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Deliverable D3.11:
First report on the use of emerging technologies in crisis situations

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EXECUTIVE SUMMARY

This is the first version of Deliverable D3.1 of the COSMIC project, released as D3.1.1. It provides preliminary results in the analysis of emerging communication technologies in support of Crisis Management.

New communication technologies and social media have greatly expanded the overall scope of communication in crisis management, because of several new synergetic factors, including: access to communication technology, richer communication modalities, communication occurring in public, and data exhaust. Therefore, the scope of emerging communication technologies, and social media and applications, encompasses intentional acts of communication, and unintentional acts of communication; and handling information as its recipient, and accessing and analysing public information as a third party. We provide a list of 27 specific emerging Technology Areas and Application Areas that are relevant according to this scope. These include: citizen journalism, cloud, crowdsourcing, data mining and big data, decision support, open data, and "organic" or smartphone sensor networks (these examples are discussed in detail in the current version of the document; all identified technologies will be elaborated on in the final version, i.e., in D3.1.2).

The new and emerging technologies, which offer significant tools for the improvement of crisis management, also entail a variety of risks, including risks to individuals' privacy and sense of identity, and to the correct allocation of responsibility in crisis management, and risks due to the possibility of information overload, risks of potentially creating conflicts of interest in crisis management providers, and risks due to the possibility of causing unintended, negative consequences when employed for the purpose of crisis management.

Social Media are transforming many aspects of crisis management. For example, social media can be used for making diagnoses of vulnerabilities in systems and infrastructures (in preparation for crises), they can be used to facilitate and simplify search and rescue actions (during a crisis), and they enhance control and community connectedness (including when recovering from a crisis). In addition to their use by individuals, Social Media are being exploited in large crisis management projects, including 'NASA style mission control centres', for monitoring and responding to Social Media, being deployed by large organisations. Social Media contribute to the openness, fairness and quickness of communication during a crisis.

1 INTRODUCTION

This is the first version of Deliverable D3.1 of the COSMIC project, released as D3.1.1. It provides preliminary results in the analysis of emerging communication technologies in support of Crisis Management. It discusses the topic of emerging technologies and focuses on: a preliminary analysis of Social Media trends; identifying a broad variety of emerging communication technologies with significance for Crisis Management; and analysing a selection of the identified emerging technologies. D3.1.2, the final version of this Deliverable, will complete the analysis of Social Media trends and analyse all the identified emerging technologies. D3.1.2 will also assess the complete analyses in order to draw final conclusions and produce recommendations for the improvement of Crisis Management in the future.

The rapid evolution of communication technologies is changing Crisis Management[1,2,3]. The COSMIC project has already discussed current uses of communication technologies in Crisis Management, especially in Deliverables D2.1 and D2.2. In this document, we address emerging technologies that have begun to impact Crisis Management or that are expected to impact Crisis Management, with emphasis on future potential.

In Section 2, partners discuss what constitutes a relevant emerging communication technology in the context of the evolution Crisis Management. We show that a very broad range of technologies is highly relevant and important. We identify 27 specific technologies that should be analysed, and categorise these technologies with respect to core features of relevance to Crisis Management.

In Section 3, partners discuss the emerging risks, for Crisis Management and beyond, that arise in the context of emerging communication technologies. Despite their great potential for positive effects, these technologies also pose a variety of threats, from invading our privacy, to potentially influencing our sense of our own identity.

In Section 4, partners discuss emerging Social Media applications. Social Media are being used increasingly and with an constantly growing level of importance in the context of Crisis Management. Here, we consider relevant Social Media trends, the behaviours of users, and the changing role of Social Media in preparation for a crisis, during the crisis and in response to a crisis.

In Section 5, partners individually analyse the emerging technologies that have been identified as important in the context of Crisis Management. The technologies are discussed in general, then specific technical background is provided and evidence of their relevance is provided, and finally the potential technical impact of the technologies on Crisis Management is discussed.

[1] Ng, Vanessa Mei-Yee. *Evolving technologies for disaster planning in US Cities*. Diss. Massachusetts Institute of Technology, 2011.
[2] Humanitarianism in the Network Age: Including World Humanitarian Data and Trends 2012, Office for the Coordination of Humanitarian Affairs (OCHA), 2013.
[3] "Software that helps populations cope with crises", http://www2.technologyreview.com/TR35/Profile.aspx?TRID=947

2 STRUCTURE OF THE DOMAIN AND SCOPE OF EMERGING COMMUNICATION TECHNOLOGIES FOR CRISIS MANAGEMENT

New communication technologies and social media have greatly expanded the overall scope of communication in crisis management, because of several new synergetic factors:

- Greater access to communication technology, particularly access for all and at any time and place through affordable mobile telephony
- More and richer communication modalities, including: voice and video communication between pairs or groups; communication through the Web and including multimedia content; and the ability to share sensor readings from mobile devices, ranging from geographical location to temperature and air pressure
- Communication occurring in public, especially including public posts on social media and other Web resources
- The "digital footprint" or "data exhaust"[4,5,6] consisting of information generated as a side-effect of users' activities, which is an indirect form of communication (comparable to body language as another indirect form of communication, but here in the context of ICT)

The first two factors contribute to a constantly increasing volume of communication.

The last two factors create an environment where it is not enough for the direct recipient of any communication to be responsible for handling it. Rather, vast amounts of useful information are available either publicly, or at least beyond the scope of the activity that generated it in the first place. Indeed, much of this information communicates facts about people, without its creation necessarily being consciously intended as an act of communication – similarly to body language. The information is published in free-access communication media, such as publicly accessible social media content, or is available to service providers, such as mobile telecoms who can collect location data for their subscribers, or search engines who can collect and analyse searches and clicks on results.

For example, we can imagine the following scenario. There is a sudden peak in searches for the keyword "flood". Furthermore, the first few search results that the search engine provides are general-purpose background, such as an encyclopaedia article about floods, but a lower-ranked result is a current article about preparing for a specific, imminent flood threat. If the search engine provider observes a majority of searchers clicking on the article about preparation, this provides valuable information. A specific behaviour involving paying attention to flood preparation can be observed, and measured, through the searching activity of users, and their choices of which results to click on. However, the analysis and interpretation of such data is often a very challenging problem. For instance, in this scenario, are people learning about flood preparation "enough"?

Therefore, the scope of emerging communication technologies, and social media and applications, encompasses:

- Intentional acts of communication, with examples including voice calls, and text messages on social media

[4] O'Hara, Kieron, Mischa M. Tuffield, and Nigel Shadbolt. "Lifelogging: Privacy and empowerment with memories for life." *Identity in the Information Society* 1.1 (2008): 155-172.
[5] "The data deluge", The Economist, Feb 25th 2010, http://www.economist.com/node/15579717
[6] "Data, data everywhere", The Economist, Feb 25th 2010, http://www.economist.com/node/15557443

- Unintentional acts of communication, with examples including messages on publicly accessible social media accounts, and service usage information
- Handling information as its recipient, with examples including individuals' need to prioritise urgent safety messages, and organisations' need to operate of a helpline during a crisis
- Accessing and analysing public information as a third party, with examples including the analysis of patterns appearing in social media posts, and analysis of clickstreams

Finally, the scope of emerging communication technologies and, media and applications also encompasses any specific crisis management technologies with a communications component.

Thus, a large and varied set of technologies is relevant for study in this deliverable. The following table summarises the Emerging Technology Areas and Application Areas that are discussed in detail in the document.

Table 1: Emerging Technology Areas and Application Areas influencing Crisis Management Communications

Sensing	Deciding	Acting	Managing	New CT	Social M.	Key: ✓ major relevance ● additional relevance Emerging Technology Area or Application Area
✓			✓	✓	✓	1 citizen journalism
●	●	●	●	✓		2 cloud
✓		●			✓	3 crowdsourcing
✓	✓				✓	4 data mining and big data
	✓			✓	●	5 decision support
				●	✓	6 e-inclusion & e-accountability
✓	✓	✓	✓	✓		7 early warning systems
	✓		✓	✓	✓	8 epidemiology and prediction
	✓			✓	✓	9 integration of heterogeneous data
✓	✓	✓	✓	✓	✓	10 internet of things
✓	✓	✓	●	✓	✓	11 mobile eHealth
		✓	✓		✓	12 natural language technologies
✓	●	●	●	✓	✓	13 open data
✓				✓		14 “organic” or smartphone sensor networks
✓	✓			✓	✓	15 pattern analysis and machine intelligence
✓	✓				✓	16 profiling social media users
✓		✓		✓	✓	17 reporting and alerts services
		✓		✓		18 robots and drones
✓	✓	✓	✓	✓	✓	19 secure communications and trustworthy ICT
✓				✓		20 sensor infrastructures inc. satellite, surveillance & environmental sensors
✓	✓	✓	✓	✓		21 smart cities and smart transportation
	✓		✓		✓	22 social media governance
	✓	✓	✓	✓	✓	23 tools for the mediation between governments and citizens
✓	✓					24 tools for transparency and accountability
✓		✓			✓	25 user generated content & ICT for creativity and expression
	✓			✓	✓	26 visualisation – information vis., knowledge vis., visual analytics
✓					✓	27 wearable sensors and sensors integrated in mobile communication devices

Table 1 shows a summary of the Emerging Technology Areas and Application Areas described in more detail in this document. For each technology or application area, two categories of relevance are indicated at the left side of the table:

- Relevance to the communication workflow
  - ¬ Sensing: relevance to the information source, including intentional transmission of information with the intention of communicating as well as any relevant kind of unintended communication
  - ¬ Deciding: relevance to the decision making process that forms a part of communication flows, such as deciding how to prioritise information being communicated
  - ¬ Acting: relevance to communicating as an action in response to a crisis, such as sending alerts, and also to the communication capabilities of the emerging technologies, which are necessary or useful as part of crisis management

actions, such as a rescue robot's capability to communicate or interact with any survivors it may encounter
  - ¬ Managing: relevance to management of communication processes, for example distributing limited computational resources to different digital communication tools
- Specific media involved[7]
  - ¬ New communications technologies
  - ¬ Social Media

The ✓ symbol in the table indicates relevance, while the • symbol is also used to indicate a lesser, but still important, degree of relevance.

Each of the technologies listed in **Table 1** is discussed in an individual sub-section of Section 5, below, which describes the technology and assesses its role in communications for crisis management.

3 RISKS, CONCERNS AND ETHICAL ISSUES

3.1 INTRODUCTION

The technologies discussed in Section 5, below, offer significant tools for the improvement of Crisis Management. Nevertheless, they also entail a variety of risks, raising concern about their usage and often posing ethical dilemmas when crisis management effectiveness is traded off against factors such as privacy. In this Section, we briefly present six important risks, concerns and ethical issues that need to be kept in mind when assessing Emerging Technology Areas and Application Areas with relevance to Crisis Management.

3.2 PRIVACY

Self-presentation and self-disclosure are an intrinsic feature of Social Media, which thus intrinsically pose privacy concerns[8]. In many contexts, such as the case of data exhaust discussed above, people reveal information about themselves unintentionally, or potentially unintentionally, which again raises serious privacy concerns. This is indeed also the case in the technically simple scenario where users voluntarily make their communications fully public; such choices may have unintentional consequences, such as later embarrassment or worse, and may come to be regretted by users who can no longer reverse such choices.

The issues above are relevant regardless of the presence of a crisis. Indeed, there is a trade-off between relaxing of privacy restrictions before a crisis occurs, and information that will be already available to individuals and organisations to use in the context of crisis management when a crisis does materialise.

Specifically during a crisis, the information that is likely to be communicated is of an especially sensitive nature, addressing for instance issues such as health and vulnerabilities. For example, when a citizen calls an emergency helpline such as 911, confidentiality is

[7] see Deliverable D2.1 of the COSMIC project
[8] Kaplan, Andreas M., and Michael Haenlein. "Users of the world, unite! The challenges and opportunities of Social Media." *Business horizons* 53.1 (2010): 59-68.

expected, however, if a citizen Tweets for help, confidentiality is forsaken. Revelations made publicly in a social media based cry for help may subsequently remain public.

The risks of violating privacy are currently a topic of debate in communities analysing and assessing Social Media, although the current trend is for their business exploitation potential to tip the balance away from privacy[9]. However, from an ethical point of view, crisis management offers a less-debatable argument against safeguarding privacy: by sharing our personal information abundantly, we may be helping to save lives – in some cases, our own. Although this argument is certainly important, the increasing difficulty of defending privacy is an important threat.

[9] for example, see the above-referenced articles "The data deluge", "Data, data everywhere", and "Users of the world, unite! The challenges and opportunities of Social Media."

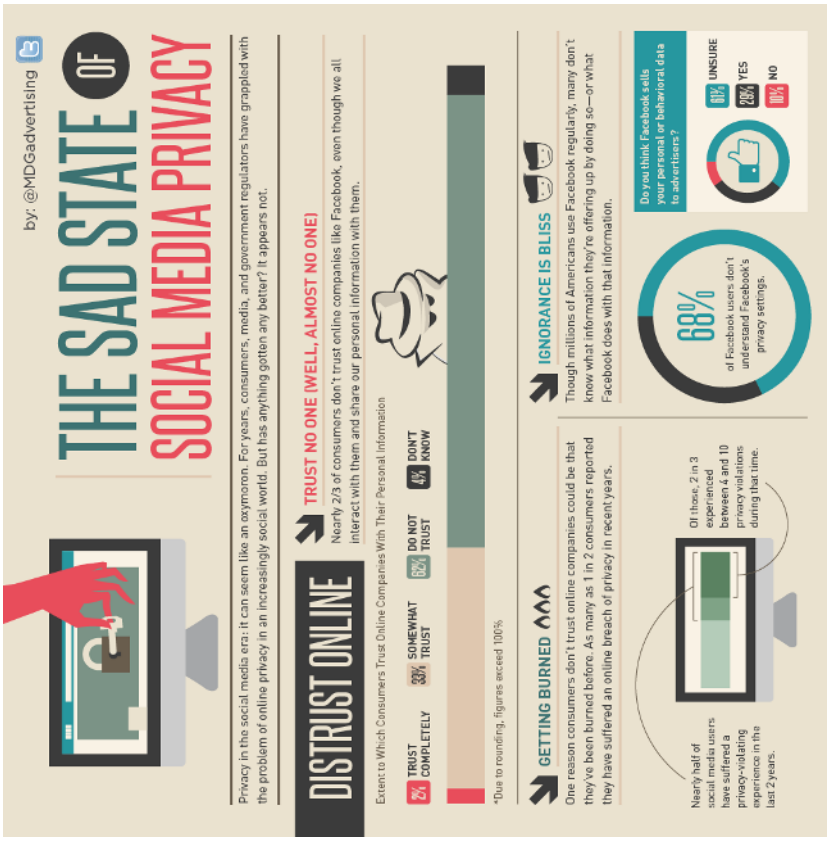
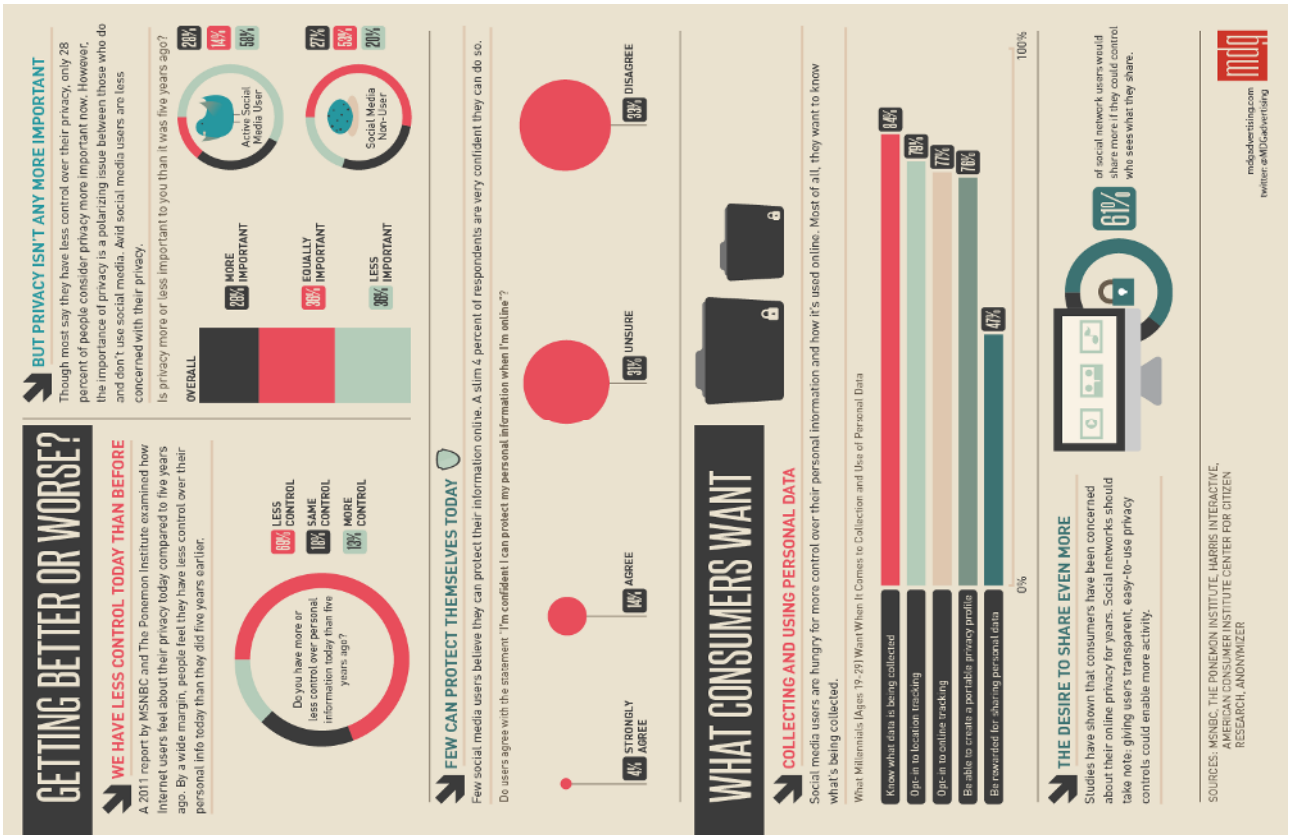


Figure 1: Infographic on privacy in Social Media[10]



[10] http://www.mdgadvertising.com/blog/wp-content/uploads/2012/02/the-sad-state-of-social-media-privacy-infographic.png

3.3 IDENTITY

Communication is an important mechanism for human beings, and our experiences of communication affect us deeply, for example influencing our very sense of our own identity[11,12,13]. Crisis management goes beyond communication in an abstract sense, and integrates communication into practical action: an external agent takes charge of our actions, potentially even our lives, during a period of danger, learns as much about us as possible, and manages our behaviour in response to the danger. This, of course, is a tremendously valuable service, precisely because we are receiving aid to defend our property, health, or life. Nevertheless, as we build mechanisms capable of guiding our behaviour in ever more finely targeted and more subtle ways, we should also be aware that by placing ourselves in the power of these tools, we may be allowing them to define us.

Figure 2: "Who am I?"[14]

3.4 RESPONSIBILITY

One emerging property of the communication technologies discussed in this document is that they result, in many cases, in non-deterministic behaviours of the human actors involved. For example, when a citizen in need makes a call to an emergency number, such as 911, the response is intended to follow a deterministic workflow; however, when a citizen posts an urgent plea for help on social media, it could provoke an immediate and effective response[15], or a late or ineffective response, or even no response at all. During Superstorm Sandy, the New York Fire Department initially instructed people not to tweet emergency calls, however it subsequently made excellent use of Twitter when 911 was overwhelmed with too many

[11] Yannopoulos, Angelos, Vassiliki Andronikou, and Theodora Varvarigou. "Behavioural biometric profiling and ambient intelligence." *Profiling the European Citizen*. Springer Netherlands, 2008. 89-109.
[12] Andronikou, Vassiliki, Angelos Yannopoulos, and Theodora Varvarigou. "Biometric profiling: opportunities and risks." *Profiling the European Citizen*. Springer Netherlands, 2008. 131-145.
[13] Gutwirth, Serge, and Mireille Hildebrandt. "Profiling the European Citizen." Springer, 2008.
[14] http://comuq.wordpress.com/2011/09/07/google-who-am-i/
[15] e.g. "Injured Biker Leigh Fazzina Rescued By Twitter", http://www.huffingtonpost.com/2010/08/03/leigh-fazzina-injured-bik_n_669175.html

calls, and Twitter conveyed urgent messages more effectively[16]. While these examples illustrate that social media can be of value in a crisis situation, the scenarios do raise the question of allocating formal responsibility.

3.5 INFORMATION OVERLOAD

Data sources including open data initiatives, crowdsourcing and social media generate or provide vast quantities of data. A resulting risk is information overload[17] – there may simply be too much information to process, and human responders may become confused, may overlook the more important information, or may spend too much time or effort analysing data rather than acting in response to a crisis. Some of the technologies and applications described in this document are relevant precisely because they address this particular risk, however the problem remains important.

3.6 CONFLICT OF INTERESTS

When for-profit organisations develop general-purpose assets that can be useful in the case of – but are not exclusively used for – crisis management, and when funds or effort intended for dealing with a crisis are used to improve these assets, a conflict of interests is present. For example, if a commercial map provider provides map assets for free during the response to a crisis, and solicits a crowdsourcing effort to enrich the map with important information about the region in question, the results may include a positive contribution to mitigating an ongoing crisis, but also a permanent improvement to the commercial map through the crowdsourced work. The contributions of for-profit organisations to crisis management are often very valuable, e.g. Google Crisis Map[18], but awareness of any potential conflict of interests is also important, any may help to ensure companies avoid making a direct effort to profit from a crisis.

Figure 3: "Crowdsourcing: a new idea for innovating!"[19]. But could it be also a new idea for exploiting volunteers, who respond to needs arising due to a major crisis, for private gain?

[16] http://news.yahoo.com/ blogs/ticket/meet-fdny-one-womantwitter-response-team-guiding-141143449.html
[17] Daniel Stauffacher, Sanjana Hattotuwa and Barbara Weekes, "The potential and challenges of open data for crisis information management and aid efficiency", ICT4Peace Foundation, March 2012, http://ict4peace.org/wp-content/uploads/2012/03/The-potential-and-challenges-of-open-data-for-crisis-information-management-and-aid-efficiency.pdf
[18] http://google.org/crisismap
[19] http://ecocrowd.wordpress.com/2010/11/22/crowdsourcing-a-new-idea-for-innovating/

3.7 UNINTENDED CONSEQUENCES OF CRISIS COMMUNICATIONS

As discussed in Section 5.5, poor use or performance of the technological tools described in this report could damage the credibility of responsible officials or agencies, provoke unnecessary costs or even panic (for example, in the case of a false alert), or in general lead to poor crisis management. In all cases, emerging technologies should only be used in real crises when sufficient confidence exists in their capability, and in the capability of responsible users, so that the expected benefits sufficiently outweigh the potential risks of such technology deployment. An important point with respect to the performance of emerging technologies in the area under consideration in this deliverable is that the many and advanced technologies entering play in the context of crisis management cause a significant increase in the overall technical complexity of the crisis management tools being used.

4 EMERGING SOCIAL MEDIA APPLICATIONS

4.1 INTRODUCTION

Especially in times of crisis, clear, complete and quick information is needed. 'Disasters are threatening and highly dynamic situations, marked by high levels of information need and low levels of information availability.'[20] Research shows that advances in information and communication technologies enlarge the possibilities for people to seek, get and send information about their situation, feelings and capacities in critical situations. In that way, the information technology is an essential factor for streamlined search and rescue actions during disasters, but also for sufficient preparation and recovery, stimulated and organised by the authorities.

The value of social networks during and after disasters, an example

An example in which all the phases of crisis management in relation to the possibilities of information and communication become visible is presented in a scientific article with results from a study of musicians in New Orleans in the aftermath of Hurricane Katrina, August 2005.[21] In the first hours after the beginning of the hurricane, cell phones and Internet were used for locating family, friends and other relatives. The new technologies function as an addition on traditional media like broadcast news, which didn't supply all the information the musicians needed. As a result of the massive search to new relevant information, communities were created within social networks. People with the same interests were linked and these social networks replaced the 'physical environments from which the musicians were barred'. For the people who had to leave the city after the hurricane, the social communities were the only manner to stay in contact with their former local communities. People who stayed have a way to share those experiences in the affected areas. Just in the recovery phase, on the moment that some musicians came back, the activity on the social networks took off. Those who returned focused on rebuilding the physical society, those who remained away found the social activities insufficient to hold a bond with their own environment.

[20] Shklovski, Ilrina, Moira Burke, Sara Kiesler and Robert Kraut, Technology adoption and use in the aftermath of Hurricane Katrina in New Orleans, *American Behavioral Scientist,* Vol. 53, Issue 8, 2010, pp. 1228-1246.
[21] Ibid.

4.2 SOCIAL NETWORKS DURING DIFFERENT PHASES OF CRISIS MANAGEMENT

As partners showed in D1.1, the process of crisis management can be subdivided in different phases. In every phase the use of social networks (as well as other communication technologies) can be of value in their own way.

4.2.1 Preparation phase

Social media can be used for making diagnoses of vulnerabilities in systems and infrastructures. Besides, some applications can facilitate the warning of citizens in the period before a threatening crisis occurs. As partners made visible in deliverable 1.2 the effects of past disasters (like wild fires and storms/floods) could have been reduced by better providing of information. Social media can be the vehicle of that information. Different forms have to be distinguished. People and groups can be connected by social networking sites like Facebook and Google+, a short message network like Twitter, (mobile) sites where photos are shared like Instagram and applications for video sharing like YouTube. For years new applications are in their developing stage (these will be examined at the end of this section).

Surveys of the American Red Cross show that a large part of the population in the United States is interested in technologies, applications or simply receiving emails for emergency communication. Information about the location of food and water, shelter locations, road closures, the location of medical services and about how to keep safe during emergencies are high rated by around a half of the questioned people. On the other hand, more than a half of the citizens who is using social media says they should post relevant information on their sites or applications during periods of crisis.[22]

For example the emergency management in Plano, Texas, uses Facebook to inform citizens on a daily basis with messages that are potentially relevant to their needs. It is to make connection with the different distinguished forms of behaviour of public that is using social media, described by Hughes et al.[23] Another example of using social media during the preparation phase is the monitoring of Twitter and Facebook during the Inauguration of President Obama in 2009, considering if there was situational information that was not obtained by the more formal sources.[24]

4.2.2 Response phase

On the one hand social media can be used to facilitate and simplify search and rescue actions. The registration of victims is fully dependent on the availability of correct and complete information. The monitoring of messages on for example Facebook and Twitter by the Red Cross has the intention to identify victims and other persons who need special aid. On the other hand emerging technologies can be useful in situations in which traditional media are not able to present the right information or voice telephony technologies are disconnected. In such moments social networks replace the tasks of the physical society. Survivors can receive the information they need and let their relatives know of their status. The following emerging

[22] Page, Sabrina, Karin Freberg and Kristin Saling, Emerging Media Crisis Value Model: A Comparison of Relevant, Timely Message Strategies for Emergency Events. *Journal of Strategic Security,* Vol. 6, Issue 2, 213, pp. 20-31.
[23] Hughes, A., Leysia Palen, Jeannette Sutton, Sophia Liu and Sarah Vieweg, *Site-seeing in Disaster: An Examination of On-Line Social Convergence.* ISCRAM08.
[24] Federal News Radio, DHS Listens and Learns from Ogma. July 25, 2009. www.federalnewsradio.com.

technologies, contributed by Google, can improve the work and results of search and rescue teams.

- Google person finder is a web application that provides information about the status of family members, friends and other relatives affected by disasters. By entering information in this application, it will be accessible by and visible for anyone. Because people are often separated in the first hours after a disaster, it's very useful to have a technology that collects all different pieces of information. By entering the website of Google Person Finder, it displays the most current disasters. Visitors are distinguished in those who are looking for someone and those who have information about someone. The database of the application links the information and informs the people who are looking for someone when the information is available.

- Google Glass is useful to members of search and rescue teams by giving them critical and relevant information, without impeding their mission. The Google Glass will be a tool that gives the information the user needs. When a fireman enters a building, information about the characteristics of both the fire and the building can be showed on his glass. For a member of a search and rescue team it can be useful to know what the medical records of a wounded survivor are. The possibility of getting the information they need on the specific emergency situation is one of the biggest advantages of the development of the Google Glass.[25]

- The application of Google Maps can be used during the preparation phase, to trace vulnerable areas. Furthermore, Google is able to change the maps in the application instantly, to give an updated view from affected areas. Hour by hour and day-by-day situations are changing, as we saw during hurricanes like Isaac[26] and Sandy[27] (both in 2012). That has huge implications for search and rescue teams and other actors involved in the process. To them updated information about the affected area is very important. In the updated version of Google Maps public alerts, active shelters, YouTube videos and recent maps of before the crisis can be viewed.

[25] David, K., *3 Ways Google Will Transform Government*. August 29, 2013. http://www.govloop.com/profiles/blogs/3-ways-google-glass-will-transform-government
[26] http://google.org/crisismap/2012-tropical-system-isaac
[27] http://google.org/crisismap/2012-sandy

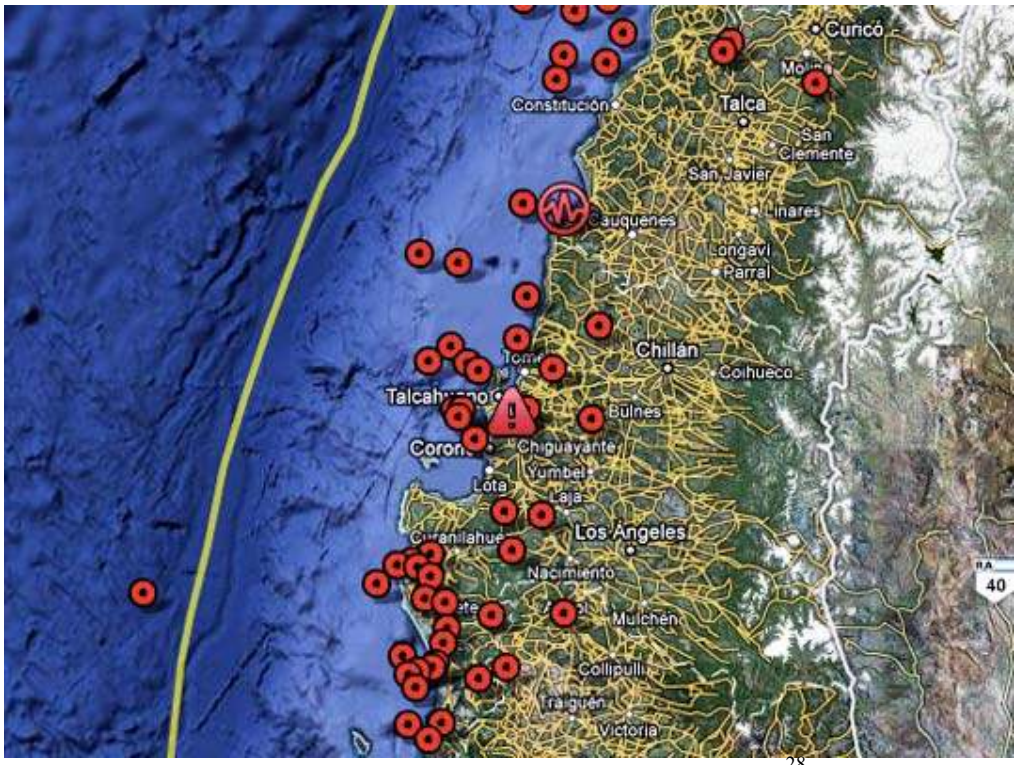


Figure 4: Example of map from the Google person finder[28]

4.2.3 Recovery phase

The value of social media and mobile technology lies in the fact that people have more control over the situation (when those technologies are used in the preparation phase) and that they have more connection with and control over the community.[29] Or: 'social media combine the use of innovative strategies with digital communication technology platforms, enabling the user to share knowledge, engage in digital storytelling through conversations and visual components, and collaborate with others.'[30] Research by the University of San Francisco's Masters of Public Administration department shows the high activity on social networks during disasters. Research among survivors of social media shows that 25% of them downloaded disaster-related apps, 20% have used an emergency app, 35% directly post a request for help on a responder's Facebook page and 76% contact friends for telling that they are safe.[31] In general (not only the victims or survivors), not less than 80% of the Americans expect emergency response agencies to monitor the stream of messages on social media and respond to the senders of those messages. Although the American figures won't be the same as in Europe, western societies are nevertheless comparable.

[28] http://www.inhabitat.com/wp-content/uploads/2010/03/googlefinder-ed01.jpg
[29] Shklovski, Burke, Kieslerb and Kraut, 2010, pp. 1228-1246.
[30] Page, Sabrina, Karen Freberg and Kristin Saling, Emerging Media Crisis Value Model: A Comparison of Relevant Timely Message Strategies for Emergency Events. *Journal of Strategic Security*, Vol. 6, Issue 2, 2013, pp. 20-31.
[31] Scott, 2013, http://socialtimes.com/even-the-red-cross-uses-social-media-during-natural-disasters-infographic_b132228

Not only the general activity and findings are showed, also the social media use during particular disasters has been examined. Some examples, which show the usefulness during the preparation, response and recovery phases:

1) During the tornado season in the United States, social media have been used to generate ideas for the rebuilding of cities. In Tuscaloosa, a social media website was created for sharing ideas between residents. 300 ideas were generated and shared on their Facebook pages by over 4,000 visitors.

2) On the first day after the Japan tsunami, Facebook recorded 4,5 million status updates from around the world, with the keywords 'Japan', 'Tsunami' or 'Earthquake'. That was 84% of all worldwide status updates on the 11th of March 2011.

3) In the period between January 12 and January 14 2010, the first days after the devastating earthquake in Haiti, 2.3 million tweets were composed with the key words 'Haiti' or 'Red Cross'. Almost 10% of those tweets contained the number '90999', which meant a donation of 10 dollars for the Red Cross.

4) In the first aftermath of hurricane Sandy the top 5 of most shared terms on Facebook exists out of 'we are ok', 'power', 'damage', 'hope everyone is ok' and 'trees'. FEMA tweeted to its followers on Twitter that phone services probably were out of service and that send texts or updating social networks were the best ways to inform loved ones that you were OK.

According to the Washington Post[32], during the Boston bombings, March 2013, millions of people used Facebook as a place for on one hand getting information and on the other hand sympathize with victims and their relatives. In this way, social media and social networks are like the market places of ancient times, with the huge amount of present people as the most important difference. The casual business that social media usually are, changes in times of crisis in a way to contact the most important people in your life, as well as a way to gather the most relevant and important information. 'It's a strange new ritual – the frantic phone call from Mom, multiplied and stretched over a thousand fainter connections.'[33] With that knowledge it appears that the benefits of social media for authorities during crisis situations have to be stressed too.

Although Twitter is already a longer existing medium, it's one of the most used social media devices in the world. 'A wide range of studies suggest that information sharing networks, such as twitter, can be very useful in times of crisis by quickly and effectively disseminating relevant news.'[34] Research on the possible benefits of Twitter for people involved in the earthquake and tsunami in Japan, March 2011, shows that rescue teams saved people who send tweets about their critical situations. People who posted messages to let their followers know that they were safe or unharmed were mobilized to help during the rescue actions. However, the high number of unreliable retweets is one of the weak characteristics of this medium. Some of the solutions offered by the respondents, and subscribed by the research

[32] Petri, Alexandra, The explosions at the Boston Marathon and the Facebook Huddle, *The Washington Post,* April 15 2013. http://www.washingtonpost.com/blogs/compost/wp/2013/04/15/the-explosions-at-the-boston-marathon-and-the-facebook-huddle/

[33] Ibid.

[34] Acar, Adam. and Yuya Muraki. Twitter for Crisis Communication: Lessons Learnt from Japan's Tsunami Disaster. *International Journal of Web based Communities.* Vol. 7, Issue 3, 2011, pp. 392-402.

team, is to introduce official hash tags (in particular for cases of emergency) and to limit the possible number of retweets with such a hash tag. Also allowing users to trace information but remain anonymous is one of the options to cope with the emerging problems of Twitter during crisis situations and disasters.

4.3 GENERAL DEVELOPMENTS IN TECHNOLOGIES AND APPLICATIONS

Besides the development of new applications, which will be presented later in this project, an important development in the world of social media is the structural screening of social media messages by large companies. They are building 'NASA style mission control centres', for monitoring and responding to the massive stream of tweets on Twitter and messages on Facebook and other applications, regarding their company.[35] While public authorities are not companies and the importance of tweets and other messages for multinationals is quite different than for public services in times of disasters, the idea of monitoring processes on social media is the same. Whereas 80% of the executives of companies believe that their market and profits can grow by monitoring and using social media[36], the real activity of local and regional authorities on one hand and emergency organisations on the other hand on platforms as Twitter and Facebook is relatively limited, and the benefits of such an approach are still not recognized enough.

However, a very active actor on social media is the international Red Cross and that is why they opened, March 2012, a Digital Operations Centre.[37] The aim of this initiative of the Red Cross is to reach out and respond to victims during natural disasters such as hurricanes, wild fires and earthquakes. Both media coverage and posts of family members who are seeking for their relatives are monitored and reacted to. An example of a disaster during which this monitoring was very successful, was hurricane Sandy. 23 employees of the Red Cross monitored 2.5 million social media postings, related to the hurricane. 4,500 of those messages were followed up with aid for people in need.[38] Also the usage of social media among authorities and public leaders is growing. 77% of all the world leaders are active on Twitter. [39] Not only individuals, also organisations increasingly take a role within social networks. For example the government of the United States uses social media for communications to assist during day-to-day emergency operations.[40] The value of activity is underlined by the following statement: 'the more that the needs of the public are considered, the more they can be active participants in preparation for, response to and recovery from emergencies.'[41]

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[35] Holmes, Ryan, NASA-style mission centers for social media are taking off. *Fortune.* October 25, 2012. http://tech.fortune.cnn.com/2012/10/25/nasa-style-mission-control-centers-for-social-media-are-taking-off/

[36] Feldman, Bob, Michael Gale, Jeff Hunt and Paul Walker, *The Economics of the Socially Engaged Enterprise,* PulsePoint Group, 2012.

[37] Hoover, J. Nicholas, Inside Red Cross Social Media Command Center, *Information Week,* March 20, 2012. http://www.informationweek.com/government/information-management/inside-red-cross-social-media-command-ce/232602698?pgno=1#slideshowPageTop

[38] Scott, Cameron, Even the Red Cross Uses Social Media During Natural Disasters: Infographic, *Social Timed, Your Social Media Source,* July 17 2013. http://socialtimes.com/even-the-red-cross-uses-social-media-during-natural-disasters-infographic_b132228

[39] Twiplomacy, *The Best connected World Leaders on Twitter,* 2013. http://twiplomacy.com

[40] Collins, H., Emergency Managers and First Responders Use Twitter and Facebook to Update Communities, *Emergency Management Magazine,* July 27, 2009

[41] White, Connie and Linda Plotnick, A Framework to Identify Best Practices: Social Media and Web 2.0 Technologies in the Emergency Domain, *International Journal of Information Systems for Crisis Response and Management,* Vol. 2, Issue 1, 2010, pp.

Companies as examples for authorities during disasters
Sometimes, companies can be good examples for public authorities. That seems to be the fact with the Dutch airline company KLM. All different divisions of the enterprise are united in a Customer Care department.[42] Most important cause for this strategy was the volcano eruption in Iceland, in 2010, a disaster that halted aviation in much of Europe for many days. Initially, KLM placed update messages on the official website, but due to the enormous attention of interest people, the site went offline. Afterwards, Twitter and Facebook became the most important vehicles of both receiving and sending information. Almost all questions to the account @klm were answered within some hours[43] and with the current 24/7 capacity load all questions will be answered within one hour. The example shows that the quality of crisis communication during the different phases of a disaster is determined by factors as quickness and fairness. Both providing information and giving citizens a perspective of action are very relevant during crises.

Interviews with people with expertise in marketing, social media and other emerging technologies indicate two other general developments in the world of social media/networks:

- Tablets and mobile phones gain more and more ground compared to personal computers. Increasingly, new technologies will only be visible and accessible by mobile devices. That has complications for the design of content and layout.
- Because disasters and crisis can destroy or disconnect mobile services, developers of applications try to make more applications accessible in an offline status. Examples of these are apps with information about what to do during emergency situations.

4.4 CONDITIONS FOR USEFUL TECHNOLOGIES AND APPLICATIONS

Communication in a crisis period needs three elements: openness, fairness and quickness.[44] We can see again these factors in the Emerging Media Crisis Value Model[45]. This is a model that describes important factors of communication during crisis situations, combined with measurement scales to categorize the performance of chosen systems based on stakeholders' values. Stakeholders can for example be the local authorities, members of search and rescue teams or citizens. By using the emerging media crisis value model research can link different methods of communication with scores on the different sub-functions. Below the general function of crisis communication (sending and receiving information during crises or disasters) a crisis message has some sub-functions too:

[42] Oosterveer, Danny. *KLM 24 uur per dag te bereiken via sociale media.,* Marketingfacts. 25 juli 2011. http://www.marketingfacts.nl/berichten/20110722_klm_24_uur_per_dag_te_bereiken_via_sociale_media
[43] Van der Velden, Nick, *KLM twittert er op los: Waar is Schiphol?,* Marketingfacts.19 april 2010. http://www.marketingfacts.nl/berichten/20100419_klm_twittert_er_op_los._waar_is_schiphol
[44] Jong, W., M. Petit and J. Jochmann. Overheidscommunicatie als instrument. In: I. Helsloot & J.V. Steenbergen, *Infectieziektebestrijding: Studies naar organisatie en praktijkwerking*. BJu. 2005.
[45] Freberg, Karen, Kristen Saling, Kathleen Vidoloff and Gina Eosco, *What makes a good social media crisis message?: Challenging traditional methodology through qualitative and quantitative value modeling.* Paper presented at the 16th International Conference on Corporate Reputation, Brand, Identity and Competitiveness, Milan, Italy, 2012.

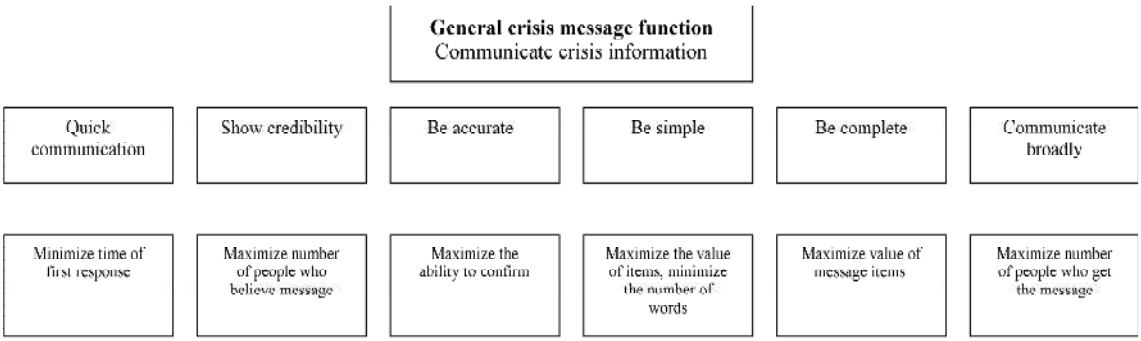

Figure 5: Essentials for crisis communication

Some sub-functions apply more or less on several disasters. Showing credibility is about taking responsibility for a crisis that will be less the case during a natural disaster as a hurricane, although responsibility can be taken for an insufficient preparation phase. Different emerging technologies and applications can be tested on the sub-functions, presented above. For instance, if an emerging technology has a small time of first response and can be used for complete messages, but reaches only a small number of citizens, the actors involved have to make choices about which measures have to be used for which crisis communication message.

Partners spoke with some experts in the field of social media and marketing and distinguish the following upcoming social media and social networks for the next couple of years. First we describe the application or technology, next we summarize the way in which the social network can be an advantage for the use in crisis situations.

- Medium: a blogging site, created by the founders of Twitter and Blogger, Evan Williams and Biz Stone. People can write a blog about several subjects, and the amount of votes of users (as Likes on Facebook) determines how prominent the blog is displayed on the page. Furthermore, like LinkedIn, it's a social network that only allows invited members to see messages.
  How it can be used during crisis situations: Medium can be seen as an instrument to connect people. One of the main problems of already existing social media like Twitter and Facebook is the noise of information and the fact that it is often not clear if information is sent by official senders or by others, like citizens. It undermines the credibility of the message. When citizens in a defined area or with specific characteristics become member of a page on medium, authorities know exactly if a message will reach their target group. The importance of a message will be showed by the prominence of the place where it is showed.

- Conversations: a social network for companies, a sort of Facebook into the workplace. Members of different teams and in the future employees of different companies can communicate by short posts on message style, instead of by long email chains. It can be seen as a digital notice board.
  How it can be used during crisis situations: One of the most critical points in crisis situations is the tuning between different actors involved. Communication is lacking or fails. With a simply accessible social network, like conversations, people can react on each other with short and 'to the point' notices. When also public organisations use this application, it can create a network of the key actors before and during crisis situations.

- Whisper: an app for the iPhone, which can be used to post secret messages. Members of the application can read the posts, respond with another whisper or send messages to the anonymous sender.
  How it can be used during crisis situations: Whisper can be used to enlarge awareness about possible threats and vulnerabilities. Whistle-blowers get a platform to attend the authorities on maltreatments. In fact, the disadvantage of such an application is the lack of control on the identity of senders and so on the credibility of the information.

Figure 6: Whisper app logo[46]

Some other emerging social networks won't be useful and effective for use in the period before or during a disaster. For example Pheed, a 'pay-as-you-go social network' where people have to pay a monthly fee for access to photos, videos and texts. Considering the important aspect of 'broad communication', Pheed doesn't seem to be an emerging social network with big implications for the future. Also deviantArt, a social network site for artists and art enthusiasts, and because of the target group (80% of the users are 18 to 29 years old) an interesting social medium for the future, won't be effective in crisis situations.

5 RELATED EMERGING TECHNOLOGIES AND APPLICATION AREAS

5.1 CITIZEN JOURNALISM

5.1.1 Introduction

The appearance of citizen journalism is significant because journalism has long been an overwhelmingly professional activity. "Freedom of the press is guaranteed only to those who own one"[47], but now billions of people own technology enabling global publication of the media they produce – thus, everybody can fulfil the role of a journalist (but does not necessarily do so).

Journalism is often an important factor in crisis situations. The decisions that a society will make in response to a crisis depend on the available information, which is now often heavily influenced by citizen journalism[48]. Such decisions for example include providing aid money to people in need, or applying political pressure to government organisations to adapt their behaviour (for example[49], the U.S. air force in the aftermath of the 2010 Haiti earthquake denied clearance to land to an airplane carrying vital aid from Doctors Without Borders, until Twitter was used to make the problem public knowledge).

In the context of citizen journalism, we can study the role of social media in allowing everybody to contribute to the public knowledge of matters of public concern, and in the

[46] https://itunes.apple.com/us/app/whisper-share-express-meet/id506141837
[47] A. J. Liebling, in "Do you belong in journalism?", *The New Yorker* (14 May 1960)
[48] As, for example, is discussed in the Case Studies of deliverable D2.2 of the COSMIC project
[49] COSMIC D2.2

context of crisis management, we can study how the ensuing new forms of information flow influence a society's reaction to crisis situations.

5.1.2 Background

The term citizen journalism is used to refer to "the involvement of non-professionals in reporting news, especially in blogs and other websites"[50]. A politically charged, insightful definition is: "When the people formerly known as the audience employ the press tools they have in their possession to inform one another"[51]. Citizen journalism arises out of a conceptually simple but extremely powerful capability offered by new communication technologies, and especially social media, to every user of such technology: the capability to broadcast information. The information being broadcast must be "news", i.e. address factual, ongoing events of public concern, and inform society about itself, potentially making public events that would otherwise remain private[52]. It sometimes occurs, though these are incidental and not necessary features of citizen journalism, that the reporting is a conscious choice of the reporter to inform the public, that citizen journalism is conducted in close collaboration with professional journalism, and that citizen journalism is a collaborative activity[53].

Because it is able to provide the public with news that professional journalism may fail to offer, as discussed above, citizen journalism is very important for crisis management. Interestingly, crisis management is also important for citizen journalism. It is in the context of crisis management that citizen journalism is considered to have begun[54], and it is a context in which it has great influence: in a time of widespread confusion and events unfolding too quickly for a few individuals to collect and curate the relevant information, the decentralised, real-time, large-scale capabilities of citizen journalism become significant advantages[55].

[50] Citizen journalism. (n.d.). *Collins English Dictionary - Complete & Unabridged 10th Edition*. Retrieved September 20, 2013
[51] Jay Rosen (14). "A Most Useful Definition of Citizen Journalism". *PressThink*.
[52] Harcup, Tony (2009), "Journalism: Principles and Practice", Thousand Oaks, California: Sage Publications, ISBN 978-1847872500
[53] David Cohn, "Time citizen journalism pulled its acts together", 15 November 2007, PressGazette, http://www.pressgazette.co.uk/node/39443
[54] Allen, Stuart, and Einar Thorsen, eds. *Citizen journalism: Global perspectives*. Vol. 1. Peter Lang, 2009.
[55] see, for example: "The Haitian News Vacuum", Columbia Journalism Review, 13 January 2010

Figure 7: Citizen Journalism – Billboard[56]

5.1.3 Potential Technical Impact on Crisis Management

Citizen journalism is an "application area" rather than a "technology area". That is, it involves new capabilities, and new behaviours, enabled and engendered by new technology. Therefore, it does not have an immediate technical impact on crisis management. However, being a critically important application area, it is one of the factors that make social media critically important technological tools during crises.

5.2 CLOUD

5.2.1 Introduction

Cloud computing is a modern paradigm of distributed computing used to provide content and services over the network (predominantly the internet) – it transforms computing into a utility, as it allows service providers to (relatively easily) deploy whatever infrastructure is necessary in order for them to provide the desired services to users[57]. (However, the term cloud computing does not have a commonly agreed scientific definition, and, rather, reflects a general understanding of multiple technologies used according to a practically important paradigm[58]).

5.2.2 Background

A variety of underlying technologies create the cloud, most prominently distributed computing and virtualisation; key technical features of the cloud's infrastructure are multi-tenancy (resource pooling), massive scalability (on-demand self-service), rapid elasticity

[56] http://pressinamerica.pbworks.com/w/page/18360163/Citizen%20Journalism
[57] Armbrust, Michael, et al. "A view of cloud computing." *Communications of the ACM* 53.4 (2010): 50-58.
[58] http://en.wikipedia.org/w/index.php?title=Cloud_computing&oldid=573703556

(automatic increase or decrease of resources committed to providing a service), and measured service (pay-per-use)[59].

Most social media can be considered to be cloud services. Many communication technologies that have been provided specifically for crisis management related communications can also be considered to be cloud services. Examples include: Facebook[60] and Twitter, Ushahidi[61] and Google Crisis Maps[62].

5.2.3 Potential Technical Impact on Crisis Management

Cloud computing provides vast resources for a vast range of existing technical solutions that are, or new ones that could be, employed to manage a crisis. For example, data mining, decision support, pattern recognition and event prediction, natural language processing[63] and many more technologies can use cloud resources to access the necessary computing resources, or can be based on the cloud so that any user, regardless of location and available hardware, can access them provided only that web access is available.

Cloud computing also facilitates the combination of services provided by different actors. For example, one provider may offer storage for vast amounts of crowdsourced data, while a different provider may offer powerful statistical or machine intelligence tools to process this data[64] – the combination allowing users to both access and understand comprehensive data about a crisis.

5.3 CROWDSOURCING

5.3.1 Introduction

Volunteers have long been an important force in crisis management. Crowdsourcing is a practice of distributing work to a "crowd" of contributors, thus managing to perform larger amounts of work than may otherwise be possible. Social networks facilitate the organisation of a crowdsourcing activity, communication between an organiser and a multitude of contributors, and also the transparency of the overall volunteering system. Social networks also contribute to the popularity of the trend to engage in crowdsourcing.

5.3.2 Background

Crowdsourcing is "the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather

[59] Carlin, Sean, and Kevin Curran. "Cloud Computing Technologies." *International Journal of Cloud Computing and Services Science (IJ-CLOSER)* 1.2 (2012): 59-65.
[60] Lenk, Alexander, et al. "What's inside the Cloud? An architectural map of the Cloud landscape." *Proceedings of the 2009 ICSE Workshop on Software Engineering Challenges of Cloud Computing*. IEEE Computer Society, 2009.
[61] Morrow, Nathan, et al. "Independent evaluation of the Ushahidi Haiti project." Development Information Systems International 8 (2011)
[62] "The Google Crisis Maps: Superstorm Sandy – excellent online resources post-Hurricane Sandy", 11/05/12, http://queens.brownstoner.com/tag/fuel/
[63] these examples are all discussed in this document
[64] Noordhuis, Pieter, Michiel Heijkoop, and Alexander Lazovik. "Mining twitter in the cloud: A case study." *Cloud Computing (CLOUD), 2010 IEEE 3rd International Conference on*. IEEE, 2010.

than from traditional employees or suppliers"[65]. It is thus also a form of large-scale online collaboration. Crowdsourcing efforts can arise spontaneously with volunteers converging to assist an organiser who steps into the scene of a crisis to offer assistance[66,67] (possibly the organiser enters the scene equally spontaneously), but they can also be organised commercially[68].

Previously discussed examples of data collection from social media, such as Google Crisis Maps and Ushahidi, are also considered crowdsourcing efforts, even though a central organiser discovers valuable information from social media or other sources, without having requested of others to provide this information. (Unsolicited information contributions may be combined with solicited information contributions, for instance Google Crisis Maps displaying both data from official information sources, and user-generated content[69]).

5.3.3 Potential Technical Impact on Crisis Management

Crowdsourcing itself is a practice, a collaboration paradigm (so it is not a technology with a technical impact).

However, tools exist to facilitate crowdsourcing, e.g. mapping platforms[70], tools for information sharing[71], and tools for finding workers[72]. Crises are often sudden and unexpected, therefore it is important that organisational resources are already available and ready to be used when a crisis strikes. Crowdsourcing is particularly effective at collecting information that is not centrally available, but where many individuals can each contribute a small amount of valuable data.

[65] http://www.merriam-webster.com/dictionary/crowdsourcing
[66] Kate Starbird, "Unpacking Crowdsourcing during Crises" April 5, 2011, http://crowdresearch.org/blog/?p=457
[67] such organisers include for example crisismappers.net, crisiscommons.org, http://www.humanityroad.org
[68] Howe, Jeff. "The rise of crowdsourcing." *Wired magazine* 14.6 (2006): 1-4.
[69] http://google.org/crisismap/2012-sandy
[70] such as opendatakit.org and ncg.nuim.ie/i2maps
[71] www.ushahidi.com
[72] www.mturk.com

Figure 8: Ushahidi map example[73]

5.4 DATA MINING AND BIG DATA

5.4.1 Introduction

Social media are a valuable communication tool that can be used to manage crises – for example, authorities can post warnings or instructions to people threatened by or undergoing a crisis; survivors can stay in contact with family and loved ones, reporting on their situation, or receiving psychological support; or political pressure can be put on governments, through the immediate dissemination of important news, to prioritise humanitarian action over exploiting a crisis so as to follow a questionable political agenda. In many useful applications, people communicate directly with other people – writing, reading, posting photos, and so on.

However, people also risk being inundated with vast amounts of information – what can an aid agency do if thousands, or even millions, of people begin to tweet about an ongoing disaster?

Also, vast amounts of information are available, and can be useful in managing a crisis, which were not originally intended for all of the valuable uses to which they can be put – for example, when individual users mention the symptoms of an illness they are experiencing to their loved ones, they may do this with the intention of communicating their family and loved ones, but a survey of all such social posts can be invaluable for an epidemiological analysis. However, how can an analyst process the vast amounts of data involved in such communication? Especially when analysing social content without prior knowledge of what conclusion is expected, huge amounts of data must be checked against huge numbers of possible threats. For example, in an after-the-event study of social media posts to determine whether the outbreak of an epidemic could have been detected early by analysing these posts, a relatively small amount of social media content may suffice for the analysis; however, in an ongoing process of constantly monitoring social media in order to detect any valuable epidemiological insights, a much larger proportion of social media content must be analysed,

[73] "Software that helps populations cope with crises", http://www2.technologyreview.com/TR35/Profile.aspx?TRID=947

and much more complex analysis is required in order to enable the possibility of detecting unknown public health threats.

Big data is the technological paradigm that enables such useful analysis of such vast quantities of data to be achieved in practice.

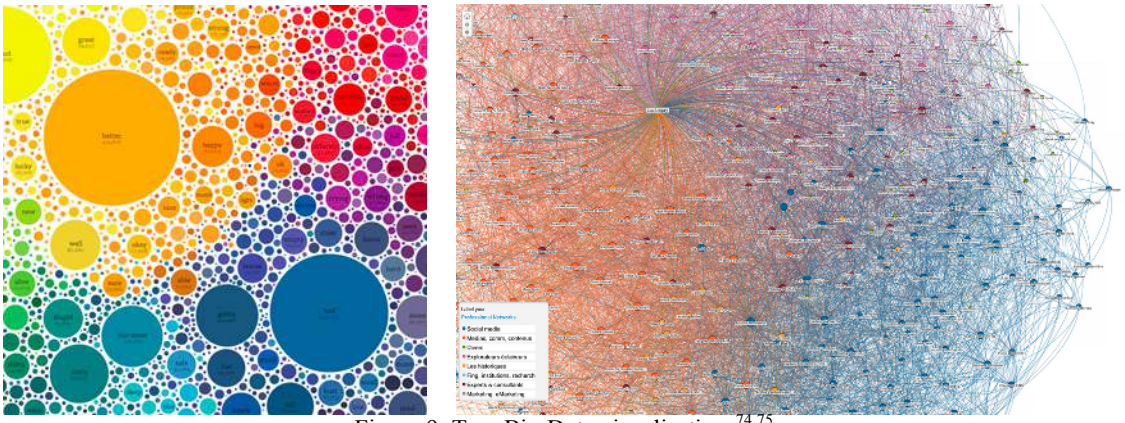

Figure 9: Two Big Data visualisations[74,75]

5.4.2 Background

According to IBM in 2012, "everyday, we create 2.5 quintillion bytes of data"[76]. Social media contribute huge amounts of data to this total, for example, on average: 400 million Tweets are tweeted every day[77], 30 billion pieces of content are shared each month on Facebook[78], 100 hours of video are uploaded to YouTube every minute[79], 55 million photos are uploaded to Instagram daily[80].

Big data is the collection of scientific and engineering methods and tools for dealing with such volumes of data, and addresses not merely the storage but also access to and distribution, analysis, and useful presentation of results (such as visualisation of analysis of the data) for huge volumes of data[81,82,83]. It exploits a multitude of scientific disciplines including high performance and distributed computing, visualisation, data mining, statistics, and machine intelligence.

[74] http://wikibon.org/blog/hadoop-big-data-focus-shifting-to-analytics-and-visualization/
[75] http://silvertonconsulting.com/blog/2011/06/24/big-data-part-3/
[76] http://www-01.ibm.com/software/au/data/bigdata
[77] https://business.twitter.com/whos-twitter, on 17/09/2013
[78] http://blog.kissmetrics.com/facebook-statistics/?wide=1, on 17/09/2013
[79] http://www.youtube.com/yt/press/statistics.html, on 17/09/2013
[80] http://instagram.com/press, on 17/09/2013
[81] LaValle, Steve, et al. "Big data, analytics and the path from insights to value. "*MIT Sloan Management Review* 52.2 (2011): 21-31.
[82] Kusnetzky, Dan, "What is "Big Data?", 16/2/2010, ZDNet, http://www.zdnet.com/blog/virtualization/what-is-big-data/1708
[83] Vance, Ashley, "Start-Up Goes After Big Data With Hadoop Helper", New York Times Blog, 22 April 2010, http://bits.blogs.nytimes.com/2010/04/22/start-up-goes-after-big-data-with-hadoop-helper

5.4.3 Potential Technical Impact on Crisis Management

Big data is a very important technological area. It is a major challenge to deal with the vast amounts of data described above, and to perform the complicated analyses of this data that is required in order to draw useful conclusions.

Big data is not a particular kind of analysis. It is not intended to enable only a specific category of conclusions to be drawn. Rather, it is the overall field of data science that addresses usefully exploiting large amounts of data. Therefore, it provides a technical foundation for any kind of collection and analysis of social media content for crisis management, ranging from epidemiological analysis, through assessing the severity of early reports of the damage caused by extreme weather conditions, to tracking social unrest in the wake of the undemocratic behaviour of governments such as often occurs throughout the world, e.g. in Africa[84], Asia[85], Europe[86] or America[87].

Big data is becoming a critical part of crisis communication due to our expanding view of the very definition of what comprises communication. Crisis communication does not involve only intentional, explicit exchange of messages – such as first responders talking over a voice connection, or a broadcast of a text message warning to citizens threatened by an approaching natural disaster. Rather, crisis communication also involves the monitoring and understanding of the full body of public, openly available communication – such as messages and content being publicly exchanged on social media. Thus, individuals may be reporting their condition to loved ones or making specific requests for help, but a complete analysis of all communications can reveal valuable information of general scope, such as a disease outbreak[88], as discussed above.

5.5 DECISION SUPPORT

5.5.1 Introduction

As framed in more precision in the following sub-section, Decision Support Systems can improve decision making in difficult circumstances, under uncertainty, risk, hard-to-define objectives (e.g. when facing moral or operational dilemmas as to which outcomes may be preferable) and rapidly changing conditions.

Therefore, their application to crisis management is highly promising, as crisis conditions match their expected operating environment:

[84] Jack Shenker, "Fighting between police and protesters is worst since Mubarak's fall as new leaders accused of same slow tactics on reform", http://www.theguardian.com/world/2011/jun/29/cairo-street-clashes-demonstrators-police-egypt
[85] "Chinese Communist party officials on trial accused of torturing man to death", http://www.theguardian.com/world/2013/sep/17/chinese-communist-party-trial-torture
[86] Aris Chatzistefanou, "Officer says government has turned blind eye to fascists and far right may be being used to provoke clashes with demonstrators", http://www.theguardian.com/world/2012/oct/26/golden-dawn-infiltrated-greek-police-claims
[87] Glenn Greenwald and Ewen MacAskill, "NSA Prism program taps in to user data of Apple, Google and others", http://www.theguardian.com/world/2013/jun/06/us-tech-giants-nsa-data
[88] Hirschfeld, D. Twitter data accurately tracked Haiti cholera outbreak. Available from http://www.nature.com/news/twitter-data-accurately-tracked-haiti-choleraoutbreak-1.9770.

During a crisis, neither human experts nor technological tools can be guaranteed to perform perfectly – not just final outcomes, but also intermediate steps of analysis, communication and intervention will be have fluid and unpredictable results.

Decision Support Systems provide a technological background, but also a body of best practices, for including scientific tools (such as weather forecasting), as well as more human considerations, in an integrated system for responding to crises. Critically, the human considerations include managing communications: dealing with credibility, panic, indifference, speed and reach issues of crisis communication.

5.5.2 Background

Decision Support Systems address human, expert, decision making, aiming to improve it by providing useful data and analysis[89]. In other words, the Decision Support System helps the expert in the decision making process, rather than replacing the expert by making decisions for her/him. Decision Support Systems normally address "soft" problems that are not completely technically specified and whose solution requires human intuition – providing the human expert with as much hard data, analysis and visualisation as possible in order to improve the decision making process – explicitly taking into account the subjectivity of the decision to be made, acknowledging the necessity to take a decision based on incomplete data, or facilitating the exploration of a problem not fully understood. Decision Support Systems are usually tools for users who are not expert computer users, or computer scientists, thus their usability is a key feature. They aim to be adaptable to changing situations and the different intuitive preferences of their users. Overall, dealing with uncertainty is a key element in Decision Support Systems, which can be defined as follows: "computer based systems that help decision-makers confront ill-structured problems through direct interaction with data and analysis models"[90].

Both during the design and implementation of Decision Support Systems, and when using them in action, we address the full spectrum of real concerns that a practical environment entails. Decision Support Systems in crisis management address scenario formulation, risk assessment, risk management, and communication[91]. Communication represents an integrating factor between the processes of understanding the situation, taking action, and involving stakeholders. A Decision Support System can contribute to the organisation and management of a large-scale communication effort, such as that conducted by a government or aid agency in response to a crisis threatening or affecting a large population. For example, human experts managing an early warning system must take into account not only the probability of a threat such as flooding, earthquakes, or hurricanes materialising, but also the potential damage that might be caused if a threat does materialise, and additionally the adverse effects of issuing a warning that proves to have been unnecessary – such as the cost of an unnecessary evacuation, loss of confidence in the early warning system itself. Thus,

[89] Sprague, R, H., Jr., "A Framework for the Development of Decision Support Systems," *Management Information Systems Quarterly*, vol. 4, no. 4, Dec. 1980, pp. 1-26.
[90] McNurlin, B. C., & Sprague, R. H. (2004). Information systems management in practice (6th ed.) *Englewood Cliffs, NJ: Prentice Hall*.
[91] Prelipcean, Gabriela, and Mircea Boscoianu. "Emerging Applications of Decision Support Systems (DSS) in Crisis Management." *Efficient Decision Support Systems—Practice and Challenges in Multidisciplinary Domains, Prof. Chiang Jao (Ed.), InTech (2011)*.

managing communication to the public is just as challenging a decision process for officials as the scientific estimation of an actual threat's significance and likelihood[92],[93].

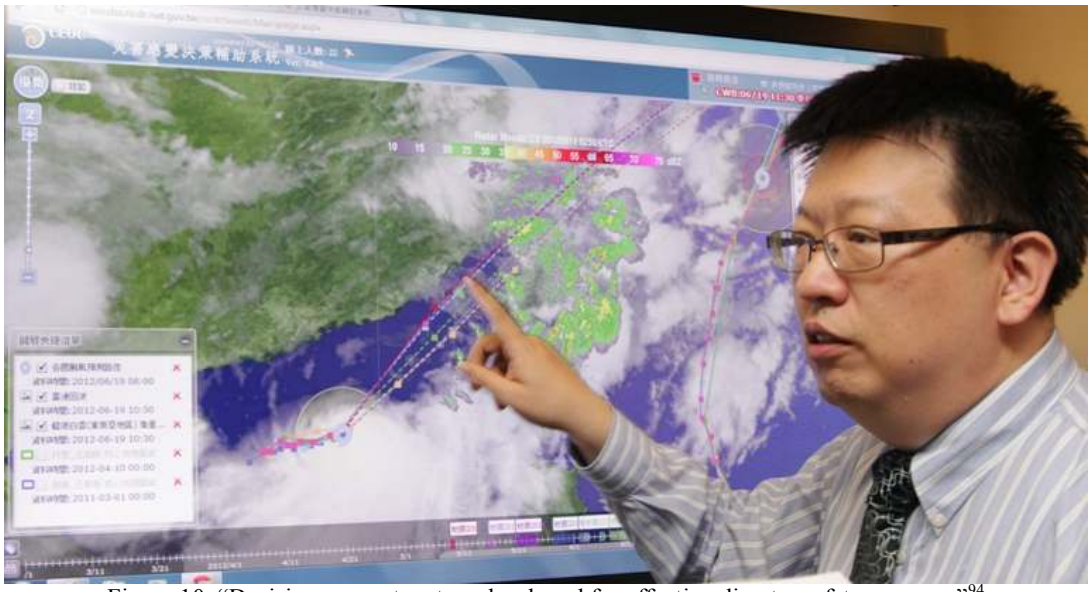

Figure 10: "Decision support system developed for effective disaster safety response"[94]

5.6 OPEN DATA

According to the *open definition*[95], "a piece of data or content is open if anyone is free to use, reuse, and redistribute it — subject only, at most, to the requirement to attribute and/or share-alike." Scientific and other data has long existed that conforms to this definition, but the modern open data movement is connected to digital communications and the Internet; when we work with open data, we normally expect it to be accessible online, with the additional implication that the data is represented in a usable format that can be understood and processed by anybody accessing the data.

Open data can play a very important role in Crisis Management. Evidence provided by Stauffacher et al.[96] indicates that open data can significantly improve Crisis Management including in response to major disasters, and that governments and major NGOs are making very important progress in actually adopting and enacting open data policies; example cases include crises in Haiti, Afghanistan, Uganda and Kenya. It is important to note that tools supporting open data are appearing, for example opendatakit, a "free and open-source set of tools which help organizations author, field, and manage mobile data collection

[92] Grasso, Veronica F., and Ashbindu Singh. "Early warning systems: State-of-art analysis and future directions." *United Nations Environment Programme (UNEP)*, 2012.
[93] Rogers, David, and Vladimir Tsirkunov. "Costs and Benefits of Early Warning Systems." *Global Assessment Report on Disaster Risk Reduction, 16pp., Published by ISDR and World Bank* (2011).
[94] http://www.narlabs.org.tw/en/news/news.php?news_id=512
[95] http://opendefinition.org/
[96] Daniel Stauffacher, Sanjana Hattotuwa and Barbara Weekes, "The potential and challenges of open data for crisis information management and aid efficiency", ICT4Peace Foundation, March 2012, http://ict4peace.org/wp-content/uploads/2012/03/The-potential-and-challenges-of-open-data-for-crisis-information-management-and-aid-efficiency.pdf

solutions"[97,98], which can then be published as open data and exploited in support of Crisis Management e.g. following a Web 3.0 approach[99].

5.7 "ORGANIC" OR SMARTPHONE SENSOR NETWORKS

5.7.1 Introduction

Situational awareness is a key factor in crisis management, and measuring the environment in which a crisis or disaster is imminent or ongoing or where it has previously struck, is a key technical capability. Networks of smartphones offer a very important opportunity for real-time and highly-detailed measurement of environments populated by smartphone users. However, technical as well as legal and ethical challenges remain to be solved for "organic" or smartphone sensor networks to be fully exploited.

Figure 11: "Transforming Mobile Phones into Sensor Networks"[100]

5.7.2 Background

Wireless Sensor Networks are a hugely promising technology limited predominantly by one core problem: energy consumption[101]. Wireless Sensor Networks integrate sensors with wireless communication capabilities and an autonomous energy supply – usually a battery. This enables the creation of a network of sensors, which function autonomously to cover the geographical space in which they are distributed, monitoring their environment according to the specific sensors that have been deployed (which can be e.g. a thermometre, barometre, or also a microphone or camera), and forming ad-hoc wireless networks to transmit

[97] http://opendatakit.org/
[98] Hartung, Carl, et al. "Open data kit: Tools to build information services for developing regions." *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development*. ACM, 2010.
[99] Schulz, Axel, Heiko Paulheim, and Florian Probst. "Crisis information management in the web 3.0 age." *9th International ISCRAM Conference*. 2012.
[100] http://www.atelier.net/en/trends/articles/transforming-mobile-phones-sensor-networks
[101] Anastasi, Giuseppe, et al. "Energy conservation in wireless sensor networks: A survey." *Ad Hoc Networks* 7.3 (2009): 537-568.

measurements back to some data collection point. Valuable application areas include "Physiological monitoring; Environmental monitoring (air, water, soil chemistry); Condition based maintenance; Smart spaces; Military; Precision agriculture; Transportation; Factory instrumentation and inventory tracking, [and] Habitat monitoring"[102]. Detailed monitoring of the environment is clearly a critically useful capability during a crisis. However, the aforementioned problem of energy consumption greatly limits the commercially and practically viable application scenarios for Wireless Sensor Networks.

Smartphones are mobile devices that often integrate a rich selection of sensors[103]. Smartphone owners recharge their smartphones in order to keep them operational – thus directly solving the energy problem, and offering an improved version of Wireless Sensor Networks[104] for a potentially broad range of applications, when considering regions densely populated by smartphone users and when the required measurements can be made by the devices in use. On the other hand, smartphones are not primarily intended for use as nodes in sensor networks – there is no guarantee regarding where a smartphone owner will take and use her/his device, and the issue of privacy needs to be resolved in order for a data aggregator to pull measurements from individual users' devices. Nevertheless, the vast number of smartphones in use around the world offers many opportunities for valuable data to be (legally) collected from them and put to a variety of important uses. Applications of "organic" or smartphone sensor networks have included tracking and analysis of CO2 emissions[105], measurement of traffic[106], and monitoring of cardiac patients[107]. An application related to traffic monitoring has been to detect accidents and provide information to first responders[108,109], which may be possible to be generalised to large scale crises. Finally, measurements for tracking the ecological impact of the Gulf Oil spill have also been made using a network of smartphones[110].

We should note that designing and validating measurement systems relying on "organic" or smartphone sensor networks is technically challenging, and research in this direction is ongoing[111]. We expect new and important applications to emerge regularly in the near future.

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[102] Estrin, Deborah, et al. "Instrumenting the world with wireless sensor networks." *Acoustics, Speech, and Signal Processing, 2001. Proceedings.(ICASSP'01). 2001 IEEE International Conference on*. Vol. 4. IEEE, 2001.

[103] see COSMIC project, Deliverable D2.1

[104] note that the communication paradigm in this case is different: Wireless Sensor Networks form ad-hoc wireless networks in order to transmit measurements, whereas smartphones are connected to data networks through commercial or other telephony services

[105] Froehlich, Jon, et al. "UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2009.

[106] Rose, Geoff. "Mobile phones as traffic probes: practices, prospects and issues." *Transport Reviews* 26.3 (2006): 275-291.

[107] Leijdekkers, Peter, and Valerie Gay. "Personal heart monitoring and rehabilitation system using smart phones." *Mobile Business, 2006. ICMB'06. International Conference on*. IEEE, 2006.

[108] Thompson, Chris, et al. "Optimizing mobile application performance with model–driven engineering." *Software Technologies for Embedded and Ubiquitous Systems*. Springer Berlin Heidelberg, 2009. 36-46.

[109] Jones, Willie D. "Forecasting traffic flow." *Spectrum, IEEE* 38.1 (2001): 90-91.

[110] Gahran, A. "Reporting on the gulf oil spill from your cell phone.", CNN (2010), http://www.cnn.com/2010/TECH/mobile/06/11/oil.spil.app/index.html

[111] Turner, Hamilton, and Jules White. "Verification and Validation of Smartphone Sensor Networks." *Mobile Wireless Middleware, Operating Systems, and Applications*. Springer Berlin Heidelberg, 2012. 233-247.

5.7.3 Potential Technical Impact on Crisis Management

Since "organic" or smartphone sensor networks are capable of providing a very rich environmental monitoring capability, they are highly promising for crisis management. They enable the measurement of physical environmental conditions (e.g. as relevant to weather prediction) in an extremely fine granularity. However, as the aforementioned applications to detecting and reporting traffic accidents and to tracking the environmental impact of the gulf oil spill demonstrate, situational awareness about the status of disaster-affected individuals and regions can also be generated. If the related privacy issues can be resolved, so as to provide valuable intelligence for exclusive use in managing crises, without violating smartphone owners' privacy, extremely extensive data collection can be enabled through this technology. Furthermore, there is a trend to integrate ever more sensors on smartphones[112]. As the sensing capabilities of smartphones expand, so will the potential value of networks of such devices.

6 CONCLUSION

The impact of new communication technologies and Social Media on Crisis Management is ever increasing. We have seen in previous reports of the COSMIC project (D1.1, D1.2, D2.1, D2.2) that new communication technologies and Social Media have already greatly impacted Crisis Management, with concrete evidence existing of their important role in a large number of major disasters and incidents. The discussion and analysis in this report, as it builds on the project's previous conclusions, shows two major trends.

Firstly, the impact of new communication technologies and Social Media on Crisis Management should be expected to grow continuously in importance and extent. More people are using these technologies in the context of Crisis Management, the level of official reliance on these technologies in the context of Crisis Management is growing, more resources especially including data resources are being devoted to enhance the impact of these technologies in the context of Crisis Management, and throughout the world take-up of these technologies is increasing and thus offering ever more opportunities for exploiting them in the context of Crisis Management.

Secondly, a far greater breadth of technologies will become increasingly important for communication in Crisis Management because they will significantly impact it, without all of these technologies being communication technologies themselves. For example, as the amount of information being communicated continues to explode in size so that it becomes impossible for the human mind to process all of it, technologies that organise, analyse and present information in human-friendly form will become integral components of the communication process.

[112] this will be discussed further in the section on wearable sensors in D3.1.2