Large scale disasters and vulnerable people: the role of ICT

Stefano Marsella[1], Marcello Marzoli[1] , Paolo Mirabelli[12]
[1]Corpo Nazionale dei Vigili del Fuoco, Istituto Superiore Antincendi, Roma, Italy
[2]Consiglio Nazionale delle Ricerche - Istituto per le Tecnologie della Costruzione
[stefano.marsella, marcello.marzoli]@vigilfuoco.it, mirabelli@itc.cnr.it

Abstract

Much progress has been made over the past decade in developing emergency planning and programs to prepare for, respond to and mitigate a wide range of hazards. The same period can be considered as a natural laboratory of disasters, from severe weather emergencies to contagious disease outbreaks and highlights the urgent need to better address safety and security issues within our communities and businesses. Also the financial impact of these major disasters demonstrates that investment in planning, hardening of assets and preparedness efforts is significantly less than the cost of recovery, which may disrupt country economies for years.

Vulnerable populations, including those with disabilities, the elderly, the situationally disabled, and those with special needs are at particular risk in a disaster.

Moreover, communicating preparedness and warning information is critical for these groups. Given the historical evidence that significant numbers of any population fail to respond or act upon warnings of imminent disaster, the question of how to deliver effective messages to those with perceptual, cognitive, communicative, or learning disabilities is all the more challenging. Additionally, tourists, recent immigrants, and refugees face challenges when confronted with disaster in unfamiliar locations, linguistically isolated, and in need of assimilating lifesaving guidance quickly.

In this specific context, public health authorities and disability organizations recognize this digital divide as part of the problem. In some cases steps have been taken to improve emergency planning and response for people in these at-risk groups.

Literature normally addresses the issue considering that informing people does not only mean to send out a message, but to send it out in time (usually, as fast as possible) and sending it in an understandable way. Also, a warning message should be distributed through different media channels, so that the coverage is as large as possible.

According the Authors, while the communication capabilities of authorities to citizens (issuing alarms *in primis*) has already been directed to a solution, mostly through the adoption of the CAP protocol, there is still at least a gap in the cycle that should be activated concerning the information flow from citizens to authorities.

1. Introduction

Large scale disasters occur every year and their frequency and magnitude seems to be increasing, with the consequence of affecting a growing part of the world population. Fig. 1 gives some meaningful numbers elaborated in the insurance sector.

In many cases, the only way to limit casualties by natural hazards is to manage adequately the emergency response, which is, according the US Department of Homeland Security, ”*a continuous cycle of planning, organizing, training, equipping, exercising, evaluating, and taking corrective action in an effort to ensure effective coordination during incident response”* [13]. In order to reach such goal, emergency communication has an important role, since the integration of the communication tools within emergency response plan improves the speed of response and the

localization of the rescue needs. The structure of the messages is complex too, as Fig. 2 shows, and the communication systems must be consistent with the different needs implied in its use.
Adequate communications allow Authorities to alert people timely and people to inform Authorities

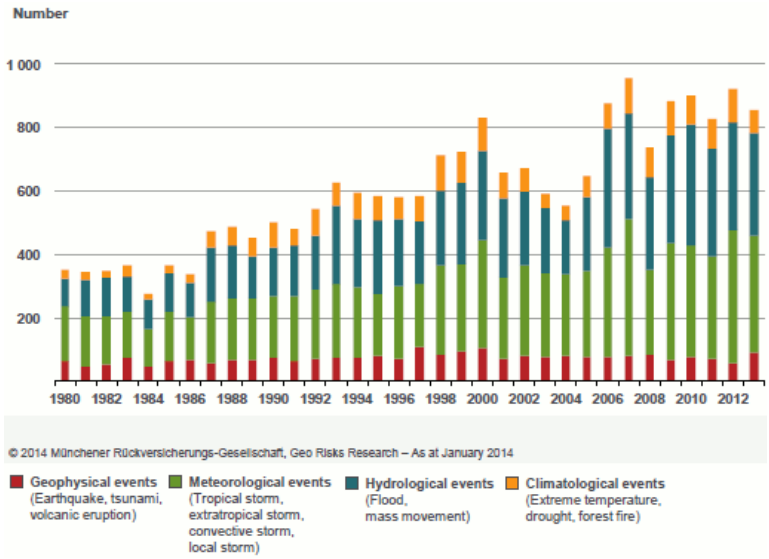

Fig. 1 - Number of natural catastrophe loss events worldwide 1980 - 2013 - Source: [11]

about their needs. Consequently, Authorities can deploy the needed rescue resources according to the emergency response plan and the priorities defined on the basis of the operational picture which the communication resources have helped to build.
World population is composed for a significant extent by people with disabilities, reaching, according to some sources, up to the 20 per cent of the total. Although a generally accepted definition of vulnerable people does not exist, normally the term is related to people with disabilities, aged and temporarily sick. Applying this term to the communication field, we must consider how to deliver effective messages to those with perceptual, cognitive, communicative, or learning disabilities, which is all the more challenging. Additionally, tourists, recent immigrants,

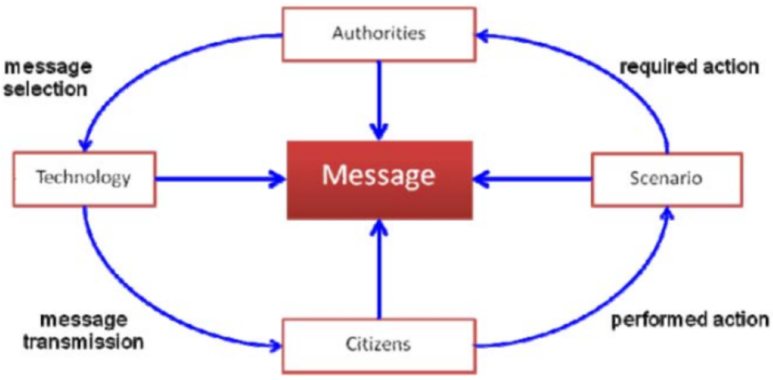

Figure 2 - Cycle of warning influences from [16]

and refugees face challenges when confronted with disaster in unfamiliar locations, linguistically

isolated, and in need of assimilating lifesaving guidance quickly. Moreover, considering the systems to be used in issuing warning messages, we must recall that the citizenships become more and more fragmented, turning to specialized outlets for news and warnings.
Such factors oblige to plan the dissemination of the public alerts through different media channels, but ensuring a coverage as large as possible means to consider also the digital divide, a problem which affects more than half of the world population.
As a result, planning the response to an emergency means choosing communication tools adequate to the need of informing people in the specific time interval that the disaster allows [15]. Its final goal is to reach all the population potentially affected by its effects to let people understand the need of taking the appropriate actions (i.e. evacuation, shelter in place, etc.).
In such situation, the problem that emergency managers have to face is at least threefold: (i) informing timely and precisely people about the extent of the damages and the location of the threats brought by the event; (ii) being informed about the rescue needs of population and (iii) deploying rescue teams and assistance services.
Both the data exchange and the coordination of the appropriate response in large scale disasters can

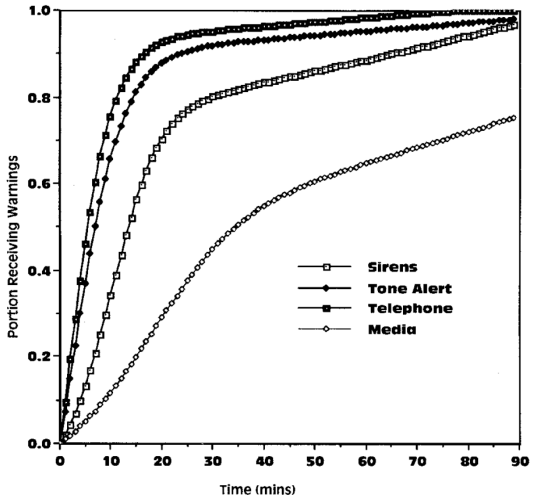

Fig. 3 - Average Dissemination Time for Alternative Warning System Technologies. From [15]

be performed only with specifically designed information and communication systems.

1.1. Emergency plans needs and communications systems role

Emergency civil protection plans normally specify procedures to handle sudden or unexpected situations. A meaningful case study which highlights the importance of consistency of warning system with emergency needs can be found in the report [8] that the NIST has elaborated after the Joplin (US) tornado disaster, in 2011.
Since the objective of the emergency plan is to be prepared to prevent fatalities and injuries and accelerate the reentry of population in their homes, its content should include all possible emergencies, their consequences, required actions and resources available. Moreover, when a risk situation is going to threaten a populated area, the time needed to evacuate population should be taken into consideration. The NFPA standard 1616 - Mass Evacuation and Sheltering Program [12] - is a comprehensive example of the amount of information, procedures and data that a plan should include.

The link between the plan and the role of the communications systems can be individuated mostly in two tasks, related to: issuing of the warning messages and collecting rescue requests from population. Both aspects are time-related. In many cases, in fact, a plan is effective if people reaches safe places before they are exposed to a risky situation (i.e. a tornado or a toxic cloud), but the time needed to evacuate includes also the time needed to be informed and to understand what to do. So that, timely informations are an important part of the process and strongly depend on the technologies used, as shown in the fig. 3. The choice of the technologies to be used to warn population before an emergency, thus, depends on the requirements of the emergency plan.

In the structural fire protection sector, when determining if a building is safe, the criterion of comparing the time available for a safe egress (ASET) with the limit of tenability time (required safety egress time, RSET) is expressed by the expression ASET > RSET, as shown in Fig. 4. The same criterion could be applied to large scale emergencies which require a mass evacuation to let people reach a safe place before the risk become no more tolerable. Fig. 5 gives a simplified

Fig. 4. Required egress safety time in structural fire protection

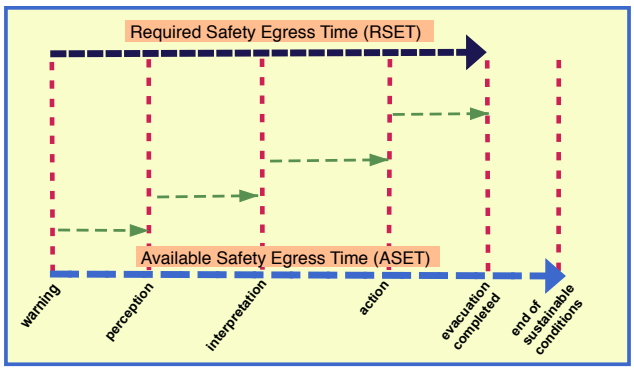

Fig. 5. The concept of ASET vs RSET applied to mass

interpretation of the concept when applied to mass evacuation, in order to highlight the role of the warning system and of the quality of the messages the systems deliver to people.

The request of rescue, on the other hand, is inherently a time-related matter. In this case the technology to be used is an issue which arises when we have to deal with big numbers of people asking for rescue at the same time. At the moment, most (if not all) of the PSAPs (Public Safety Answering Point) in the world have a limited possibility to deal at the same time with more than two dozens of calls, putting on hold the majority of calls. But, how to manage the emergency when hundreds of people call the PSAPs? Even if the rescue resources are limited, there's a clear responsibility in deploying the rescue teams according the priorities, which once again arises a time issue.

1.2. Digital divide as a risk factor

In 2014 mobiles have outnumbered the world population. That implies that during the emergencies too, people relies more and more on the use of mobiles and, in a vastly growing way, on smartphones. On the other hand, half of world population does not have access to ICT resources.
Consequently, the unavailability of access to such devices in the course of emergencies can be considered as a risk factor. In fact, people life or integrity can be often threatened if not timely informed on hazard situations or instructed with the actions to take
A meaningful description of the problem faced by emergency planners to ensure timeliness and effectiveness of alarm messages in real-life situations (where digital divide and vulnerable people have to be taken into account) can be found in [1]. This report highlights that, even though US specific requirements about alarm messages require that National Emergency Alarm System (EAS) messages have to be delivered in both audio and visual (captions, message boards, other) formats, "*regular broadcasts about emergencies, do not have to comply with the requirement. The community of disabled individuals, therefore, is often under-served when emergency information is disseminated outside the EAS network. Although a number of technologies exist to provide accessible formats for people with special needs—such as those with disabilities, the elderly, and those who do not understand English—many of these solutions are not supported by the current EAS system or are so expensive as to be inaccessible to most*" [10]. Such consideration, when applied to a global view of the problem, must take into consideration that more than half the people in the world have not mobiles yet. Digital divide affects two different levels: (i) the divide within countries, which may refer to inequalities between individuals, households, businesses, or geographic areas, and (ii) the divide between differing countries or regions of the world.
Actions to limit the divide effects on the management of large scale disasters must consequently be taken considering both levels. Such consideration will not be further discussed in this paper, but is strictly connected to the use of broadcast messages on TV and radio to enhance the capacity of informing people on incumbent risks or actions to be taken, with a specific attention to the needs of vulnerable people.

1.3. Vulnerable population: emergency communication peculiarities

The picture depicted above highlights how many are the gaps which have still to be filled by the emergency management community. In this framework, some specific considerations must be added to address the problem of communicating with vulnerable people. We can summarize the open issues as follows:

- emergency calls: emergency calls are still problematic in the case of (i) deaf people, (ii) language barriers, lack of communication capabilities due to the (iii) lack of adequate ICT systems or for (iv) disruption induced by disasters. In the first case (deaf people), research projects have shown that the use of IP-based systems can help people at improving the efficiency of the communication flow with sustainable cost, wherever people can have access to the web. The use of SMS service could be accepted in the other cases, but has strong limits due to the impossibility of ensure reasonable delivery times [14]. Also the limited length and consequently poor content of the messages between control rooms and the citizen asking for help does not help using such tool. The second problem (language barriers) has been addressed in many EU countries through the provision of simultaneous translation services to the 112 European emergency number. The third case (digital divide due to lack of ICT systems) is one of the most challenging problems and at the moment the only way to overcome it may be seen in providing low cost services to the areas or the citizens who face such problem. The case of lack of communication systems due to the effects of the disasters

can be dealt through emergency management plans which foresee redundant systems to ensure the communication between citizens and emergency control rooms;

• public alerts: issuing a public alert timely and comprehensively still presents problems. In such context, the vulnerability of people for physical disabilities or digital divide can be considered one of the main aspects to be dealt, though the common approach to address the complexity is issuing the alerts also through public and private broadcasting systems. Such solution normally allows the alerting Authority to reach areas not completely covered by IT systems, but ask for a regulation effort for a sector which is not always covered by any kind of rule for such purpose. May be worth to highlight that several real cases show the utility of adopting a standard protocol to distribute alerts in a faster and more reliable way.

1.4. Available technologies and communication flows

Having regard to vulnerable people, the main issues which arise analyzing the emergency management systems are:

• Access to emergency calls for deaf and hard-of-hearing people . In the EU member states, according the EU Directive 2002/22/EC [4] on Universal Service, it should be guaranteed access to all publicly available telephone services for disabled users and users with special social needs. Though the directive has been issued 14 year ago, there is not yet a common solution, to a problem which involves some 360 million people in the world. In particular, some emergency services make use of SMS-based systems, in other cases they allow the use of fax, but most PSAPs have not adopted any measure.

• Reaching vulnerable people in the aftermath of a disaster. Presently the problem of contacting vulnerable people in the aftermath of a disaster, in order to give specific information and collect specific assistance needs, is lacking solutions. Such role has actually been played by social media in the aftermath the Fukushima disaster (Japan, 2011) [6], [17], but no programs seem to be started with the aim of collecting the needs of people with disabilities and make such information real-time available to the control rooms of the emergency services;

• Reaching people affected by the digital divide. Warning people on incumbent hazards and instructing them on the actions to take, could become more and more difficult in situations where access to communication systems fails (both for disaster-related causes and for digital divide). In both cases the emergency plan and the warning systems must be consistent in order to define which systems can be used to warn people.

This short (and probably incomplete) list highlights the basic information flows during emergencies, which may be summarized as follows:

• Authorities to Citizens (A2C), which normally initiates with the issue of the alert;

• Citizens to Authorities (C2A), that is the call to the PSAP from the person who needs to be rescued;

• Authorities to Authorities (A2A), which is strictly connected to the need of coordinating rescue and relief operations, possibly through the interoperability of the communication systems [9].

One of the most critical aspects of large scale disaster operation is the risk of not reaching all the population exposed to the disaster, both with the correct information and with the rescue activities (Katrina, USA 2005). In particular, the first two flows directly concern citizens and specially the vulnerable part of the population.

2. Problems solved

2.1. A2C and the CAP standard protocol

The main role of A2C communications is to provide timely and appropriate information regarding incumbent risks and instructions for the population affected by a disaster. In this field, significant improvements have been made by the adoption of the CAP standard, which allow a fast flow on information among control rooms and from control rooms to mass-media. The IDIRA project (co-funded in the framework of the EU - FP7 research and development program), has further shown the need and the feasibility of solution with the available technologies [7]. Specific studies developed by the FIA [1] show how wide can be the range of people reached by alerts issued with the CAP standard protocol [3]. Such peculiarity of the standard can be also used to improve the reach of the alerts to vulnerable people. Dedicated multi language platforms could be set up to provide early warnings to people with faces language barriers. Issuing public warnings through text messages can immediately reach deaf people. In case of situations marked by the digital divide, the broadcasting of the alerts through TV or radio could benefit from the advantages of the CAP standard as well.

2.2. Emergency calls for deaf people

Different solutions have been proposed to replace the early solutions selected to allow deaf people to call rescue services. The need of replacing SMS messages is mainly related to the impossibility of ensure the timely delivery of the SMS (at the moment service levels do not provide immediate delivery times), which is crucial when rescue is needed or life is threatened. Fax messages, on the other hand, cannot provide much flexibility and ease of use [14].

As a response to the needs of exchanging information between deaf people and PSAPs, trial IP based applications have been developed. In the course of the EU-funded FP7 research project SAVE ME [5], for example, the Italian Fire Corps and a deaf people National association developed a system that allows data exchange in real time, typing text messages on a custom-made web interface or using a mobile device application. Such solution needs an internet connection, which is not always available and may pose sustainability problems, but at the moment seems to be the only possible answer to such specific need.

3. Problems to be solved

3.1. C2A: a problem still open

One of the possible ways to improve the capacity of vulnerable people at reaching rescue services is to allow them to contact rescue/relief control rooms, through social media. However such solution is strongly limited during large emergencies for the impossibility to simultaneously manage large numbers of messages. E.g. , during the terroristic attacks of Nov. 13th, 2015 in Paris, some 2.3 million of messages (with peaks of 1.200 messages per minute) have been exchanged on the social media [2]. Such enormous flow of information could not be managed by any manned control room (which are normally understaffed with respect to situations slightly more complex of the daily activity). As a matter of fact large scale disasters strongly challenge the capacity of rescue authorities when in comes to collect emergency calls from hundreds or thousands of people and still calls for an effective answer, which should be respectful of the special needs of vulnerable people.

3.2. Families reunification

Reunification of families and groups as well as searching for missing relatives can pose a serious problem in many cases. During large scale emergencies (e.g. in 2011 in Japan, the Tohoku

earthquake which caused the death of some 18,000 people, the need of a sudden relocation of thousands of people and disruption of many services) one of the first problems felt by the population is the urge of contacting relatives to assess their health status, rebuild family and social contact. This need, that concerns the relief activities more than the rescue operations, in the 2011 Japan earthquake case was partially satisfied by a spontaneous massive use of social networks. In this case, when "*Websites, powered by broadband connections, became a lifeline for many when mobile phone networks and some telephone landlines collapsed in the hours following the 8.9 scale earthquake*" [6], broadband resilience was critical to help people and facilitated the work of emergency managers, who did not have to commit excessive resources to help find relatives or to restore relationships.

In this framework, commendable initiatives from both NGOs and IT companies played a crucial role, as it was the case of the "*Restoring Family Links programme*" (http://familylinks.icrc.org/en/Pages/home.aspx) offered by the ICRC and National *Red Cross* and the Red Crescent Societies and the "*Google Person Finder*" service (https://google.org/personfinder/global/home.html), which could both allow the use of interoperability services based on the Emergency Data Exchange Language (EDXL) Tracking of Emergency Clients (TEC) Client Registry standard drafted by the same OASIS Committee which maintain the EDXL-CAP standard..

4. Conclusions

In general terms, the first problem to solve is the adoption of a shared vision of the communication problems related to the vulnerability of the population, since emergency planners and ICT experts seems not to know each other's needs. The final goal should be to develop economically sustainable technologies able to satisfy the needs of vulnerable people, while being consistent with the needs of emergency management planning.

Improving safety of vulnerable people during large scale emergencies is strongly dependent on the communication quality. Physical impairments and digital divide create very challenging situations when a disaster occurs.

The possible solution lies in the use of a multi modal approach to ensure timely warnings and easier communications from citizens to PSAPs.

Even considering that the digital divide among differing regions of the world imposes to address the analysis of these specific needs, existing ICT systems and the use of the CAP standard can play an important role to timely spread correct information and warnings.

At the moment the problem of receiving thousands of rescue calls in a limited time interval is still not addressed and this fact also impact on the safety of people with special needs. Social media could be useful for helping people with special needs, but solutions to allow calls for assistance from the most vulnerable sectors of the population when a disaster occur have yet to be proposed.

5. References

(1) (FIA), F. for I. A. (2014). Public Warning Design Guidelines for FIA Messaging.

(2) Ahmad, K. (2015). *SLANDAIL Project - Security System for Language and Image Analysis*. *I4CM*. *http://doi.org/10.1007/s13398-014-0173-7.2*

(3) Common Alerting Protocol Version 1.2le. (2010). Retrieved from http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html

(4) EUR-Lex - 32002L0022 - EN - EUR-Lex. (n.d.). Retrieved January 23, 2016, from http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32002L0022

(5) European Commission : CORDIS : Projects & Results Service : Periodic Report Summary - SAVE ME (System and actions for vehicles and transportation hubs to support disaster mitigation and evacuation). (n.d.). Retrieved January 23, 2016, from http://cordis.europa.eu/result/rcn/56966_en.html

(6) Glionna, J. M. (n.d.). Report: Japan, utility at fault for response to nuclear disaster. Retrieved September 3, 2015, from http://latimesblogs.latimes.com/world_now/2011/12/japans-march-11-earthquake-and-tsunami-fukushima-daiichi-nuclear-power-plant-meltdown.html

(7) IES. (2015). *Interoperability of data and procedures in large-scale multinational disaster response actions* - IDIRA FP7 Project, March 2015, from http://www.idira.eu/index.php/downloads

(8) Kuligowski, E. D., Lombardo, F. T., Long T., P., & Levitan, M. L. (2014). *http://dx.doi.org/10.6028/NIST.NCSTAR.3*. Retrieved from http://dx.doi.org/10.6028/NIST.NCSTAR.3

(9) Marsella, S., Marzoli, M. (2014). Interoperability as a Daily Challenge: Enhancing Operational Data Exchange between Rescue Organisations. In *9th SECURITY RESEARCH CONFERENCE »Future Security*. Berlin: Fraunhofer IOSB.

(10) Moore, L. K. (2010). *Emergency Communications: The Emergency Alert System (EAS) and All-Hazard Warnings*.

(11) Munichre. (n.d.). number of catastrophes worldwide 2014. Retrieved from http://www.munichre.com/en/homepage/index.html

(12) NFPA 1616 - Mass Evacuation and Sheltering Program 2017 edition. (2014).

(13) Plan and Prepare for Disasters Homeland Security. (n.d.). Retrieved January 23, 2016, from http://www.dhs.gov/topic/plan-and-prepare-disasters

(14) Rey, D. (2012). EENA Operations Document 112 Accessibility for People with Disabilities, 1–21.

(15) Sorensen, J. H. (2000). hazard warning systems: review of 20 years of progress. *Natural Hazards Review*, 120–125.

(16) Sullivan, M. T., & Häkkinen, H. T. (2006). Disaster preparedness for vulnerable populations: Determining effective strategies for communicating risk, warning, and response. *Third Annual Magrann Research Conference at Rutgers University*, *4*, 1–36. Retrieved from http://magrann-conference.rutgers.edu/2006/_papers/sullivan.pdf

(17) Wallop, H. (n.d.). Japan earthquake: how Twitter and Facebook helped. Retrieved from http://www.telegraph.co.uk/technology/twitter/8379101/Japan-earthquake-how-Twitter-and-Facebook-helped.html

(18) Emergency Data Exchange Language (EDXL) Tracking of Emergency Clients (TEC) Client Registry Exchange Version 1.0 from: http://docs.oasis-open.org/emergency/edxl-tec-registry/v1.0/csprd01/edxl-tec-registry-v1.0-csprd01.html