IN-PREP

"An INtegrated next generation PREParedness programme for improving effective inter-organisational response capacity in complex environments of disasters and causes of crises"

D2.1 Success and Failure Factors in Responding to Crisis

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Executive Summary

The IN-PREP project adheres to the following definition of a crisis: A crisis is a shared perception of threat to a fundamental part or value of a society, which requires urgent action on the part of authorities under conditions of deep uncertainty (Rosenthal et al. 1989). A transboundary crisis (TBC) is a crisis that plays out across boundaries - regional and national. A key factor is that transboundary crises introduce even more complexity to crisis management, as they do not fall neatly within specific borders or policy domains.

Europe has not seen many TBCs.[1] However, there is a good argument to be made that they will increase in prevalence due to the increasing complexity and interconnectedness of European economies, and the rise of new types of transboundary threats (such as new technologies, new forms of terrorism, climate change, etc.).

In order to describe the factors that either facilitate or hinder transboundary crisis response, the IN-PREP consortium conducted a literature review and eight interviews with crisis management experts. This research underlined the notion that during crises, a set of overarching managerial tasks must be performed. The findings - success and failure factors as well as existing technologies – will be incorporated into the IN-PREP tools, which aim to improve training and preparedness for (transboundary) crisis management.

[1] For a discussion of transboundary crises in Europe, see Attina, F., Boin, A., and Ekengren, M. (Eds.) (2014)

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
AAF	Amsterdam-Amstelland Fire Service
ACPO	Association of Chief Police Officers
AIIMS	Australian Inter-service Incident Management System
ALOS	Advanced Land Observing Satellite
BGAN	Broadband Global Area Network
CBRN	Chemical, Biological, Radiological and Nuclear
CIWIN	Critical Infrastructure Warning Information Network
CLIO	Central Logging of Intelligence Operations System
CM	Crisis Management
CNVVF	Corpo Nazionale dei Vigili del Fuoco (Italian National Fire Corps)
COP	Common Operational Picture
CPM	Civil Protection Mechanism
CPO	Civil Protection Office
DC	Direct current
DMC	Disaster monitoring constellation
DMIS	Disaster Management Information System
DRM	Disaster Risk Management
ECDC	European Centre of Disease Prevention and Control
EDXL	Emergency Data eXchange Language
EFSA	European Food Safety Authority
EMN	European Migration Network
EMSA	European Maritime Safety Agency
ENISA	European Network and Information Security Agency
ENVISAT	Environmental Satellite
eOSOCC	Electronic On-Site Operations Coordination Centre
ERS	Emergency Restoration Structures
ERUs	Emergency Response Units
ETM	Enhanced Thematic Mapper
EU	European Union
FEMA	Federal Emergency Management Agency
FM	Frequency modulation (in telecommunications and signal processing)

Frontex	European Agency for the Management of Operational Cooperation at the External Border
GDACS	Global Disaster Alert and Coordination System
GIS	Geographic Information Systems
GOARN	Global Outbreak Alert and Response Network
GPS	Global Positioning System
GSM	Global System for Mobile Communications
H-CLOP	Humanitarian common logistic operating picture
HFOSS	Humanitarian Relief and Humanitarian Free and Open Source System
HSE	Health Service Executive (Irish public health and social care services)
ICCS	Institute of Communication and Computer Systems, National Technical University of Athens
ICPR	International Commission for the Protection of the Rhine
ICT	Information and communications technology
IFRC	International Federation of Red Cross and Red Crescent
INSARAG	International Search and Rescue Advisory Group
ISAC	Inter-Organizational Situation Assessment Client
IT	Information technology
JESIP	Joint Emergency Services Interoperability Programme
LCMS	National Crisis Management System of the Netherlands
LEA	Law Enforcement Agencies
LOCC	National Operational Coordination Centre
LSS	Logistics Support System
MDRU	Movable and Deployable Resource Unit
MIC	Monitoring and Information Centre
MRPP	Mixed Reality Preparedness Platform
NASA	National Aeronautics and Space Administration
NIMS	U.S. National Incident Management System
NPoCC	National Police Coordination Centre
NRF	National Response Framework
OEMC	Office of Emergency Management and Communications
OGC	Open Geospatial Consortium's
PNICC	Police National Information Centre
PSNI	Police Service of Northern Ireland
RASF	Rapid Alert System for Food and Feed

RFID	Radio Frequency Identification
RHO	Municipality of Rhodes, Greece
SARS	Severe acute respiratory syndrome
SATCOM	Satellite Communications
SMAT	Social Media Analysis Tools
SMSRM	Solution Methodology of the Structured Robust Model
SPOT	Satellite Pour l'Observation de la Terre
SRIJ	Safety Region of IJsselland
SRMLM	Stochastic/Robust Model for Logistics Management
SUMA	Humanitarian Supply Management System
SWE	Sensor Web Enablement
TBC	Transboundary Crisis
TCM	Transboundary Crisis Management
TerraSAR-X	An imaging radar Earth observation satellite
TFEU	Treaty on the Functioning of the European Union
TP-DRO	Transportation Problem in Disaster Response Operations
TSO	Tactical situation object
TSP	Travelling salesman problem
UK	United Kingdom
UNDAC	United Nations Disaster Assessment and Coordination
UNISDR	United Nations Office for Disaster Risk Reduction’s
USAR	Urban Search and Rescue
USAR.NL	Urban Search and Rescue team of the Netherlands
VGI	Volunteered geographic information
VOSOCC	UN’s Virtual On-Site Operations Coordination Centre
VRP	Vehicle routing problem
VSAT	Very Small Aperture Terminal
WHO	World Health Organisation

1 Introduction

The purpose of Task 2.1 (Success and Failure factors) of the IN-PREP project was to describe the factors that facilitate or hinder crisis response. The results will on the one hand serve as input for the IN-PREP system design which should respond to the existing technological and procedural gaps in transboundary crisis management. On the other hand, outcomes of this Task will also build the basis for the Cross-organisational Handbook of Transboundary Preparedness and Response Operations (IN-PREP Task 2.6), a guideline for managing transboundary crises. To analyse success and failure factors as well as best practice examples in responding to transboundary crises, a set of core tasks in crisis management was identified. The focus of analysis was on tools and procedures that serve the management of transboundary crisis and its particular challenges.

From a methodological point of view, the analysis was based on a literature review and expert interviews. Overall, 8 interviews were conducted, mainly with end-user partners from the IN-PREP consortium. All interviews were based on an interview guideline. This guideline was structured according to this report, along the five crisis management (CM) tasks “situation assessment”, “decision making”, “co-ordination, command and control”, “supply of basic services to enable CM and logistics”, and “communication with the public”. More specifically, the technologies available, their strengths and weaknesses as well as organisational procedures were discussed. The outputs of the interviews are reflected by information boxes in the text.

1.1 Addressing the IN-PREP Description of Action

This report addresses IN-PREP Grant Agreement (GA) requirements as follows:

IN-PREP GA requirements	Section(s) of present deliverable addressing IN-PREP GA	Description
Task 2.1: “Literature review [..] for identifying and describing the factors that facilitate a crisis response”	The results of the literature review are presented in chapter 3.	A thorough literature review comprising more than 180 references has been performed using mainly research articles as well as websites of recent research projects or official information of state authorities.
Task 2.1: “Validation interviews [..] for identifying and describing the factors that facilitate a crisis response”	The results of the validation interviews are presented in boxes within chapter 3.	The consortium has performed 8 expert interviews with end-users of crisis management tools.
Task 2.1: “A set of core tasks in crisis management will be analysed (sense-making, decision-making, communication and coordination)”	The identification of the core tasks is explained in chapter 2 and summarized in Figure 4.	On the basis of the EU project ACRIMAS a set of core tasks in crisis management has been developed.
Task 2.1: “Highlighting best	The best practices and current technologies are	On the basis of the literature review and interviews current technologies and best

practices and current technologies employed by civil protection units"	described in chapter 3.	practices in crisis management have been compiled and explained.
Task 2.1: "Considering factors contributing to failure factors"	The failure factors are described in chapter 3.	On the basis of described case studies in the literature and also the interviews failure factors have been described.

Table 1: Deliverable's adherence to IN-PREP objectives and Work Plan

1.2 Document outline

Chapter 2 describes the different phases of Disaster Risk Management (DRM): Prevention, preparedness, response and recovery. It also outlines their relation to Crisis Management (CM) and the specificities of a transboundary crisis which are considered within the IN-PREP project. Furthermore, the different (groups of) actors in CM have been identified and classified according to their operational tasks. Cross-sectional to these operational tasks, managerial tasks have been described, so that the overall picture of crisis management tasks can be described as a matrix of operational and managerial tasks.

For each of these managerial tasks the existing procedures and supporting tools, best practices and failure factors have been described in chapter 3. The basis of this chapter is a literature review in combination with the results of 8 interviews with end-users of crisis management tools. Each subsection contains the general aspects of this specific managerial task, a review of existing procedures and supporting tools used, best practices in past crisis as well as known failure factors.

This reports ends with the conclusion in chapter 4 summarizing the main results of this deliverable and giving recommendations regarding the further development of the IN-PREP tools for response planning and scenario building.

Overall, this report is one of the first deliverables of the IN-PREP project. It aims at establishing an overview of procedures used by different end-users for different managerial tasks. Since many tasks are increasingly becoming engineered, tools that are used in CM have also been part of the analysis. However, this was done in a general manner from an end-user perspective focusing on the functionalities in CM, meaning that technological specifications, providers etc. have not been part of the analysis.

2 Disaster Risk and Crisis Management

The Disaster Risk Management (DRM) community has identified different phases in risk management which have become commonly accepted over the last three decades, as the below figure of the United Nations Office for Disaster Risk Reduction's (UNISDR) Global Assessment Report shows. Usually they encompass a pre-crisis-phase (mitigation and preparedness), a post crisis phase (response and relief) as well as a restoration or recovery phase (rehabilitation, reconstruction).

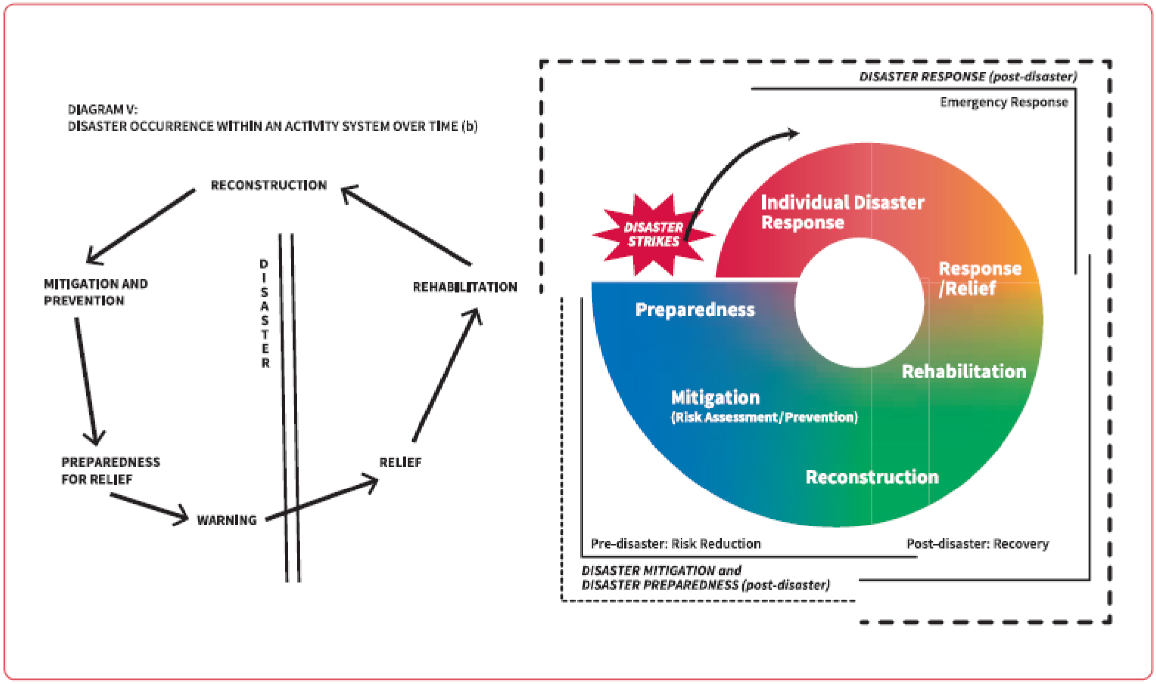


Figure 1: The Disaster Risk Management Cycle and its Phases (UNISDR 2015), based on (Baird et al. 1975) and (Khan et al. 2008)

The entirety of DRM therefore encompasses a broad range of activities which includes for example risk and vulnerability assessments, the development and adaptation of land-use strategies and building codes, the set-up and employment of early-warning systems as well as relief operations aiming to improve DRM by "building back better". Crisis Management (CM) instead focuses on the direct aftermath of an event and therefore represents response actions in the context of the risk management cycle.

Although planning is an important aspect of Disaster Risk Management (DRM), careful planning approaches do not necessarily facilitate successful Crisis Management (CM). Unfortunately, research has even shown that there is frequently a big gap between what is planned and what actually happens in a major crisis. One reason for this is that strategies need to be adapted in a crisis due to situational factors or other contingencies which require particular attention[2]. Consequently, successful crisis management depends to a large extent on the relevant emergency organisation and such as their ability to communicate and process information, to make decisions, and to co-ordinate their activities (Quarantelli 1988).

Urban Search and Rescue (USAR) crises may be considered an exception however, and specifically related to large-scale earthquake response missions. The difference of course is that the nature of the crisis is known, and there have been many past missions to learn from. While the location and severity is unique, many of the response

[2] In this respect, Quarantelli (1988) refers to the differentiation between strategy and tactics as used by the military (p. 374).

complications can be anticipated. However, there are lessons to be learned, specifically related to the International Search and Rescue Advisory Group (INSARAG) guidelines, which establish minimum international standards for USAR teams and methodology for international coordination in earthquake response. Even in cases when the crisis itself does not cross boundaries, the response effort is achieved by teams from around the world, working under extreme time pressure. Efficient execution of managerial tasks inherent to (transboundary) crisis management (see chapter 2.2) is a top priority. Lessons learned from past missions are incorporated into updated version of the INSARAG guidelines. New technologies are being introduced into what is now a heavily paper-based information sharing process, with a goal to improve situational awareness, which will help with prioritization, improved coordination of teams, and improved assignment and use of exiting capacities[3].

The INSARAG guidelines consist of three volumes (INSARAG Preparedness Reponse 2015): one on Policy, a second on Preparedness and Response (including a capacity building and an operations manual) and the third, an Operational Field Guide. High level tasks and processes are identified, and in this case, because the nature of the crisis is well understood, the guidelines are able to go into great detail in many areas.

The high-level thinking is useful in all transboundary crises planning, considering the overarching managerial tasks and working on improving training and preparedness.

This high level of detail INSARAG is able to achieve is not possible in all types of crisis. However, in some cases, preparedness with a high level of detail is possible – and incredibly useful, for example, detailed information about specific capacities. Having this (dynamic) information prepared ahead of time is of great value during a time-pressured response.

2.1 Identification of Crisis Management Actors

The emergency organisations active in crisis management are manifold. In the literature, two main categories of approaches to classifying them exist: sectorial and functional categorisation. (Kreps 1983) and (Perry 1991) have for example argued in favour of a sectorial classification that differentiated between actors in the public sectors, in private industries and volunteer agencies. The functional approach developed by (Stolk et al. 2012) clustered actors according the main operational (on-site) task they fulfil[4]:

- Crisis Mitigation
- Search and Rescue
- Security/Law Enforcement
- Evacuation and Shelter
- Inform and involve the public
- Health service
- Clear crisis area
- Supply and/or restoration of basic infrastructure

This is particularly useful since "research has shown that successful disaster management results from emergency organizations coping well with certain problematical matters. In particular, there tend to be [...] problems with

[3] The INACHUS project currently aims to achieve a significant time reduction related to Urban Search and Rescue (USaR) phase by providing wide-area situation awareness solutions for improved detection and localisation of the trapped victims assisted by simulation tools for predicting structural failures and a holistic decision support mechanism incorporating operational procedures and resources of relevant actors (https://www.inachus.eu/).

[4] In the context of the ACRIMAS project (Aftermath Crisis Management System-of-systems Demonstration Phase I, FP7), which was concerned with the identification of critical areas and topics within EU Crisis Management (CM).

respect to: the communication process and information flow; the exercise of authority and decision-making; and, the development of co-ordination and loosening the command structure" (Quarantelli 1988, p. 375). These challenges are the same for all emergency organisations. Consequently, from an analytical point of view, a matrix structure that links the operational cluster with the management tasks needs to be applied (see Figure 2) while the identification of organisations and their assignment to a certain operational category is only of secondary importance. At the same time, this highlights the importance to identify the managerial tasks all of them face.

Figure 2: Crisis Management Matrix

2.2 Identification of Managerial Tasks

Wybo and Kowalski (Wybo and Kowalski 1998) introduced a functional classification for actors and technologies which might also be applied to the above mentioned tasks. It was developed for command and control centres and is coherent with the incident command system's organisational architecture. It differentiates four functions:

1. perception (data collecting and processing);
2. analysis (decision making);
3. communication (inside organisations); and
4. information (communication outside organisations)

While it can be expected, that a number of best practice examples and failure factors can be summarised under these categories, CM functions outside the command and control centre are however neglected. A more encompassing approach considering a broader number of CM actors was developed by the ACRIMAS project (ACRIMAS 2014) which identified six supporting tasks:

1. Co-ordination, Command and Control
2. Situation assessment
3. Information management/distribution
4. Monitoring/Information gathering
5. Supply of basic services to enable CM
6. Logistics

This categorisation of supporting CM tasks is broader than the one introduced by Wybo and Kowalski (Wybo and Kowalski 1998) and allows for the consideration of success and failure factors beyond the command and control room. At the same time, it deviates from the time dimension and is lacking additional detail regarding information management as both suggested by Wybo and Kowalski. For the purpose of this analysis and to consider the advantages of both concepts, the two categorisations of crisis management tasks are merged for IN-PREP Task 2.1:

1. Situation assessment (data collecting, processing and monitoring);
2. Decision making (data analysis)
3. Co-ordination, Command and Control
    a. Information management/distribution (inside the organisation)
    b. Command and Control
    c. Co-ordination and information sharing with other actors
4. Supply of basic services to enable CM and logistics
5. Communication with the public

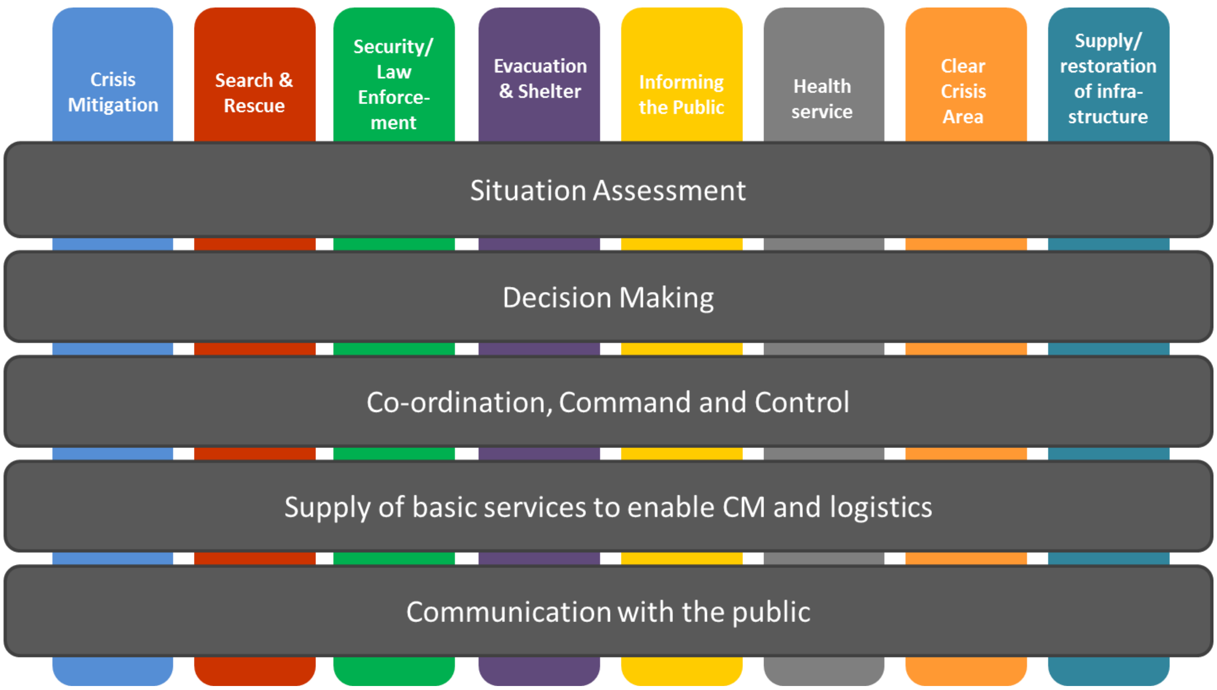


Figure 3: Crisis Management Matrix with Managerial Tasks

These categories will build the basis for analysing the success and failure factors as well as the current technologies employed in order to derive response needs of civil protection agents.

2.3 Transboundary crisis management

Overall, the focus of analysis is dedicated to transboundary specificities in crisis management. Transboundary crises encompass more participants dispersed over a vast geographic area, operating on the basis of divergent agendas and contexts and being less acquainted with each other as compared to local crises. This poses notable analytical and managerial challenges, e.g. with respect to rapid information sharing and the coordination of action across organisational, political and professional boundaries. This includes also extreme organisational adaptation requirements and unprecedented cooperation needs under severe conditions which create difficult patterns of interdependencies. These challenges create the need for specific *transboundary* technological and procedural solutions (Ansell et al. 2010). Specifically from a technological point of view, respective solution are however still mainly lacking.

Responding to this gap, the IN-PREP project aims to safeguard societies and prepare them for large-scale disasters and complex crises by on integrating novel technology tools to support various preparedness activities and to interlink a wide range of stakeholders for a collaborative response. It addresses two main preparedness challenges: improving transboundary response planning and enabling a novel and holistic approach for scenario building. IN-PREP will establish and demonstrate a next generation programme as a reference implementation of tools and processes, applicable to the entirety of CP stakeholders (firefighting units, medical emergency services, police forces, CP units, command & control centres, assessment experts) aiming to achieve realistic cross-organisational coordination at all levels of operations (strategic, tactical, operational) before and during an incident.

Consequently, the analysis of success and failure factors will not take into account the entirety of existing CM procedures and supporting tools but focuses on those solutions and procedures that can be of added value of the above described specificities. From an organisational and procedural point of view, it is important to stress that for all those activities, planning can play an important role. However, the situations encountered in transboundary crisis management will be situation specific and difficult to plan for. They will thus to a large extent, be also determined by ad hoc decision and the ability to improvise. It might therefore be useful to understand the analysis as a review of tactical aspects as compared to an overall strategic planning that has to be advanced (Quarantelli 1988).

Situation assessment is one of the most important tasks in crisis management because all crisis-related decisions are dependent on an accurate knowledge of the actual situation. The key dimensions for depicting crisis situations are time and space (Liu and Palen 2009). These dimensions are vital for the coordination of disaster relief efforts. Examples are information about the environment, reported damages, used and required resources and forces. (Ley et al. 2012)

Decision Making in general involves the selection of a course of action from among two or more possible alternatives in order to arrive at a solution for a given problem. (Trewatha and Newport 1982). In a management setting, decision cannot be taken abruptly. It should follow the steps such as: (ManagementStudyGuide.com 2017)

1. Defining the problem
2. Gathering information and collecting data
3. Developing and weighing the options
4. Choosing best possible option
5. Plan and execute
6. Take follow up action

Control is the overall direction of response activities in an emergency, operating horizontally across agencies. Authority for control is established in legislation or in an emergency response plan, and carries with it the responsibility for tasking other agencies in accordance with the needs of the situation. The "line-of control" refers to the line of supervision for those appointed to perform the control function. (State of Victoria 2015)

Command is the internal direction of personnel and resources of an agency, operating vertically within the agency. Each agency appoints agency commanders to supervise their personnel and ensure they are working safely. The "chain-of-command" refers to an agency's organizational hierarchy that defines the accountability of people or positions and identifies the link between individuals and their supervisor. (State of Victoria 2015)

Coordination is the bringing together of agencies and resources to ensure effective response to emergencies (see Figure 5 as an example for Coordination, Command and Control in Victoria, Australia). (State of Victoria 2015)

Within IN-PREP the provision of energy, water and telecommunications are seen as **basic services** to enable crisis management. **Emergency logistics** is understood as a "A process of planning, managing and controlling the efficient flows of relief, information, and services from the points of origin to the points of destination to meet the urgent needs of the affected people under emergency conditions" (Sheu 2007b).

Communication with the public is highly relevant in crisis response and can be supported by different technologies. Radio, television, newspapers, wallpaper, social networks and other channels can be employed to transmit critically valuable information to as many people as possible. (Radisch et al. 2013)

Figure 4: Definition of core managerial tasks in crisis management.

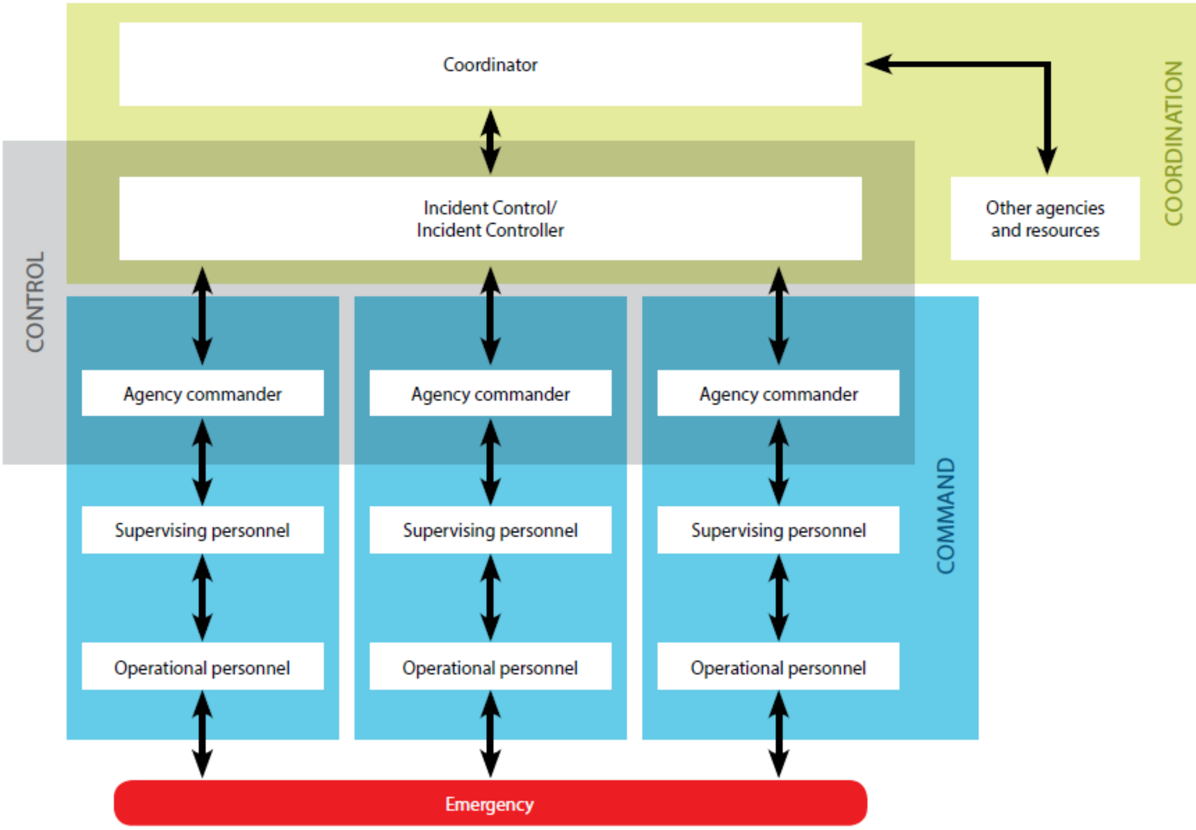


Figure 5: State Emergency Response Plan of Victoria, Australia as an example for Coordination, Command and Control in crisis management: The control function is responsible for emergency response activities and the command and coordination functions provide support to those performing the control function (State of Victoria 2015).

3 Analysis of existing procedures, best practice, and failure factors

The analysis of existing technologies, best practices, and failure factors in transboundary crisis management (TCM) follows the above described structure of managerial tasks which is reflected in the structure of the subchapters 3.1 to 3.5. Each chapter refers at its beginning to some general aspects of the specific task. Thereafter, existing technologies that facilitate transboundary crisis management are introduced, followed by procedural best practice and failure factors that could be identified (see Table 2).

<table>
<tr><th>Chapter</th><th>Title</th><th>Structure</th></tr>
<tr><td>3.1</td><td>Situation assessment</td><td rowspan="5">1. General aspects
2. Procedural review and analysis of supporting tools
3. Best practice
4. Failure factors
5. Recommendations</td></tr>
<tr><td>3.2</td><td>Decision Making</td></tr>
<tr><td>3.3</td><td>Co-ordination, Command and Control
Subchapters:
1. Information Management
2. Command and Control
3. Co-ordination with other actors</td></tr>
<tr><td>3.4</td><td>Supply of basic services and logistics</td></tr>
<tr><td>3.5</td><td>Communication with the public</td></tr>
</table>

Table 2: Structure of analysis

The chapters are based on a literature analysis which was complemented by expert interviews. The literature review considered a wide range of scientific literature stemming from different disciplines such as psychology, public engineering, information technologies and health. Lessons learned relating to managerial tasks in crisis management and existing solutions at EU level (mainly under the Civil Protection Mechanism (CPM)) were considered wherever possible and useful[5]. For a better overview, each of the chapters contains a summary table on the findings. They are structured according to the aspects mentioned in Table 2.

For the interviews the experts from the following organisations have been selected:

- Safety Region of Ijsselland (SRIJ)
- Dipartimento dei Vigili del Fuoco, del Soccorso Pubblico e della Difesa Civile (CNVVF)
- Municipality of Rhodes (RHO)
- Health Service Executive Ireland (HSE South)
- Police Service of Northern Ireland (PSNI)
- German Police University (DHPol)

[5] Civil protection and Crisis Management are a scattered European policy field with instruments, policies and venues which have hardly been institutionalised (see also Boin et al. (2014c)).

- Dutch Urban Search and Rescue Team (USAR.NL)

3.1 Situation Assessment

3.1.1 General aspects

The analysis of situation assessment as a managerial crisis management task encompasses the continuous data collection, processing and monitoring from different information sources. More precisely, it can be defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley 1995), p. 36). Although a variety of tools might be used to support situation assessment, it is important to stress that situation assessment is finally made by individuals by the means of information available and interactions with other people. Consequently, it is also suggested to use *Common Operating Picture* (COP) as a term describing the shared understanding of an incident which is created by assessing and fusing information and data from multiple sources to facilitate decision-making (Robert MacFarlane and Mark Leigh 2014).

Challenges

A specific challenge in transboundary crisis management is uncertainty about the cause of the crisis and its evolution which becomes even harder to understand when a crisis stretches across countries and policy sectors. This is especially true in situations where situation assessment requires information from other organisations or jurisdictions (Ansell et al. 2010). Consequently, information sharing as one of the most important tasks in transboundary crisis management will also be addressed under chapter 3.3.3 "Coordination with other actors". Overall, the dispersion of information over a range of organisational and geographical boundaries aggravates general challenges in crisis management which frequently fall under one of the following categories:

- Data/information availability;
- Data/information quality; or
- Data/information management.

Usually, information on the crisis is lacking right after the event since some time is required for its collection and transmission. As time passes, the supply of information increases and can even exceed the demand (see figure 4). Consequently, during this information-overload period, with respect to information management, tools and methods used in CM must be decision-centric and make sure that only the most relevant information is presented to decision-makers, i.e. strategic-level information with immediate consequences for the relief effort. In this context, the increasing amount of data available via smartphone applications and its transformation into reliable and useful information for situation assessment is a major challenge. At the same time, information must not be too general and standards are needed for terminology for information to be precise (information quality).

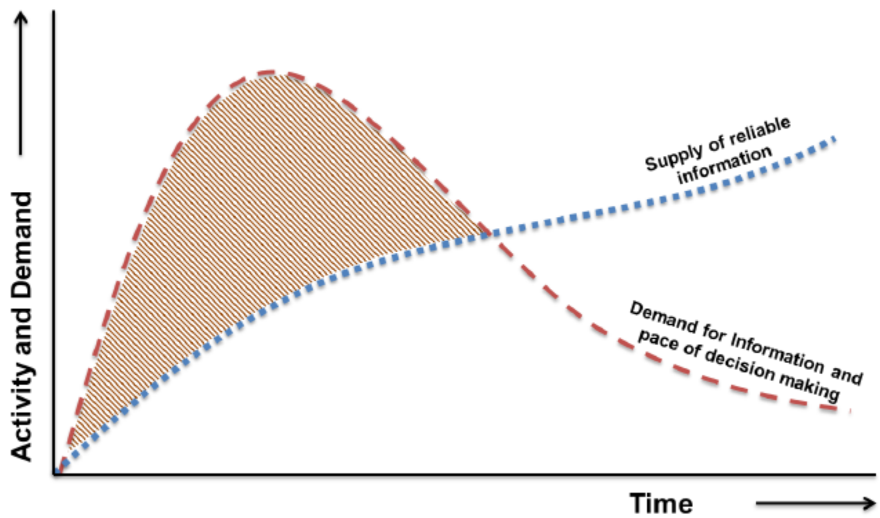


Figure 6: Evidence gap in crisis management (MacFarlane, R. and M. Leigh 2014)

Besides an imbalance of the demand for information and its actual availability, additional factors might limit the generation of crisis information. These factors can encompass for example (see also (Ley et al. 2012), p. 9 as well as (Robert MacFarlane and Mark Leigh 2014), p. 14 f.):

- a lack of transmission caused by human or ICT failure
- detection failures due to confused signals, distraction, background noise
- failure in observing the information due to stress/ a lack of awareness about existing information
- misperception
- not yet developed or underdeveloped technology

In addition to challenges regarding the availability of data/information, its quality and reliability vary e.g. with respect to relevance, accuracy, completeness and format (Ley et al. 2012).

3.1.2 Procedural Review and Analysis of Supporting Tools

Situation assessment is one of the most important tasks in crisis management because all crisis-related decisions are dependent on an accurate knowledge of the actual situation. The key dimensions for depicting crisis situations are time and space (Liu and Palen 2009). These dimensions are vital for the coordination of disaster relief efforts. Examples are information about the environment, reported damages, used and required resources and forces. (Ley et al. 2012). In general, situation assessment encompasses three different aspects of the situation: early-warning (mainly pre-crisis) as well as damage and needs assessments. While these assessments had mainly been based on oral communication and paper based notes, they are increasingly becoming supported and/or replaced by technological solutions. (Boin et al. 2014a) have for example analysed the technologies available for sense-making[6] in the European Union. The 84 (EU-level) systems they identified as situation awareness systems, varied strongly with respect to the policy fields they addressed (civil protection, health boarder management, etc.), their technical specificities (the system characteristics with respect to gathering, verifying and distributing information varied

[6] The term sense-making is rooted in social psychology and organizational sciences and can formally be defined as "the ongoing retrospective development of plausible images that rationalize what people are doing" Weick, K., Sutcliffe, K. M. and Obstfeld (2005). In the civil protection context, it is frequently used synonymously with situation assessment and can be supported by a range of technologies.

broadly) and the time horizon they addressed (acute crisis vs. long-term reflection), to name just a few. Only few of the systems were however designed to provide the full-range of sense making functions. Some cross-sectoral efforts with respect to situation assessment are progressing (such as the European rapid alert system ARGUS and transboundary flood risk management in the context of the International Commission for the Protection of the Rhine (ICPR)). However, those initiatives are slow and have to overcome the tremendous variation in systems. Consequently, general technologies that can be used for situation assessment have also been considered in the Procedural Review and Analysis of Supporting Tools.

3.1.2.1 Early warning systems

There are early-warning, detection and surveillance systems which collect data about the occurrence of crisis events, their intensity and expansion. Early-warning allows for the mitigation or even prevention of negative hazard impacts by encompassing three main aspects: detecting oncoming disasters, predicting their development and disseminating alerts. There are numerous early warning systems already in place, both overarching and relating to specific disaster types. Usually, these systems are based on cameras[7], weather stations[8] or other forms of sensors[9] (Jirka et al.) and can also include model-based prediction tools which forecast for example weather or flooding or the development of forest fires[10]. Early-warning systems have been developed for a broad variety of natural hazards. With respect to man-made hazards, detection and surveillance systems exist for CBRN threats but are still lacking for terrorist attacks.

3.1.2.2 Impact assessment

Information of interest in the aftermath of an event concerns the affected area, the losses incurred, the disrupted critical infrastructure and the potential for secondary hazards (Mehrotra et al. 2004). Existing technologies basically fall into two categories: Sensors (including remote sensing) and participatory sensing, including crowd-sourcing.

Sensors

Sensor data is usually generated by satellites or (un-)manned vehicles (drones) and translated into GIS (Geo Information System) data formats which are used to visualise the data and information derived and to complement them with additional descriptive variables, e.g. on hazards, environmental evolution, critical infrastructures or available CM resources (e.g. (Lettieri et al. 2009)). A second category of sensors generating data and information on damages occurred are cameras. They are for example embedded in civil infrastructure, dispersed at the crisis site or carried by first responders (Mehrotra et al. 2004), p. 181). Finally, sensors can also be integrated in buildings such as fire detectors, smoke detectors, temperature, humidity, luminosity or door sensors (opened/closed) from which algorithms can create higher level information[11].

[7] Used for example to monitor rain detention basins or aerial images for forest fire detection.
[8] e.g. for monitoring wild fire risk
[9] e.g. for monitoring air or water quality or water and rain gauges
[10] NRT_ ACF provided by Satways realizes for example the prediction of front propagation of large forest fires and the dispersion or trajectory of particles and gas released in the atmosphere by industrial CBRN incidents or large forest fires.
[11] The Wireless Sensor Network provided by ICCS is for example open source wireless sensor platform specially focused on the implementation of low consumption modes to allow the sensor nodes (“motes”) to be completely autonomous and battery powered. It can be used in many applications such as Emergencies (Presence detection, water level sensors and temperature), Forest fires (CO, CO2) or CBRN (chemical, biological, radiological, nuclear exposure). Another example is the Indoor Positioning System (Q-Track NFER Technology (UWB)) also provided by ICCS. It facilitates the provision of position and orientation in indoor spaces where first responders operate. The technology utilizes the peculiarities of the near field of radio waves operating at low frequencies to achieve the localization (e.g. position, velocity and tracking of multiple persons).

Participatory sensing/Crowd-sourcing

This potential source of information is generated by the increasing use of smart phone technologies. It is based on first responder interactions or includes the public (eye witnesses) as information source (crowd-sourcing). In the former case, it was proven in exercises that real-time data transmitted to a single electronic On-Site Operations Coordination Centre (eOSOCC) reached similar situation awareness levels[12] as compared to the paper-based version. However, the information is electronically available and sharable and can also serve to monitor changes over time (Rester et al.)[13]. With respect to crowd-sourcing technologies, geo-mapping and the exploitation of social media can be distinguished. Geo-mapping technologies are usually based on GPS which allows for the geo-referencing crisis information. Tools such as GeoChat, Sahana, Ushahidi or Crowdmap were used for example during the 2010 Haitian earthquake and Thailand Flood Crisis (Kamel Boulos et al. 2011). Numerous case studies stressed the added-value of using volunteered geographic information (VGI) in various types of crisis events, such as earthquakes (De Rubeis, V., Sbarra, P., and Tosi, P. 2009), forest fires (De Longueville, B., Smith, R.S., and Luraschi, G. 2009), hurricanes (Hughes, A.L. and L. Palen 2009), floods (Longueville et al. 2010) and terrorist attacks (Palen, L., Vieweg, S., Liu, S.B. and A. L. Hughes 2009).Overall, participatory sensing and crowd-sourced geo-mapping gain from the Open Geospatial Consortium's (OGC) Sensor Web Enablement (SWE) standards which allow developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable (for tasking, eventing and alerting) via the Web by defining service interfaces that enable an interoperable usage of sensor resources (Kamel Boulos et al. 2011). The information provided via crowd-mapping tools is also referred to as volunteered geographic information (Roche and Propeck-Zimmermann, E. and B. Mericskay 2013).

Crowd-sourcing technologies for situation assessment based on social media extract information from platforms by using various data mining techniques, including burst detection, text classification, online clustering, and geotagging (Yin et al. 2012). When using social media information, it is specifically critical to verify information since rumours can interfere with the decision making of crisis responders and lead to dangerous mislead of first responders due to supplying communication lines with incorrect information. In practice, a level of trustworthiness is assigned to each data sources Crowd sourcing is often tagged as low trusted.

3.1.3 Success factors: best practice

The scientific literature does hardly suggest best practice procedures for situation assessment although technological and system design recommendations have been published (e.g. (Endsley 2011)).The following examples stem from the end-user interviews:

The Safety Region of Ijselland (SRIJ) employs an information sharing and management platform (LCMS). It consists of different GIS layers containing information on critical objects (e.g. schools, hospitals etc.) as well as an actual incident layer which is created and updated by an information manager in the field. The shared situation awareness tool can be accessed by all organization involved in crisis management such as fire fighters, police, rescue and health services as well as with other organisations such as the Water Board or defence agencies[14]. A technology which operates on a lower scale and only between the police, rescue services and missing people registries in Germany is GSL Net. It facilitates among others information about the number of casualties, victims' names and the degree of their injury to give information about their fitness to be questioned (DHPol).

[12] In an exercise, teams had to develop situation awareness maps.
[13] Overview of Systems available can be found in Annex I.
[14] Of course, some information cannot be shared for privacy reasons.

Although technologies for situation assessment are hardly used by a majority of respondents for managing crisis, best practice can be regarded in two ways. Firstly, some organisations use software tools for log keeping and keeping an overview of the received information and decisions taken (Police Service of Northern Ireland (PSNI), Corpo Nazionale dei Vigili del fuoco (CNVVF), DHPol). This can also serve the institutional learning at a later stage. Secondly, some countries use information hubs, e.g. crisis management offices under the municipality, for collecting information from all organisations and providing a common operational picture to the individual crisis organisations (Municipality of Rhodes (RHO)). Sometimes, liaison officers are employed which facilitate the information exchange with other organisations (DHPol).

In some cases, GPS systems are used to track staff and/or resources such as vehicles. This allows to allocate information received from the front line more precisely to a geographic location and to keep an overview over the deployed resources respectively (e.g. PSNI). Some initiatives for including geo-referenced pictures from the front line are also established (CNVVF).

Due to the lack of a (visualised) situation assessment tool, emergency managers frequently also use social media reports and pictures to get an overview over the crisis situation (e.g. PSNI, Health Service Executive (HSE)). Some organisations make specific use of platforms which allow the public to upload images and videos (to be used for prosecution purposes) (DHPol).

3.1.4 Failure factors/ Shortfalls

The literature suggests that specifically in transboundary crisis situations, reliable information is rare and facts and figures often turn out to be less than secure. It is thus difficult to assess the actual crisis situation and its likely progress in the near future. Simultaneously, the pressure for decision making (see also next chapter) is high which might require for accepting lower accuracy information instead of losing valuable time to wait. Nevertheless, also an overload of (useless) information and its separation from valuable information can pose a challenge in assessing crisis situations.

In practice, technologies supporting Situation Assessment are hardly used. Instead, information is passed on orally (mostly by radio communication) from the frontline to the control centres (e.g. CNVVF, DHPol, HSE South, PSNI). This shortfall was identified by a majority of the end-user partners. This lack of technologies also leads to difficulties in information sharing and storing (PSNI, HSE South, DHPol)). The use of manual recording methodologies (HSE South uses for example White Boards) leads to challenges in tracking situation development in prolonged crisis situations.

Wrong and missing information and the mistrust in information provided from outside the own organisation are an important failure factor in responding to crisis (DHPol).

Finally, data protection regulations have to be respected which makes data sharing in some cases only possible under very restricted requirements (CNVVF).

Summary Situation Assessment	
General aspects	Tools can support situation assessment but never replace the sense making by individuals. The lack of information in the direct aftermath of an event is a major challenge. If information is available, ensuring its quality and management are general challenges that have to be addressed.
Procedural Review and Analysis of Supporting Tools	Basically, three groups of situation assessment technologies can be identified: 1. Early-warning systems 2. Systems focusing on damage assessments 3. Systems focusing on needs assessment
Best practice	The Dutch Safety Regions use a shared Situation Assessment tool across the involved organisations.
Failure factors	While crisis management organisations make use of above mentioned technologies to a different extent, it is usually hazard specific and encompasses for example the monitoring of water levels. For overall situation assessment however, mainly radio communication is used. In some cases, information is entered into log-keeping systems. Some organisations use social media as an add-on to derive a clearer picture of the emergency site and few make already use of pictures from the front line. Some organisation use GPS systems for tracking their staff and/or resources such as vehicles. Usually, operational pictures are not available electronically which would allow for sharing them in a timely manner.
Recommendations	Although the employment of joint situation assessment tools was assessed as an advantage by the interview partner, information is hardly kept and shared between organisations electronically which leads also to time lags in decision making and taking action. The development/adaptation of respective solutions and their implementation across organisations should thus be envisaged.

Table 3: Summary "Situation Assessment"

3.2 Decision making (data analysis)

3.2.1 General aspects

In general, two main ways of decision making and information sharing can be found in the literature. *Coordination* thereby describes a rather *hierarchical chain of command and control* within crisis management (see also 3.3.2). In contrast, *cooperative ways* of crisis management can be characterised as more *decentralised decision making structures* (Groenendaal et al. 2013). Although different in their applied ways of decision making, both systems share the assumption that central coordination must collaborate with other emergency response organisations (Drabek and McEntire 2003; Buck et al. 2006). Additionally, both models presume that commanders at different hierarchical levels are able to exercise control over the responding frontline units specifically during the first hours of large-scale emergencies (Groenendaal et al. 2013). According to Danielsson and Ohlsson (Danielsson and Ohlsson 1999), both ways of decision-making co-exist and have to be adapted according to the scale and extent of a crises. While a hierarchical command and control system might work in smaller scale incidents, researchers found that large-scale emergency situations are frequently too complex to understand and control its different aspects by one leader ((Schneeweiss 2003). Instead, it is suggested that distributed decision making (DDM) was a useful approach to address the deficiencies in obtaining a central overview over the crisis (Rasmussen and Brehmer, B. and J. Leplat 1991), (Brehmer 2000), (Scholtens 2008b; Scholtens 2008a) since complex problems are divided into smaller components that can be processed by individuals. According to this approach, each individual unit takes its own decisions independently according to the overall goal (Rasmussen et al. 1991). In this respect, (Danielsson and Ohlsson 1999) wrote that "large-scale emergency operations imply distributed decision making in that decisions are distributed among many actors, of which no single individual has complete knowledge of the current situation".

Distributed decision making will have to be applied in transboundary crises situations also due to the fact that no central hub with decision-making competences exists. In this regard it is usually challenging that competences between organisations are not clear. Consequently, it will be difficult to determine which organisation might lead certain tasks. Additionally, tasks and perspectives on the crisis differ between organisations and thus complicate co-ordination between them (see also below).

Contrary to this, decision making within the individual CM organisations might be centralised. Regarding the performance of front-line actors, however hardly any information is available about the effects of decision-making structures. Instead, literature provides evidence that frontline actors are not only influenced by their managers and the action they want them to take but to a large extent by their own moral judgements, knowledge, and experience, e.g. (Considine and Lewis 2003) or (Maynard-Moody and Musheno 2003). Scholtens (Scholtens 2008a) found for example that centralized coordination was no necessary prerequisite for task-adjustment in the frontline. Instead, she concluded that emergency services operated reasonably well in the field despite the chaos at the levels above them. Klein and Calderwood (Klein et al. 1989) also reported limitations in the extent to which frontline responders can be centrally coordinated which was also confirmed by tactical and strategic commanders of the Amsterdam-Amstelland Fire Service (AAF) who stated that frontline-alignment was almost impossible during the first few hours of large-scale emergencies. Problems resulting from this lack of control were however not reported (Groenendaal et al. 2013). Instead, it is important that each level needs the information that is needed for taking specific decisions. This can range from very operational (e.g. how many fire trucks are on the ground) to strategic decisions (e.g. to evacuate a certain area).

Overall, the quality of situation assessment and the respective data and information build the basis for decision making and thus determine also its efficiency and quality. With specific respect to transboundary crisis, the exchange and fusion of information for an encompassing situation assessment play an important role.

3.2.2 Procedural Review and Analysis of Supporting Tools

Decision Making in general involves the selection of a course of action from among two or more possible alternatives in order to arrive at a solution for a given problem. (Trewatha and Newport 1982). In a management setting, decision cannot be taken abruptly. It should follow the steps such as: (ManagementStudyGuide.com 2017)

1. Defining the problem
2. Gathering information and collecting data
3. Developing and weighing the options
4. Choosing best possible option
5. Plan and execute
6. Take follow up action

Decision making can be facilitated by decision support tool which might help to overcome inherent human limitations (Simon 2013) and help to facilitate rapid but informed decision making. Respective technologies support the assessment of information, suggest decision making options and integrate scenarios. Although much progress has been made in the development of decision making technologies in the recent years, specifically tools for distributed decision making (which would be needed in transboundary crisis situations) remain underdeveloped. Information remains scattered across political and geographic boundaries and signals from surveillance systems can usually not be brought together in a useful manner (Ansell et al. 2010).

From a technological point of view, solutions for sense and decision making range from laboratories to the use of modelling techniques. They encompass the analysis of (large amounts) of raw data, stemming amongst others from situation assessment technologies and aim at discovering patterns in the absence of reliable information (Ansell et al. 2010). Technologies are usually very specific and address certain aspects of a crisis such as evacuation strategies[15]. Consequently, they can facilitate only certain aspects of decision making in a complex transboundary crisis. However, decision making in transboundary crisis can be strongly improved by sharing information about the individual situation assessment while it has to be kept in mind that it will be hard to develop a joint situation assessment methodology generating a shared operational picture. Instead, such a picture will frequently have to build on incomplete and sometimes even contradictory information from a large number of actors (Lagadec 1997; Comfort 1999; Moynihan 2008; Demchak 2010).

In the humanitarian context, the Global Disaster Alert and Coordination System (GDACS) as well as the Sahana open-source humanitarian information and decision support system are used. Whereas GDACS is used to issue alerts and to provide impact estimations after sudden-onset disasters, the Sahana system serves to address common coordination problems during a disaster. It therefore encompasses a missing person registry and an organisation registry as well as a camp registry and a request management system. The GDACS system was however considered too general and containing too few detailed information (Stolk et al. 2012). The information exchange via GDACS still lacks predictability, quality and standardised formats. In addition, many organisations make information available only after the internal analysis and decision making process has been completed (Groeve et al. 2006).

[15] urbanEXODUS for example is a large scale evacuation simulation tool capable of simulating the movement and evacuation of large crowds from large complex spaces. Via a GIS web interface (webEXODUS) it is capable of interacting with situation awareness and command and control environments.

In practice, a variety of organisations translate the information received from the front line into an electronic Common Operational Picture. They frequently also use decision recording systems such as CLIO (Central Logging of Intelligence Operations System) (PSNI) or similar (SRIJ, CNVVF)

3.2.3 Success factors: best practice

The basis for decision making can build a definition of rules which describe where the tasks and associated information should go, and what should be done with them. In other words, the mapping of decision making processes and their consequences by a workflow model gives the opportunity to optimise processes. At the same time, it can simulate a whole range of possible actions, such as the interactions between the various crisis management processes or the mechanisms for distribution of tasks and associated information (see also Mak et al. 1999). In practice, respective decision making and information flows play an important role for intra-organisational work. They have however been hardly defined for transnational crises but have been developed on ad hoc basis in the past. Irrespective of the methodology used for establishing such processes, it is important that actors focus on the information they need for taking decisions at their level.

Transboundary crises require different organisations to work together. Recognising this, several nation states such as the UK or Ireland have set up frameworks for their collaboration (see details under chapter 3.3.3 "Coordination with other actors"). In the UK for example, the "Joint Doctrine: the interoperability framework" (JESIP) is applied (Chief Fire Officers Association, Association of Ambulance Chief Executives and National Police Chiefs' Council 2016) (Chief Fire Officers Association, Association of Ambulance Chief Executives and National Police Chiefs' Council 2016). In Ireland, the Framework for Major Emergency Management and its Annexes outline the inter-organisational emergency management collaboration (National Steering Group Ireland 2017).

According to JESIP, the decision making process is structured in a standardised way among organisations (Figure 7):

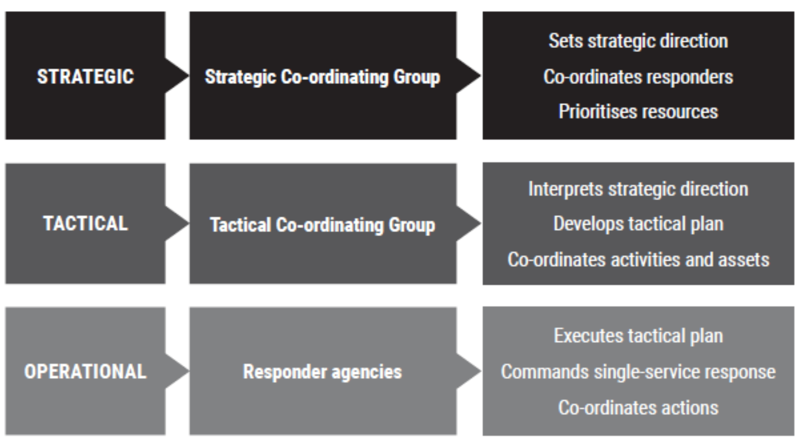


Figure 7: Response and decision making structure according to JESIP (Chief Fire Officers Association 2016).

Another example for well-handled decision making in a transnational crisis is the SARS outbreak during which the World Health Organisation (WHO) for example used the Global Outbreak Alert and Response Network (GOARN) to provide decision support to responders globally. GOARN was built on a network of institutions and experts which participated in outbreak surveillance and which could be mobilised for supporting outbreak response. GOARN was used to create four response networks: a senior advisory group to the WHO on its global alerts and travel recommendations, a virtual laboratory that was used to isolate the disease agent, a working group for the establishment of clinical guidelines and a network of experts who monitored the spread of the disease. In addition, the WHO provided a daily update on its website which was based on tele- and video-conferences with its dispatched GOARN teams (Ansell et al. 2010; Michelson 2005; WHO 2003).

This example shows that a central hub that coordinates sense and decision making and gathers information can facilitate efficient transboundary crisis management. This hub must play a clearinghouse rule in connecting different types of information and decision-making and it needs to be scaled up to level that involves all stakeholders which contribute the management of the crisis. Finally, this hub should also be able to operate in the field. In the WHO example, own field teams could be deployed (Ansell et al. 2010).

In the context of Urban Search and Rescue, the "Search-and-Rescue Decision Support Portal and Mobile Application" represents a good technological example. It gives a quick overview of the operation, the Team Management and the sector management of the incident.

From a practical point of view, some states have set up central information and decision-making hubs at the nation state level. In Greece for example, the municipality operates with their Civil Protection Office (CPO) at hub at municipal level which can be upscaled to the nation state level (RHO). Comparative structures which gather the information of the involved crisis management organisations exist also for example in the Netherlands (Safety Regions) (SRIJ). In some cases, respective hubs are represented by crisis co-ordination centres of centres for information exchange (e.g. RHO). In other cases, staff of individual contributing crisis management organisations is delegated to co-ordination centres (for example HSE South or PSNI) or serves as liaison officer for inter-organisational information exchange (DHPol).

For the policy context, it is suggested that policy-makers should be trained to deal with crisis and disaster and should learn about challenges to be expected such as insufficient availability of information and complex dilemmas. They should be able to use simple check lists to improve crisis performance while balancing short- and long-term crisis effects (Boin and 't Hart 2010).

3.2.4 Failure factors/Shortfalls

One of the biggest challenges in decision making in crisis situations is the high pressure for decision which might require for accepting lower accuracy information instead of losing valuable time to wait. Refusing to take decisions in the absence of reliable information can be regarded as an avoidable failure (Boin and 't Hart 2010).

The lack of reliable information is a major failure factor in responding particularly to major crisis (DHPol).

Additionally, and although it is clear that the establishment of a common operating picture builds the very basis for successful transboundary crisis management, crisis management organisations face sometimes difficulties in sharing information with others, mainly due to legal or organisational/procedural constraints. In this respect, the main failure factor in decision making stems however not from challenges in this specific managerial task but rather from co-ordinating and communicating with other actors (see below 3.3.3)

Summary Decision making (data analysis)	
General aspects	Two decision making structures can be differentiated: centralised vs. decentralised. While there are good arguments in favour and against each of the structures, it is questionable whether a central

	information (and decision) hub can be identified and established in a major transboundary crisis. Usually however, both structures will co-exist.
Procedural Review and Analysis of Supporting Tools	Available technological support for sense and decision making ranges from laboratories to the use of modelling techniques. In practice however, they are hardly applied.
Success Factors	The use of central information hubs such as the municipality or gathering of staff from different crisis management organisations in centralised locations facilitates the generation of a common operation picture (COP). But also information sharing platforms as used for example by the Dutch Safety Regions (see 3.1 "Situation Assessment" above) can facilitate decision making.
Failure factors	Challenges arise from difficulties in information sharing and management. Respective information sharing structures are however hardly in place. Overall, the main failure factor in decision making stems however not from factors in this specific managerial task but rather from co-ordinating and communicating with other actors
Recommendations	The sharing of information (situational awareness and action taken by other organisations) remains the main obstacle of efficient decision making. Consequently, the introduction of respective structures and technologies/platforms is recommended.

Table 4: Summary "Decision Making"

3.3 Co-ordination, Command and Control (C3)

The Co-ordination, command and control is subdivided into three different aspects. They address *Information management* or the *distribution of information inside an organisation* (3.3.1), *Command and Control* structures (3.3.2) as well as *Co-ordination with other actors* and organisations (3.3.3).

3.3.1 Information management/distribution (inside the organisation)

In major emergencies, communication often involves a complex multi-level enterprise of vertical, horizontal and diagonal communication lines of both formal and informal character (Bram and Vestergren 2011). Research on communication in crisis situations has made scholars claim that as much as 70 to 80 per cent of all problem solving activities involve some form of communication (Weisæth et al. 2002). Although this accounts specifically for inter-organisational communication in transboundary crises situations, it holds of course also true for intra-organisational information flows.

3.3.1.1 General aspects

Information management provides the technology and procedures to support that (a) the right information is provided to the right persons, at the right time in the right format in the right place, and (b) the information infrastructure is used in an optimal way. Its data structure and details are determined by the tasks that the system has to fulfil (Stolk et al. 2012). The specific challenge in a transboundary crisis situation stems from the environment that involves a variety of actors and information while the situation might constantly change and the operating picture remains frequently unclear for longer periods of time.

Since technologies in theory provide a lot of possibilities to facilitate information management, in practice, mainly radio, e-mail and telephone are used. When developing information management systems for crisis management organisations, it is thus essential to question the level of detail that is useful in the field.

3.3.1.2 Procedural Review and Analysis of Supporting Tools

Technologies that facilitate information management in crisis management support existing processes for managing information and resources in emergencies, enabling greater efficiency and improved decision making. Frequently, respective technologies are applied by coordination centres (Ianella and Henricksen 2007).

The applied structures and technologies vary from country to country but also among organisations in one country. Usually however, they are applied within one organisation only and do not facilitate information exchange with other organisations and some organisations do not employ respective technologies at all. One best practice example which applied a trans-organisational information management system is introduced below.

With respect to technical requirements, information management systems need to be interoperable to allow for cross-organisational compatibility and collaboration (Comfort 2006; Jungert et al. 2006; Bharosa et al. 2009). Further important factors facilitating the efficient use of technology are a user-friendly design (Woltjer et al. 2006) taking the limits of human cognitive abilities into account (Engelbrecht et al. 2011) and displays that provide the ability to visualise common operational pictures among different actors (Norros et al. 2009). Finally, ICT infrastructure used for Crisis Management needs to be robust enough to handle strain (e.g., weather conditions, solar storms, system overload) (Banipal 2006) and to have sufficient geographic coverage (Bram and Vestergren 2011).

3.3.1.3 Success factors: Best Practice

A best practice for trans-organisational information management system is LCMS, the Dutch national crisis management system, used by all of the country's 25 Safety Regions, as well as the national police, national crisis centre, national operational coordination centre, fire brigades, and medical response teams. While it serves inter-organisational information sharing and the development of a Common Operational Picture, it also records actions taken by the individual organisations and links it through GIS to the emergency site (SRIJ).

INSARAG's Virtual On-Site Operations Coordination Center (VOSOCC) is an information management system used to track details of large-scale international earth quake response missions. The basis is good, but the system is complicated to navigate, and desired information is not easily found. However, improvements are underway, including moving away from paper based information sharing (USAR.NL).

Other methods to keep record of decisions taken are (electronic) records or blogs (RHO, CNVVF). In some cases, information is gathered at a central organisation (RHO, Civil Protection Office at local or national level). In other cases, information is recorded and exchanges via White Boards (HSE South). The Information Management is structured as follows (compare Figure 8):

Recognised Current > Situation	Key Issues>	Strategic Aim>	Actions
Recognised Current Situation*	**Key Issues***	**Strategic Aim/ Priorities***	**Actions***
The present situation, described clearly and succinctly, as a basis for co-ordination and decision-making. To include a list of key events that informs understanding and interpretation of the recognised current situation.	The important issues arising and against which the overall response needs to be constantly assessed.	The overall aim (strategic direction) and the priority items that must be actioned in order to meet the aim.	Actions that have been decided in order to bring the situation under control.

*These should be to a level of detail consistent with the mandate of the co-ordination centre

Figure 8: Information Management System Structure as suggested by the "Framework for Major Emergency Management Appendices " (IRL) (An Garda Síochána, the Health Service Executive and Local Authorities 2005)

Frequently, social media and available pictures are used by emergency managers to get an overview of the emergency cite since pictures from the front line are not typically available (PSNI, HSE South). In some countries, pilot studies/initiatives to integrate visualisations form the emergency site into the Common Operational Picture are in place (CNVVF, SRIJ).

3.3.1.4 Failure Factors/Shortfalls

Communication technology frequently becomes damaged by a crisis event. This does not only have a negative effect on the crisis operations but also on its restoration which needs to be coordinated. This is frequently further hampered by the lack of back-up communication solutions (Reynolds and Seeger 2005). Irrespective of the actual availability of communication infrastructure, communication failures are often caused by *individual social factors* such as the misinterpretation of messages by the receiving individual. At the same time, information quality is frequently poor and thus impedes the process but also failures in filtering the important information can lead to communication failures (Hale et al. 2005).

In addition to that, frequently, internal communication systems are not designed to address a greatly increasing number of staff and changed information flows during a crisis. They are based on clearly defined command-and-control chains, information needs and conditions under which information is exchanged. Requirements typically differ strongly in a crisis situation. This leads to missing or incomplete data (McEntire 2002; Day et al. 2009), insufficient data quality (Horan and B. L. Schooley 2007) and a lack of control of data flows resulting in an overall lack (McEntire 2002) or overload of data (Bruijn 2006). At the same time, it has to be admitted that the integration of information across different sources and interpretations from different organisational backgrounds is difficult. (Dawes et al. 2004; Hale et al. 2005; Bruijn 2006; Day et al. 2009). It is also hard to overcome since it is particularly difficult to plan for the uncertainties regarding communication requirements in a transboundary crisis situation. Exercises and training could however take this aspect into account (Quarantelli 1988).

With respect to the implementation of (new) technologies within organisations *non-acceptance* poses a challenge. This holds particularly true if solutions are not handy and adapted to the usability requirements of first responders (Lee et al. 2011; Manoj and A. H. Baker 2007; van de Walle and M. Turoff 2007). This is specifically true since crisis responders frequently collect data on paper and not for electronic processing (Day et al. 2009). The user-driven development of technologies and subsequent training and explanation of the added value are thus essential (Gomez and M. Turoff 2007).

Finally, a limited ability to learn from past events and exercises can represent a major failure factor in crisis management (Official Norwegian Reports (ONR) 2012). Conceptualizations and measurements of key characteristics of emergency management which would allow to assess the success of operations and to improve them are mainly lacking (Becerra-Fernandez et al. 2008).

From a practical point of view, specifically the lack of electronic information management creates challenges for storing and retrieving information (HSE South) which becomes particularly relevant for the change of shifts (PSNI).

Although the above described White Board method is established and works well also with respect to its procedural requirements, it does not allow for an electronic sharing of information and also derives difficulties in prolonged crisis situations. When the board needs to be cleaned, information has to be stored via pictures (HSE South).

Finally, trans-organisational experiences in crisis management frequently only lead to local solutions which are not up-scaled. The main reason behind this is that frequently only experience triggers the need to find new solutions.

Summary Information management/distribution (inside the organization)	
General aspects	The specific challenge of information management inside an organisation during a crisis is the involvement of a variety of actors and information in a constantly changing situation. Information management inside an organisation includes also the evaluation of response operations and the integration of lessons learned.

Procedural Review and Analysis of Supporting Tools	While a lot of requirements for information management systems have been formulated from a theoretical point of view, the employed systems on the ground fulfil only basic requirements of log-keeping.
Best practice	Some organisations apply software solutions for log-keeping of their information and decisions taken upon them. This can also be used for past-crisis evaluation, learning and training. The more advanced solutions are information sharing platforms as applied by the Dutch Safety Regions (see also above 3.1. "Situation Assessment") which include joint operational pictures and measures taken but also allow for the use of an organisation internal space.
Failure factors	While the literature frequently mentions the breakdown of infrastructure, limited information quality, and overload of information as a main factors delimiting communication, the time lag due to manual processing of information and a lack of technologies for managing major amounts of information were mentioned in the interviews. Additionally, it was mentioned, that trans-organisational experiences in crisis management frequently only lead to local solutions which are not up-scaled. The main reason behind this is that frequently only experience triggers the need to find new solutions.
Recommendations	While many organisations use log-keeping technologies, they are usually not connected to an information sharing system. It should thus be elaborated how information sharing platforms (see above) can link to or improve the internal information management/log-keeping. Additionally, the lack of pictures from the ground is frequently balances by the (unstructured) use of social media. The integration of visualisations form the emergency site as currently tested in pilot studies should thus be extended.

Table 5: Summary "Information management/distribution (inside the organization)

3.3.2 Command and Control

3.3.2.1 General aspects

In general, two different approaches to coordinating a crisis situation exist (see also introduction to Chapter 3.2 *Decision Making*). One school of thought argues that collaboration between a variety of actors can only be achieved in an efficient and timely manner under some form of guidance. However, these mechanisms, including plans, protocols, rules and routines (Okhuysen and Bechky 2009) work best in stable (routine) environments (Thompson 1967; Chrisholm 1989). Due to high levels of uncertainty involved in transboundary crisis and its non-adherence to hierarchical lines and routine processes (Boin and Bynander 2015), another school of thought argues that formal structures and planned responses are “too slow, disconnected, and inadequate” (Majchrzak et al. 2007). Arguing that traditional coordination tools have limited applicability in complex crisis situations (Barton 1969), it is thus claimed that groups and organisations can work most efficiently without being guided from top (Chrisholm 1989). Boin and Bynander (Boin and Bynander 2015) merge the two concepts by introducing a time dimension. Frequently, the immediate aftermath of an event will be characterised by bottom-up initiatives while the formal intervention of higher authorities might be arranged with a delay. In this regard it is however also stressed that both approaches do not necessarily reinforce each other but might be counter-productive.

Overall, it is challenging for crisis management organisations to switch operations from usual and daily practices to major emergency situations which require for specific and organisational structures. (DHPol).

3.3.2.2 Procedural Review and Analysis of Supporting Tools

Control is the overall direction of response activities in an emergency, operating horizontally across agencies. Authority for control is established in legislation or in an emergency response plan, and carries with it the responsibility for tasking other agencies in accordance with the needs of the situation. The “line-of control” refers to the line of supervision for those appointed to perform the control function. (State of Victoria 2015)

Command is the internal direction of personnel and resources of an agency, operating vertically within the agency. Each agency appoints agency commanders to supervise their personnel and ensure they are working safely. The “chain-of-command” refers to an agency’s organizational hierarchy that defines the accountability of people or positions and identifies the link between individuals and their supervisor. (State of Victoria 2015)

Literature on Command and Control technologies is sparse. This can be explained by two main reasons. Firstly, Command and Control is not necessarily understood as a management task that requires specific technology. Instead, it combines many aspects from situation assessment and decision making that result in the development of strategies and tactics. Secondly and consequently, specific technologies are not applied by many crisis management organisations. Instead, instructions are usually passed on via radio communication, e-mail, telephone or fax. Some organisations use however log-keeping technologies. Nevertheless a range of technologies is available for example for incident management including the management of emergency calls and the assignment of tasks (e.g. Fortion or ENGAGE IMS CAD).

A new technology that can open a new dimension of Command and Control, but is currently hardly applied, is *Crowdtasking* (a form of *Crowdsourcing*). It encompasses the selection and provision of tasks by a professional organisation allowing volunteers with specific skills or physical location to contribute to a disaster or crisis relief operation with the aim to integrate volunteers into crisis management in a structured way (Auferbauer et al. 2016a).

Specific challenges in transboundary crisis management instead stem from organisational aspects, i.e. how tasks and efforts are coordinated among organisations. While some countries established frameworks that define the procedures, structures for inter-organisational response are still lacking in others.

Additionally, questions of prioritising response measures play an important role in Command and Control aspects of crisis management. In this regard, however non-technological solutions identifying the exact discrepancy between demand and supply have been developed. The structured assessment of resources and needs is described as a best practice example below.

3.3.2.3 Success factors: Best practice

The preparation of coordination actions builds an important basis which can encompass for example checklists as reminders of lessons learned or simple mechanisms.

Frameworks for inter-organisational collaboration have been established for example in Ireland and the UK (see also *Best Practice* under chapter 3.2 "Decision making" and 3.3.1 "Information management".

Additionally, in the UK a generic emergency plan was developed, complemented by an asset registry. This registry contains information on available resources and capabilities, giving an overview on who and what is available and what these specific assets can do (this includes also the training level of staff e.g. for the use of certain equipment). Assets can be deployed according to the demand. The effective use of assets can be tested and improved by training (PSNI). In Germany, deployment documentation systems are used (DHPol).

Communication is another important factor of successfully commanding in a complex crisis. This encompasses three main aspects. Firstly, this encompasses the establishment of information management procedures. Secondly, the selection and implementation of platforms[16] facilitating horizontal and vertical coordination can contribute to successful crisis management (Boin and Bynander 2015). This should also consider modern information technology tools that can help victims to organise themselves. In the aftermath of Hurricane Katrina for example the *Katrina Help Wiki* was created. The Ushahidi software used to map disaster-stricken areas played an important role in the aftermath of the Haiti earthquake. Respective initiatives should be sought out by strategic leaders in order to establish collaboration (Boin and Bynander 2015).

Respective tools are usually not integrated into the crisis management work of involved organisations such as fire brigades, police or health services in a structured way. Social media are however used for situation assessment and deriving a clearer picture of the emergency site (PSNI, HSE South).

Finally, the communication with other organisation and personnel is an aspect of Commanding crises. In this respect, strategic actors should avoid imposing pre-planned mechanisms. Recognition for those on the ground might not comply with formal plans but make also an important difference (Boin and Bynander 2015).

In this respect, the Civil Protection Offices at municipal and national level in Greece operate as information broker which will also communicate the existing needs backwards to the crisis management organisations (RHO). In other countries, joint strategies and tactics would be developed inter-organisationally. Based on them and in line with them, the front line takes its own decisions (PSNI).

[16] LCMS as applied by the Dutch Safety Regions is described as a Best Practice example in chapter 3.3.3 (Co-ordination with other actors).

3.3.2.4 Failure factors

Decision-makers attempts to plan and command every aspect of crisis management impedes flexibility that might be needed in a transboundary crisis (Boin and 't Hart 2010). Uncertainty is however the inherent nature of transboundary crisis. Consequently, planning for all eventualities is hardly possible. Although the development of plans is an important aspect of crisis preparedness, it is important that reliance on these plans does not become too tight and unexpected events can be integrated into operational and management task. The above mentioned best practice example suggest exemplarily how this could be achieved.

Besides the rigidity of plans, the active involvement of the public remains mainly unaddressed. While many organisations use social media for the communication of warnings and instructions (see also chapter 3.5 Communication with the public), they do not make active use of their potential for supporting crisis management activities by *Crowdtasking*.

Grass-rout initiatives which organise themselves via the internet and use of social media are usually not integrated into the command and control structures of crisis management organisations such as fire brigades, police or health services. In some cases, social media are used for situation assessment purposes in a non-structures manner an as add on the existing structures though (PSNI, HSE South).

Summary Command and Control	
General aspects	Command and Control can either be centralised or decentralised. The literature suggests that the approaches are often merged. The lack of information in the direct aftermath of an event and the time needed for the involvement of higher authorities will frequently require for an initial bottom-up approach, usually shifting to a more centralised structure at a later stage.
Procedural Review and Analysis of Supporting Tools	In practice, mainly radio communication but also email, telephone and fax are used to pass on information and instructions inside and across organisations. Crowd-tasking technologies usually do not play a role in Command and Control activities of crisis management organisations.
Best practice	The identification of strategic and tactical aims allows the front line to take (decentralised) decisions which are in line with overall aims. The identification of a central information hub collecting information from all crisis management organisations can be of added value.
Failure factors	The rigidity of and reliance on plans is a failure factor in managing transboundary crisis. The lack of applying crowd-tasking technologies leaves resources of the public unused.

Recommendations	Overall, internal Command and Control structured have been developed over decades and in most cases work efficiently. It should however be analysed in how far crowd-tasking could be of added value to crisis management. The technology allows for new options to integrate volunteer and grass-root organisations which are frequently not yet integrated into crisis management efforts.

Table 6: Summary "Command and Control"

3.3.3 Coordination with other actors

3.3.3.1 General aspects

One of the most difficult challenges in transboundary crisis management is the coordination with other actors. This does not only encompass information sharing and situation assessment but specifically also the coordination of an effective response. Coordination is a substantial challenge in every crisis (Quarantelli 1988; Hart et al. 1993; Kettl 2003). People and organisations with different backgrounds, resources and motivations have to suddenly collaborate under pressure and with frequently only little information. In addition, the crisis usually hardly corresponds with the plans in place (Ansell et al. 2010).

In other words, crises are in general characterised by high amounts of communication needs. Transboundary crises add the requirement to co-ordinate information across boundaries and between a broad range of actors. This concerns information about a Common Operational Picture (COP) as well as information about CM activities to allow organisations to identify their own role and tasks in the specific event (Ansell et al. 2010). Consequently, the focus of this chapter is information sharing between organisations in transboundary crisis response. While each of the above and below mentioned managerial tasks has to be fulfilled by the CM organisations individually, a continuous sharing of information and action can help them to improve their involvement. The flow of information is thereby determined by technical but also by cultural factors encompassing for example trust or organisational structure. In an ideal transboundary crisis setting, Comfort suggests a *Bowtie Architecture* for a joint and iterative flow of information (see Figure 9)

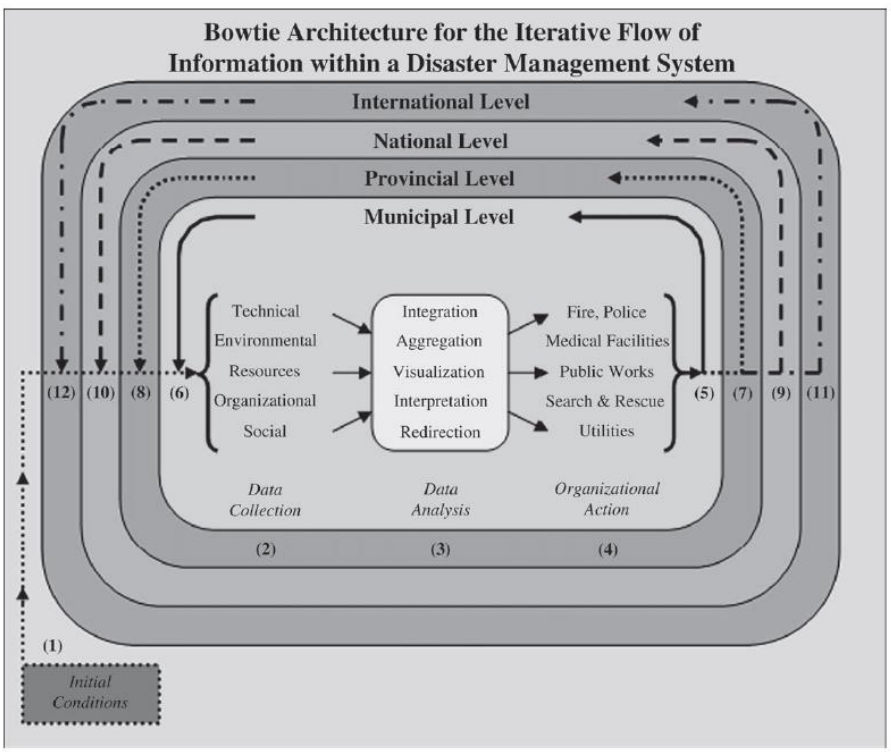


Figure 9: Reorganisation of a Disaster Management System (Comfort 2007)

Some authors argue that in practice it was difficult to find a problem owner (Ansell et al. 2010) and that top-down coordination from a central office would never fit the specificities of a transboundary crisis, e.g. (Harrald et al. 1992; McEntire 2002). Instead it is claimed that self-organisation tended to work better than imposed cooperation schemes would be more effective (Kendra and Wachtendorf 2003), cf. (Chrisholm 1989; Solnit 2009). Consequently, they argue, political leaders should facilitate self-organisation in response rather than try to control and command it. At the same time, it can be contested that communication remains particularly difficult in the absence of an established high-status organisation that can act as a hub for information sharing (Ansell et al. 2010). In practice however, a respective (pre-established) hub is lacking.

The co-ordination between CM actors becomes even more complicated due their different nature. Dynes (Dynes 1970) captured this variety well by suggesting the following matrix (see Table 7). It differentiates organisations typically being involved in direct crisis response (*established* organisations), organisations addressing secondary effects of a crisis such as economic, social or psychological impacts (*extending* organisations), volunteer dominated human services organisations (*expanding* organisations), and those organisations which are created during a crisis (*emergent* organisations).

Tasks Structure	***Regular***	***Non-regular***
Existing	Type 1: *Established* (e.g. police, fire, ambulance services)	Type 2: *Extending* (e.g. housing, family and social services, tax, schools)
New	Type 3: *Expanding* (e.g. Red Cross, Salvation Army	Type 4: *Emerging* (e.g. Bushfire Recovery Authority, disaster victims' organisation)

Table 7: Types of Organizations in Disaster Response Processes (Boin and 't Hart 2010), based on (Dynes 1970)

These actors are characterised by different aims and organisational structures. In addition, transboundary crisis management has also to practically overcome heterogeneous political and legislative contexts in which they operate[17]. Co-ordination efforts thus have to take into account a wide range of different procedures and available tools which create differing information needs. It is thus suggested, that transboundary crisis requires for formal structures that prescribe how decision-making authority is organised across political, geographic and time boundaries (Ansell et al. 2010). Due to its legal dimension a respective authority structure must be thought through and cannot be developed during a crisis situation (Egan 2010).

From an organisational point of view, several countries have developed so-called incident-management systems. This terminology is misleading since it does not (necessarily) refer to a technological solution. The Australian as well as the U.S. incident management *systems* could also be regarded as frameworks, doctrines or approaches to incident management, encompassing templates, documents and structures. The Australian Inter-service Incident Management System (AIIMS) and the U.S. National Incident Management System (NIMS) both facilitate cross-organisational cooperation by describing common concepts and processes for incident response but are also used to capture management and control hierarchies (entities such as sections and units with broadly described roles and responsibilities) (Ianella and Henricksen 2007). AIIMS was designed to be scaled according to the size of the incident. NIMS offers a common operating philosophy and architecture that can allow different organisations work together. While trained officials specifically in the fire-fighting community find it easy to cooperate and could collaborate more

[17] See also Deliverable 2.3 "Recommendations on relevant organizational, policy, social and human factors relevant for system developments" of the IN-PREP project.

effectively. While, it remains questionable whether it can be used in all types of crisis and in an ever growing network of actors, it was successfully used in the aftermath of the Columbia space shuttle disaster (Donahue 2004) and in response to the 9/11 Pentagon attacks (Varley 2003). It failed however in the Hurricane Katrina response since most actors were unaware of the exact NIMS workings.

Within the EU (despite nb. national frameworks which will be mentioned under best practice below), *generic* and *sectoral* crisis management capacities have been developed in the last decades. The most prominent generic capacities thereby encompass the Solidarity Clause (Art. 222 TFEU)[18] which requires the Member States to support each other in times of crisis as well as the Civil Protection Mechanism (CPM) which can be used to coordinate assistance in the EU. The CPM run by DG ECHO encompasses amongst others the rapid alert system ARGUS which brings together information from the variety of early warning systems within the Commission services and the Monitoring and Information Centre (MIC) where impending crisis situations and monitored 24/7. Additionally, it encompasses a variety of civil protection modules which serve different on the ground crisis management tasks. They encompass for example forest fire fighting tools, field hospitals as well as aerial evacuation, water purification or CBRN detection and sampling technologies (Annex II of Decision 2010/481/EU). However, respective modules do hardly support managerial tasks as analysed in this document. Additionally, in case of a major emergency frequently bilateral agreements between nation states facilitate support.

With respect to sectoral capacities, several structural measures which are functional with respect to different crises are in place at EU level. For example, structures to trace and prepare food risks or measures to prevent oil spills such as those of *Prestige* have been developed. Sectoral structures and measures are frequently entrusted to EU agencies (Boin et al. 2014b). Agencies that have been created in the wake of crisis encompass the European Food Safety Authority (EFSA), the European Centre of Disease Prevention and Control (ECDC), the European Maritime Safety Agency (EMSA), Europol, the European Agency for the Management of Operational Cooperation at the External Border (Frontex), the European Network and Information Security Agency (ENISA) (Boin et al. 2014b). Additionally, a variety of civil protection networks are relevant for transnational crisis management at EU level. Usually they encompass contact points which are supported by IT tools such as RASF (the Rapid Alert System for Food and Feed), CIWIN (Critical Infrastructure Warning Information Network) or EMN (European Migration Network).

3.3.3.2 Procedural Review and Analysis of Supporting Tools

Coordination is the bringing together of agencies and resources to ensure effective response to emergencies (State of Victoria 2015). Technologies facilitating transboundary crisis management encompass on the one hand inter-organisational tools supporting managerial tasks such as situation assessment. On the other hand, information sharing tools which merge information on their activities are available.

The Inter-Organizational Situation Assessment Client (ISAC) is a map-based information repository, which aims to support aggregation and visualization of information, individualization of information compositions, collaborative situation assessment, and accessibility of information resources (Ley et al. 2012).

Regarding the establishment of a Common Operating Picture to which organisations can contribute and from which they might extract information, standardised ways of exchanging information have been established. In Europe, the OASIS project (OASIS project 2007) developed an information exchange model for public safety called "tactical situation object" TSO[19]. The European Research Project REACT evaluated TSO and implemented its own model for

[18] The Solidarity Clause remains however hardly specified with respect to its practical implementation.

[19] An introduction to the TSO as well as specification documents and XML schemas can be found on the former website (Tactical Situation Object (2012))

semantic interoperability and also performed user trials on European level (IDIRA Project 2013). In practice however, a majority of the interviewed end-users reported that they lack a respective technology which results in time lags for decision making due to oral/manual communication.

In addition, technological solutions going beyond situation assessment have been developed. Jixel for example, is one of the State of the Art Web 2.0, GIS enabled Joint Control Room, specifically built with the aim to allow interoperability and information sharing during emergency management, already adopted successfully in real-life scenarios (IDIRA Project 2013).

A solution which facilitates joint situation assessment but also the communication of action taken was developed in the Netherlands. An information sharing and management platform (LCMS) was successfully established for all Safety Regions. In gathers information on the emergency site as well as information on the action taken by the individual organisations (see also below under Best practice "System configuration").

3.3.3.3 Success factors: best practice

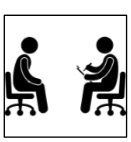
With respect to best practice in co-ordination with other crisis management actors in transboundary events, two main aspects have to be differentiated. On the one hand side, the scientific literature identifies a variety of factors contributing to or facilitating co-ordination. They range of sociological factors such as trust to procedural and system configuration aspects. On the other hand side, practical and applied examples of successful co-ordination will be described.

Sociological factors

Irrespective of the available technologies, communication and coordination between organisations will only happen if *common concepts* are used and *trust* exists. A steady coordination between all organisations and inside each organisation through team working along all the phases, from strategy to recovery and not only during response would thus be useful to build trust and train staff to collaborate cross-organisationally. With respect to 9/11 a New York government service official stated for example that "more networking in preparation for disasters is needed. The issue was not technology or policy; it was that many of us had not taken the time to get to know staff at key organizations" (Kapucu 2006). Obviously, in order to allocate and coordinate resources efficiently, the organizations need to be aware of each other's units and their capabilities (Oomes 2004). A collaboration that goes beyond the pure awareness of each other would also facilitate the testing of contingency and recovery plans (Kapucu 2006), the development of policies regarding data sharing and collaboration as well as the understanding of (different) needs and urgency levels regarding certain information (Mehrotra et al. 2004). Trusting networks of relationships between organization can best be built prior to emergency situations (Kapucu 2006).

Procedural factors

Prior planning can serve to *identify* the more likely *key organizations* which will be involved in responding to a (transboundary) disaster. However, it is particularly difficult to predetermine likely extra-community responders. Consequently, training and exercises should also prepare crisis managers in communication and collaborating with unfamiliar officials. On the ground, name tags or specific clothing can ease the orientation (Quarantelli 1988).



The identification of information needs is an issue that is frequently mentioned in the context of establishing systems for co-ordination. (Seppänen et al. 2013) have for example differentiated different types of information that could be shared. However, they also found that some of it is hard to (pre-) define and to identify. Contrary to approach of defining respective needs, formats etc., end-users operating inter-organisational co-ordination and collaboration frameworks have reported that they do not encounter difficulties with respect to information needs and formats (PSNI, HSE South, SRIJ). The main reason therefore is that hardly data is exchanged but processed information e.g. on actions taken is shared either orally/manually (PSNI and HSE South) or electronically (SRIJ).

With respect to training and the continuous updating of planning, those organisations which build their collaboration on established frameworks have however good experience in the implementation of trainings and the development of lessons learned (e.g. HSE South). Overall, it can be stated that collaboration works well if it was established before a crisis (DHPol).

The establishment of *formalised structures and processes* is an important step in effectively managing transboundary crises. The management literature suggests in this regard that organisations can develop routines which help them to respond to rapidly changing conditions (Teece et al. 1997; Eisenhardt and Martin 2000). This aspect can also be transferred to the management of transboundary crisis management. Organisations involved need to develop routines that help them to respond dynamically to new situations they might not have been trained for (Ansell et al. 2010). At its best, this encompasses a trans-organisational collaboration and communication strategy and single points of reference who manage communications across organisations (Helsloot 2005). In establishing a strategy, several aspects should be taken into account (Boin and 't Hart 2010):

1. Activities of organisations involved in crisis management have to be coordinated, i.e. a set of common purposes based on existing interdependencies has to be articulated. Of course, inclusive membership should be a basis for network design. However, it is frequently found that existing networks are too narrow focusing on Type 1 and Type 3 organisations (see table Table 7). Non-regular organisations such as social or victim organisations are mainly neglected.
2. The *establishment* of decision-making and conflict resolution structures at the network level can facilitate efficient crisis management.
3. Thirdly, interpersonal trust is an important aspect of successful collaboration (see also *Networking* below).
4. Collaborative functions should be prepared for in the same way that individual organisation prepare for crisis. This means, that basic functions such as warning, mobilisation, registration and evacuation (Quarantelli 1988) should be addressed jointly during the planning phase and be ready to use. Of course, exercises support planning and adapting of collaboration. This should also encompass the establishment of relationships between response agencies, the media and politicians and experts (Boin and 't Hart 2010).
5. It is important to understand that crisis planning efforts are never completed but that and effective management requires for a continuous monitoring, updating and adjustment of planning efforts and processes through experience and exercises. This includes also the structured analysis and integration of lessons learned into the planning process (Boin and 't Hart 2010), who built on (Leonard and Howitt 2009; Rosenthal et al. 1989; Rosenthal et al. 2001; Helsloot et al. 2012).
6. Ideally, the adaptation of decision making structures is taken into account in the development of collaborative processes. This might even include collaborative structures with authorities.

Examples from the U.S.:

During Hurricane Katrina, the US Coast Guard's distributed organisational structure allowed for a deployment of assets and first responders to locations at which they were most needed. At the same time, shared standards allowed for an efficient collaboration (Ansell et al. 2010) cf. (General Accountability Office (GAO) 2006).

With respect to adaptive authority systems, in the U.S. the National Response Framework (NRF) was developed which defines the adaptation of authority relations in case a crisis affects more than one state (Federal Emergency

Response Agency (FEMA) 2008).It was developed after 9/11 and refined after Hurricane Katrina. In response to Hurrciane Gustav (2008), participating organisations at state and federal level seemed to be satisfied with the proposed procedures (Boin and Egan 2012).

Finally and in terms of quality assurance, regular audits by independent experts would be useful to improve the overall collaboration in transboundary crisis management (Boin and 't Hart 2010).

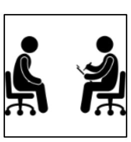
System Configuration

Generally speaking, infrastructures need to be complementary. Solutions must be able to be adapted to individual/local needs instead of concepts that require centralized, aligned procedures dominating the practices of the individual organizations. Procedures and suitable software tools for cross-agency tasking and material and personnel resource planning need to respect the responsibilities and roles of different command configurations (Stolk et al. 2012).

With respect to their technical configuration, Crisis Management Systems system should not be a traditional single monolithic system, run by one organization, and requiring all participants to access this one service but provide several functional services such as:

- Incident Management,
- People Management,
- Resource Management,
- Notification Management, and
- Situational Awareness Management

A set of user interfaces for composing, sending and receiving resource messages, as well as tracking the status of requests should be provided. A standard for linking resources messages to automatically track and display the progress of each request and group together the thread of messages related to that request should be developed. Interfaces for formulating a resource request should also be standardized (Ianella and Henricksen 2007), p. 7f). For example, systems should be conform to the Emergency Data eXchange Language (EDXL) Distribution Element standard (OASIS project 2014). XML message formats can be used for resources management (Ianella and Henricksen 2007), p. 7). While some technological information sharing approaches exist, they frequently only take selected organisations into account. For example, the EMCR (Emergency Management Content Router) allows for the sending of messages between Law Enforcement Agencies and Fire Brigades upon registration. The German GSL Net facilitates the exchange of information between organisations. However, is includes Law Enforcement Agencies, Rescue Services and person enquiry offices only.Finally, co-ordination system must fulfil security and data protection standards which exclude data misuse and ensure that in case of a failure (in the data warehouse and/or with communications) the information is not lost.



The Safety Region of Ijsselland (SRIJ) uses an information sharing and management platform (LCMS) which is used by all 25 safety regions in the Netherland. It is applied for training as well as for operational purposes and different disciplines such as police, fire fighters, rescue and health services and by different teams including the front row as well as control centre staff. It encompasses different GIS layers containing information on critical objects (e.g. schools, hospitals etc.) as well as the actual incident level. One information manager in the field is responsible for updating this layer. Each organization has its own access to the system and takes its own action. However, the action is reported via LCMS is the organisation's layer. Also photos and videos as well as modelling (e.g. on flooding) can be added to the system. Overall, LCMS allows for sharing an operational picture among all involved organisations. It however important, that information is kept up-to-date to avoid decisions based on wrong or outdated information.

3.3.3.4 Failure Factors/Shortfalls

Co-ordination with other actors is mainly a question of communicating with each other and sharing information. During many crises this communication breaks down. This is however frequently not caused by technical failures but by *cultural* communication barriers which result from a lack of pre-existing communication channels and routines as well as from a lack of trust between organisations. Nevertheless, if crisis management organisations become not active in cultivating trust, they will perform work in parallel but not jointly and will fail to benefit from the integration of operations (Boin and 't Hart 2010).

Additionally, local, narrow and mono-disciplinary views on the information needs of others contribute to failures in crisis management coordination. If information is however not passed on within a system, response capacity is reduced and scarce resources might be misallocated. Nevertheless, crisis planning efforts frequently concentrate on technological solutions while neglecting cultural failure factors (Boin and 't Hart 2010). Additionally, a precondition for collaborating in crisis management is that all involved organisations identify the *need* to create a common knowledge base for collective action and are willing to share actual (non-processed) information and even own assessments on the situation among each other (Comfort 2007), p. 191). This lack in identifying a joint need remains a major challenge for transboundary crisis management. If this need for collaboration is however acknowleged, its exact meaning does not easily generate consensus among the organisations. While some define it as information sharing, others understand a form of control. Consequently, it needs to be defined, which activities collaboration should encompass (Quarantelli 1988).

From a *technical* point of view, major parts of CM are still organized via email and large efficiency gains by automating the information management tasks surrounding resource management are lost. The volume of emails exchanged during the exercises is usually very high and tracking the progress of a particular issue or request could require searching through a large number of emails (although an efforts are sometimes made to centrally record all requests and actions taken in the operations log within the disaster coordination centre which requires manual transcription of the information into a spreadsheet by the administration person). Information about the progress of a particular issue could even become unavailable when the shifts end and another person takes over (Ianella and Henricksen 2007), p. 7).

Regarding technical innovation in CM collaboration, it is still difficult to get multiple organizations to accept and adopt the same technology (Aedo, I., Díaz, P., Carroll, J. M., Convertino, G. and M. B. Rosson 2010). This is specifically true since CM systems are often developed to address crisis management functions within one organization. They are thus not interoperable among multiple organizations (Fischer et al. 2016) These standalone systems, addressing only a part or parts of the crisis and usable by some but not all responders, limit the ability to exploit fully the efficiencies of crisis management as a whole (Dilmaghani and R. R. Rao 2008). For the mentioned reasons, responders often bring various technical resources and diverse data and information formats to a crisis situation that have never before been applied together (Day et al. 2009).

Furthermore, if crisis responders are not accustomed to a new technology intended for crisis response communication they may not use it, opting instead to stick to more familiar technology they already use. This is specifically true since many systems were developed to address crisis problems without adapting usability specifically to the user group of responders (Lee et al. 2011; Manoj and A. H. Baker 2007)(van de Walle and Turoff

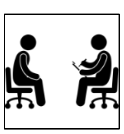
2008). In addition to this, crisis responders frequently collect data on paper and not for electronic processing because they do not see the value of the technology (Day et al. 2009).

Organisational aspects of barriers to effective shared situational awareness (MacFarlane, R. and M. Leigh 2014), p. 25):

1. concepts are not commonly understood
2. terminology is not commonly understood
3. baseline conditions or denominators are not commonly understood
4. graphical representations (e.g. signs and symbols) are not commonly understood
5. assumptions which are valid within teams are made about other teams and then go unchallenged, or even unacknowledged
6. operating procedures and objectives of one team are not understood by others
7. information required by one team is not shared by others
8. expertise held by one team is not made available to the collective effort

Additionally, the lack of established contacts between involved organisations that would increase the likelihood for formal and informal communication (Kapucu 2006) hampers transboundary CM. If collaborations has been initiated, a lack of continuity in collaboration due to the infrequency of event is also a challenge in decision making (Danielsson and Ohlsson 1999), p. 94 f). "Physical resources for most disasters do not come together until the disaster occurs" ((van de Walle and M. Turoff 2007), p. 312). In this respect, virtual organisations using the same command and control software together with the development of collaboration continuity (training) are suggested to overcome this challenge.

From an organisational point of view, also the emphasis on the presence of a plan as a document rather than an emphasis on the planning process (Perry and Lindell 2003), p. 336) lead to overlooking inter-linkages with other organisation and collaboration needs. This again causes an asymmetry in information processes, difficulties in building in feedback from the ground, but also to the impossibility of correcting mistakes and allocating resources in an efficient way. During Hurricane Katrina, information was disseminated in an asynchronous way which led to participating groups receiving information at different times (Comfort 2007). Pre-designated and pre-organised command and control centres which build the basis for centrally managing the mobilisation and deployment of resources in crisis situation have improved and professionalised in recent years (Mignone, JR. and Davidson 2003), (Militello et al. 2007). It remains however open in how far they are interconnected and can collaborate in a transboundary crisis (Ansell et al. 2010).



While the main barriers in organisational collaboration in emergency management are 'Silo' thinking, organisational factors as well as a lack of willingness and time, technological aspects were mentioned by not even 20% (IDIRA Project 2013), figure 6). At the same time, technologies were identified as major support where collaborative structure have already been established since information is at the moment shared orally which leads to time lags and problems retrieving information (RHO, PSNI, HSE South). Additionally, established collaboration structures are only efficient of they are known to the staff and the contact persons are known. Consequently, training is crucial and new details after a change of staff need to be communicated. Frequently the established collaboration frameworks are not legally binding. Potentially their impact could even be improved if they would become more binding (HSE South).

At the same time, the technological solutions facilitating the exchange of data and information raise legislative aspects of data protection. While of course, data protection legislation has to be respected, regulations are particularly rigid in some countries and require for high administrative efforts which can conflict with urgent requirements in crisis situations (CNVVF, DHPol). At the same time, emergency management organisations tend to be reluctant to arrange for data sharing procedures in peace time and the operational field is reluctant to make use of innovative technologies if they are not reliable (CNVVF). Specific attention needs to be given to the protection of patient information (HSE South).

With respect to training, transboundary aspects are sometimes only considered in regions which have already made experiences and had to face challenges stemming from the transboundary nature of the emergency. This leads also to a regional diversity in transboundary preparedness (CNVVF).

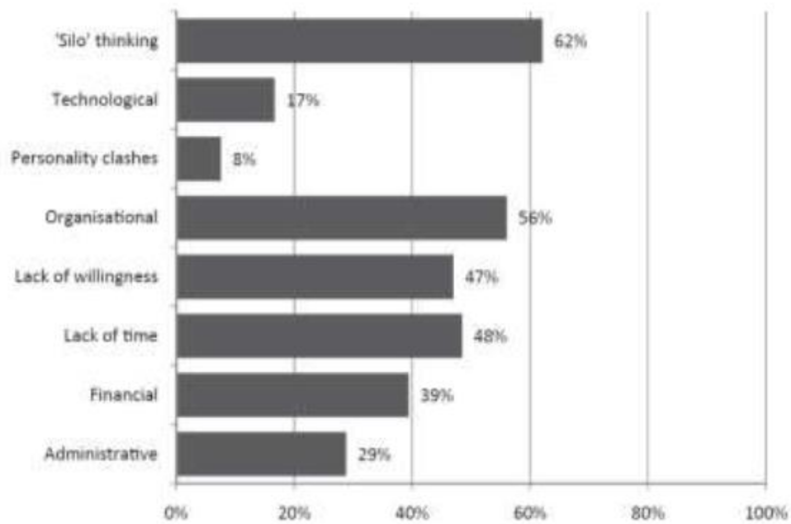
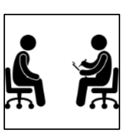


Figure 10: Main Barriers to Organisational Interaction in Emergency Management (IDIRA Project 2013)

Regarding the above suggested adaptation of decision making structures in transboundary crisis situations, traditional public bureaucracies can hardly facilitate highly dynamic responses since they were designed to routine problems emerging in known ways (Wilson 1989). With respect to the crisis management capacities available at European Union level, a lack of competencies hampers supranational activities. While the EU has constantly gained competencies, civil protection remains characterised by the dominance of the Member States. In other words, the EU is lacking own resources and depends on the support of Member States and their willingness to make resources available. These inputs and efforts by the Member States are coordinated by the Council and the Commission. However, crisis management capacities remain distributed across a network. Typically, mechanisms aiming at strengthening the ties between them would focus on the compatibility, i.e. establishing communication across institutional boundaries, creating coordinating bodies, organising exercises and building trust (Boin et al. 2014b) p. 423).



With respect to the EU, the exit of Great Britain from the EU (Brexit) leaves specifically Ireland with concerns about its impact on crisis management and the sharing of information across borders (HSE South).

Finally, political infighting can hamper crisis management, i.e. inter-organisational competition and disagreement have been reported by experts (Rosenthal et al. 1991). Specifically when new CM tasks have to be performed, questions about authority arise (Quarantelli 1988).

Summary: Co-ordination with other actors	
General aspects	Information sharing and co-ordination with a range of different organisations in major crisis situations is a major challenge, requiring a lot of communication, which is a challenge in itself.
Procedural Review and Analysis of Supporting Tools	Technologies have been developed for joint situation assessment (e.g. map repositories) and GIS-based joint control rooms are available. While standards for communication have been developed, technologies are hardly applied. The Dutch LCMS information management and sharing platform is an outstanding best practice example in this regard.
Best practice	The LCMS system used by the Dutch response organisations gathers information on the emergency site as well as information on the action taken by the individual organisations. Procedural challenges of trans-organisational collaboration have been addressed in several nation states through the development of frameworks (for example Ireland or the UK). Central information hubs are used to co-ordinate information. They are either own administrative units (e.g. municipality) or centres established jointly by the multiple organisations.
Failure factors	In practice, technologies that could facilitate the exchange of information are hardly employed. Instead, information is frequently shared orally which leads to time lags and problems retrieving information. In some countries, data protection legislation hinders the exchange of information. Volunteer organisation/non-state actors/grass-root efforts are not necessarily part of the established co-ordination efforts.
Recommendations	The establishment of electronic and trans-organisational information sharing platforms that allow for the communication of details about the operational picture as well as actions taken can contribute to an efficient management of transboundary crisis. They do not only allow for the efficient sharing of information and thus for the avoidance of time-lags but contributes to a better understanding of the crisis and thus a more adequate selection of measures and resources. A basis for trans-organisational collaboration and its structuring can build frameworks as established for example in the UK (JESIP) or Ireland (Framework for Major Emergency Management).

Table 8: Summary "Co-ordination with other actors"

3.4 Supply of basic services to enable CM and logistics

3.4.1 General aspects

General challenges that characterise this management task are the loss of critical infrastructure which can leave responders without electricity, water, telecommunication and other important basic infrastructure services. These issues have different aspects: **technical**, in the sense that special equipment is needed; **organizational**, relating to the need for special planning and preparedness activities; and **logistical**, since equipment and personnel needs to be deployed to the affected area. It is important to note that the subtasks do have interlinkages, for example communication of first responders can also be tied to the provision of power. Many of the respective experiences and insights stem however from the context of humanitarian operations since examples from the European Union are few and poorly documented.

Communications:

The breakdown of essential communications is one of the most widely shared characteristics of all disasters. Whether partial or complete , the failure of the telecommunications infrastructure leads to preventable loss of life and damage to property, by causing delays and errors in emergency response and disaster relief efforts (Stolk et al. 2012). The US department of Homeland Security concedes that there is still **no simple solution** to solve the communications problems that challenge law enforcement, firefighting, rescue, and emergency medical personnel. At the moment they recommend implementing an **integrated communications and information system** for disaster management with a multi-level wireless voice and data communications infrastructure, as well as integrated applications that reflect the currently selected organizational structure adequate to the rescue effort. This might include land mobile trunked radio networks, satellite technology for wide area communications, wireless LAN networks for disaster hot spots, and body area networks for frontline personnel – allowing them to collect data using robust mobile terminals and sensors -as well as flexible information workflow applications that can be quickly adapted to modifications to the organizational structure due to disaster situation changes (tait communications 2012).

Energy supply:

There are many reported cases of natural disasters causing power losses. Almost without exception, such situations will typically involve **multiple interrelated hazards** that occur either simultaneously or in a cascading fashion, with serious effects beyond the losses suffered directly by the utility or electric system operators. Electricity is essential to maintain the functionality of emergency services and other lifelines such as water supply, fuel supply and communications (Wenzel and Zobel)(Liu).

The **distribution systems** are the most vulnerable parts of the system. Most failures occur because of damage to this system that propagates across the network. In some cases (geological disasters) sub-stations are also damaged. Nevertheless, the growing complexity of the distribution system represents an immanent exposure to natural disasters (Wenzel and Zobel).

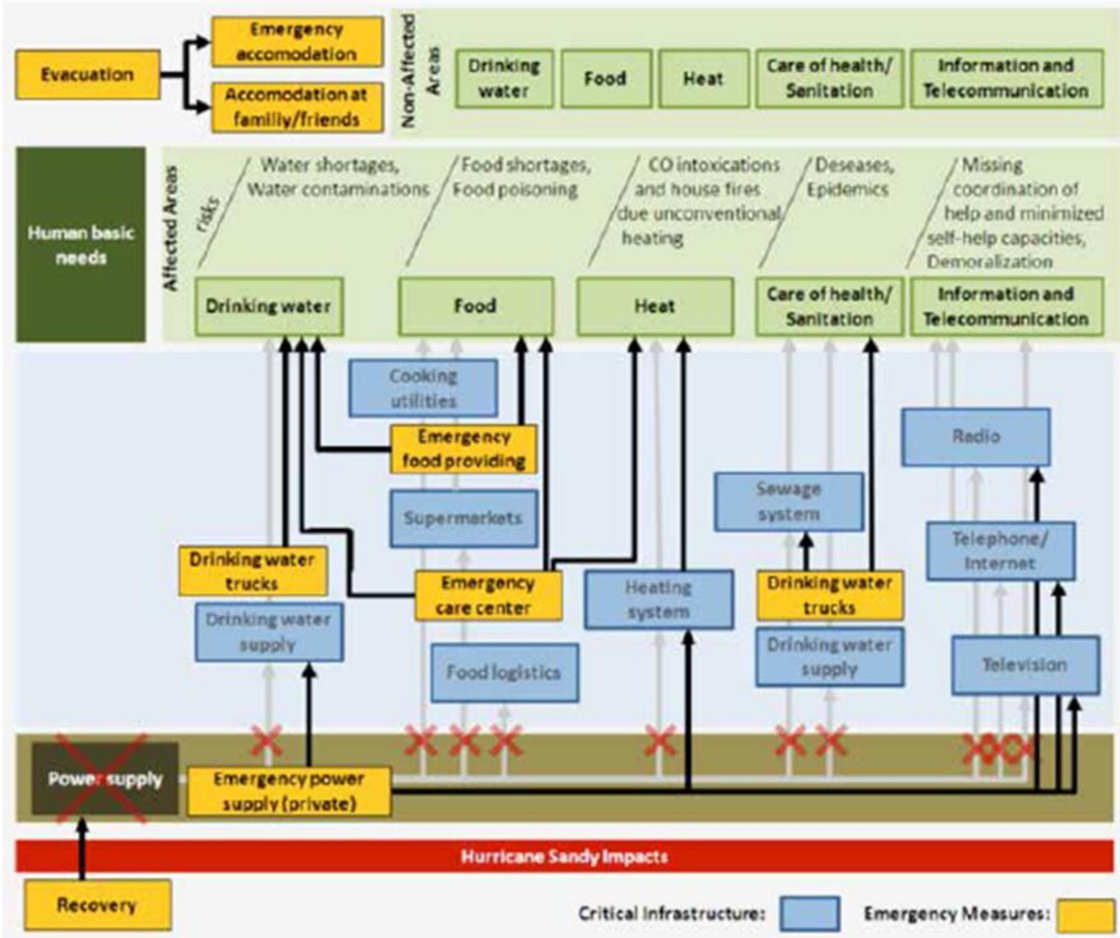


Figure 11: Main effects of extended power outages for human basic needs and possible emergency measures to avoid further risks (example: hurricane Sandy) (Balthasar et al.); Source: Center for Disaster Management and Risk Reduction Technology (CEDIM)

Logistics:

Emergency logistics is understood as a "A process of planning, managing and controlling the efficient flows of relief, information, and services from the points of origin to the points of destination to meet the urgent needs of the affected people under emergency conditions" (Sheu 2007b).

In short, all logistics operations have to be designed in such a way that they get the right goods from the right place and distribute them to the right people at the right time. The **critical components of logistics** include medical supply, communications, facilities and security (Figure 12).

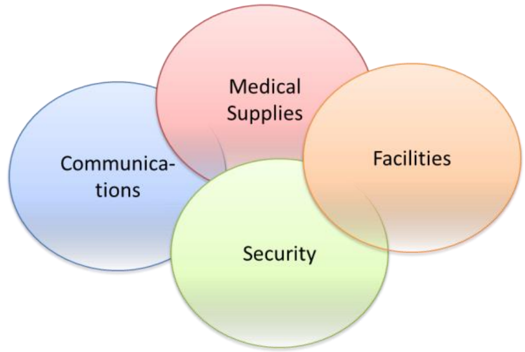


Figure 12: Logistic components (CHALIAMALIAS 2012)

In emergency relief operations, logistics are required to support the organization and implementation of response operations in order to ensure their **timeliness and efficiency**. Mobilizing the staff, equipment and goods of humanitarian assistance organizations, the evacuation of the injured or the resettlement of those directly affected by the disaster, requires a logistics system to maximize effectiveness (Sheu 2007a).

The **key challenges to emergency logistics planning** as compared to the business logistics case are highlighted in Balcik and Beamon (Balcik and Beamon 2008) and Sheu (Sheu 2007b) as:

1. *Additional uncertainties* (unusable routes, safety issues, changing facility capacities, demand uncertainties);
2. *Complex communication and coordination* (damage to communication lines, involvement of many third parties, government, and civilians, inaccessibility to accurate real-time demand information);
3. *Harder-to-achieve efficient and timely delivery*; and
4. *Limited resources* often overwhelmed by the scale of the situation (supply, people, transportation capacity, fuel).

Water & Sanitation:

Water supply and sanitation are amongst the first considerations in disaster response. The greatest water-borne risk to health in most emergencies is the **transmission of faecal pathogens**, due to inadequate sanitation, hygiene and protection of water sources. However, some disasters, including those involving damage to chemical and nuclear industrial installations, or involving volcanic activity, may create acute problems from **chemical or radiological water pollution**. Sanitation includes safe excreta disposal, drainage of wastewater and rainwater, solid waste disposal and vector control (Hlavinek op. 2009).

However, many major multi-sectoral humanitarian agencies have developed **considerable capacity to execute emergency water and sanitation projects**. International NGOs such as Oxfam, ACF, MSF, and IRC are recognised as the more prominent and experienced agencies in the sector. For example, the IFRC takes the lead in natural disasters and have particular expertise in the quick deployment of Emergency Response Units (ERUs), which consist of pre-trained teams of specialists and pre-packed sets of standardised watsan equipment ready for immediate use (European Commission - DG for Humanitarian Aid - DG ECHO 2005).

So far, in other EU research projects (Stolk et al. 2012) no specific gaps or improvement needs have been identified with respect to watsan (Water, sanitation and hygiene).

3.4.2 Procedural Review and Analysis of Supporting Tools

3.4.2.1 Communication[20] of first responders (in remote areas)

SATCOM is a key capability for crisis management, whether inside or outside the EU as, for example, in the case of exceptional natural disasters, technological man-made accidents and other disasters like terrorist attacks. In these cases terrestrial communication networks are often put out-of-service and First Responders activities consequently based primarily on satellite communications that allow actors to manage high peaks of traffic and a huge variety of data in real-time and share it with various agencies (European Commission 2016).

Commercially-available SatCom options, such as the **Broadband Global Area Network (BGAN)** or **Very Small Aperture Terminal (VSAT),** can be rapidly deployed to provide connectivity to support a range of needs, from a single user accessing e-mail to a small command centre. The unique capabilities of satellites are well suited to fill certain gaps in communications during disaster response (Massachusetts Institute of Technology 2013).

Athena-Fidus is a French-Italian project, which addresses the needs of a resilient and reliable communication anywhere and at any time is with very high rates of data transmission (around 3 Gbits/s). It will use cutting-edge civilian technologies for broadband internet access (European Commission 2016).

The **Multi-hop Ethernet data radio system** (Surecross DX80ER2M-H) provides extremely reliable communication in large plants, over long distances, or through difficult terrain. A network of such systems can easily cover many square miles and has a raw bit rate of 300Kbps (Banner 2018). This system is part of the IN-PREP platform.

The layers and operational model recognizes three layers for disaster recovery communications: (Devasirvatham 2011)

1. **Space Layer**: Quickly covers large areas with SATCOM
   - Goal: Strategic communications/management/situational awareness (Low capacity portable terminals. Some tactical voice & data comms)
2. Add **Airborne Layer** to increase recovery information flow
   - Goal: Continue to expand spectrally efficient data communications (Allows common access network terminals such as mobile radios to function at limited capacity to enable significant tactical communications)
3. Begin traditional **Terrestrial Layer** communications recovery
   - Goal: Gradually bring up ground infrastructure supported tactical comms

Airborne communication networks have been studied during the last years for the provision of wireless communication services and it is a promising candidate for rapidly deployable and resilient emergency networks. However, the choice of communication technologies from Aerial platforms is a challenging issue and depends on a variety of factors including platform payload capacity, coverage and capacity requirements, to name a few (Gomez et al. 2013).

Temporary mobile cell towers are another provisory solutions to uphold emergency communications (McEntire 2002, p. 375; Kapucu at al. 2010, p. 239).

A Japanese consortium has been experimenting with what they call a "**Movable and Deployable Resource Unit**" (MDRU), which can be transported to a disaster area and set up to provide network services. This system, mounted

[20] This chapter analyses communication from a technical point of view, e.g. the (technical) solution allowing to people to speak to each other. The act of "communicating" is not addressed here.

for example in a regular van, is self-reliant and does not need any existing infrastructure to function (Sakano et al. 2016).

Another proposal uses peer-to-peer communication, or **decentralised communication networks**. Should enough communication nodes exist, such networks would be a lot more resilient. Within an urban context, wireless routers could provide such a network. Panitzek et al. (2012: 110f.) discuss the possibility of an "emergency switch" for routers, which would then enable emergency services to access routers and use them for communication. However, this brings up questions of data protection and privacy should these routers be privately owned.

Project Loon is a research and development project being developed by X (formerly Google X) with the mission of providing Internet access to rural and remote areas. The project uses high-altitude balloons placed in the stratosphere at an altitude of about 18 km to create an aerial wireless network with up to 4G-LTE speeds (Levy 2013). This project was also acknowledged for the potential of utilizing Loon for disaster recovery (Smith-Spark 2013).

3.4.2.2 Energy supply

Usually, **mobile power/diesel generators** are deployed. Obviously, this requires sufficient amounts of fuel to be available. Therefore, the availability of fuel supplies is a constant anxiety to those in remote areas who rely on fossil-fuel-powered generators in crisis situations. **Renewables energies** eliminate this worry and also work without producing overbearing noise that accompanies gasoline and diesel generators (Stolk et al. 2012).

Two types of renewable energy systems are generally used for meeting the energy requirements of disaster management: fixed and portable systems. Fixed systems tap the renewable resource most appropriate for specific locations, which might be solar, wind, hydro or biomass. For portable systems **solar electricity** is the most appropriate renewable energy source. PV cells convert solar energy into direct current (DC) electricity. However, portable systems are best suited for meeting smaller-scale needs (Stolk et al. 2012).

Energy consumption by the organizations on the ground, e.g. through field hospitals, water pumps etc., has to be **closely monitored** according to available energy budget. Energy can be provided by the power grid, if still functional, or mobile generators (Mendonca 2007, p. 960).

3.4.2.3 Logistics

There is an ever increasing amount of research dedicated to supply chain management and logistics in humanitarian and disaster contexts. Kovács and Spens define **relief supply chain management** as "the planning and management of all activities related to material, information and financial flows in disaster relief" (Kovács and Spens 2012: xxii). There is a distinction between relief supply chain management and humanitarian logistics, with the later encompassing aspects of development aid (Kovács and Spens 2012: 21–22)[21]. While the IN-PREP platform will mainly rely on relief supply chain management, this paper will draw conclusions from experiences in the field of humanitarian logistics as well.

One key aspect which has been highlighted is the benefit of cooperation: **reducing redundancies, duplication and competition** can have a significant positive impact on the overall effectiveness of humanitarian logistics. However, such cooperation poses a real coordination challenge to all organizations involved (Tatham et al. 2017: 77f.). This coordination challenge has also been identified as one of the main research gaps in the field of humanitarian logistics (Jabbour et al. 2017: 15).

[21] Synonyms for relief supply chain management include humanitarian supply chain, humanitarian supply chain management; synonyms for humanitarian logistics include emergency relief logistics, relief logistics, disaster relief logistics, humanitarian operation and catastrophe logistics.

In the immediate aftermath of a crisis event, resources from local first responders will be used, if still possible. External resources must first be mobilised. Additional resources must, upon arrival, be integrated into a functioning organisation on the ground. These new capabilities and capacities are likely to be beyond those of the first responders. Mobilisation of additional resources must be based on accurate needs assessment to ensure easier integration (Harrald 2006, pp. 260ff). Furthermore, **mobilising resources**, both internally and externally, requires a staging area and warehouses spacious enough to accommodate all incoming personnel and material (McEntire 2002, p. 372).

From a technical point of view, there are three main components to humanitarian logistics which need to be covered: **Geographic Information Systems (GIS), resource tracking and management, and mathematic models to support decision making** (Özdamar and Ertem 2015: 62).

GIS can rely on satellite imaging, allowing supply chain managers help their logistical planning. Services like European Remote Sensing satellites (ERS), Radarsat, ENVISAT, or the Advanced Land Observing Satellite (ALOS)the German TerraSAR-X System and the Italian Cosmo-Skymed are examples of radar imaginary that can be used to assess post-event damages to infrastructure, allowing supply chain managers to react to blocked roads and others obstacles (Voigt et al. 2007: 1522).

The limited time and availability of personnel and vehicle require for an optimal use of both to ensure timely delivery of resources. A crisis management system should thus involve a transportation module to help crisis managers to quickly solve logistical problems. The creation of lists of available resources and warehouses should be arranged during the preparedness phase (Özdamar and Ertem 2015: 56).

Warehouse and inventory management can be supported by the use of Radio Frequency Identification (RFID) sensors (Özdamar and Ertem 2015: 63).

Some scholars have been using **special applications** of e.g. the traveling salesman problem[22] or the vehicle routing problem[23]. This has resulted in different software applications and algorithms which can be used to quickly create logistic plans during crises. Examples are Transportation Problem in Disaster Response Operations (TP-DRO) (Berkoune et al. 2012), Stochastic/Robust Model for Logistics Management (SRMLM) or Solution Methodology of the Structured Robust Model (SMSRM) (Najafi et al. 2013). Also, software such as GAMS or CPLEX 12.1 might be used to simulate logistics models.

According to Tatham et al. (2017: 81f.), humanitarian actors need to be provided a means which shows them information on the **(near) real-time supply and demand situation** as seen by the individual actors and at a cumulative level, which the authors coin "humanitarian common logistic operating picture (H-CLOP)". Such systems are already successfully in use in different militaries, allowing for better informed supply chain decision making. Such a system should include a variety of information, e.g. on type, volume, and location of relief goods required and available, destination and time frame for delivery, availability and mode of transport to and within affected area, and warehouse availability and usage (Tatham et al. 2017: 89).

[22] The travelling salesman problem (TSP) asks the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?" It is an NP-hard problem in combinatorial optimization, important in operations research and theoretical computer science. Wikipedia (2017a)

[23] The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem which asks "What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?". It generalizes the travelling salesman problem (TSP). Wikipedia (2017b)

One attempt to implement such a H-CLOP is the **HELIOS IT-system**, developed by the members of the Consortium of British Humanitarian Agencies, (Tatham et al. 2017: 86). Some other systems used in humanitarian logistics are SUMA, LSS, LogistiX, Sahana, Disaster Management Information System (DMIS, in use exclusively by the International Federation of Red Cross and Red Crescent (IFRC)), FleetWave (used by IFRC and World Food Programme), Aidmatrix Network for Humanitarian Relief and Humanitarian Free and Open Source System (HFOSS) (Özdamar and Ertem 2015: 61–63). Maps and GIS for humanitarian logistics can be accessed through, for example, the Global Disaster Alert and Coordination System (GDACS), Map Action and Humanitarian OpenStreetMap. Some systems, like DMIS, integrate GIS and logistical tools (Özdamar and Ertem 2015: 61f.).

ENGAGE is an incident management, computer aided dispatch and automatic resource location system for public and private safety organizations. The Operational Resource Module (ORM) provides the capability to register, plan, allocate and assign resources (personnel, vehicles, air assets, or maritime resources) to specific incidents. Inheriting all Autotrack capabilities it monitors resources, such as vehicles, vessels, aircrafts and personnel by offering seamless integration with multiple tracking technologies (AVL, AIS, LRIT etc.) over multiple communication bearers (3G/4G, TETRA, VHF etc) (satways 2017). ENGAGE is also part of the IN-PREP platform.

TARONA is an RFID based application for the end-to-end tracing of logistics flows and is also part of the IN-PREP platform. (INPREP 2018)

3.4.3 Success factors: best practice

Generally speaking, logistics and their planning and the provision do not play a particular role for many crisis management organisations. This is true, since **frequently basic services such as radio networks or generators are available**. In the majority of the CM organisations work, respective resources are also not stressed. In case that the "own" resources are stressed, support can usually be granted from the next higher level or related organisations and entities such as the local authority (e.g. HSE South). For certain resources which are only randomly needed such as very heavy vehicles for forest fires, also service contracts with private companies exist (RHO).

Overall, the **challenge is to prioritise resources** in major crisis situations and to match capabilities, capacities and needs. Because this is a key challenge, PSNI has reduced their planning efforts to a generic version and addresses disaster specific shortfalls in resources by a specific asset registry. It aims at having a clear picture of specialist police resources available across the country and the most effective processes in place to enable them.

Commissioned by the Home Office and led by Association of Chief Police Officers (ACPO), NPoCC replaced the Police National Information Centre (PNICC) and was created with a wider remit to ensure policing is better prepared for wide scale disorder like the riots of 2011. NPoCC supports police forces in responding to large scale operational challenges by facilitating requests for 'mutual aid' assistance from other forces. It played a part in 73 incidents in its first year - moving 12,000 police officers around the country to assist colleagues in meeting the challenges posed by major incidents or events (NPCC 2014).

3.4.3.1 Communication of first responders

To avoid a lack of inter-agency communication in a crisis event, research suggests prior exercises and common planning processes. Any interaction of actors before a crisis takes place creates formal and informal communication channels which can be used during a crisis (Ansell et al. 2010: 199).

A functioning GIS, also helpful for logistics, can help with communication and coordination of first responders. The GIS in use in New York City for notifications on storms and weather emergencies proved flexible enough to be successfully used in the aftermath of the **9/11 attacks**, allowing the sharing of information and helped support the rescue and clean-up activities (Comfort and Kapucu 2006: 321).

When **Hurricane Katrina** hit New Orleans, the emergency communications systems were completely destroyed, including power stations, internet servers, mobile phone towers, and 911 services. The Federal relief workers' satellite phones weren't interoperable, even when they did work (Miller). Amateur radio was instrumental in the rescue process and maintained signals when 911 communications were damaged or overloaded (Krakow 2005).

In practice, the **tracking of staff and resources** such as vehicles ease not only the allocation of information received but also further planning. Respective GPS sensors are used for example the Police Service Northern Ireland (PSNI).

3.4.3.2 Energy supply

The **9/11 attacks in New York City** led to a partial shut-down of the electricity network, leaving about 13 000 customers without power. Trailer-mounted and diesel-fuelled generators were obtained to provide critical customers, e.g. emergency services, with power. To facilitate this, the power company organised a special group tasked with procuring generators and fuel, selecting the locations, organizing transport, setting up the generators, as well as running and managing them until the buildings could be re-connected to the power grid. This was by and large successful, mainly due to the organizational capability and flexibility of the power company to quickly respond to the situation, successful inter-agency cooperation and coordination to gain necessary permits and facilitate transportation, and the availability of both generators and fuel (Mendonça and Wallace 2015: 86f.).

Severe icing caused a big power disturbance in **Slovenia in February 2014**. Damage occurred to overhead transmission lines, overhead distribution lines, and LV lines for a total length of more than 1 000 km. About 5 000 x 20/0.4kV substations were affected. Over 250 000 people were without electrical power, and some were left completely without electricity for over 10 days. In total, over 100 diesel generators up to 1MVA were used to generate electricity. At the peak, over 1 500 workers were working together to re-establish the supply of electric power to at least the cities and bigger settlements. For some important HV overhead lines, modular Emergency Restoration Structures (ERS) were used temporarily to bring electricity to transformer stations. ERS is a quick way of temporarily replacing damaged lines after natural hazards strike. Applying the ERS approach creates a number of challenges and issues, that need to addressed to ensure an effective response and crisis management, for example: (Kersnik 2016)

- Timely activation of maintenance personnel; effective management of staff
- providing sufficient numbers of specialists for implementation
- Public response
- Availability and satisfactory condition of work equipment, including personal safety equipment and materials
- Transportation and logistics
- Functioning communication systems (FM, GSM)
- Keeping records of the works, material consumption, and final remediation of defects
- Keeping records of aggregates, fuel consumption, and consumers connected on aggregates

In mid-May 2014 continuous, heavy rainfall resulted in extensive **flooding in Serbia, Bosnia and Herzegovina**, and Croatia. The floods caused landslides and devastation of overhead and underground infrastructure, transformer stations, customer connections, and metering equipment. The floods affected millions and resulted in 80 casualties. Power supply to more than 250 000 customers was interrupted. Developing a comprehensive restoration plan which takes full account of access to affected areas, priority connections and pace of restoration of consumption sites and facilities was identified to be vital (Mumovic 2016).

The magnitude 9.0 **Japan's Tohoku Earthquake** in March 2011 rattled the large parts of Japan and some part of east China and Russia with 30 km depth of the hypocentre. This earthquake caused a 130 km long by 159 km wide rupture zone on the pacific plate subduction zone and followed by a huge tsunami with more than 40 meter waves (Zaré und Afrouz 2012). Zaré and Afrouz deduced that energy issues and management of power plant's crisis was a blind spot in Tohoku disaster management. On the other hand they concluded that Japanese social ethics and their manner in dealing with the problem were the most advantageous points. Discipline, maintaining calm, public confidence in managers and scientific management based on the plans helped to improve the situation more quickly (Zaré und Afrouz 2012).

Liu et. al. have demonstrated that in the case of the **earthquakes in China in 2008 and 2017** the following four properties are crucial for the disaster resilience of the electricity network: robustness (ability to withstand a shock), redundancy (functional diversity), resourcefulness (ability to mobilize when threatened), and rapidity (ability to contain losses and recover in a timely manner) (Liu).

Frequently, the vehicles of first responders are equipped with generators. In many cases, they are needed for the operation of own tools and equipment (e.g. CNVVF).

Fire fighters are autonomous. They have power generators on trucks in different sizes and types and different tools are available that work with engines. They only need fuel to operate the generators but also own tanks are maintained. They can use this to fulfil their tasks. **Supplying the population is however a different task which is normally implemented by power providers**[24]. These companies are however slower (although also having their own emergency plans). Usually they have their own priorities in re-establishing infrastructure but fire fighters can give them a notification for priorities. This works usually via the command and control centre which is notified from the field (CNVVF).

3.4.3.3 Logistics

Since resources and personnel need to be deployed rapidly in the event of a crisis, normal logistical procedures are often impractical. Fast track procedures, specifically designed to rapidly deploy necessary assets, can help (Ansell et al. 2010: 202).

After the **tsunami in the Indian Ocean**, different system producing medium [Landsat-7 Enhanced Thematic Mapper (ETM), SPOT, disaster monitoring constellation (DMC)] and very high-resolution imageries (IKONOS, Quickbird) were used to assess the damage. This allowed crisis managers to provide vital information to local logistic teams. Other examples were such technology was successfully used are the **Portugese wildfires** in 2005, the 2005 **earthquake in Kashmir** and the 2005 **landslide in the Philippines** (Voigt et al. 2007: 1523–1527).

The IFRC is using DMIS to coordinate its crisis response within the organization. Together with the UN's Virtual On-Site Operations Coordination Centre (VOSOCC), popular among International Search and Rescue Advisory Group, this allows the IFRC to track the response phase thoroughly (Vinck 2013: 122–124).

Sometimes, professional crisis responders do not possess what Mason et al. (Mason et al. 2017) term local knowledge. In the aftermath of a **tornado in Joplin**, the local fire department couldn't acquire cots from professional organizations to set up a shelter, so they used their own local networks to get all the necessary equipment. This

[24] However, firemen have their own larger power generators which are sometimes tasked to fast supply energy to hospitals etc.

flexibility and use of local knowledge can complement bigger logistical plans, which by nature of the topic cannot account for every eventuality of a crisis event.

HSE has a services, public procurement and logistics specialist within each division which would contact the Head of Logistics if required. If the own resources are exhausted, local authorities can be contacted. A data base of key inventory is available at the logistics department. The logistics department will deploy the necessary equipment. Logistics will be coordinated with local authorities which also use the "Framework for Major Emergency Management" and are present in the joint emergency management room (HSE South).

The procedures for sharing resources with other organisations are established by the Joint Doctrine (JESIP) (Joint Emergency Services Interoperability Programme 2013) (PSNI).

In the Netherlands, a representative from the fire brigade has a laptop with an inventory list on basic services, capacities and logistics (which can however not be shared). Additionally, the National Manual on Decision-making in Crisis Situations was developed. Based on this manual and a data base of all equipment of the crisis management organisations, the National Operational Coordination Centre (LOCC) can offer additional resources to security regions when there is a scarcity of resources. The LOCC has databases of al logistical information of our partners (for example police, defence). The fire brigade is now filling this database on a national base. They are also working on the sharing point (SRIJ).

CPO Rhodes is responsible for the coordination of equipment and resources. During an emergency, it asks all emergency management organisations about their available resources and organises their deployment in collaboration with them and the prefecture. All resources that will be quickly needed in an emergency are/have to be on the island. It is either government equipment or private equipment (for example bulldozers and platforms to carry them) which will be rented in case of an emergency (RHO).

In Germany, PC based check lists and inventory lists in combination with instructions for action are used (DHPol).

3.4.4 Failure factors

On the day of the 7 July 2005 **London bombings**, mobile phone networks, including Vodafone, reached full capacity and were overloaded by 10:00 a.m., only an hour and ten minutes after the bombs went off (History of London 2011). Because of an antiquated radio system, the damaged trains were unable to communicate with the Transport for London control centre or emergency personnel (McCue 2006). In the aftermath, the London Assembly determined the need for a digital radio communications system in London that can operate underground (London Assembly 2007).

Fritz Institute has observed that logistics planning during the 2004 **Indian Ocean tsunami** was conducted manually without the presence of logistics experts. Also the 2010 **Haiti earthquake** provides an excellent example of this lack of expert planning. In January 2010, after the first seismic shocks in Haiti, various on-field journalists reported that relief efforts were stalling in the logistics web and that, therefore, much aid remained undelivered (Caunhye et al. 2012).

Summary: Supply of basic services to enable CM and logistics	
General aspects	General challenges that characterise this management task are the loss of critical infrastructure which can leave responders without • electricity (here the distribution systems are the most vulnerable parts), • water supply and sanitation (but many humanitarian agencies have developed considerable capacity in the watsan area), • telecommunication (the breakdown of communication is one of the most widely shared characteristics of all disasters), • other important basic infrastructure services. Another important factor is the planning of emergency logistics: mobilizing the staff, equipment and goods as well as the evacuation.
Procedural Review and Analysis of Supporting Tools	In general there are three layers of disaster recovery communications: • space layer (SATCOM) • airborne layer (e.g. mobile radios) • terrestrial layer (gradually bringing up ground infrastructure)
Best practice	Usually basic services such as radio networks or generators are available. A functioning GIS (for tracking staff and resources) and a digital radio communication system are helpful for first responders. The different communication modules should be interoperable. Modular emergency restoration structures (ERS) are helpful to set up the power network. The resilience of the electricity network depends on its robustness, redundancy, resourcefulness and rapidity (recover in a timely manner). A restoration plan should be developed before a crisis occurs. Logistics experts should be consulted for the planning of emergency logistics.
Failure factors	The mobile phone network is likely to be overloaded shortly after the incident. It is a challenge to prioritize resources in major crisis situations. In an emergency normal logistic procedures are often impractical – logistical experts are needed.
Recommendations	One of the typical challenges in big disasters is the breakdown of telecommunication infrastructure, a breakdown of the electricity network as well as the logistics planning and prioritisation.

	However, the end-user dispose of several solutions in the area of communication (e.g radio networks, GPS sensors), electricity (generators) and logistics (e.g. databases, implemented procedures), so that the pressure to innovate is not very high.

Table 9: Summary of "Supply of basic services to enable crisis management and logistics".

3.5 Communication with the public

3.5.1 General aspects

It is a myth that the public would panic when confronted with crisis information that cannot be supported by research. This argument has been used for not communicating with the public in the past (Kathleen Tierney 2003). New research focuses on the way how to successfully communicate with the public and what technologies to use for it. A lot of new studies take a closer look at ICT-technologies like smart devices, crowd-sourcing or social media and their efficient usage in the context of an emergency.

Communication with the public is highly relevant in crisis response and can be supported by different **technologies**. Radio, television, newspapers, wallpaper, Facebook, twitter and other channels can be employed to transmit critically valuable information to as many people as possible. The Internet can speed up communication and awareness, beyond that of the traditional risk and crisis communication strategy, because it allows real time communication (Radisch et al. 2013).

Most crisis and disasters pose common response challenges. At an operational/tactical level practitioners and operations manager are faced with a cluster of different challenges. One of them is the **informing and empowering**: transmitting accurate and timely information amongst others to relevant citizens and communities, so that these are enabled to make informed crisis response decisions. It is also necessary to make sure that these different units and actors work together effectively, so **coordination and collaboration** is another challenge in crisis response (Boin and 't Hart 2010). In this respect, it has to be differentiated between a press conference and a statement. While for a conference, sufficient information should be available to answer the journalists' questions, the statement allows for informing the public in case that not much information is at hand (SRIJ).

One problem for example is that the communication with the public is often incoherent or doesn't reach target audience or doesn't help the organisation with its task. Consequently, communication strategies should be designed. **Coordinated dissemination** of information reduces confusion, can help steer the population and reduce fear (Comfort 2007; Seeger 2006).

It is also important to create an **effective two-way communication** (Drury and Cocking 2007). In the past, the population was frequently regarded as passive actor to be evacuated and sheltered. Its active contribution to disaster risk management can however actually be an asset. It has to be actively addressed, if it should not turn into a risk, e.g. by remaining exposed to the disaster or by hindering the crisis management efforts (Seeger 2006).

Instead the public should be considered as an equal partner, who has the right to be informed about existent risks and it should be educated about risk assessment management and mitigation efforts to which it might even contribute. In other words, a **dialogic approach** might contribute the public becoming a resource rather than a burden (Seeger 2006).

Another challenge that authorities face in a crisis is providing **correct, clear and actionable information** right away. This requires a major public relations effort (Ansell et al. 2010). It is a challenge for crisis managers to produce one clear and coherent message that provides people with relevant information and relieves the collective stress (Ansell et al. 2010)

Experts and politicians are often accused of not being **transparent** enough, especially in times of crisis. The internet can be used to communicate hard facts in a timely manner, so that the rational for decisions can be shared with a large audience and be better understood (Radisch et al. 2013).

The increasing use of the internet and availability of mobile phones offers the possibility to go one step further by linking volunteers together beyond the official and traditional channels of communication. Furthermore, the monitoring of the social media through analytics can also help reduce costs of disaster, thanks to the early detection of digital smoke signals. Various tools of **crowd sourcing and participatory sensing** are being developed to enhance an early detection of crises. Research (Thaler and Sunstein 2009) has shown the potential for using mobile phones as remote sensors or for encouraging volunteers to report any abnormal situations to help decision makers take appropriate measures using this participatory sensing (Radisch et al. 2013).

3.5.2 Procedural Review and Analysis of Supporting Tools

In big destructive events, one of the main challenges for public health workers and rescuing teams is to have a **stable emergency communication system** (Huang et al. 2010)(see also chapter 3.4)

Web-based communication for example via government pages can transport authorized information from a single source. Respective pages should contain for example information like an online hospital patient-locator, missing people information, DNA collection protocols, counselling information, and death certificate applications (Kapucu 2006).

Mobile devices and their widespread ownership are obvious additions to a crisis management system. The ability to send emergency messages or be located via GPS makes them very attractive for search and rescue tasks. Mobile devices can also provide new information like eyewitness reports for first responders or they can be used to receive information that has been disseminated by command and control (Andrews 2017).

Social media offers a big potential for communication with the public during a crisis and for monitoring the citizen's concerns (Alexander 2014). Over the last years social media analysis tools have also increasingly been used in, during and after a disaster for situational awareness and to support response mechanisms (Preparecenter.org - American Red Cross 2016).

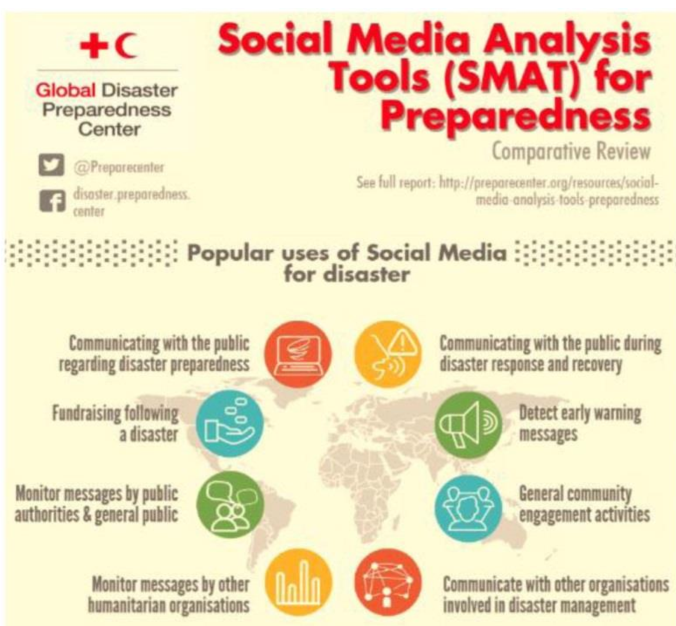


Figure 13: Infographic showing the common use of social media in disasters (Preparecenter.org - American Red Cross 2016).

Type of social media	Examples	Use for risk and crisis communication
Social networking	e.g. Facebook	Enhance coordination among volunteers and emergency services, allow to share information inside a community, provide swift update on emergency situation
Content sharing	e.g. YouTube, Flickr	Enhance situational awareness in real time through exchange of pictures and videos, allow emergency services to easily launch viral campaigns about risks, can help identify missing individuals, victims, etc.
Collaborating knowledge sharing social media	e.g. wikis, Forums, Message boards, Podcasts	Enhance dialogue between victims and emergency services
Blogging and microblogging	e.g. Twitter	Convey recommendations, warnings, share facts. Twitter allows to have immediate information sharing with a wide reach and feedback possibilities.
Specialised crisis management platforms managed by Volunteer Technology Communities (VTCs)	Mapping collaboration: • OpenStreetMap • Crisis mappers • Google map maker Online and onsite contribution: • Ushahidi • Crisis commons • Sahana foundation • Geeks without bounds Public-Private-People Partnership: • Random Hacks of Kindness (with Google, Microsoft, Yahoo, NASA, World Bank)	Mapping of emergencies, Community Emergency response team facilitator

Table 10: The different types of social media used in risk and crisis management (Radisch et al. 2013)

In the past few years there has been a very rapid growth of interest in **volunteered geographic information (VGI)** (Goodchild 2007), a version of crowd-sourcing in which members of the general public create and contribute georeferenced facts about the Earth's surface to websites where the facts are synthesized into databases (Goodchild and Li 2012). Volunteered Graphic Information (VGI) and Geotagging are also very valuable for crisis management. When the public uploads videos or photos to the internet they may have the ability to add a geotag to their post. Emergency managers can obtain a picture of the destruction occurring in an area through these posts. Through the use of internal Geographic Information Systems (GIS) or free online sources (such as Google Earth) these posts can be plotted on a map which will give a high angle view of what is occurring in the community. Many social networks, like Facebook, Twitter, and Flickr are making their services compatible with geotagging, which can most easily be accomplished when updating social media through a smart phone (Radisch et al. 2013).

Working inside **communities like Ushahidi**, volunteers have already responded to major disasters, such as earthquakes in Haiti, Chile and flooding in Pakistan. Volunteers created detailed maps, processed imagery and geo-located posts. Some have already been deployed under the United Nations Disaster Assessment and Coordination (UNDAC) (Radisch et al. 2013).

The project "Resilience Enhancement by Advanced Communication for Team Austria" had the aim to implement a prototypical **crowdtasking** workflow. It utilised new media and mobile handheld devices to support decision making. The prototype "CrowdTasker" realises the core functionality of crowdtasking: defining tasks, distributing them to selected volunteers (based on their skill and/or location) and visualising the results for crisis managers (Auferbauer et al. 2016b).

The **Sahana module** is a social media platform dedicated to emergency situation and offers the possibility to create an event to mobilise volunteers, both medically trained and not. The system sends out the deployment requests and processes the replies. Each volunteer willing to be deployed is automatically sent details on where to go and to whom to report. The general deployment volunteers report to the OEMC Incident Commander while the medical deployment is sent to the on-scene Medical Director (Radisch et al. 2013).

An example for an overall concept is the **ATHENA system**. ATHENA is a crisis communication and management system that encourages and enables the public to participate in the process of emergency communication in crisis situations and for search and rescue actions. ATHENA makes use of new social media and high tech mobile devices to acquire, analyse and disseminate crisis information and intelligence that is appropriate and useful to Law Enforcement Agencies (LEA), police, first responders and the public (Andrews et al. 2013).

3.5.3 Success factors: best practice

In general, crisis communication should be **designed in advance** since the effectiveness of crisis communication is typically reduced if implemented ad hoc after the incident. Concerns and needs of key audiences should be taken into account. It should also consider different phases of crisis communication such as educating the public about preparation in a pre-crisis phase or codifying and communicating lessons learned after the crisis (Seeger 2006).

It is also important to **use social media prior to crises** as an awareness raising strategy, as the corresponding Tweets or Facebook pages become the recognised authority for the information prior to the event (Radisch et al. 2013).

The **credibility of an organisation** has to be developed in advance. It builds the basis for trust between the population and the crisis managing organisations and is essential for successful crisis management (Coombs 1999;

Ulmer 2016). Organisations that fail to establish trust with the public will have it hard to (re-)gain after an event (Seeger 2006).

The information communicated by the crisis managing organisation should be **true and complete** in order to avoid the public obtaining it from other sources and loses trust in the crisis management organisation. Existing uncertainties and ambiguities should also be communicated to the public (Seeger 2006).

Since social media has become one of the most important sources of information for many people during and after a crisis, use should be made of social media by adopting a **social media policy and train information officers**. Respective communication strategy should be tailored to the type of crisis (Jin et al. 2011) .FEMA and Red Cross for example provide regular training with updated versions of social media tools, technologies and strategy roadmaps (Veil et al. 2011).

Recent studies show that **behavioural changes** are more easily achieved **through personalised communication**. Social media can be a powerful tool to encourage resilient behaviour in a community. Thanks to the social media, the messages sent out can be adapted to different categories of the targeted population (Radisch et al. 2013).

The use of the social media to **identify survivors and victims** has also proved successful. Applications like safeandwell.org of the American Red Cross were created for people to register if they are safe in an area of disaster so that their loved ones can know whether are ok (Radisch et al. 2013).

Crisis managers should address the public opinion, no matter whether it is accurate or not. Consequently, **monitoring the public opinion** about risk and severity of a crisis respectively would represent a prerequisite (Seeger 2006).

The **media** are a crucial partner in crisis communication to the public and crisis communicators should engage the media as a strategic resource to aid in managing the crisis (Seeger 2006).

HSE and the police have been actively using Twitter and Facebook in collaboration with the local authorities. The use of social media is however usually a one-way process to send out information, i.e. the issuing of warning and instructions.

Twitter and Facebook are frequently used by crisis management organisations to communicate with the public (e.g. HSE South, DHPol, PSNI). They are used for warning and informing the public, but also used for gaining situational awareness. The latter process is however not formalised. In Germany, specific warning *Apps* are operated to inform the public about emergency and crisis situations. Additionally, local, regional and national radio stations are collaborated with (HSE South, PSNI, DHPol). Print media are frequently too slow for emergency management purposes.

Sometimes, Communication Managers are employed and responsible for sending out information (e.g. HSE South, PSNI) and communication strategies exist (PSNI). In Ireland, the Crisis Management Framework also defined an Information Management Task Force (HSE South). A corporate communications team is responsible for respective communication at PSNI (PSNI).

Another way of communicating with the public is via the emergency management organisations including fire brigades, the police and volunteer organisations. This communication channel is useful to ensure that people obey with the evacuation order. To reach the population during an emergency via radio, CPO Rhodes owns about 30 transceivers which are deployed to the local authorities 42 villages of 200 to 10.000 people. Transceivers are given to the presidents of the communities since they will be in their village for 90% of the time or a substitute will be able to take over the responsibility. They will take the necessary measures in their communities. There is a plan for deploying and using the transceivers, but no training is foreseen for it. In contrast to the transceivers, cell phones are very useful at the very first minutes/hours of the emergency. After this, not everyone is in position of battery etc. and also **not** everybody is holding a phone. In case that phone and battery are available, it remains unclear whether individuals will be able to use them due to adrenalin, smoke etc. and whether they will be blocked due to too many incoming phone calls. Consequently, **mobile technologies are no reliable way of communication during an emergency** (RHO).

Several organisations have already published **guidelines for risk and crisis communications** to public, as an example the guidelines of the US Disease Control and Prevention Center and the US Environmental Protection Agency are presented in Figure 17 and Figure 15. A summary of a comprehensive list of general standards in crisis communication of Seeger et. al. is shown in Figure 15.

3.5.4 Failure Factors

A study of the University of Georgia shows that on 22 may 2011 during Joplin tornado, a Facebook employee started to create a dedicated page from her IPhone called Joplin tornado info, less than two hours after the event. She quickly received 44000 followers, which means that people searching for information on the situation were **relying on her and other volunteers instead of on the direct official services** of FEMA, which felt they could have done better (Radisch et al. 2013).

Social media should not automatically be viewed as the most effective mode of communication adopted by key stakeholders during the various stages of a disaster. The persistence of the **digital divide** (the persistence of the gap between those who are able to benefit from the internet and those who are not) militates against the adoption of crisis communication strategies that rely solely on digital media technologies. Only about half of the European population can be characterised as active social media users, with a 21 percent identified as completely off-line. Thus, radio, television, newspapers and telephone calls remain important channels for social, cultural, and also technical reasons (Tiripelli and Reilly 2017)

The **risk of not including the people who felt concerned** by a disaster is that they can now turn to the blogosphere if they have the impression they are not heard to. This was the case during the Cosco Busan oil spill in November 2007 in the United States. The coast guards and other emergency services were so much involved in the crisis response that they did not monitor or counterbalance the communication of these people who, as they could not be involved, criticised their actions (Radisch et al. 2013).

A general problem is the speed of social media and the respective challenges to communicating with the public. This is specifically true, since crisis management organisations have to rely on people to share/retweet their messages to be effective and thus messages have to be up to date and relevant (PSNI).

*1. **Be First:** Crises are time-sensitive. Communicating information quickly is almost always important. For members of the public, the first source of information often becomes the preferred source.*
*2. **Be Right:** Accuracy establishes credibility. Information can include what is known, what is not known, and what is being done to fill in the gaps.*
*3. **Be Credible:** Honesty and truthfulness should not be compromised during crises.*
*4. **Express Empathy:** Crises create harm, and the suffering should be acknowledged in words. Addressing what people are feeling, and the challenges they face, builds trust and rapport.*
*5. **Promote Action:** Giving people meaningful things to do calms anxiety, helps restore order, and promotes a restored sense of control.*
*6. **Show Respect:** Respectful communication is particularly important when people feel vulnerable. Respectful communication promotes cooperation and rapport.*

Figure 16: The Centers for Disease Control and Prevention has published six principles of crisis and emergency risk communication: (Centers for Disease Control and Prevention (CDC) 2014)

*1. **Accept and involve the public as a legitimate partner.***
*2. **Listen to the audience** (If your audience feels or perceives that they are not being heard, they cannot be expected to listen. Effective risk communication is a two-way activity.)*
*3. **Be honest, frank, and open.***
*4. **Coordinate and collaborate with other credible sources.***
*5. **Meet the needs of the media***
*6. **Speak clearly and with compassion***
*7. **Plan carefully and evaluate performance***

Figure 15: Seven Cardinal Rules of Risk Communication of the Environmental Protection Agency: (Centers for Disease Control and Prevention (CDC) 2014)

1. ***Honesty, candour and openness:** withholding information may contribute to panic and public agencies should be open about risks in order to encourage the public to share responsibility for their management*
2. ***Communicate with compassion, concern and empathy:** these characteristics will enhance the perceived credibility of the message and the sender*
3. ***Accept uncertainty and ambiguity:** acknowledging the fluidity and uncertainty of the situation will help build trust with the public*
4. ***Messages of self-sufficiency:** giving people advice on how to minimize harm will help them feel more in control during uncertain situations*

Figure 14: Best practices of crisis communication according to Seeger et. al. (Seeger 2006).

Summary: Communication with the public	
General aspects	Communication with the public is highly relevant in crisis response and can be supported by different technologies (e.g. Radio, television, newspapers, wallpaper, Facebook, twitter). It is important to create an effective two-way communication with the public.
Procedural Review and Analysis of Supporting Tools	There are several technologies for communication with the public available: • Web-based communications (e.g. via government pages) • Mobile devices (with specific emergency apps) • Social media • Volunteered geographic information (VGI) • Communities like Ushahidi • Crowdtasking platforms • Overall concepts like the ATHENA system
Best practice	Crisis communication should be designed in advance. Social media channels should also be used prior to crisis. The information disseminated should be true und complete. Communicating information quickly is almost always important. Communication should contain compassion, concern and empathy. The media is a crucial partner. Mayors should organize a press conference only when the have enough information to answer question. If not, then a statement will be a better choice.
Failure factors	There is a risk of not including people who feel concerned. The digital divide should be taken into consideration. Mobile technologies (alone) are no reliable way of communication during an emergency. A failure factor in communicating with the public is also to organize a press conference too early. A general problem is the speed of social media.
Recommendations	Communication with the public is an important part of crisis management. In recent times a lot of ICT technologies and trends like, smart devices, social media or crowd sourcing have come up as additional communication channels in emergencies. The internet has several advantages; it can speed up the information of the public and also allows for two-way communications. However, these tools come with new challenges, e.g. the authorities have to think of social media policies, personalised and

	emphatic communication means as well as the digital divide in the society. Several organisations have already published basic rules and regulations for the communication with the public.

Table 11: Summary of "Communication with the public".

4 Conclusion

Certainly each crisis and all of its intricacies cannot be anticipated, which complicates detailed planning. However, while many of the specific challenges may be near impossible to anticipate, a set of managerial tasks inherent to any response has been identified:

- Situation assessment
- Decision making
- Coordination, command and control
- Supply basic services to enable CM and logistics
- Communication with the public

These already challenging tasks are further exacerbated when managing transboundary crises, which cross regional and national borders. In this report, a literature review and expert interviews have revealed some of the difficulties related to these tasks, along with current (or absent) technologies for crisis managers. Furthermore, it has identified best practices and failure factors. Specifically, this report helps to achieve the second policy objective of IN-PREP "Identify and characterise gaps and shortcomings of the existing transboundary framework, drawing lessons from recent experiences with transboundary crisis."

This document highlights improvements to be made in crisis management technology. The systems in place now tend to be limited in scope, used only for one of the abovementioned tasks. Furthermore, the expert interviews highlighted the absence of systems that are also compatible with those of other response partners. IN-PREP seeks to bridge this gap by creating a Mixed Reality Preparedness Platform (MRPP) that allows end users to integrate their existing systems when desired into a comprehensive training and preparedness platform. While the MRPP focuses on planning phases, many end users have noted that it will also be useful in the response phase.

The added value of training and preparedness using the IN-PREP MRPP will be that crisis managers will be able to think more critically about transboundary crisis management, dissecting it into manageable tasks that can be trained and prepared for. While they may not perfectly anticipate a future transboundary crisis, crisis managers will gain a deeper understanding of their overall aims, the types of (strategic level) decisions they should focus on, which actors they may need to work with, and what capacities are available to them internally and outside of their organization. They can train on any type of scenario, focusing on specific training goals: improving situation assessment, for example, or improving crisis communication. They can measure their progress and track improvement.

End users are enthusiastic about IN-PREP's goals, as see the importance in training and preparedness for this fairly new domain of transboundary crises. They note that act of training and preparedness is more important than creating detailed, written plans. Inherent to crisis response is the need for flexibility and making decisions under time pressure. There is no way to know exactly how a future unknown event will play out, but training on the types of tasks that arise in every crisis will greatly improve crisis managers' joint capacity to respond.

In addition to the MRPP, IN-PREP will incorporate the findings of this report into a Cross-Organisational Handbook of Preparedness and Response Operations.

5 References

ACRIMAS, 2014. Aftermath Crisis Management System-of-systems Demonstration Phase I. https://www.acrimas.eu/. Accessed 12/6/2017.

Aedo, I., Díaz, P., Carroll, J. M., Convertino, G., M. B. Rosson, 2010. End-user oriented strategies to facilitate multi-organizational adoption of emergency management information systems. Information Processing and Management (46 (1)): 11–21.

Alexander, D. E., 2014. Social media in disaster risk reduction and crisis management. Science and engineering ethics 20 (3): 717–733. 10.1007/s11948-013-9502-z.

An Garda Síochána, the Health Service Executive and Local Authorities, 2005. Framework for Major Emergency Management Appendices. http://mem.ie/framework-documents/.

Andrews, S., 2017. Best Practices in the Design of a Citzen Focused Crisis Management Platform. In: Akhgar, B., Staniforth, A., Waddington, D. P. Application of social media in crisis management: Advanced sciences and technologies for security applications, 59–75. London [etc.]: Springer.

Andrews, S., Yates, S., Akhgar, B., Fortune, D., 2013. The ATHENA Project: Using Formal Concept Analysis toFacilitate the Actions of Responders in a Crisis Situation. http://shura.shu.ac.uk/8601/1/Andrews_Athena_project.pdf. Accessed 11/28/2017.

Ansell, C., Boin, A., Keller, A., 2010. Managing Transboundary Crises: Identifying the Building Blocks of an Effective Response System. Journal of Contingencies and Crisis Management 18 (4): 195–207. 10.1111/j.1468-5973.2010.00620.x.

Attina, F., Boin, A., and Ekengren, M. (Eds.), 2014. Designing EU crisis management capacities (Special Issues). Journal of Contingencies and Crisis Management 22 (3).

Auferbauer, D., Ganhör, R., Tellioglu, H., Pielorz, J., 2016a. Crowdtasking: Field Study on a Crowdsourcing Solution for Practitioners in Crisis Management. Proceedings of the ISCRAM 2016 Conference.

Auferbauer, D., Ganhör, R., Tellioglu, H., Pielorz, J., 2016b. Crowdtasking: Field Study on a Crowdsourcing Solution for Practitioners in Crisis Management: Short Paper – Community Engagement and Practitioner StudiesProceedings of the ISCRAM 2016 Conference – Rio de Janeiro, Brazil, May 2016. http://idl.iscram.org/files/danielauferbauer/2016/1408_DanielAuferbauer_etal2016.pdf. Accessed 11/28/2017.

Baird, A., O'Keefe, P., Westgate, K., Wisner, B., 1975. Towards an Explanation and Reduction of Disaster Proneness. Bradford.

Balcik, B., Beamon, B. M., 2008. Facility location in humanitarian relief. International Journal of Logistics Research and Applications 11 (2): 101–121. 10.1080/13675560701561789.

Balthasar, B., Hamm, T., Lehmann, M. Insurance industry, 85.

Banipal, K., 2006. Strategic approach to disaster management: lessons learned from Hurricane Katrina. Disaster Prevention and Management 15 (3): 484–494.

Banner, 2018. Ethernet-Datenfunkgeräte. https://www.bannerengineering.com/de/de/products/wireless-sensor-networks/wireless-io-data-and-network-connectivity/ethernet-data-radio.html#all. Accessed 1/22/2018.

Barton, A. H., 1969. Communities in disaster: A sociological analysis of collective stress situations: Garden City, NY: Doubleday.

Becerra-Fernandez, I., Xia, W., Gudi, A., Rocha, J., 2008. Task Characteristics, Knowledge Sharing and Integration, and Emergency Management Performance: Research Agenda and Challenges. Proceedings of the 5th International ISCRAM Conference: 88–92.

Bharosa, N., Lee, J., Janssen, M., 2009. Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: Propositions from field exercises. Information System Frontiers 12 (1): 49–65. 10.1007/s10796-009-9174-z.

Boin, A., Bossong, R., Brazova, V.-K., Di Camillo, F., Coste, Frédéric, Dorussen, H., Ekengren, M., Fanoulis, E., Hegemann, H., Hellenberg, T., Kirchner, E., Kuipers, S., Marrone, A., Matczak, P., Nexon, E., Petterson, Y., Rhinard, M., Samardzija, V., Tessari, P., Ungaro, A. R., Visuri, P., 2014a. Civil Security and the European Union: A Survey of European civil security systems and the role of the EU in building shared crisis management capacities.

Boin, A., Busuioc, M., Groenleer, M., 2014b. Building European Union capacity to manage transboundary crises: Network or lead-agency model? Regulation & Governance 8 (4): 418–436. 10.1111/rego.12035.

Boin, A., Bynander, F., 2015. Explaining Success and Failure in Crisis Coordination. Geografiska Annaler: Series A, Physical Geography 97 (1): 123–135. 10.1111/geoa.12072.

Boin, A., Egan, J., 2012. Hurricane Gustav: The management of a transboundary crisis. In: Helsloot, I., Jacobs, B., Boin, A. Mega-Crises: Understanding the Prospects, Nature, Characteristics and the Effects of Cataclysmic Events, 66–76: Charles C. Thomas.

Boin, A., Rhinard, M., Ekengren, M., 2014c. Managing Transboundary Crises: The Emergence of European Union Capacity. Journal of Contingencies and Crisis Management 22 (3): 131–142. 10.1111/1468-5973.12052.

Boin, A., 't Hart, P., 2010. Organising for Effective Emergency Management: Lessons from Research1. Australian Journal of Public Administration 69 (4): 357–371. 10.1111/j.1467-8500.2010.00694.x.

Bram, S., Vestergren, S., 2011. Emergency Response Systems: Concepts, features, evaluation and design. CARER Report 2012.

Brehmer, B., 2000. Dynamic Decision Making in Command and Control. In: McCann, C. and R. Pigeau. The Human in Command: Exploring the Modern Military Experience. New York: Kluwer Academic/Plenum Publishers.

Bruijn, H. de, 2006. One fight, one team: The 9/11 commission report on intelligence, fragmentation and information. Public Administration 84 (2): 267–287.

Buck, A. D., Trainor, E. J., Benigno, E. A., 2006. A Critical Evaluation of the Incident Command System and NIMS 3. 10.2202/1547-7355.1252.

Caunhye, A. M., Nie, X., Pokharel, S., 2012. Optimization models in emergency logistics: A literature review. Socio-Economic Planning Sciences 46 (1): 4–13. 10.1016/j.seps.2011.04.004.

CHALIAMALIAS, T., 2012. The Logistics Chain of Emergency Supplies in Disasters: Master's Course in: International Medicine-Health Crisis Management. crisis.med.uoa.gr/elibrary/15.pdf. Accessed 11/20/2017.

Chief Fire Officers Association, 2016. Association of Ambulance Chief Executives and National Police Chiefs' Council.

Chief Fire Officers Association, Association of Ambulance Chief Executives and National Police Chiefs' Council, 2016. Joint Doctrine: The interoperability framework (JESIP). Joint Doctrine: The interoperability framework.

Chrisholm, D., 1989. Coordination Without Hierarchy: Informal Structures in Multi-organizational Systems. Berkley: University of California Press.

Comfort, L. K., 1999. Shared risk: Complex systems in seismic policy. Amsterdam and Oxford: Pergamon.

Comfort, L. K., 2006. Communication, Coherence, and Collective Action: The Impact of Hurricane Katrina on Communications Infrastructure. Public Works Management & Policy 10 (4): 328–343. 10.1177/1087724X06289052.

Comfort, L. K., 2007. Crisis Management in Hindsight: Cognition, Communication, Coordination, and Control. Public Administration Review 67: 189–197.

Comfort, L. K., Kapucu, N., 2006. Inter-organizational coordination in extreme events: The World Trade Center attacks, September 11, 2001. Natural Hazards 39 (2): 309–327. 10.1007/s11069-006-0030-x.

Considine, M., Lewis, J. M., 2003. Bureaucracy, Network, or Enterprise? Comparing Models of Governance in Australia, Britain, the Netherlands, and New Zealand. Public Administration Review 63 (2): 131–140. 10.1111/1540-6210.00274.

Coombs, W. T., 1999. Ongoing crisis communication: Planning, managing, and responding. Thousand Oaks: Sage Publ.

Danielsson, M., Ohlsson, K., 1999. Decision making in emergency management: A survey study. International Journal of Cognitive Ergonomics 3 (2): 91–99.

Dawes, S. S., Cresswell, A. M., B. B. Cahan, 2004. Learning from crisis: Lessons in human and information infrastructure from the World Trade Center response. Social Science Computer Review 22 (1): 52–66.

Day, J. M., Junglas, I., I. Leiser, 2009. Information flow impediments in disaster relief supply chains. Journal of the Association for Information Systems (10 (8)): 637–660.

De Longueville, B., Smith, R.S., and Luraschi, G., 2009. OMG, from here, I can see the flames!": a use case of mining location based social networks to acquire spatio-temporal data on forest fire: Proceedings of the 2009 international workshop on location based social networks.

De Rubeis, V., Sbarra, P., and Tosi, P., 2009. Web based macroseismic survey: fast information exchange and elaboration of seismic intensity effects in Italy: Proceeding of the 6th International ISCRAM conference.

Demchak, C. C., 2010. 4 lessons from tHe military. Designing Resilience: Preparing for Extreme Events: 62.

Devasirvatham, D., 2011. Achieving Communications Operability and Interoperability after Large Incidents. http://www.wirelessinnovation.org/assets/Proceedings/2011Europe/2011-europe-2b-devasirvatham-presentation.pdf. Accessed 11/22/2017.

Dilmaghani, R. B., R. R. Rao, 2008. An ad hoc network infrastructure: Communication and information sharing for emergency response. Proceedings of the 41st Hawaii International Conference: 442–447.

Donahue, A., 2004. The Day the Sky Fell: The Space Shuttle Colombia Disaster. Public Management (86(8)): 8–12.

Drabek, T. E., McEntire, D. A., 2003. Emergent phenomena and the sociology of disaster: Lessons, trends and opportunities from the research literature. Disaster Prevention and Management: An International Journal 12 (2): 97–112. 10.1108/09653560310474214.

Drury, J., Cocking, C., 2007. The mass psychology of disasters and emergency evacuations: A research report and implications for practicefindings, arguments and the implications of these. Sussex: University of Sussex.

Dynes, R. R., 1970. Organized Behavior in Disaster. Lexington: Heath Lexington Books.

Egan, J., 2010. Private Goods and Services Contracts: Increased Emergency Response Capacity or Increased Vulnerability? International Journal of Production Economics (126 (1)): 46–56.

Eisenhardt, K. M., Martin, J. A., 2000. Dynamic Capabilities: What are they? Strategic Management Journal (32 (10/11)): 1105–1121.

Endsley, M. R., 1995. Toward a theory of situation awareness in dynamic systems. Human Factors (37): 32–64.

Endsley, M. R., 2011. Designing for situation awareness: An approach to user-centered design. Boca Raton, FL: CRC Press.

Engelbrecht, A., Borges, M. R. S., Vivacqua, A. S., 2011. Digital tabletops for situational awareness in emergency situations. Proceedings of the 2011 15th International Conference on Computer Supported Cooperative Work in Design: 669–676. 10.1109/CSCWD.2011.5960190.

European Commission, 2016. Satellite Communication to support EU Security Policies and Infrastructures: Final report. http://ec.europa.eu/DocsRoom/documents/16147/attachments/2/translations/en/renditions/pdf. Accessed 11/22/2017.

European Commission - DG for Humanitarian Aid - DG ECHO, 2005. A REVIEW OF WATER AND SANITATION ISSUES RELATING TO THE FUNDING OF HUMANITARIAN OPERATIONS UNDER THE EC HUMANITARIAN REGULATION. http://ec.europa.eu/echo/files/evaluation/watsan2005/files/concept_paper.doc. Accessed 11/21/2017.

Federal Emergency Response Agency (FEMA), 2008. National Response Framework. U.S. Department of Homeland Security. Washington.

Fischer, D., Posegga, O., Fischbach, K., 2016. Communication Barriers in Crisis Management: A Literature Review. Research Papers (168).

General Accountability Office (GAO), 2006. Coast Guard: Observations on the Preparation, Response, and Recovery Missions Rrelated to Hurricane Katrina: Report to Congressional Committee. GAO-06-903.

Gomez, E. A., M. Turoff, 2007. Community crisis response teams: Leveraging local resources through ICT e-readiness. Proceedings of the 40th Hawaii International Conference on System: 1–10.

Gomez, K., Rasheed, T., Reynaud, L., Kandeepan, S., 2013. On the performance of aerial LTE base-stations for public safety and emergency recovery. In: IEEE Globecom workshops (GC wkshps), 2013: 9 - 13 Dec. 2013, Atlanta, GA, USA, 1391–1396. Piscataway, NJ: IEEE.

Goodchild, M. F., 2007. Citizens as sensors: The world of volunteered geography. GeoJournal 69 (4): 211–221. 10.1007/s10708-007-9111-y.

Goodchild, M. F., Li, L., 2012. Assuring the quality of volunteered geographic information. Spatial Statistics 1: 110–120. 10.1016/j.spasta.2012.03.002.

Groenendaal, J., Helsloot, I., Scholtens, A., 2013. A Critical Examination of the Assumptions Regarding Centralized Coordination in Large-Scale Emergency Situations 10. 10.1515/jhsem-2012-0053.

Groeve, T. de, Peter, T., Annunziato, A., Vernaccini, L., 2006. Global Disaster Alert and Coordination System. https://www.researchgate.net/profile/Tom_De_Groeve/publication/265217646_Global_Disaster_Alert_and_Coordination_System/links/54b7991f0cf2bd04be33aaee.pdf. Accessed 8/16/2017.

Hale, J. E., Dulek, R. E., D. P. Hale, 2005. Crisis response communication challenges: Building theory from qualitative data. Journal of Business Communication 42 (2): 112–134.

Harrald, J. R., Cohn, R., Wallace, W. A., 1992. "We Were Alwayr Re-Organizing… ": Some Crisis Management Implications of the Exxon Valdez Oil Spill. Industrial Organization Qurateriy (6): 1997-1217.

Hart, P. 't, Rosenthal, U., A. Kouzmin, 1993. Crisis Decision Making: The Centralization of Thesis Revisited. Administration & Society (25(1)): 12–45.

Helsloot, I., 2005. Bordering on Reality: Findings on the Bonfire Crisis Management Simulation. Journal of Contingencies and Crisis Management 13 (4): 159–169. 10.1111/j.1468-5973.2005.00472.x.

Helsloot, I., Boin, A., Jacobs, B., Comfort, L. K., 2012. Mega-crises: Understanding the prospects, nature, characteristics, and the effects of cataclysmic events. Springfield: Charles C Thomas Publisher.

History of London, 2011. 7/7 London Bombings. https://web.archive.org/web/20121014202918/http://www.history.co.uk/explore-history/history-of-london/london-bombings.html. Accessed 11/17/2017.

Hlavinek, P., op. 2009. Risk management of water supply and sanitation systems. Dordrecht: Springer.

Horan, T. A., B. L. Schooley, 2007. Time-critical information services. Communications of the ACM 50 (3): 73–78.

Huang, C.-M., Chan, E., Hyder, A. A., 2010. Web 2.0 and Internet Social Networking: A New tool for Disaster Management? - Lessons from Taiwan. BMC medical informatics and decision making 10: 57. 10.1186/1472-6947-10-57.

Hughes, A.L. and L. Palen, 2009. Twitter adoption and use in mass convergence and emergency events: Proceeding of the 6th international ISCRAM conference.

Ianella, R., Henricksen, K., 2007. Managing information in the disaster coordination centre: Lessons and opportunities. Proceedings of the 4th International ISCRAM Conference.

IDIRA Project, 2013. D 1.2 State-of-the-art and user needs: " Interoperability of data and procedures in large-scale multinational disaster".

INPREP, 2018. TARONA - An RFID based application for the end-to-end tracing of logistics flows.

INSARAG Preparedness Reponse, 2015. INSARAG Guidelines. https://www.insarag.org/methodology/guidelines. Accessed 12/18/2017.

Jabbour, C. J. C., Sobreiro, V. A., Lopes de Sousa Jabbour, A. B., Souza Campos, L. M. de, Mariano, E. B., Renwick, D. W. S., 2017. An analysis of the literature on humanitarian logistics and supply chain management: Paving the way for future studies. Annals of Operations Research. 10.1007/s10479-017-2536-x.

Jin, Y., Liu, B. F., Austin, L. L., 2011. Examining the Role of Social Media in Effective Crisis Management. Communication Research 41 (1): 74–94. 10.1177/0093650211423918.

Jirka, S., Bröring, A., Stasch Christoph. Applying OGC Sensor Web Enablement to Risk Monitoring and Disaster Management. http://www.arne-broering.de/Paper%20-%20Applying%20OGC%20Sensor%20Web%20Enablement%20to%20Risk%20Monitoring%20and%20Disaster%20Management.pdf. Accessed 8/14/2017.

Joint Emergency Services Interoperability Programme, 2013. Joint Doctrine: the interoperability framework. http://www.jesip.org.uk/uploads/resources/JESIP-Joint-Doctrine.pdf. Accessed 12/5/2018.

Jungert, E., Hallberg, N., Hunstad, A., 2006. A service-based command and control systems architecture for crisis management. International Journal of Emergency Management 3 (2/3): 131–148. 10.1504/IJEM.2006.011164.

Kamel Boulos, M. N., Resch, B., Crowley, D. N., Breslin, J. G., Sohn, G., Burtner, R., Pike, W. A., Jezierski, E., Slayer Chuang, K.-Y., 2011. Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. International Journal of Health Geographics (10:67): 1–29.

Kapucu, N., 2006. Interagency Communication Networks During Emergencies. The American Review of Public Administration 36 (2): 207–225. 10.1177/0275074005280605.

Kathleen Tierney, 2003. Disaster beliefs and institutional interests: Recycling Disaster Myths in the Aftermath of 9-11. Terrorism and Disaster: New Threats, New Ideas Research in Social Problems and Public Policy 11: 33–51.

Kendra, J. M., Wachtendorf, T., 2003. Elements of Community Resilience in the World Trade Center Attack. Disasters (27 (1)): 37–53.

Kersnik, M., 2016. Slovenia: Icing in 2014. In: OSCE. Protecting Electricity Networks from Natural Hazards, 63–66: Organization for Security and Co-operation in Europe (OSCE).

Kettl, D. F., 2003. Contingent Coordination: Practical and Theoretical Puzzles for Homeland Security. American Review of Public Administration (33(3)): 253–277.

Khan, H., Vasilescu, L. G., Khan, A., 2008. Disaster Management Cycle: A Theoretical Approach. http://www.mnmk.ro/documents/2008/2008-6.pdf.

Klein, G. A., Calderwood, R., MacGregor, D., 1989. Critical decision method for eliciting knowledge. IEEE Transactions on Systems, Man, and Cybernetics 19 (3): 462–472. 10.1109/21.31053.

Kovács, G., Spens, K. M., 2012. Relief supply chain management for disasters: Humanitarian aid and emergency logistics. Hershey, Pa: IGI Global (701 E. Chocolate Avenue Hershey Pennsylvania 17033 USA).

Krakow, G., 2005. Ham radio operators to the rescue after Katrina. http://www.nbcnews.com/id/9228945/ns/technology_and_science-wireless/t/ham-radio-operators-rescue-after-katrina/#.T5HBY6tDxjQ. Accessed 11/16/2017.

Kreps, G. A., 1983. The organization of disaster response: core competences and processes. International Journal of Mass Emergencies and Disasters (13): 439–465.

Lagadec, P., 1997. Learning processes for crisis management in complex organizations. Journal of Contingencies and Crisis Management 5 (1): 24–31.

Lee, J., Bharosa, N., Yang, J., Janssen, M., Rao, H. R., 2011. Group value and intention to use— A study of multi-agency disaster management information systems for public safety. Decision Support Systems (50 (2)): 404–414.

Leonard, H., Howitt, A., 2009. Managing Crises: Responding to Large-Scale Emergencies: Washington, DC: Congressional Quarterly Press.

Lettieri, E., Masella, C., Radaelli, G., 2009. Disaster management: Findings from a systematic review. Disaster Prevention and Management: An International Journal 18 (2): 117–136. 10.1108/09653560910953207.

Levy, S., 2013. How Google Will Use High-Flying Balloons to Deliver Internet to the Hinterlands. https://www.wired.com/2013/06/google_internet_balloons/all/google.com/loon/. Accessed 11/17/2017.

Ley, B., Pipek, V., Reuter, C., Wiedenhoefer, T., 2012. Supporting inter-organizational situation assessment in crisis management. Proc. ISCRAM. Vancouver, Canada.

Liu, S., Palen, L., 2009. Spatiotemporal Mashups: A Survey of Current Tools to Inform Next Generation Crisis Support.: Proc. of the 6th International ISCRAM.

Liu, W. Resilience of ElectricityNetworks to Natural Disasters, 71–75.

London Assembly, 2007. 7 July Review Committee, follow-up report. https://web.archive.org/web/20120107004751/http://legacy.london.gov.uk/assembly/reports/7july/follow-up-report.pdf. Accessed 11/16/2017.

Longueville, B. de, Annoni, A., Schade, S., Ostlaender, N. and C. Whitmore, 2010. Digital Earth's Nervous System for crisis events: Real-time Sensor Web Enablement of Volunteered Geographic Information. International Journal of Digital Earth 3 (3): 242–259. 10.1080/17538947.2010.484869.

MacFarlane, R. and M. Leigh, 2014. Information Management and Shared Situational Awareness: Ideas, Tools and Good Practice in Multi-Agency Crisis and Emergency Management. http://www.epcresilience.com/EPC/media/Images/Knowledge%20Centre/Occasionals/Occ12-Paper.pdf.

Majchrzak, A., Jarvenpaa, S. L., Hollingshead, A. B., 2007. Coordinating expertise among emergent groups responding to disasters. Organization Science 18 (1): 147–161.

ManagementStudyGuide.com, 2017. Management Study Guide. http://www.managementstudyguide.com/what-is-decision-making.htm. Accessed 12/18/2017.

Manoj, B., A. H. Baker, 2007. Communication challenges in emergency response. Communications of the ACM (50 (3)): 51–53.

Mason, A. M., Drew, S., Weaver, D., 2017. Managing Crisis-induced uncertainty: First responder experiences from the 2011 Joplin-Duquesne Tornado. International Journal of Disaster Risk Reduction 23: 231–237. 10.1016/j.ijdrr.2017.04.012.

Massachusetts Institute of Technology, 2013. A Review of Satellite Communications and Complementary Approaches to Support Distributed Disaster Response. https://www.dhs.gov/sites/default/files/publications/A Review of Satellite Communications 1-15-14.pdf. Accessed 11/22/2017.

Maynard-Moody, S. W., Musheno, M. C., 2003. Cops, teachers, counselors: Stories from the front lines of public service: University of Michigan Press.

McCue, A., 2006. 7/7 bomb rescue efforts hampered by communication failings. http://www.zdnet.com/article/77-bomb-rescue-efforts-hampered-by-communication-failings-3039273086/. Accessed 11/16/2017.

McEntire, D. A., 2002. Coordinating multi-organisational responses to disaster: Lessons from the March 28, 2000, Fort Worth tornado. Disaster Prevention and Management: An International Journal 11 (5): 369–379. 10.1108/09653560210453416.

Mehrotra, S., Butts, C., Kalashnikov, D., Venkatasubramanian, N., 2004. Project Rescue: Challenges in Responding to the Unexpected.

Mendonça, D., Wallace, W. A., 2015. Factors underlying organizational resilience: The case of electric power restoration in New York City after 11 September 2001. Reliability Engineering & System Safety 141: 83–91. 10.1016/j.ress.2015.03.017.

Michelson, E. S., 2005. Dodging a Bullet: WHO, SARS, and the Successful Management of Infectious Disease. Bulletin of Science, Technology & Society 25 (5): 379–386. 10.1177/0270467605278877.

Mignone, A. T., JR., Davidson, R., 2003. Public Health Response Action and the Use of Emergency Operations Centres. Prehospital and Disaster Medicine (18 (3)): 217–218.

Militello, L. G., Patterson, E. S., Bowman, L., Wears, R., 2007. Information Flow During Crisis Management: Challenges to Coordination in the Emergency Operations Center. Cognition, Technology, and Work (9): 25–31.

Miller, R. Hurricane Katrina: Communications & Infrastructure Impacts. https://blackboard.angelo.edu/bbcswebdav/institution/LFA/CSS/Course%20Material/BOR4301/Readings/Hurricane%20Katrina%20Communications%20%26%20Infrastructure%20Impacts.pdf. Accessed 11/17/2017.

Moynihan, D. P., 2008. Learning under Uncertainty: Networks in Crisis Management. Public Administration Review 68 (2): 350–365. 10.1111/j.1540-6210.2007.00867.x.

Mumovic, M., 2016. South-Eastern Europe:Floods in 2014. In: OSCE. Protecting Electricity Networks from Natural Hazards, 66–69: Organization for Security and Co-operation in Europe (OSCE).

National Steering Group Ireland, 2017. A framework for major emergency management. http://mem.ie/. Accessed 12/6/2017.

Norros, L., Colford, N., Hutton, R., Liinasuo, M., Grommes, P., Savioja, P., 2009. Analysis of work demands of multi-agency emergency response activity for developing information support systems. European Conference of Cognitive Ergonomics: 92–95.

NPCC, 2014. National Police Coordination Centre (NPoCC) a year on. https://news.npcc.police.uk/releases/national-police-coordination-centre-npocc-a-year-on. Accessed 11/28/2017.

OASIS project, 2007. Homeopage. http://www.oasis-fp6.org. Accessed 11/18/2007.

OASIS project, 2014. Emergency Data Exchange Language: OASIS Emergency Management TC. https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=emergency. Accessed 12/14/2017.

Official Norwegian Reports (ONR), 2012. 14: Report from the 22nd July commission.

Okhuysen, G. A., Bechky, B. A., 2009. 10 Coordination in Organizations: An Integrative Perspective. Academy of Management Annals 3 (1): 463. 10.1080/19416520903047533.

Oomes, A., 2004. Organizational Awareness in Crisis Management: Dynamic Organigrams for More Effective Disaster Response. Proceedings of the First International Workshop on Information Systems for Crisis Response and Management: 63–68.

Özdamar, L., Ertem, M. A., 2015. Models, solutions and enabling technologies in humanitarian logistics. European Journal of Operational Research 244 (1): 55–65. 10.1016/j.ejor.2014.11.030.

Palen, L., Vieweg, S., Liu, S.B. and A. L. Hughes, 2009. Crisis in a networked world: features of computer-mediated communication in the April 16, 2007, Virginia Tech event. Social Science Computer Review (27(4)): 467480.

Panitzek, K., Schweizer, I., Bönning, T., Seipel, G., Mühlhäuser, M., 2012. First responder communication in urban environments. International Journal of Mobile Network Design and Innovation 4 (2): 109–118. 10.1504/IJMNDI.2012.048489.

Perry, R. W., 1991. Managing disaster response operations. In: Drabek, T. E., Hoetmer, G. Emergency Management: Principles and Practice for Local Government, 201–223. Washington D.C.: International City Management Association (ICMA).

Perry, R. W., Lindell, M. K., 2003. Preparedness for Emergency Response: Guidelines for the Emergency Planning Process. Disasters 27 (4): 336–350. 10.1111/j.0361-3666.2003.00237.x.

Preparecenter.org - American Red Cross, 2016. Social Media Analysis Tools for Preparedness. https://www.preparecenter.org/resources/social-media-analysis-tools-preparedness. Accessed 11/30/2017.

Quarantelli, E. L., 1988. Disaster Crisis Management: A Summary of Research Findings. Journal of Management Studies (25(4)): 373–385.

Radisch, J., Wendling, C., Jacobzone, S., 2013. OECD Working Papers on Public Governance: The Use of Social Media in Risk and Crisis Communication.

Rasmussen, J., Brehmer, B. and J. Leplat, 1991. Distributed Decision Making: Cognitive Models for Cooperative Work. Chichester: John Wiley and Sons.

Rester, M., Groeve, T. de, Annunziato, A., Galliano, D., Hirner, a., Vernaccini, L. and S. Paris. Interoperability of Mobile Devices for Crisis Management.

Reynolds, B., Seeger, M., 2005. Crisis and Emergency Risk Communication as an Integrative Model. Journal of Health Communication 10 (1): 43–55. 10.1080/10810730590904571.

Robert MacFarlane, Mark Leigh, 2014. Information Management and Shared Situational Awareness: Ideas, Tools and Good Practice in Multi-Agency Crisis and Emergency Management. Emergency Planning College Occasional Papers New Series, 12.

Rosenthal, U., Boin, A., Comfort, L. K., 2001. Managing crises: Threats, dilemmas, opportunities. Springfield: Charles C Thomas Publisher.

Rosenthal, U., Charles, M. T., Hart, P., 1989. Coping with crises: The management of disasters, riots, and terrorism: Charles C Thomas Pub Ltd.

Rosenthal, U., Hart, P., KOUZMIN, A., 1991. THE BUREAU-POLITICS OF CRISIS MANAGEMENT. Public Administration 69 (2): 211–233. 10.1111/j.1467-9299.1991.tb00791.x.

Sakano, T., Kotabe, S., Komukai, T., Kumagai, T., Shimizu, Y., Takahara, A., Ngo, T., Fadlullah, Z. M., Nishiyama, H., Kato, N., 2016. Bringing movable and deployable networks to disaster areas: Development and field test of MDRU. IEEE Network 30 (1): 86–91. 10.1109/MNET.2016.7389836.

satways, 2017. ENGAGE IMS/CAD. http://www.satways.net/products/engage-ims-cad/. Accessed 1/22/2018.

Schneeweiss, C., 2003. Distributed decision making––a unified approach. European Journal of Operational Research 150 (2): 237–252. 10.1016/S0377-2217(02)00501-5.

Scholtens, A., 2008a. Controlled Collaboration in Disaster and Crisis Management in the Netherlands, History and Practice of an Overestimated and Underestimated Concept. Journal of Contingencies and Crisis Management 16 (4): 195–207. 10.1111/j.1468-5973.2008.00550.x.

Scholtens, A., 2008b. Controlled Collaboration in Disaster and Crisis Management in the Netherlands: History and Practice of an Overestimated and Underestimated Concept. Journal of Contingencies and Crisis Management (16(4)): 195–207.

Seeger, M. W., 2006. Best Practices in Crisis Communication: An Expert Panel Process. Journal of Applied Communication Research 34 (3): 232–244. 10.1080/00909880600769944.

Seppänen, H., Mäkelä, J., Luokkala, P., Virrantaus, K., 2013. Developing shared situational awareness for emergency management. Safety Science 55: 1–9. 10.1016/j.ssci.2012.12.009.

Sheu, J.-B., 2007a. An emergency logistics distribution approach for quick response to urgent relief demand in disasters. Transportation Research Part E: Logistics and Transportation Review 43 (6): 687–709.

Sheu, J.-B., 2007b. Challenges of Emergency Logistics Management. Transportation Research Part E: Logistics and Transportation Review 43 (6).

Simon, H. A., 2013. Administrative behavior: Simon and Schuster.

Smith-Spark, L., 2013. Up, up and away: Google to launch Wi-Fi balloon experiment. http://edition.cnn.com/2013/06/15/world/asia/new-zealand-google-balloons/index.html. Accessed 11/16/2017.

Solnit, R., 2009. A Paradise Bult in Hell: The Extraordinary Communities that Arise in Disaster. New York: Viking Adult.

State of Victoria, A., 2015. Fundamentals of Emergency Management. files.em.vic.gov.au/Doctrine/Fund/Fundamentals-EMC1.pdf. Accessed 12/18/2017.

Stolk et al., 2012. ACRIMAS - D 5.1 Approaches and Solutions. https://www.acrimas.eu/attachments/article/5/D5-1_ACRIMAS_report_Approaches_Solutions.pdf.

Tactical Situation Object, 2012. Homepage. http://www.tacticalsituationobject.org/. Accessed 2/20/2012.

tait communications, 2012. Race against time - Emergency response - preventing chaos in a disaster. http://go.taitradio.com/rs/dataratitaitradio/images/Tait_WP_Race%20Against%20Time_US_v1_WEB.pdf?mkt_tok=3RkMMJWWfF9wsRogvKzNZKXonjHpfsX56OkqXqa%2FlMI%2F0ER3fOvrPUfGjI4FT8tmI%2FqLAzICFpZo2FFcG%2FSUboFU8%2BFcAlWgWT%2F2jw%3D%3D.

Tatham, P., Spens, K., Kovács, G., 2017. The humanitarian common logistic operating picture: A solution to the inter-agency coordination challenge. Disasters 41 (1): 77–100. 10.1111/disa.12193.

Teece, D. J., Pisano, G., Shuen, A., 1997. Dynamic Capabilities and Strategic Management. Strategic Management Journal (18 (7)): 509–553.

Thaler, R. H., Sunstein, C. R., 2009. Nudge: Improving decisions about health, wealth, and happiness. New York: Penguin Books.

Thompson, J. D., 1967. Organizations in action: Social science bases of administrative theory: Transaction publishers.

Tiripelli, G., Reilly, P., 2017. Guidelines for Effective Crisis Communication: CascEff. http://casceff.eu/media2/2017/07/Topic4-Lesson2-Effective-Crisis-Communication-FIN-1.pptx. Accessed 11/30/2017.

Trewatha, R. L., Newport, M. G., 1982. Management. Plano, Tex.: Business Publications.

Ulmer, R. R., 2016. Effective Crisis Management through Established Stakeholder Relationships. Management Communication Quarterly 14 (4): 590–615. 10.1177/0893318901144003.

UNISDR, 2015. Global Assessment Report on Disaster Risk Reduction. http://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR2015_EN.pdf.

van de Walle, B., M. Turoff, 2007. Emergency response Information Systems: Emerging trends in emergency management. Communications of the ACM (50 (3)): 29–31.

van de Walle, B., Turoff, M., 2008. Decision support for emergency situations. Information Systems and e-Business Management 6 (3): 295–316. 10.1007/s10257-008-0087-z.

Varley, P., 2003. Command Performance: County Firefighters Take Chared if the 9/11 Pentagon Emergency. Case Studies in Public Policy & Management.

Veil, S. R., Buehner, T., Palenchar, M. J., 2011. A Work-In-Process Literature Review: Incorporating Social Media in Risk and Crisis Communication. Journal of Contingencies and Crisis Management 19 (2): 110–122. 10.1111/j.1468-5973.2011.00639.x.

Vinck, P., 2013. World disasters report: Focus on technology and the future of humanitarian action. Geneva, Switzerland: International Federation of Red Cross and Red Crescent Societies.

Voigt, S., Kemper, T., Riedlinger, T., Kiefl, R., Scholte, K., Mehl, H., 2007. Satellite Image Analysis for Disaster and Crisis-Management Support. IEEE Transactions on Geoscience and Remote Sensing 45 (6): 1520–1528. 10.1109/TGRS.2007.895830.

Weick, K., Sutcliffe, K. M., Obstfeld, D., 2005. Organizing and the process of sensemaking. Organization Science (16(4)): 409–421.

Weisæth, L., Knudsen, Ø., Tønnessen, A., 2002. Technological disasters, crisis management and leadership stress. Journal of Hazardous Materials 93 (1): 33–45. 10.1016/S0304-3894(02)00036-5.

Wenzel, F., Zobel, C. Multi-hazard perspectivesfor power network resilience, 29–34.

WHO, 2003. The operational response to SARS. http://www.who.int/csr/sars/goarn2003_4_16/en/. Accessed 10/20/2017.

Wikipedia, 2017a. Travelling salesman problem. https://en.wikipedia.org/wiki/Travelling_salesman_problem. Accessed 11/28/2017.

Wikipedia, 2017b. Vehicle routing problem. https://en.wikipedia.org/wiki/Vehicle_routing_problem. Accessed 11/28/2017.

Wilson, J. Q., 1989. Bureaucracy; What Government Agencies Do and Why They Do It. New York: Basic Books.

Woltjer, R., Lindgren, I., Smith, K., 2006. A case study of information and communication technology in emergency management training. International Journal of Emergency Management 3 (4): 332–347.

Wybo, J. L., Kowalski, K. M., 1998. Command centers and emergency management support. Safety Science 30 (1): 131–138. 10.1016/S0925-7535(98)00041-1.