The Role of Social Media in Crisis:

A European Holistic Approach to the Adoption of Online and Mobile Communications in Crisis Response and Search and Rescue Efforts

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Abstract

Worldwide crises recently prompted new attention to the role information communication technologies (ICT) play in SAR and crisis response efforts, due to the growing citizens' participation through online (social) media and mobile communications. Empowered by new communication media, such as mobile phones with cameras, text messaging and internet-based applications connecting to social media platforms, citizens are the *in situ* first *sensors*, but their added-value involvement in crisis response efforts is often disregarded by First Responders (FRs) and Public Protection and Disaster Relief (PPDR) organisations, whose traditional command and control models do not easily adapt to the new crises' trend of including a global, digitally enabled social arena, a condition that is further hampered by restrictive legal framework and privacy concerns.

Founded in the analysis of several case studies, we present herein **iSAR+**, a holistic approach to the effective adoption of the new communication media in emergencies or crises by PPDRs and Citizens. The proposed approach shall enable the use of these technologies for a bi-directional provision, dissemination, sharing and retrieval of information between PPDR, FRs and citizens, with the later acting as strong enablers for the rapid generation of high levels of awareness and C2 agility, during and after crisis situations.

Addressing a complex subject, the multi-dimensional nature of this approach considers the organisational, human, technological, legal and ethical aspects that entail the increasingly relevant role of new online and mobile media in crises.

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Key Definitions

- **Crisis**: The beginning of the XXI century has been deeply marked by the repetitive occurrence of large-scale natural disasters and human-provoked emergencies, events commonly known as crises. Crises come in many forms – natural disasters, economic collapses, infrastructural destructions and terrorist actions – but crisis terminology, its exact meaning and its relation to other concepts remain unclear. What prevails is a common understanding of the disturbance of stability that a crisis situation entails, that is, the threat to fundamental priorities, the challenge of making the right decisions under severe pressure and the fatality of loss of control, property and life. In this paper, crisis is defined in the security context as resulting of human activities, technological hazard events or natural phenomena, and understood as the situation in which the priority values, interests, preconditions or critical functions of large social systems are seriously threatened, challenged, impaired or overloaded [1].

- **Social Media**: Social media refers to *"online technologies and practices to share content, opinions and information, promote discussion and build relationships. Social media services and tools involve a combination of technology, telecommunications and social interaction. They can use a variety of formats, including text, pictures, audio and video*." [2]. Accordingly to Kaplan and Haenlein, there are six different types of social media: collaborative projects (e.g. Wikipedia), blogs and microblogs (e.g. Twitter), content communities (e.g. Youtube), social networking sites (e.g. Facebook), virtual game worlds (e.g. World of Warcraft) and virtual social worlds (e.g. Second Life). The applied technologies include blogs, picture sharing, vlogs, wall-postings, email, instant messaging, music sharing, crowdsourcing and voice over IP [3].

- **Online and Mobile Communications**: Online communications refer to the definition of social media; mobile communications encompass all the communication that is based upon the use of mobile devices, such as mobile phones, smartphones, tablets, portable computers and personal digital assistants (PDAs) [4].

- **iSAR+** is the acronym for "Online and Mobile Communications for Crisis Response and Search and Rescue" to be interpreted as an aggregation of characters each conveying the following meaning:
    - 'i' is the first letter of 'internet' and highlights the state of being always connected to the global platform, which is why it is commonly associated to mobile online tools (e.g., iPhone). Thus, it refers to online mobile technology that is always connected.
    - 'SAR' is the convenient acronym to "Search and Rescue", a particular mission within the crisis response efforts addressed by this paper.
    - '+' reinforcing the enhancement proposed by the iSAR+ approach, as a direct result from the combination of online mobility with SAR operations, considering frequent social behaviours and interaction, bi-directionality and participation or involvement of citizens in the crisis response efforts headed by Public Protection and Disaster Relief (PPDR) agents.

1. INTRODUCTION

Worldwide crises recently prompted new attention to the role information communication technologies (ICT) play in SAR (Search And Rescue) and response efforts. With a century old history of investigation, the sociological study of crises is aware that ICT *expanded the reach of disaster sociology* [5] and is now focused on the emerging trend of the growing citizens' participation through online (social) media and mobile communications (computer-mediated interaction), providing, seeking and brokering information, connecting those within and outside the geographical space of the crisis, with implications for both informal and formal response. However, First Responders (FRs) and Public Protection and Disaster Relief (PPDR) organisations[2] and their traditional command and control models, do not easily adapt to the new crises' trend of including a global, digitally enabled social arena.

iSAR+, the approach described herein, proposes the integration of ICT tools and functionalities (e.g., web portal, PPDR support tools and mobile applications) that offer additional communication channels between PPDRs and citizens. In the process, iSAR+ aims to enable PPDRs to (rapidly) generate high levels of awareness, during and after a large emergency or crisis situation, by exploiting the bi-directionality communication potential of the citizens' wide adoption of mobile technology and social media and integrating it into existing PPDR crisis management and response systems. How today's crisis responses include social media and how they will benefit from mobile and online (social) media as envisioned by iSAR+ is portrayed in Figure 1.

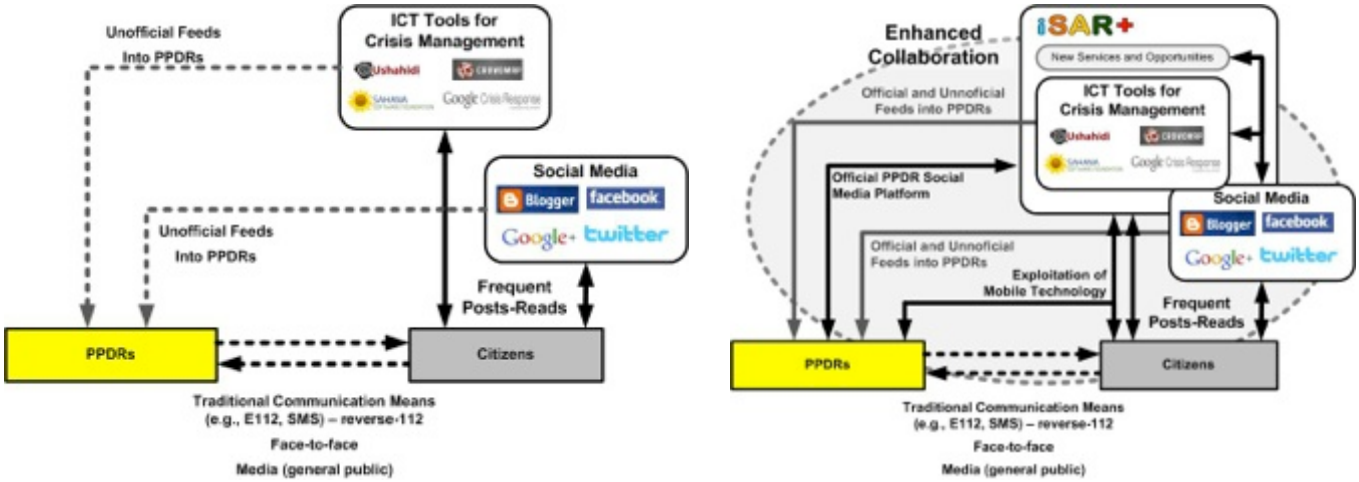

Figure 1 – Social Media in Crisis Response: Today and As Envisioned by iSAR+

This paper is structured as follows: we start by presenting lessons learned on past crises, then we acknowledge the role ICT tools and social media platforms play in crises, to then present the iSAR+ Way, that is, the approach to the problem (in a multi-dimensional way) and a proposed platform that will enable the involvement of new media users in the effort to leverage the citizens' security in crisis situations. As ancillary material, we present two annexes: in the first, presents the analysis of several past crisis situations and, in the second one, we present several ICT Tools that have been useful during emergencies and crisis.

2. LESSONS FROM PAST CRISIS SITUATIONS

Large-scale natural disasters and human-induced emergencies, or simply crises, disturb routines and raise significant public scrutiny and undivided media attention, a reality that is not dissociable of today's global emphasis in ICT. Orlikowski's theory on the co-adaptation of technology and society, highlighting the creative interdependence of social evolution and technological innovation, has its ultimate token in society's addiction to the use of Internet and mobile technologies, displaying unprecedented information and communication capabilities [6]. Today, mobile and online social media are dramatically changing geopolitics, economic contexts and business competitiveness, that is, transforming societies, a catharsis that is also present in the potential for an improved response to disasters and crisis response efforts.

[2] Typical entities dealing with these domains are governmental organisations (police, law enforcement agencies, civil protection, fire brigades, medical emergency and military organisations) and humanitarian organisations (e.g., Red Cross).

Throughout History, several overwhelming natural disasters and human-induced actions have prompted crisis response efforts that have made their mark, providing valuable lessons on crisis management systems, plans and organisations. We analysed some of those lessons[3], aiming to understand how current crisis response efforts are carried out by local FRs and PPDRs and how common citizens are involved in those efforts, focusing mostly on the use of mobile technology and online (social) media.

The analyses reveal that, in emergencies and crisis, amidst the collapse of all critical infrastructure, communications withstand extreme damage or destruction. Landline phone networks are unavailable or intermittently available, with the surviving stations of the 112 or 911 emergency service rapidly becoming overwhelmed by the incoming volume of calls, as occurred in the 9/11 terrorist attacks [7], the Madrid train bombings [8] and the London tube explosions [9]. A different case was registered in Norway, for 112 operators dismissed all calls that were not related to the Oslo bombings, although they were made to report the shooting at Utoya, proving that the failure of official emergency systems is not only determined by technology [10]. Fibre-optic connectivity and mobile telephone networks are severely affected but, in most of the crisis situations studied, they exhibit a more resilient performance, especially concerning the capacity to establish SMS and text messaging communication [11]. Overall, the scarcity of communications access hampers information availability and, consequently, crises' situational awareness and response efforts, in what was fairly evident both in the 2004 Indian Ocean Tsunami and the 2010 Haiti Earthquake.

In fact, ICT have proven their worth in providing both PPDRs and the public the scarcest resource in crisis situations: information. In a society that has grown accustomed to immediacy and instantaneity, ICT and their strong real-time emphasis are fundamental to gather and deliver information, not only in terms of alert and emergency notifications but also respecting the attainment of the most complete situational awareness picture. And yet the large majority of official PPDR channels do not include online social media, instead choosing to practice a unidirectional information dissemination model towards the public, that is often scarce in availability, details and empathy and usually resorts to the traditional TV and radio broadcasts – in the Californian Wildfires and the Norwegian massacre, those media have been heavily criticised for being prone to sensationalism and irresponsive to the local communities' real needs [35] [6]. Communicating with the public is always a challenge, a difficulty further highlighted in the 2005 London Tube attacks, for the United Kingdom's Data Protection Act prohibits sharing personal data without the consent of those concerned, thus limiting what information officials could give agencies and families on the identity and status of victims [8]. Indeed, crises such as this question the balance between individual privacy and public security.

As a result of the repetitive lack of official information, and because it is rare the high-levels of preparedness of some societies, such as the Chilean people[4], citizens choose the rich contents provided through the mobile and online social media technologies, requesting assistance, looking for information and trying to locate missing relatives and friends. This is why, over the long span of the Chinese SARS outbreak crisis, 120 million text messages were exchanged [13] and, immediately after the 2010 Great Japan Earthquake, Twitter became the emergency service with 1200 tweets per minute [14] or even why Mission 4636[5] received 1000 SMSs per day [15]. Moreover, the growing global phenomenon of citizens' journalism through the online social media has been instrumental in providing eye-witness accounts and first reports from the affected areas, thus contributing to the enhancement of the general public's situational awareness in crisis situations and SAR actions – it was so in natural catastrophes like the 2004 Indian Ocean Tsunami, the 2005 Hurricane Katrina and the 2010 Haiti Earthquake, but also in the US, London and Madrid terrorist attacks. Also volunteering across the Globe and the use of ICT tools have prompted citizens' initiatives like the South East Asia Earthquake and Tsunami Blog[6], the *Digitales por Chile*[7] or the Ushahidi platform to became useful sources of information on the crisis' evolving situation, the relief assistance and the tracking of missing persons.

[3] The crisis responses analysed were the September 11th 2001 Terrorist Attacks on the US, the 2003 China SARS Epidemic, the March 11th 2004 Madrid Train Bombings, the December 24th 2004 Indian Ocean Tsunami, the July 7th 2005 London Tube Bombings, the August 29th 2005 Hurricane Katrina, the April 16th 2007 Virginia Tech Shooting, the 2007 Southern California Wildfires, the January 12th 2010 Haiti Earthquake, the January 27th 2010 Great Chilean Earthquake, the 2011 Australian Victoria Floods, the March 11th 2011 Great Japan Earthquake, the 2011 Middle East Upheavals, the 2011 England Riots and the July 22nd 2011 Norwegian Terrorist Attacks.

[4] The high level of knowledge about earthquakes and tsunamis of the Chilean citizens have determined their adequate response to the 2010 Great Chilean earthquake and tsunami [12].

[5] "4636" was the number of the free aid SMS service established in Haiti.

[6] Built by more than fifty worldwide contributors, this blog aggregated news and included a tracker for missing persons' reports and humanitarian efforts concerning the 2004 Indian Ocean Tsunami.

[7] *Digitales por Chile* is a 300-volunteer organisation that, in just 12 hours, created the www.chileayuda.com portal, with disaster-related information, including Twitter, Facebook, Ushahidi and Google's Person Finder, multi-layered geo-referenced mapping, official communications and donations. The information was constantly updated on rescue centres, medical assistance and police warnings.

Notwithstanding the amazing Facebook, Twitter, flickr, YouTube, instant messaging, SMS, MMS and emails technologies' benefits, it is also relevant to bear in mind its misuses and abuses. Not only they are extremely efficient instruments for defamation, slander, rumour and misguidance, but also social networking platforms have proven to serve as tools of change, in the 2011 Middle East upheavals to respectively organise protests and in the 2011 UK riots to coordinate looting activities. Today, there is an ongoing debate whether these tools should be further monitored or controlled, a matter that the Chinese government already resolved during the 2003 SARS Epidemic, when it used Operation Golden Shield to prevent public unrest [16].

The harsh reality of the crisis response efforts analysed often refers that PPDRs seldom have the ability to fully implement the national official emergency plan, carefully thought and defined to provide an effective and efficient response to crisis events.

Moreover, albeit most European emergency plans show concern for the general public and the media to be properly informed - so as to be able to follow the instructions provided by authorities and adopt the most auto-protective measures - there is no reference to Internet-based tools (e.g., institutional webpages or email) or to social media (e.g., Facebook or Twitter) as additional means for informing and contacting citizens, reinforcing the model's underlying *unidirectionality*.

In conclusion, the reports and evaluations from past crisis events and European emergency plans have enlighten us that: (1) PPDRs emergency services rapidly become overloaded or inoperational, including the emergency call service, disabling citizens to reach PPDRs; (2) short-text messaging has proven to be a resilient and efficient way for citizens to communicate (via SMS cellular, Twitter or Facebook) heavily (e.g., 5530 TPS during the Japan Earthquake as referred before) and save lives in the process (e.g., Mission 4636); (3) PPDRs do not regard social media as a valid authoritative tool to use nor they exploit the enormous potential of locating, reaching and communicating with citizens via their mobile technology. In fact, PPDRs still follow structures, models and approaches defined well before the Information Age.

The straightforwardness of the classic approach to crisis response efforts and the natural and human-provoked crises here presented do tackle the diversified aspects that convey today's crisis response efforts and citizens' involvement, particularly through the use of mobile technology and social media communications. Together with the statistics that prove the growing global trend of online and mobile adoption, these examples are true accounts of the current state-of-the-art in the use of new communication/social media in crisis situations. Still, it is worth noting the few exceptions that demonstrate the potential of that use, even when the example for these new ICT tools for crisis management is provided by the civil society.

3. THE ROLE OF ICT TOOLS AND SOCIAL MEDIA IN CRISIS

From the Haiti's earthquake to the Japan's tsunami, from the Katrina hurricane to the Californian wildfires, from the Virginia Tech shootings to the Norwegian island massacre, from the upheavals in the Middle East to the English riots, peer-to-peer communications, through mobile phones and social media, text and instant messaging applications, blogs, wikis and web *fora*, have became the designated ways for citizens to be involved and active in society, in crisis events.

Citizens' engagement, strongly enabled by social media and mobile technology, is supporting the dissemination of information, often critical and accurate, into the public sphere: providing eye-witness accounts, sending alert messages, exchanging evacuation and rescue experiences, searching and publishing event-related information, volunteering goods and services, collecting donatives. More than mere information distribution tools, these technologies connect people and information, establish collaboration mechanisms, create informal networks and build no-boundary communities. With a strong emphasis on real-time, new mobile and online technologies have significantly improved the affected citizens' and the victims' capability to help each other and themselves, with their messages enabling improved situational awareness amongst PPDRs and FRs, guaranteed by the gathering of a wide variety of data and information – an activity coined as *crisis informatics*[8].

Indeed, several initiatives, mostly private, leverage the real tributes of citizenship and volunteering towards crisis response efforts, whether on web-based crisis management systems, mobile applications for

[8] The University of Colorado researchers (Palen, Vieweg, Sutton, Liu & Hughes) define the **activity of crisis informatics** as a documented phenomenon that illustrates how people in and out of the disaster go on line through computers using Web 2.0 applications, cell phones and other personal devices to provide, seek and broker information in times of emergency [5].

emergencies, location awareness technology in crises, RSS feeds, social networking platforms or web citizenship on security. Web-based systems for crisis, such as Ushahidi and Sahana, contribute to the permanent monitoring of the evolution of crisis events, enabling crowdmapping functions, reports tracking on maps and calendar, alert services and the interaction with multiple sources of information (text messages, email, tweets, webforms). Also in this field, Google's Crisis Response is a free portal service applied in past crises (e.g., Chile, Haiti and Japan) to enable donations, alerts and infrastructure status reports, as well as satellite imagery and the Google Person Finder, whereas OpenStreetMap provides free worldwide geographical data created by a community of volunteers. These web-based systems started off as project-oriented initiatives and since evolved to accommodate the requirements of several other crises. Other projects remain confined to the specifics of determined events, namely the KatrinaHelp Wiki dedicated to the Katrina hurricane or DigiCel's Mission 4636, launched as a free phone number to meet the urgent needs of the Haitian people (medical care, food, water, security and shelter) through SMS messaging. Even the US Department of Homeland Security (DHS) launched the Haiti Social Media Disaster Monitoring Initiative to assist the Haiti response and recovery effort, creating a situational awareness vehicle able to monitor the publicly available online forums, blogs, websites and message boards to collect critical information.

Web-based crisis systems are also present at official headquarters, within the United Nations (UN) and the European Union (EU), aiming solely to facilitate and support crisis response efforts, for civil protection is a well-recognised national responsibility. Hence, the DG Humanitarian Aid and Civil Protection operates the European Community Mechanism for Civil Protection, comprising the Monitoring and Information Centre (MIC) tool, which provides all participating Member States permanent access to a platform of national civil protection resources, and the Common Emergency and Information System (CECIS) tool, a web-based alert and notification application that facilitates emergency communication among participating states, providing details of required assistance and offered help and making available the status information on emergency developments, through an online logbook. The Global Disaster Alert and Coordination System (GDACS) is a cooperation framework between the EC and the UN to strengthen worldwide network of crises information providers and users in order to provide reliable and accurate alerts and impact estimations upon major crises and improve the cooperation of international responders in the immediate aftermath of natural, technological and environmental crises[9].

Addressing ICT tools for crises, it is quite clear the relevance of mobile applications for affected citizens to contact closed ones and authorities, to send and receive text messages or to access platforms like Ushahidi or Google to know and provide critical up-to-date information. Today, mobile technology supports advanced functions for improved user experience, a benefit exploited by applications published by FEMA[10], the North Dakota State University (NDSU)[11], Ushahidi[12] and the Pacific Disaster Centre[13], providing citizens useful crisis-related information and upholding built-in bi-directional communication. A notable initiative recently undertook by the North Yorkshire Police Authority (NYPA) resulted in *the first police mobile app to be launched in the UK,* now shortlisted for the Good Communication Awards 2011 [17]. The NYPA application offers numerous functions, including news, contact numbers, alerts and online maps and it is well integrated with Facebook, Twitter and YouTube platforms, accessible by different smartphones (e.g., iPhone and Android) and tablets (e.g., iPad). In Figure 2, the NYPA application is also used to disseminate photos from suspects and has been accessed more than 5,000 times [17].

[9] Crises published by GDACS are compiled from information provided by GDACS partners or by the Internet and, to date, it is part of the international disaster response to crises, similarly to the UN's OneResponse platform, a collaborative inter-agency website enhancing humanitarian coordination and supporting information exchange in emergencies. Since 2008, OneResponse became one of the few official initiatives to use online technology for improved operational information exchange, attentive to existing web platforms and web-based resources.
[10] http://apps.usa.gov/fema-mobile/.
[11] http://www.ag.ndsu.edu/extension/apps/disaster-recovery-journal.
[12] http://itunes.apple.com/us/app/ushahidi-ios/id410609585?mt=8.
[13] http://itunes.apple.com/us/app/disaster-alert-pacific-disaster/id381289235?mt=8.

Figure 2 – NYPA Mobile Application
The image on the right refers to a photo of a suspect that was shared by the police to citizens.
The image was anonymized in this paper.

Also the mobile application Gaia GPS has a special version dedicated to the Haitian Disaster Relief, interfacing with OpenStreetMap to retrieve map and satellite information (and associated geolocalised data), to provide lat-long coordinates location and guidance to waypoints and along tracks. Indeed, location awareness services are valuable for crisis response efforts, namely search and rescue actions, particularly in what concerns automated location-based services for directed messaging and alerts generation. In this context, governmental approach has been careful and even conservative, considering not only the legal framework involved but also the pertaining ethical considerations. Nonetheless, mobile phones can be located using the equipment's own capabilities (e.g., GPS receiver) and/or existing communications infrastructure (e.g., cellular and WiFi), a functionality widely accessible through the Google Latitude service, by which citizens share their location and visualise it over a map[14]. Soon, Apple followed the example and is now offering the Find My Friends' service allowing users to share their location and the Find my iPad service for users to locate their Apple devices (e.g., iPad, iPhone and MacBook). Additional commercial solutions exist to locate mobile devices in cooperative and non-cooperative modes and to provide automatic alerts (e.g., when a phone enters or exits a zone, when a phone is nearby, when a phone is turned on) by means of SMS or email (e.g., Deveryware's TeamLoc, WhereAreYou and PermiLoc applications).

The cooperative mode enables users to provide their location as explicit content and 'opt-out' at anytime, whereas the non-cooperative mode uses the phone's beacons for real-time location, a method that requires legal authorisation and data from telecommunication operators, thus being primarily used for law enforcement and security purposes. These features' benefits in crisis response and SAR actions are relevant for their life saving potential, provided suitable legislation and ethical principles are safeguarded.

A final word for social networking sites and their relevance in crises: initially created to connect those with common relationships or interests, these sites have become a ubiquous reference and, as a result, also present in times of crises: there was a peak of 5530 TPS during the 2011 Japanese Earthquake and YouTube[15] has extensive video footage of the Haitian and Japanese crises. Notably, these social media platforms successfully attained mobile reach, enabling all users to easily post text, messages or videos. Table 1 presents some of the most popular social networking sites worldwide and its use by citizens.

Moreover, citizens prove to be highly proficuous in launching and contributing to innovative security-related initiatives, such as the portals and websites created by volunteers in the aftermath of major crises to coordinate assistance and help rebuilding efforts, or the 2007 Virginia Tech shooting Wikipedia page composed by 1500 individuals, the wide collection of tweets posted by citizens to assist firefighters and citizens during the 2007 Californian wildfires. However, the presented ICT tools, platforms and services require communications to be accessible to those located within affected areas. And after large crises, it is often the case that communications infrastructures are damaged or destroyed. In Haiti[16] and New Orleans[17] the option was to rapidly deploy communications networks via cellular and/or IP-based connectivity (typically WiFi), assisted by satellite links when necessary.

[14] Google, on the other hand, can provide geo-based advertisements by knowing the user's location.
[15] YouTube had more than 13 million hours of video uploaded during 2010, in what represents approximately 48 hours of video uploaded every minute, and over 3 billion videos are viewed a day (http://www.youtube.com/t/press_statistics).
[16] The local main telecommunications operator DigiCel provided acceptable level of SMS service and donated 50.000 mobile phones to non-governmental and non-profit organisations in order to support relief efforts [18].
[17] With the communications infrastructure severely damaged, there were several initiatives to build ad hoc wireless networks to provide rescue workers VoIP-based phone networks (Freedom4Wireless) and to enable police radio capabilities on solar power and battery equipment [19].

Social Networking Mobile App	Citizens' Main Use
Facebook	The most used social media worldwide, with the ability to share messages, images and video EU alternatives are Hyves.nl (in the Netherlands) and Nazka-kazka.pl (in Poland)
Twitter	Real-time micro blog with short text geotagged messages connecting those that share interest in specific topics
YouTube	Online video publisher that supports videos upload (captured by smartphones)
flickr	Online image publisher that supports geotagging images. Alternatives are Picasa and Panoramio (photos of the world).

Table 1 – The Main Use of Social Networking Platforms

Table 2 summarises the rich ICT tools ecosystem applicable to crises response efforts, with the potential to promote the ambitioned bi-directional communication between PPDRs and citizens:

Type of Communication	ICT Tools
Web-based Emergency and Crisis Platform	Google Crisis Response; Sahana; Ushahidi
Mobile Applications for Crisis	Disaster Recover Log; FEMA Mobile Application; Gaia GPS; NYPA Mobile Application
Mobile Location	Google Latitude / Apple "Find my iPad" Deveryware's TeamLoc, WhereAreYou and PermiLoc applications for location permission in cooperative and non-cooperative modes
Voice Calls	112 service calls supported by telecommunications operators VoIP (e.g., Skype and Freedom4Wireless service)
SMS / text messaging	Telecommunication operators' service; Mission 4636; Twitter; Facebook
Images	flickr; Panoramio
Video	YouTube
Communications Infrastructure	Telecommunications operators and ISP. TEKEVER and THALES solutions for MANET and hybrid networks

Table 2 – ICT Tools Ecosystem

Built upon online social and mobile technologies, the new citizen-centric approach evolved from the basic citizens' journalism to raising awareness on the benefits of a bi-directional communication between citizens and officials, with eyewitness accounts, first-hand observations, photos and video directing responders to where they are most needed and guiding citizens away from harm's way, so that better decisions are made and the existing situational awareness gap is closed.

However, despite the global trend on the growing use of mobile technology and social media platforms, visible in worldwide crises' lessons learned, and the empowerment enabled by the new ICT tools dedicated to crisis management and response, FRs and PPDRs remain with an impaired ability to gather, process and distribute information, reinforced by the likely inoperability, overload or destruction of local communication infrastructures. Upon such circumstances, PPDR organisations struggle to develop situational awareness in order to establish priorities, develop a realistic response plan and properly assign resources. Thus, their decisions are often based on partial, limited and incomplete information and, even, intuition. This state of low awareness and high uncertainty ought to be avoided and prevented, so as not to compromise expected performance, concerning the efficiency and effectiveness of crisis response efforts. It is therefore clear that a challenge emerges:

MAIN CHALLENGE

To enable PPDRs and citizens to (rapidly) generate high levels of situational awareness upon the occurrence of a large emergency or crisis event.

Considering current European economic-financial constraints, it is unfeasible to advance solutions that would require significant resource demand or overload, whether personnel and/or equipment to cope with uncertain crisis events, independently of the later's negative impact. But there are two key factors that,

properly exploited, would bring strong benefits to crisis response efforts, without significant added cost: (1) the high level of adoption and use of mobile technology by citizens and (2) the citizens pro-active behaviour of (online) producing and consuming information in crisis situations. The iSAR+ Consortium understands these factors as an unavoidable main opportunity:

MAIN OPPORTUNITY	To exploit the citizens' (i) high-level of adoption and use of mobile technology and (ii) their pro-active behaviour of online information production and consumption.

In crises, citizens are the *in situ* first *sensors*. Empowered by the new communication media (mobile phones with cameras, text messaging and internet-based applications connecting to social media platforms), citizens are capable to receive and transmit large quantities of data, capture high-resolution imagery and video, retrieve geolocation information (e.g., GPS and orientation) and run sophisticated applications. Experiencing the urgent crave for information, citizens frequently exchange information with PPDRs and are often confronted with the inoperability of the widely known voice-based emergency number (112 for Europe), caused by its infrastructure damage, its incapacity to handle large demand or the official unwillingness to provide information continuously. Consequently, citizens found prevailing online social media to be useful tools in crises, allowing information sharing, assistance requests and contacts to loved ones. Figure 3 illustrates current communication flows between citizens and PPDRs (the dashed grey line represents communication channels likely to be non-operational in crises[18]). PPDRs have for years relied in broadcast media and local signs to keep citizens informed; more recently, internet-based services (RSS and email in near real-time[19]) have been adopted but most PPDRs still remain disconnected from online and social media platforms[20].

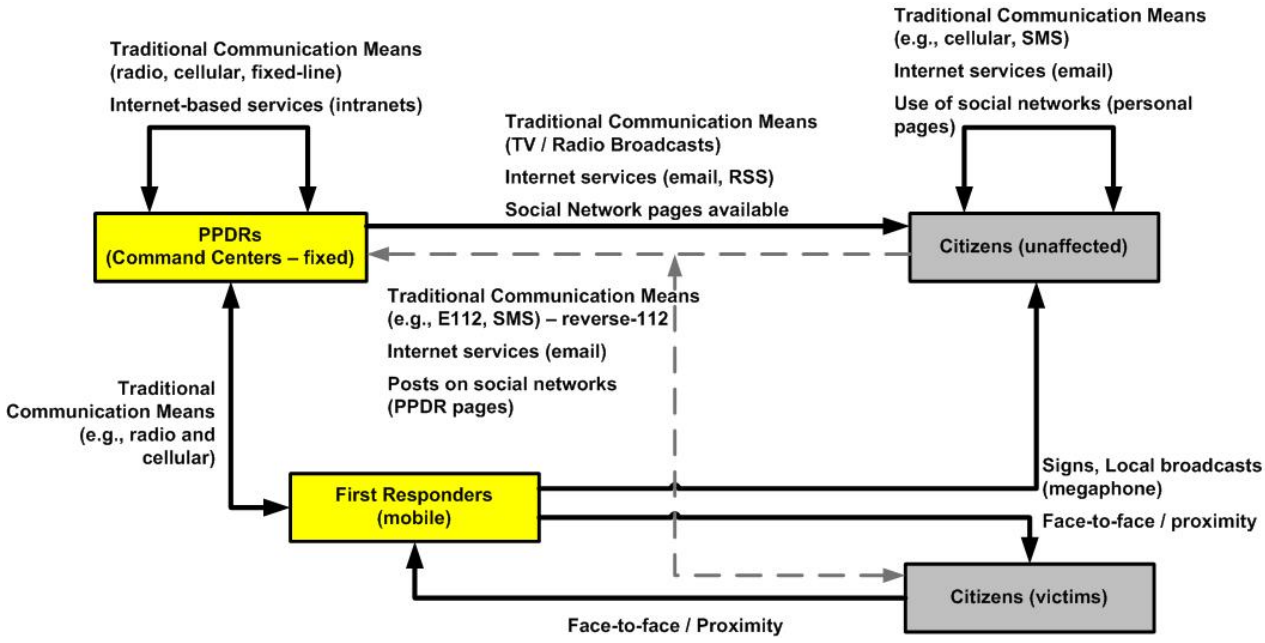

Figure 3 – Current Communication Flows Between PPDRs and Citizens

Hurdles To The Use of New Communication/Social Media in Crisis Situations

Indeed, FRs and PPDR organisations, and their traditional command and control models, do not easily adapt to the new crises' trend of including a global, digitally enabled social arena. PPDRs have centralised governance, with clearly defined roles and well-established processes. Bach and Kaufman have determined that the lack of trust between officials and the public is a significant obstacle to overcome when

[18] Several case studies (2010 Japan Earthquake, 2010 Haiti Earthquake) concluded that, in crises, Internet is a more resilient infrastructure than landline or cellular communications, due to the network's redundancy [11].
[19] Email is an effective way to proactively reach thousands when urgent situations arise. As the number one use of the Internet, email is a channel that plays a critical role in any emergency communication strategy [20].
[20] It is still a low number of organisations that have initiated the adoption of bi-directional communication channels, via internet-based services (emails, RSS) to provide notifications and collect citizens' contributions.

it is required to create bonds and establish the necessary confidence to act on the basis of another's words, actions and decisions [21].

BARRIER (PPDRs)	PPDRs distrust online social media as a credible information source and a viable communication tool with citizens in crises.

Apart from Bach and Kaufman's mistrust, there are also control, ownership, privacy and security issues, but also information overload, accuracy, verification and (source and content) validation problems, concerns with the responsibility or accountability of ICT providers and the possibility of citizens' overzealous behaviour. On another token, it is legitimate the fear of commercial exploitation of private data, the use of misinformation as a weapon and, even, of political and ethnical pursuit, once people's location information becomes part of the public sphere. Overall, it is comprehensible that the absence of a thorough ethical and legal framework to address the issues raised by the use of social media in crisis response efforts also contributes to the PPDRs' general scepticism towards the integration of new social media as an additional public communication tool.

BARRIER (PPDRs)	Popular online social media platforms cannot be used as a formal PPDR tool for they do not uphold EU ethical principles and legal framework.

Likewise, the long-time established PPDR organisational culture and tradition will probably act as an additional obstacle to change, especially considering that the integration of social media in PPDR processes will certainly provoke a significant impact on existing structures, roles, functions, procedures, information workflows and technology, as well as add a new risk into a critical activity that serves, protects and saves lives. The absence of superior endorsement, sometimes prompted by unfamiliarity, and the lack of expertise, resources and budget are major hurdles to consider in the analysis, especially at a time when public safety budgets shrink and fewer resources have to address greater needs. Although the impact of not adhering to the new mobile and social communication media is unlikely to be considered, the impact of the integration of social media in crisis response efforts is certainly reduced if the proposed change is a process carefully structured, managed and tested, before implementation.

BARRIER (PPDRs)	Introducing change to PPDRs entails new risks and it is a process to be carefully structured, managed and tested, before implementation.

Old habits are difficult to change and they are not exclusive to PPDR organisations. Also citizens have recurrent loyalty behaviour towards specific social media networking and, in face of a new PPDR social media platform, there could be some difficulty to rapidly aggregate a significant number of followers. Undoubtedly, to have a PPDR social media platform segregated from the online circles widely adopted by the public, such as Facebook or Twitter, would be a high-risk enterprise.

BARRIER (Citizens)	Citizens use the online platforms they are accustomed to. Forcing a change of habits and the adoption of an unfamiliar platform will likely result in failure.

To overcome current hurdles and respond to these interesting challenges, the iSAR+ approach delivers a platform that addresses the organisational, human, ethical and legal framework and technological dimensions of constructing an integrated, unified pathway towards meeting PPDRs and citizens needs in crisis events, when time is of the essence, information overload a problem and actionable intelligence a requirement. This is our vision, *The iSAR+ Way*, presented in the next section.

4. THE ISAR+ WAY: BEYOND THE STATE-OF-THE-ART

To surpass PPDRs' state of low awareness and high uncertainty, which compromises efficiency and effectiveness, it is possible to explore the opportunity to involve citizens in crisis response efforts as information providers. Nowadays, citizens are equipped with advanced mobile and online communication platforms (including social media) and are capable to provide critical crisis information that otherwise would be impossible to collect by FRs and PPDRs. This opportunity becomes clearer in face of the fact that citizens post crisis-related information in public social media networks, as opposed to the PPDRs provided channels – in fact, in the Digital Era, there is still no 112-equivalent in the Internet. However, to enable the engagement of citizens and PPDRs in crisis response efforts, by encouraging the use of the new communication media requires more than yet another PPDR technological system: it requires a profound change in PPDR communication principles, as simply presented in Table 3.

PPDR Communication Principles	Today	With New Communication Media
On information exchange policies	Strictly defined; top-bottom approach Unidirectional (from PPDRs to citizens)	Not pre-defined; bottom-up approach Bi-directional (between PPDRs and citizens)
On control of information	Fully controlled by PPDRs	Control-free and community-driven
On information trust and quality	Official sources with adequate verification and validation	Anonymous or unofficial sources and self-correcting
On citizens inclusion	Seen as auxiliary source and reactive	Seen as primary source and proactive
On communication target	General public	Tailored according to user profile
On approach	Need-to-know. Command & Control.	Need-to-share. Connect & Collaborate.

Table 3 – PPDR Communication Principles: Today and With the New Communication Media

With the integration of the new (mobile and online) communication media, the communication scenario between citizens and PPDRs could be as depicted in Figure 4.

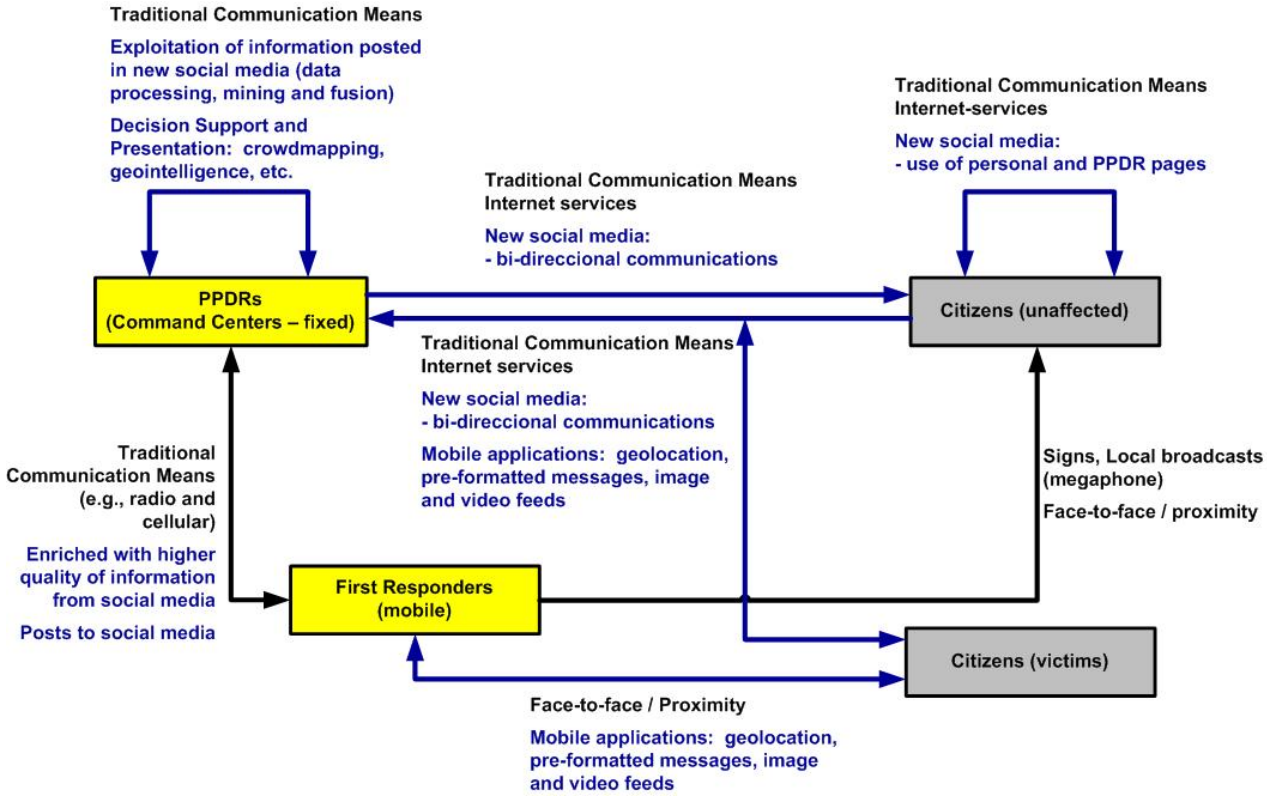

Figure 4 – Enhanced Communication Flows with the New Mobile and Online Social Media

4.1. The Multi-dimensional Problem

We consider that the challenge to incorporate new social media and mobile tools as a way to significantly engage citizens and PPDRs, and contribute to the exchanged information flow, requires a multi-dimension analysis, involving the organisational, the human, the ethical and legal framework and the technological dimensions, portrayed in Figure 5.

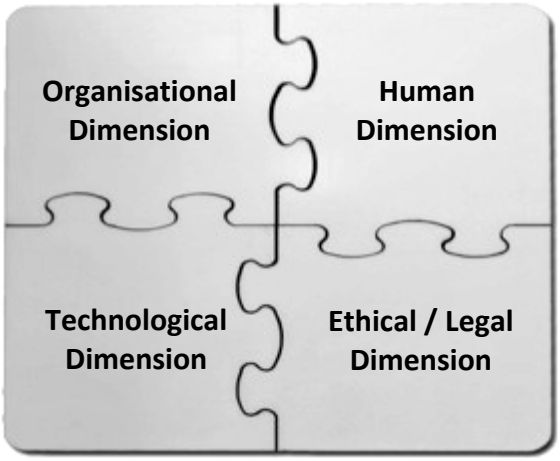

Figure 5 – The iSAR+ Analysis Dimensions

Therefore, achieving the *iSAR+ Way* requires tackling the following dimensions:

- Organisational: this dimension focus the PPDR organisations and their culture, roles, processes, competences, training and technologies to explore how to adapt these organisations to work with social media platforms, building their trust in online networking platforms and thus facilitate the process of introducing the iSAR+ Prototype into the organisations' operational processes.
- Human: this dimension comprises the citizens' perspective on the acceptance and adequate employment of state-of-the-art mobile and social media communication technologies in crisis situations, concerning human factor analyses, message delivery channels and message content.
- Ethical and Legal: this dimension deals with the iSAR+ platform requirement to abide to the ethical principles and legal framework applicable when developing an ethics-by-design project approach, but also with the ethical and legal framework concerns and waivers emerging from the debate on the boundaries of privacy rights and public security, with respect to the integration of new online and mobile technology in crisis response efforts.
- Technological: this dimension entails the integration of current ICT tools for crisis, equipment, communications, information processing technologies and current standards into the iSAR+ platform so as to explore the real potential of ICT and mobile technologies in what concerns crisis response and search and rescue actions.

It is our conviction that the unified perspective achieved, derived from the multidisciplinary alignment, will be a guide to future policies, processes, organisations, individuals and technologies, to support existing and newly extended social dimensions of search and rescue and crisis response efforts.

Upholding ethical and legal framework principles, the iSAR+ Way considers not only the citizens' and human factors' approach but also the involved organisations' operational culture and processes as it proposes the integration of existing ICT tools (including mobile applications and social media) already field-tested in crisis situations, and the research and development of technical and technological improvements for advanced added-value services for citizens and PPDRs.

Table 4 addresses the communication improvements iSAR+ introduces.

Involved actors	Expected Improvement
PPDRs - Citizens (unaffected)	Bi-directional posts through social media (the traditional 112 is likely to be frequently unavailable) Automatic PPDR push alerts with instructions: geobroadcast alerts (e.g., enter danger zone)
PPDRs - Citizens (affected)	Bi-directional posts through social media (the traditional 112 is likely to be frequently unavailable) Automatic PPDR push alerts with useful instructions: geobroadcast alerts (e.g., emergency channels available) Automatic localisation of affected citizens (acknowledgment messages) Messages exchange (e.g., cellular SMS, email, web posts, application-based messages) Multimedia messages from citizens in real-time
Citizens (affected) - Citizens (unaffected)	Messages exchange with family and friends (e.g., cellular SMS, web posts, email) Multimedia messages to social media (e.g., flickr and YouTube).
FRs - Citizens (affected)	FRs call citizens' mobile phones for on-site assistance. Information exchange via mobile phones (e.g., localisation, SMS, application-based messaging) RT exchange of images/video Assisted telemedicine
PPDRs - FRs	Accurate localisation of victims and affected citizens Exchange of information in rich multimedia formats
PPDRs - PPDRs	Exchange of enhanced or actionable information Enhanced tooling to exchange and validate rich and smarter information Cross-agency / Cross-EU state members exchange of information

Table 4 – iSAR+ Communication Improvements

4.2. The iSAR+ Platform and Services

The proposed iSAR+ platform is based on two different spaces: the PPDRs and the citizens'.

The PPDR space comprises the applications, services and data storage fit for PPDR specific needs, such as "fusion centre" and "risk maps" and, because of the ethical and legal concerns towards protecting citizens' privacy and upholding public security, part of the information within the PPDR space is not disclosed to the public. With respect to the involvement of the general public, the PPDR space includes traditional unidirectional broadcast media (television and radio) but also new bi-directional interfaces, connected to social media and the i112 Portal, later described. Moreover, it includes pluggable interfaces to external crisis systems and other iSAR+ portals.

The Citizens' space consists in the (open source) applications and services available for the general public, with information that is deemed of an open and public nature but still relevant for iSAR+ purposes.

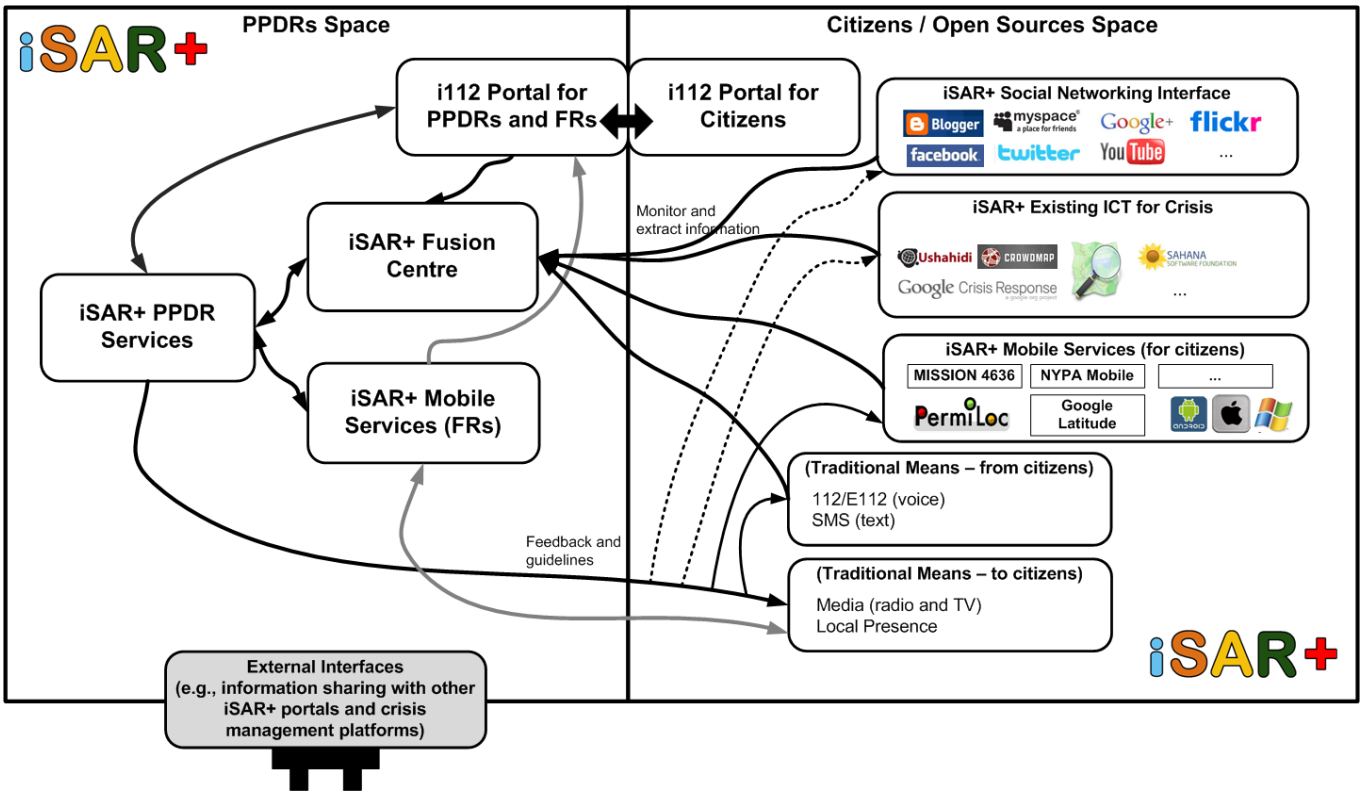

Figure 6 – iSAR+ Platform Overview

As perceived from the figure, both spaces interact in numerous and bi-directional forms. To deliver its technological vision, depicted in Figure 6, we suggest a number of technological components introduced next.

The i112 Portal (for Citizens and PPDRs)

Most PPDR authorities do not provide citizens with official channels enabling rich information sharing (include image and voice). So citizens turn to existing social media platforms, like flickr, to upload pictures taken with mobile phones that become globally accessible in a matter of seconds.

To bridge this obvious gap, we propose an iSAR+ Portal (Figure 6) that enables a bi-directional and rich communication channel between citizens and PPDRs. Citizens will be able to upload a significant amount of crisis-related information, in multiple formats and optionally geotagged: short messages, email, posts, images and video. Additionally, the iSAR+ platform will provide useful services to citizens in crisis (e.g., people finder, contact numbers and geolocalised information such as safety houses and food distribution centres) and operator-assisted feedback (reply-to) messages. Existing ICT tools for crisis will be embedded, such as Ushahidi and Sahana, as well as social networking functionality (and links to external social networks), in the i112 portal. With respect to the PPDRs and FRs component of the i112 Portal, authorities will benefit from an additional channel to provide useful crisis-related information (recommendations, guidelines, warnings, situation updates) to citizens, continuously interacting with them, in their time of need and despair. The i112 Portal will also include areas of the PPDRs and FRs exclusive access, where they will find functionalities to ease crisis response efforts and SAR actions.

A major differentiating characteristic of the i112 Portal from the existing social media platforms consists in its assured compliance with the EU's ethical and legal framework on citizen's privacy rights, with the adoption of the ethical and legal framework dimension's recommendations, which paves the way for this tool to be formally adopted by official organisations, abiding to the organisational dimension's recommendations.

Interoperability with Existing Social Media and ICT Tools for Crisis

In this component, iSAR+ integrates existing social networking platforms and ICT tools applied for crisis, as follows:

- For the Social Media Networking component (e.g., blogger, twitter and flickr), and because the applicable service providers host these platforms, an information extractor is placed in accordance to ethical and legal recommendations, enabling automatic or manual extraction of information into the iSAR+ fusion centre.
- For the Existing ICT Tools for Crisis component, two options are proposed: (1) the open-source platforms (e.g., Ushahidi) are embedded in the i112 portal and an iSAR+ service provided by PPDRs and hosted within PPDR servers (see previous component). This option grants PPDRs full control on the platforms and the possibility to create built-in events and external interfaces (i.e., a built-in information extractor); (2) an information extractor is placed to extract information from already deployed platforms (e.g., Google Crisis Response, OpenStreetMap, Ushahidi hosted by third parties), assuming bi-directional links exist (e.g., PPDRs may publish information in third party platforms). Both options assume an active use of the platforms by the PPDRs, with the purpose of developing enhanced situational awareness and improved communication with the public.

Albeit the potential high positive impact Social Media and ICT Tools in Crisis, its large diversity and dispersion is a source of disruption for PPDRs, a factor the iSAR+ platform eliminates by developing a mechanism allowing PPDRs to easily retrieve relevant information from a large number of sources – the information overload aspect will be tackled in the data fusion centre, described next. A mechanism to extract public information to feed the iSAR+ fusion centre is proposed, using a technique often referred as open source intelligence (OSINT). This information extractor includes an anonymiser filter to ensure the citizens' data privacy.

The iSAR+ Fusion Centre

The iSAR+ Fusion Centre is the platform's component in which large quantities of (open) information are stored, processed, mined and fused so that actionable information can be presented to FRs and PPDRs. It monitors information from all iSAR+ components, including the interfaces with existing social media platforms (the open sources' space). Nowadays, crisis events prompt an overwhelming number of posts translating a enormous amount of data to process for any PPDR entity, if not aided by computer-assisted tools. Candidate technologies portrayed are: **Text Analysis** (automatic extraction of relevant information from data that is heterogeneous, malformed and noisy); **Image and Video Analysis** (detection, identification and recognition of specific objects and/or situations on the images and videos directly or indirectly via YouTube of flickr); **Information Mining and Fusion** (combine information arriving from multiple sources and processed information assuming imperfect sources of information and generate alerts[21] based on detected trends).

iSAR+ PPDR Services

To deliver increased situational awareness for PPDRs, we identified several relevant services such as: **Crisis detection and monitoring** (use open social networks as sensors to detect, provide and maintain information relative to ongoing crises); **Mapping / Crowdsourcing** (information over online maps to reveal the crises' location, citizens' presence (depending on individual express consent) and the coordinates of helpful resources such as hospitals, shelters and assistance centres, an information further enriched with text, photos and video); **Visualisation and Decision Support Tools** (application of statistical techniques to spatial data for real-time pattern or signature detection, use of charts, sociograms and smart search for information and mapping and crowdsourcing capabilities); **Missing People Tracking** (include missing people's information, publicly accessible and constantly updated, as provided by the Sahana platform [22]); **Risk Maps** (probability of the crisis occurrence with its consequences or impact. It requires the integration of geographical information systems (GIS) or spatial maps with hazards, exposures and vulnerability functions to obtain quantitative factors to be visualised on maps, often represented as threats [23]).

[21] Automatic alerts will be generated to PPDRs for further human validation. No automatic alerts will be generated to the public for it may involve life-critical information.

iSAR+ Mobile Services

Concerning services targeted at mobile users, the following opportunities are proposed:

- SMS Services Gateway: service that enables to send (information, warnings, alerts) and receive SMS from mobile phones located within and outside the crisis area. Aiming most mobile phones, this service benefits affected citizens, deployed FRs, PPDRs and the public.

From the PPDRs perspective, this is an important tools for sending important or critical messaging alerts to the citizens' phones per geographical area (i.e., geobroadcasting), as illustrated in Figure 7 (French authorities sending SMS and MMS indications to English citizens).

Figure 7 – Fictional Geo-directed SMS (text) and MMS (image map) Alerts

- Mobile Applications: mobile application to run on the most popular mobile platforms (e.g., iPhone and Android) that provides access to the i112 Portal and delivers location-based services and other functions critical for citizens in crisis situations: automatic localisation of mobile phones, receiving crisis-related information specific to a geographical location, easy upload of crisis-related images and videos and a pre-formatted SMS capability (to send SOS requests and receive relevant crisis-related information).

Advanced Services

We also looked into emergent technologies that bring additional important functionalities, interactivity (including human-factors) and enhancements thus improving the response to the crisis. Interesting options included **Text-to-Speech and Speech-to-Text Services** (fundamental services for people with special needs or disabled (from birth or as a consequence of an emergency event), whose voice command could initiate a 112 call and send a standardised message with the user's geolocalised information), **Augmented Reality** (for improving the generation of awareness even in the face of a crisis, as depicted in Figure 8 using wikitude[22] and similar platforms) and **Mobile Assisted Medicine** (real-time images and video transmission on injured citizens and receive medical indications from medical emergency professionals remotely located on how to proceed with emergency treatment measures).

Figure 8 – iSAR+ Augmented Reality Services
With this advanced iSAR+ service, citizens point their mobile phones to a street and receive indications on safety and danger areas, on shelters' location, among other useful information

[22] http://www.wikitude.com/en/.

iSAR+ Interfaces: The iSAR+ Network

Crises (natural or man-provoked) do not discriminate borders or citizens nationalities, thus exchange of information between distributed iSAR+ platforms (each managed by its respective national authority) regarding, for example, affected non-national citizens, would be very beneficial and easy to implement, as an alternative to a single iSAR+ centralised architecture (and control authority). We propose this information exchange between iSAR+ platforms through an iSAR+ Interfaces module, as presented in Figure 9. The presented configuration, with different countries involved, is a reference scenario for a demonstration that we target to conduct at a final stage of the project.

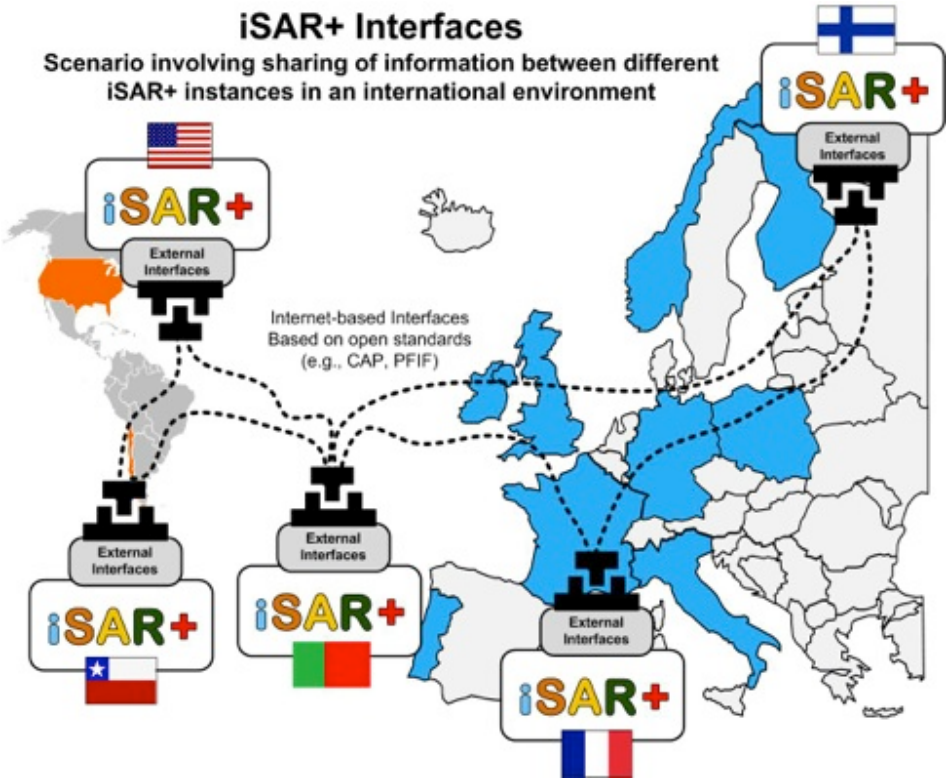

Figure 9 – iSAR+ Interfaces Concept

5. CONCLUSIONS

The iSAR+ Platform encourages the use of mobile technology and social media to improve crisis communications between citizens and PPDRs, contributing to the information gathering and sharing processes as well as to an enhanced situational awareness, by exploring two main behavioural trends observed on the use of mobile and online technologies: (i) the ubiquitous presence of mobile devices in society and (ii) the citizens broad adoption and use of social media, including in crisis, to share information.

These new communication channels – mobile technology and social media – between PPDRs and citizens in crisis situations have proven to be, in past events, more resilient and effective than traditional channels, e.g., 112-call (lack of capacity to cope with high number of incoming calls) and broadcast media (e.g., TV is considered as being too generic). Additionally, the proactive exploitation of new mobile technology capabilities, namely the automatic localisation of cell phones, contributes to dramatically increase the PPDRs' situational awareness levels, thus enabling better planning and resource allocation and, consequently, increased effectiveness and efficiency.

iSAR+ broadens the reach and richness of PPDR-citizens communication, highlighting specific benefits:

- **Faster response reaction times for the citizens' benefit**

In the iSAR+ way, citizens reach PPDRs using multiple communication channels and different options. In this case, more options directly generate better outcomes, especially when commonly used communication channels experience unavailability (e.g., 112 call).

Additionally, the integration of advanced mining and fusion tools into the iSAR+ platform with the purpose to monitor specific events in the social networking activity, while observing all legal and ethical principles, may generate automatic early warning alerts concerning relevant events.

- **Improved links amongst prevention, detection, reporting and rescue**

The iSAR+ platform includes a suite of tools improving linkages of the prevention, detection, reporting and rescue stages of a crisis operation:

  - On Detection, the iSAR+ Portal offers access to citizens using the new technology media to report emergencies with additional supporting data (in image or video formats). Furthermore, iSAR+'s information analysis and mining mechanisms on social networks provide excellent detection capabilities of crises as they happen.
  - On Reporting, iSAR+ allows both citizens and PPDRs to post multimedia information pertaining to crisis or emergency situations, therefore enabling highly detailed, accurate, precise and effective reports.
  - On (Search and) Rescue, iSAR+ includes a set of tools, from crowdsourcing to the capability to exploit mobile technology to locate citizens in affected areas that are able to pinpoint the victims' locations, hence reducing the search time and, consequently, the response time.
  - On Prevention: during emergency and crisis, iSAR+ is the preferred information source to warn non-affected citizens of nearby dangers and other hazards; always, as a training tool, for iSAR+ guidelines are freely available on traditional and new fora to iSAR+ *friends* and *followers*, contributing to a better informed society on the right behaviour and decisions on emergencies, crisis situations and security in general, actually empowering the citizens' role in those situations.

- **Improved performance of first responders, medical personnel, police and law enforcement agencies**

The iSAR+ way contributes to a faster and better development of PPDR situational awareness, when compared to traditional means. Enabled by social networking and mobile technology, iSAR+ delivers added-value communication channels that support rich interactions (e.g., real-time imagery, sounds, videos), advanced data mining and analysis techniques and enhanced planning and resource.allocation capabilities, resulting in increased reach and performance. Consequently, PPDRs perform more efficiently (i.e., faster to respond, better allocation of resources) and effectively (i.e., relevant event detected, crisis situation solved, citizens saved).

6. ABOUT THE ISAR+ CONTRIBUTORS

This paper is the collective result of a multi-disciplinary group of expert entities that were gathered to present their view on the use of social media and mobile technology in crisis for purposes of disaster response and citizens' security. Our view has been selected by the European Commission for implementation on a timeframe of 30 months. As part of this effort, we plan to conduct a number of open workshops, including one in the U.S.A. to be organised by EBR Inc.

The entities that contributed to this paper are[23]: TEKEVER (Portugal), Bridge129 (Italy), Centre for Science, Society and Citizenship (Italy), Deveryware (France), Emergency Services College (Finland), Ernst-Moritz-Arndt-University Greifswald - Institute of Psychology - Department Health and Prevention (Germany), ITTI Sp z o.o. (Poland), National Centre on Emergency Communication in Health (Norway), North Savo Rescue Department (Finland), North Yorkshire Police Authority (UK), Pôle Pilote de Sécurité Locale (France), Police College of Finland (Finland), University of Dublin - Trinity College - Aerospace Psychology Research Group (Ireland), Thales Communications and Security (France), University of Eastern Finland (Finland) and Zanasi & Partners (Italy).

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9. ANNEX A – THE WORLDWIDE REALITY OF CRISIS RESPONSE EFFORTS IN THE INFORMATION AGE

"We are all becoming more familiar with the extraordinary power of information and communication technologies. As the underpinning for early warning systems, ICTs are crucial in weather forecasting and in building resilient communities better able to respond to humanitarian emergencies. When disaster does strike, ICTs are helping us to better coordinate complex relief missions. This role has taken on even greater significance in the past year, following the Indian Ocean tsunami, hurricane related flooding in Central America and a devastating earthquake in Pakistan."
Kofi A. Annan, Secretary-General of the United Nations, 2005

The beginning of the XXI century has been deeply marked by the repetitive occurrence of large-scale natural disasters and human-induced emergencies, events commonly known as crises. Crises come in many forms - natural disasters, economic collapses, infrastructural destructions and terrorist actions – but crisis terminology, its exact meaning and its relation to other concepts remain unclear. What prevails is a common understanding of the disturbance of stability that a crisis situation entails, that is, the threat to fundamental priorities, the challenge of making the right decisions under severe pressure and the fatality of loss of control, property and life. In the iSAR+ Project, crisis is thus defined, in a security context, as resulting of human activities, technological hazards or natural phenomena, and understood as the unforeseen situation in which the priority values, interests or critical functions of large social systems are seriously threatened, challenged, impaired or overloaded. Indeed, crises reflect overall loss of control, a complete disturb of routine that arises significant public scrutiny and gathers undivided media attention, a reality that is not dissociable of today's global emphasis in information and communication technologies (ICT).

In 1992, Orlikowski presented an interesting theory concerning the co-adaptation of technology and society, highlighting the creative interdependence presiding social evolution and technological innovation, of which the ultimate token has been the society's addiction to the use of internet and mobile technologies, displaying unprecedented information and communication capabilities, such as the ones hosted by social media, which dramatically change geopolitics, economic contexts and business innovation and competitiveness.

For the purpose of this paper, online communications refer to "social media", a term the European Commission defined in "Communicating with the outside world – Guidelines for All Staff on the Use of Social Media" as the "… *online technologies and practices to share content, opinions and information, promote discussion and build relationships. Social media services and tools involve a combination of technology, telecommunications and social interaction. They can use a variety of formats, including text, pictures, audio and video.*" Accordingly to Kaplan and Haenlein, there are six different types of social media: collaborative projects (e.g. Wikipedia), blogs and microblogs (e.g. Twitter), content communities (e.g. Youtube), social networking sites (e.g. Facebook), virtual game worlds (e.g. World of Warcraft) and virtual social worlds (e.g. Second Life). The technologies applied include: blogs, picture sharing, vlogs, wall-postings, email, instant messaging, music sharing, crowdsourcing and voice over IP, to name a few. Similarly, mobile communications encompass all the communication that is based upon the use of mobile devices, such as mobile phones, smartphones, computers and PDAs. Throughout the World, online and mobile technologies are now transforming societies, a catharsis that is also present in the potential for an improved response to disasters and crisis response efforts.

Increasingly simultaneous and intertwined, worldwide crises have recently prompted new attention to the role ICT plays in search and rescue and response effort activities. In emergencies, with landlines down and power grids offline, ICT have proven their worth in providing both public safety organisations and the public the scarcest resource: information. In a society that has grown accustomed to immediacy and instantaneity, ICT and their strong real-time emphasis are fundamental to gather and to deliver information, not only in terms of alert and emergency notifications but also respecting the attainment of the most complete situational awareness picture.

With a century old history of investigation and research, the sociological study of crises is aware that ICT has expanded the reach of disaster sociology and now is particularly focused on the emerging trend of expanding citizens' participation through online and mobile communications (computer-mediated interaction), providing, seeking and brokering information, connecting those within and outside the geographical space of the crisis and having implications for both informal and formal response.

In fact, it already is impossible to downplay the role emerging online and mobile trends play in crises communications, but there is still the opportunity to improve these trends' benefits to promote a faster, more efficient and better performed crisis response effort.

Surfing History's Lessons of Crisis Response Efforts

The great Lisbon Earthquake (and resultant tsunamis and fires) of 1755 not only caused around 100,000 deaths but also transformed the western thinking of the time, dislodging religion as the central explanation in intellectual life. In 1883, the eruption of Krakatoa (and resultant tsunamis) killed around 35,500 people and was the first global disaster to be made known through electronic communication (undersea telegraphy) making a wide social and political impact. Indeed, throughout History, several overwhelming natural disasters and human-provoked actions have prompted immediate crisis response efforts that have made their mark, providing valuable lessons on crisis management systems, plans and organisations.

Next, a set of examples that highlight how different crises were dealt with by the local emergency services and how citizens were involved in the overall crises response efforts:

September 11th 2001 – Terrorist Attacks on the USA

On September 11th 2001, four hijacked passenger airplanes crashed into the two World Trade Centre (WTC) Towers in New York, the Pentagon in Washington and a field in Pennsylvania, killing 2,974 people and provoking the collapse of several buildings.

Cell phones and in-plane credit card phones played a major role during and after the attack, starting with hijacked passengers who called family or notified the authorities, providing details of the presence of hijackers aboard each plane. After the two hijacked aircrafts struck the WTC Towers, people inside the buildings made calls to family, loved ones and 911 and rapidly the cell phone network of New York City was overloaded with traffic, leading to crashes of the cell phone network. At the Twin Towers, the Fire Department of New York City (FDNY) quickly deployed 200 units to the site, assisted by numerous off-duty firefighters and EMTs. The New York Police Department (NYPD) sent Emergency Service Units and other police personnel, along with deploying its aviation unit. But, once on the scene, the FDNY, NYPD and Port Authority police set up separate command posts and used incompatible radio communications, so they did not coordinate efforts, performing redundant searches and not sharing evacuation warnings. Also communications breakdowns prevented the announcements to evacuate from reaching civilians in the buildings, contributing to the World Trade Centre death toll. Lacking awareness about the Twin Towers situation, emergency 911 operators were overwhelmed by the volume of calls and unable to share information effectively with on-scene officials.

Two minutes after the first plane crashed into the WTC, the first news reports appear on TV and radio that a plane may have crashed into the WTC. However, fire officials on the scene were not monitoring broadcast news reports and did not immediately comprehend the full impact the first tower's collapse. Since major broadcast networks stayed on the air, providing extensive media coverage, the Emergency Alert System was never activated. Rather than relying on cellular telephone systems or the local telephone network, which were damaged and inundated with traffic, citizens opted to communicate through text messages in their quest to seek information about what was happening and the whereabouts of people in the impacted region. After the immediate impact and initial rescue efforts, another form of citizen communication emerged: peer-to-peer communication in the form of flyers and posters literally papered buildings, fences, cars and signposts around the region of impact.

2003 China SARS Epidemic

An epidemic of severe acute respiratory syndrome (SARS) began in the Chinese Foshan municipality, Guangdong Province, in November 2002 and in the first four months of 2003, it became an emerging crisis with a total of 8,422 known infected SARS cases and 916 confirmed human deaths. Within weeks, SARS spread from Hong Kong and rapidly infected individuals in 37 countries around the World.

Still, little information was provided by official sources, giving rise to peer-to-peer communications (SMS text messaging) that, discretely and without repercussion, sought and provided information about the physical locations of apparent SARS victims. Over the long span of the SARS outbreak crisis, 120 million text messages were sent, some disseminating opinions, rumours and even humorous content. Citizens knew about the SARS before the mainstream media and before the Chinese Government reported it to the World Health Organization (WHO), which occurred on February 11th.

The WHO set up a network for doctors and researchers dealing with SARS, communicating through videoconferences, and attempts were made to control further SARS infection through for a 10-day mandatory home quarantine, with public and private services being closed. Specific medical facilities were designated for the sole treatment and isolation centre for all confirmed and probable cases of SARS and a dedicated phone line was designated to report SARS cases, whereupon a private ambulance service was dispatched to transport the required patients to the designated medical facility. Thermal imaging was set up in airports to screen all departing passengers

After April 20th, when the Chinese Government acknowledged the existence of SARS and it became obvious they had been concealing the vastness of the outbreak, again citizens used their mobile phones and text messaging to share their apprehension and concerns regarding the Chinese Government's behaviour. Ultimately, the Chinese Government restricted the use of online and mobile technologies to keep control of the situation, applying a censorship policy called the Golden Shield that uses 2800 facilities across China to monitor and restrict SMS messages on the Internet and sent via personal mobile communication devices (citizens were even arrested because of the content they post online or send through a text message).

March 11th 2004 – Madrid Train Bombings

On the morning of March 11th 2004, the commuter train system of Madrid endured a terrorist attack of 10 bomb explosions that killed 191 people and wounded 1,800. Thirteen improvised explosive devices, detonated by cell phones, were placed on four trains travelling between Alcalá de Henares and the Atocha station in Madrid during the peak of that morning's rush hour.

The RENFE CCTV surveillance supervisors alerted the emergency services as the attacks unfolded and, within 15 minutes of the explosion, emergency services, including the police, the fire department, the ambulance service and the mobile police, in a total of 70,000 people, arrived at the scene, intervening independently, with their own communication systems and technologies. There was a swift and massive medical response, although very uncoordinated and with serious lack of command in every emergency service, specifically attributed to inappropriate planning since no common emergency plan clearly sets responsibilities and procedures in the event of a major crisis.

Once the staging area had been established, access routes identified and controls introduced, the response effort became more organised. Still, the radio frequencies of each emergency service were not compatible and there are no shared tactical channels for responders in the field, so communication among the different emergency services at the scene was only possible via personal contact or telephone. The situation quickly deteriorated when the mobile telephone network suffered overload (or when the police intentionally blocked frequencies in certain areas to prevent potential activation of secondary devices), leaving many units without any possible means of communication. Because no joint field command post for all of the emergency services was set up, inter-agency coordination followed a pattern of improvisation and informality.

December 24th 2004 – The Indian Ocean Tsunami

On the morning of December 26th 2004, a 9.3 magnitude earthquake was felt in the Indian Ocean and within minutes a giant tsunami decimated Banda Aceh, on the island of Sumatra, and massively struck twelve countries bordering the Indian Ocean, killing over 280,931 people, in what is considered the greatest natural disaster.

The 2004 Indian Ocean tsunami was also the first internet-mediated natural disaster but the ubiquity and power of advanced information and communication technologies failed to map the destruction of coastal Aceh for several hours. No advance warning was given to the affected coastal populations by their governments or others and even information on the destruction of Sri Lanka's coast reached (by telephone) the media, and then the general public, prior to the news of Banda Aceh's fate. In fact, the mere existence of available information was severely hindered by the low connectivity and scarce telecommunications access in developing Asia. While the UN Humanitarian Information Centre in Banda Aceh became the local information hub, the first reports of this disaster came from tourists that used their phones and digital cameras to snap photos and videos of the surrounding destruction and uploaded them into the Web. Likewise, more than fifty worldwide contributors built The South-East Asia Earthquake and Tsunami Blog, which aggregated news and set up a tracker for missing persons' reports and humanitarian efforts.

July 7th 2005 – London Tube Bombings

The first terrorist suicide attacks in modern Western Europe occurred on July 7th 2005, at 8:50 a.m., with three bombs detonated on three London Underground trains and a fourth bomb on a double-decker bus. The attacks were the deadliest in London since World War II, killing 52 people and injuring more than 700 others.

Initial information was scarce and passengers fled from multiple station exits, causing further confusion about the number of attack sites, located in three different police jurisdictions, which added to coordination-related problems, exacerbated by failures in leadership. The City of London Police, responsible for the Square Mile in the centre of London, restricted cell phone network access to specific users to reduce network traffic and improve first responders' access. However, this action had the unintended consequence of cutting off access for many responding agencies, including the London Ambulance Service.

Responders also encountered problems with radio communications. Although the radio systems used by the British Transport Police and London Underground staff worked in the subway tunnels, the radios of other responding agencies, including the Metropolitan Police Service, did not. Additionally, the Connect radio system used by London Underground staff was still not fully compatible with the Airwave system used by the emergency services. Thus, information and requests for help and assistance were not passed on to the surface.

Legal issues also complicated the agencies' response, for the United Kingdom's Data Protection Act prohibits sharing personal data without the consent of those concerned, thus limiting what information officials could give agencies and families on the identity and status of victims. One of the biggest challenges faced by the London agencies was how to communicate with the victims' families. Family members and friends found it difficult to get information on the status and location of injured or deceased loved ones — so MPS set up a family assistance centre on the day following the bombings.

Vodafone reported that its mobile telephone network reached capacity at about 10 a.m. on the day of the bombings, and it was forced to initiate emergency procedures to prioritise emergency calls. Other mobile phone networks also reported failures and BBC speculated that the telephone system had been shut down by security services to prevent the possibility of mobile phones being used to trigger bombs. It became clear later that the intermittent unavailability of both mobile and landline telephone systems was due only to excessive usage.

Victims trapped underground were able to take photos and video of their surroundings, though the lack of mobile phone coverage in the subway and a general failure of the telecommunication infrastructure to support emergency services meant that this information would only be later forwarded to police and broadcasted through the media around the world. Still, local and national radio either suspended regular programming, or provided regular updates, whereas continuous, uninterrupted TV news coverage of the attacks was broadcast throughout the day, empowered by the use of mobile phone footage sent in by members of the public and live pictures from traffic CCTV cameras. This day marked how day-to-day technology undertook a major role in citizen's journalism.

August 29th, 2005 – Hurricane Katrina

In August 2005, Hurricane Katrina caused severe destruction, including 53 different levee breaches in greater New Orleans that devastated the city and flooded 80% of the region for weeks, forcing 1.2 million residents to evacuate and killing 1,836 people. Katrina was the most destructive and costliest natural disaster in the History of the United States.

The criticism of the government's crisis response was focused on mismanagement and lack of leadership in relief efforts, leading to the lack of basic coordination and a delayed reaction to both the flooding and the subsequent state of chaos in the Crescent City.

Amongst the widespread critical infrastructure collapse, communications was a critical sector extremely affected. The emergency 911 service was severely damaged and surviving stations were soon overwhelmed by the awesome volume of calls as desperate people tried to get help. The New Orleans Police Department's communications system was inoperative for three days, and only a few backup channels were available to first responders in the area. Likewise, the Mississippi's National Guard could not establish effective communications with the governor or the state's emergency management agency. Law enforcement units had two-way radios that used different frequencies than local police, firefighters and military responders – so, even when the systems succeeded to remain operational, eighty percent of the city's emergency networks were incompatible amongst themselves and with those of federal agencies.

Land mobile radio and wireless capabilities were degraded as 2,000 cell towers were put out of commission, although some of the private networks continued to function reasonably well. Satellite phones also worked once the immediate storm passed, although they were in very short supply and many ran out

of power. Satellite radio, such as XM and Sirius, continued to function. Volunteers from amateur (ham) radio's emergency service wing, the Amateur Radio Emergency Service, provided communications in areas where the communications infrastructure had been damaged or totally destroyed, and the SATERN network of amateur radio operators helped to locate more than 25,000 survivors. Also the Federal Emergency Management Agency's (FEMA) Mobile Emergency Response Support (MERS) teams provided assistance with emergency communications, with limited impact in the first days.
This near total failure of communications degraded situational awareness and exacerbated problems with agency coordination, command and control, logistics and search and rescue operations. The absence of authoritative and believable information from public officials created a climate of rumour, misinformation and speculation, and added to the loss of citizens' confidence and the government's inability to maintain public order. Because of this situation, field reporters became conduits for information between victims and authorities, often using internet sites such as blogs, wikis, fora and community journalism. The authorities, who monitored local and network news broadcasts, as well as internet sites, would then attempt to coordinate rescue efforts based on reports. An example of this online effort was NOLA.com, the web affiliate of New Orleans' Times-Picayune, whose blog became a vital link for rescue operations and for reuniting scattered residents, as it accepted and posted thousands of individual pleas for rescue. Much of NOLA's information came indirectly from trapped victims via SMS messaging of their cell phones. Also shelters emerged as information hubs for seeking and providing information and the large Red Cross-run shelters had to establish well-organized call centres and processes for recording and transmitting messages, whether to residents, to survivors nearby, to families and friends and to the Federal Emergency Management Agency (FEMA). A few shelters had computers to access the internet but, for many, this was their first time using computers, and they needed training. Volunteers assisted with this task and helped them to share information, find missing people and follow-up relief efforts.

April 16th 2007 – Virginia Tech Shooting

Moments of terror were lived by students and professors of the Virginia Tech College on April 16th 2007 when, over the course of two-and-a-half hours, a shooter killed 32 people and wounded 25 others, before committing suicide. This massacre is the deadliest shooting incident by a single gunman in U.S. History and the worst act of mass murder on college students' population.
The campus police delayed issuing a campus-wide notification of the gunman, trying to prevent panic reactions, so students were only informed via e-mail at 9:26 a.m., more than two hours after the first shooting, thought at the time to be isolated. This e-mail was not viewed by all students and those who have seen it did not grasp its sense of urgency. The report following the incident concluded that the Virginia Tech Police Department had erred in delaying a stronger, clearer, campus-wide initial alert and in not issuing a campus evacuation order, decisions that could have reduced the total death toll. With no official information, students began to exchange messages amongst them with respect to the occurrence and afterwards used Facebook to learn and confirm the identities of those who had been killed and injured. Following the 2007 shootings, Virginia Tech created an alert system on its website, as well as text messages to warn students of danger.
The Virginia Tech and Blacksburg police departments responded quickly to the report of shootings, as did the Virginia Tech and Blacksburg rescue squads, and their responses were well coordinated. The emergency medical care onsite and at the hospitals was very effective, although providers from different agencies had some difficulty communicating with one another.
The Virginia Tech massacre also served as the trigger to re-examine gaps on gun purchase laws and issues concerning the balance between individual privacy and public safety concerns.

2007 Southern California Wildfires

From October 20th and for the following twenty days, multiple wildfires in Southern California destroyed 1500 homes and burned over 500,000 acres of land, killing 9 people, injuring 85 and provoking the evacuation of more than half a million people. In the process, six counties were declared disaster areas: Los Angeles, Riverside, Orange, San Bernardino, San Diego and Ventura.
Prompt evacuation and road blockades were fundamental to reduce public exposure and maximise firefighters' access to threatened locations. Implemented by blocks within zip codes, the Reverse 911 system worked extremely well notifying residents of danger, in spite of provoking increased congestion on exit routes. Unified command was also considered a key asset in providing a swift and effective response, for it included all jurisdiction stakeholders, fire officials, law enforcement, emergency medical services and utility and water authorities, engaged in information flow activities and decision-making.

Still, the absence of Internet connectivity for the first 48 hours hampered crisis response efforts. Counties with patch capabilities provided coverage over the majority of their jurisdictional response areas, connecting VHF to their 800 MHz system, but the system quickly became overcrowded (each dispatch centre had three incoming and two outgoing phone lines). A portable satellite system, networking the computers of local fire authorities and the Sheriff's trailers and providing internet access and 16 phone lines, performed remarkably. Still, the noise level in the area was very disruptive to onsite communications. Even the complexity resulting from the evacuation of residents and the continuous feeding of information to the public, media and political representatives frequently overshadowed firefighting activities.
Anticipating a high need for information from the public, the media and political representatives, several local fire authorities ordered a large number of Public Information Officers (PIO) early on and established a multiagency Joint Information Centre, responsible for providing volunteers the official information and disaster relief contacts as well as for connecting to the media and the public the vast amount of information they required. This unidirectional model of information dissemination failed to account for all the peer-to-peer communications occurring during the 2007 wildfires. Unable to learn critical information from the media (too general and often incorrect), people in the affected region used mobile and social media to be informed: mobile phones to contact relatives and friends, information portals and websites to know about road closures and fire-line status. During the course of the fires, citizen journalists used Twitter and Flickr to provide real-time updates about evacuations, meeting points and places to gather supplies or bring animals. These updates combined reports from broadcast television news, local radio, streaming video, instant messages, text messages, online scanner radio feed and e-mails from friends in the area. Also San Diego's local National Public Radio affiliate turned to Google Maps and Twitter to report the news online when excessive web traffic brought down its website. Likewise, some people acted as *information brokers*, distributing information, giving advices and providing console.

January 12th, 2010 – The Haiti Earthquake

On Tuesday, January 12th 2010, a 7.0 magnitude earthquake struck Haiti, killing 316,000 people, injuring as many as 300,000, destroying 300,000 houses and leaving 1,600,000 people homeless, in what makes the Haiti Earthquake one of the deadliest natural disasters in modern history.
Amidst the collapse of all critical infrastructure, communications withstood a considerable high damage: the public telephone system was not available, two of Haiti's largest cellular telephone providers, Digicel and Comcel Haiti, reported affected services and fibre-optic connectivity was disrupted. Still, within hours of the earthquake, it became clear that most of Haiti's cell phone towers were still operational and that text messages were getting through. Because text messaging (SMS) is the primary means of remote communication in Haiti – surpassing email, traditional mail and actual phone calls – this crucial fact did not escape the notice of several concerned citizens in the Diaspora. Josh Nesbit, the Executive Director of FrontlineSMS:Medic and Katie Stanton of the US State Department contacted DigiCel hoping to obtain the "4636″ short code as a free aid service. Votident established the data connection with Digicel and sent messages were collected by Brian Herbert's software platform, created within hours of the devastation. Energy for Opportunity and Stanford University mobilized a workflow of thousands of Kreyol-speaking volunteers to translate and categorize SMS messages, while plotting the senders' location in a map. The triaged messages were then streamed back to relief groups in Haiti. Within 48 hours, the 4636 Mission was supported by a global collective of leaders in mobile technologies, content management and crisis response. The number was publicised on local radio, making the service known to large numbers of the Haitian population, which was especially crucial in areas outside of Port-au-Prince that wouldn't have direct contact with aid agencies for many days or even weeks to follow. A week later, the Ushahidi Haiti platform was linked directly to the "4636″ live feed and, from this time, the US Marines starting taking the feed of messages and established a dedicated force to monitor and respond to them. A release articulating the impact of this collaboration was written by Francesca Garrett, a long time volunteer from Texas who had been coordinating the resources of the involved organizations. Through her release, the name "Mission 4636″ (and this site) was born, presenting a unified front in disaster relief in Haiti. While the emergency response continued, an increasing number of organisations were using the maps to plan and coordinate relief efforts, including the Red Cross, Plan International, Charity Water, US State Department, International Medical Corps, AIDG, USAID, FEMA, US Coast Guard Task Force, World Food Program, SOUTHCOM, OFDA and UNDP. By the fourth week, messages to 4636 had become steady at about 1000 per day. Response teams were still targeting aid, food and water, and it was implemented a stable efficient system where messages were quickly translated, categorized, geo-coordinated and streamed to the response teams.

Because the literacy rate in Haiti is about 62 percent, radio is the most common medium used by Haitians. Radio Lumière was initially knocked off the air, but resumed broadcasting across most of its network within a week. The International Charter on Space and Major Disasters was activated, allowing satellite imagery of affected regions to be shared with rescue and aid organizations. Members of social networking sites, such as Twitter and Facebook, spread messages and pleas for help. Facebook was even blocked by continuous updating messages. The OpenStreetMap community responded to the disaster by improving the level of mapping available for the area (using post-earthquake satellite photography provided by GeoEye) and tracking website Ushahidi messages to assist Haitians still trapped and keep survivors' families informed.
Rescue efforts began immediately with Haitians looking for trapped victims amidst the rubble, but effective attendance was hampered by the lack of hospital and morgue facilities: only the Argentine military field hospital was operational until the 13th January. Humanitarian organisations working in Haiti (Red Cross and Red Crescent) were fundamental to provide early emergency assistance to the victims, but rescue work only intensified with the arrival of doctors, police officers, military personnel and firefighters from various countries two days after the earthquake. On January 22nd, the UN and the United States formalised the coordination of relief efforts by signing an agreement giving the US responsibility for the ports, airports and roads, and making the UN and Haitian authorities responsible for law and order. Critics rose concerning evacuation policies that favoured citizens of specific nationalities and the priority being given to the transportation of security troops, while rescuers and medical supplies remained unattended at the airport and port. Finally, with roads being repaired, safe landing areas established and distribution centres secured, food packets and water containers were distributed to Haitians. Afterwards, the Haitian government began moving homeless people out of Port-au-Prince to temporary camps and thousands sought refuge in the Dominican Republic.

January 27th 2010 – The Chilean Earthquake

A destructive 8.8-magnitude earthquake shook Chile for about three minutes on January 27th 2010, ranking as the sixth largest quake ever to be recorded by a seismograph. Felt in eighty per cent of the country, from Valparaíso in the north to Araucanía in the south, the earthquake killed 525 people, left 12.000 injured and 25 missing, and displaced one million and a half people (information provided by the Chilean government in January 2011). The quake set off tsunami waves that swamped the Valparaiso-Concepcion-Temuco area and nearby islands, before moving across the Pacific, where fifty-three countries, including Japan and the Philippines, were on alert and ordered limited evacuations. Since the 2004 Indian Ocean tsunami, increased awareness and preparedness led to swift tsunami alerts across the Pacific, with thousands of people evacuated from low-lying coastal areas in Hawaii and other Pacific Islands.
The earthquake's and the tsunami's destruction impact in Chile was heavy, with at least 370,000 houses, 4,013 schools, 79 hospitals and 4,200 boats damaged or destroyed. A global blackout was generated, affecting 93% of the country's population and continuing for several days in some locations, complicating rescue efforts. In the hardest-hit zones, for the first days, there was no communication with the exterior because of the failure of electricity and the destruction of telephone lines. The only intact communication was via hand-held emergency radio at the local level. Throughout the country, electricity, telecommunications and water supplies were disrupted, cell phone and Internet service were sporadic and major seaports and airports, including the main airport in Santiago, were out of operation across the country's central region.
In the immediate response to the earthquake and tsunami, first responders, emergency personnel and search and rescue teams handled many challenges. Loss of communications was significant and effective coordination to support life-sustaining efforts was gravely impacted due to the lack of inter- and intra-agency coordination. The initial response and resilience of individuals and communities was fundamental to the overall response, by providing much of the initial search and rescue and surpassing the government's limited situational awareness, that affected the adequate assistance to local needs. The *Officina National de Emergencias, Ministerio de Interior* (ONEMI or National Emergency Office of the Ministry of Interior) reported that most coastal communities practiced evacuating the coastal area, which contributed to the high level of successful evacuation achieved by the communities ultimately hit by the tsunami. The Chilean military played a key role in supporting many aspects of the response, but were not immediately mobilized. With the President's declaration of the "state of catastrophe", the military were sent to take control of the most affected areas and curfews were imposed in some areas of looting and public disorder. Situational awareness gradually increased over the second and third days, but coordinated situation status in the region was not fully achieved for nearly 10 days.

Communications were restored over days, but the timeframe was highly variable, depending on modality and location. The media played a mixed role. Only a single radio station remained on the air in Concepción immediately following the earthquake, but it was helpful since no one had situational awareness or means of receiving information. There was a general sense that some of the media, especially television, exacerbated the chaos rather than providing helpful emergency messaging and risk communications. In Concepción, text messaging became available within the first day, followed by cell phone communication and Internet. By the end of the first day, half of the hospitals in the Bio Bio region had been contacted through text messaging.

Still, social media tools were mostly used in Chile not as immediate rescue helpers but as coordinating tools for relief and aid non-governmental organisations and private social initiatives. Google mobilised several teams to help with the disaster response, with Google Map Maker made available in Chile, as well as the Person Finder tool to submit or search for information about individuals who may have been affected. Twitter and other web-based resources were a key source of information about the disaster, helping families to state their difficulties and know their loved ones whereabouts. One successful enterprise in this field was the emergence of *Digitales por Chile*, a volunteer organisation that used Twitter to gather the highly skilled IT professionals and technicians that worked for several months to help citizens affected by the disaster. In just twelve hours, the 300 volunteers of *Digitales por Chile* created in 12 hours the www.chileayuda.com portal, which supported the systematisation and integration of the disaster-related information, including Google's Person Finder, geo-referenced mapping, official communications and donations. *Digitales por Chile* intensively used Twitter (in one week, the portal had 4000 followers), Facebook (in a week and a half, it joined more than 150.000 members) and Ushahidi, with its multi-layered maps being constantly updated with information on rescue centres, medical assistance and police warnings.

In July 2010, in an effort to reduce future catastrophic natural disaster losses for California, the American Red Cross sent a delegation of 20 multidisciplinary experts on earthquake response and recovery to Chile. Their goal was to understand how the Chilean society and relevant organizations responded to the 2010 Great Earthquake and how an application of these lessons could better prepare California communities, response partners and state emergency partners for a comparable situation. To this expert team, it was clear a multidisciplinary approach was required to properly analyse the emergency response, technical and social components of this disaster. In their report, four factors were deemed relevant for the restrained extent of the damage and death toll in Chile: the strict building codes, the limited number of fires following the earthquake (because of the national electrical grid shutdown early in the shaking and because there is a general use of propane gas for cooking instead of gas pipelines, especially outside the city centre), the local close coordination between emergency management, fire and police, empowered to respond without communication with the central government and the overall high level of knowledge about earthquakes and tsunamis by much of the population that helped them respond more appropriately after the event.

2011 Victorian floods

High intensity rainfall between January 12th and 14th 2011 caused major flooding across much of the western and central parts of the Australian state of Victoria, leading to thousands of evacuations, twelve dead and seventy-two missing persons. As of 18th January, more than 51 communities had been affected and over 1,730 properties had been flooded, devastating 51,700 hectares of pasture and 41,200 hectares of field crops.

Hundreds of roads were closed, train services were disrupted and electricity was down. The Australian Defence Force, Victoria's 4th Reserve Response Force and the South Australian State Emergency Service assisted the Victorian State Emergency Service in gathering information on the impact of the floods on community and private infrastructure. Relief packages were distributed across the affected region with the help of 3,000 emergency service volunteers. Under the aegis of the Australian Red Cross, fifty-seven emergency shelters were set-up in schools, community centres and sport facilities throughout Queensland and, as much as possible, the Australian police went door-to-door ordering evacuations and patrolling flooded suburbs. With emergency services overwhelmed, media and social networking sites are also part of the response to the flooding. Australia public broadcaster had a dedicated digital radio channel providing interactive mapping of the flooded region and Twitter and Facebook provided updates and messages of support.

March 11th 2011 – The Great Japan Earthquake

On March 11th 2011, a powerful 9.0 magnitude earthquake (the seventh most powerful earthquake in recorded History) struck the coast of Japan, causing widespread power outages, fires and a severe

tsunami reported to be 40.5 meters high and traveling 10 km inland. At least 15,647 people were killed, 4,643 missing, 5,924 injured, 130,927 displaced and more than 332,395 buildings, 2,126 roads, 56 bridges and 26 railways destroyed or damaged. Electricity, gas and water supplies, telecommunications and railway service were disrupted and several reactors severely damaged at Fukushima's nuclear power plant. This is the fourth largest earthquake in the World and the largest in Japan since instrumental recordings began in 1900.

One minute before the earthquake was felt in Tokyo, the Earthquake Early Warning system, which includes more than 1,000 seismometers in Japan, sent out warnings of impending strong shaking to millions. The early warning is believed by the Japan Meteorological Agency to have saved many lives, since the warning for the general public was delivered about 31 seconds after the earthquake occurred.

Cellular and landline phone service suffered major disruptions in the affected area but internet services were largely unaffected for the system rerouted around the affected segments oto redundant links. In an hour, with the Japanese fixed telephone network destroyed, Twitter became the emergency service, with almost 1,200 tweets per minute coming from Tokyo, accordingly to Tweet-o-Meter. Twitter users even shared the tsunami's estimated times of arrival on U.S. shores, long before an official government tsunami warning went into effect. Even the media reported that Twitter was the only functioning communication tool immediately after the earthquake. Several Wi-Fi hotspot providers reacted by providing free access to their networks, and some American and German telecommunications and VoIP companies offered free calls to (and in some cases, from) Japan for a limited time.

Concerning the crisis response effort, more than 100,000 Self-Defense Force personnel were mobilised for the rescue and relief work. But Japan lacks a unified Disaster Management framework allowing the swift mobilisation of separate agencies under a unified operational command. Every level of the Japanese administration has a clearly delineated disaster prevention (Bousai) organisation, with policies that are regularly reviewed and communicated to the local community. Also local refuges are clearly identified and regular training ensures that everyone knows what to do in the event of an earthquake or tsunami. Thus, failures at the tactical and operational level were mostly derived from the lack of leadership at the political level. In fact, there there was no clear decision-making structure that would allow the disparate stakeholders on disaster recovery to work together. The traditional problem of Japanese decision-making, mixed with the stove-piped *tatewarigyousei* and protective *nawabari* cultures, makes the protection of own information the priority, prompting a agency-centric response management instead of a coordinated and integrated capability. Additionally, four factors, unattended in planning, also contributed to the innefectiveness of the crisis response management programme: the actual scale of the disaster, the inacessible characteristics of the terrain, the nuclear hazard and the winter weather conditions. As a result, relief supplies were delayed to some disaster areas.

On a different token, Japan's earthquake tragedy is a study case in terms of crisis communications, namely with respect to the way the Japanese authorities, specifically Cabinet Secretary Yukio Edano, used social media tools to calm public fears and remedy media speculation. As expected, the crisis at the Fukushima power plant was catapulted online almost instantly and within a few days generated 64% of blog links and 32% of Twitter news links, according to a research conducted by the Pew Research Center's Project for Excellence in Journalism. Public criticism in the Japanese society both against the government and against Tepco, the operator of the plant, started to rise. Cabinet Secretary Edano's live press conferences were praised on Twitter, for he was clear, articulate and unafraid of difficult questions, presenting leadership qualities.

2011 Middle East Upheavals

In December 2010, a mass protest in Tunisia led to the ouster of the country's autocratic ruler. It was the first successful mass uprising against an Arab leader in years. Fuelled by the successful protests in Tunis, political unrest and change are sweeping North Africa and the Middle East, on what is already known as "the Arab Spring".

Pro-democracy and anti-government protests began in Egypt and are occurring in Jordan, in Yemen, in Syria, in Algeria, in Morocco and in Libya, where after a 42-year rule, Muammar Kadhafi was defeated by rebel troops.

Social networking platforms are among the tools of change as much of the organisation of these popular protests is being done on Facebook, Twitter and YouTube, despite the governments' blocking efforts (network monitoring site BGPmon found that 88 percent of Egyptian networks had become unreachable, with many Egyptian internet service providers no longer offering connectivity). There is a growing number of Middle East users to available social networking tools, especially after March 2009, when Facebook adopted an Arabic language interface and attained 35 percent of the UAE population and 49 percent of

Qatar's resident base. The growth of social media in the Middle East and the shift in user trends has played a major role in citizens' mobilisation and empowerment, marking the winds of change in the 2011 Middle East upheavals.

2011 England Riots

As a consequence of Mark Duggan's killing by the police in Tottenham, a peaceful protest was organised on August 6th but it quickly deteriorated into violent confrontations between Metropolitan Police and rioters. These disturbances continued and spread to other locations, including Birmingham, Liverpool, Bristol and Manchester, with numerous cases of vehicles and buildings burning and widespread looting. A total of five people have died and more than 1,600 arrests have been made.

Twitter was initially reported as the prime means of communication for rioters but later BBC and The Guardian have identified it to be the Blackberry Messenger, apparently heavily used to coordinate activities such as looting and to avoid authorities. These rumours led Research In Motion, the company that manufactures BlackBerry smartphones, to issue a statement of its willingness and availability to cooperate with law enforcement and regulatory authorities and track users that incited to violence. Public criticism has emerged with respect to the police's inefficiency to monitor social networking. Still, a number of arrests have been made in the United Kingdom for posting Facebook and Twitter messages inciting to criminal behaviours. Also authorities have used social media themselves to identify criminals, posting photographs on Flickr and scanning the Web for clear photographs of rioters' faces.

Social media has also been quite relevant for the citizen's journalism trend. The hyper-local site The West Londoner offered a live blog of the riots that achieved one million views in just 24 hours, because of its ability to provide immediate updates, with no speculation or rumour. After the riots, social media is also instrumental to correct inaccurate information, to assist on debris cleaning and to disseminate messages of hope and commiseration.

July 22nd 2011 – Norwegian Terrorist Attacks

On July 22nd 2011, a car bomb explosion in the executive government quarter in Oslo, placed outside the Prime Minister's office, caused the death of seven people, critically injured eighty-nine people and severely damaged several buildings, including the state broadcaster NRK and the Norwegian tabloid newspaper VG. Less than two hours later, the same perpetrator took the ferryboat to the island of Utøya, where youngsters were at a political retreat. Dressed as a police officer and with a false identification badge, he said to be performing a routine check following the bombing event in Oslo. Instead, he started to shoot indiscriminately. He gunned down 84 people and wounded 153 in the course of an hour and a half, before the Norwegian Police Service arrested him. This mass shooting is one of the worst in History and the deadliest terror day in Western Europe since the 2004 Madrid Train Bombings.

One minute after the bomb exploded, the police received the first message about the explosion and, two minutes later, the first police patrol reported it had arrived at the scene. At the same time, the news agency NTB broadcasted that the Prime Minister was unhurt and safe. Then, the police cleared the area, searching for additional explosive devices, and urged citizens to evacuate central Oslo, through media outlets. The subway system remained operational as did the tram network, with the exception of the specific downtown lines. Also buses continued to run.

On the island, witnesses report to have hidden in the undergrowth and in lavatories, communicating by text message to avoid giving their positions away to the gunman. The messages also informed their relatives and friends not to phone, so that the ringing would not give away the location of those hiding from the gunman. Initially, as the besieged people from Utøya tried to call the emergency services, they were told to keep off the line unless they were calling about the Oslo bomb. After the local police district learned about the shooting, the police in Oslo were informed and the Norwegian central counter-terrorist unit *Beredskapstroppen* was dispatched to Utøya. However, the special force did not have a helicopter available that could take them straight to the island and had to drive to the ferry crossing and waited for a (recreational) boat to take them across. Thus, the SWAT team arrived at the island 79 minutes after the reports that the shooting had begun. Paramedics did not arrive for another 10-15 minutes. The police also reported that the gunman called 112 at least twice to surrender, but continued killing people in between. The police tried to call him back but did not succeed.

Meanwhile, media helicopters were filming the killings from the air, long before the arrival of armed anti-terrror police officers, more than an hour after the shooting started. Long before any emergency services came to assistance, local residents in little motorboats and fishing dinghies sailed out to rescue the survivors who were pulled out bleeding from the water and picked up from hiding places in the bushes and

behind rocks around the island's shoreline. After also the police searched the island's surrounding waters for survivors and victims. After the terrorist attacks, Norway did not change its threat level, but contacts continued between the government and the police, to maintain this condition under continuous scrutiny. During the unfolding of the attacks, security and emergency services were paralyzed with communication disruption. While the district police used an old analogue radio system, the elite SWAT unit, dispatched to assault the island, and paramedics had switched to a new secure digital network. Police commanders had to contact different units via email and fax, as the mobile network was down.
Soon after the attacks, the Norwegian media, headed by the Norwegian national broadcaster NRK, identified the suspect and reported that police was investigating his internet activity with respect to political and religious believes. Social media, namely Twitter and Google+, served as a main information provider, for the survivors and their families. Both traditional and online media refer that the Norwegian security and emergency services are under scrutiny, heavily criticised for their slow reaction time response to the Utøya island shooting, on account of being short of transport capacity: they rely on a military helicopter that was stationed at a 60 km distance and a police surveillance helicopter whose crew was on vacation; engine failure also delayed the arrival of one commando police boat. Also the concentration of response units in Oslo contributed to the delayed response to the Utøya massacre, raising questions of whether the security and emergency services were prepared to handle well a dual attack. The Norwegian intelligence services are also under fire, for they had the suspect on a security service watch list, after he ordered chemicals online from Poland, in March, and did not continued to monitor his activities, in what could have prevented the slaughtering.

November 1st and 8th 2011 – Polish Air Incidents

On November 1st 2011, at 14:40 CET, the Boeing 767 flying from New York to Warsaw successfully performed an emergency landing at Warsaw Chopin Airport. On November 8th, the chartered aircraft Boeing 737 flying from Katowice to Egypt turned back on the Polish-Slovak border and circled for an hour over the airport in Katowice.

These recent air incidents in Poland are examples of how citizens' publish news online, through Internet portals (e.g. Alert24.pl), before the information is officially published by news stations. In the first case, the Polish public TV information channel showed the moment of landing, in live broadcast (only few seconds before landing [24]), while Internet users sent images of the Boeing being escorted by military fighter jets, circling over the airport and consuming excess fuel [25]. Evidently, those images had been published online already several minutes before being live broadcasted by official TV. In the second case, one of the Internet publishers tracked the flight path through the flightradar24com portal, and sent such information to the Alert24 portal [26].
Alert24 portal [27] is maintained by a publisher of information portals such as gazeta.pl and gazetawyborcza.pl, as well as of popular daily newspaper "Gazeta Wyborcza". Alert24 allows users to send messages via MMS, SMS or text, images and videos through the form. These information are published before the official confirmation of given incident by reporters / news agencies, and often are the first source information about a disaster, accident, etc. The similar approach is used in the Kontakt24 portal, which is a subsection of tvn24.pl [28] news website (on-line edition of nationwide information television channel - TVN24).

Figure 10 – Screen from the www.flightradar24.com Posted by An Internet User

One situation in particular reveals the immediacy of the online information: the Boeing 737 aircraft, after using redundant fuel, landed safely at about 12:00, while information about possible problem / incident was delivered to the Portal while the airctaft was still in the air (before 12:00). After receiving the message, reporters of gazeta.pl confirmed technical problems in the aircraft, through the press officer of the airport in Katowice. However, official and confirmed news about described incident only were present on information portals (including gazeta.pl) after 13:00 [29].

Figure 11 – Heading of the First News On the Incident
(ca 1,5h after unofficial alerting by Internet users).

These two examples show that citizens with access to video cameras, mobile phones and Internet (including social networks) are often the first sources of information. The fast publishing time of the information (after immediate confirmation by reporters) may be critical and invaluable upon crisis occurrence.

10. ANNEX B - A NEW ERA FOR ICT TOOLS IN CRISIS SITUATIONS?

Citizens' engagement is supporting the dissemination of additional information, often critical and accurate, into the public sphere: providing eye-witness accounts, sending alert messages, exchanging evacuation and rescue experiences, searching and publishing event-related information, volunteering goods and services, collecting donatives. More than mere information distribution tools, these technologies connect people and information, establish collaboration mechanisms, create informal networks and build no-boundary communities.

With a strong emphasis on real-time, new mobile and online technologies have significantly improved the affected citizens' and victims' capability to help each other and themselves, with their messages enabling improved situational awareness amongst the involved public safety organisations (PPDRs) and first responders (FRs), guaranteed by the gathering of a wide variety of data and information – an activity previously known as *crowdsourcing* and now named *crisis informatics*[24].

Web-based Systems for Crisis

Several initiatives, primarily emerging from the private sector, have essayed to capture the benefits of this new age of citizens' involvement and awareness in the management efforts concerning crisis response. Of these initiatives, **Ushahidi** (Swahili meaning "testimony") (http://www.ushahidi.com) is probably the most popular one. It is a website that, using web and mobile phones' reports, mapped reports of violence and peace efforts in Kenya during 2008, after the post-election fallout; later, the *ad hoc* group of volunteers evolved to a non-profit tech company, specialised in developing the Ushahidi platform and free and open source software for information collection, visualisation and interactive mapping. Using mobile phones as the primary means to send and receive crisis incident reports (a mobile application is available[25]), the Ushahidi platform already monitored the elections in India, Mexico, Lebanon and Afghanistan, tracked unrest events in Congo, medicine stock-outs in Zambia and mobile phone companies in the Philippines. It was successfully used in Haiti, being recently replaced by Noula (http://www.noula.ht/), which was developed by the Haitian company Solutions. The Ushahidi platform allows tracking reports (e.g., incidents and victims) over a map[26] and over time (and filtering over multiple categories), offers crowdmapping funcionality, enables users to submit incidents (in a simple and intuitive way), provides alert services (via RSS or email) and collects data from multiple streams (e.g., text messages, email, twitter and web-forms), including news posted in social media (e.g, twitter and sparked), data from Mission 4636 and Google PFIF. An overview of an Ushahidi instance used in Haiti is presented in Figure 12.

[24] The University of Colorado researchers ((Palen, Vieweg, Sutton, Liu & Hughes) define the **activity of crisis informatics** as a documented phenomenon that illustrates how people in and out of the disaster go on line through computers using Web 2.0 applications, cell phones and other personal devices to provide, seek and broker information in times of emergency.
[25] Ushahidi iOS (http://itunes.apple.com/us/app/ushahidi-ios/id410609585?mt=8).
[26] Different map providers can be used, including OpenStreetMap and GoogleMaps.

Figure 12 – Ushahidi User Interface Overview

Another similar example is **Sahana** (*relief* in Sinhalese) (http://sahanafoundation.org/) is a free and open source software developed and managed by the Lanka Software Foundation and intends to support national and local authorities and relief agencies in their response to numerous sudden, large-scale disasters, namely the 2004 Indian Ocean Tsunami, the 2005 Pakistan Kashmir Earthquake, the 2008 Chengdu-Sitzuan Earthquake and the 2010 Haiti Earthquake. The Office of Emergency Management of New York City also applies Sahana since 2007, to manage its all-hazards sheltering plan, used for the response to Hurricane Irene in 2011. Sahana's Disaster Risk Reduction (DRR) Project Portal is also a useful resource in all DRR initiatives in Asia and the Pacific for effective regional coordination, under the auspices of the UNISDR Asia Partnership on Disaster Reduction and the Asian Disaster Preparedness Centre and funding support from the Asian Development Bank. Sahana provides three main products:

- **Eden** is a flexible humanitarian platform that can be rapidly customised to adapt to existing processes and integrate with existing systems in order to provide effective solutions for critical humanitarian needs' management, either prior to or during a crisis;
- **Vesuvius** is focused on the disaster preparedness and response needs of the medical community, contributing to family reunification and assisting with hospital triage;
- **Mayon**, currently under development, is a highly scalable emergency personnel and resource management solution to manage large numbers of events, persons and resources.

Provided by Google, **Google Crisis Response** is a free service for crisis response, already applied in past crisis events (e.g., Chile, Haiti and Japan). The portal provides a main page displaying a number of useful services, including donations, people finder (**Google Person Finder**), alerts and status (related with power grids, government, transit), important call numbers and maps and satellite imagery.

A key feature is the ability to provide updated satellite imagery and maps of affected areas to highlight damaged areas and help relief organisations navigate disaster zones. On top of maps, the crowdmapping provided by Google includes: marking crisis information such as road closures or emergency medical stations, drawing lines and shapes to highlight paths and areas, adding text, photos, and videos to provide

context and to enrich situational awareness during crisis, sharing maps and other resources taking into account security/privacy issues, as well as importing KML (Keyhole Markup Language), KMZ (compressed KML), and RSS/GeoRSS (RDF Site Summary) formatted data into updateable maps [30].

The platform supports multi-language (English and Asian languages) and provides a link to a free translation application between English and Japanese that can be installed in Android platorms. This tool, as it was used in Japan, is presented in Figure 46.

Figure 13 – Google Crisis Response

OpenStreetMap (http://www.osmfoundation.org) is *an initiative to create and provide free geographic data, such as street maps, to anyone*. Thus, it follows an open data model[27]. The OpenStreeMap content is created by a community of volunteers all over the world: before Haiti's earthquake, *there were no good, up to date maps of Haiti. OpenStreetMap contributors Ikiya, in Japan, and Firefishy in England started improving the map of Port au Prince from Public Domain satellite imagery within hours of the earthquake. OpenStreetMap contributors from around the world updated the map of Haiti every few minutes* (every 5 minutes [31])[28]. The result can be visualised in Figure 14, where it is presented the Haiti map before the Earthquake, two days after the Earthquake [32] and on October 14th 2011[29].

Figure 14 – Haiti in OpenStreetMap

Before (left) the Earthquake, two days after (center) the Earthquake and on October 14th 2011 (right)

OpenStreeMap quickly mapped road data (including obstacle points), food and water distribution points, up-to-date satellite imagery (courtesy of GeoEye) and way finding&routing. *Five days after the earthquake, the Fairfax Urban Search And Rescue Team was using OpenStreetMap data in their handheld GPS devices on the ground in Haiti. They were greatful to have this crowdsourced, Open Data to help in their rescue efforts*. [31]

Ushahidi, Sahana, Google Crisis Response and OpenStreetMap started of as projects thought to address a specific crisis situation and since evolved to accommodate the requirements of several other crisis situations. On a different token, several other projects remain confined to the specifics of determined events. For example, the **KatrinaHelp Wiki** and the **Katrina PeopleFinder Project** represent a clear effort

[27] The open data model is especially relevant in iSAR+ and will be described in detail later on.
[28] OpenStreetMap is an example of citizens' participation on a large-scale volunteer effort via online and through open and global collaborative platforms, also in crisis situations.
[29] Snapshot taken from www.openstreetmap.org on October 14th 2011 at 11:05am.

from volunteers throughout the World to support ongoing communication and collaboration for rescue, recovery and relief efforts concerning the Katrina disaster. In conjunction with Skype, the KatrinaHelp Wiki established a messaging centre that was able to convey critical information and to appease disturbed spirits, whereas the Katrina PeopleFinder Project created a uniform standard for collecting, compiling and searching information on people affected by Hurricane Katrina.

Also with a focused purpose, **Mission 4636** (http://www.mission4636.org/) was launched as a free phone number (4636) established to meet the urgent needs of the Haitian people (medical care, food, water, security and shelter) through SMS messaging. The service was provided by DigiCel, the country's largest cell phone network. Through the Mission 4636 service, 80,000 messages[30] were received predominantly written in Haitian Kreyol, translated, geo-located[31] and categorised via online crowdsourcing platforms by need and priority, and distributed to various emergency responders and aid organisations. A large workforce – more than 1000 volunteer translators – was required to translate and process the overwhelming amount of SMS [33]. An example of an SMS received and processed by Mission 4636 in Haiti is presented next [34].

> *[1/21/10 23:59]*
>
> *Jodi a fe 4 jou mwen pa mange tanpri mouin grangou mouin kay yon moun nan sain marc rue louverture numero 75. kowodone: 19.10196, -72.69954*
>
> *[Very rough translation: Today haven't eaten for 4 days, please in a basement Saint Marc Rue L'Ouverture #75]*

Indeed, the 2010 Haiti catastrophe was extremely catalytic in terms of prompting innovative projects to deal with the overwhelming response effort. The US Department of Homeland Security (DHS) launched the **Haiti Social Media Disaster Monitoring Initiative** to assist in the response, recovery and rebuilding effort in Haiti. The Initiative became a vehicle to provide situational awareness and establish a common operating picture for the US Government and the local government, and information was also shared with international partners and the private sector where necessary and appropriate for humanitarian assistance and disaster relief. The Initiative included monitoring publicly available online forums, blogs, public websites and message boards to collect information critical for situational awareness and the common operating picture.

Also with a humanitarian essence and an authority-based nature, the **OneResponse** platform presents itself as the collaborative inter-agency website designed to enhance humanitarian coordination and support the exchange of information in emergencies. Owned and managed by the United Nations' Office for the Coordination of Humanitarian Affairs (OCHA), OneResponse aimed to avoid the multitude of ad hoc websites developed in each new emergency and, since 2008, it has become one of the few official initiatives to use online technology to enable the improved exchange of operational information in emergencies at the country level, taking into account the agencies' relevant existing web platforms and web-based resources. A particular feature upheld by OneResponse as an official initiative has certainly be security, with the platform's information being categorised as either public or private, to allow sensitive information to be made accessible only to cluster specific working groups.

Mobile Applications for Emergencies

Addressng ICT tools and their application in crisis situations, it becomes rapidly clear the relevance of mobile applications for large emergencies. Through mobile technology, affected people may reach their closed ones and authorities, making and receiving phone calls, sending and receiving SMSs (e.g., Mission 4636) and accessing platforms such as Ushahidi or Google, to read critical information or to provide up-to-date information.

[30] An average of 1000 per day [33].
[31] Automatic geotagging of messages would have been possible if localisation techniques, such as those used by iSAR+ partner Deveryware), would use.

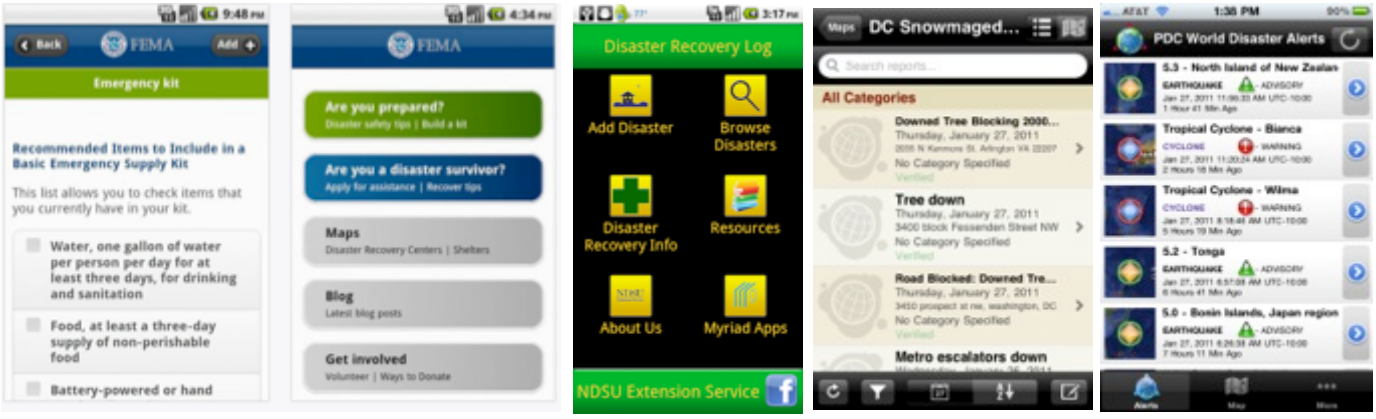

Figure 15 – Emergency and Disaster Response Mobile Applications for Citizens

Today, most mobile technology supports advanced functions for improved user experience. Figure 15 presents examples from applications published by U. S. FEMA[32], North Dakota State University (NDSU) in Fargo[33], Ushahidi[34] and Disaster Alert (Pacific Disaster Center's World Disaster Alerts)[35]. These applications provide citizens useful information, instructions and alerts (push). Both the NDSU platform and the Ushahidi app allow citizens to post information into the platform (e.g., add disaster), that is, they support built-in bi-directional communications.

Another recent and notable initiative was taken by the North Yorkshire Police Authority (NYPA), an iSAR+ partner and end-user. The goal was to develop *the first police mobile app to be launched in the UK and has now been shortlisted for the Good Communication Awards 2011* [17]. The application offers numerous functionalities, including news, contact numbers, alerts and online maps, and it is well integrated with Facebook, Twitter and YouTube. Accessible through different smartphones (e.g., iPhone and Android) and tablets (e.g., iPad), the **NYPA application** is also used to disseminate suspect photos. Snapshots of the application are presented in Figure 16.

Figure 16 – NYPA Mobile Application
The image on the right refers to a photo of a suspect that was shared by the police to citizens.
The image was anonymized in this paper.

Since its lauch, the NYPA application *has been accessed more than 5,000 times by people looking for the latest news, detailed crime data, witness appeals, details about their local Safer Neighbourhood Team and crime prevention advice* [17].

Another example of a mobile application for *in-situ* use, is the **Gaia GPS** developed by Trailbehid Inc. and instantiated in a an special version to support the Haitian Disaster Relief, that interfaces with OpenStreetMap, for purposes of retrieving map and satellite information (and associated geolocalised data), provides localisation in lat-long coordinates and delivers guidance to waypoints and along tracks. Presented in Figure 17, Gaia GPS is available for download via iStore[36].

[32] http://apps.usa.gov/fema-mobile/
[33] http://www.ag.ndsu.edu/extension/apps/disaster-recovery-journal
[34] http://itunes.apple.com/us/app/ushahidi-ios/id410609585?mt=8
[35] http://itunes.apple.com/us/app/disaster-alert-pacific-disaster/id381289235?mt=8
[36] http://itunes.apple.com/us/app/gaia-gps-for-haitian-disaster/id351031999?mt=8.

Figure 17 – Gaia GPS Application (for Haitian Disaster Relief)

Location Awareness in Crisis Situations

Crisis response efforts, especially search and rescue actions, understand the benefits enabled by the citizens' automated location-based services for directed messaging and alerts generation. In this context, governmental approach has been careful and even conservative, considering not only the legal framework involved but also the pertaining ethical considerations.

Nonetheless, mobile phones can be located using the equipment's embedded capabilities (e.g., GPS receiver) and/or existing communications infrastructure (e.g., cellular and WiFi), a functionality that has recently became accessible at a large scale, when Google created the '**Google Latitude'** service. Via this service, citizens can share their location with others and visualise it over a map[37]. Soon, Apple followed the example and is now offering the '**Find my iPad'** service that, among other features, enables its users to locate their own Apple devices (e.g., iPad, iPhone and MacBook). More recently, Apple's '**Find My Friends'** service allows sharing location information between groups of people. A result of what these applications provide is presented in Figure 18.

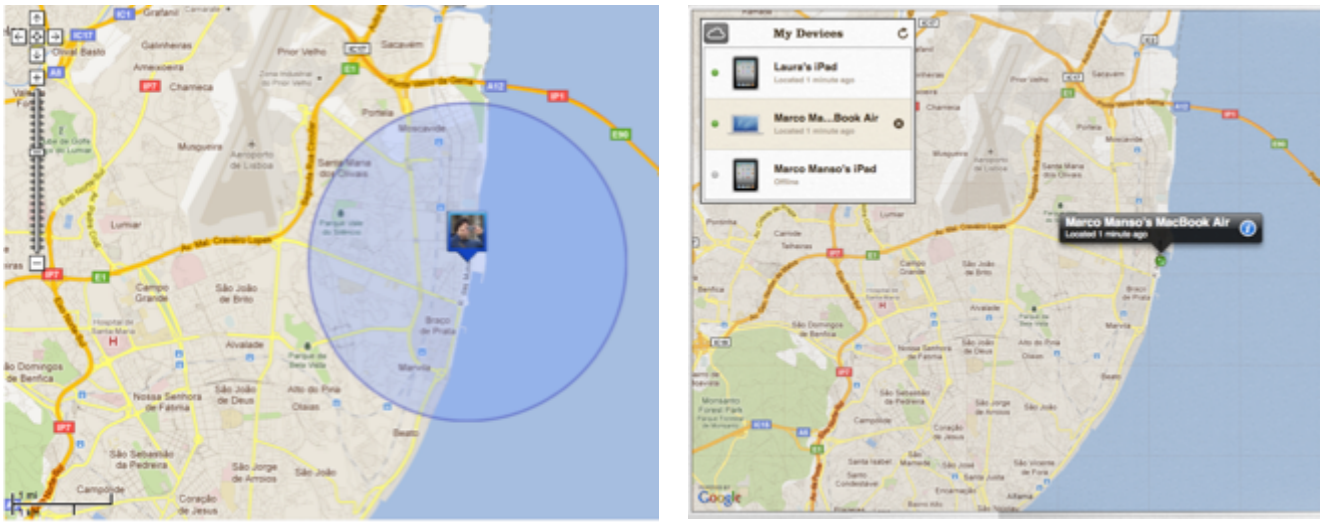

Figure 18 – Google Latitude (left) and Apple "Find My iPad" (right)
showing the location of the main author at the time he was writing this caption

PermiLoc

Deveryware, an insightful iSAR+ partner, provides the TeamLoc, WhereAreYou and PermiLoc applications to locate mobile devices in cooperative and non-cooperative modes, following privacy-by-design policies and recognised ethics principles. Data visualisation is provided by GeoHub, a central platform with the capacity to support tens of million locations per day with a 99.9% availability rate and to provide automatic alerts (e.g., when a phone enters or exits a zone, when a phone is nearby, when a phone is turned on) by means of SMS or email. The cooperative mode enables users to provide their location as explicit content and 'opt-out' at anytime, whereas the non-

[37] Google, on the other hand, can provide geo-based advertisements by knowing the user's location.

cooperative mode uses the phone's beacons for real-time location, a method that requires legal authorisation and data from telecommunication operators, thus being primarily used for law enforcement and security purposes. These features' benefits in crisis response and SAR actions are relevant for their life saving potential, provided suitable legislation and ethical principles are safeguarded.

Really (Simple) Notification

Conservative has also been a key feature in the traditional communication that PPDRs entail with the general public, adopting a prevalent unidirectional flow (from PPDRs to citizens) that particularly neglects social media even for the most innovative agencies. But a few exceptions prevail. The U. S. FEMA 2007 **GovDelivery's Digital Subscription Management** solution is *an automated system that hat uses email, text messaging, RSS*[38] *and social media to keep citizens informed when new information is available on topics of interes*t [20]. Its benefits, as stated by FEMA, suggest that *more people are aware of preparedness plans that help in FEMA's goal of reducing loss of life and property*. *The return on investment is great for FEMA as it can be expressed most clearly in lives saved and property damage prevented* [20].

It is also worth mentioning another technological endeavour carried out by Portland's City: the **Connect and Protect Programme**. Applied in nine Oregon counties, this programme transformed the traditional 911 into a truly interactive system, combining real-time networked communication devices with private-sector location-based applications. The system analyses incoming requests and warnings, extracts the essentials and reverses the information flow, redistributing them to medical emergency assistance, fire brigades and police, to hospitals, schools and other public institutions, as well as to citizens. For example, receiving warnings directly from parole officers, the system redirects them immediately to nearby schools, the same way that storm alerts are more rapidly communicated by hotel managers than by the official meteorological agency. With respect to citizens, the use of the Common Alerting Protocol (CAP) provides precise warning definitions in proximity, urgency and certainty and these warnings are tagged with geographical coordinates, so citizens can customise their own mobile phones, pagers or other devices to receive only the messages that are relevant to their location. Portland's Connect and Protect programme has very strict security features to prevent abuse of the warnings[39].

Social Networking Platforms

Going through ICT tools and their application in the crisis realm would not be complete without an approach to social networking online platforms. Initially created to connect individuals with common relationships or interests, social network sites have expanded to become almost a ubiquous reference for every citizen. As a natural result, these platforms are extremely active upon crisis situations. It is also relevant to note that these platforms have successfully attained a mobile applications' reach, enabling every user to post text, messages or videos in a fairly easy way. Table 5 presents some of the most popular social networking platforms worldwide and in the European context and its use by citizens.

Social Networking Mobile App	Citizen Main Use
Facebook	Share messages, images and video with friends or anyone. Most used social media worldwide. EU alternatives are Hyves.nl (in the Netherlands) and Nasza-klasa.pl (in Poland)
Twitter	Connect with and follow people based on a similar topic. Short text messaging in real-time. Supports geotagging messages.
YouTube	Share videos. Easy to post a video recorded by a smartphone.
Flickr	Share images. Supports geotagging images. Alternatives are Picasa, Panoramio (photos of the world).

Table 5 – Social Networking Platforms Main Use

[38] RSS (Really Simple Syndication) is a web-based technology that can be used to publish content that is frequently updated and that users can subcribe to and receive notifications when updates occur. RSS is mainly used for news and blog services.
[39] Certain calls (warnings), such as reports of sexual crimes, are not publicly disclosed. The alerts can not be easily copied and anonimity is totally forbidden.

In a nutshell, it is worth referring the 5530 TPS during the 2011 Japanese Earthquake in 2011 and the large video footage of the Haiti and Japan crisis events in YouTube[40] (http://www.youtube.com), as shown in Figure 19.

Figure 19 – Videos of Crisis Situations in YouTube

In what concerns images, two web-services are particularly popular: flickr and Panoramio. Both services§ support uploading images with geotagging information that, associated with the map display, enables the visualization of the 'what' and 'where' of an image. In flickr, "Haiti" and "Hope for Haiti 2010" have more than 10.000 photos posted.

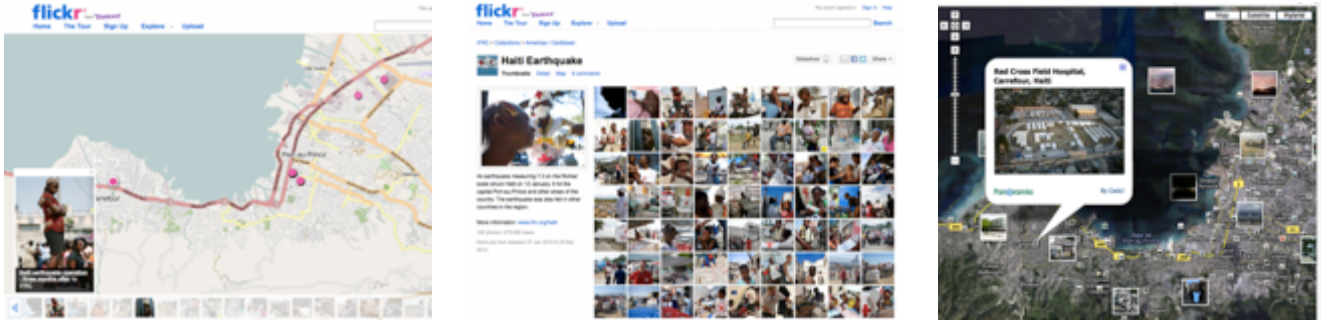

Figure 20 – Images of Crisis Situations in flickr (left and centre) and Panoramio (right)

Web Citizenship on Security

Moreover, citizens are indeed proficuous in launching and contributing to new, citizen-based initiatives, some security-related. Some examples are: the websites created by volunteers in the aftermath of the 2005 Hurricane Katrina, to coordinate assistance, offer food, provide housing and help rebuilding activity; the Wikipedia page that 1500 individuals composed after the 2007 Virgina Tech shooting to inform outsiders of latest events; the collection of photos in flickr and tweets in Twitter posted by citizens to assist firefighters and other citizens during the Californian wildfires.

Another successful community safety effort has been the **AMBER Alert System** (www.amberalert.gov), named after 9-year-old Amber Hagerman kidnap and brutal murder, which was launched in 1996 by the Dallas-Fort Worth broadcasters, teamed with local police, as an early warning system to help find abducted children[41]. Another example is the US resident-to-resident assistance initiative **Nation of Neighborgs** (http://www.nationofneighbors.com/) that *facilitates real-time collaboration within communities and law enforcement to work together to fight and deter crime and improve our communities*. The platform allows citizens to issue reports about anything that negatively impacts public safety or security, and has a ranking, a scoring algorithm to avoid spam or misinformation and a subsequent approval system. The private contact details are only visible to public authorities.

Built upon online social and mobile technologies, this new citizen-centric approach has evolved from the so-called citizen journalism and has now brought about insightful critics to the traditional media (press, radio and television) coverage of crisis events, accused of being too much focused on global facts and undetailed information, unable to attend to the needs and requirements of small communities and their particular local specificities. A bi-directional communication channel between citizens and officials, with eyewitness accounts, first-hand observations, photos and video, directing responders to where they are

[40] YouTube had more than 13 million hours of video uploaded during 2010, in what represents approximately 48 hours of video uploaded every minute, and over 3 billion videos are viewed a day (http://www.youtube.com/t/press_statistics).
[41] This alerting system is now coordinated by the US Department of Justice and claims to have directly assisted in 540 safe returns of abducted children (http://www.amberalert.gov/statistics.htm).

most needed and guiding citizens away from harm's way, allows better decisions and closes the existing situational awareness gap.

The presented ICT tools, platforms and services need communications to be accessible to individuals, communities and organisations positioned in the affected areas. After a large-emergency or crisis, it is often the case that communications infrastructures become damaged or affected and recovering them requires a substantial time-consuming effort. Therefore, a number of initiatives have been created to allow the rapid deployment of communications networks via cellular and/or IP-based connectivity (typically WiFi), assisted by satellite links when necessary. For example, in Haiti, the main local telecommunications operator DigiCel provided acceptable SMS service (see Mission 4636 introduced in the beginning of this section) and donated 50.000 mobile phones to non-governmental and non-profit organisations to support relief efforts [18]. Additionally, the existing internet connectivity *proved to be robust because most Haitian ISPs connect to the Internet via satellite and are not dependent on the country's lone undersea fiber optic cable link, which was knocked out the during the quake*[42]. Other efforts managed to quickly provide long-distance WiFi connectivity to the *last mile*, supported by satellite link[43]. Also during the Katrina disaster, the communications infrastructure was severely damaged and initiatives, such as Freedom4Wireless, built ad hoc wireless networks to provide rescuers VoIP-based phone networks or enabled police radio powered by solar and battery equipment [19].

Surfing through the diversity of ICT tools, platforms and services used in crisis situations, there is a rich ecosystem of applications that jointly offers powerful tools for the purposes of bi-direcctional and continuous communication between PPDRs and citizens. Table 6 summarises the ICT tools applied in crisis situations that have been herein presented, highlighting its communication features:

Type of Communication	ICT Tools
Web-based Emergency and Crisis Platform	Google Crisis Response Sahana Ushahidi
Mobile Applications for Crisis	Disaster Recover Log FEMA (mobile application) Gaia GPS NYPA mobile
Mobile Location	Google Latitude / Apple "Find my iPad" Deveryware's applications (e.g., TeamLoc, WhereAreYou and PermiLoc) for location permission in cooperative and non-cooperative modes
Voice Calls	911 service calls supported by telecommunications operators VoIP (e.g., Skype and Freedom4Wireless service)
SMS / text messaging	Service provided by telecommunications operators Mission 4636 (via telecommunicarions operator) Twitter and Facebook
RSS / Email alerts	GovDelivery's Digital Subscription Management from FEMA Portland's Connect and Protect Programme
Images	flickr Panoramio
Video	YouTube
Communications Infrastructure	Telecommunications operators and ISP TEKEVER and THALES solutions for MANET and hybrid networks

Table 6 – ICT Tools Ecosystem

[42] http://spectrum.ieee.org/tech-talk/telecom/internet/engineers-race-to-restore-communications-after-haiti-quake
[43] http://spectrum.ieee.org/telecom/wireless/engineers-help-ngos-get-online-after-haiti-quake.