluations were developed for planning, designing, and installing countermeasures. A first step toward the utilization of innovative materials and safety procedures arose after the earthquakes of 1997 in Umbria - Marche (central Italy) and of 2002 in Molise (southern Italy). The experiences acquired subsequent to these earthquakes led to the publication of books dealing with the design and the construction of shoring (Bellizzi, 2001; Dolce *et al*., 2006).

Despite huge improvements in the definition of short-term countermeasures, some issues were still without specific analysis or solutions, in particular:

- the delineation of specific procedures to ensure the safety of firefighters during the construction and installation of short-term countermeasures;
- the establishment of a specific system capable of organizing and handling a large number of activities in the affected territory;
- the definition of the operative approaches with regard to the potential shift of personnel during the interventions;
- the organization of courses and training, to increase the skills and specialization of people working on short-term countermeasures.

2.1. Skills and experiences from the 2009 L'Aquila earthquake emergency

In 2009, the M_W 6.3 earthquake of L'Aquila (Abruzzo, central Italy) pointed out a critical condition, which led to the declaration of a "red zone" (i.e., an area with restricted access due to unsafe conditions) comprising the entire historical centre of L'Aquila city. The seismic damage to the buildings led to critical issues related to the safety of the city's cultural heritage and to traffic conditions, especially in L'Aquila's historical centre. The scenario needed a rapid response to streamline, standardize, and speed up the processes of emergency management. It became necessary to plan strategic and operational solutions together with effective implementation of interventions. In this context, a collaboration started between CNVVF and SPRINT-Lab researchers at the University of Udine (Italy) in order to develop solutions for coping with the crisis, particularly with regard to the urgency surrounding the seriously damaged cultural heritage sites.

In order to deal with the organization and management of the shoring interventions, a "coordination unit for shoring" (in Italian "Nucleo Coordinamento opere Provvisionali", NCP) was set up. NCP dealt with the following tasks:

- to coordinate and implement the shoring interventions;
- to define standards and technical solutions for the short-term countermeasures;
- to develop technical and organizational procedures for the management of interventions in agreement and in collaboration with other institutions (universities, Ministry of Culture, and local authorities);
- to monitor the interventions through the establishment of a technical secretariat, and the acquisition of data and pictures for ongoing activities;
- to provide technical advice, information, and training of personnel for complex interventions.

These activities led to the definition of the Vademecum STOP (Grimaz *et al.*, 2010b), an operational tool to support shoring interventions and the training of personnel. The Vademecum STOP consists of a set of operative fact sheets, which define pre-codified solutions in order to standardize the shoring process. The development of the Vademecum STOP considered the problem of the safety of operators during the execution and installation of short-term countermeasures. The procedures defined within the Vademecum STOP led to a complete reorganization of the operating procedures, favouring the realization of some parts of the countermeasures in a safe working area and the subsequent placement on site, so as to minimize the exposure times of the personnel to the damaged buildings (Grimaz, 2011).

The Vademecum STOP analysed and proposed the following pre-codified short-term countermeasures:

- STOP-PR: Timber raker shores;
- STOP-PC: Timber wall-to-wall shores;
- STOP-SA: Shores for apertures;
- STOP-SB: Shores for slabs and balconies;
- STOP-SV: Support of vaults and arches;
- STOP-TA: Steel wire rope tie backs;
- STOP-CP: Bracing of columns with polyester ratchet straps;
- STOP-IP: Interlocked packing of walls.

The fact-sheet structure of the Vademecum STOP allows the immediate connection between the collapse mechanism identified for the damaged building and the suggested countermeasures. The fact sheets also highlight the main points of caution to observe during the construction and installation of the shoring interventions. For an explanation of the approach and a detailed analysis of the theory and calculation of the Vademecum STOP, see Grimaz *et al*. (2010a).

Within the NCP unit, a specific role (technical secretariat) was assigned to develop and maintain an up-to-date database of the shoring interventions. The analysis of this database, at the end of the emergency, permitted the following summary of data concerning the interventions done during the L'Aquila seismic emergency:

- the NCP dealt with 452 interventions for the installation of short-term countermeasures

on cultural heritage structures: 306 interventions on churches and 146 on public or private buildings;
- considering the NCP interventions on churches, the median intervention time was 14 days, 15% of the data corresponded to four-day interventions, and 85% to interventions of 32 days;
- considering the NCP interventions on public or private buildings, the median intervention time was seven days, 15% of the data corresponded to six-day interventions, and 85% to interventions of 34 days.

The evaluations highlight that most of the interventions on churches and cultural heritage structures required more than seven days of work, thus implying at least one shift of personnel (a team changes every seven days). The standardization of the short-term countermeasures facilitates the passage from one team to the other.

Moreover, the surveys piloted by a team of SPRINT researchers with the support of CNVVF engineers permitted the investigation of the damage caused by the earthquake on industrial facilities and lifelines, and pinpointed the recurring problems and criticisms (Grimaz and Maiolo, 2010). This led to the realization of the "Guidelines for the seismic vulnerability reduction of fire protection systems" (CNVVF, 2012) by adopting, for existing premises, a systematic approach named INSPECT ["INspection and Study of Potential Emergency scenarios for Countermeasure Tailoring" (Grimaz *et al.*, 2014b)]. Furthermore, the process permitted the development of evaluations concerning the seismic design of sprinkler systems according to Italian and international standards (Grimaz *et al.*, 2014a, 2015).

2.2. DRHOUSE project: CNVVF deployed in international safety assessment and securing of damaged buildings

The positive results and feedback after the L'Aquila emergency proved that the building safety assessment and the short-term countermeasures were interoperable activities and exportable to international emergency scenarios. The Italian Civil Protection Department, together with the Eucentre foundation and the CNVVF, participated in the program of the European Commission: "Civil Protection Preparatory Action on an EU Rapid Response Capability". The program financed the preparation of a rapid-response capability in case of emergency within the Community Mechanism for Civil Protection (Dolce *et al.*, 2012). Under this program, the European Commission funded the DRHOUSE project (Development of Rapid Highly-specialized Operative Units for Structural Evaluations) for the definition, preparation, maintenance, and possible deployment of a macro-module of European civil protection for the safety assessment and securing of buildings damaged by earthquakes within 15,000 km of Italy.

The macro-module, identified as "Build-Safe", consists of three modules (Dolce *et al.*, 2012):
- the Basic Safety Assessment (BSA): provided by the Civil Protection Department, it deals with the conventional visual assessment of the safety conditions;
- the Advanced Safety Assessment (ASA): provided by Eucentre, it focuses on advanced numerical-experimental evaluations;
- the Short-Term Countermeasures (STC): provided by the CNVVF, for securing the damaged buildings during the emergency.

The purpose of the STC module is both to stop the progression of the seismic damage on buildings during aftershocks (especially for historical heritage sites) and to ensure the quick restoration of main roads and other strategic facilities. Within the module, a program was implemented with five courses aimed at training 100 firefighters and 15 fire officers. The courses, based on Vademecum STOP, were carried out in Alessandria (Italy) at the "Cittadella", an eighteenth-century fortress badly damaged by age and lack of maintenance. The project facilitated the translation of the Vademecum STOP both into English and into French, to ensure international divulgation.

A full-scale exercise was organized in Patras (Greece) in October 2012. The exercise tested and validated the operating procedures, the organization, and the logistics interoperability of the modules. Furthermore, during the exercise, the STC module trained local operators (firefighters) in the procedures and techniques for the shoring of damaged buildings, eliciting positive feedback both from local emergency teams and from international observers.

2.3. Establishment of CU-STC during the 2012 Emilia earthquake and a new approach to emergencies

On the occasion of the earthquakes in Emilia, Italy (May 20, 2012, M_W 5.8; May 29, 2012, M_W 5.9), CNVVF already possessed the ability to construct and install short-term countermeasures on buildings; in any case, however, the emergency context in Emilia was significantly different from that of L'Aquila, with reduced rescue interventions and a larger affected territory. The emergency in Emilia concerned mainly:

- the reopening of the red zones, through the detection of criticalities and the implementation of required interventions;
- the definition of solutions for simplifying and accelerating the relaunch of industrial activities, both by salvaging the goods from the storehouses and by shoring the structures of the factories;
- the shoring of damaged buildings (cultural heritage).

Considering all of these aspects, the CNVVF decided to improve the approach adopted during the emergency management in L'Aquila by moving towards a more articulated organization, called CU-STC (Coordination Unit for Short-Term Countermeasures). The CU-STC systematized three CNVVF units in order to deal with the previously listed activities: the NCP unit (coordination unit for shoring), the TAS unit (Topography Applied to Safety and rescue), and the CDV unit (Centre for photographic Documentation and Video). Furthermore, SPRINT-Lab researchers from the University of Udine provided scientific support for the development of the tools and procedures for the management of the emergency.

As a first step, in order to provide decision-making support to the rescue operations commander, the CU-STC focused on the identification and characterization of the areas hit by the earthquake. To accomplish this, CU-STC developed and adopted specific forms to characterize the emergency scenario according to specific priority criteria (Grimaz and Malisan, 2012). Furthermore, in the framework of the process for the damage and usability assessment using the AeDES forms (Baggio *et al*., 2007), Civil Protection requested that the CNVVF perform rapid safety evaluations of buildings. For this purpose, CU-STC developed and adopted the V3S forms. By the end of July 2012, CNVVF had completed 63,067 rapid safety assessments, while AeDES evaluations reached 39,122 (http://www.protezionecivile.gov.it/jcms/it/le_verifiche_di_agibilit.wp).

Fig. 1 - EmerMap produced during a final walk-around carried out by a joint team of CU-STC technical personnel and SPRINT-Lab researchers in the red zone of Mirandola (Modena, Italy, June 2012).

The TAS unit and the SPRINT-Lab researchers used the data acquired to produce thematic maps (called “EmerMaps”, Emergency Maps). The EmerMaps were conceived as a series of thematic maps developed to support decisions during the emergency. Indeed, the extent of the affected area and the need to monitor the interventions on buildings and roads required a continuous updating of the situation. The cartographic support was essential to reformulate the rescuers deployment and monitor the development of the interventions in the territory. Furthermore, the EmerMaps supported the decision-making process by mapping the useful data and indicators, such as the priority indicators (more information is provided in the next section). Therefore, it was possible to simply define the strategies to adopt for achieving the expected results (for example, in the case of the reinstatement of the red zones). Finally, the evaluation of the required interventions permitted the determination of whether they necessitated specific skills and technologies (thus implying the involvement of CU-STC units) or if they could be handled by ordinary teams of CNVVF personnel (this was the case with simple remediation, opening closures, etc.).

Concerning the red-zones, specific tools and mapping procedures were developed in order to identify critical issues and, at the same time, to define the short-term countermeasures or quick interventions to remove unstable and unsafe elements. These measures were considered necessary to restore access to the streets and therefore to permit construction companies to start the interventions on buildings inside the red zone. Fig. 1 shows an example of an EmerMap produced during a walk-around carried out by a joint team of CU-STC technical personnel and SPRINT-Lab researchers in the red zone of Mirandola (Modena, Italy); the EmerMap shows the characterization of the façades facing the street. It is important to underline that the judgement is assigned, not to the building, but to the potential consequences on the street access if another significant earthquake were to occur. In correspondence with the dangerous situations (non-green segments), the required interventions are suggested and illustrated by using pre-codified icons, with a cross-reference to more detailed sketches when necessary.

Another important activity coordinated by CU-STC was the assistance provided to the biomedical industry for the recovery of materials in storage, so they would be readily available to meet health needs. To allow the safe recovery of materials, warehouse structures and shelving were shored. The CU-STC team coordinated operations to permit firefighters to safely access the damaged warehouses and salvage the medical equipment and material to guarantee its availability to national and international medical services.

The positive outcomes obtained during the emergency management were strongly determined by the coordination of all the involved units of the CU-STC and by the organization of the different CNVVF units cooperating during the emergency, and this proved the importance of working as a system with a coordination unit. Furthermore, the preparedness of CNVVF personnel to perform specific tasks (for example, thanks to the CNVVF training courses on shoring methodologies) and the predefined operative tools (such as the Vademecum STOP) permitted efficient handling of the emergency.

During the Emilia emergency, the NCP unit of CU-STC followed the same procedures adopted in L'Aquila in order to deal with the shoring of historical-landmark buildings. As a result, at the end of the emergency, the NCP technical secretariat had a detailed database containing all of the interventions undertaken by the NCP unit, together with photos and videos provided by the CDV group. The TAS unit downloaded these data daily and used them in order to create updated EmerMaps with the locations of the interventions and their status (e.g., concluded, ongoing, suspended, to-do, etc.). These EmerMaps were fundamental to the strategic execution of the short-term countermeasures.

The analysis of the Emilia NCP database showed that:

- the NCP unit dealt with 126 interventions involving the installation of short-term countermeasures: 73 intervention on churches, 49 on public or private buildings, and 4 interventions on other structures;
- regarding the NCP interventions on churches, the median intervention time was 15 days, 15% of the data corresponded to five-day interventions, and 85% to interventions of 35 days; these data are comparable with that of L'Aquila;
- regarding the NCP interventions on public or private buildings, the median intervention time was 6 days, 15% of the data corresponded to three-day interventions, and 85% to interventions of 14 days.

It is possible to observe that the mean time required for the interventions in Emilia and in L'Aquila is almost the same, despite some differences in interventions on public or private buildings. A specific analysis was done, considering only the interventions that adopted the STOP typologies, both in L'Aquila and in Emilia. Fig. 2 synthesises the outcomes for each STOP typology, and shows the total number of interventions and the time required for the installation of the pre-codified short-term countermeasures.

The management of the Emilia earthquake emergency highlighted the following:

- the importance of a quick and preliminary characterization of buildings in terms of safety; the purpose of this characterization is not to immediately send people back to their homes,

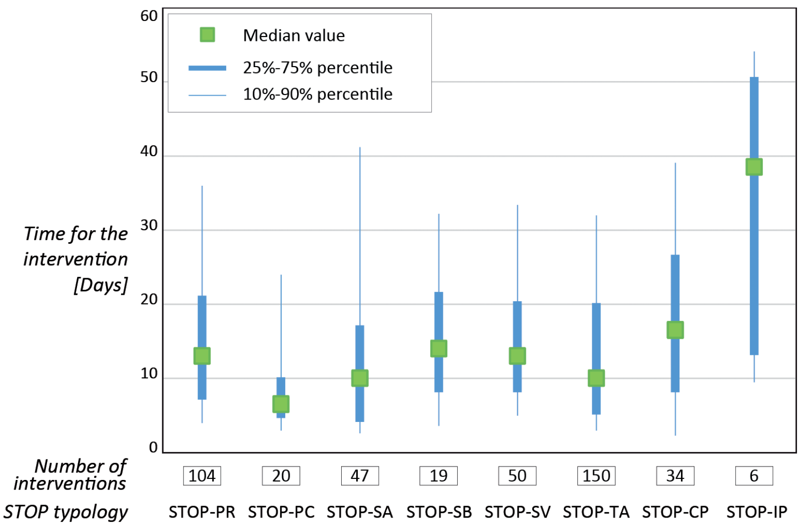


Fig. 2 - Synthesis of intervention time for the Vademecum STOP short-term countermeasures during the L'Aquila and Emilia seismic emergencies.

but to permit the definition of strategies to cope with the emergency;

- the relevance of EmerMaps as a tool for planning the interventions during the emergency;
- the necessity to distinguish between ordinary and special interventions, in order to assign the proper teams with specific technical skills to each intervention;
- the importance of the coordination among several technical and specialized units (NCP, TAS, CDV, etc.) and the organization of the units in a system;
- the importance of the delineation of different phases, distinguishing the preliminary strategic characterization from the realization of the interventions;
- the need for new tools for the definition of indicators useful for decision-makers in order to define strategies and plans for management of the emergency, especially in the first phase of the emergency; this necessity relies on: a) expert surveyors and predefined tools, forms, procedures, and map layouts, and b) a connection between the rapid safety evaluations and the damage and usability assessments (Ae DES).

Considering the experience acquired during the Emilia emergency, the CNVVF decided to endorse a systemic organization of the units for short-term countermeasures, under a single coordination unit called STCS.

Finally, the observation of damage evidence on buildings after the May 20 and 29 earthquakes highlighted the relevance of near-field effects, and opened a debate concerning the importance of incorporating the near-field effects (especially the vertical ground motion) into the seismic codes (Grimaz and Malisan, 2014).

3. The Short-Term Countermeasures System (STCS) organization

The experiences of L'Aquila, 2009, and Emilia, 2012, led the CNVVF to systematize the operational approaches under technical expert supervision. This contributed to the creation of the STCS, developed to provide technical support for the management of the emergency phases entailing the assessment of damage and the definition and realization of temporary interventions

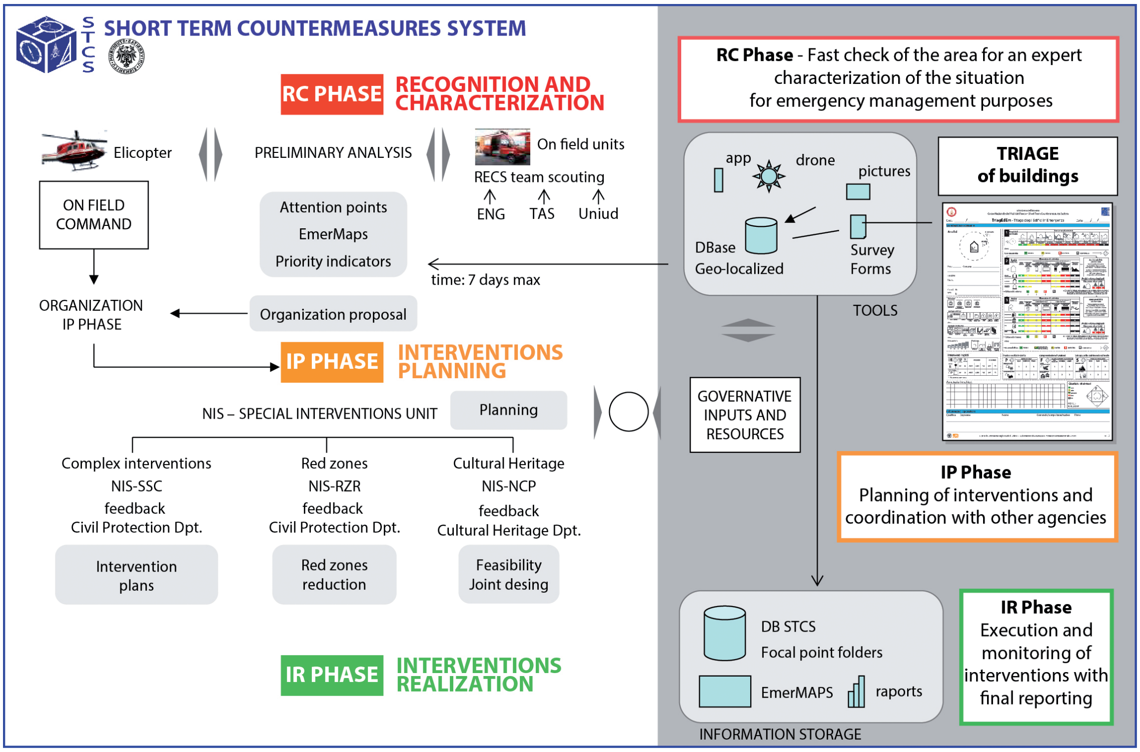


Fig. 3 - Explanatory diagram of the phases of the STCS system.

to increase safety conditions (e.g., shores, protection work, controlled removal and disassembly, monitoring and surveys in complex scenarios and/or with specific structural problems, etc.).

The activities of STCS are conceived according to three main phases (Fig. 3):

- Recognition and Characterization (RC) phase: a preliminary analysis with the aim of characterizing the situation for emergency purposes;
- Interventions Planning (IP) phase: planning of interventions and coordination with other agencies (universities, Ministry, etc.);
- Interventions Realization (IR) phase: execution and monitoring of interventions, with final reporting.

3.1. RC phase: preliminary characterization

When a major event strikes a territory, decision-makers need a rapid overview of the situation in order to plan strategies to deal with the emergency. In order to provide useful data for this task, it is necessary to pre-codify the indicators that permit the effective characterization of the emergency context, and to train firefighters to acquire those indicators through specific surveys (e.g., overlook with helicopters or drones, quick inspections, etc.). The RC phase of the STCS framework relies on a rapid check of the affected area, aimed at defining the situation by identifying dangerous conditions, both for people and for the safeguard of cultural heritage or strategic buildings. The main goals of the RC phase are:

- to identify and characterize the structural problems, using specific tools for surveying and recording (maps, modules, computer equipment, etc.);

- to identify any problems that might affect the practicability of the roads;
- to produce priority indicators, useful for planning interventions;
- to identify any critical situations to be monitored.

The RC phase can be developed by adopting different survey modalities: flight recognition (helicopter as well as drone) or land recognition (preliminary quick check of damaged buildings). STCS personnel with the support of SPRINT-Lab researchers developed specific procedures and tools for this phase. The RC phase should provide a kind of technical triage, which is necessary for establishing a plan for the interventions. This is essential, assuming that the available resources are generally lower than the required resources in terms of money as well as time and personnel. For this reason, the allocation of the resources during the emergency should optimize efficiency, according to predefined values and objectives. Effective planning at this stage permits the efficient deployment of resources in the next phases.

In order to deal with the RC phase, STCS adopted the quick radio check (RCP form, Radio Check for Patrol), and the TriagEdEm form (in Italian "Triage dell'Edificato nell'Emergenza", i.e., the triage of the built environment during the emergency, also used for the strategic characterization of buildings by experts). These tools were conceived to be used by trained CNVVF personnel.

3.1.1. Quick radio-check survey (RCP form)

The purpose of the quick radio check is to recognize, in a short period of time, the so-called "points of attention", together with their effects on safety in public areas. The "points of attention" consist of all the situations (e.g., collapses, damage, unstable elements, etc.) that could cause danger to public safety in the event of relevant aftershocks. Fig. 4a shows the RCP form, which synthesizes the main issues in order to evaluate them together with the explanation of the required inputs provided during the survey. In order to streamline the survey, firefighters with strong technical skills adapted some standard equipment radios in order to send the position and the classification of each point of attention to a STCS back-office.

During the survey, the team has to assess the conditions of the following potential points of attention: the street (road), the elements beside the street, and the elements beyond the street. First, the surveyors have to assign a class to the point of attention: "ordinary", "special" or "USAR". They should consider that an "ordinary" point of attention can be managed by ordinary CNVVF teams; a "special" point of attention should be handled by STCS (some examples of special points of attention are bridges, churches, hospitals, dams, etc.); a "USAR" point of attention implies the necessity of an urban rescue team.

The surveyor has to provide a quick judgement on the conditions of each ordinary or special point of attention. This judgement is expressed according to the definitions in Fig. 4a.

The TAS unit developed a system for the acquisition, communication, and re-elaboration of the information provide by the RCP survey. The tool developed for the RCP surveys is based on the radio-location system "GeoVVF". It is designed and manufactured by CNVVF personnel and consists of a computer, with an instrumental and a conceptual part aimed at adapting the use of the instruments to the needs of CNVVF (Fig. 4b). The system is completely autonomous, and this guarantees continuous operation, even when mobile phone coverage is not operational. Specific updates made it possible to program the radio to send the RCP procedure information. The radio is programmed to process the inputs of the surveyor, and to build a response code

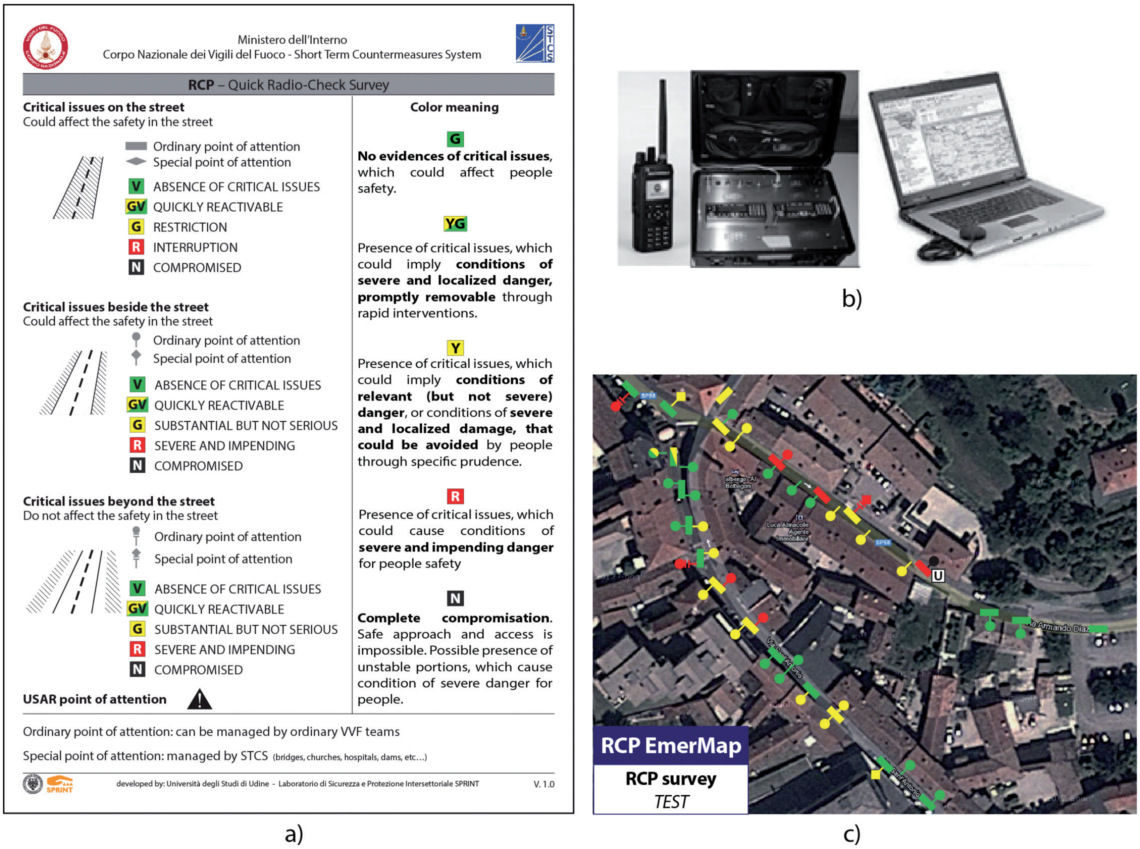
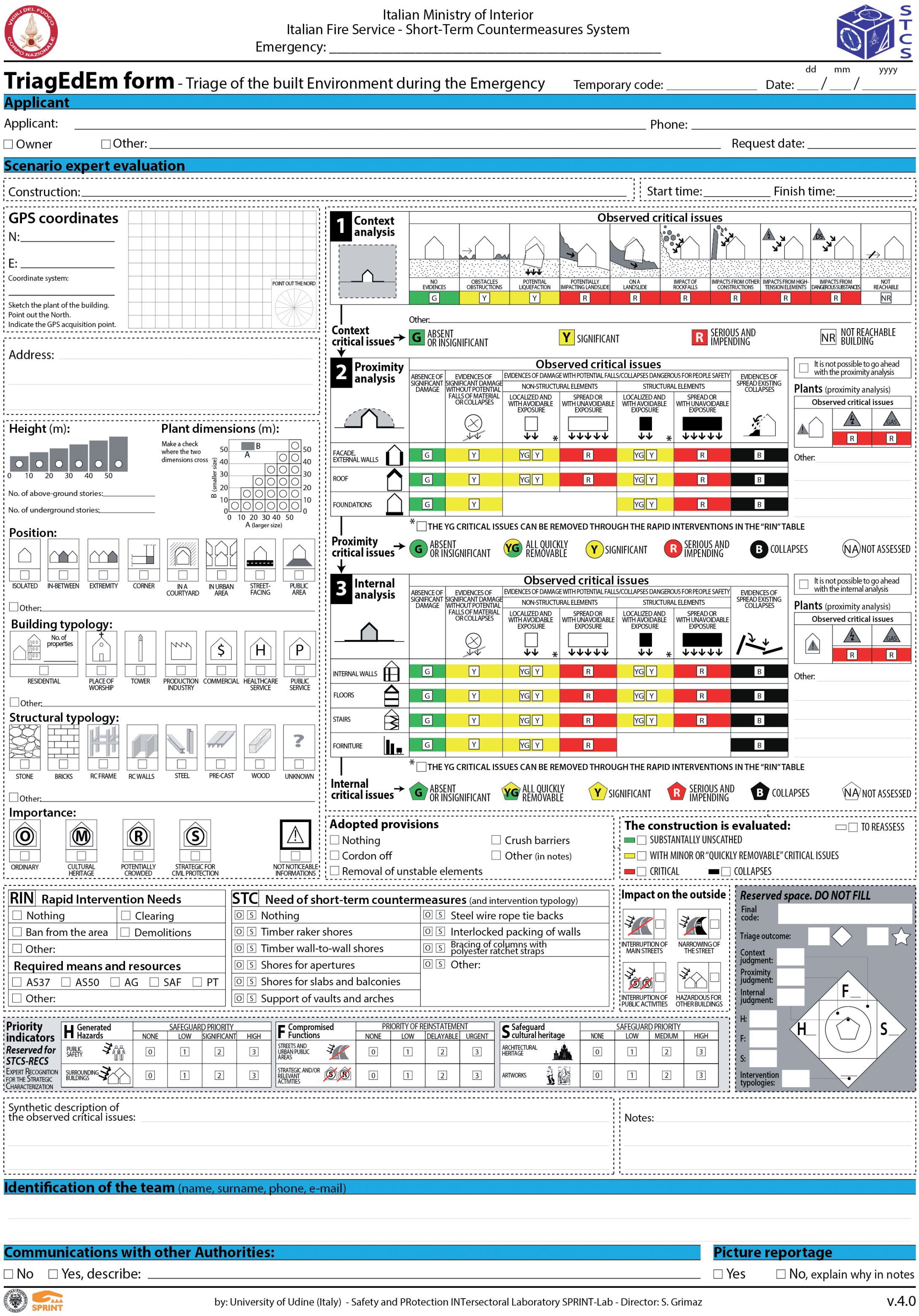


Fig. 4 - Radio-check surveys: a) RCP form (translated from Italian). b) Radio, mobile receiving station, and laptop with software "GeoVVF". c) Example of RCP EmerMap achieved after the radio-check survey (test).

that is transmitted and decoded by the receiving station. The receiving station processes the incoming radio signal and, in real time, archives the data in a database and on a map (the RCP EmerMap). Fig. 4c shows a (theoretical) example of a RCP EmerMap. The outcomes of the radio-check surveys allow the rapid identification of areas that are candidates to become "red zones" (i.e., areas with entry authorization strictly limited for safety reasons).

3.1.2. TriagEdEm form

Starting with the V3S form used during the Emilia earthquake, SPRINT researchers designed the TriagEdEm form (Triage of the built Environment during the Emergency). The form guides the CNVVF personnel through a triage process (i.e., a rapid evaluation) for assessing the conditions of the buildings through a uniform pre-codified procedure. The technical triage approach was borrowed from the emergency medical approach and adapted to the seismic emergency context. Medical triage is employed in cases requiring the rapid identification of the most urgent interventions for saving the largest number of lives. The TriagEdEm form permits the definition of a rapid triage of the safety conditions after a major event (e.g., an earthquake) by categorizing ordinary and special points of attention. The design of the forms is based on the VISUS methodology, implementing the expert-reasoning process (Grimaz and Malisan, 2016).


Italian Ministry of Interior
Italian Fire Service - Short-Term Countermeasures System
Emergency: ____________________

TriagEdEm form - Triage of the built Environment during the Emergency
Temporary code: __________ Date: dd / mm / yyyy

Applicant

Applicant: ____________________ Phone: __________
☐ Owner ☐ Other: ____________________ Request date: __________

Scenario expert evaluation

Construction: ____________________ Start time: __________ Finish time: __________

GPS coordinates
N: __________
E: __________
Coordinate system: __________
Sketch the plant of the building. Point out the North. Indicate the GPS acquisition point.
POINT OUT THE NORD

Address: ____________________

Height (m): 0 10 20 30 40 50
No. of above-ground stories: ______
No. of underground stories: ______

Plant dimensions (m):
Make a check where the two dimensions cross
B (smaller size) 10 20 30 40 50 — A (larger size) 10 20 30 40 50

Position: ISOLATED, IN-BETWEEN, EXTREMITY, CORNER, IN A COURTYARD, IN URBAN AREA, STREET-FACING, PUBLIC AREA
☐ Other: __________

Building typology: RESIDENTIAL (No. of properties), PLACE OF WORSHIP, TOWER, PRODUCTION INDUSTRY, COMMERCIAL, HEALTHCARE SERVICE, PUBLIC SERVICE
☐ Other: __________

Structural typology: STONE, BRICKS, RC FRAME, RC WALLS, STEEL, PRE-CAST, WOOD, UNKNOWN
☐ Other: __________

Importance: ORDINARY, CULTURAL HERITAGE, POTENTIALLY CROWDED, STRATEGIC FOR CIVIL PROTECTION, NOT NOTICEABLE INFORMATIONS

1 Context analysis — Observed critical issues

NO EVIDENCES	OBSTACLES OBSTRUCTIONS	POTENTIAL LIQUEFACTION	POTENTIALLY IMPACTING LANDSLIDE	ON A LANDSLIDE	IMPACT OF ROCKFALLS	IMPACTS FROM OTHER CONSTRUCTIONS	IMPACTS FROM HIGH-TENSION ELEMENTS	IMPACTS FROM DANGEROUS SUBSTANCES	NOT REACHABLE
G	Y	Y	R	R	R	R	R	R	NR

Other: __________

Context critical issues → G ABSENT OR INSIGNIFICANT; Y SIGNIFICANT; R SERIOUS AND IMPENDING; NR NOT REACHABLE BUILDING

2 Proximity analysis — Observed critical issues

	ABSENCE OF SIGNIFICANT DAMAGE	EVIDENCES OF SIGNIFICANT DAMAGE WITHOUT POTENTIAL FALLS OF MATERIAL OR COLLAPSES	NON-STRUCTURAL ELEMENTS: LOCALIZED AND WITH AVOIDABLE EXPOSURE	NON-STRUCTURAL ELEMENTS: SPREAD OR WITH UNAVOIDABLE EXPOSURE	STRUCTURAL ELEMENTS: LOCALIZED AND WITH AVOIDABLE EXPOSURE	STRUCTURAL ELEMENTS: SPREAD OR WITH UNAVOIDABLE EXPOSURE	EVIDENCES OF SPREAD EXISTING COLLAPSES
FACADE, EXTERNAL WALLS	G	Y	YG Y	R	YG Y	R	B
ROOF	G	Y	YG Y	R	YG Y	R	B
FOUNDATIONS	G	Y			YG Y	R	B

(EVIDENCES OF DAMAGE WITH POTENTIAL FALLS/COLLAPSES DANGEROUS FOR PEOPLE SAFETY)

☐ It is not possible to go ahead with the proximity analysis
Plants (proximity analysis) — Observed critical issues: R R
Other: __________

* ☐ THE YG CRITICAL ISSUES CAN BE REMOVED THROUGH THE RAPID INTERVENTIONS IN THE "RIN" TABLE

Proximity critical issues → G ABSENT OR INSIGNIFICANT; YG ALL QUICKLY REMOVABLE; Y SIGNIFICANT; R SERIOUS AND IMPENDING; B COLLAPSES; NA NOT ASSESSED

3 Internal analysis — Observed critical issues

	ABSENCE OF SIGNIFICANT DAMAGE	EVIDENCES OF SIGNIFICANT DAMAGE WITHOUT POTENTIAL FALLS OF MATERIAL OR COLLAPSES	NON-STRUCTURAL ELEMENTS: LOCALIZED AND WITH AVOIDABLE EXPOSURE	NON-STRUCTURAL ELEMENTS: SPREAD OR WITH UNAVOIDABLE EXPOSURE	STRUCTURAL ELEMENTS: LOCALIZED AND WITH AVOIDABLE EXPOSURE	STRUCTURAL ELEMENTS: SPREAD OR WITH UNAVOIDABLE EXPOSURE	EVIDENCES OF SPREAD EXISTING COLLAPSES
INTERNAL WALLS	G	Y	YG Y	R	YG Y	R	B
FLOORS	G	Y	YG Y	R	YG Y	R	B
STAIRS	G	Y	YG Y	R	YG Y	R	B
FORNITURE	G	Y	YG Y	R			B

☐ It is not possible to go ahead with the internal analysis
Plants (proximity analysis) — Observed critical issues: R R
Other: __________

* ☐ THE YG CRITICAL ISSUES CAN BE REMOVED THROUGH THE RAPID INTERVENTIONS IN THE "RIN" TABLE

Internal critical issues → G ABSENT OR INSIGNIFICANT; YG ALL QUICKLY REMOVABLE; Y SIGNIFICANT; R SERIOUS AND IMPENDING; B COLLAPSES; NA NOT ASSESSED

Adopted provisions
☐ Nothing ☐ Crush barriers
☐ Cordon off ☐ Other (in notes)
☐ Removal of unstable elements

The construction is evaluated: ☐ TO REASSESS
☐ SUBSTANTIALLY UNSCATHED
☐ WITH MINOR OR "QUICKLY REMOVABLE" CRITICAL ISSUES
☐ CRITICAL ☐ COLLAPSES

RIN Rapid Intervention Needs
☐ Nothing ☐ Clearing
☐ Ban from the area ☐ Demolitions
☐ Other:

Required means and resources
☐ AS37 ☐ AS50 ☐ AG ☐ SAF ☐ PT
☐ Other:

STC Need of short-term countermeasures (and intervention typology)
O S Nothing — O S Steel wire rope tie backs
O S Timber raker shores — O S Interlocked packing of walls
O S Timber wall-to-wall shores — O S Bracing of columns with polyester ratchet straps
O S Shores for apertures — O S Other:
O S Shores for slabs and balconies
O S Support of vaults and arches

Impact on the outside
INTERRUPTION OF MAIN STREETS; NARROWING OF THE STREET; INTERRUPTION OF PUBLIC ACTIVITIES; HAZARDOUS FOR OTHER BUILDINGS

Reserved space. DO NOT FILL
Final code:
Triage outcome:
Context judgment:
Proximity judgment:
Internal judgment:
H: F: S:
Intervention typologies:

Priority indicators *Reserved for STCS-RECS* (Expert Recognition for the Strategic Characterization)

H Generated Hazards	NONE	LOW	SIGNIFICANT	HIGH
PUBLIC SAFETY	0	1	2	3
SURROUNDING BUILDINGS	0	1	2	3

(SAFEGUARD PRIORITY)

F Compromised Functions	NONE	LOW	DELAYABLE	URGENT
STREETS AND URBAN PUBLIC AREAS	0	1	2	3
STRATEGIC AND/OR RELEVANT ACTIVITIES	0	1	2	3

(PRIORITY OF REINSTATEMENT)

S Safeguard cultural heritage	NONE	LOW	MEDIUM	HIGH
ARCHITECTURAL HERITAGE	0	1	2	3
ARTWORKS	0	1	2	3

(SAFEGUARD PRIORITY)

Synthetic description of the observed critical issues: __________ Notes: __________

Identification of the team (name, surname, phone, e-mail)

Communications with other Authorities:
☐ No ☐ Yes, describe: __________

Picture reportage
☐ Yes ☐ No, explain why in notes

by: University of Udine (Italy) - Safety and PRotection INTersectoral Laboratory SPRINT-Lab - Director: S. Grimaz v.4.0

Fig. 5 - TriagEdEm form, in English (v. 4.1). This form was adopted during the seismic emergency in Nepal, in 2015.

The TriagEdEm form allows the assessment of the safety of a building as a preliminary step in the usability assessment: the first check assesses if the construction is safe or unsafe, further evaluations establish if it is usable or unusable.

The TriagEdEm form (Fig. 5) is divided into several sections; the first section identifies the general information of the person/institution asking for the evaluation (very often the applicant is the STCS itself). The main section of the form is dedicated to the evaluation of the scenario. This section requires the identification of the building under analysis, through name, address, and coordinates. A small sketch of the plan of the building is also required. The compiler also describes the building by providing an assessment of its dimensions (base size and height), its position with reference to other buildings, the building typology, the structural typology (e.g., stone, bricks, reinforced concrete, steel, etc.), and the building's relevance (cultural heritage, strategic building, etc.).

In any case, the description of the building features comes after the acknowledgement of potential critical issues in the area; this evaluation should follow a three-step predefined procedure, with the analysis of:

1. the "context critical issues" that could affect the building and cause unsafe conditions (e.g., landslides or unsafe buildings in a neighbourhood);
2. the "proximity critical issues" caused by the presence of unsafe parts/elements that could pose a hazard when approaching to the building;
3. the "internal critical issues" that make the building unsafe due to the condition of the structures or internal systems.

The procedure suggests stopping the analysis whenever a critical issue that could affect the safety of CNVVF personnel is identified.

The "context critical issues" analysis asks the surveyor to judge the safety of the context by considering the potential effects and/or impacts of different predefined scenarios. Concerning the "proximity critical issues", the evaluations are divided into the façades, the roof, and the foundations. The surveyor associates a judgement with each of these elements, also considering the definitions in Table 1.

The analysis of "internal critical issues" implies similar evaluations concerning internal walls/partitions, floors, stairs, and furniture or other movable elements. Furthermore, both external and internal analysis require the evaluation and recognition of critical issues caused by utility equipment (electrical or gas).

The critical issues identified and the analysis for each step of the procedure are associated with a judgement, defined as illustrated in Table 2; to simplify the procedure, a color is associated with each judgement class, following other international associations of the color code to the gravity of the situation [e.g., FEMA colored tagging: FEMA (2010)].

A section of the form indicates the provisions adopted (e.g., cordon off, removal of unstable elements, crush barriers, etc.). At the end of the analysis procedure, the surveyor has to express a global judgement on the construction, choosing among "substantially unscathed", "with minor or quickly removable critical issues", "critical", "with collapses," and "to reassess".

After the assessment of the building conditions, the surveyor indicates the necessary rapid intervention needs and short-term countermeasures (together with a preliminary definition of means and personnel required). Finally, a section of the form requires the estimation of the potential impact of the recognized situation on the context (streets, other buildings, or activities, etc.).

Table 1 - List of observed critical issues and associated icon.

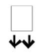
Element	Observed critical issues		Icon
All	Absence of significant damage		No icon
	Evidence of significant damage, without potential falls of material or collapses		
Non-structural elements	Evidence of substantial damage, with potential falls/collapses dangerous for people's safety	Localized and with avoidable exposure	
		Widespread or with unavoidable exposure	
Structural elements	Evidence of substantial damage, with potential falls/collapses dangerous for people's safety	Localized and with avoidable exposure	
		Widespread or with unavoidable exposure	
	Evidence of widespread existing collapses		 or 
Utilities	Critical issues due to electrical systems or electrified elements		
	Critical issues deriving from potential releases of dangerous substances		

Table 2 - Predefined judgement classes and association with colours.

Judgment class description	Colour	
No evidence of critical issues, which could affect people's safety.	Green	
Presence of critical issues, which could imply **conditions of severe and localized danger, promptly removable through rapid interventions.**	Yellow/green	YG
Presence of critical issues, which could imply **conditions of significant (but not severe) danger**, or conditions of **severe and localized damage, that could be avoided** by people through specific prudence.	Yellow	Y
Presence of critical issues, which could cause conditions of **severe and impending danger**.	Red	R
Generalized collapses or complete compromise. Safe approach and access is impossible. Possible presence of unstable portions, which cause condition of severe danger for people.	Black	B

The form also includes a section for the identification of priorities. This section is reserved for STCS-RECS teams (STCS teams for the "expert RECognition for the Strategic characterization"), and is filled out to assess the special attention points. Within the section, three tables assist the surveyor in assigning the following priorities to the interventions:

- the safeguard priority assigned according to the hazards generated by the critical issues (identified with the capital letter "H"): the surveyor has to identify if the observed critical

issues could generate a hazard for public safety or for surrounding buildings (for example, a bell tower that could collapse on a public space like a plaza or on nearby buildings);
- the priority of reinstatement of the compromised functions, which could involve the utilization of streets and/or public urban areas like a square or a plaza. The section also assesses the priority of reinstatement of strategic and/or important facilities (e.g., police stations, post offices, schools, etc.) with compromised functions because of the recognized critical issues;
- the priority of safeguarding cultural heritage, considering both architectural heritage and works of art.

The form has a blank space for a short description of the observed critical issues and for notes. In the last part of the forms, the surveyors identify themselves and notify if there were communications with other institutions (for example MiBAC: the Ministry of Cultural Heritage and Activities and Tourism).

The survey procedure also requires a picture reportage for identifying the construction and the observed critical issues.

The form has a space reserved for the STCS specialists at the coordination unit. Here, a unique ID (the final code) is associated with each form. The STCS specialists check all the information provided by the surveyors, and assign the final judgements using predefined indicators. The first indicator is a synthesis of the triage outcome; it consists of a marker colored according to the "construction evaluation" color. The marker symbol is a rhombus in the case of an ordinary point of attention and a star for a special point of attention. The second indicator synthesizes the judgements of the context, proximity and external analysis, the priorities of intervention, and the intervention typologies. The indicator consists of different symbols. The internal pentagon shows the outcomes of the internal analysis of the building. The color of the circle illustrates the results of proximity analysis. The square shows the judgement for the context. In the external part of the indicator, the content of the four triangles refers to the priority evaluations and intervention typologies. From left, clockwise: "H" indicates the potential hazard, "F" the compromised functions, "S" the importance of safeguarding the cultural heritage, and the last triangle refers to the intervention needs, if they are required and if they are ordinary or special. The definition of the final indicators took into account the necessity of representing the judgements on maps for the support of decision-makers. It is possible to filter the information, showing only the points satisfying specified criteria.

The acquired data and the interpretation of the indicators define the priority of actions, based on decision-makers' requests. Taking the gathered information into account, STCS supports the commander of the rescue operations in planning the deployment of the firefighter contingent, the equipment, and the specialized units required for the management of technical operations.

The TriagEdEm form can be filled out on paper or on electronic devices, using pdf modules. In the case of significant aftershocks, surveys should be repeated in order to check if the condition of the structures has changed. The TAS unit processes the assessment results and reports them on the EmerMaps using the final indicators.

The first test of the TriagEdEm form occurred during the "Lunigiana - Garfagnana" earthquake emergency in 2013 and, after some adaptation, during the SERM-ex full-scale exercise in 2014. The STCS-RECS teams deployed in Nepal during the 2015 seismic emergency adopted the English version of the TriagEdEm form.

3.2. IP and IR phases: planning and realization of interventions

At the end of the RC phase, the analysis of the data and maps identifies how to proceed with the organisation of the STCS in order to deal with IP phase. When deemed necessary, the NIS unit (acronym for the Italian “Nucleo Interventi Speciali”, i.e., special interventions unit) is activated. The purpose of the NIS is to analyse, plan, and control the execution of short-term countermeasures. The NIS unit may split into more sections, dealing, for example, with complex interventions, red zones, and cultural heritage. NIS uses DTS (fire officers - technical directors) and ROS (fire officers - team leaders), similarly to what NCP unit did during the L’Aquila and Emilia earthquake emergencies. NIS contacts the organizations involved in the emergency and shares with them the technical solutions. NIS personnel and local decision-makers discuss the priorities and the strategies to deal with the emergency; the discussions are supported by the characterization done during the first phase. In the NIS unit, technicians also work to define the most suitable shoring interventions on structures, so that it is possible to effectively deploy personnel and material.

During the IR phase, NIS is the centre of control for the execution of the countermeasures and interventions, and it monitors the progression of work. For this reason, NIS needed tools for deploying personnel and acquiring material to do the work, and these tools were developed by analysing the data from past earthquakes and extracting the required information. NIS unit acquires all the available information on interventions, especially from pictures and reports provided daily by the DTS and CDV. The acquired database allows the adaptation of the planning tools to the ongoing emergency, as well as supporting subsequent training with the illustration of real cases. When an intervention is concluded, the NIS secretary communicates to the designated authorities and creates a final report on the intervention.

4. First tests of STCS activities in the field

4.1. Lunigiana-Garfagnana earthquake, 2013

The first test of STCS activities occurred during the seismic emergency after the Lunigiana-Garfagnana earthquake (Tuscany, central Italy, June 21, 2013, M_L 5.2). During the emergency, a preliminary version of the TriagEdEm form was tested (i.e., version 0.1). After the one-day survey for the RC phase, 16 points of attention were recognized (Fig. 6), in the provinces of Lucca and Massa. The coordination unit analyzed the data from the surveys and, with the support of the TAS unit, created the EmerMaps. The data were also displayed on web maps, which linked each point of attention, the pictures, and the TriegEdEm form.

During the emergency, a new form for the definition of the required short-term countermeasures was defined and tested; this form provided an indication of the budget allocation for the execution and installation of the countermeasures (Mannino and Grimaz, 2013).

The analysis of the data revealed the need for 18 interventions (on 16 buildings), with three cases requiring special attention (assigned to trained CNVVF personnel with skills in short-term countermeasures). The report also provided an estimate of the intervention costs, together with the number of personnel needed and the timeframe for the work.

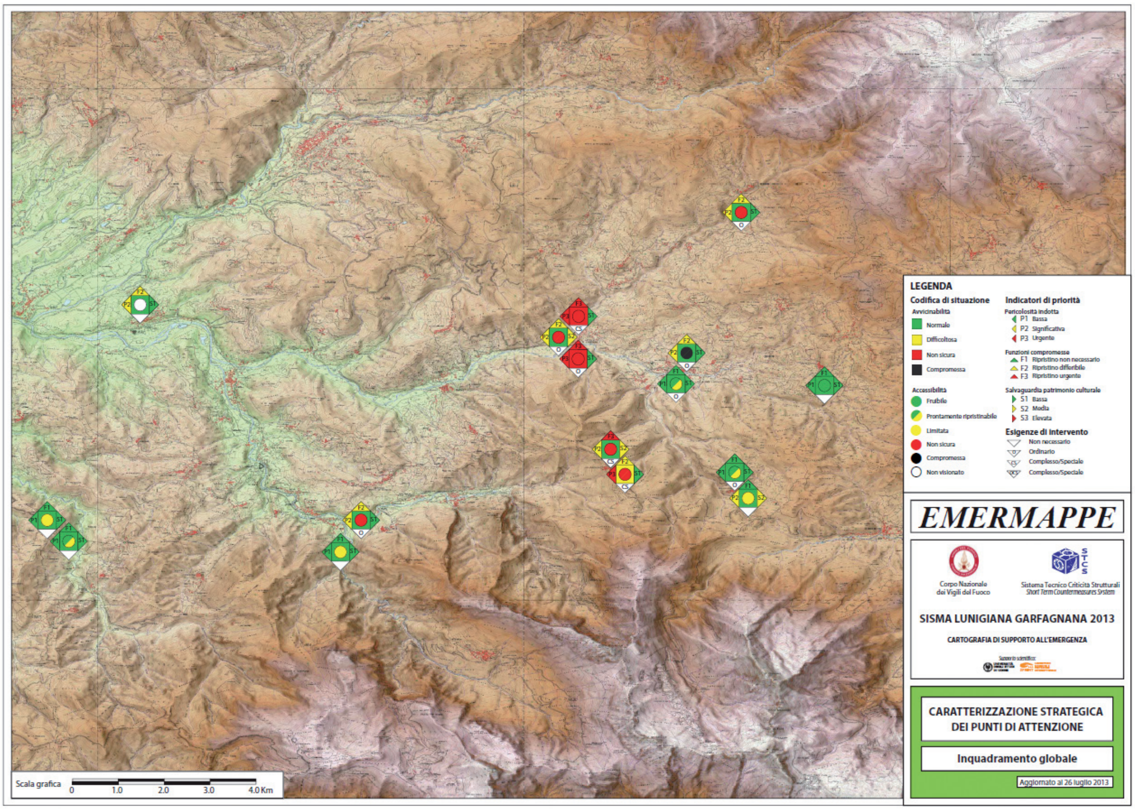


Fig. 6 - EmerMap for the strategic characterization of the attention points during the Lunigiana - Garfagnana (Italy), 2013 seismic emergency. The map shows the area affected by the M_L 5.2 earthquake of June 21, 2013. In correspondence with each building, a specific indicator identifies the critical situations (in Italian).

4.2. SERM-ex full-scale exercise, 2014

The SERM-ex full-scale exercise was organized within the activities of the school of Seismic Emergency Response Management (SERM), provided by the University of Udine (Italy). SERM-ex trains rescue personnel of the STCS of the Italian National Fire Service, and tests new procedures of assessment developed with the scientific support of the SPRINT-Lab of the University of Udine. The SERM-ex exercise was held in the town of Venzone (Udine, Italy), from April 28 to May 8, 2014. The exercise was organized in the small district of Portis Vecchio. Portis Vecchio was abandoned after the 1976 earthquake because it was located under an impending rock-fall landslide; nowadays, it shows a situation of "how it was" immediately after the 1976 earthquake. This case of real post-earthquake scenario has been recognized as extremely useful for full-scale exercise purposes.

The SERM-ex exercise simulated the response of the STCS to an earthquake with the same intensity as the one that in 1976 struck the area (Friuli earthquake, May 6, 1976, M_L 6.4). Therefore, on April 28 at 8 a.m., an earthquake was simulated, hitting the municipality of Venzone. STCS was activated with the scientific support of SPRINT-Lab researchers of the University of Udine and with the Italian National Fire Service personnel of the Friuli Venezia Giulia Region.

During the first hour after the alarm, the aerial support of a CNVVF helicopter permitted the identification of the area with the major damage. On-site STCS personnel used new remote sensing technologies to recognize and characterize the identified area; a highly detailed aerial view was obtained thanks to a fixed-wing drone. In little time, the aerial views permitted the definition of the main damaged area to the village of Portis Vecchio. Consequently, trained STCS personnel carried out a pilot test of the radio-check survey on the entire municipality. The radio-check survey relies on the rapid assessment of the safety conditions regarding both roads and buildings. The surveyors transmit the evaluations to a STCS back-office using a modified version of the standard equipment radio. The radio-check procedure permitted the characterization of a residential area of about 5 km^2 in half a day with five teams of two firefighters each. The aerial view and the radio check highlighted that the main affected area in the municipality of Venzone was the village of Portis Vecchio (Figs. 7a and 7b). The outcomes permitted the definition of the "Quick Check Patrol" EmerMap. This EmerMap identified the points of attention in the municipality of Venzone, i.e., the streets or buildings revealing unsafe conditions that could affect access to roads.

On the second day of the training, three teams of STCS surveyors focused on each point of attention (previously recognized during the surveys of the first day), using the TriagEdEm form (Fig. 7c). The STCS teams for the survey were composed of two locally trained STCS personnel, one SPRINT-Lab researcher, and one member of the STCS-TAS (Topography applied to safety and rescue) personnel. The SERM-ex exercise tested both a paper- and a tablet-based version of the TriagEdEm form, considering different situations depending on the availability of electronic devices and Internet connection. With a working Internet connection, the surveyors can send the information in real time to the "local command unit", where the STCS experts check, process, and archive the data. On the other hand, if no Internet collection is available, the survey team uploads the data directly at the "local command unit" at the end of the day, and the data are immediately checked. The TriagEdEm data permitted the creation of the "Characterization of the Attention Points" EmerMap. Analysing the data, STCS decision-makers identified two points of special attention, which required short-term interventions in order to guarantee the safety of the main street of Portis Vecchio and the safe access to the ancient graveyard of the village.

During the second week, the SERM-ex exercise tested the design and execution procedures of the short-term countermeasure on the identified buildings. The SERM-ex exercise tested both the "standard" intervention (defined according to already tested solutions) and a new "experimental" solution. The "standard" intervention involved the stabilization of the main entry of a severely damaged church facing the access to the village graveyard, in a site of historical and artistic interest. The "experimental" intervention (on a former nursery school) was designed to secure the utilization of the main street crossing Portis Vecchio: the collapse of the façade of the highly damaged building could severely affect the street access. The experimental intervention consisted of the construction and installation of a wooden trellis to contain the potential collapse of the damaged façade. SPRINT-Lab researchers and STCS personnel designed the interventions with the cooperation of local authorities (major of the municipality and the superintendent of cultural heritage).

The SERM-ex exercise validated the methodologies and the procedures for:

- the automatic achievement of the EmerMaps from the radiocheck and TriagEdEm surveys;
- the use of combined aerial and on-ground surveys in a wide territory;

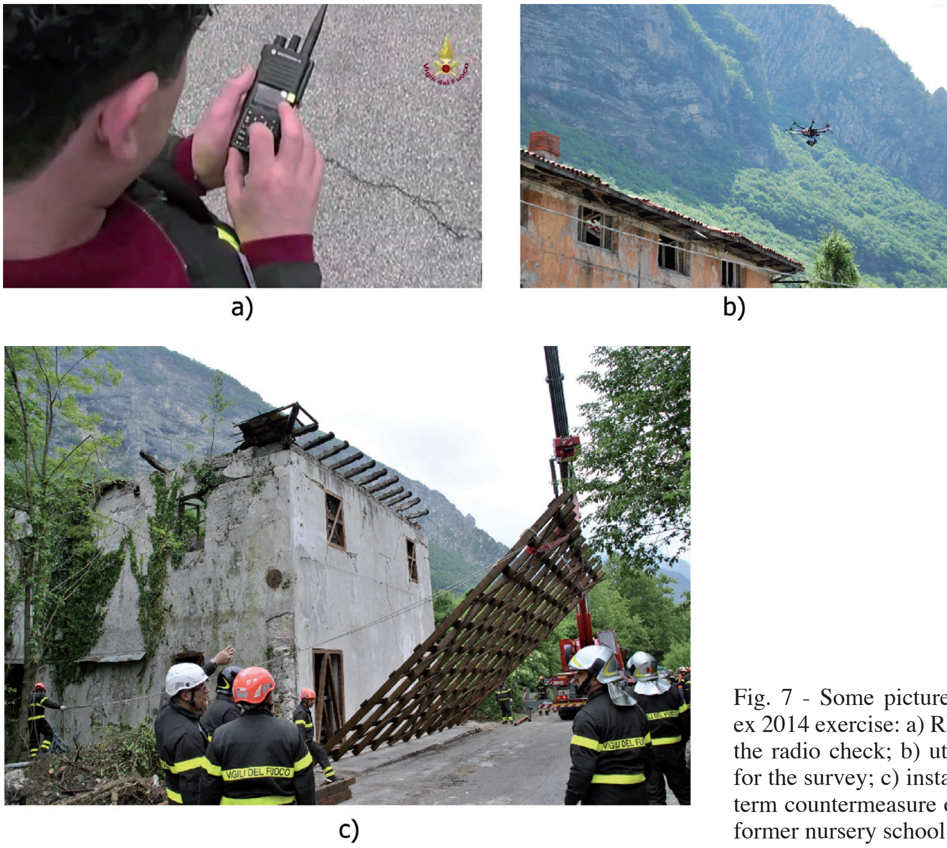


Fig. 7 - Some pictures from the SERM-ex 2014 exercise: a) RECS surveyor using the radio check; b) utilization of a drone for the survey; c) installation of the short-term countermeasure on the façade of the former nursery school.

- the utilization of the TriagEdEm forms through tablet- and paper-based forms;
- new types of short-term countermeasures for securing street access.

The SERM-ex exercises ended with a debriefing on the developed activities. The outcomes of the debriefing were very positive and highlighted the following items:

- the EmerMaps, conceived and elaborated as decision-making support, proved to be very useful for the definition of the strategies for managing the emergency;
- the collected information and its representation in the EmerMaps helped define the priorities of intervention by adopting a multi-criteria approach, depending on the identified scenario;
- the utilization of webGIS allowed the sharing of outcomes in real time with decision-makers far from the affected area;
- the adoption of indicators designed ad-hoc permitted the communication of results in a simple and complete way, meaning the decision-makers could outline the strategies of intervention considering a variety of criteria;
- the exercise proved that it is possible to transfer the knowledge of the adopted methodologies and procedures in the field, i.e., during the evaluations (capacity building);
- the exercise tested a new type of short-term countermeasure for guaranteeing street access in the case of a façade threatening to collapse on a street.

After the exercise, taking into account the results of the debriefing, the National Fire Service officially adopted the procedures tested during the SERM-ex exercise.

4.3. Nepal earthquake, 2015

After the large earthquake that hit Nepal, specialists from the STCS system were deployed to the affected areas in order to provide support for the assessment of the condition of cultural heritage buildings. At the same time, at the SPRINT-Lab of the University of Udine, the scientific unit established a coordination unit in continuous contact with the STCS personnel in Nepal.

The STCS surveyors adopted the TriagEdEm form (translated into English) to evaluate the safety condition of the buildings. In the field, all the operations were managed in strict cooperation with UN and UNESCO local authorities. At the end of each day of surveys, the team in Nepal uploaded the compiled forms and pictures in a shared folder on a cloud storage service. Three teams of STCS surveyors assessed the conditions of 90 strategic building in the Kathmandu area, from the May 1 to May 11, as illustrated in Fig. 8a. At the same time, the scientific unit at the coordination office in Italy processed the data (Fig. 8a), producing daily reports and maps to share with the deployed teams and with the national and international organizations interested in the mission (Ministry of Interior, UNESCO, and Nepalese local authorities). Fig. 8b shows a synthesis of the final judgements, both for ordinary buildings and special buildings. Figs. 8c and 8d show the EmerMaps with the final indicators. The EmerMaps are also online (shared privately with the involved organizations), and it is possible to select individual points and download more information acquired during the surveys. Furthermore, in coordination with UNESCO's local authorities, the monuments of the Patan Durbar square in

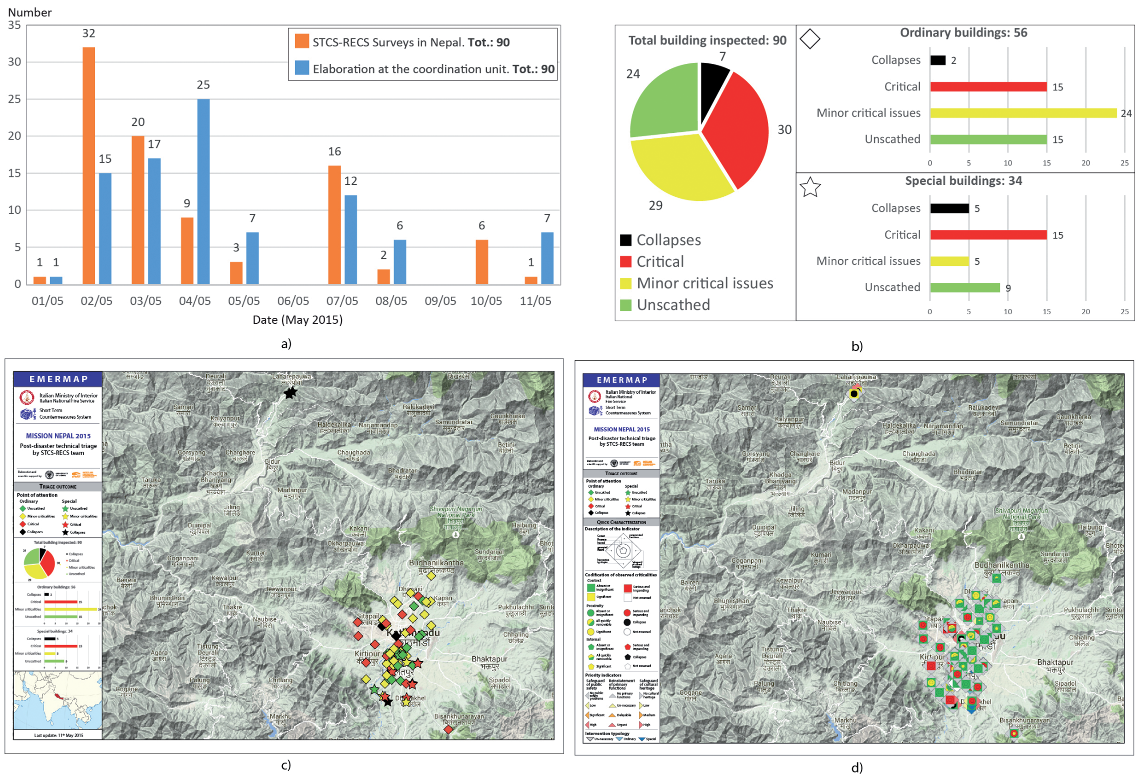


Fig. 8 - a) Distribution of the number of surveys done by STCS-RECS teams in Nepal and number of surveys processed at the coordination unit in Italy. b) Synthesis of the outcomes in terms of final judgement. c) EmerMap summarizing the Triage outcomes. d) EmerMap summarizing the outcomes of the quick characterization.

Kathmandu were assessed and specific proposals for short-term countermeasures to secure the structures were developed.

This experience demonstrated the effectiveness of the adopted methodology. In particular, the link between the deployed team and the scientific unit optimized, not only the quick assessment and the design of the short-term countermeasures, but also the interaction with local authorities.

5. Conclusions

The experiences of CNVVF during seismic emergencies highlight the importance of facing an emergency with predefined operational and organizational procedures. The STCS capitalizes on past experiences and takes advantage of the different skills of several units of the CNVVF in order to cope with the emergency phase. The purpose of the STCS procedures is to approach the emergency in an organized way, and to provide the necessary data to decision-makers for a prompt response. Also, STCS organization and procedures create a link with many organizations working during the emergency, especially within the National System of Civil Protection, but also at the international level, as proved by the Nepal experience.

The predefined operational procedures increase the safety of the CNVVF personnel. In fact, the predefined procedures explicitly foresee the safe approaches for the surveys and for the construction and installation of the countermeasures. Furthermore, the participation of the personnel in specific formative paths and training courses on the different phases of the STCS activities also increases their safety.

The first two tests of the STCS framework, although on a small scale, provided good feedback regarding the entire process, but it is expected that the next emergency requiring the deployment of STCS will evaluate if further improvements are required. In any case, the adaptability of the STCS framework should allow adjustment of the procedures to specific requirements.

The establishment of STCS was possible thanks to the collaboration between CNVVF and the SPRINT-Lab researchers of the University of Udine, highlighting the synergy between scientific and operative institutions.

Finally, it is important to underline the relevance of having a system to coordinate the different CNVVF units and scientific support from universities during an emergency, in order to create the safety conditions required to move from the state of emergency to rehabilitation and reconstruction.

Acknowledgements. The authors would like to express their gratitude to all the members of the STCS and all the firefighters who contributed to enhancing and improving STCS activities with their constructive comments and suggestions. A special thanks to the SPRINT-Lab researchers who actively contributed to the activities. The authors would also like to thank the reviewers M.P. Boni and C. Spagnesi for their comments, which improved the manuscript.

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