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Recommendations for improvement of current incident management in crisis

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Table of Content

Executive Summary **4**

Nomenclature **6**

1 Scope, objectives and methodological approach **9**
1.1 Introduction: cascading incidents as a societal challenge 9
1.2 The CascEff project 9
1.3 Task 1.5 Description 10
1.4 Scope and structure of the report 10
1.5 Link to other project results 11
1.6 Methodological approach 12

2 Challenges of Incident management **14**
2.1 Key characteristics of incidents with and without cascading effects 14
2.1.1 Key characteristics of incidents 14
2.1.2 Key characteristics of incidents with cascading effects 15
2.2 Challenges of incident management 20
2.2.1 Dealing with complexity, uncertainty, urgency and scale of the incident 20
2.2.2 Managing diversities of organisation and structure 23

3 Practices for successful incident management **27**
3.1 Current Incident management practices 27
3.1.1 Preparation through emergency planning 28
3.1.2 Coordinated response and multidisciplinary structures 30
3.1.3 Information before and during incident response 33
3.2 Communication – a key for achieving interoperability 36
3.2.1 Creating a common operational picture despite diverse objectives and foci 36
3.2.2 Diverging strategies for managing an incident 37
3.2.3 Communicating the underlying rationale for decisions 37
3.2.4 Communicating with a wide range of stakeholders 37
3.3 Identifying potential cascading effects 39
3.4 The link between Risk and Incident management processes 41
3.5 Key word multidisciplinarity 42
3.6 Multi-, inter- and/or transdisciplinarity? 43

4 A methodology for improved incident management **45**
4.1 The added value of a transdisciplinary approach to incident management 45
4.2 The role and contribution of an Incident Evolution Methodology 46
4.3 The transdisciplinary character of the Incident Evolution Methodology and Tool 48
4.3.1 Analysis of feedback from outreach activities 50

5 Recommendations **57**
5.1 Recommendations for improved incident management 57
5.2 Policy recommendations 60

6 Conclusions 62

7 References 64

Appendix 1 - Typology of incidents based on their characteristics 67

Appendix 2 – IET/IEM user feedback evaluation and implementation 68
Focus Group 1 Workshops summary 69
Focus Group 2 Workshops Summary 70

Appendix 3 – Revised D1.3. A flowchart of the methodology for improved incident management in crisis 74

List of figures

Figure 1 Illustration of Buffer time, Propagation time, Endurance time and Time delay.
Figure 2 Conceptual model of the propagation of effects between systems in an incident that involves cascading effects.
Figure 3 Frequency analysis of the cascading effects between originating systems and impacted systems.
Figure 4 Summary of level of government responsible for the provision of emergency services based on an average of all responding countries (note that the Netherlands have both national and regional police forces
Figure 5 Scenarios as an instrument for emergency planning for writing concrete procedures
Figure 6 Representation of the first response step, Analysis (Oefenbank Nederland)
Figure 7 The link between Risk and Incident management processes
Figure 8 Representation of the specific focus of a transdisciplinary approach
Figure 9 Contribution of transdisciplinary mechanisms to improve current incident management practices

List of tables

Table 1 System categories and how they are defined in the CascEff project.
Table 2 Levels of Command
Table 3 Overview of a gradual multi-, inter- and transdisciplinary approach for improved incident management
Table 4 SWOT analysis of feedback from outreach participants.

Executive Summary

The CascEff project

The goal of the FP7 CascEff project is to improve our understanding of cascading effects in crisis situations through the identification of initiators, dependencies and key decision points. This report summarises general considerations and recommendations for improvement of incident management practices based on a better understanding of cascading effects. It proposes a transdisciplinary methodology for improving incident management that is fully supported by use of the CascEff Incident Evolution Methodology and Tool (IEM/IET).

Problem statement

Current incident management practices are usually based on mono- or multi- disciplinary responses where each organisation is concerned primarily with fulfilling its own specific objectives. The new transdisciplinary incident management framework extends the scope of existing preparedness activities such as risk assessments of systems to include identification of potential weaknesses within, across, and between organisations, systems and borders. By following the IEM the organisations involved will be prepared to work together toward a common goal. The IEM/IET also enables better communication and situational awareness during the response to complex incidents that, in turn, promote sound decision-making for mitigation of cascading effects.

Methods of analysis

This report is a synthesis of the main research findings of the CascEff project. It provides an integrated description of the characteristics, challenges, and limitations associated with current incident management practices concerning incidents both with and without cascading effects. Based on an analysis of current incident management practices, a transdisciplinary methodology for improved incident management is proposed. Information collected from outreach activities such as the CascEff External Expert Advisory Board, focus groups, and validation exercises was also used to guide the development of the methodology (in the form of the IEM/IET) in order to optimize the value they bring to the incident management community.

The IEM is comprised of six steps that lead the user to a better and deeper understanding of cascading effects caused by system dependencies. These steps identify and integrate all aspects relevant to the incident from a case perspective. The IET is a web based tool that stores data collected throughout the IEM process, calculates and visualizes the cascade and key decision points for the decision makers.

Findings

The objective of this report is to provide valuable insights to the emergency response community regarding best practices for management of incidents with cascading effects. To that end, recommendations are provided that enhance and support knowledge of crises, strengthen crisis management, and facilitate communication across systems, borders, organisations and

disciplines. These recommendations are based on the experience and knowledge of the CascEff project researchers and on information collected from potential users of the IEM/IET. In essence, it was found that preparedness is of vital importance for a successful response to a complex incident having cascading effects. This includes establishing solid relationships that transcend the individual objectives of the organisations involved so that informed decisions can be made quickly during the response.

The results of the CascEff project will be disseminated to stakeholders via dissemination activities within WP6, the design and distribution of training materials, and the CascEff website. A link to the IET prototype resides on the website, allowing registered users access to it at any time.

Conclusions

Research within CascEff has shown that one of the key challenges for managing incidents with cascading effects is dealing with an often high level of indeterminacy, mirroring the lack of insight into links and dependencies between systems which creates a specific type of (societal) vulnerability. Cascading incidents may also be more complex, larger in scale, and display increased time pressure compared to incidents that don't have cascading effects. It was found that a transdisciplinary approach, in which incident managers transcend their own discipline and actively cooperate across, between, and beyond the input of each involved discipline or organisation, could be most effective in managing the challenges associated with cascading incidents.

In order for emergency response organisations and other stakeholders to optimize their efforts, a structure that facilitates the transdisciplinary approach and mentality is required. This approach has been explicitly described in a step-by-step methodology (IEM) and supported by a tool (IET), guiding users through the transdisciplinary process. The IEM provides a structured approach to the collection of all relevant information and asks for the identification of links, relationships, and dependencies and offers an integrated and holistic view of the incident. When used in the preparation and response phase, this methodology will improve the understanding of the evolution of an incident and lead to better, informed decisions.

Limitations of this document

This report is a condensed summary of the results of the entire CascEff project. It is not beneficial to include the details of each work package and task here; therefore, many references to other deliverables have been included so that the reader knows where to find additional information. It is also anticipated that readers of this document will have widely disparate backgrounds. Chapters 2 – 4 build a conceptual foundation for a transdisciplinary approach (presented in Chapter 4), which may be of particular interest to academics, the research community, and politicians. The recommendations and conclusions in Chapters 5 are written primarily with competent authorities and practitioners in mind.

Nomenclature

The specific definitions of central terms used in this report are listed here. This is an abstract of the report dedicated to the CascEff nomenclature (Deliverable 1.6, CascEff Definitions[1])

Buffer time

The time between the start of an outgoing effect in the originating system and the time before a cascading effect occurs in a dependent system, i.e. when the performance of the dependent system starts to degrade, see Figure 1. The buffer time is the sum of the Propagation time and the Endurance time.

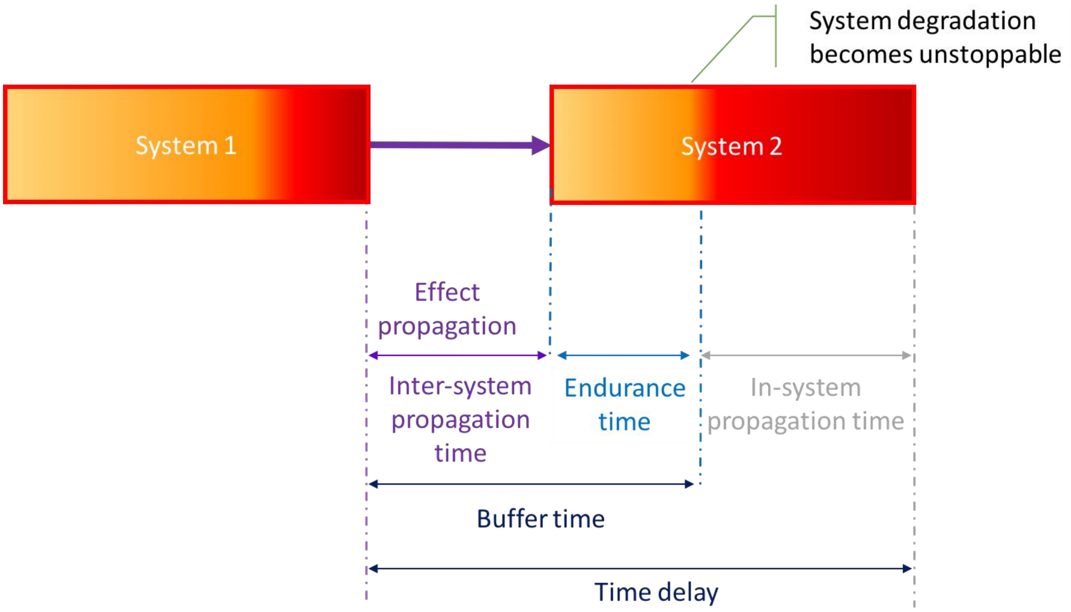

Figure 1 Illustration of Buffer time, Propagation time, Endurance time and Time delay.

Cascade order

The number of stages in a propagation from a directly impacted system to a particular system that is impacted indirectly.

Cascading Effects (Technical definition, e.g. for selection of scenarios)

Cascading effects are the impacts of an initiating event where

1. System dependencies lead to impacts propagating from one system to another system, and;

2. The combined impacts of the propagated event are of greater consequences than the root impacts, and;

3. Multiple stakeholders and/or responders are involved.

[1] CascEff Deliverable 1.6, Glossary and Definitions, 30 June 2016

Cascading Effects (Pedagogical definition)
An incident can be said to feature cascading effects when a primary incident propagates resulting in overall consequences more severe than those of the primary incident.

Conditions
Circumstances that can enable, prevent, aggravate or mitigate dependencies and impacts.

Dependency
Mechanism whereby a state change in one system can affect the state of another system.

Dependent system/Impacted system
A system that is negatively affected by either an initiating event or an originating system.

Event
A singular instance of a phenomenon affecting one or several systems.

Impact
Describes the effect (usually negative) of an incident on a system or, where systems are dependent, on multiple systems. The impact may be measured in one of the five interrelated dimensions: technical, organizational, social, economic and environmental.

Impacted system
A system which is negatively affected by either an initiating event or an originating system.

Incident
Situation that might be, or could lead to, a disruption, loss, emergency or crisis. (EN ISO 22300:2014). In CascEff also the following explanatory definition is used: A chain of events affecting multiple systems, either in series or spreading in parallel.

Incident Evolution Tool
An incident evolution tool is based on a methodology (the Incident Evolution Methodology: IEM) which relies on input from incident data, Incident Management Tools, models or past experience to describe how the impact of an incident on a system may spread to dependent systems. The IET is an informative tool, which can be used for improved crisis management by supplementing the knowledge and experience of crisis managers with additional information as to the likely progression of an incident from initiating event through multiple dependent systems.

Incident management
An ongoing process to prevent, mitigate, prepare for, respond to, and recover from an incident that threatens life, property, operations, or the environment.
(see Emergency management)

Incident Management Tool (IMT)
An Incident Management Tool (or Incident Management System) is actually a toolbox from which an incident commander can pick a tool to assist them in managing an incident (Cote,

2003). An incident management tool can be used for different purposes and during different phases of the incident management cycle: pre-planning, response, debriefing, and training.

The proposed contribution to Incident Management Tools is a means whereby the IET will be able to communicate with existing tools. This means that the IET will form a part of the toolbox from which an incident commander can pick to assist them in managing an incident. The development in the CascEff project will be the ability to draw on information which is presented to the incident commander IC by the IET so that the incident commander can make better informed decisions about their response strategy including, e.g. allocation of capital resources (e.g. equipment), personnel, and knowledge.

Initiating event (initiator)
The first in a sequence of natural (e.g. flood), accidental (e.g. fire) or intentional (e.g. bombing) events that may affect one or several systems. (D2.3)

Interdependency – A mutual dependency between two systems, i.e. system A is dependent on system B and vice versa.

Methodology
Methodology can be defined as a collection of related processes, methods, and tools. A methodology is essentially a "recipe" and can be thought of as the application of related processes, methods, and tools to a class of problems that all have something in common (Bloomberg, and Schmelzer 2006).

Originating system
A system in which a failure propagates to another system. (D2.3)

System
A "system" refers to a distinct societal unit (such as a sector, function, collective, infrastructure or nature resource) which may be affected by, or give rise to, consequences in another unit. (D4.3)

1 Scope, objectives and methodological approach

1.1 Introduction: cascading incidents as a societal challenge

Modern socio-technical systems are increasingly characterized by a high degree of interdependencies. Whereas these interdependencies generally make systems more efficient under normal operations, they also create vulnerabilities that might trigger cascading effects[2]. This induces specific challenges for preparedness, planning and incident response; challenges that exist for both natural and man-made incidents (accidental and intentional).

An escalating incident can quickly become extremely difficult for first responders to handle and lead to severe cascading effects. The incident can ultimately have enormous consequences with respect to life, property and the environment and for both infrastructure and the general public. These consequences can in many situations have both direct and indirect effects, not only in the immediate surrounding geographical area but also across very large areas, potentially extending across borders. In such instances the incident management needs to be as efficient as possible and build on up to date decision support information.

New strategies, structures and methodologies are therefore needed to meet these challenges, including strengthened cooperation in conducting operations and providing or receiving support across borders.

1.2 The CascEff project

The goal of the FP7 CascEff project is to improve our understanding of cascading effects in crisis situations through the identification of initiators, dependencies and key decision points. Based on that knowledge, an Incident Evolution Methodology (IEM) was developed with the aim of strengthening incident management for present and future threats. Furthermore, the IEM has been implemented in a prototype version of the Incident Evolution Tool (IET). The IET is an internet based platform for tactical and strategic levels of incident management supporting decision makers with prediction of incident evolution and identification of key decision points in the cascade.

In order to achieve this goal, the research and development within the CascEff project has been structured around four objectives:

1. **Gaining a better understanding of cascading effects in crisis situations** by the identification of initiators, dependencies in complex systems and key decision points in incident management. This identification methodology is developed in a general sense in order be applicable to a wide range of scenarios that could be experienced by users.
2. **The development of an Incident Evolution Methodology (IEM) and Tool (IET) for predicting past, present and future crisis evolution leading to cascading effects.** The knowledge

[2] CascEff D6.9 Project vision and approach, 2016

of initiators, dependencies and key decision points provided input for the development of an IEM, and a corresponding web based IET that facilitates the use and implementation of the IEM. Both have been developed in cooperation with practitioners such as first responders, incident managers, decision makers and representatives of competent authorities.

3. **Exploring the impact of human activities in a crisis situation.** CascEff studied the impact of human activities in a crisis, specifically in relation to incident response tactics and crisis communication.

4. **Improved incident management for present and future threats.** The development of the IEM and IET aims at facilitating improved incident management throughout Europe by providing an open methodology for understanding and modelling cascading effects in an emerging incident. The project focussed specifically on emergency planning and incident response, but also considered other phases of emergency management. After the project ends, the IEM and the prototype IET are available as a generalised methodology and tool for implementation at a national level and aims at a widespread applicability regardless of national differences in incident management frameworks.

The information and guidance provided via the IEM/IET during planning as well as response, allows first responders to:

- identify potential cascading effects;
- identify key decision points in which the cascade can be broken;
- enable prioritization of decisions and resources.

1.3 Task 1.5 Description

This report corresponds to Task 1.5 of the CascEff project. As described in the Description of Work (DoW), it covers: "*Following completion of the simulated exercises in WP5, the systems and methodologies identified and developed in this work package will be reviewed and any recommendations for improvement of current systems to take account of lessons learned prior to implementation of the revised methodology developed will be made*."

The expected deliverable as described in the DoW is: "*Recommendations for improvement of current incident management in crisis*"

1.4 Scope and structure of the report

This report is the final output of CascEff Work Package 1, "Incident management". Previous work within this work package has covered a comparative study (survey, experts workshop) of incident management in cascade crisis situations (Task 1.1, D1.1 and Task 1.2, D1.2), the design of a methodology for improved incident management (Task 1.3, D1.3) and the elaboration of a methodology for scenarios used for testing of the incident evolution methodology (Task 1.4, D1.4). Furthermore, in order to establish a common terminology for the project and its outputs, a CascEff glossary was established (D1.6)[3].

The aim of task 1.5 is to provide general considerations and recommendations arising as a result of the CascEff project, providing a conceptual incident management framework that will improve the quantity and quality of information provided to an incident commander in order to facilitate improved decision making.

This report thus creates a synthesis of the main research findings of the project, retaining the perspectives of all work packages. It gives an integrated description of aspects related to the four project objectives, explaining:

- characteristics of incidents, incident management challenges and a better understanding of cascading effects in Chapter 2;
- incident management practices, the actors involved, merits and shortcomings of multidisciplinarity in Chapter 3;
- a methodology for improved incident management, based on a transdisciplinary approach, in Chapter 4.

The overall focus of the report is to provide recommendations for improvement of incident management based on a better understanding of cascading effects, including a clarification on the added value of the CascEff IEM/IET. Recommendations on improved incident management are provided throughout the text, including recommendations related to the use of the IEM/IET. Chapter 5 consists of a summary of the most important lessons learned and a comprehensive collection of related recommendations.

1.5 Link to other project results

Major sources of input to these recommendations on improved incident management are elaborations of previous studies of incident management executed in WP1 and learnings on the impact of the simulated exercises of WP5.

In work package 1, we have reviewed current incident management practices and identified opportunities for improved incident management as a result of information provided by the project's Incident Evolution Tool. At the beginning of the work, a workshop held with the CascEff external expert advisory board (EEAB) provided understanding of their interpretation of cascading effects and their needs in response to these types of incidents[4].

Deliverable D1.2 *Report on incident management in crisis* reports on a wider review of incident management methods in crises, and details incident management practices, how agencies

[3] See CascEff Deliverables D1.2, D1.3, D1.4 and D1.6.

[4] D1.1 Workshop with EEAB, 2014

respond to incidents with cascading effects and how they handle cross border and inter-agency collaboration. Different enablers and challenges are also described and discussed. This information is gathered from a series of interviews and questionnaires which were distributed by the consortium to different actors.

In D1.3. *A Flowchart for improved incident management*, a methodology for improved incident management was developed. The revised version (June 2017) forms the basis of the recommendations on improved incident management provided here, and a comprehensive, updated version of the deliverable is attached to this report.

Deliverable D1.4 *Report on scenarios to be elaborated for testing the incident evolution methodology* describes the methodological approach for the elaboration of scenarios which are to be used for the evaluation of the incident evolution tool, as well as for testing its use in the improved incident management methodology. In D1.4 the scenarios are described in terms of the fictional or historical event which led to the definitions of these scenarios, and although interdependencies are identified, cascading effects are not fully elaborated here.

The further elaboration of the scenarios was the main focus of deliverable D5.1. *Description of selected scenarios*. A basic methodological approach for the organisation of validation sessions was also included in this report, because of the obvious link with the purpose of scenario elaboration. This was further developed in Task 5.2 *Initial testing and feedback to WP 1-4*.

Furthermore, work within WP2 provided knowledge derived from the analysis of previous incidents with regard to originator, dependencies and consequences. In particular, D2.2, reporting on a review of previous incidents involving cascading effects, and D2.3, listing identified originators and dependencies in studied incidents and the conditions which lead to cascading effects, added understanding on the nature and characteristics of cascading effects.

Sources of input to these recommendations were also found in WP3, with the objective of developing a methodology for communication and coordination during crisis situations that reflects the roles of the public, media, first responders and incident managers. Specifically, material was drawn from D3.2 *A report on human behaviour in a crisis situation and the effect on the course of events* and D3.3 *A strategy for communication between key agencies and members of the public during crisis situations including the use of social and traditional media channels in crisis scenarios*.

1.6 Methodological approach

During the project, the methodology differed per task in accordance with the topic and aspects to be developed: input from practitioners for the identification of their needs (D1.1, D1.2) and current tools (D4.1) based on surveys and interviews; academic research for a better understanding of cascading effects (WP2), technical research and development for the IE

Methodology and Tool (WP4), with the participation of practitioners for technical testing, focus groups and validation sessions (WP5), academic research, complemented with expert opinions on human behaviour & communication in crisis situations (WP3), comparative analysis of literature and national guidelines for the elaboration of scenarios (D1.4) and their use as an instrument for a better understanding of the evolution of an incident (WP5), comparative analysis of literature and national guidelines for the identification of opportunities for improvement of incident management (D1.3).

Most aspects were thus viewed from different angles: academic, expert views, discipline specific or generic.

2 Challenges of Incident management

Incident management is the term used in the CascEff project[5] to refer to the management of a situation or event that leads or could lead to damages, losses or disruption. ISO 22300:2012 also adds emergency and crisis as the consequences of such an event. In other sources, such as national practices and literature, the terms incident management, emergency management, disaster management and crisis management are sometimes used interchangeably, as synonyms.

Because of the variety of definitions, it is relevant to identify common aspects covered by these synonyms in order to highlight the specific characteristics that describe incident management. It is all the more important because the internationally accepted definitions[6] of incident/emergency/disaster management primarily refer to the main activities of the incident management process, without including further indication about the specific characteristics and challenges that differentiate it from the management of daily, routine safety and security relief and rescue operations.

2.1 Key characteristics of incidents with and without cascading effects

2.1.1 Key characteristics of incidents

Common characteristics of incidents can be found in comparative studies of legal definitions at a national level and definitions found in guidelines, good practices and literature[7]. Here, key characteristics of incidents are identified as:

1) A certain level of **complexity** of the situation, as a result of multiple hazard causes and/or multiple consequences;
2) **Uncertainty** as an intrinsic part of incident management, which can be subdivided into ignorance, uncertainty and indeterminacy;
3) Time pressure or a sense of **urgency** to remedy the situation;
4) A certain scale of damages or a serious or imminent threat of potential damages of a certain **scale**.

These four cumulative characteristics distinguish incident management from daily, routine rescue operations, such as firefighting, police, medical or environmental interventions. They require a specific type of management, often including multidisciplinary interventions demanding a certain level of coordination.

[5] CascEff D1.6 Glossary and definitions (2016)

[6] Such as from ISO and NFPA

[7] CascEff D1.4(2), 2016, Brugghemans et.al., 2015; University of Leicester, 2011

2.1.2 Key characteristics of incidents with cascading effects

In order to understand the differences and communalities of incidents with and incidents with cascading effects, it is essential to first explain the nature of cascading effects and gain further understanding on their impact on incident management.

2.1.2.1 What are cascading effects?

An incident can be said to feature cascading effects when a primary incident propagates resulting in overall consequences more severe than those of the primary incident[8].

A more technical definition is provided by Reniers and Cozzani[9] who define cascading effects as the impacts of an initiating event where

1) System dependencies lead to impacts propagating from one system to another system, and;
2) The combined impacts of the propagated event are of greater consequences than the root impacts, and;
3) Multiple stakeholders and/or responders are involved.

As summarized by Pescaroli and Alexander[10]: "*Cascading effects are the dynamics present in disasters, in which the impact of a physical event or the development of an initial technological or human failure generates a sequence of events in human subsystems that result in physical, social or economic disruption.*"

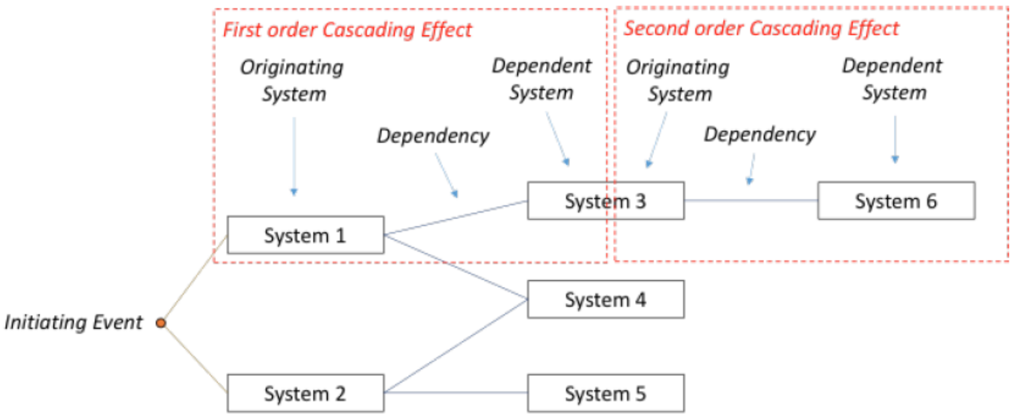

Figure 2 Conceptual model of the propagation of effects between systems in an incident that involves cascading effects[11].

[8] CascEff D1.6 Glossary and definitions (2016)

[9] Reniers, G; Cozzani V. (2013)

[10] Pescaroli, Gianluca and David Alexander (2015)

[11] CascEff D2.1, A methodology for analysing incidents involving cascading effects (2014)

In Figure 2 it can be seen that an incident always starts with an initiating event, for example a natural event such as an earthquake, an accidental event such as an explosion, or an internal system failure such as malfunctioning of a technical component. This initiating event in an originating system may then affect one or several systems (System 1 and System 2). Originating systems are all systems that transfer the effect to another, dependent system. Due to dependencies to other systems, cascading effects may arise when impacts arise in other systems (Systems 3, 4, and 5). Returning to the example above, the initiating event may be a fire in a power station happening in the power system, i.e. the originating system called System 1 in Figure 2. Cascading effects arise due to a dependency between the power system and the railway system (System 3). If this impacted system gives rise to additional impacts to other system, there is a continuation of the cascading effect. The first resulting effects from directly impacted systems from the initiating event to dependent systems are defined as “first-order cascading effects”. If this line of propagation continues, second, third, etc. order cascading effects arise.

Within the CascEff project, 22 systems have been identified that could be affected in case of cascading effects:

Categories	No.	Description and exemplification
Power supply	1	Activities and assets that ensure continuous supply of electric power from suppliers to customers, e.g. production, transmission and distribution of electric power.
Telecommunication	2	Activities and assets that ensure electronic communication of information over significant distances, e.g. landline and mobile phone systems, Internet, servers, etc.
Water supply	3	Activities and assets that ensure continuous supply of water from suppliers to customers, including pipes, pumps, water treatment plants, infiltration areas, etc.
Sewage	4	Activities and assets that collect and treat wastewater and day water, such as treatment plants, drain pipes, etc.
Oil and gas	5	Activities and assets that ensure continuous supply of oil and gas products, e.g. production, distribution and processing of oil and gas.
District heating	6	Activities and assets that ensure continuous supply of hot water for heating houses and premises, e.g. heating plants, pumping stations, water pipes.
Health care	7	Activities and assets that provide professional services to people in order to achieve or sustain mental and physical well-being and prevent illness and impaired health, e.g. emergency care, primary care, elderly care, child care, medicine distribution and production, disease control, etc.
Education	8	Activities and assets that contribute to a formalised transfer of knowledge, e.g. primary school, secondary school, universities, etc.
Road transportation	9	Activities and assets that enable transportation of people and goods on roads, e.g. road networks, bridges, tunnels, road maintenance activities, etc.
Rail transportation	10	Activities and assets that enable transportation of people and goods on railways, e.g. railway networks, subways, trams, signal systems, maintenance activities, etc.
Air transportation	11	Activities and assets that enable transportation of people and goods by airplane, e.g. airport operations, flight management, airspace security, etc.
Sea transportation	12	Activities and assets that enable transportation of people and goods by sea, lake and waterways, e.g. port operations, shipping industry, etc.
Agriculture	13	Activities and assets related to the cultivation of animals and plants in order to support e.g. food, biofuel and medical production, farming, livestock, etc.
Business and industry	14	Activities and assets that enable the production and exchange of goods and services to customers. Activities and assets covered in other categories are excluded here.
Media	15	Activities and assets that enable the dissemination of news and other information in society, e.g. radio, television, newspaper, social media, etc.
Financial	16	Activities and assets related to the continuous provision of economic services performed by the financial industry, e.g. insurance, cash availability, central banking system, credit cards, etc.
Governmental	17	Activities and assets that enable the provision of governmental/public services at local, regional and national levels, e.g. municipal government, county administration and national agencies. Activities and assets that are covered in other system categories are not included here.
Emergency response	18	Activities and assets that are necessary to respond to acute events where human life and health, environment or property is threatened, e.g. rescue services (land, sea, etc.), police, ambulances, emergency care, national guard, etc.
The public	19	People in a society or a community and their ability to live a normal life where they have continuous access to the services that characterise a modern society
Environment	20	Flora (i.e. all types of plants), fauna (all type of animals) and the ecosystems in which they habituate, e.g. sea, ocean, forest, etc.
Political	21	The political leadership on local, regional and national level
Food supply	22	Activities and assets that are necessary to produce and distribute food to people, e.g. food producers, wholesaler, food inspections

Table 1 System categories and how they are defined in the CascEff project.

2.1.2.2 **Between which systems do cascading effects occur?**

The detailed analysis of 40 events involving cascading effects[12] (see Figure 3) shows that the two most frequent cascading effects between systems are *'Power supply' to 'Business & industry'* and *'Power supply' to 'The public'. 'The public'* is often represented as an impacted system (i.e. most events have an impact on the public). Parallel to this, the behaviour of *'The public'* frequently has an impact on the functioning of other systems, such as overloading telecommunications systems during emergencies. The most common originating systems were identified to be *'Power supply'*, *'Telecom'* and *'Sewage'*, while common impacted systems are *'Business & industry'*, *'The public'*, *'Health care'* and *'Education'*.

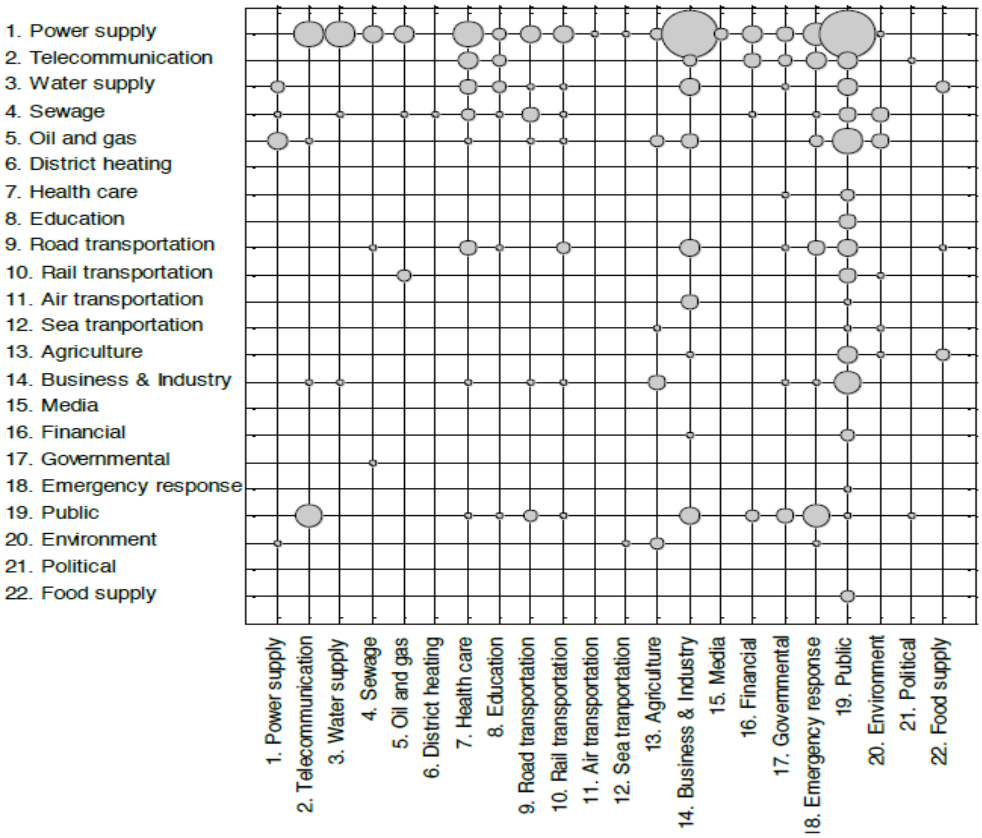

Figure 3 Frequency analysis of the cascading effects between originating systems (y-axis) and impacted systems (x-axis). Large circles represent more frequent cascades.[13]

Some systems are more frequently involved in events, irrespectively of the type of initiating event. While, as already mentioned, *'Business & industry'* and *'The public'* are frequently represented systems, the systems *'District heating'*, *'Media'* and *'Political'* are only represented a few times – concluding that both *'The public'* and *'Businesses & industries'* seems to be

[12] CascEff D2.3 A list of identified originators and dependencies in studied incidents and the conditions which lead to cascading effect

[13] Figure 5.1 of CascEff D2.3

dependent on a number of other systems, in fact in some sense receiving systems of cascading effects, and a failure in any one of these systems leads to consequences.

2.1.2.3 **Geographical scales.**

Initial events can vary significantly in term of the geographic extent of the first impact area. In general, weather-related events such as hurricanes and heat waves tend to impact a larger area, while other initiating events such as fires and volcanic eruptions impact smaller areas.

2.1.2.4 **Coping capacity**

The most notable mitigating condition in the case of an incident with cascading effects is identified as coping capacity, primarily in terms of external resources but also concerning buffers, structural integrity and preparedness plans. Other common mitigating conditions are the operational state (above normal capacity) and favourable timing of the event in terms of time of day and weekdays. Furthermore, CascEff results indicate that the most aggravating condition is when the operational state is below normal capacity and also when the coping capacity (buffers and external resources) were below normal. Other aggravating conditions are location (e.g. metropolitan vs. rural area), timing of the event (specifically the season) and the current weather conditions.

2.1.3 Key characteristics of incidents with cascading effects

Given the definition of incidents with cascading effects used in the CascEff project, the key characteristics of incident management discussed in paragraph 2.1.1 will to a great extent apply to both incidents with or without cascading effects. These can be considered to be generic characteristics of incident management, regardless of the type, nature or scale of the incident.

However, there are some dissimilarities. For large-scale incidents, the scale and extent of the damages is emphasized in the denomination. For incidents *with cascading effects*, the main differentiating criterion is the '**multicause/multihazard and multiconsequence** aspect' that is a consequence of system dependencies. This general hallmark of incidents with cascading effects results in a number of specific characteristics that can be summarized as follows (CascEff D1.3(2), 2017):

- The **level of complexity** *might* be higher, because of the fact that dependencies create additional risks and a possible chain of events;
- The **level of uncertainty** might be higher, especially the **level of indeterminacy**, which refers to the lack of an overview and overall insight in the system as a whole and/or because of institutionalised fragmentation of information and knowledge and the lack of insight in links, relations and dependencies;
- Time pressure and the sense of **urgency** will not necessarily be different for cascading incidents, but might be bigger because of the multiple consequences to handle, or in case

multiple consecutive events differ in nature and require other first response disciplines to be called upon;

- The additional notion of **buffer time** is specific for cascading incidents;

- Cascading effects do not per definition involve large scale damages. Since dependencies and the corresponding vulnerabilities are omnipresent in today's society, a second (or n) order event can occur as a consequence of minor events as well. The notion of 'incidents with cascading effects' is generally **reserved for more severe events**, fulfilling the aforementioned criteria for incidents (complexity, uncertainty, urgency, scale).

In conclusion, the difference between incidents and large-scale incidents can be said to be a matter of gradation, inducing possible higher complexity, uncertainty and urgency as a result of bigger consequences in terms of scale. An overview of how common key characteristics of incident management relate to different types of events is summarized in Appendix 1. The main difference between incidents with or without cascading effects is not a matter of gradation, but of a different type of vulnerability, as a consequence of diverse system dependencies. In an incident with cascading effects, effects spread between systems, highlighting the importance of vulnerabilities and dependencies between societal systems. The final total consequences are as a rule significantly larger than the initiating event (however large or small). As a consequence, in an incident with cascading effects there might well be more complexity and a higher level of uncertainty (especially indeterminacy), and the scale might be bigger according to the number (and type) of impacted systems.

2.2 Challenges of incident management

2.2.1 Dealing with complexity, uncertainty, urgency and scale of the incident

By their nature, incidents are unique and differ with regards to a number of variables such as occurrence agent and magnitude, incident dynamic, number of societal systems affected, risk for escalation, composition of stakeholders and responding agents.

The four key characteristics of incident management illustrate the challenges that incident management logic and procedures have to deal with. These are clarified in the following paragraphs:

2.2.1.1 Complexity

Incident management involves a certain level of complexity, which is determined by factors such as the concrete hazards, possible consequences of the incident and (consequently) the profile and number of actors involved, the specificity of their modi operandi, the boundaries of their assignment, their focus and knowledge etc.[14]

[14] Brugghemans et.al., 2015; Van Heuverswyn, 2009a; Stirling and Calenbuhr, 1999; Viaene, 1998

- **Possible multi hazards**: the causes of incidents can be natural and/or man- made, accidental and/or intentional. Every incident, from small to large scale, is a specific, often unique, configuration of a multitude of factors.

- **Multiconsequence:** not only the hazards, but also the nature and scale of the consequences determine the appropriate interventions for the first response as well as for other disciplines involved. Consequences of incidents can, for example, include or combine in different combinations the presence of victims, material damages, impact on transportation or other critical infrastructure.

- **Actors and disciplines:** Both hazards and possible consequences determine the actors involved in the incident. Incident management is complex because it is intrinsically multidisciplinary, encompassing multiple actors from different disciplines and services, belonging to different authorities (see extensive explanation in D1.3(2), 2017). They also represent different levels such local, regional, national or cross border (different hierarchical lines).

- These actors also include the public, such as the citizens of a community impacted by a disaster, and the virtual cross border spaces they inhabit, i.e. social media. This adds to the complexity of multiple actors' management, and highlights the vital role that expertise on human behaviour and mediated communication can play in preventing or curtailing further damage or affecting the scale and nature of the consequences of a disaster[15].

- **Modi operandi**: all actors involved have their specific (and limited) assignment, tasks and corresponding operating procedures.

- **Knowledge**: all actors' interpretation of an incident is based on their subjective reference frame, shaped by their discipline. Incident response interventions oblige those actors to work together towards a common goal that transcends their respective assignments and powers[16].

2.2.1.2 **Uncertainty: ignorance, uncertainty and indeterminacy**

Uncertainty is a broad notion which can be subdivided into[17]:

- **Ignorance**, which means not being aware of a problem or not being aware that information or knowledge is lacking.

- **Uncertainty,** referring to the awareness of lack of information or knowledge. In this case, incident managers are aware that information and state of the art knowledge might be

[15] This has been the focus of much of the work done in CascEffs work package 3, First responder tactics, human activities, interaction and behaviour.

[16] Van Heuverswyn, 2009c

[17] Van Heuverswyn, 2009a

insufficient or unavailable, or that they lack the skills to deal with the information e.g. in case of overload of information and not being able to create a global picture.

- **Indeterminacy**, which describes a specific type of uncertainty as a result of fragmentation of available information and knowledge[18]. This is caused by the fact that some challenges transcend the boundaries of existing disciplines[19] and/or e.g. because of lack of insight in the system. This is in part a result of specialisations that are too monodisciplinary, that involve a single discipline. Incident managers might be unaware of information and knowledge available elsewhere in the system or might lack insight in interactions, interrelationships, interdependencies, possible synergies, etc.[20].

As many authors and incident managers stress, *reducing* uncertainty is of crucial importance, but *eliminating* uncertainty is an illusion, and thus uncertainty should be considered as a constituent element in every decision-making procedure[21]. However, ignorance and lack of information can be reduced as a continuous process of developing more information and knowledge. Indeterminacy on the other hand, which is often underestimated or neglected, can primarily be reduced by providing more insight in how the society as a whole (as a system) works, paying attention to links between subsystems and processes in terms of relations, interactions, interdependencies, etc. Rather than by the availability of more information alone, indeterminacy is reduced by more knowledge about the links and interdependencies of our society. Providing an improved methodology to facilitate this greater understanding is a keystone of the Incident Evolution Methodology (IEM) presented later in this report.

2.2.1.3 **Time pressure and a sense of urgency**

The big challenge of incident management is that a variety of actors have to deal instantly with a range of aspects, often in a chaotic environment. The actual occurrence or threat of serious damages, and the actual or possible disruption of critical societal functions and social life, create a sense of urgency and have to be dealt with. During the response phase, there is limited time to gather relevant information and virtually no time to generate or develop new information/knowledge[22].

2.2.1.4 **Scale of the damages, threat, or potential damages**

Incident managers are regularly confronted with situations having considerable real, possible or probable damages. It is their responsibility to take appropriate measures to reduce the impact, by ensuring a status quo, remedying the situation, containing the damages and the restoration

[18] Stirling en Calenbuhr, 1999

[19] Lierman, 2004; Craye et.al., 2001; Wynne, 1996

[20] Stirling en Calenbuhr, 1999

[21] Brugghemans et.al., 2015; Van Heuverswyn, 2009a; Seillan, 2005; Stirling en Calenbuhr, 1999; Stirling, 1998

[22] Brugghemans et.al., 2015

of normality. The scale of the impact will often determine the level of interventions (local, regional or national), mainly because of the required resources to provide for an appropriate response. Every country has its own criteria for scaling up or down, they are either legally defined (de lege) or based on common practices (de facto).

Incidents and large-scale incidents differ as to the scale of the impact and the required resources to manage the situation. The qualification of large scale is often a subjective decision, taken by the incident commanders or the competent authorities.

2.2.2 Managing diversities of organisation and structure

While dealing with the complexities, uncertainties, time pressure and substantial consequences that characterize large scale incidents, incident management also needs to relate to a number of inherent structural and organisational diversities that have been identified within the CascEff project.

2.2.2.1 Actor heterogeneity

One evident diversity that impacts the process of incident management is **actor heterogeneity** with regards to e.g. differences in goals, logistics, capabilities, training, equipment, terminology, language, leadership and cultural practices. The CascEff results suggest that actor heterogeneity can have numerous consequences both within and between organizations[23], such as:

- Common operational pictures are often incomplete. Problems often relate to working methods and data sources.
- Judgement and analysis are often based on sub-units' "own information" rather than the aggregate of all units' information.
- Judgement and analysis often lack a joint perspective.

2.2.2.2 Technical diversities: interoperability and standardization

Each actors or organisations level of preparation, knowledge, readiness and resilience determines its individual ability. Furthermore, today's highly interconnected and tightly coupled society means that incidents often develop faster and affect greater portions of society compared to 10-20 years ago. As a result, actors are today more dependent on each other than before, and incident management today is multi-actor as a general rule.[24]

As discussed above, the success of incident management actions is ultimately determined by the total ability of the constellation of actors involved. Such joint ability requires instant **interoperability**, meaning the ability to cooperate and collaborate on short notice. This ability,

[23] CascEff D1.2 Report on incident management in crisis, Dec. 2014

[24] CascEff D1.2 Report on incident management in crisis, Dec. 2014

however, does not readily fall into place when faced with a major incident, but rather needs to be established before an incident occurs. There are keys for the incident management community to achieve this instant interoperability: standardization and a culture of understanding the perspectives of others.

Common efforts that respond to the challenge of attaining **standardisation**[25] include terminology, operational picture formats, technical interfaces, information management strategies and decision-making processes. However, the process of progressing standardisation has generally speaking been slow. While there is evidence that standardization efforts have had a positive impact, actors rarely embrace standards fully and to the letter. Instead, the standards are subject to interpretation and adaptation to the actors' legislative environment, resources, core mission and culture.

2.2.2.3 **Inter-agency and cross border collaboration**

All countries studied within the scope of CascEff have the same three core emergency response agencies: police force, fire and rescue service, and the ambulance service. In addition, rescue agencies such as the coast guard, air sea rescue, border guard or customs, water rescue, mining rescue, mountain rescue and other activity specific search and rescue agencies were identified as important actors. Besides these traditional emergency services, other political offices and non-governmental agencies or the private sector were identified by incident management experts as potential contributors to the response to crisis scenarios, for example government departments for social welfare may assist in large-scale incidents[26]. NGOs are also identified as potential contributors to crisis response, including for example the Red Cross and the POSOM organization in Sweden. Another potential contributor to emergency response is the military, primarily in instances where the incident response exceeds the capacity of the civilian services.

While the available response agencies were relatively similar across the responding countries, there were significant differences between the levels of government responsibility for providing the emergency services. For example, some countries may have a fire and rescue service which is provided and administered at a local level whereas some may have this service provided at a national level. In Finland and France, the level of government responsible is noted as depending upon the scale of the incident; although for small incidents provision of emergency services is reported on a local or municipal level (see also CascEff D1.3(2), 2017).

Figure 4 summarizes the provision of emergency services, indicating the level of government responsible for the different services. However, reality is frequently more complex; for example,

[25] For example, FEMA offers the National Incident Management System (NIMS) which is a core set of concepts, principles, procedures, organizational processes, terminology, and standard requirements. The International Organization for Standardization (ISO) has issued a standard for emergency management (ISO 22320:2011(E), the National Fire Protection Association has issued NFPA 1600: Standard on Disaster/Emergency and Management and Business Continuity Programs.

[26] D1.2 Report on incident management in crisis, Dec. 2014

city police are noted as being provided on a local level in Poland, although a national police service is also present.

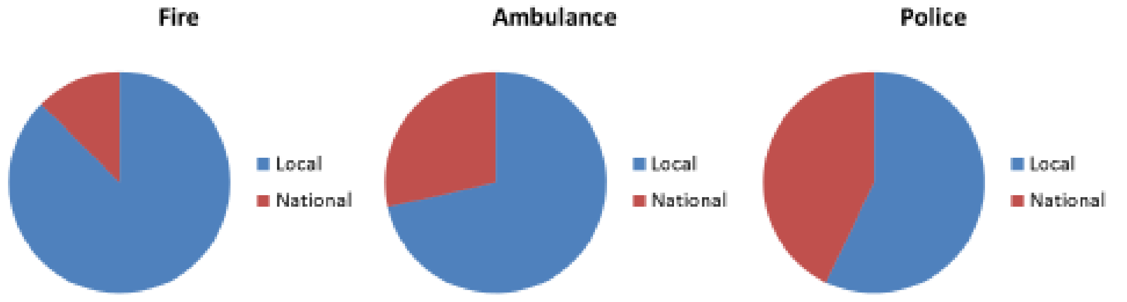

Figure 4 Summary of level of government responsible for the provision of emergency services based on an average of all responding countries (note that the Netherlands have both national and regional police forces[27]***)***

Generally, there are some established provisions for cooperation between these emergency services. Also, there are some means for sharing information between the different emergency services, although it is not always a formalized system. In Belgium, the Netherlands and France, for example, information is shared via an operational command centre which is responsible for gathering and distributing all information to the different responders. In Ireland a task force is put in place at the national coordination centre for managing of information, although a more formalized incident management information technology communications system is under development.

With regards to the command structure, the majority of the studied countries have a similar structure where one individual has the overall responsibility for incident command. Under this individual, there may be commanders of the individual rescue services. Here Italy and Sweden are exceptions; all emergency services retain their own incident commander and command structure although they are required to collaborate during the execution of the response. Most countries require a local commander on site but for very large incidents this individual may answer to an off-site commander.

In summary, different countries studied in CascEff have the same or similar composition of rescue services, potentially allowing for good collaboration and cooperation between countries. However, these services are often provided on different government levels by different countries, which, together with structural differences between different agencies, cause potential problems both within countries (which are easily addressed) and between countries (which are less easily addressed).

In general countries seem to maintain the capacity for both providing and receiving assistance for escalating incidents, both from their neighbours and from other EU-member states[28]. By and

[27] CascEff D1.2 Report on incident management in crisis, Dec. 2014

[28] CascEff D1.2 Report on incident management in crisis, Dec. 2014

large, provisions for interagency response and cross border collaboration in the case of large scale events are in place, links with neighbouring countries' emergency services are either centralised or maintained by individual municipalities, and joint exercises take place in order to test cooperative ability. All countries uphold centralised links to relevant EU offices (such as the EU Emergency Response Coordination Centre) that coordinate mutual aid and manage member states requests for assistance.

Specific cross border challenges

Besides the previously identified challenges of management of incidents, a few additional organizational challenges seem to mostly affect work across organizational borders. These primarily concern familiarity and knowledge about other organizations, and dealing with the incident in terms of information management and decision making. Common challenges are often more difficult to handle on both sides of the border, such as[29]:

- responsibilities, roles and mandates for cross border actions are indistinct;
- people are not familiar with each other's and other organisations responsibilities, roles and mandates;
- people do not know what resources others need and can contribute with;
- common operational pictures are often lacking;
- concrete recommendations for decisions are often missing.

Prepare for cross-border events.

For cross border events, generally no overall coordination or management body is installed as a result of distinct jurisdictions. Arrangements mainly cover alerting, exchange of information and assistance. If countries affected by a common incident make use of the same methodology and tool (such as the Incident Evolution Methodology described in Chapter 4), they would benefit in terms of:

i. improved exchange of information as a result of using the same format to assess the risk and evolution of the incident as well as using a common terminology;
ii. a speedier and more efficient alert process as different time aspects are taken into account in the methodology (e.g. buffer time and propagation time);
iii. enhanced opportunities for optimal assistance across borders, resulting from a better understanding of potential incident development paths, the identification of priorities and key decision points, as well as a greater understanding of available resources and opportunities for cooperation and mutual assistance;
iv. identification of cross border dependencies and vulnerabilities.

In other words, using a common methodology and tool makes it easier to overcome the lack of a common cross-border management structure: it is an operational way to achieve better mutual understanding and collaboration, without touching complex institutional and legal aspects. This does not only refer to national borders, but also borders within or between different regions.

[29] CascEff D1.2 Report on incident management in crisis, Dec. 2014

3 Practices for successful incident management

In essence, incident management can be described as an ongoing process to prevent, mitigate, prepare for, respond to, and recover from an incident that threatens life, property, operations, or the environment. Given the wide range of possible incidents and circumstances, the details of this process vary and are a consequence of the set of actors involved and the context at hand.

In the following subchapter, three common incident management practices that have been identified within the CascEff project are presented:

- Preparation, through emergency planning;
- Coordinated response, through specific structures for strategic coordination and operational command;
- Information management before and during the incident.

Due to its merits for interoperability, communication is dealt with as a separate aspect in the ensuing subchapter. Issues that are discussed cover:

- Creating a common operational picture despite diverse objectives and foci;
- Dealing with diverging strategies for managing an incident;
- Communicating the underlying rationale for decisions to a wide range of stakeholder;
- Communication with a wide range of stakeholders.

As the early detection of potential cascading effects is both desirable and efficient, a subchapter is dedicated to knowledge regarding the identification of cascading effects.

As previously established, it is the total joint ability of the constellation of actors that in the end determine the success of incident management efforts (CascEff D1.2, 2014). Crucial in this joint ability is the capacity to view incidents from a systems perspective, in other words understanding not only which parts of a system are involved but also how these different parts relate to each other and function as a whole. Building on this argument, the connection between risk and incident management processes is established, and the concepts of multi-, inter- and transdisciplinarity introduced.

3.1 Current Incident management practices

The core practices for dealing with incident management challenges are: emergency planning and the creation of a specific organisation for response, both based on a multidisciplinary approach[30].

Legislation, literature, practices and models show and stress the importance of sound preparation for an optimal response, whether formally by emergency planning or by other

[30] Van Heuverswyn, 2009b; Bremberg and Britz, 2009; Van Heuverswyn, 1998

means[31]. Both activities, planning and coordinated response, require input from a broad variety of different actors and specific mechanisms to integrate the multidisciplinary input to support well-informed decisions.

In CascEff D1.3, *three common practices to deal with incident management challenges* were identified:

- Preparation, through emergency planning;
- Coordinated response, through specific structures for strategic coordination and operational command;
- Information before and during the incident.

3.1.1 Preparation through emergency planning

The context in which incident management actors operate is almost always complex, dynamic and uncertain. This means that decision making needs to be able to deal with assumptions. As a consequence, the basis for **successful incident management is to a great extent set before the incident**, in terms of planning, preparation, training and anticipation. In addition, the need to manage lessons seems to be universal to the community.

The preparatory work of writing emergency plans contributes to[32]:

- the establishment of familiarity amongst all involved actors;
- the identification of available expertise;
- the identification of hazards and risks;
- a clear definition of roles and responsibilities;
- the implementation of standards, agreements and procedures;
- the identification of weaknesses and strengths of the whole system;
- the clarification of language and meanings.

Alexander (2005) also identifies some criteria for optimal Emergency Planning:

- The plan should be coordinated with other government levels (than those legally responsible for the plan) and neighbouring institutions;
- One of the objectives is to allocate appropriate resources to the needs in an appropriate and faster manner;
- The plan should take into account realistic hazard and risk assessments related to the area of application;
- The plan has to contemplate urban planning knowledge regarding hazardous areas and critical facilities;
- The plan should present a full set of resources needed during its implementation;
- Part of the plan should focus on processes and procedures;
- Roles and responsibilities should be adequately indicated;

[31] CascEff D1.3(rev), 2017

[32] Alexander (2005)

- The disaster cycle should be always included into the plan;
- The plan should integrate arrangements for other public and private bodies;
- The plan should be constantly under revision and frequently tested.
- The plan reduces uncertainty during the preparation and response phases as a result of the multidisciplinary effort to exchange information (on risks, available resources, procedures, etc.) and to deliberate in order to align actions, prepare measures, allocate available resources, etc.
- If scenarios are included in the planning, the elaboration of these scenarios will provide an understanding of complexity and insight in (inter-)dependencies, thus reducing indeterminacy;
- Emergency planning ensures gain of time in the response phase.

The use of scenario elaboration can facilitate improved quality of information for emergency planning and response decisions

The task of elaborating scenarios enables the transformation of static data on actors, resources, risks etc. into contextualised and applicable information, relevant for both emergency planning as well as incident management. The use of scenarios requires the identification of relevant risks or incident information, and also putting it into perspective, based on possible evolutions of the incident.

The IEM described in chapter 4 supports scenario elaboration by obliging risk & incident management team members to identify the relevant information for a specific case (geographical, functional etc.), as well as indicating the possible evolution of the incident and the identification of key decision points

3.1.1.1 **Preparing for incidents with cascading effects**

The approach, elaboration process and content of emergency plans for incidents with cascading effects is basically identical to those of other incidents. *However, the effort will be more substantial due to the higher level of complexity, the greater number of actors involved, and the greater need for information on vulnerabilities that is required because of dependencies*. For countries and organizations working with scenarios, identifying cascading effects and the specific means to deal with them is part of the scenario elaboration and might result in specific scenarios.

As many authors and incident managers stress, *reducing* uncertainty is of crucial importance, but *eliminating* uncertainty is an illusion, and thus uncertainty should be considered as a constituent element in every decision-making procedure[33]. However, ignorance and lack of

[33] Brugghemans et.al., 2015; Van Heuverswyn, 2009a; Seillan, 2005; Stirling en Calenbuhr, 1999; Stirling, 1998

information can be reduced as a continuous process of developing more information and knowledge. Indeterminacy on the other hand, which is often underestimated or neglected[20], can primarily be reduced by providing more insight in how the society as a whole works, paying attention to links between subsystems and processes in terms of relations, interactions, interdependencies, etc. Rather than by the availability of more information alone, indeterminacy is reduced by more knowledge about the links and interdependencies of our society. Providing an improved methodology to facilitate this greater understanding is a keystone of the IEM presented later in this report.

Improve the preparation process by cataloguing and detailing specific information for easy availability

As successful incident management is to a great extent determined by proper preparation and planning. This includes detailing specific information on systems within the area covered by the emergency plan. A specific recommendation is to assemble the emergency planning team responsible for obtaining, maintaining and updating the information stored in the IET so that its references are as accurate as possible when using the tool in the response phase. This way, a library of studied systems and cases can be created.

As stated in this report, indeterminacy can be reduced by providing more insight in how the society (as a system) works. Setting aside resources for continuous work with cataloguing and detailing information, paying attention to interdependencies and links between subsystems and processes will add context and relevance to the preparation process.

3.1.1.2 Preparing for cross border incidents

Specific arrangements might need preparation in case of incidents with cross border impact. In the case of crossing national borders, national jurisdictions limit the action radius of the emergency planning. Only formal bilateral agreements between the two or three bordering countries can provide for a legal basis – a legal ground or mandatory obligation – for exchange of information and collaboration[34].

3.1.2 Coordinated response and multidisciplinary structures

As a general rule, no local, regional or national organizations, institutions or services have the mandate, power or jurisdiction over other organizations (with some few exceptions). This also applies to incident management within national borders. This means that a single event can be simultaneously managed as a police operation under Police regulations, an emergency medical operation under the Health Care regulations and a fire and rescue operation under the Civil

[34] CascEff D1.2, Report on incident management in crisis, 2014

Security regulations. This occurs at basically any type of event where different organizations are alerted, ranging from minor accidents to large scale incidents. The overall intervention is based on interaction and collaboration, which needs to be assessed, prepared and tested in advance[35].

Incident management differs from daily, routine operations because of the shift from monodisciplinary interventions (possibly joint) to a multidisciplinary management of the event. This demands appropriate structures to avoid conflicts, align actions, and ensure collaboration. Two complementary mechanisms are observed: monodisciplinary command and control and a superposed level where the monodisciplinary command structures are coordinated.

3.1.2.1 **Monodisciplinary Command and Control**

In this structure, all the actors involved in incident management have their own command and control structure, which refers to the way they are organised internally. In some countries, this is documented in monodisciplinary emergency plans. The concept of command capacity is defined as the organization's capacity to manage itself in relation to its surroundings. The purpose of leadership and a command system as part of an operation is to be able to perform operations efficiently, effectively and safely.

Command and Control has its origin in military and policy terminology. It has since been developed to a more generic term for decision making in situations with incomplete information and time pressure. Managing those situations requires a structured command and control system. The structured approach aims at, amongst others:

- a common understanding of the goals and purposes;
- a common operational picture of the situation;
- links with other, external organisations;
- the appointment of relevant functions.

Although command and control structures vary from one discipline to another (fire, police, medical and other) and vary at national level, comparable functions can be identified. A distinction is made between strategic, tactical and operational command and is sometimes referred to as gold, silver and bronze level of command.

[35] Döbbeling, 2012

Levels of command	
Gold	Strategical
Silver	Tactical
Bronze	Operational

Table 2 Levels of Command

3.1.2.2 Multidisciplinary structures for strategic and operational coordination

From the moment multiple disciplines are involved, cooperation between them and coordination of their actions is required.

Most countries have operational as well as strategic structures at a superposed level[36]. The composition, role and responsibilities etc. are the subject of national regulations. The concrete composition of the structures is determined by the type of incident: generally, one representative of each intervening discipline participates in the operational and strategic body. The strategic body is presided by the competent authority, legally responsible for managing the incident. The operational body is led by the leading officer of one of the first response disciplines.

3.1.2.3 Coordinated response for incidents with cascading effects

Response bodies (command and coordination) will not be different in case of cascading effects. More actors might be needed both at operational and strategic level, depending on the number and type of the impacted systems, such as industrial operations, hazmat or CBRN experts, representatives from critical infrastructures, etc.

3.1.2.4 The specific Case of Cross Border Coordination

As appears from D 1.2, formal cooperation agreements and informal arrangements deal with specific aspects in case of cross border effects. None of these provide for specific provisions for command and coordination structures. On both sides of the border, the usual command and coordination structures are put in place. They are not replaced by a single, common body.

There are, however, regional cross border examples of interest, e.g. in Sweden where the authorities can appoint a regional incident commander if an incident becomes large and spreads

[36] Van Heuverswyn, 2009

to several municipalities. The command structure can then transfer from having several local incident managers communicating with each other to a structure with an appointed joint incident manager.

Promote transdisciplinarity
A recommendation on policy level stresses the need for EU regulations to impose (preferably) or encourage (minimally, as a transition measure) transdisciplinarity. This would oblige members to promote transdisciplinary thinking by using a scenario-based instrument for national, cross- and transborder planning and response. Transdisciplinarity as an approach for achieving improved incident management is discussed in chapter 4 of this report.

3.1.3 Information before and during incident response

3.1.3.1 Information in the preparation phase

Incident management requires a lot of information for the preparation of efficient response (see also the details in CascEff D1.3, 2017).

Emergency plans are an instrument for the assessment of information needs, the identification of relevant sources and the corresponding information owners. Beyond collecting and assembling that information, it needs to be put into the right perspective. This task will differ for general plans, monodisciplinary plans and specific risk-related multidisciplinary plans.

The table of contents template for emergency plans shows what type of information is required: identification and analysis of risks, inventory of available resources and means, identification of responsible actors (authorities, services), etc. The CascEff deliverable D1.3 provides a more detailed discussion on the content of emergency plans, while the identification of actors and information owners is further discussed in Appendix 2. This information will determine the procedures prepared for in the plans: for alarming, evacuation, protective measures for people, environment, public health, infrastructure, etc.; specific modus operandi and command rules per discipline, specific modi for alignment and coordination for the operational and strategic multidisciplinary structures.

Scenarios are a tool used to ensure the creation of a link between information and procedures, putting information into perspective according to the probable evolution of a certain type of event, including the identification of dependencies, vulnerabilities and key decision points. Most countries have a legal obligation for certain types of risks[37] or are familiar with scenario writing as a common practice for preparation, as part of the elaboration of emergency plans.

[37] As a minimum for nuclear and Seveso risks, as imposed by EU Regulations

Figure 5 Scenarios as an instrument for emergency planning for writing concrete procedures

Clearly, the more accurate and comprehensive information is available during the preparation stage, the better and more sound the quality of preparation of interventions and the quality of available information during a response phase will be.

Comprehensively prepared information can be subdivided into:

- **Actor related information** on:
  - the first response disciplines involved, their resources and monodisciplinary procedures;
  - other, supporting disciplines (water management, critical infrastructure, hazmat, health experts, etc. following the nature of the event);
  - multidisciplinary, joint procedures.
- **Risk/Incident related information** on:
  - risks, probabilities, impact, dependencies, vulnerabilities etc.;
  - the incident evolution, incl. key decision points.

Improve shared situational awareness and analysis in the preparation phase by establishing relationships and protocol prior to incidents.
During an incident that lasts longer than a few hours it is often necessary to analyse the vulnerabilities of nearby and threatened systems, and share this analysis with others. Sustaining situational awareness and communication during an incident can be challenging, especially during incidents with cascading effects. As described in chapter 4, using the Incident Evolution Methodology facilitates the establishment of relationships and protocols during the preparedness phase, prior to the occurrence of incidents. Furthermore, potential issues such as differences in language, terminology, and dimensional units can be identified in advance. By using the IET, the structured information can be stored and made available to others.

Thus, the information provided by the IET/IEM can make it easier to make coordinated decisions, as all users have access to the same information at the same time, and it also simplifies an efficient and correct handover process between shifts.

3.1.3.2 **Information during response**

During the response phase, decisions are taken to manage the event: actors are called upon, resources are deployed, and measures are implemented. Ideally, all these actions are based on previously identified information and covered by previously prepared procedures. As for emergency planning, the required information is actor related and incident related.

An example of this is shown in the figure below, representing the view of the 'Oefenbank' of the Dutch fire and rescue service:

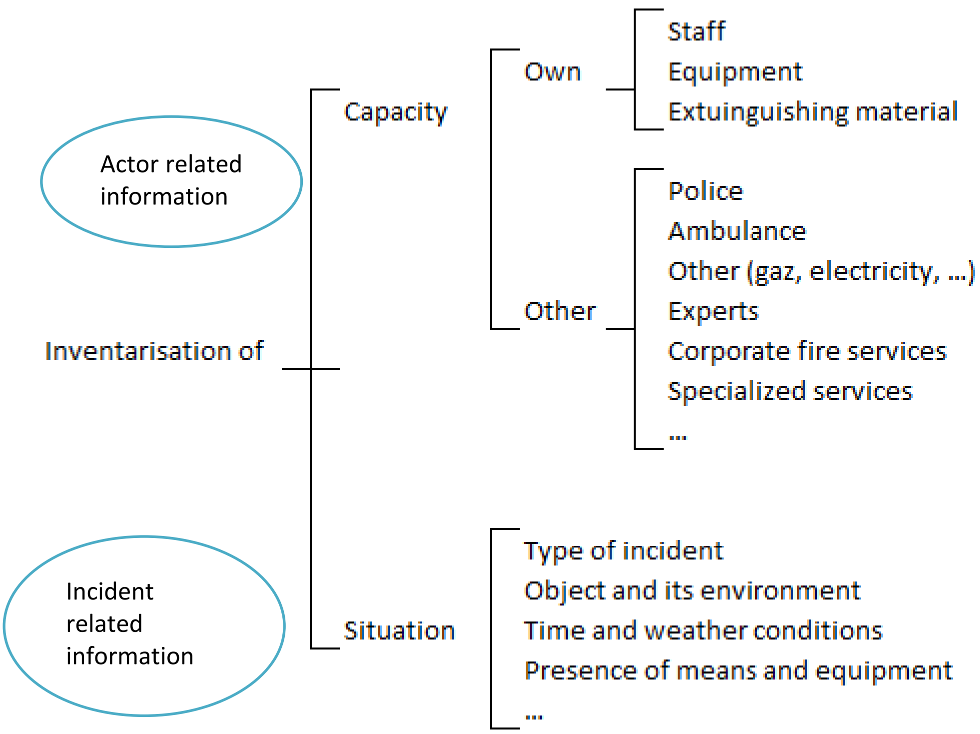

Figure 6 Representation of the first response step, Analysis (Oefenbank Nederland)

An overview of incident decision process models[38] teaches us that being prepared for an efficient response requires gathering a lot of information from wide range of sources in order to develop a common operational picture for all actors involved. That information needs to be available during response in order to provide guidance for the incident command, who has to deal with the overall situation. *If soundly prepared, the available information, possibly presented in scenarios, reduces uncertainty and can avoid overload of unstructured information during response thus reducing complexity.* If dependencies, vulnerabilities and key decision points are previously identified, it also reduces indeterminacy (lack of insight and oversight). These benefits will make it in turn more comfortable for the incident command to deal with time pressure.

[38] D1.3 A flowchart of the methodology for improved incident management in crisis, 2017, see Appendix 2

3.1.3.3 **Information for incidents with cascading effects**

Information needs for incidents with cascading effects are similar to those previously identified for the preparation and organisation of response. However, more efforts are needed to reduce indeterminacy, which in turn requires more information on systems and their characteristics such as vulnerabilities, resistance, potential effects and impacts.

In WP2, a categorisation was developed of systems that can be impacted and between which a chain of consecutive events might occur as a result of the existence of dependencies and vulnerabilities. The identification of those systems characteristics indicate that information is required from all these systems, ideally prepared beforehand, in order to be available for the incident command team during a response phase (see Table 1 for the list of systems and the corresponding risk or incident management responsibility of the competent authorities and services). That is what makes the preparation of information for incidents with possible cascading effects unique compared to other rescue operations, incidents and large-scale incidents.

3.2 Communication – a key for achieving interoperability

As mentioned above, one key for achieving interoperability is the establishment of a culture of understanding the perspective of others[39]. Communication and dialogue works better between people who work together on a regular basis. While social networks are necessary for success and efficient communication, project results indicate that people tend to be reactive rather than proactive in the establishment of these networks and that often too little effort is made to establish these social networks before incidents occur.

3.2.1 Creating a common operational picture despite diverse objectives and foci

As previously mentioned, one of the recognized challenges associated with cascading effects is the necessity to improve actors' ability to identify, understand and deal with the unexpected in a proactive and cooperative manner. To be able to prepare for and contribute efficiently to a joint effort of incident management, actors need to be aware of the full picture. An initial complication is that actors frequently fail to reach consensus on *whether cascading effects are likely or even already are a fact*. The reason for this is that actors' different objectives and foci lead to dissimilar operational pictures and subsequently differing analysis outcomes. Indications of cascading effects may thus be strong for some actors but non-existent for others. To overcome this, actors need to clearly communicate their respective views (situational awareness) of the operational picture and risk analysis of potential cascading effects to other actors involved.

[39] D1.2 Report on incident management in crisis, Dec. 2014

3.2.2 Diverging strategies for managing an incident

During the course of an incident, some parts of the societal system may be subject to visible cascading effects, while others show no sign of being affected. Consequentially, some actors will modify their incident management while others will not. The resulting differences in management create *modified lines of communication and methodologies*, adding a component of novelty and unfamiliarity to the joint system of actors. This is particularly the case in incidents with cascading effects, where actors need to be prepared to considerably add resources to communication and dialogue with other actors in order to ensure efficient coordination of effort in the presence of diverging strategies and their consequent additional and new *lines of communication*.

3.2.3 Communicating the underlying rationale for decisions

One of the conclusions drawn in D1.2 is that incident managers need to be prepared to explain the rationale behind some measures. One common issue in large-scale incident management is the increased probability for *measures which are perceived as uncalled for by others*. There are two major factors contributing to this effect, both of which can be reduced by improved communication between actors. First of all, the aim to prevent cascading effects implies that measures may have to be implemented before anything has actually happened. Since preventive measures are almost always associated with costs, the ability to quantify and communicate risk becomes crucial. This is not unique for cascading effects, but the nature of cascading effects, where second and third order effects may occur, makes it difficult for actors (including politicians and the public) to understand which measures need to be taken and why.

Second, during an incident, time always is a scarce commodity. To avoid incident management falling behind the dynamic of the incident, decisions will often be based on assumptions. Project results also indicate that it is not uncommon that incident command deviates from the process of “plan, analyse, implement” by skipping the analysis[40]. Therefore, some decisions will turn out to be wrong, regardless of how carefully they have been taken. For incidents with cascading effects, the risk for second and third order effects increases the number of assumptions that have to be made, and in the end also the risk for making less than optimal decisions.

This illustrates again the importance of crisis communication. As always, crisis communication during incidents with cascading effects needs to contain clear, rich, coordinated, consistent information about the incident and what is expected from the receiver. Furthermore, incident managers also need to be able to communicate the reasoning and motivation behind some measures, in particular decisions that appear to be uncalled for or drastic.

3.2.4 Communicating with a wide range of stakeholders

As concluded in WP3 of the CascEff project[41], disasters invariably involve some form of **communication failure** that contributes to the disruption of other essential services in the

[40] CascEff results from Revinge workshop reported in D1.2 Report on incident management in crisis, Dec. 2014.

[41] CascEff D3.3 A strategy for communication between key agencies and members of the public during crisis situations, 2016

affected area. Furthermore, the continuing replacement of traditional 'command and control' approach to emergency management by a multi stakeholder approach (see also chapters 3.1 and 4 of this deliverable), does not only put increasing emphasis on information exchange between incident management professionals, blue light organisations and other stakeholders. It also contributes to unveil the importance of mediated communication with members of the public, and the need to reshape relations with established institutions, like the journalistic sector, for managing and verifying content related to the crisis. While the public previously was regarded to be unreliable conduits and recipients of crisis information, it is now recognized that citizens can play a vital role in the collection and sharing of data that (amongst other effects) can help emergency respondents to develop situational awareness.

Identifying and implementing effective strategies of communication is thus a key success factor for incident management during cascading incidents. Timely dissemination of clear and unambiguous information enhances decision making during a crisis situation. Incorporating social media in risk and crisis communication is also essential for successful management of these disasters (Veil et al 2011),[42] as it becomes even clearer that all key stakeholders, including lay people, journalists, and other non-emergency institutions, have an important function in the creation of message consistency and accuracy. In results from CascEff work package 3, elements of a successful communication mix are presented in greater detail, including guidelines for effective communication between blue light organisations and members of the public during crisis situations. These guidelines are referred to as 'SPEAK' and include:

1) **S**tudy the information-seeking behaviours of your audience before deciding upon which communication platforms to use during crisis situations;
2) **P**repare for the loss of critical infrastructure during such incidents by employing a communication mix that includes both traditional and digital media;
3) **E**ngage key stakeholders e.g. civil society organisations in order to ensure that the information shared with the general public is both accurate and consistent;
4) **A**lways consider the ethical implications of using crowdsourced information obtained from social media sites; and
5) **K**nowledge gained from previous incidents should be used to inform future communication strategies.

In that manner emergency management can, by choice of channel and message, impact on citizen engagement and behaviour during crisis situations and facilitate education and preparation[43]. In particular, the unavoidable presence of social media during and after crises can both disrupt and facilitate crisis management, and offer a new information flow that has the potential to impact the development of incidents (in particular of incidents with cascading effects).

[42] Veil and Palenchar, 2011
[43] CascEff D3.4 Report on the role of the media in the information flows that emerge during crisis situations, 2016

Rely on a thoroughly planed communications mix when communicating with communities and other stakeholders not directly involved in crisis management.
Emergency management should design and employ a 'communication mix' aiming to maximise the reach and impact of risk and crisis public communication. Outlets should be chosen among those media channels that disaster-affected populations are likely to use to satisfy their disaster information needs. Both traditional (e.g. radio) and digital media should be part of this mix, in preparation for the likely loss of critical infrastructure during such incidents.
Furthermore, the communication mix should be based on the SPEAK Guidelines presented in CascEff deliverable D3.3.

Include news media and social media as integral components of the communication mix.
For the greater part of society, the news media are generally still the most trusted source of information in crisis situations, and also play a fundamental educational role. Emergency management should be prepared to help news media focus on what triggers "good" citizen engagement. Furthermore, emergency management should make sure they have adequate relations and channels with news media for supporting their quick and reliable verification of content against disaster myths.
Social media are an unavoidable presence before, during and after crises, and can either disrupt or facilitate crisis management. Harnessing of collective intelligence via social media has the potential to create new information flows during the response and recovery stages that could prevent disruption spreading to other elements of the socio-technical system. Emergency managers can benefit from these information flows through the crowdsourcing of information that helps build situational awareness. For more details, see deliverable D3.4.

3.3 Identifying potential cascading effects

While cascading effects are more probable during natural disasters and major accidents, they can potentially be triggered by any incident. Such effects can be identified by incident managers either before or during an incident, where the detection of potential cascading effects *before* an incident is the most desirable and efficient alternative[44]. Work done within CascEff has studied the benefits of using detection systems and integrating cloud monitoring (in particular in vulnerable areas) as input to incident management of crisis, and suggests that cloud monitoring solutions can be a beneficial decision-support tool for the early assessment of hazards likely to happen and hence in adapting actions and measures to be taken[45].

On a general level, strategies for identifying cascading effects **ahead of an incident** include analysis, identification, planning, simulation and intuition.

[44] See results from Revinge workshop presented in D1.2

[45] The CascEff D2.4 Report on technical needs for integrating the e.cenaris platform for cloud monitoring of hazards in crisis situations, March 2016, illustrated with the e.cenaris cloud monitoring platform.

The second chance is to identify cascading effects **during an incident**. This is the last opportunity to avert a deepening of the crisis or to reduce harm and damage. Strategies for identifying potential cascading effects include operational picture indications and reports showing first-order effects propagating to secondary and tertiary effects. The possibility of using cloud monitoring for gaining information from sites with limited or too dangerous access has also been studied within this project[46].This process also includes differentiating between:

- Cascading effects related to system design only (tightly coupled systems) with no human error in incident management, and
- Cascading effects through concurrent failures in technology in combination with human performance (such as failure to understand system interdependencies).

In practice, identifying cascading effects involves noticing when the initial incident escalates and transforms from routine to a situation where a system or organisation in the community is overloaded. This in turn requires access to information, methods to analyse the information and competence to interpret the results.

The break-down of these strategies identified by experts as common management procedures includes (in no particular order):

Analysis of:

- historical and statistical data;
- risks (including risk mapping and the analysis of changeable risks, e.g. hours, weekday, season etc.);
- worst-case scenarios;
- available reports (e.g. safety reports), lessons learned and case studies;
- existing policies and management systems (i.e. the management factor);
- safety culture (i.e. the human factor).

Identification of:

- hazards. This is followed by risk assessment;
- critical infrastructures or systems in which failure is likely to trigger cascading effects;
- possible cascading effects. In establishments with significant major accident potential (such as chemical nuclear industry, transport of dangerous substances including pipelines), the identification of possible domino effects should be mandatory.

Planning ahead by:

- using an all-hazards, risk based-approach;
- designing and regularly updating plans (e.g. rescue plans, crisis response and emergency management);

[46] A number of installations and regions have a large amount of sensors installed for monitoring and for security (e.g. Structural Health Monitoring (SHM), Close-circuit television (CCTV) security cameras, smoke detection), collecting data concerning abandoned or active mines subject to collapses or rockburst hazard, underground storage areas, landslides evolving over or close to inhabited areas, etc. Within CascEff Task 2.4 it has been proposed to develop solutions to merge together data acquired through the use of cloud monitoring technologies and to evaluate the benefit of integrating such methodologies into CascEff Incident Evolution Tool (IET).

- securing the horizontal (inter-agency) as well as the vertical (local, regional, central) integration of plans.

Simulation:

- aiming at the identification of vulnerabilities and triggers for cascading effects. The identification of key decision points in the cascade tree where decisions can be taken to prevent or break the cascade, is an important element of the Incident Evolution Methodology developed within the CascEff project.

Intuition:

- taking advantage of professional experience.

3.4 The link between Risk and Incident management processes

Risk management models show two additional phases of relevance before and after the preparation/planning phase and the response phase, that is prevention and recovery. Generally, these activities are not the responsibility of the first response disciplines. Nevertheless, the way they are performed, and the information generated in those phases is relevant, often crucial for first responders: the results of risk analyses, information on contextual factors, preventive measures, available expertise and logistic means, etc.

As this information is mostly generated by actors whose core business is not incident management, they are not involved in preparedness and response unless invited, and they have no (legal) responsibility for response. This makes it all the more important to identify these relevant sources, their owners and to ensure their collaboration in order to have the appropriate access to crucial information. The CascEff project work package on originators and dependencies identified 22 systems from the analysis of past events, indicating that information owners within those 22 systems hold relevant information (see Table 1).

Figure 7 gives the following picture of the incident management process, and its place within the broader risk management processes:

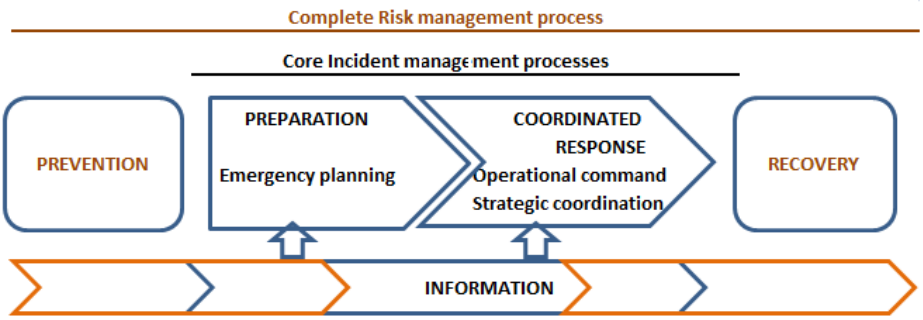

Figure 7 The link between Risk and Incident management processes

3.5 Key word multidisciplinarity

The abovementioned description of current common practices clearly shows that actors involved in current practices both before and during the response phase of an incident have to make a re-unifying and coordinating effort of institutionalised fragmented powers and information to manage crises. Given the engagement of multiple actors (first response and other disciplines) and systems in this joint effort across a range of social sectors, the discourse regarding improved incident management practices currently centres on the concept of multidisciplinarity[47]. Incident management with a multidisciplinary approach is by many seen as an additional and complementary to monodisciplinary actions, efforts and resources. Also, it refers mainly to the operational preparation and response phases, such as multidisciplinary preparation in emergency plans and the multidisciplinary coordination of monodisciplinary interventions.

Confirmation of the establishment of this multidisciplinary approach is found in national guidelines from competent authorities[48] and incident management literature and theory, as shown in the overview by J. Jensen (2010) on mono, multi and interdisciplinary approaches to emergency management education.

The etymological meaning of multi, from the Latin word multus, refers to many, much, multiple, more than one[49]. It thus covers activities with many, multiple disciplines involved and draws on the knowledge of those disciplines, yet all staying within their own boundaries. There is no transcending dimension in multidisciplinarity[50].

A lot has been written about the need and the use of multidisciplinarity, its merits and challenges, etc., as shown in national guidelines and abundant literature[51]. Advantages and benefits can be summarized as: *a more profound, rich and depth of understanding can result from multidisciplinary than could have been achieved by one single discipline*. Obstacles and shortcomings of a multidisciplinary approach relate to disciplinary chauvinism, different world views, status differences among team members, logistical and geographic obstacles.

Given the multihazard and multiconsequence character of incidents, emergencies and disasters; the discussion on the usefulness of multidisciplinarity has become somewhat outdated by reality. Today, there is not one single (first response) discipline able to prevent and respond to

47 A google search gives 250 000 results for ‘multidisciplinary incident management’ versus 410 000 for incident management; 1 400 000 for ‘multidisciplinary emergency management’ versus 120 000 000 for ‘emergency management’

48 i.a. Circular Letter on Emergency planning (BE), 2006; Devroe et.al. (BE, NL), 2015; Ministerie van Veiligheid en Justitie (NL), 2016; Napucu N. (UK); Maestracci B. (FR), 2011,

49 Alvargonzalez, 2011

50 Alvargonzalez, 2011; Choi and Pak, 2006

51 Jensen, 2010; Van Heuverswyn, 2009b; Scholtens, 20062009; Younglove-Webb et.al.,, Gray, Abdalla & Thurow 1999; Quaranteli, 1994

incidents. Even everyday routine interventions often call upon more than one discipline, for example policy and/or medical and/or rescue and fire fighters.

3.6 Multi-, inter- and/or transdisciplinarity?

The question is whether multidisciplinarity is sufficient and adequately efficient to deal with the incident management complexity of impacted systems and actors involved in different process steps, as shown in the summarizing Figure 7. To answer this question, we looked at two other, more integrated approaches, applicable to a multi-actor environment: interdisciplinarity and transdisciplinarity[52]. These approaches were then compared to multidisciplinarity.

> **Multidisciplinarity** is mainly additive juxtaposition, at best some kind of coordination is involved. Relevant disciplines are identified and gathered, the coverage of all relevant aspects is achieved through a collaboration or coordination effort.
>
> **Interdisciplinarity** is more integrated, interacting, linking and focusing, yet limited to searching for knowledge, methods and means from other disciplines to serve one single other discipline, in this case incident management (which is not in itself a fully recognised discipline).
>
> **Transdisciplinary** starts from a completely different mind-set, recognising that reality is more than the sum of our fragmented knowledge and powers; takes an umbrella view giving specific attention to the dimensions between, across and beyond.

These approaches all recognize the value and merits of specialised, mono disciplines and thus add extra layers and an integrated level without denying **monodisciplinarity**. Simultaneously, transdisciplinarity is the most comprehensive and holistic approach and includes the advantages (such as juxtaposition and attention to links and relations) of the two other approaches.

Transdisciplinarity

The Latin prefix 'trans' mean 'across', 'beyond' and 'transcending', 'through' something - as in transpiration - and 'change' - as in transformation[53]. Transdisciplinarity thus refers to an approach, transcending, going across, through and beyond the boundaries of individual disciplines. Transdisciplinarity is characterized by a holistic vision, transcending the individual disciplines involved by looking at the dynamics of the whole[54].

Transdisciplinarity is closely related to systems thinking, which also pays attention to links and interactions between distinct processes. Transdisciplinarity differs from multi and

[52] Alvargonzalez, 2011; Choi and Pak, 2006

[53] Alvargonzalez, 2011

[54] Alvargonzalez, 2011; Van Heuverswyn, 2009; Choi and Pak, 2006

interdisciplinarity because of the cumulative attention for two specific conceptual aspects, based on systems thinking:

1) per definition it considers aspects between (interactions, interdependencies, relations) as well as across (common) the different disciplines involved;

2) most significantly, it adds a level above, beyond the actors involved : a transdisciplinary approach considers the whole as more than the sum of the individual composing parts.

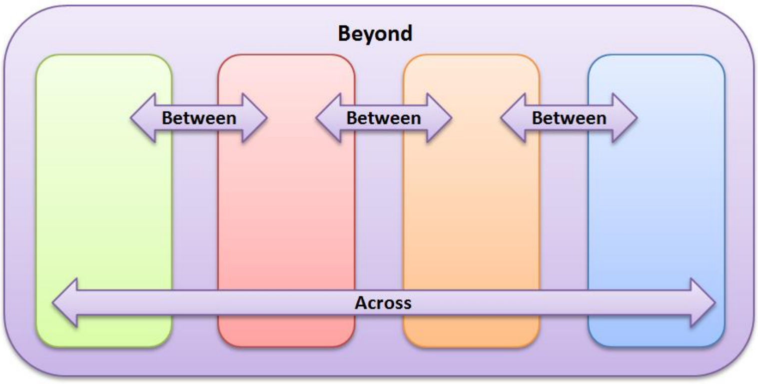

Figure 8 Representation of the specific focus of a transdisciplinary approach (Van Heuverswyn, 2009)

From the comparison, transdisciplinarity is the most comprehensive and holistic approach and includes the advantages (juxtaposition, attention to links and relations) of the two other approaches.

A recommended approach to improve current incident management practices could be to upgrade the role and work done in multidisciplinary structures: emergency planning bodies, operational command post and strategic coordination bodies by:

- Supporting a transdisciplinary mentality, approach and vision: encouraging incident managers to transcend their own discipline, take an umbrella view from the case (emergency planning) or incident at stake (response) and look for aspects across, between and beyond the input of each individual participating discipline;
- Encouraging the use of a methodology and corresponding tool to support that transdisciplinary effort.

Following from this, the three success factors for the application of a transdisciplinary approach are: structures providing a platform for transdisciplinary thinking, mentality and methodology/tools.

4 A methodology for improved incident management

4.1 The added value of a transdisciplinary approach to incident management

In the context of incident management, the added value of a transdisciplinary approach consists of the recognition that all divisions in disciplines and specializations are artificial, whereas reality doesn't take them into account. As the French sociologist Lagadec[55] states: reality and especially major incidents oblige us to transcend our artificial boundaries and subdivisions and force us to work together. This is an important vision for dealing with all types of risks and incidents, but specifically important for incidents with cascading effects because the main challenge is to understand and anticipate vulnerabilities resulting from dependencies, i.e. vulnerabilities that are embedded in the system as a whole and to which we have become blind because of our fragmented, monodisciplinary approach to parts of reality.

Although all relief and rescue operations, from daily routine to the most complex incidents, could benefit from transdisciplinary thinking, this is not easy to achieve. A pragmatic and gradual approach is more realistic when aiming to improve current incident management practices:

- **Multidisciplinary actions** could be sufficient for *daily, routine operations* and refers to the joint rescue and relief operations if several first response disciplines are involved.
- **Multidisciplinary structures** are needed for more *complex events*, characterised as incidents (See above, Table 5), demanding specific command and control and coordinating bodies. This especially applies to large scale incidents and incidents with cascading effects.
- As a minimum, an **interdisciplinary mentality** is needed for incidents: all actor and case/incident related information needs to be collected, analysed and synthesised. As there is no full home discipline, this would be an interdisciplinary approach by analogy: it is an ad hoc assembling of actors and their knowledge for emergency planning and response based resp. on scenarios and the response efforts during an incident. This could be sufficient for smaller, less complex incidents.
- Complex, large scale incidents and incidents with cascading effects require a **transdisciplinary mentality**, as all case/incident related information needs to be collected, analysed and synthesised from a perspective that transcends the knowledge, competence, skills and means of all the disciplines involved. This is by definition a transdisciplinary approach. It is especially relevant for incidents with cascading effects because indeterminacy is the main differentiating characteristic for this type of incidents. The identification of links and dependencies and an umbrella view of relations and the dynamic of the whole are of crucial importance to manage these situations efficiently.

[55] Lagadec P., 2005

•

	MULTIDISCIPLINARITY	INTERDISCIPLINARITY	TRANSDISCIPLINARITY
Characteristics of the approach	= juxta**position**	= juxta**position** + links and relations between	= juxta + links, relations between + dimensions across + dimension of the whole beyond
Daily, routine operations	Mono or multidisciplinary, joint but parallel actions		
Incidents	Multidisciplinary **structures** needed	A minimum integrated effort/**mentality** required	
Large scale incidents and Incidents with cascading effects	Multidisciplinary **structures** needed		Preferably a transdisciplinary **mentality, methodology and tools** required to take an umbrella view on links between, dimensions across and the dynamic of the whole event (beyond the sum of the input of individual disciplines)

Table 3 Overview of a gradual multi-, inter- and transdisciplinary approach for improved incident management (Van Heuverswyn, 2017)

4.2 The role and contribution of an Incident Evolution Methodology

The CascEff project developed a decision support methodology for incident management, to be used in the preparation and response phases of small and large incidents with cascading effects: the Incident Evolution Methodology (IEM). For a comprehensive description and explanation, we refer to the CascEff deliverable 4.2 as well as the training and educational material found on the CascEff website[56].

In the following paragraphs we highlight the specific steps and features of the methodology that provide for better and more in depth understanding of vulnerabilities caused by system dependencies, as well as the analytical and synthetic capacity of the methodology based on a case specific approach, identifying and integrated all aspects relevant from a (regional) case perspective.

[56] CascEff D4.2 For one of the most central themes; learnings on improved incident management; a visual power point presentation and recorded voice over has been prepared in order to facilitate maximum dissemination of the topic and http://casceff.eu/

The six steps methodological framework
of the Incident Evolution Methodology and Tool

1. Set the case area and the individual systems in a given territory: all the systems are described in terms of functionality/provision services, vulnerability and potential outgoing effects;
2. Identify dependencies between systems: dependencies are identified in regards to systems' proximity and functionality,
3. Propagate the effects between systems: an initiating event is set in the case area, threatening the systems which can be impacted and which can impact, through cascading effects, other dependent systems,
4. Determine temporal aspects: buffer time, time-delay and overviews of timeline and tree-view are assessed in order to evaluate the potential time interval emergency responders have for mitigating effects,
5. Assess the impacts: social, human, economic, environmental and infrastructure impacts are evaluated for each impacted system in order for the emergency responder to compare impacts of cascading effects,
6. Identify the key decision points: the combined assessment of timeline (step 4) and impacts (step 5) help the emergency responders to prioritize mitigation actions.

Step 1 asks for the **selection of a regional area** in which dependencies and cascading effects will be identified and modelled. A regional case approach in itself demands the user to let go of a discipline-specific perspective. The systems within that area are to be identified, as well as their characteristics, such as the geographical location of power supply stations, hospitals, etc. Vulnerabilities and outgoing effects of those systems are assessed.

In **step 2** geographical, functional and logical **dependencies** between systems are identified, such as the proximity of a school near a chemical plant (geographical) or the hospital depending on supply of drugs and thus on transportation in order to stay operational (functional). This step is a typical transdisciplinary step, looking at an area from an umbrella view and identifying links, relations, dependencies between all the systems located in the area.

The information collected in step 1 and 2 is 'case- or incident-neutral' and purely area-related. It is important to go through these steps before the case based approach starts because of our natural tendency to look at a problem, an accident, an incident, etc. from a problem-solving perspective. The validation session clearly demonstrated that incident managers' reflex is to go straight forward to the identification and consideration of possible solutions without having the patience to create a global picture.

Once this inventory is done, an **initiating event** is selected in **step 3**, and only then the risk conditions and outgoing effects of impacted systems are assessed.

In order to identify priorities for decision making, **temporal aspects** are defined in **step 4**: propagation time, endurance time, buffer time etc. All this information regarding the possible evolution of the selected incident is assembled and visually represented in a timeline overview and a tree-view overview.

Step 5 assesses the **impacts**, based on five categories: human, social and economic, as well as environmental impacts and impacts on infrastructure. The impact is estimated per category and visually represented in a scorecard, thus giving a global overview of all possible impact.

In **step 6**, this is further put into perspective by comparing the impact per system combined with an estimation of the available timeframe to break the cascade, thus providing informed and visual support for the identification of **key decision points**.

Strengthen procedures for risk-, vulnerability-, and dependency analyses
While the practice of analysis and assessments of risk, vulnerability and dependency is part of the standard operating procedures for most emergency management organisations, the IET/IEM strengthens the process. In addition to providing a methodological approach to these procedures, following the entire IEM makes it possible for these standard assessments to be applied to cascading effects.

4.3 The transdisciplinary character of the Incident Evolution Methodology and Tool

The added value of the IEM is that it provides for a structured approach to collect all relevant, monodisciplinary information and asks for the identification of links, relations, dependencies creating vulnerabilities, in order to get an integrated and holistic view on all case/incident relevant aspects to manage. Both the links and the global overview are exemplary of transdisciplinary thinking, different from a traditional multidisciplinary approach.
Without the support of a transdisciplinary methodology, it is difficult to obtain the same result, because of the large amount of information and because of the complexity once links and dependencies are identified. Without support is it difficult to keep the overview in mind. The step by step approach of the IEM ensures completeness of the required information and ensures the logical and chronological putting into perspective of case-specific information as well as the building up of a comprehensive picture.

Increase awareness of cascading effects and facilitate their incorporation into incident management procedures following the structured methodology provided by the IEM.
The IEM provides a structure and a fixed set of steps that the emergency planning officer or incident commander needs to follow in order to manage risks with cascading effects. This process increases risk managers awareness of the concept of cascading effects and ensures that they use a well-structured methodology when taking cascading effects into account within a crisis situation or an emergency situation.
The structured work process will also increase the awareness of potential cascading effects and their impact resulting from a given initiating effect within a specific region (during the preparedness phase).

The Incident Evolution Tool (IET) under development is an example of a transdisciplinary instrument, guiding the users systematically through the six steps and providing visual support with the mapping, timeline view, tree view and scorecard.

Both the IEM and IET thus answer one of the key challenges of incident management: gathering information from multiple sources, putting them into perspective, in a context which is highly complex, uncertain and in which decisions need to be made under time pressure. It is designed to be generic and applicable to all kinds of incidents, including incidents with cascading effects, regardless of the originating event (natural, man-made accidental, man-made intentional). It is applicable to both strategic and tactical command levels and useful regardless of the number of actors involved, the level and type of coordination.

When used in the preparation and response phase, this methodology will improve the understanding of the evolution of an incident and lead to better informed decisions. The use of a transdisciplinary instrument will automatically lead to more awareness of the added value of transcending the boundaries of individual disciplines in multifaceted cases and thus encourage over time a transdisciplinary mentality. Without the need to touch upon existing structures, the current multidisciplinary bodies might transform in the longer run to truly transdisciplinary bodies.

The contribution of a transdisciplinary methodology such as the IEM is visually summarized in the following picture:

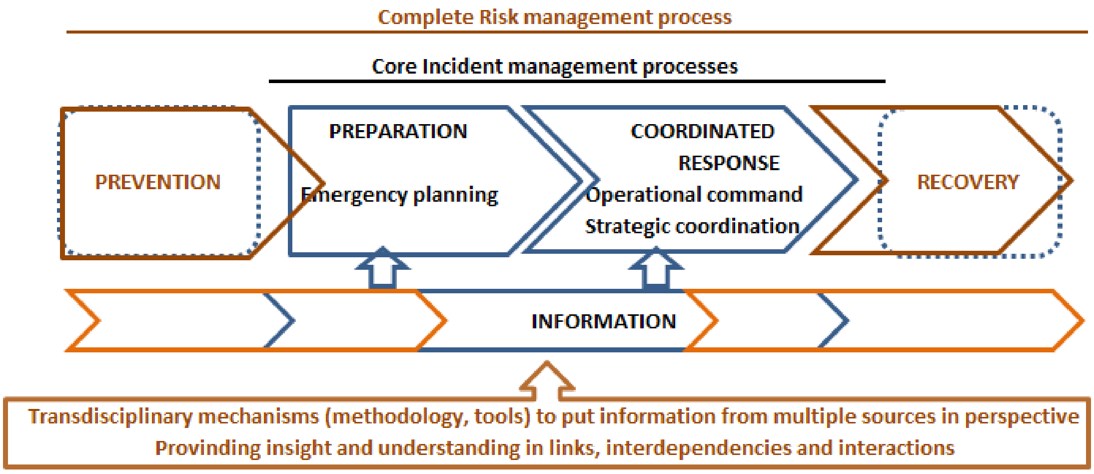

Figure 9 Contribution of transdisciplinary mechanisms to improve current incident management practices (Van Heuverswyn, 2017)

This added value based on a transdisciplinary approach was indeed highly appreciated by the participants of the various outreach activities of the CascEff project. Without calling it ‘transdisciplinary’, some of their positive feedback relates to and illustrates awareness of transdisciplinary thinking as a way to improve current practices.

4.3.1 Analysis of feedback from outreach activities

Within the task of identifying key characteristics of incidents, little input was given by the practitioners involved in the CascEff project as they rarely look at incident management from that perspective[57]. Input from interviews, focus groups and validations sessions indicate that they are predominantly action-oriented and solution-focused, and tend to look at incidents from a rather process-based approach on ‘how to deal with incidents’. However, there is still much interesting feedback from the outreach activities to report.

There were three main sources of feedback from the incident management community. Early in the CascEff project an External Expert Advisory Board (EEAB) was formed to help guide the work. This group is comprised of representatives from emergency services, police forces, infrastructure owners and operators as well as from the academia. Focus groups were formed during the development of the IET and participated in workshops designed to generate feedback on the progress of the work. Late in the project validation exercises were conducted in which participants were asked to respond to scenarios, both using and not using the IEM. The results of these activities are presented in the following paragraphs.

[57] CascEff D1.1 Report from workshop with EEAB

When asked what modifications to regular incident management practices are essential, the EEAB identified a wide range of activities[58]. Their feedback suggests that modifying incident management in advance before cascading effects occur involves:

- Identifying, reducing or eliminating shortfalls that exist between estimated requirements, standards, and performance measures and the actual response and short-term recovery capabilities using an all-hazards risk-based approach;
- Verifying existing plans and procedures;
- Organizing training and practical exercises (including inter-agency harmonization);
- Safety checks and inspections;
- Reducing or eliminating risks;
- Strengthening the safety culture (human factor).

When considering the acute phase, after cascading effects have been triggered, the EEAB suggested that modifying incident management could involve:

- Expanding the command structure;
- Activating higher-level (strategic) incident management with decision power over more resources;
- Enhancing the reporting process to superiors and enhancing briefing within and between actors;
- Organising incident operation, planning (including anticipation) and logistics;
- Collaboraing with key actors and stakeholders for advice;
- Gathering pre-defined crisis/emergency management team;
- Involving pre-identified experts and liaison personnel from useful agencies/institutions;
- Putting in place information management processes to improve situational awareness at all levels;
- Verifying tactical assumptions;
- Considering the use of a "Devil's Advocate" as a safeguard against misjudgement;
- Determining rescue priorities (considering "cost-effect" approach);
- Dividing into operational sectors and functional groups;
- Closely monitoring system parameter evolution (process, installation, weather);
- Isolating the affected portions of the system;
- Modelling secondary/tertiary effects;
- Taking decisions to protect people, environment and assets in secondary effect zones well ahead of time (time according to resource availability);
- Considering evacuation carefully;
- Re-connecting the affected portions of the system in a controlled manner;
- Organising demobilisation of resources;
- After incident: ensuring that lessons identified also become lessons learned (and implemented).

[58] CascEff D1.2 Report on incident management in crisis, Dec. 2014

The relative importance, chronological order and detailed content of each of the bullet points above depend on the situation at hand- and must be analysed before taking action. However, most of these actions can and should be prepared in advance. Efficient incident management during natural disasters and major accidents, including avoiding cascading effects, is possible only if based on a major effort during pre-incident planning stage.

Furthermore, it is also acknowledged that some of the identified modifications are not limited to incidents with cascading effects but applicable to all major incidents. However, failure to manage lessons may have greater consequences in incidents with cascading effects.

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was conducted using feedback from the CascEff outreach activities, especially the focus group meetings, in order to better understand the reaction of potential users to the new transdisciplinary approach used by the IEM/IET and to use their feedback for guidance during its development. The results of the SWOT analysis are given in **Table 4**.

Strengths	Weaknesses
Innovative tool/methodology for providing prediction of cascading effects.	Some procedures are not intuitive.
Needs little user training beyond the development of a coherent and user-friendly manual.	It is difficult to understand some of the required data and find reasonable values to use.
The process of collecting all the input needed for the IEM is mutually beneficial for risk and vulnerability assessment activities.	A very large amount of user input is required, making the IEM difficult to use during the response phase for many types of incidents.
Especially useful during planning and preparation phases.	Users are not able to customize the systems to fit their specific area or situation.
Use of the IET/IEM could improve handover from one shift to another during a response.	
Lessons learned during incidents can be channelled back into the IEM and used for training.	
Opportunities	**Threats**
Interoperability/interconnectivity with existing databases and incident management tools.	The users might not accept the IET/IEM due to difficulties in using it.
May be possible to incorporate predictive models into the IEM to improve the accuracy of the effects.	There might be other tools/methodologies that provide similar functions that users prefer.
The consequences of potential changes (e.g. building use) can be predicted using the IEM.	There is concern about intellectual property rights and security.
Users can use the IEM to learn more about incident management and cascading effects.	Liability issues if decisions are based on information provided by the IET/IEM.
	Users may want some features that are not in the best interest of incident management.
	If users do not maintain up to date risk inventory used by the IEM, the results will not be accurate.

Table 4 SWOT analysis of feedback from outreach participants.

Clearly, the participants recognized the added value of the IEM/IET during the planning phase for incidents, as seen in the "Strengths" section of **Table 4**. One of the recommendations following the validation sessions was that the IEM improves situational awareness and communication, particularly between disciplines and across borders by identifying potential cases/scenarios prior to an incident.

They also identified opportunities to add additional value to Incident Management through extending the scope of the methodology to incorporate other tools and models. In particular, they realized that using the new methodology would help them to better understand incidents having cascading effects.

Training personnel for managing high impact events with potential cascading effects.
The IET/IEM can be used to acquaint personnel with the specific risks and vulnerabilities that exist within their response area. Furthermore, it can help train people/staff to think in terms of cascading effects. Different options and scenarios can be tested, providing a strong foundation for decision-making during an actual event.
In order to obtain the most relevant, correct and usable results, we recommend that the IEM is introduced in the training curriculum of the next generation of responders in order to familiarize trainees with its usage and relevance at an early stage.
For the current generation of practitioners, it is recommended to hold several training/try-out sessions on the preparation phase. In this way, the staff can become familiar with the IEM before implementing it into the current workflow and adopted as basis for standard or applied practices and processes. It is also recommended to first populate the IET with system information and test it for a period of time before considering using it for response decisions.

With respect to implementing the methodology and tool, there was concern that collecting the required information would be too great a burden, especially during an incident. The feedback also indicated that users would like to be able to customize the methodology/tool to suit their own needs. Some of these perceived weaknesses relate to the use and especially the unfamiliarity of a new way of thinking; however, these issues must be overcome in order for users to accept the methodology and tool. As with all new knowledge and technologies, especially when deviating from well-anchored concepts and approaches, a transition period and transition measures are needed to ensure acceptance.

Threats to the implementation of the IEM/IET centre around three issues: 1) difficulties in understanding and using the methodology/tool, particularly if there are other options available; 2) potential liability for bad decisions; and 3) security of the information used.

There were inconsistencies in the feedback regarding the ease of use of the methodology/tool, which is understandable given that people have different aptitudes for learning new procedures. It is expected that incident managers will assume responsibility for their decisions regardless of whether or not they use the new methodology. This includes ensuring that the information used by the methodology is kept up to date. These issues must be taken into account for the development of accompanying measures to create solid foundations for the application of both the IEM and IET.

On the other hand, some of the strengths and opportunities mentioned by the participants can be used as leverage to promote the use of the Incident Evolution methodology and tool.

The validations sessions, reported in D5.4, aimed at assessing the added value, credibility and applicability of the IEM. Therefore, the improved incident management was not in specific focus during the validation, but rather the use of the different steps of the methodology. Still answers to questionnaires and different observation were still interesting and some of the results are briefly summarized below.

It seems the IEM application is perceived as globally bringing added-value for crisis management in response phase, mainly by providing a global structure of the situation analysis. The main difficulties to use the IEM come from fast kinetic propagation effects which limit the capacity to run the IEM until the final steps. These results are in line with the comments of the observers of this validation test who found the IEM as providing a global structure for crisis analysis. Some general comments from the participants were that much data is needed to follow the methodology and that it is best to start using the IEM for small incident and when one is experienced one can use it for large-scale incidents as well. They recommend then to get familiar first with the IEM by using it during planning and prevention phases so that to be able to use it appropriately during response phase. The participants appreciated the steps of the IEM differently and for some of the participants' step 6 of the IEM, where the key decision points were identified and discussed, was the step where they understood the real value of the IEM.
A final conclusion can be that the IEM as methodology to a very large extent is good and useful, but it is important how it is presented and taught.

Identify Key Decision Points based on estimations of temporal aspects and consequences
The timing aspects of the chronology of cascading effects and can be used to determine priorities among systems for making efficient decisions and estimate the needed resources for each decision.

Many of the outreach activities have resulted in the comment that much data is needed, even if the IEM has been seen as a good way for structuring the data anyhow needed for vulnerability and dependency studies.
One way to obtain data is to use different types of modelling, e.g. simplified physical modelling, CFD simulations or evacuation modelling. More information on this is found in deliverable D2.5, but is summarized in a recommendation below.

Incorporate physical modelling in decision making during crisis situations.

The use of physical modelling (either simplified or CFD modelling) can inherently provide a lot of valuable information in the planning phase to be used towards decision making during crisis situations and the study of cascading events. It can be used in all three phases of an incident with cascading effects: beforehand, as a form of training exercise for prevention of future accidents and by providing valuable information about future events that might occur; during, providing help during the decision-making process by information from sensors; and afterwards, by providing information about the consequences of the incident. It can also be used to revisit the conditions and the evolution of the incident in order to learn lessons from it.

The level of accuracy of the information required from the physical modelling will determine the modelling approach chosen. While simple models and correlations are easily applicable and the result is immediate, there are still many cases of modelling scenarios involving cascading effects that will require CFD modelling.

All the different physical modelling approaches can potentially be useful for the study of cascading effects. The most appropriate approach (or combination of approaches) depends on the conditions present, the type of incident and the actions that need to be performed.

A summary of the outreach activities (focus groups and validation exercises) is provided in Appendix 3 for reference. For more detailed information please see deliverables D5.3 and D5.4.

5 Recommendations

The task of this report is to elaborate recommendations on improved incident management based on four years of research into cascading effects within the CascEff project. Some of these identified recommendations identified are general in nature and relate to incident management processes, other cover specific aspects, such as communication, information etc. They all focus on improvement of current incident management practices in crisis situations and are based on the understanding of cascading effects, the analysis of current incident practices and challenges, the added value of a transdisciplinary approach and feedback from practitioners throughout the project.

The continuous contacts with end users and stakeholders over the course of this project have shown that many of the functions, structures, processes and tools suggested in this report are already available in different organisations (to some extent or in some form). However, results from the CascEff project highlight the need for a continuous development of tools and processes, and show that there is a lack of knowledge regarding cascading effects. Public reports, investigations etc. place a considerable emphasis on the causes leading to the initiating event, while less information is provided about the characteristics and evolution of cascading effects and consequences.

This chapter first presents recommendations on the improvement of incident management given throughout the report. As part of these recommendations, we discuss how the IET and IEM are helpful in achieving these aims[59]. They are followed by policy recommendations that aim at reinforcing the contextual and societal environment which will allow to embed these recommendations.

5.1 Recommendations for improved incident management

Recommendation 1

Increase awareness of cascading effects and facilitate their incorporation into incident management procedures by following the structured methodology provided by the IEM.

Incidents in general and specifically incidents with cascading effects, require incident managers to deal with a wide range of actors, risk- and incident related information (for planning resp. response). A supporting methodology and tool facilitates the identification of relevant information from the involved disciplines and systems. It will also provide an overview on links, relations and dependencies. A structured approach supports first responders by systematically guiding them through the collection and interpretation of all relevant information.

The IEM provides a structure and a fixed set of steps that the emergency planning officer or incident commander needs to follow in order to manage risks with cascading effects. This

[59] Note that specific and detailed wishes or recommendation for development of the IEM and/or IET can be found in other deliverables as D4.5, D5.2, D5.3 and D5.4, even if some comments on that are given also in this deliverable.

process increases risk managers awareness of the concept of cascading effects and ensures that they use a well-structured methodology when taking cascading effects into account within a crisis situation or an emergency situation. The structured work process will also increase the awareness of potential cascading effects and their impact resulting from a given initiating effect within a specific region (during the preparedness phase).
This recommendation is elaborated in section 4.3.

Recommendation 2

Strengthen procedures for risk-, vulnerability-, and dependency analyses

While the practice of analysis and assessments of risk, vulnerability and dependency is part of the standard operating procedures for most emergency management organisations, the IET/IEM strengthens the process. In addition to providing a methodological approach to these procedures, following the entire IEM makes it possible for these standard assessments to be applied to cascading effects.
This recommendation is elaborated in section 4.2.

Recommendation 3

Improve the preparation process by cataloguing and detailing specific information for easy availability

Indeterminacy can be reduced by providing more insight in how the society (as a system) works. Setting aside resources for continuous work with cataloguing and detailing information, paying attention to interdependencies and links between subsystems and processes will add context and relevance to the preparation process.
This recommendation is elaborated in section 3.1.1.1.

Recommendation 4

Use scenario elaboration to improve the quality of information for emergency planning and response decisions

The elaboration of scenarios enables the transformation of static data on actors, resources, risks, etc. into applicable information both for emergency planners and incident command managers. The use of scenarios necessitates the identification of relevant risk or incident related information, and facilitates the task of putting it in perspective, based on a possible evolution of the incident. The use of scenarios thus improves the quality of information for emergency planning and response.
The use of scenarios, supported by a methodology and tool such as the IEM/IET, requires not only the identification of relevant risks or incident information, but also to putting it into perspective, based on possible evolutions of the incident. Risk and incident management are forced to take a case perspective, complementary to their usual discipline-perspective.
This recommendation is elaborated in section 3.1.1.

Recommendation 5

Improve shared situational awareness and analysis in the preparation phase by establishing relationships and protocol prior to incidents.

Sustaining situational awareness and communication during an incident can be challenging, especially during incidents with cascading effects. Using the Incident Evolution Methodology facilitates the establishment of relationships and protocols during the preparedness phase, prior to the occurrence of incidents. Furthermore, potential issues such as differences in language, terminology, and dimensional units can be identified in advance.
By using the IET, the structured information can be stored and made available to others. This makes is easier to make coordinated decisions, as all users have access to the same information.
This recommendation is elaborated in section 3.1.3.2.

Recommendation 6
Identify Key Decision Points based on estimations of temporal aspects and consequences
Breaking down the conception of 'time pressure' into different concepts of time, provides the risk- and emergency management team with a more concrete time line for decision making both in risk planning and incident management.
The different time aspects used in the IEM/IET (buffer time, endurance time, propagation time, etc.), provide a basis for an incident command team to determine priorities and to take decisions on appropriate actions and allocation of resources.
This recommendation is elaborated in section 4.3.1.

Recommendation 7
Incorporate physical modelling in decision making during crisis situations.
The use of physical modelling (either simplified or CFD modelling) can inherently provide valuable information for decision making during crisis situations and the study of cascading events. It can be used in all three phases of an incident: before, as a form of training exercise for prevention of future accidents and for providing valuable information about possible future events; during, providing help during the decision-making process by information from sensors; and afterwards, by providing information about the consequences of the incident. It can also be used to revisit the conditions and the evolution of the incident in order to learn lessons from it.
This recommendation is elaborated in section 4.3.1.

Recommendation 8
Consider and use lessons learnt, stored data, scenarios and feedback loops as opportunities for continuous improvement
Every incident, and especially major incidents, reveal the failures and weaknesses in the way we organise our society. Even though every incident is unique, valuable lessons can be learnt from the preparation and the response phase. Incident management would benefit from an approach, methodology and tool that aids the evaluation of the preparation and response effort.
The IEM and IET allow storage of relevant information; region-specific and incident neutral as well as case specific information. It thus provides for a tool to store data and learn from previous cases and scenarios. It facilitates continuous improvement for preparation and planning, for response and for educational purposes.

Recommendation 9

Rely on a thoroughly planed communications mix when communicating with communities and other stakeholders not directly involved in crisis management.

A well designed communication mix, for example based on the SPEAK guidelines, aims to maximise the reach and impact of risk and crisis public communication[60]. Both traditional and digital media should be part of this mix, in preparation for the likely loss of critical infrastructure during such incidents.

For the greater part of society, the news media are generally still the most trusted source of information in crisis situations, and also play a fundamental educational role. Social media are an unavoidable presence before, during and after crises, and harnessing collective intelligence via social media has the potential to create new information flows during the response and recovery stages that could prevent disruption spreading to other elements of the socio-technical system.

This recommendation is elaborated in section 3.2.4.

Recommendation 10

Train personnel for managing high impact events with potential cascading effects.

The IET/IEM can be used to acquaint personnel with the specific risks and vulnerabilities that exist within their response area. Furthermore, it can help train people/staff to think in terms of cascading effects. Different options and scenarios can be tested, providing a strong foundation for decision-making during an actual event.

This recommendation is elaborated in section 4.3.1.

Recommendation 11

Use a common methodology and tool to prepare for cross-border events.

Using a common methodology and tool makes it easier to overcome the lack of a common cross-border management structure: it is an operational way to achieve better mutual understanding and collaboration, without touching complex institutional and legal aspects. Using a common methodology and tool, such as the IEM/IET, provides the benefit of:

- Improved exchange of information and communication
- a speedier and more efficient alert process
- enhanced opportunities for optimal assistance across borders
- identification of cross border dependencies and vulnerabilities

This recommendation is elaborated in section 2.2.2.3

5.2 Policy recommendations

Recommendations to take into account in risk policies at national level:

[60] The SPEAK guidelines include elements of a successful communication mix, including the Study of the information-seeking behaviour of audiences, Preparing for the loss of critical infrastructure, Engaging key stakeholders, Always considering ethical implications and the application of Knowledge gained from previous incidents. More details can be found in D3.2.

Policy Recommendation 1

Improve incident management for cascading effects by encouraging an upgrade from the current multidisciplinary practices to a transdisciplinary approach

This requires the emergency planners and incident managers involved to transcend the boundaries of their own discipline and to manage the risks (preparation) and the incident (response) from a case or scenario-perspective instead of a discipline-perspective.

A transdisciplinary approach requires a shift in mentality, appropriate structures and an adequate methodology and supporting tool.

Policy Recommendation 2

Improve incident management for cascading effects by encouraging intensified collaboration with other actors beyond the traditional first response disciplines.

As information management is a crucial supporting process both for emergency planning and response, successful incident management needs to collect that information from all actors concerned, including those whose responsibility is prevention and recovery.

Only from a comprehensive approach throughout the whole risk and incident management cycle, all pieces of the puzzle related to information, knowledge and resources can be brought toghether, which is necessary for informed decisions on actions to be taken and resources to be deployed. The whole cycle covers: prevention (incl. risk assessment), preparation (incl. planning and training), response and recovery.

Policy Recommendation 3

Improve incident management for cascading effects by encouraging a common approach for all the actors involved: a common methodology and instrument or tool to align all those concerned, from an incident-perspective.

Gathering a multitude of actors, with different background, knowledge, dynamics, visions, goals etc. could benefit from one single methodology and supporting tool to facilitate alignment of visions and efforts. That requires an incident-based, trans-disciplinary methodology and tool, that does not belong to one specific discipline, nor serves one specific discipline but serves the interest of society as a whole and public safety and security in particular.

Recommendations for EU policy

Promote transdisciplinarity

EU regulations could impose (preferably) or encourage (minimally, as a transition measure) transdisciplinarity. This would oblige member states to promote transdisciplinary thinking by using a scenario-based methodology and instrument for national, cross- and transborder planning and response. This could for instance be done as a proposal for amendment of the Seveso III Directive, since measures on domino effects are already specifically covered.

This recommendation is elaborated in section 3.1.2.4.

6 Conclusions

The most important key characteristic of incidents with cascading effects, distinguishing them from other incidents, is the high level of indeterminacy that incident managers face. Indeterminacy is a specific subcategory of uncertainty and refers to the lack of insight in society, in the relations and links between societal systems. This is what characterises the vulnerability in case of cascading effects as per definitions multiple systems are impacted.

Over the course of the project, it was confirmed that preparedness is of vital importance for a successful response to a complex incident having cascading effects. This includes establishing solid relationships that transcend the individual objectives of the organisations involved so that informed decisions can be made quickly during the response.

The objective of this report is to provide insights to the emergency response community regarding best practices for management of incidents with cascading effects. To that end, recommendations are provided that enhance and support knowledge of crises, strengthen crisis management, and facilitate communication across systems, borders, organisations and disciplines. These recommendations are based on the experience and knowledge of the CascEff project researchers and on information collected from potential users of the IEM/IET, and are presented throughout the report as well as collectively in Chapter 5.

Recommendations to improve incident management practices:

- Increase awareness of cascading effects and facilitate their incorporation into incident management procedures by following the structured methodology provided by the IEM.
- Strengthen procedures for risk-, vulnerability-, and dependency analyses.
- Improve the preparation process by cataloguing and detailing specific information for easy availability.
- The use of scenario elaboration can facilitate the improvement of the quality of information for emergency planning and response decisions.
- Improve shared situational awareness and analysis in the preparation phase by establishing relationships and protocol prior to incidents.
- Identify Key Decision Points based on estimations of temporal aspects and consequences.
- Incorporate physical modelling in decision making during crisis situations.
- Consider and use lessons learnt, stored data, scenarios and feedback loops as opportunities for continuous improvement.
- Rely on a thoroughly planed communications mix when communicating with communities and other stakeholders not directly involved in crisis management.
- Train personnel for managing high impact events with potential cascading effects.
- Use a common methodology and tool to prepare for cross-border events.

Policy recommendations to improve incident management at national level include:

- Improve incident management for cascading effects by encouraging an upgrade from the current multidisciplinary practices to a transdisciplinary approach.
- Improve incident management for cascading effects by encouraging intensified collaboration with other actors beyond the traditional first response disciplines.
- Improve incident management for cascading effects by encouraging a common approach for all the actors involved: a common methodology and instrument or tool to align all those concerned, from an incident-perspective.

Recommendation for EU policy

- Promote transdisciplinarity in EU regulations

Research within the CascEff project has illustrated that a deeper understanding of the characteristics and evolution of cascading effects and consequences would facilitate a more efficient incident management process. While many of the established procedures and functions for incident management to some degree already include elements of the recommendations identified in this report, an increased overall understanding of the rationale for the suggested improvements, such as a transdisciplinary approach and a common, structured methodology and tool, is elemental for reaching a new level of efficiency in incident management for cascading effects.

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Appendix 1 - Typology of incidents based on their characteristics

<table>
<tr><th>Daily, routine safety and security events</th><th colspan="2">Incidents</th></tr>
<tr><td>In the majority of cases, these are single-cause/hazard events (fire, medical, police, … interventions). They can also be multi- cause/hazard or multiconsequential.

Relief operations are often monodisciplinary[61]. If multidisciplinary, there will be joint interventions (with mutual arrangements, alignment of actions, etc.) without the need for a specific structure for coordinated actions or specific joint preparation.

The complexity of the situation does not transcend the capabilities and expertise of the actors involved.

Generally operational interventions without the involvement of competent authorities (no strategic level).</td><td colspan="2">Can be single-cause/hazard, will most often be multihazard.
The impact is by definition multiconsequential.

The complexity of causes and consequences determines the level of complexity to handle

The level of complexity determines the type and number of first response and other disciplines involved, as well as the level of incident management (local, regional, national) and demands specific/multidisciplinary command and coordination structures (both. operational and strategic).

Generally competent authorities will take strategic responsibility.

The complexity and nature of potential consequences (material, human, economic and social) will determine the sense of urgency and define time pressure.</td></tr>
<tr><td></td><td><u>Incidents</u>
A certain scale of damages</td><td><u>Large-scale incidents</u>
Damages qualified as large scale by the incident command team or competent authority</td></tr>
<tr><td colspan="3"><u>Cascading effects</u>
Involving an originating event including the risk of a second or more events as a result of system dependencies. The impact and consequences are by definition multisystem.</td></tr>
<tr><td><u>Routine events with cascading effects</u>

Combine the characteristics of routine events with cascading effects</td><td colspan="2"><u>Incidents and large-scale incidents with cascading effects</u>
Combine the characteristics of incidents with damages of a certain scale, resp. large scale damages</td></tr>
</table>

Table 5 Overview how common key characteristics of incident management relate to different types of events (Van Heuverswyn, 2017)

[61] See also Chapter 3.2.2. on multi-, inter- and transdisciplinarity

Appendix 2 – IET/IEM user feedback evaluation and implementation

The results of several evaluation activities are presented in this appendix to provide the basis for recommendations for improvement of incident management using the IET/IEM. The evaluation activities consisted of Focus Group workshops (providing feedback on the IET) and Validation Exercises (providing feedback on the IEM).

An evaluation methodology for testing and guiding the validation of the IET/IEM was created in WP1[62], to be further developed in WP5. For the IET this effort was focused on two general areas:

1. ensuring that the IET functions without bugs or errors (pertains to the IET), and
2. the IET has the correct set of features to optimize its value to the users.

For the IEM the focus was on:

1. Added value of the IEM
2. Applicability of the IEM

The actual testing of the IET/IEM is part of WP5 (Tasks 5.2 and 5.3). The protocols for handling the information collected from the Focus Groups and Validation Exercises are described in detail in D5.3 and D5.4, respectively. Recommendations for improvements of the IET functionality (point 1 above), based on feedback from Focus Group participants, were used in WP4 (Task 4.2) to guide the further development of the IET. This appendix will focus mainly on ensuring that the IEM has been optimized to provide the best value to users (point 2 above).

According to the D1.4 report, most testing/evaluation methodologies distinguish 4 phases:

- a preparatory and planning phase: *Design and development*;
- the actual running of the exercise: *Conduct*;
- the evaluation of the exercise: *Evaluation*; and
- the integration of lessons learnt into the overall project or program: *Improvement Action Plan*.

The main results of the *Evaluation* and *Improvement Action Plan* phases are integrated into this appendix; however, the full analyses are reported in D5.3 and D5.4. The *Evaluation* phase is an analysis of Focus Group and Validation Exercise results and debriefings. The *Improvement Action Plan* phase provides actions, guidelines and recommendations for improvement of the IET/IEM and its subsequent ability to provide added value to incident management operations in crises having cascading effects. The ultimate goal of this appendix is to develop recommendations for the use of the IEM in incident management of potentially cascading events.

A brief summary of the two sets of Focus Groups and the two Validation Exercises is given in in the following paragraphs. Analysis and implementation of the feedback, in terms of ensuring that the IET/IEM have the optimal features for improving incident management in cascading events, is structured as follows:

1. Discussion of the feedback from the Focus Groups that was originally intended to apply to development of the IET but which can also be applied to the IEM.

[62] This methodology is described in D1.4 “Report on scenarios to be elaborated for testing the incident evolution methodology”, section 3.2 “Testing objectives & evaluation criteria for testing”, pages 27 – 29.

2. Discussion of the feedback from the Validation Exercises that is related to the underlying methodology. In this case, the feedback provides guidance for determining the most appropriate scope, logical structure, features, etc that make up the IEM.
3. Recommendations for implementation of the IEM into incident management operations.

The main focus of this appendix is point 3 above, i.e. what is the added value of using the IEM, what recommendations can be given in relation to the use of IEM in incident management, and what recommendation on improved incident management does this lead to. To reach this point, however, some background information is given first.

Focus Groups and Validation Exercises
Feedback was collected from two sets of Focus Group workshops and two Validation Exercises. The first set of Focus Group workshops was held in May, 2016 and was intended to test the IET at a relatively early stage of development. The second set of Focus Group workshops was held in January, 2017 and was intended to test a relatively advanced version of the IET. The Validation Exercises were held in April/May, 2017 and were intended to test the added value and applicability of the IEM. The main results of these tests are summarized in the following paragraphs.

Parallel with the development of the IET, scenarios were also being developed for evaluation purposes. Some of these scenarios, or parts of them, were used in the Focus Group workshops to guide the participants through the IET procedures for building cases. Two of the scenarios were chosen to be fully elaborated and used for the Validation Exercises; these scenarios are described in D5.3. Descriptions of the scenarios developed within the project are available in the D5.1 report.

Focus Group 1 Workshops summary [63]

The first set of Focus Group workshops was held from May 9 to 20, 2016 with participants representing different types of potential end users of the tool. Due to their role as risk and crisis managers, potential users of the IET were selected as Focus Group participants, rather than IET development theorists. The experiences, opinions and feedback shared in these meetings were helpful for the IET design and for understanding implementation issues as well as the real needs of management actors facing incidents having cascading effects. The workshop objectives were to test the creation of cases and entering data to the demo version of the IET under development.

The participants were asked to describe their understanding of cascading effects and their experience in facing crises leading to cascading effects. It appeared that sometimes they were confused between large scale incidents and incidents having cascading effects. They indicated various levels of experience based on their personal tenure at their current positions.

The IET user interface presented at these workshops was a temporary and rudimentary way to enter data into the IET. When using this demo version of the tool, it was difficult for participants to precisely understand what to do because it didn’t work properly. Only the General Info page of a case was accessible online. A subjective assessment of the comments and questions collected from the participants and observers is given in later in this appendix.

[63] See the deliverable report D5.3.

Since much of the IET was not functioning during these workshops, it allowed the participants to think more about the underlying methodology, which was more beneficial to the project later, after the focus shifted away from the IET and toward the IEM.

The participants were interested in the project and its objectives. Several advantages were seen, e.g. for risk management within municipalities and to have the “same” information relating to cascading effects. They thought the IET would be useful, especially for planning and preparation[64]. In relation to the response phase it was suggested to have two different versions: one on site where one could input information on the actual situation immediately, and one with the management staff where they can use the information to see what could happen in the future.

Focus Group 2 Workshops Summary [65]

The second set of Focus Group workshops was held from 6 to 12 January 2017. The objective was to test the available version of the IET, from data input to results visualisation, for getting useful information on the perceived added value of the tool, to identify what, if any, changes might be needed to improve user friendliness of the tool, and to determine a roadmap for the next development steps.

The attendees were asked to create a test case, simulate the related cascading effects, and give feedback on:

- the added value of the present version of IEM/IET for their jobs (in the planning, training, response and recovery phases);
- the difficulties faced when dealing with the different steps of the IEM (case creation and management, systems creation and management, incoming/produced effects definition, impacts definition, initiating event characterisation); and
- the most relevant presentation of results for identifying key decision points along the chronology of events.

This set of Focus Group workshops provided useful insight into the potential added value of the IET/IEM, compliance with the expectations a user could have for a cascading effects decision-support tool or methodology, its functionality, its usability, and how the available version could be improved. The findings made it clear that the IEM/IET has great potential to support crisis/emergency management or policy. One of the strengths is the use of tree views to display results; this was greatly appreciated by participants. However, the workload for entering data, the lack of clarity for some labels, and the lack of intuitiveness of the IET are amongst the potential weaknesses. Further development should focus on reducing weaknesses and fixing bugs before the Validation Exercises planned for April and May 2017.

At the end of the workshops participants were asked to fill in an online questionnaire for statistical data and comments about the points that had not been discussed deeply during the discussion. They were also asked to continue testing the IET during the days following the workshops and send their feedback to their national focus group coordinator.

[64] This point supports Recommendation 1 in subsection 3.3.5.

[65] See the deliverable report D5.3.

Validation Exercises summary[66]

The two Validation Exercises were held in Nancy, France on 25 – 26 April, and in Ranst, Belgium on 10 – 11 May. The objectives of the validation exercises were to assess the added value and understand the applicability of the IEM (from the perspective of potential users). The scenario used in the French exercise was the Séchilienne landslide and the scenario used in the Belgian exercise was the cross-border blackout.

On the first day, after an orientation session, the participants were asked to do a preparedness exercise without using the IEM, and then they were taken through the same exercise using the steps of the IEM. For each IEM step the participants were asked to record their thoughts in a validation template. The information collected in the validation templates was discussed at the end of the day.

On the second day the participants took part in a simulation of the response phase of their respective scenario using 3d views supplied by XVR and the IEM. Their use of the IEM was observed by project staff. Again, the participants were asked to record their thoughts in a validation template that was discussed after the session. The IET prototype was also presented as a way to visualise the steps of the IEM.

Analysis of the IET/IEM feedback

In this subsection the feedback coming from the Focus Groups, which was originally intended to cover the physical IET, are addressed. Only those issues that can also be applied to the IEM are discussed here; the feedback that deals exclusively with the IET is reported in D5.3.

The results of the Focus Groups, along with some input from the project researchers, indicate that users would like to have the following improvements incorporated into the IET/IEM:

- **Connectivity -** Make use of existing online tools (such as mapping and weather), and existing databases to provide some of the input data, and existing IMTs. For the IEM this would encompass accessing knowledge bases and knowing where to find the information.
- **Customization –** Ensure that users are familiar and comfortable with units and terminology used. There might be both national and regional differences. Allow users to modify or add their own subsystems, types of effects and impact subcategories.
- **Scope -** A large number of effects were suggested to be added. However, the 22 systems built into the IEM are seen as too many. On the other hand, these systems should be further detailed into subsystems as shown in Figure A below. Apparently there are contradictory opinions about the level of detail/complexity of the IEM.
- **Logical structure -** Show how much of the total impact of a system collapse is attributed to each of the systems/subsystems. This would clarify the relationship between systems/subsystems and help rank or assign value to them. Clarify the distinction between a system boundary and a case boundary.
- **User requirements -** Base the dispersion of contaminants on realistic principles (spread in direction of wind/flow rather than radial expansion from source). Allow the IEM to receive output from modelling tools be used as input for predicting the extent of effects. Provide guidance on which values to use for the effects and the sensitivity of these values. Allow users to access historical or generic cases from which to build new cases. Possibly use the

[66] See deliverable report D5.4.

systems, sub-systems, effects and dependencies developed in WP2 and/or the Netherlands 24 high impact scenarios as reference cases. Provide an e-learning course to train users. Clarify the legal consequences if the IET/IEM provides faulty guidance.

- **Functions/features -** Use threshold values for vulnerabilities and be warned when a threshold value is about to be reached. Allow systems to have more than one incoming effect. Allow the use of multiple generic reference cases within one real incident. Distinguish between immediate and long term effects and impacts. Allow subsystems to have varying levels of response when an impact occurs to the parent system.
- **Output -** Provide a prioritized list of actions for the systems and subsystems affected by the incident. Include probabilities for the effects and impacts. Include a checklist of possible cascading effects using visualization of potential targets in combination with potential consequences, similar to Figure A. Provide a worst-case timeline for cases. Add a timescale for the predicted evolution of the incident.

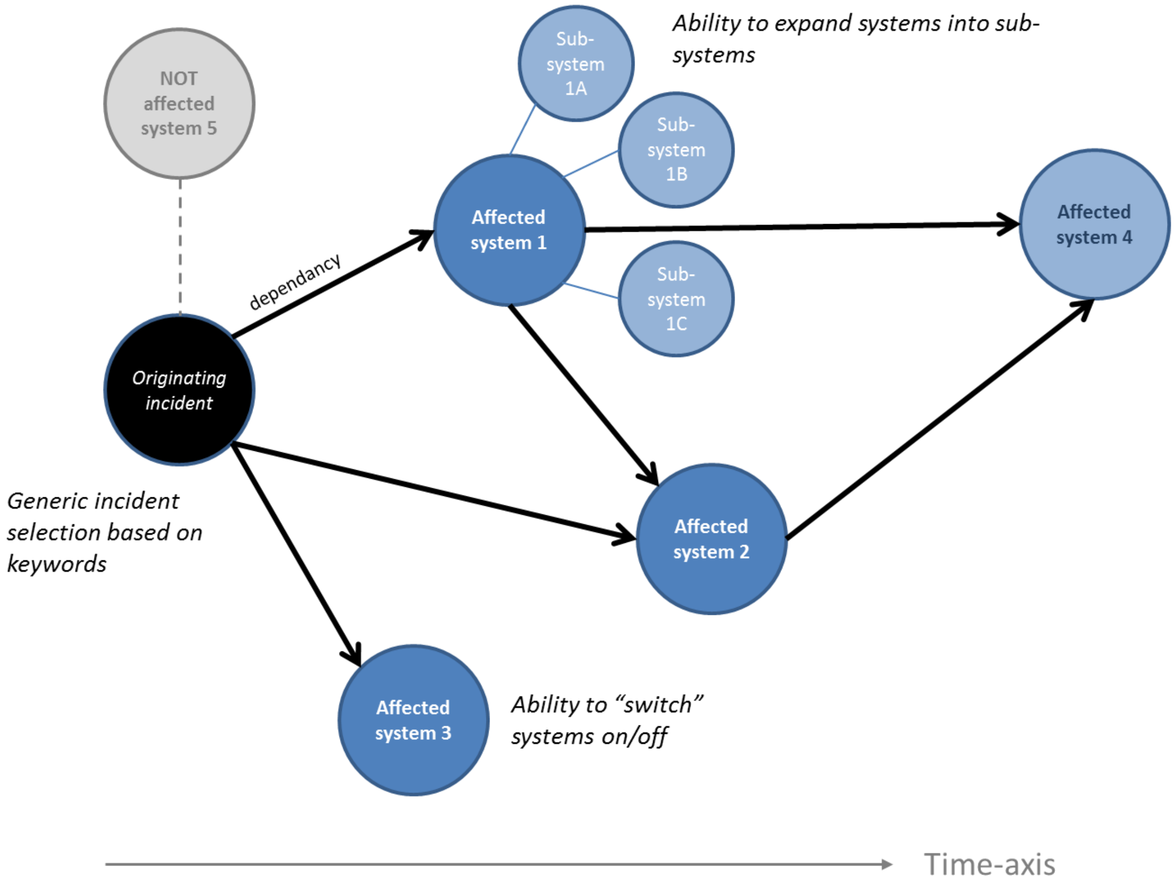

Figure A: Visualisation as suggested by Focus Group 2 users. The nodes are the systems, which could expand into sub-systems and can be switched on/off based on IET automatic analysis and by users.

Recommendations for implementation of IET/IEM in incident management
Based on the feedback discussed in the previous subsections, the following recommendations for implementing improvements to incident management practices are given:

Recommendation 1. Use the IET/IEM as a supporting methodology for risk, vulnerability, and dependency assessments.

Incident managers and other potential users of the IET/IEM felt that the IET/IEM could provide a valuable foundation for risk, vulnerability, and dependency assessments due to the extensive amount of knowledge needed to set up and maintain the IET/IEM. This process could provide structure to the work that users would need to do anyway. These assessments are already part of the standard operating procedures for most emergency management organisations. By following the entire IEM, the assessments can be applied to cascading effects.

Recommendation 2. Improve situational awareness and communication, particularly between disciplines and across borders, by identifying potential cases/scenarios prior to the incident.

Situational awareness and communication are sometimes difficult to sustain during incidents, especially those with cascading effects. The IEM makes it possible for relationships and protocols to be established during the preparedness phase, before the incident occurs. The information provided by the IET/IEM can make it easier to make coordinated decisions, since all users would have access to the same information at the same time, and also simplify the handover process between shifts. Potential issues such as differences in language, terminology, and dimensional units can be identified in advance.

Recommendation 3. Train personnel for managing high impact events with potential cascading effects using the IET/IEM.

The IET/IEM can be used for training purposes. It can be used to acquaint personnel with the specific risks and vulnerabilities that exist within their response area and it can help train people to think in terms of cascading effects. Different options and scenarios can be tested, providing a strong foundation for decision-making during an actual event.

There were several requests for the IET/IEM to provide users with a prioritized list of actions based on the consequences of potential cascading effects. They wanted to know where to focus their attention in cases where many things could happen. This need is understandable, however it was not implemented because: 1) cascading effects often occur when something unexpected happens that causes the evolution of an incident to change, by focussing on the expected sequence of events the incident manager could miss an important opportunity to stop the cascade; 2) resources may be used in an inefficient way; and 3) ethical issues, i.e. if the tool should take decisions that would affect people, e.g. via prioritizations. However, some users have expressed interest in adding their own specific lists of actions (generated outside the IET/IEM) to the IET, to be able to easily find them if a certain system is affected.

Appendix 3 – Revised D1.3. A flowchart of the methodology for improved incident management in crisis

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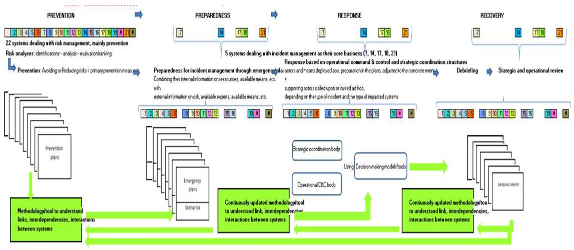
A flowchart of the methodology for improved incident management in crisis



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Executive summary

This report looks into the logic and procedures followed by an incident response team in order to identify opportunities to improve current practices.

The report starts with a description of key characteristics and challenges of incident management. A typology of different subcategories of incidents is given, highlighting common and specific characteristics for daily, routine interventions, incidents, including those with large scale impact and cascading effects.
Secondly, common practices to deal with the challenges are described. Good practices developed over the years include preparation through emergency planning, a coordinated response based on multidisciplinary structures and information management as a supporting process for both practices.
To complete the understanding of logics and procedures, the link between incident management and the institutional framework for civil security and risk management models is explained. This shows the importance of involving other actors than the first responders in the process of collecting relevant information, for preparation as well as for response.

From the comprehensive overview of logics and procedures and links to other processes before and after (risk management processes: prevention and recovery) as well as beyond (institutional frameworks for civil security), opportunities to improve current incident management practices are identified.

A transdisciplinary approach is proposed; the role and contribution of the Incident Evolution Methodology and Tool are explained.
The recommended approach to improve current incident management practices consists of an upgrade of the role and work done in multidisciplinary structures (the emergency planning, operational command post and strategic coordination bodies) by:
- promoting a transdisciplinary mentality, approach and vision: encouraging incident managers to transcend their own discipline, take an umbrella view from the case (emergency planning) or incident at stake (response) and look for aspects across, between and beyond the input of each individual participating discipline;
- Encouraging the use of a methodology and corresponding tool to support that transdisciplinary effort.

In the context of incident management, the added value of a transdisciplinary approach consists of the recognition that all divisions in disciplines and specializations are artificial, whereas reality doesn't take them into account. This is an important vision for dealing with all types of risks and incidents, but specifically important for incidents with cascading effects because the main challenge is to understand and anticipate vulnerabilities because of dependencies, i.e. vulnerabilities that are embedded in the system as a whole and to which we have become blind because our fragmented, monodisciplinary approach of parts of reality.

The added value of the IEM is that it provides for a structured approach to collect all relevant, monodisciplinary information and asks for the identification of links, relations, dependencies creating vulnerabilities, in order to get an integrated and holistic view on all case/incident relevant aspects to manage. Both the links and the global overview are exemplary of transdisciplinary thinking, different from a traditional multidisciplinary approach.

When used in the preparation and response phase, this methodology will improve the understanding of the evolution of an incident and lead to better informed decisions. The use of a transdisciplinary instrument will automatically lead to more awareness of the added value of transcending the boundaries of individual disciplines in multifacetted cases and thus encourage over time a transdisciplinary mentality. Without the need to touch upon existing structures, the current multidisciplinary bodies might transform in the longer run to truly transdisciplinary bodies.

Table of Content

1 Introduction 6
1.1 Task description 6
1.2 Methodological approach 6
1.3 Relevant definitions 9

2 Key characteristics of incidents and challenges for incident management 10
2.1 Key characteristics of incidents 10
2.2 Incident management challenges 10
2.2.1 Summary of key elements characterising incident management 13
2.2.2 Common and specific key characteristics for incidents with cascading effects 13
2.2.3 Typology of incidents based on their characteristics 16
2.3 Concluding remarks on characteristics and challenges of incident management 18

3 Common practices to deal with incident management challenges 19
3.1 Preparation through Emergency planning 20
3.2 Coordinated response and multidisciplinary structures 23
3.2.1 Monodisciplinary Command and Control 23
3.2.2 Multidisciplinary structures for strategic and operational coordination 24
3.3 Information before and during incident response 25
3.3.1 Information in the preparation phase 25
3.3.2 Information during response 26
3.4 How common practices answer current incident management challenges 29

4 Interdependent frameworks for civil security, risk management models and incident management logics and procedures 30
4.1 Institutional frameworks 30
4.2 Risk and incident management models 31
4.3 Identification of actors from a comprehensive perspective 36
4.3.1 Core and supporting incident management actors 36
4.3.2 Risk and Incident management Information owners 37

5 Opportunities to improve incident management logics and procedures 40
5.1 Lessons drawn from challenges and the current logic and procedures 40
5.1.1 Characteristics and challenges of incidents with and without cascading effects 40
5.1.2 Common incident management practices 40
5.1.3 Core and supporting incident management actors 41
5.1.4 Logics and procedures beyond incident management preparedness and response 41
5.1.5 Key word multidisciplinarity 42
5.1.6 Multi-, inter- and/or transdisciplinarity? 43
5.2 A methodology for improved incident management 46
5.2.1 The added value of a transdisciplinary approach 46
5.2.2 The role and contribution of the CascEff Incident Evolution Methodology 47
5.2.3 The transdisciplinary character of the Incident Evolution Methodology and Tool 48

6 Conclusion on opportunities to improve incident management 50

Flowcharts for improved incident management 51

References 55

List figures 59

List tables 60

Annex I – Table of correspondence midterm review D1.3 61

1 Introduction

This report includes the revised version of CascEff Deliverable 1.3 (July 14, 2015), taking into account the feedback from the midterm review report (January, 2016)[1].

1.1 Task description

Task 1.3., 'Development of a methodology for improved incident management', is described in the DoW as follows: "*A method for improved incident management will be developed taking advantage of the improved information available for preplanning, response and recovery from the incident evolution tool. The methodology will define the logic and procedures to be followed by an incident response team engaged in pre-planning, response, debriefing and training and foresight.*"
The expected Deliverable cf. the DoW is: "*A flowchart of the methodology for improved incident management in crisis* "

D1.3 2015 was criticized at the midterm review on the following aspects:

- The focus on cascading effects, and the potentially necessary interaction, or iterative nature of the different phases is unclear;
- The Deliverable does not sufficiently clarify in how far the IET improves current practices;
- The literature review (one of the research methods) is too autoreferential (too many references to CascEff Deliverables);
- Definitions are not sufficiently in line with other CascEff Deliverables and are sometimes contradictory (e.g. incident management).

A CascEff glossary was developed and published as a new Deliverable 1.6 (June 2016) in order to ensure a coherent use of definitions in all CascEff publications. The first three points of attention are taken into account in this revised version of Deliverable 1.3., included as a distinct report attached to Deliverable 1.5[2]. The main findings of the revised D1.3 are also integrated in Chapter 2-4 of D1.5.

1.2 Methodological approach

Focus and scope
The aim of this task was to develop a methodology to improve incident management, which is also one of the main objectives of the CascEff project as a whole: "*Improved incident management for present and future threat*", with a specific focus on incidents with cascading effects (CascEff, 2013).
It was decided by the task partners to focus first on the logic and procedures of incident management and to search for opportunities for improvement (Chapter 2-4). In the second part, a methodological, transdisciplinary approach to improve current incident management practices is proposed. This also includes an explanation on how the CascEff Incident Evolution Methodology (IEM) and corresponding Tool (IET) match this new approach (Chapter 5).

[1] CascEff Consolidated Review Report, 2016
[2] A table of correspondence, refering to the midterm review report, is included in Annex I

Logic and procedures

No definition of 'logic and procedures' was given in the Description of Work (CascEff, 2013). At this stage of the project, they are understood as the customary or mandatory practices aiming at efficient incident management.

Areas of attention

The following areas of attention have been included as part of the methodological approach of this chapter, in order to increase a widespread applicability of the proposed methodology for improved incident management:

- **Awareness of interdependencies between *all* relevant logic and procedures: not only within the incident management process but also beyond, such as those of the broader risk management process and institutional frameworks for civil security**

A key activity of the CascEff project is the understanding of (inter)dependencies of (possibly) impacted systems in case of incidents with cascading effects. The understanding of (inter)dependencies across systems is not only of major importance for the anticipation of the evolution of an incident and the estimation of the possible impact and consequences (crucial for planning and response), it is equally important to understand links and relations between the logic and procedures of the whole incident management process. This relates in the first place to the fact that incident management includes sub processes before, during and after an incident, generally referred to as Preparedness & Planning, Response and Recovery. Moreover and in turn, the incident management is in itself part of a larger risk management process, including risk analysis and prevention; and influenced by (national) institutional frameworks shaping the organisation of civil security.

Because of chronological and functional interdependencies between risk and incident management (Van Heuverswyn, 2009), the logic and procedures of these broader models and frameworks and their interdependencies also need to be taken into account in the methodological approach for the identification of opportunities to improve current incident management practices.

⇨ Attention to interdependencies between incident management logic and procedures and risk management models and institutional frameworks for civil security

- **Awareness of diversity in a continuously evolving context**

A second aspect of importance to achieve the Task 1.3 goal is the fact that a methodology needs to take into account the rapidly evolving societal environment and has to deal with a diversity of factors determining the organisation of incident management at national level. Besides varieties in priorities because of local risks and threats, the national safety and security culture, the level of awareness of the local population etc., this diversity also relates to institutional and operational aspects, such as the profile and number of organisations involved at local, regional and national level, their degree of involvement before, during and after an incident, their internal organisation following from their assignments, the organisation of monodisciplinary command and control structures, of multidisciplinary coordination structures, etc.

Because of this diversity, a comprehensive and detailed methodology could encounter resistance if not all risk specific or national specific aspects are covered. For this reason, a conceptual choice was made to look for common threads based on generic aspects and shared practices and approached.

⇨ Focus on common threads, resistant in time and independent of national differences

Methodology

The main methodological approach to achieve the Task 1.3 objectives consists of a comparative analysis of different approaches and models describing institutional, risk and incident management logics and procedures.

The main sources are:

- Literature review related to incident management, risk management, civil security strategies and methodologies proposed and used by academics, competent authorities and practitioners;
- Previous CascEff Deliverables and ongoing tasks, including feedback from practitioners and representatives of competent authorities participating in the CascEff Focus Groups and CascEff Validation Exercises (See CascEff D5.3, 2017; CascEff D5.4, 2017).

Research delimitations

Delimitations of this research are first of all related to the overall scope and goal of the CascEff project, viz. the development of an Incident Evolution Methodology and Tool to improve the management of incidents with cascading effects.

The literature study covered national as well as international models and theory. Information on national practices is limited to the countries represented in the CascEff project: Belgium, France, the Netherlands, the United Kingdom and Sweden.

The abundant literature on incident management rarely deals specifically with incidents having cascading effects. A preliminary step in the research therefore consisted of looking into common and diverging characteristics of incidents in order to ensure that findings based on incident management in general also apply for incidents with cascading effects. As is demonstrated in 2.2.32.1, the latter are a subcategory of incidents in general and similar dynamics of processes could be identified. Diverging characteristics, specific for incidents with cascading effects, were also identified and explained.

A complete overview of national models and practices in the EU was not considered feasible within the timeframe of this task. The comparative analysis shows however that national and international models have a solid common ground despite the differences, which made it possible to draw a common methodology from a sample of national and international practices.

Structure of the report

This report consists of 4 chapters, describing: 1) the characteristics of incidents and incident management challenges (Chapter 2); 2) common practices to deal with them (Chapter 3); 3) interdependent processes from civil security and risk management (Chapter 4); including a clarification on the profile of core and support incident management actors (4.3) and 5) opportunities to improve current incident management practices (Chapter 5).

This report starts with a description of key characteristics and challenges of incident management. A typology of different subcategories of incidents (general, large scale, cascading) is given, highlighting common and specific characteristics.

Secondly, common practices to deal with the challenges are described. Good practices developed over the years include preparation through emergency planning, a coordinated response based on multidisciplinary structures and information management as a supporting process for both practices.

To complete the understanding of logics and procedures, the link between incident management and the institutional framework for civil security and risk management models is explained. This shows the importance of involving other actors than the first responders in the process of collecting relevant information, for preparation as well as for response.

From the comprehensive overview of logics and procedures and links to other processes before, after - risk management: prevention and recovery - and beyond - institutional frameworks for civil security -, opportunities to improve current incident management practices are identified.
A transdisciplinary approach is proposed; the role and contribution of the Incident Evolution Methodology and Tool are explained.

1.3 Relevant definitions

The following notions and terms are used cf. the definitions mentioned in CascEff Deliverable 1.6. (CascEff D1.6, 2016).

- Cascading effects (technical and pedagogical definitions);
- Competent authority;
- Dependency, dependency type, dependent/impacted system;
- IET;
- Impact;
- Disaster/Emergency management cycle and phases: mitigation/prevention, preparedness, response, recovery;

Only the definitions of key notions in this report are listed here to facilitate the reading:

- **Incident** Situation that might be, or could lead to, a disruption, loss, emergency or crisis;
- **Crisis** - Situation with high level uncertainty that disrupts the core activities and/or credibility of an organisation and requires urgent action (EN ISO 22300:2014) In CascEff D1.6, also this further explaining definition is used: A chain of events affecting multiple systems, either in series or spreading in parallel.
- **Incident management** - an ongoing process to prevent, mitigate, prepare for, respond to, and recover from an incident that threatens life, property, operations or the environment; **Emergency management** - same definition (NFPA 1600, 2016);
- **Emergency** - A sudden and usually unforeseen event that calls for immediate measures to minimize its adverse consequences. (UNDHA, 1992)
- **Interdependency** - A mutual dependency between two systems, i.e. system A is dependent on system B and vice versa

2 Key characteristics of incidents and challenges for incident management

2.1 Key characteristics of incidents

Incident management is the appellation used in the CascEff project (CascEff D1.6, June 2016) to refer to the management of a situation or event that leads or could lead to damages, losses or disruption. It is 'an ongoing process to prevent, mitigate, prepare for, respond to, and recover from an incident that threatens life, property, operations or the environment'. ISO 22300:2012 also adds emergency and crisis as the consequences of such an event. In other sources, such as national practices and literature, incident management, emergency management, disaster management and crisis management are sometimes used interchangeably, as synonyms.

Because of the variety of appellations, it is relevant to identify common aspects covered by these synonyms, in order to highlight the specific characteristics that qualify incident management. It is all the more important because the internationally accepted definitions, such as from ISO and NFPA, define incident/emergency/disaster management referring to the main activities of the incident management process without further indication about the specific characteristics and challenges that differentiate it from the management of daily, routine safety and security relief and rescue operations.

From a comparative study of legal definitions at national level and definitions and circumscriptions found in guidelines and good practices (CascEff Deliverable D1.4(2), 2016, Brugghemans et.al., 2015; University of Leicester, 2011) the following common characteristics of incidents become clear:

1) A certain level of complexity of the situation, because of multi hazard causes and/or multiple consequences;
2) Uncertainty as an intrinsic part of incident management, which can be subdivided in: ignorance, uncertainty or indeterminacy;
3) Time pressure or a sense of urgency to remedy the situation;
4) A certain scale of damages or a serious or imminent threat of potential damages of a certain scale.

These four cumulative characteristics distinguish incidents from daily, routine rescue operations, such as fire fighting, police, medical or environmental interventions. They require a specific type of management, often demanding a certain level of multidisciplinary coordination.
Incidents can be further subdivided into incidents, large scale incidents and incidents with cascading effects (see below, 2.2.3).

2.2 Incident management challenges

The four key characteristics of incident management point out the challenges incident management logic and procedures have to deal with. They are clarified in the following paragraphs:

1. Complexity

Incident management involves a certain level of complexity which is determined by a number of factors, such as the concrete hazards as well as the possible consequences of the incident and consequently the profile and number of actors involved, the specificity of their modi operandi, (the boundaries of) their assignment, the focus and knowledge of those actors, etc. (Brugghemans et.al., 2015; Van Heuverswyn, 2009a; Stirling and Calenbuhr, 1999; Viaene, 1998)

- **Possible multi hazards**: the causes of incidents can be natural and/or man made, accidental and/or intentional. Every incident, from small to large scale, is a specific, often unique, configuration of a multitude of causes, factors, etc. Moreover (possible) interactions often increase the level of complexity.
- **Multiconsequence:** not only the hazards, but also the nature and scale of the consequences determine the type of appropriate interventions and accordingly the first response as well as other disciplines[3] called upon: only material damages and/or victims and/or impact on transport or other critical infrastructure, etc.
- **Actors:** Both hazards and possible consequences determine the actors involved: Incident management is complex because it is intrinsically multidisciplinary, with multiple actors from different disciplines and services, belonging to different authorities at different levels: local, regional, national, cross border (different hierarchical lines).
- **Modi operandi**: all actors involved have their specific (thus limited) assignment, tasks and corresponding operating procedures. As incidents are rather exceptional phenomena in terms of frequency of occurrence, standard monodisciplinary modi operandi are elaborated for the more frequent, routine operations. Coordinating the interventions of those actors with different background, who are not used to work together in a complex and chaotic setting, adds to the complexity of managing incidents.

- **Knowledge**: all actors look at an incident based on their reference frame shaped by their discipline. Incident response interventions oblige those actors to work together towards a common goal that transcends their respective assignments and powers (Van Heuverswyn, 2009c). This requires a superposed level of coordination to create a common overall picture in order to decide on the most appropriate measures and their implementation, as well as an adequate allocation of resources, in accordance with the respective powers.

2. Uncertainty

Uncertainty is a broad notion and can be subdivided into (Van Heuverswyn, 2009a):

- **Ignorance**, which means not being aware of a problem or not being aware that information or knowledge is lacking.
- **Uncertainty** referring to the awareness of lack of information or knowledge: in this case, incident managers are aware that information and state of the art knowledge might be insufficient or unavailable, or that they lack the skills to deal with the information e.g. in case of overload of information and not being able to create a global picture.
- **Indeterminacy**, a specific type of uncertainty as stressed by Stirling (1998) because of fragmentation of available information and knowledge. This is caused by the fact that some challenges transcend the boundaries of existing disciplines (Lierman, 2004; Craye et.al., 2001; Wynne, 1996) and/or because of lack of insight in the system e.g. caused

[3] 'Disciplines' in this report is a synonym for 'Agency', which is also frequently used in literature on civil security, public safety and security. The word 'disciplines' is chosen to be used consistently in this report because of the argumentation on mono- and multidisciplinarity (synonyms for single-agency and multi-agency)

by specialisations that are too monodisciplinary. Incident managers might be unaware of information and knowledge available elsewhere in the system or might lack insight in interactions, interrelationships, interdependencies, possible synergies, etc. (Stirling en Calenbuhr, 1999). Ulrich Beck (Risk Society, 1992) calls this 'manufactured uncertainty' as opposed to intrinsic uncertainty. 'Manufactured', because it is generated by and structurally embedded in 'the system', in the way we organise our society, dividing power, knowledge and information. Whereas intrinsic uncertainty is typical for the human condition as knowledge is always running behind reality. We never know everything.

As many authors and incident managers stress, reducing uncertainty is of crucial importance, but eliminating uncertainty is an illusion, and thus uncertainty should be considered as a constituent element in every decision making procedure (Brugghemans et.al., 2015; Van Heuverswyn, 2009a; Seillan, 2005; Stirling en Calenbuhr, 1999; Stirling, 1998).
Ignorance and lack of information can be reduced as a continuous process of developing more information and knowledge. indeterminacy on the other hand, which is often underestimated or neglected (Stirling, 1998), needs mainly to be reduced by providing more insight in how the society as a whole (as a system) works, paying attention to links between subsystems and processes in terms of relations, interactions, interdependencies, etc.

3. Time pressure and a sense of urgency

The big challenge of incident management is that a variety of actors, first response and other disciplines, have to deal instantly with a variety of aspects, often in a chaotic environment. The actual occurrence or threat of serious damages, and the actual or possible disruption of critical societal functions and social life, create a sense of urgency and have to be dealt with. During the response phase, there is limited time to gather relevant information and as good as no time to generate or develop new information/knowledge.

As much relevant information, knowledge and expertise as possible should ideally be identified ex ante, during the preparation and planning phase and should be available in the right place, at the right time for an efficient response (Brugghemans et.al., 2015).

4. Scale/extent of the damages, threat, or potential damages

Incident managers are confronted with situations having considerable real, possible or probable damages. It is their responsibility to take appropriate measures to reduce the impact, by ensuring a status quo, remedying the situation, containing the damages and the restoration of normality. The scale of the impact will often determine the level of interventions: local, regional or national, mainly because of the required resources to provide for an appropriate response. Every country has its own criteria for scaling up or down, they are either legally defined (de lege) or used de facto, based on common practices.

Incidents and large scale incidents differ as to the scale of the impact and the required resources to manage the situation. Although a certain threshold is assumed for large scale incidents, no generally accepted set of criteria can be found in definitions or literature (see the definitions in annex to CascEff D1.4). Thresholds are often related to a specific type of incident, such as:

- the internationally accepted

- Richter scale for earthquakes[4];
- INES scale of nuclear incidents[5];

- An attempt to classification of natural disaster (Wirasinghe et.al., 2013);
- the Dutch GRIP categorisation of incidents[6]
- the classification of industrial accidents in type I, II and III (Meyer and Reniers, 2016)
- the codes yellow-orange-red for weather related events.

For CascEff Deliverable 1.4 an extensive literature search was undertaken to find a single set of criteria, some kind of multi-type categorisation and corresponding thresholds; none could be found.

The qualification of large scale is mostly a subjective decision, taken by the incident commanders or the competent authorities. For instance in Belgium, two legal documents give a list of indications to guide that decision: the Royal Decree on Emergency planning (2006) and the Royal Decree on the national emergency plan (2003). A circular letter (NPU-1) gives additional guidance. The criteria mentioned in these regulations are: geographical area affected, number of people affected, socio-economic impact, etc. No thresholds are mentioned for these criteria.

2.2.1 Summary of key elements characterising incident management

The key characteristics and corresponding challenges can be summarised for a more detailed, instrumental definition of incident management as follows: "*management of appropriate measures to deal with a (potential) situation, characterized by a certain level of complexity, uncertainty and time pressure, that leads or could lead to (large scale) damages and requires a specific organisation and coordination to manage the situation*".

2.2.2 Common and specific key characteristics for incidents with cascading effects

Given the instrumental definition of incidents with cascading effects used in the CascEff project (see below), the aforementioned key characteristics of incident management will apply to both incidents with and without cascading effects. They can be considered as generic characteristics of incident management, regardless of the type, nature or scale of the incident.

Large scale incidents and incidents with cascading effects can both be considered as specific subcategories of incidents/emergencies/disasters and therefore the general characteristics also apply to incidents with cascading effects.

For large scale incidents, the scale and extent of the damages is emphasized in the denomination. For incidents with cascading effects, the 'multicause/multihazard and multiconsequence aspect because of system dependencies' can be considered as the main differentiating criterion.

This follows from the instrumental definitions of cascading effects and incidents used in the CascEff project:

[4] See: https://en.wikipedia.org/wiki/Richter_magnitude_scale

[5] See at the website of the International Atomic Energy Agency – IAEA: http://www-ns.iaea.org/tech-areas/emergency/ines.asp

[6] GRIP means Gecoördineerde Regionale Incidentbestrijdings Procedure, see: https://nl.wikipedia.org/wiki/Geco%C3%B6rdineerde_Regionale_Incidentbestrijdings_Procedure

Technical definition (e.g. for selection of scenarios) (Reniers, G. and Cozzani V., 2013):
Cascading effects are the impacts of an initiating event where
1. System dependencies lead to impacts propagating from one system to another system, and;
2. The combined impacts of the propagated event are of greater consequences than the root impacts, and;
3. Multiple stakeholders and/or responders are involved.

Pedagogical definition:
An incident can be said to feature cascading effects when a primary incident propagates resulting in overall consequences more severe than those of the primary incident.

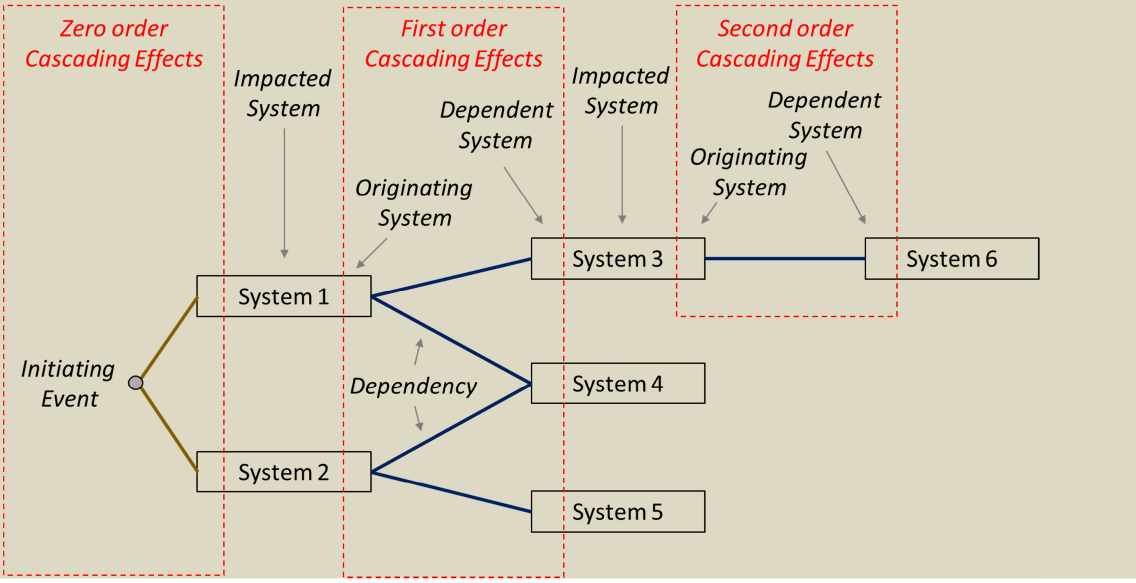

Figure 1 Schematics of the dependencies between systems in case of cascading effects[7].

It is not explicitly mentioned in the definitions but can be found in the additional explanations in D1.6 that a determining aspect for cascading incidents is the multiple system impact due to multiple events chronologically following each other.

For incidents with cascading effects, several notions related to time, esp. buffer time, are also relevant. These specific concepts break down the general notion of time into several specific notions, related to specific moments in the evolution of an incident. They help to determine the time pressure and the sense of urgency (See below in footnote 11 and CascEff D4.2).

Buffer time
The time between the start of an outgoing effect in the originating system and the time before a cascading effect occurs in a dependent system, i.e. when the performance of the dependent system starts to degrade (see Figure 2).
The buffer time is the sum of the Propagation time and the Endurance time

As the definition indicates, a buffer time can only occur in the case of a sequence, a cascade of multiple events.

[7] CascEff D2.2

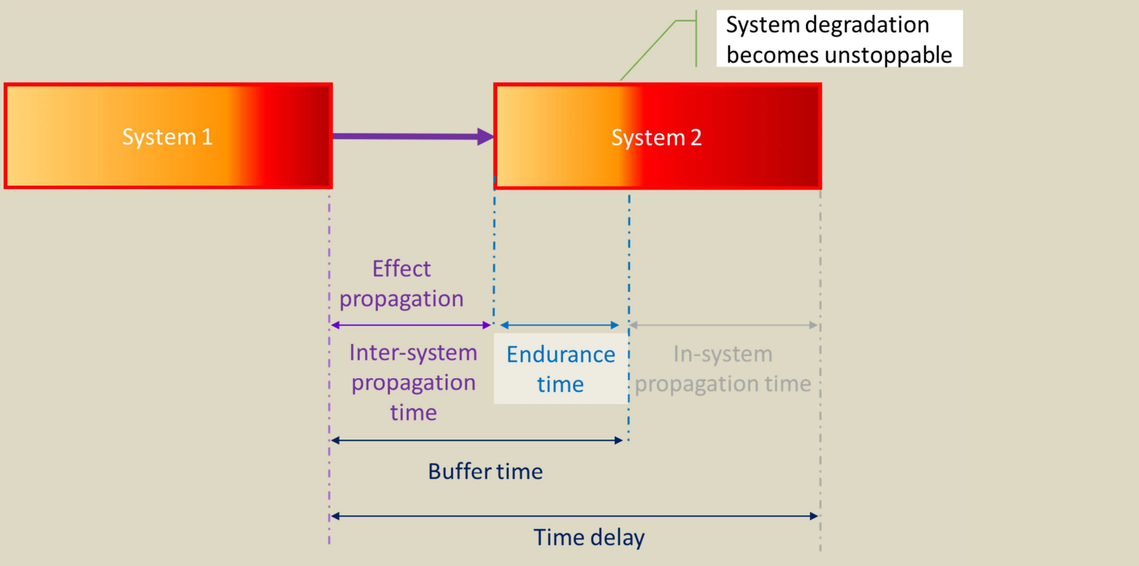

Figure 2 Illustration of Buffer time, Propagation time, Endurance time and Time delay[8].

A distinctive criterion between cascading and non-cascading incidents is thus the fact that in the first case one of the consequences of the initial event is the occurrence of one or more new events and the fact that this is happening because of the existence of system dependencies.

Dependency type

Rinaldi (2001) identified four types of dependencies.

- *Physical dependency occurs when the state of different types of systems are dependent on the output(s) of another.*
- *Cyber dependency occurs when the state of one system depends on information transmitted through the information or telecommunications infrastructure.*
- *Geographic dependency occurs when systems are located in one region and where changes in the local environment can create state changes in all of them.*
- *Logical dependency occurs when a state change in one system results in a state change in another, without any of the other dependencies occurring.*

From this classification, the first two were combined into the broader concept of functional dependency in D2.1-2.3, which was defined as follows:

- *Functional dependency occurs when the state of a system is dependent on the output(s) of another system(s).*

[8] CascEff definitions of notions related to time aspects (CascEff D4.2):

- ***Inter-system propagation time***: Propagation of effects between two different systems.
- ***In-system propagation time:*** (time of) propagation of effects between sub-systems within the same system.
- **Endurance time**: Time a system can resist incoming effects before they start to create impact on the system;

These notions apply to all types of incidents.
For more information on these notions, see CascEff D4.2.

Specific and distinctive key characteristics of incidents with cascading effects can be summarized as follows:

- The level of complexity *might* be higher, because of the fact that dependencies create additional risks and a possible chain of events;
- The level of uncertainty might be higher, especially the level of indeterminacy, which refers to the lack of an overview and overall insight in the system as a whole and/or because of institutionalised fragmentation of information and knowledge and the lack of insight in links, relations and dependencies;
- Time pressure and the sense of urgency will not necessarily be different for cascading incidents, but might be bigger because of the multiple consequences to handle, or in case the two consecutive events differ in nature and require other first response disciplines to be called upon;
- The additional notion of buffer time is specific for cascading incidents;
- Cascading effects do not by definition involve large scale damages, as a second (or n) order event can occur as a consequence of minor events as well (because dependencies and the corresponding vulnerabilities are omnipresent in today's society). The notion of 'incidents with cascading effects' is generally reserved to more severe events, fulfilling the aforementioned criteria for incidents (complexity, uncertainty, urgency, scale).

2.2.3 Typology of incidents based on their characteristics

In the following table, the distinction between daily, routine situations, incidents in general, large scale incidents and incidents with cascading effects is summarized.

<table>
<tr><th>Daily, routine safety and security events</th><th colspan="2">Incidents</th></tr>
<tr><td>The complexity of the situation does not transcend the capabilities and expertise of the actors involved.

Generally operational interventions without the involvement of competent authorities (no strategic level)In the majority of cases these are single-cause/hazard events (fire, medical, police, … interventions),
they can also be multi- cause/hazard or multiconsequence

Relief operations are often monodisciplinary; if multidisciplinary, there will be joint interventions (with mutual arrangements, alignment of actions, etc.) without the need for a specific structure for coordinated actions or specific joint preparation.</td><td colspan="2">Generally competent authorities will take strategic responsibility.

The complexity and nature of (potential) consequences (material, human, economic, social) will determine the sense of urgency and define time pressure
Can be single-cause/hazard, will most often be multihazard
The impact is by definition multiconsequence

The complexity of the causes and consequences determines the level of complexity to handle

The level of complexity determines the type/ profile and number of first response and other disciplines involved, the level of incident management (local, regional, national) and demands specific/multidisciplinary command and coordination structures, both. operational and strategic.</td></tr>
<tr><td></td><td><u>Incidents</u>
A certain scale of damages</td><td><u>Large scale incidents</u>
Damages qualified as large scale by the incident command team or competent authority</td></tr>
<tr><td><u>Cascading effects</u>
Originating event including the risk of a second or more (n order) event, because of system dependencies. The impact and consequences are by definition multisystem</td><td colspan="2"></td></tr>
<tr><td><u>Routine events with cascading effects</u>

Combine the characteristics of routine events with cascading effects</td><td colspan="2"><u>Incidents and large scale incidents with cascading effects</u>
Combine the characteristics of incidents with damages of a certain scale, resp. large scale damages</td></tr>
</table>

Table 1 Overview how common key characteristics of incident management relate to different types of events (Van Heuverswyn)

2.3 Concluding remarks on characteristics and challenges of incident management

From the summarizing overview in Table 1, it is clear that incidents and large scale incidents are a matter of gradation inducing possible higher complexity, uncertainty and urgency (time pressure) because of bigger consequences in terms of scale.

The main difference between incidents with or without cascading effects is not a matter of gradation, but a matter of a different type of vulnerability, which is structurally embedded. As a consequence, there might well be more complexity, a higher level of uncertainty, especially indeterminacy and the scale might be bigger according to the number (and type) of impacted systems.

3 Common practices to deal with incident management challenges

The previous explanation on the characteristics of incidents will help us to understand the logics and procedures for managing those situations.

Common practices to deal with the incident management challenges are: emergency planning, and a specific organisation for response, both based on a multidisciplinary approach. (Van Heuverswyn, 2009b; Bremberg and Britz, 2009; Van Heuverswyn, 1998)
As Gerber and Robinson (2014) state: "*In general terms, the ability of any jurisdiction to cope with a disaster event, or a catastrophic event, is in large part a function of the ability of public authorities to effectively plan for and manage a disaster event*."
In the following paragraphs, the crucial role of information, as a core supporting activity of those processes will be demonstrated and explained.

Legislation, literature, practices and models (see below) indeed show and stress the importance of sound preparation for an optimal response, whether or not formally by emergency planning. Both activities, planning and coordinated response, require input from a broad variety of different actors and specific mechanisms to integrate the multidisciplinary input to support well-informed decisions.

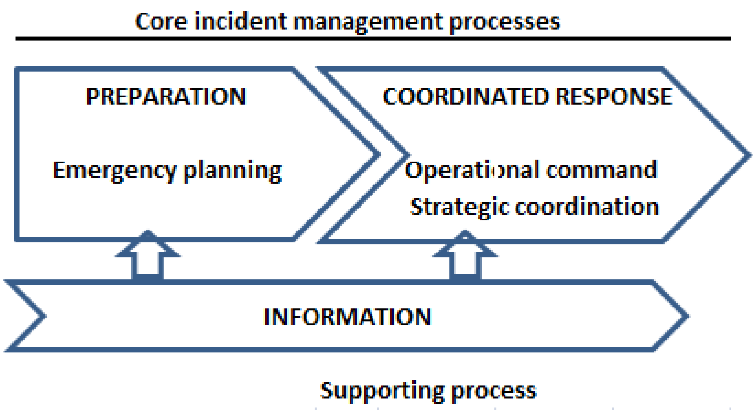

Figure 3 Core and supporting incident management processes – common practices

The common practices, explained in the following paragraphs, relate to:

- Preparation, through emergency planning;
- Coordinated response, through specific structures for operational command and strategic coordination;
- Information before and during the incident.

3.1 Preparation through Emergency planning

Most EU countries[9] use emergency planning as an instrument to assess the risk of an incident and to organise the preparation of adequate response.

External emergency plans, elaborated by public services[10], are legally obliged in all EU countries for Seveso risks since the first Seveso Directive[11]. Prior to these requirements, some countries had a similar practice or approach in place, de lege or de facto, for some or for all types of risks (natural and/or manmade). Since the legal obligation for industrial risks (Seveso), the practice of emergency planning has become more widespread/anchored for all types of risks in most EU countries (Porter and Wettig, 1999).

The actors responsible for and involved in the elaboration of emergency planning are those responsible for and involved in the response phase.

Country	General plans	Specific plans	De lege or de facto	Responsible actor
BE	General Emergency and Intervention Plan (ANIP)	Specific Emergency and Intervention Plans for localized and non-localized risks (BNIP)	Legal obligation in a Royal Decree (2006)	Competent authorities: Mayor, Governor, Minister of Interior
NL	Administrative Network card crisis management	Specific Network cards (25 cards and 22 authorised bodies)	Royal Law Safety Regions (February 2010)	Competent authorities: Mayor, chairman Safety Region, Kings Commissioner, Minister of Safety and Justice
UK	National Risk Register	Community Risk Register	Civil Contingencies Act 2004[12]	Cat1 responders[13]

Table 2 Overview of emergency plans in Belgium, the Netherlands, and the United Kingdom

The preparatory work of writing emergency plans , contributes according to Alexander (2005) to:

- All actors involved could get to know each other;
- Identification of available expertise;
- Identification of hazards and risks;
- Clear definition of roles and responsibilities;

[9] See the description of national systems for emergency planning in the so-called Vademecum of the European Commission, available as online publication at: http://ec.europa.eu/echo/files/civil_protection/vademecum/index.html

[10] as opposed to internal emergency plans, elaborated as a legal obligation upon the employer or operator in order to protect his employees and belonging to the discipline Occupational Safety and Health

[11] EU Council Directive 82/501/EEC of 24 June 1982 on the major-accident hazards of certain industrial activities, *OJ L* 230, 5.8.1982

[12] The Civil Contingencies Act 2004 established a framework for emergency planning and response at both local and national level

[13] The Act divides local responders into 2 categories, imposing a different set of duties on each. Those in Category 1 are organisations at the core of the response to most emergencies (the emergency services, local authorities, NHS bodies)". "Category 1 and 2 organisations come together to form 'local resilience forums' (based on police areas) which will help co-ordination and co-operation between responders at the local level" see https://www.gov.uk/guidance/preparation-and-planning-for-emergencies-responsibilities-of-responder-agencies-and-others

- Implementation of standards, agreements and procedures;
- Identification of weakness and strength of the whole system;
- Clarification of language and meanings;

Some of the criteria for optimal Emergency Planning according to Alexander (2005) are:

- The plan should be co-ordinated with other government levels (than those legally responsible for the plan) and neighbouring institutions;
- One of the objectives is to allocate appropriate resources to the needs in an appropriate and faster manner;
- The plan should take into account realistic hazard and risk assessments related to the area of application;
- The plan has to contemplate urban planning knowledge regarding hazardous areas and critical facilities;
- The plan should present a full set of resources needed during its implementation;
- Part of the plan should focus on processes and procedures;
- Roles and responsibilities should be adequately indicated;
- The disaster cycle should be always included into the plan;
- The plan should integrate arrangements for other public and private bodies;
- The plan should be constantly under revision and frequently tested.

The minimum table of content for Seveso risks is mandatory in all EU countries, as it is listed in annex to the Directive, since 1996 called COMAH Directive: Control of Major Accidents Hazards.

SCHEDULE 4[14]

Information to be included in internal and external emergency plans

Part 2

External emergency plans

An external emergency plan must include the following information—

(a)the name or position of—

(i)any person authorised to set emergency procedures in motion; and

(ii)any person authorised to take charge of and co-ordinate action outside the establishment;

(b)the arrangements for receiving early warning of incidents, and alert and call-out procedures;

(c)the arrangements for co-ordinating resources necessary to implement the external emergency plan;

(d)the arrangements for providing assistance with mitigatory action within the establishment;

(e)the arrangements for mitigatory action outside the establishment, including responses to major accident scenarios as set out in the safety report and considering possible domino effects, including those having an impact on the environment;

(f)the arrangements for providing the public and any neighbouring establishments or sites that fall outside the scope of these Regulations in accordance with regulation 24 (domino effects and domino groups) with specific information relating to an accident and the behaviour which should be adopted;

(g)the arrangements for the provision of information to the emergency services of other Member States in the event of a major accident with possible trans-boundary consequences.

The minimal, legally mandatory Table of content of Emergency plans in Belgium is listed here as an example at national level (Royal Decree on Emergency planning, 2006):

[14] EU Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances, *OJ L* 10, 14.1.1997

The current Directive is Seveso III or COMAH II Directive: Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC, *OJ L* 197, 24.07.2012

General plans (ANIP)	**Specific risk related plans** (BNIP)	**Specific plans for localized risks** (BNIP)
1. general information - all relevant functions - inventory of risks - available means - list of information centre, specialized services, their means 2. procedures for alarming the organizations involved 3. means and scheme for communication 4. modalities for announcing and scaling up/down of phases 5. organization of strategic and operational coordination 6. how to inform public and victims 7. organization of exercises (incl. frequency) 8. methodology for keeping the plan up to date 9. modalities and means of transportation and shelter of victims in case of evacuation 10.templates for information, template for a log book	Complementary information 1. description of the risk and the emergency zone 2. special/specific means of intervention 3. information on persons specifically involved 4. accident scenarios and intervention procedures for each scenario 5. organization of operational coordination 6. protective measures for people and assets 7. possible locations for the CP-OPS 8. how to inform the disciplines and the population, incl. procedures 9. appointed of the discipline who will lead the CP-Ops	Additional information: 1. geographical information and plan/design of the site 2. general information on the facility: - on their activities, incl. risks and inventory of hazardous products/material - list of responsible staff and their coordinates - inventory of the intervention equipment of the facility 3. the emergency zone, incl. - possible perimeters -relevant geographical, demographical and economic factors - other dangerous facilities and activities

Emergency planning as a practice to deal with incident management challenges:

- reduces uncertainty during preparation and response because of the multidisciplinary effort to exchange information (on risks, available resources, modus operandi, etc.) and to deliberate in order to align actions, prepare measures, allocate available resources, etc. ;
- If scenarios are included in the planning, the elaboration thereof will give an understanding of complexity and insight in (inter)dependencies, thus reducing indeterminacy;
- Emergency planning ensures gain of time in the response phase.

Preparation for incidents with cascading effects

The approach, elaboration process and content of emergency plans for incidents with cascading effects is basically identical to those of other incidents. The effort will be more substantial because in case of higher complexity, more actors might be involved, and more information will be needed on vulnerabilities because of dependencies. For those countries working with scenarios, identifying cascading effects and the specific means to deal with them is part of the scenario elaboration and might result in specific scenarios.

Preparation for cross border incidents

Specific arrangements might need preparation in case of incidents with cross border impact. In the case of crossing national borders, national jurisdictions limit the action radius of the emergency planning. Only formal bilateral agreements between the two or three bordering countries can provide for a legal basis – a legal ground or mandatory obligation – for exchange of information and collaboration (See CascEff D1.2, 2014).

3.2 Coordinated response and multidisciplinary structures

As a general rule, local, regional or national organizations, institutions or service do not have the mandate, power or jurisdiction over other organizations (with some few exceptions). This also applies to incident management within national borders. This means that a single event can be simultaneously managed as a police operation under Police regulations, an emergency medical operation under the Health Care regulations and a fire and rescue operation under the Civil Security regulations. This occurs at basically any type of event where different organizations are alerted, ranging from minor accidents to large scale incidents. The overall intervention is based on interaction and collaboration, which needs to be assessed, prepared and tested in advance (Döbbeling, 2012).

Incident management differs from daily, routine operations because of the shift from monodisciplinary interventions (possibly joint) to a multidisciplinary management of the event. This demands appropriate structures to avoid conflicts, align actions, and ensure collaboration. Two complementary mechanisms are observed: monodisciplinary command and control and a superposed level where the monodisciplinary command structures are coordinated.

3.2.1 Monodisciplinary Command and Control

All the actors involved in incident management have their own command and control structure, which refers to the way they are organised internally. In some countries, this is documented in monodisciplinary emergency plans .

The concept of command capacity is defined as the organization's capacity to manage itself in relation to its surroundings. The purpose of leadership and a command system as part of an operation is to be able to perform operations efficiently, effectively and safely.

Command and Control has its origin in military and policy terminology. It has since been developed to a more generic term for decision making in situations with incomplete information and time pressure (Döbbeling, 2012). Managing those situations requires a structured command and control system. According to Döbbeling, the structured approach aims, amongst others, at:

- A common understanding of the goals and purposes;
- A common operational picture of the situation;
- Links with other, external organisations;
- The appointment of relevant functions.

Fundamental aspects of command and control are indeed the role and responsibilities of the incident commander(s), internal hierarchical lines for decision making and the operational (monodisciplinary) execution of those decisions.
Although command and control structures vary from one discipline to another (fire, police, medical and other) and vary at national level, comparable functions can be identified. A distinction is made between strategic, tactical and operational command and is sometimes referred to as gold, silver and bronze level of command.

Levels of command	
Gold	Strategical
Silver	Tactical
Bronze	Operational

Table 3 Levels of Incident Management Command

3.2.2 Multidisciplinary structures for strategic and operational coordination

From the moment multiple disciplines are involved, cooperation between them and coordination of their actions is required.

Most countries have operational as well as strategic structures at a superposed level. Their composition, assignment, etc. are the subject of national regulations.
The concrete composition of the structures is determined by the type of incident, gathering representative of the intervening first response disciplines in the operational as well as the strategic body. The strategic body is presided by the competent authority, legally responsible for managing the incident. The operational body is led by the leading officer of one of the first response disciplines. In Belgium, the discipline which is the most concerned by the incident will lead the Operational Command Post (RD 2006); in other countries, such as Sweden, the leading fire officer will always take the lead, regardless of the type of the incident.
The UK in general has a Gold Silver Bronze system of actors, with the Gold ones being more strategic, and Silver and Bronze more tactical and operational. In practice, however, the division of duties really depends if a Gold officer happens to be on the scene and if they are in charge. Then the specialisation per incident takes precedence, for example for a terrorist event it is the police's highest officer who is in charge for coordination; for mass casualty is the medical highest officer, for fire or rescue is the fire service's highest officer

The composition of those structures and the identification of possible participants (first response disciplines as well as others) will often be discussed and decided during the elaboration of the emergency planning, using scenarios and specific risk-based plans to fill this in concretely. Once an incident occurs, these mechanisms automatically come in place.

EU member state	Strategic	Operational	De lege or de facto
BE	Coordination committee – CC	Command Post Operations – CP OPS	Legal obligation – Royal Decree 2006
UK	Gold	Bronze	De facto
FR	Direction des Operations de Secours (DOS)	Poste de Commandement Communal (PCC)	French regulations

Table 4 Overview of response bodies for coordination in Belgium, the United Kingdom and France

Coordinated response for incidents with cascading effects

Response bodies (command and coordination) will not be different in case of cascading effects. More actors might be needed both at operational and strategic level, depending on the number and type of the impacted systems, such as industrial operations, hazmat or CBRN experts, representatives from critical infrastructures etc.

The specific Case of Cross Border Coordination

As appears from CascEff D 1.2. (2014), formal cooperation agreements and informal arrangements deal with specific aspects in case of cross border effects.

None of these provide for specific provisions for command and coordination structures. On both sides of the border, the usual command and coordination structures are put in place. They are not replaced by a single, common body. Instead liaisons of the strategic level can be detached to the corresponding strategic coordination centre in the other country.

3.3 Information before and during incident response

3.3.1 Information in the preparation phase

Incident management requires a lot of information for preparation of efficient response.

Emergency plans are an instrument to assess the information needs, to identify relevant sources and the corresponding information owners. Besides collecting and assembling that information, it needs to be put into the right perspective. This will differ for general plans, monodisciplinary plans, specific risk-related multidisciplinary plans.

The table of content of emergency plans shows what type of information is required: identification and analysis of risks, inventory of available resources and means, identification of responsible actors (authorities, services), etc. (see above for the content of emergency plans, p. 22; see below for the identification of actors/information owners, p. 36) This information will determine the procedures prepared for in the plans: for alarming, evacuation, protective measures for people, environment, public health, infrastructure, etc.; specific modus operandi and command rules per discipline, specific modi for alignment and coordination for the operational and strategic multidisciplinary structures.

Scenarios are a tool to ensure the link between information and procedures, putting information into perspective according to the probable evolution of a certain type of event, including the identification of dependencies, vulnerabilities and key decision points. Most countries have a legal obligation for certain types of risks (nuclear, Seveso) or are familiar with scenario writing as a common practice for preparation, as part of the elaboration of emergency plans.

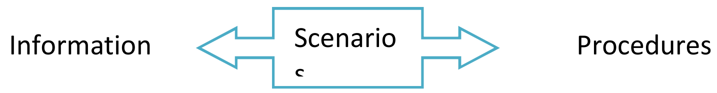

Figure 4 Scenarios as an instrument for emergency planning for writing concrete procedures

The more accurate and comprehensive the available information at the preparation stage, the better and more sound the quality of preparation of interventions and the quality of available information during a response phase will be.

Comprehensively prepared information can be subdivided in:

- **Actor related information** on:
    - The first response actors involved, their resources and monodisciplinary procedures;

    - Other, supporting disciplines (water management, critical infrastructure, hazmat, health experts, etc. following the nature of the event);
    - Multidisciplinary, joint procedures.
- **Risk/Incident related information** on:
    - Risks, probabilities, impact, dependencies, vulnerabilities etc.;
    - The incident evolution, incl. key decision points.

3.3.2 Information during response

During the response phase, decisions are taken to manage the event: actors are called upon, resources are deployed, measures are implemented, ideally based on previously identified information and covered by previously prepared procedures. As for emergency planning, the required information is actor related and incident related.

This is shown in the picture below, which represents the view of a fire department (Oefenbank NL)

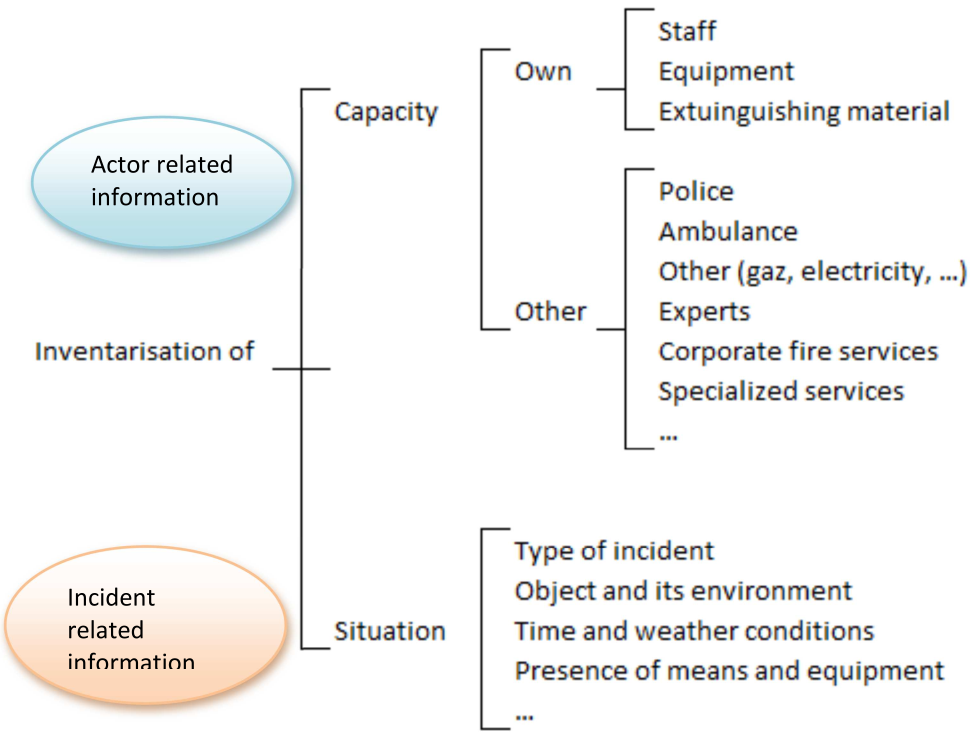

Figure 5 Representation of the first response step, Analysis (Oefenbank Nederland)

To treat the relevant information for decision making, specific incident management decision making models have been developed (Brugghemans and Van Achte, 2015). Examples of these models are (See also CascEff D3.1 v1 (2015) for more information on these decision making models):

- The Dutch BOB model, with the following steps: 1. Representation, 2. Analysis/judgement, 3. Decision (Brugghemans et al, 2015);

- The cybernetic model: 1. Data collection, 2. Analysis, 3. Decision, 4. Dissemination (Brugghemans et al, 2015);
- The so-called OODA or Dynamic OODA – DOODA loop. OODA stands for: Observation, Orient, Decide, Act. Consecutive steps are: 1. Collection of data and information, 2. Assimilation of data and information, 3. Assessment of the situation, 4. Determination of goals and methods, 5. Decision, 6. Planning, 7. Division of tasks, 8. Monitoring (Brehmer, 2008).

As can be observed from the listed steps, and confirmed by a comparative analysis, recently performed in Belgium (Brugghemans et.al., 2015), most of these models, from basic to more detailed, list the process steps without paying specific attention to the multi-actor environment, thus representing decision making as a single command process.
The ISO 22320 chart for multiple hierarchical command and control processes however clearly visualises the multi-actor reality on site.

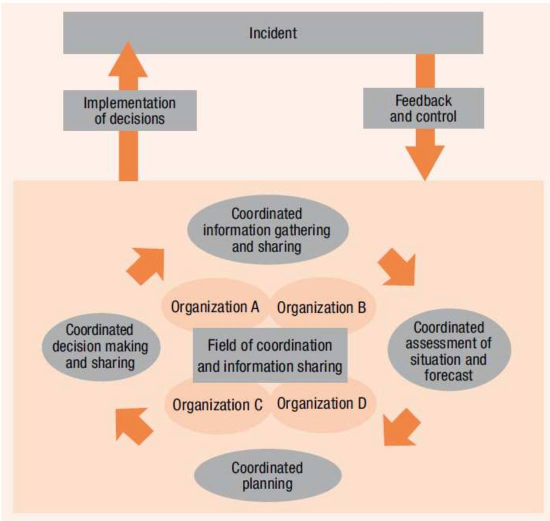

Figure 6 Circular chart for multiple hierarchical command and control (Döbbeling, 2012)

To stress these specific characteristics of decision making in crisis situation, the IBOBO model was developed in Belgium: it shows that data collection and implementation of the decisions are monodisciplinary actions, whereas the representation of the incident is a multidisciplinary action, as well as the analysis and the decisions to be taken.

The consecutive steps are: Collection of information, Representation, Analysis/judgment, Decision, Implementation of the decisions/Command, and Monitoring/Control.
The visual representation differentiates between 3 monodisciplinary steps (individual) and 3 multidisciplinary (concertation) steps.

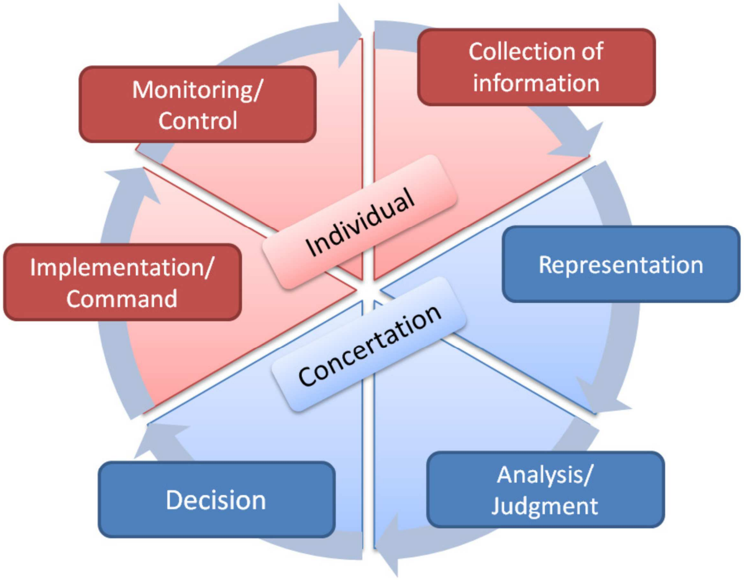

Figure 7 Belgian IBOBBO model (Brugghemans et al, 2015)

Again, incident decision models teach us that being prepared for an efficient response requires gathering a lot of information from different sources in order to develop a common operational picture. That information needs to be available during response in order to provide guidance for the incident command, who has to deal with the overall situation. If soundly prepared, the available information, possibly presented in scenarios reduces uncertainty and can avoid overload of unstructured information during response thus reducing complexity. If system dependencies, vulnerabilities, effects and key decision points are previously identified, it also reduces indeterminacy (lack of insight and oversight). These benefits will make it in turn more comfortable for the incident command to deal with time pressure.

Information for incidents with cascading effects

Information needs for incidents with cascading effects follow from what has previously been identified for preparation and organisation of response. More efforts are needed to reduce indeterminacy, which requires more information on dependencies, vulnerabilities and key decision points.

In WP2, a categorisation was developed of systems that could possibly be impacted and between which a chain of consecutive events might occur because of the existence of dependencies. The identification of those systems indicate that information is required from all these systems, ideally prepared ex ante, in order to be available for the incident command team during a response phase (see below for the list of systems and the corresponding risk or incident management responsibility of the competent authorities and services). That is what makes the preparation of information for incidents with possible cascading effects unique compared to other rescue operations, incidents and large scale incidents.

3.4 How common practices answer current incident management challenges

Summarizing characteristics and proposed solutions based on common practices gives the following overview.

Looking at the challenges and the proposed solutions, the key role of supporting processes dedicated to information is obvious: being prepared through emergency planning, whether or not formally or de facto, requires gathering a lot of information from different sources and bringing the relevant actors (owners of those sources) together.
That information needs to be available during the response phase in order to provide guidance for the incident command, who has to deal with the overall situation.
The central role of sound information also shows the interrelationship between the characteristics:

- relevant information reduces uncertainty – esp. indeterminacy;
- efficient management of information brings more transparency and thus reduces complexity (in the sense as explained above, p. 10);
- both make it in turn more comfortable to deal with the time pressure.

As the difference between incidents with cascading effects and other incidents is rather a matter of gradation (see more explanations below): it can be stated that the higher the possible level of complexity and uncertainty, the more probable it is that an appropriate approach and tool for information simulation can provide for a substantial improvement of incident management.

Characteristics of incidents with cascading effects	Common practice solutions
Multi-cause/multi-hazard	Being prepared through emergency planning
Multi consequences/multiple systems impacted	⇕
(Possibly higher) level of complexity	Being informed before and during the incident
(Possibly higher) level of uncertainty - Ignorance - Uncertainty - (Definitely a higher level of) indeterminacy	⇕
Time pressure, sense of urgency	Coordinated response through multidisciplinary coordination, complementary to monodisciplinary command and control

4 Interdependent frameworks for civil security, risk management models and incident management logics and procedures

The so far described incident management process is a specific sub process of risk management and shaped by institutional frameworks for civil security at national level. When looking for opportunities to improve incident management logics and procedures, these broader contexts are relevant, as will be demonstrated in the following paragraphs.

4.1 Institutional frameworks

Creating a framework for efficient incident management starts at the institutional level. This relates more to the national organisation of civil security than incident (or response) management as such. It is important to mention though because it determines two relevant aspects:

- The type of all the actors involved and their level of organisation: local, regional or national;
- The preferred level of coordination: centralised (national), decentralised (local), or in between (regional) or a combination of different levels, in case of scaling up.

These aspects will generally be dealt with in national regulations or equivalent documents. For that reason, ISO 22320:2011 adds a 'normative level' to the previously mentioned levels of operational and strategic command.

The normative level shapes the national organisation of relief and rescue operations.

Command band	Command level	Description	Support
Strategic	Normative	State and national/federal government levels which operate according to the demands of the incident to either monitor, support or to intervene	Administrative (e.g. transport, waste management, education department, social services, financial support services)
	Command of strategic operations, policy and objectives	Heads of jurisdictions, e.g. the executive mayor, and chiefs of individual response agencies, the final operational decision-makers	
Tactical	Incident command, control, coordination cooperation	Incident command level of each participating organization	
	Task level control of operations	Control and support operation on the ground (crews and sectors/divisions, and at equivalent levels in support functions)	

NOTE 1 The objective of the strategic and tactical components is to be able to make comprehensive and effective decisions in a timely manner taking into account all necessary aspects under the time-critical regime of the incident, as shown exemplarily in Table A.1.

NOTE 2 The objective of the administrative component on a strategic level is to bring administrative departments and institutions not directly involved in the strategic incident response "into the loop", to enable them to assist in the return to normal conditions as quickly as possible.

Figure 8 Example of how to divide command and control structure into different levels, including a normative level[15]

[15] ISO 22320:2011 - Societal security -- Emergency management -- Requirements for incident response

The type of level and the profile of the corresponding competent authority might be different at national level, the use of internal administrative borders and corresponding powers though is common practice, as shown in the following table.

Country	Local	Regional	National
Belgium	Mayor	Governor (Province)	Federal Minister of Interior
France	Mayor	Prefect (Department)	Minister of Interior
UK	Local Resilience forum	Local Resilience forum	Cabinet office
NL	Mayor	Chairman Safety Region	Kings Commissioner and/or Minister of Safety and Justice

Table 5 Overview of administrative levels with legal responsibility for incident management per country

The table shows that most countries have a two or three level structured organisation of civil security. The main differences lie in the administrative circumscription of the regional level: provinces, counties, departments, etc.
The preferred level of coordination is a matter of national culture and customary practices (centralised or decentralised), often reflected in formal regulations (Van Heuverswyn, 1998).

National differences related to the institutional framework do not affect the generic character of national organisation of civil security with coordinating structures at local, regional and national level.

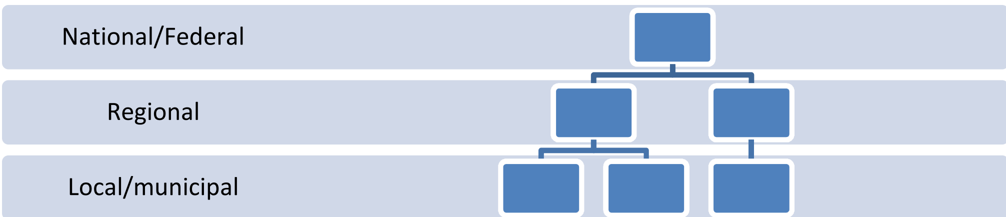

Figure 9 Common institutional structure of the organisation of civil security at national level

4.2 Risk and incident management models

National and international management models exist, conceptualising the different steps or phases for managing incidents. Some of them focus on the incident response phase only, others give a more comprehensive picture of the whole incident management cycle, including phases before and after an incident.
In the following paragraphs, the chronological and functional interdependencies between the process steps before, during and after an incident are explained.

Response phases
From good practices at national level, concrete and generic steps can be identified.
From Sweden (Svenson, 2015), we retain the following sequence of relevant response activities: alarm - responding - arriving - start to work. Activities between the start and the end of the operations are not elaborated in the Swedish model (See also CascEff D3.1v1).

More inspiration could be found in a Dutch practice, in the so-called 'processes that create the conditions for efficient incident management', which include a sequential loop of Alert/alarming - scaling up/down - leadership and coordination (Decretale normen, 2006). The Dutch model places information management in the middle, linked to all other processes.
In the UK, the main framework to manage incidents is known as Joint Emergency Services Interoperability Principles (2012)[16]. Those principles could be summarised in (JESIP): Joint working - Shared situational awareness - Joint decision model - Joint understanding of risks; Multi agency communications (Flanagan, 2015).
According to ISO 22320:2011 the main processes of the incident response phase are: Warning, alerting and activation of the incident response - Command and Control - Information, Coordination and Cooperation - Response measures to deal with the situation. ISO 22320 however does not limit the process to response and places these phases in perspective of a broader incident management process (see below, Figure 11).

Incident management phases
In Belgium, no model for incident response exists, the core steps of incident response can be found in the legal obligations on emergency planning, imposing mandatory preparations for alarming, coordination, etc. (see above, the minimal content of emergency plans). However, Belgium does impose an incident management loop as a legal obligation (Law Civil Security, 2003), including: pro-action - prevention - preparedness - execution - evaluation. The Belgian so-called safety cycle is in fact a combination of the risk management process and the PDCA-principle (Plan-Do-Check-Act) for continuous improvement (Van Heuverswyn, 2009b).

Most other countries use incident management models, either legally obliged or used de facto, as shown in the Table 6 below and EU and international bodies developed even more elaborate cycles, such as the Disaster Risk Management Cycle – DRMC (Piper, 2011), also used by DG Home (Working Paper Community of Users, 2015); the unified theoretical approach proposed by the UN and the World Bank, the National Disaster Risk Reduction Strategies (Kelman, 2003). and the ISO 22320:2011 "Societal security – Emergency management – Requirements for incident response". ISO 22320 can be considered a generally accepted generic framework, as ISO standards reflect a widespread common vision and are widely supported thanks to their validation and adoption procedure.

[16] See the official website: http://www.jesip.org.uk/home

Figure 10 The Disaster Risk Management Cycle (DRMC) Diagram

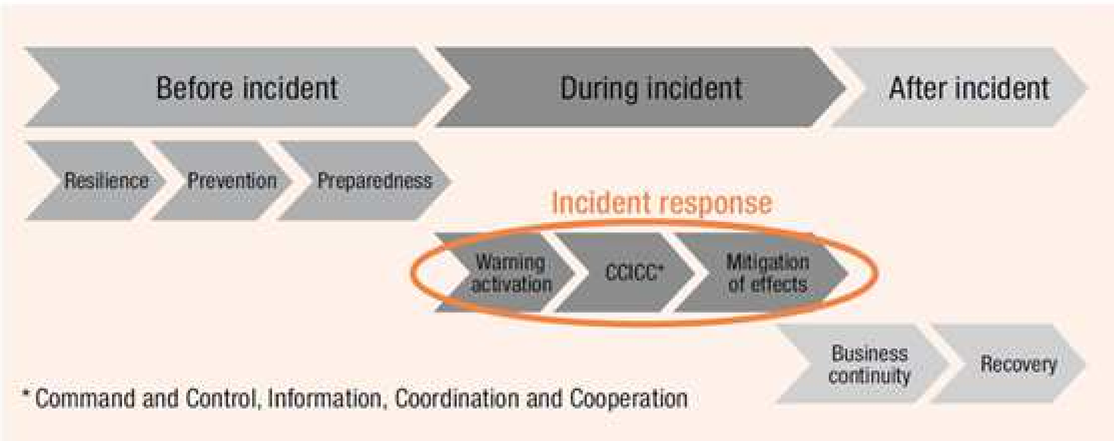

Figure 11 ISO 22320:2011 distinguishes 3 phases of emergency management: before, during and after an incident.

Similar models are abundantly found in literature (i.a. Neal, 1997; Alexander, 2002; Demeter, 2003; Coetzee, 2010).

Common incident management phases

An overview of the phases in the CascEff partner countries confirms the broadly accepted phases.

	CascEff, UN OCHA, FEMA	EU[a)]	Belgium[b),c)]	France	Sweden[d)]	The Netherlands[e)]	UK
Before			Proactie / Proaction	Identification du risque / Risk identification	Risk- och sårbarhetsanalys / Risk and capability assessment	Proactie / Proaction	Anticipation
				Evaluation du risque / Assessment			Assessment
	Mitigation	Prevention/ detection	Preventie / Prevention	Prévention / Prevention	Förebyggande / Prevention	Preventie / Prevention	Prevention
	Preparedness	preparedness	Preparatie / Preparation	*Préparation* / Preparation	Förberedelse / Preparation	Preparatie / Preparation	Preparation
During	Response	Surveillance/ response	Uitvoering / Execution	Evènement / Event	Insats / Response	Repressie / Repression	Response
After			Evaluatie / Evaluation	Retour à la normale / Recovery			
	Recovery	Recovery		Retour d'expérience / Feedback	Återställning / Recovery	Nazorg / Recovery	Recovery

Table 6 Common incident management phases (see full references (a, b, etc.) in CascEff D1.6)

The DoW (2013) promised a methodology for improved incident management related to five processes, explicitly mentioning: pre-planning, response, debriefing and training, foresight. As the comparison of national processes clearly indicates, a loop of rather four generic main processes exists, including Prevention, Preparedness, Response and Recovery. Therefore, the methodology and flowchart for improved incident management (see p. 51) will focus on these 4 generic phases.

As comprehensive incident management models show the chronological and functional interdependency of actions before and during incident response, it is usefull to have a look at those broader risk management models, in the search for opportunities to improve incident management.

The broader perspective of risk management

Incident management models are less customary than risk management models. Risk management models or standards provide for a conceptual framework to deal with risks in the most efficient and effective way. Those models are very often developed at an international level, which demonstrates again that it is possible to identify generic steps, despite national differences. With risk management models, we refer to a broad category of guidelines and tools that cover different aspects of risk management.

Some models mainly focus on the management loop, such as the international ISO 14001:2015[17], the European voluntary EMAS - EU Eco-Management and Audit Scheme, both for environmental risks; the British but internationally used OHSAS 18001:2007[18] for occupational safety and health (basis for the forthcoming ISO 45001). These models deal with one specific type of risk only. The generic management loop consist of: risk analysis - policy - planning - implementation processes - checking and corrective actions - management review (Van Heuverswyn, 2009a).

The more generic models, such as FERMA 2003[19] and ISO 31000:2009 Risk management[20], applicable to all types of risks, combine a management loop and the explicit mentioning of core processes. These core processes emphasize the different steps in management risks.

[17] ISO 14001:2015 Environmental management systems -- Requirements with guidance for use

[18] OHSAS 18001/2007 Occupational Health and Safety Assessment Series

[19] AIRMIC, ALARM, IRM: 2002 Risk Management Standard - FERMA:2003, http://www.ferma.eu/app/uploads/2011/11/a-risk-management-standard-english-version.pdf

[20] ISO 31000 Risk management -- Principles and guidelines

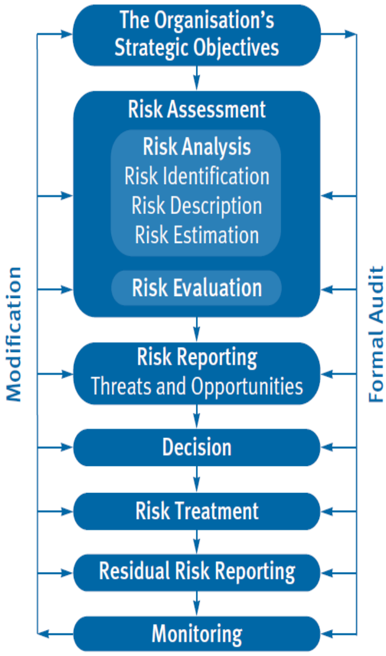

Figure 12 FERMA 2003

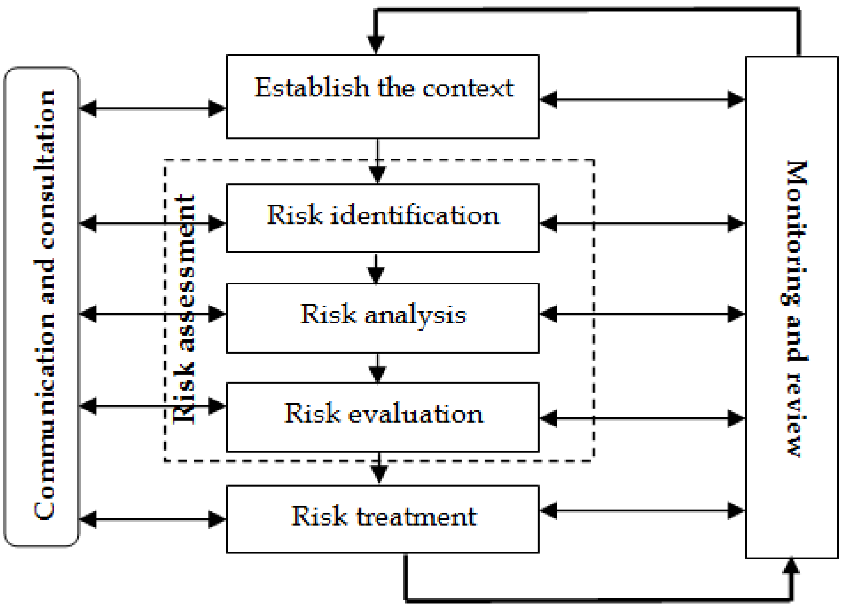

Figure 13 The ISO 31000:2009 risk management processes in detail

Risk management models and frameworks provide insight in logic and procedures for improved incident management (they are not as such the scope of this report and will not be developed in detail).

It is striking that risk management models do not explicitly mention incident management. It is considered to be part of risk treatment. That is because risk management models focus mainly on preventing risks.

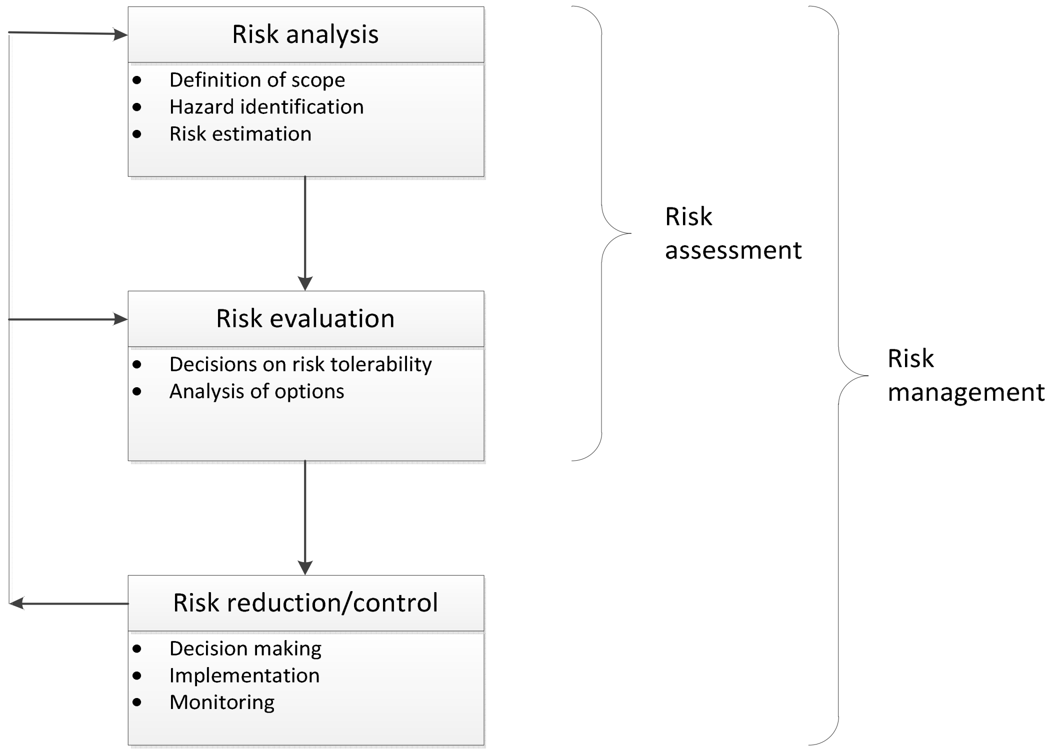

Figure 14 Representation of Risk assessment as subprocess of Risk management based on ISO/IEC Guide 51:2014(E)

From literature, the risk treatment process can be subdivided in primary, secondary and tertiary prevention, focussing resp. on avoiding risks, avoiding accidents and reducing damage (Van Heuverswyn, 2009b). Incident management is a tertiary prevention process, but as it is a process, it needs to take into account and build upon the efforts made in previous processes in order to be managed efficiently.

For the purpose of this report, risk management models are important because a lot of information relevant to incident management is developed in the framework of risk management: the results of risk analyses, information on contextual factors, preventive measures, etc. This needs to be taken into account for any methodology aiming at improving current practices.

4.3 Identification of actors from a comprehensive perspective

So far current common practices and models have shown the building blocks for successful incident management. From that comprehensive overview of relevant processes related to risk and incident management, the actors who detain responsibilities, means, including information can now be identified.

4.3.1 Core and supporting incident management actors

Incident management involves per definition a multitude of actors because of the multi-cause and multi-consequence characteristics of such events. The type and number of actors involved, their respective contribution in the overall management of the situation and thus the exact composition of operational and strategic structures is determined case by case because of the concrete and unique configuration of each incident.

Core actors can be identified for the core processes of incident management: preparedness , incl. planning and response. These are the first response disciplines dealing with safety and security rescue operations, such as fire fighters, police and medical services and the competent authorities, legally obliged to ensure public safety and security.

It is the additional services called upon that mainly differ according to the type of event: natural, manmade accidental or intentional: water management, hazardous materials, forensics, health experts, critical infrastructure, industrial operators, etc. They can be considered as secondary or **supporting incident management actors**.

4.3.2 Risk and Incident management Information owners

The main actors responsible for incident management are only partially responsible for prevention:

- Fire fighters: fire prevention;
- Medical services: health care;
- Police: security.

Other actors (public authorities and operational services) dealing with prevention do generally not have a responsibility for response. Their assignment lies in the responsibility as a public service to ensure continuation of the services they provide: water supply, transport, electricity, communication, environmental policy, etc. Their core business is prevention and recovery, they can be invited to the preparation of emergency plans and involved in command or coordination structures during response, depending on the type of incident. Although their involvement in incident management lies more in a **supporting role**, their contribution to the quality of the emergency plans can be substantial because they own relevant information on risks, on measures in place, on means to deal with risks, etc. Moreover, they are the experts in their specific domain.

The relations between actors dealing with distinct yet interdependent risk management processes such as prevention, preparedness, response and recovery can be demonstrated, based on the 22 categories of systems identified in WP2 as possibly impacted by cascading effects.
The overview shows the distribution of roles and responsibilities for incident management.

Categories	**N.**	Prevention, incl. risk analysis ⇨	Preparedness, incl. planning ⇨	Response, operational and strategic ⇨	Recovery
Power Supply	1	Core business	Support	Support	Core business
Telecommunication	2	Core business	Support	Support	Core business
Water supply	3	Core business	Support	Support	Core business
Sewage	4	Core business	Support	Support	Core business
Oil and gas	5	Core business	Support	Support	Core business
District heating	6	Core business	Support	Support	Core business
Health care	**7**	**Core business**	**Core business**	**Core business**	**Core business**
Education	8	Core business	Support	Support	Core business

Categories	N.	Prevention, incl. risk analysis	Preparedness, incl. planning	Response, operational and strategic	Recovery
Road transportation	9	Core business	Support	Support	Core business
Rail transportation	10	Core business	Support	Support	Core business
Air transportation	11	Core business	Support	Support	Core business
Sea transportation	12	Core business	Support	Support	Core business
Agriculture	13	Core business	Support	Support	Core business
Business and industry	**14**	**Core business**	**Core business**	**Core business**	**Core business**
Media	15	Core business	Support	Support	Core business
Financial	16	Core business	Support	Support	Core business
Governmental	**17**	**Core business**	**Core business**	**Core business**	**Core business**
Emergency response	**18**	**Core/support**	**Core business**	**Core business**	**Support**
The public	19	Core business	Support	Support	Core business
Environment	20	Core business	Support	Support	Core business
Political	**21**	**Core business**	**Core business**	**Core business**	**Core business**
Food supply	22	Core business	Support	Support	Core business

Table 7 Core and supporting incident management actors in the 22 systems identified as possibly impacted by cascading effects

In every system actors can be identified with a clear responsibility in preventing risk and restoring the situation after a disastrous event. When the impact of incident transcends the boundaries of the system into the public domain and threatens societal functioning, only a few actors have a specific responsibility to take action: public authorities (Health, Emergency response, Political, Government) and the first response disciplines. Business and industry are legally obliged to prepare and take care of response measures for the protection of their employees and others on their own premises, based on Occupational Safety and Health regulations.

The overview clearly shows how fragmented the distribution of power is within the risk management cycle and as a consequence how dependent the few incident management actors are on autonomous information owners dealing with prevention (and recovery).

For internal risks (within 1 organisation), such as occupational safety and health, it is common practice to investigate the possible interactions between proposed prevention measures in order to take into account the interdependencies, possible impact, interactions, shift of risks, etc. (Van Heuverswyn, 2009b) This obligation relies on the risk owner, the employer or the operator of the organisation.
In civil security this procedure is not common practice and it is difficult to achieve in the absence of one single ‘risk owner’ taking responsibility and having the power to deal with all societal risks. Dealing with societal risks is a joint effort of a multitude of actors, all having specific assignments and partial powers to manage these risks.
It is this fragmentation that Ulrich Beck, the author of Risk Society (1992), calls ‘manufactured uncertainty’ and ‘organised irresponsibility’: too many actors have a partial responsibility, no one is responsible for the whole. According to Beck, it is also this fragmentation that makes us blind to links, (inter)dependencies and interactions because no one has a global overview.

Looking at the whole, there are plenty and sufficient actors to deal with every single relevant aspect, which means that all relevant information is usually available *within* the system as a whole. The challenge for incident managers is more often to understand who holds that information (and who has the corresponding power to provide means and resources to deal with system-specific or multisystem events) and who needs to be invited to share information and to assist in the preparation of emergency plans or support the deliberations in operational command and strategic coordination structures. (Van Heuverswyn, 2009b)

Lagadec (2005) and Beck (1992) state that, unfortunately, it is major crisis situations that currently reveal to us the interdependencies that we are blind to in a normal situation. Blind, because they are embedded in the system; unfortunately, because only in case of major disruptions such as crisis situations we cannot afford to ignore them. The outside reality does not care about artificial subdivisions in specialisations, ministries and services and thus obliges every major crisis situation all those autonomous and falsely independent actors to work together to deal with the situation in all its aspects.
Being aware of this should encourage us to make the effort of restoring a vision on the whole as early as possible in the risk management process. This would ideally be in the prevention phase, as is already a legal obligation for private actors, owners of an economic entity.
This would require a political decision to do so, but is not the scope of this project (Van Heuverswyn, 2009c).
Within the scope of this project, we can provide remedies for the preparation and response phase, which will be developed in the following paragraphs.

5 Opportunities to improve incident management logics and procedures

5.1 Lessons drawn from challenges and the current logic and procedures

For the identification of opportunities for an improved incident management methodology, we first looked into the key characteristics and challenges of incident management in general as well as for incidents with cascading effects, then into on the logic of current practices, their key activities and actors to deal with them.

5.1.1 Characteristics and challenges of incidents with and without cascading effects

The main challenges of incident management are:

1. A certain level of complexity as a result of multi hazard causes and/or multiple consequences, requiring a specific type of coordination due to the involvement of multiple actors at different institutional levels;
2. Uncertainty, as an intrinsic element of incident management and subdivided into ignorance, uncertainty, indeterminacy;
3. Time pressure or a sense of urgency to control and remedy the situation;
4. A certain scale of damages or a serious threat or imminent threat of potential damages of a certain scale.

The most important key characteristic of incidents with cascading effects, distinguishing them from other incidents, is the high level of indeterminacy as a result of vulnerabilities due to links, dependencies and interactions between different systems, as per definition multiple systems are impacted in case of cascading effects.

Depending on the number and type of impacted systems as well as the nature of the impact, the level of complexity, the scale of the damages and the time pressure might be bigger for incidents with cascading effects than for incidents without.

5.1.2 Common incident management practices

The widely supported answers to these challenges, as described before (Chapter 3), are:

- Sound preparation, especially through emergency planning;
- A coordinated response, based on monodisciplinary command and control structures and procedures as well as ad hoc multidisciplinary coordination structures, both operational as strategic;
- Risk/incident and actor related information to be managed before and during an incident: informed preparation in the emergency plans, and informed decision making during the response phase:
  - Being prepared through emergency planning, whether or not formally or de facto, requires gathering a lot of information from different sources and the need to bring the relevant actors (information owners) together;
  - This actor and risk related information needs to be available during the response phase of an incident in order to provide guidance for the incident commander or incident command team, who has to deal with the overall situation. It needs to be complemented with additional and more concrete information related to the concrete event, it's possible evolution and the available means and resources of the actors called upon;

- The key role of information management also shows the interrelationship between the characteristics: adequate and sound information offers opportunities not only to reduce uncertainty and indeterminacy but also to reduce complexity, which in turn facilitates dealing with time pressure. In the case of possible cascading effects, this information needs to cover insight and understanding of links, dependencies and interactions between systems.

5.1.3 Core and supporting incident management actors

The national organisation of incident management is generally shaped by institutional frameworks related to civil security. These frameworks specifically determine:

- The type of actors involved and their level of organisation: local, regional or national;
- The preferred level of coordination: centralised (national), decentralised (local), or in between (regional) or a combination of different levels during the incident, in case of scaling up or down.

National differences regarding the institutional framework do not affect the generic character of key processes and activities of incident management.

5.1.4 Logics and procedures beyond incident management preparedness and response

Risk management models show two additional phases of relevance before and after preparation/planning and response, respectively: prevention and recovery. These activities are in general not the responsibility of the first response disciplines. Nevertheless, the way they are performed, and the information generated in those phases is relevant, often crucial for first responders: the results of risk analyses, information on contextual factors, preventive measures, available expertise and logistic means, etc.

As this information is mostly generated by public and private actors whose core business is not incident management, they are not involved in preparedness and response unless invited, and they have no (legal) responsibility for response. This makes it all the more important to identify these relevant sources, their owners and to ensure their collaboration in order to have the appropriate access to their data and knowledge.

In previous CascEff research (WP2), 22 systems were identified from the analysis of past events; this means that information owners within those 22 systems hold relevant information.

This gives the following picture of the incident management process, and its place within the broader risk management processes:

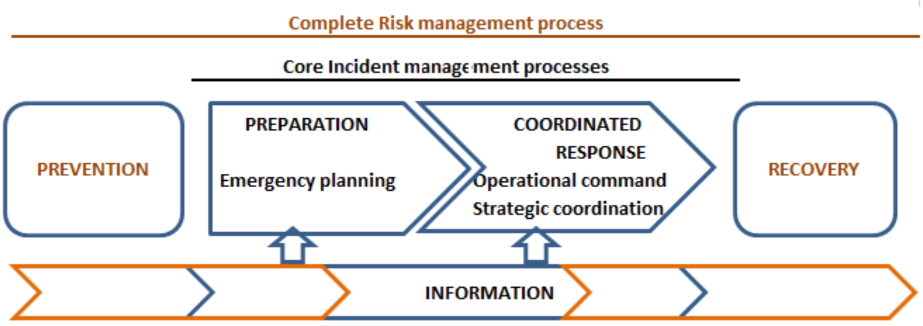

Figure 15 The link between Risk and Incident management processes

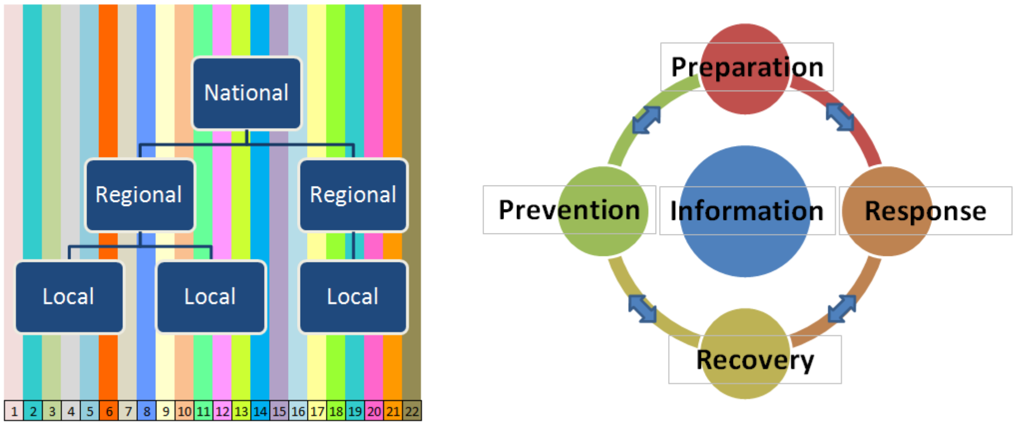

Figure 16 Schematic overview of fragmented power and process steps – Actors from 22 possibly impacted systems at three administrative levels dealing with the 4 phases of risk and incident management

5.1.5 Key word multidisciplinarity

The abovementioned description of actions - the current common practices - and the distribution of responsibilities between the actors involved – shaped by institutional frameworks, risk and incident management models –clearly shows that current practices both before and during the response phase of an incident have to make a re-unifying effort of institutionalised fragmented powers and information.

Because of multiple actors (first response and other disciplines) and systems involved, the key word for incident management practices is currently ***multi***disciplinarity, as is abundantly shown in literature and publications on incident management[21].
The etymological meaning of multi, from the Latin word multus, refers to many, much, multiple, more than one (Alvargonzalez, 2011). It thus covers activities with many, multiple disciplines involved and draws on the knowledge of those disciplines, yet all staying within their own boundaries. There is no transcending dimension in multidisciplinarity (Alvargonzalez, 2011; Choi and Pak, 2006).
It is additional and complementary to monodisciplinary actions, efforts and resources and refers mainly to the operational preparation and response phase: the multidisciplinary preparation in emergency plans and the multidisciplinary coordination of monodisciplinary interventions.
Confirmation of this is found in national guidelines from competent authorities, incident management literature and theory (i.a. Circular Letter on Emergency planning (BE), 2006; Devroe et.al. (BE, NL), 2015; Ministerie van Veiligheid en Justitie (NL), 2016; Napucu N. (UK); Maestracci B. (FR), 2011), and the broad supply of multidisciplinary training courses, as shown also in the overview by J. Jensen (2010) on mono, multi and interdisciplinary approaches to emergency management education. She even argues that because of the multiple disciplines

[21] A google search gives 250 000 results for ‘multidisciplinary incident management’ versus 410 000 for incident management; 1 400 000 for ‘multidisciplinary emergency management’ versus 120 000 000 for ‘emergency management’

involved, the question can be raised whether it would not be more efficient to create a new, multidisciplinary discipline.

A lot has been written about the need and the use of multidisciplinarity, its merits and challenges, etc., as shown in national guidelines and abundant literature (Jensen, 2010; Van Heuverswyn, 2009b; Scholtens, 2006; Younglove-Webb et.al., 1999; Quaranteli, 1994) Advantages and benefits can be summarized as: a more profound, rich and depth of understanding can result from multidisciplinary that could not have been achieved by one single discipline.

Obstacles and shortcomings of a multidisciplinary approach relate to: disciplinary chauvinism, different world views, terminology and references; status differences among team members, logistical and geographic obstacles.

Given the multihazard and multiconsequence character of incidents, emergencies and disasters, the discussion on the usefulness of multidisciplinarity has become somewhat outdated by reality. Today, there is not one single (first response) discipline able to prevent and respond to incidents. Even daily, routine interventions often call upon more than one discipline, such as policy and/or medical and/or rescue and fire fighters.

The question at stake is whether multidisciplinarity is sufficient and sufficiently efficient to deal with the incident management complexity of impacted systems and actors involved in different process steps, as shown in the summarizing Figure 15 and Figure 16.

5.1.6 Multi-, inter- and/or transdisciplinarity?

To answer this question, we look at two other, more integrated approaches, applicable to a multi-actor environment, as mentioned and argued in literature: interdisciplinarity and transdisciplinarity.

We look at it from an academic perspective, based on theories developed in a research or an educational context, because this kind of discussion is usually not held among incident managers.

Interdisciplinarity

Interdisciplinarity, based on the latin meaning of ‘inter’, includes the notion of 'among', 'together', 'mutually', 'reciprocally' (Alvargonzalez, 2011). It refers to an activity *between* independent disciplines. As Choi and Pak (2006) state: *'Interdisciplinary analyses, synthesis and harmonises links between disciplines into a coordinated and coherent whole'*. In interdisciplinarity there is often a transfer of knowledge or application of methods from one (or more) discipline(s) to one other, existing or new discipline, e.g. bio-engineering.

In the case and to the extent that emergency planning and coordinated response efforts do more than just collect information and knowledge, but also uses that information for case-specific scenarios (planning) or a common operational picture (response), the term interdisciplinary would also apply for current incident management practices. Still, there is no umbrella or home discipline in incident and risk management, there is only ad hoc, case based collaboration, exchange, analysing and synthesizing efforts.

Most incident management actions lie somewhere in between: in a minimal approach, there is multidisciplinary; when there is an integrated effort, it is close to interdisciplinarity.

Transdisciplinarity

The Latin prefex 'trans' mean 'across', 'beyond' and 'transcending', 'through' something - as in transpiration - and 'change' - as in transformation (Alvargonzalez, 2011). Transdisciplinarity thus refers to an approach, transcending, going across, through and beyond the boundaries of individual disciplines. Transdisciplinarity is characterized by a holistic vision, transcending the individual disciplines involved by looking at the dynamics of the whole (Alvargonzalez, 2011; Van Heuverswyn, 2009a; Choi and Pak, 2006). Alvargonzalez refers to Klein (2010) to stress that a transdisciplinary approach focuses on research questions and practices and not on the disciplines.

Transdisciplinarity is closely related to systems thinking, which also pays attention to links and interactions between distinct processes. Transdisciplinarity differs from multi and interdisciplinarity because of the cumulative attention for two specific conceptual aspects, based on systems thinking :

1. per definition it considers aspects between (interactions, interdependencies, relations) as well as across (common) the different disciplines involved;
2. It adds a level above, beyond the actors involved : a transdisciplinary approach considers the whole as more than the sum of the individual composing parts (Van Heuverswyn 2009a; Morin 1998)

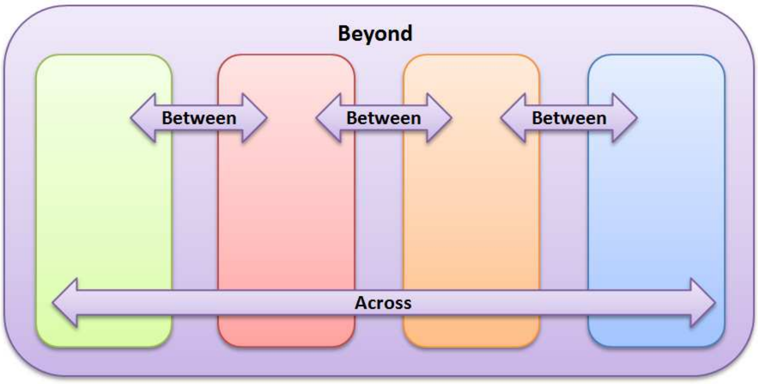

Figure 17 Representation of the specific focus of a transdisciplinary approach (Van Heuverswyn, 2009)

The comparison of the three approaches can be summarized as follows:

Multidisciplinarity is mainly additive juxtaposition, at best some kind of coordination is involved. Relevant disciplines are identified and gathered, the coverage of all relevant aspects is achieved through a collaboration or coordination effort.

Interdisciplinarity is more integrated, interacting, linking and focusing, yet limited to searching for knowledge, methods and means from other disciplines to serve one single other discipline, in this case incident management (which is not in se a fully recognised discipline, as is further developed below).

Transdisciplinary starts from a completely different mindset, recognising that reality is more than the sum of our fragmented knowledge and powers; takes an umbrella view giving specific attention to the dimensions between, across and beyond.

They all recognize the value and merits of specialised, mono disciplines and thus add extra layers and an integrated level without denying **monodisciplinarity**

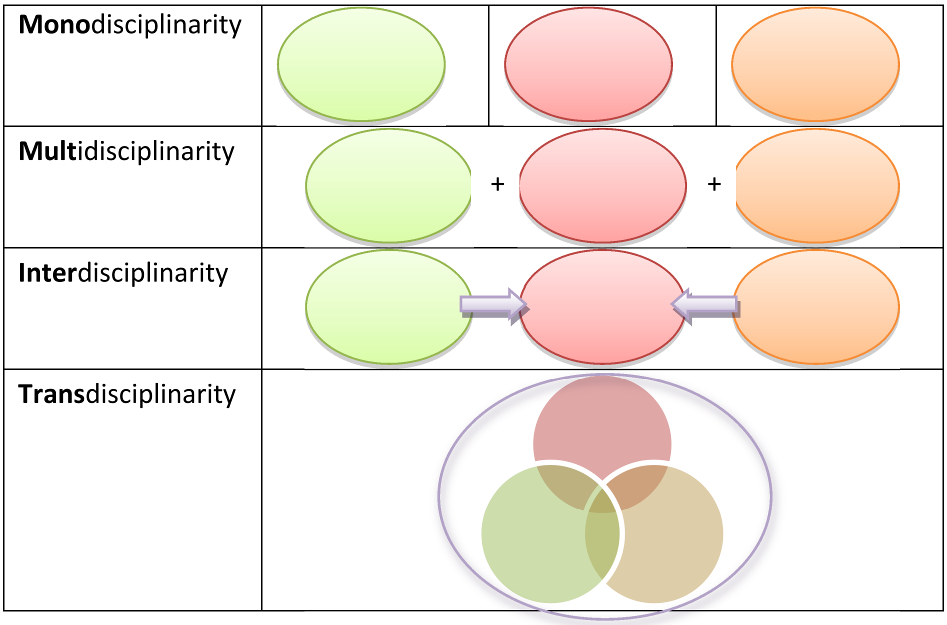

Figure 18 Visual representation of mono-, multi, inter- and transdisciplinarity

From the comparison, transdisciplinarity is the most comprehensive and holistic approach and includes the advantages (juxtaposition, attention to links and relations) of the two other approaches.

A recommended approach to improve current incident management practices could be to upgrade the role and work done in multidisciplinary structures: emergency planning bodies, operational command post and strategic coordination bodies by:

- Supporting a transdisciplinary mentality, approach and vision: encouraging incident managers to transcend their own discipline, take an umbrella view from the case (emergency planning) or incident at stake (response) and look for aspects across, between and beyond the input of each individual participating discipline;
- Encouraging the use of a methodology and corresponding tool to support that transdisciplinary effort.

Following from this, the three success factors for the application of a transdisciplinary approach are: structures providing a platform for transdisciplinary thinking, mentality and methodology/tools.

5.2 A methodology for improved incident management

5.2.1 The added value of a transdisciplinary approach

In the context of incident management, the added value of a transdisciplinary approach consists of the recognition that all divisions in disciplines and specializations are artificial, whereas reality doesn't take them into account. Lagadec's statement in mind (see before p. 39), reality and especially major incidents oblige us to transcend our artificial boundaries and subdivisions and force us to work together. This is an important vision for dealing with all types of risks and incidents, but specifically important for incidents with cascading effects because the main challenge is to understand and anticipate vulnerabilities because of dependencies, i.e. vulnerabilities that are embedded in the system as a whole and to which we have become blind because our fragmented, monodisciplinary approach of parts of reality.

Although all relief and rescue operations, from daily, routine to the most complex incidents could benefit from transdisciplinary thinking, this is not easy to achieve as it is not a natural way of thinking. A pragmatic and gradual approach is more realistic in order to improve current incident management practices:

- Multidisciplinary actions could be sufficient for daily, routine operations and refers to the joint rescue and relief operations when several first response disciplines are involved;
- Multidisciplinary structures are needed for more complex events, characterised as incidents (See above, Table 1), demanding specific command and control and coordinating bodies. This especially applies to large scale incidents and incidents with cascading effects.
- As a minimum, an interdisciplinary mentality is needed for incidents: all actor and case/incident related information needs to be collected, analysed and synthesised. It would be an interdisciplinary approach by analogy, because there is no full home discipline: it is an ad hoc assembling of actors and their knowledge for emergency planning and response based resp. on scenarios and the response efforts during an incident. This could be sufficient for smaller, less complex incidents.

Complex, large scale incidents and incidents with cascading effects require a transdisciplinary mentality, because all case/incident related information needs to be collected, analysed and synthesised from a perspective that transcends the knowledge, competence, skills and means of all the disciplines involved. This is by definition a transdisciplinary approach. It is especially relevant for incidents with cascading effects because indeterminacy is the main differentiating characteristic for this type of incidents. The identification of links and dependencies and an umbrella view of relations and the dynamic of the whole are of crucial importance to manage these situations efficiently.

	MULTIDISCIPLINARITY	INTERDISCIPLINARITY	TRANSDISCIPLINARITY
Characteristics of the approach	= juxta**position**	= juxta**position** + links and relations between	= juxta + links, relations between + dimensions across + dimension of the whole beyond
Daily, routine operations	Mono or multidisciplinary, joint but parallel actions		
Incidents	Multidisciplinary **structures** needed	A minimum integrated effort/**mentality** required	
Large scale incidents and Incidents with cascading effects	Multidisciplinary **structures** needed		Preferably a transdisciplinary **mentality, methodology and tools** required to take an umbrella view on links between, dimensions across and the dynamic of the whole event (beyond the sum of the input of individual disciplines)

Table 8 Overview of a gradual multi-, inter- and transdisciplinary approach for improved incident management (Van Heuverswyn)

5.2.2 The role and contribution of the CascEff Incident Evolution Methodology

Within the CascEff project, a decision support methodology for incident management, to be used in the preparation and response phases of small and large incidents with cascading effects has been developed: the Incident Evolution Methodology - IEM. For a comprehensive description and explanation, we refer CascEff Deliverable 4.2.

In the following paragraphs we highlight the specific steps and features of the methodology that provide for more, better and more in depth understanding of vulnerabilities because of system dependencies, as well as the analytical and synthetic capacity of the methodology based on a case specific approach, identifying and integrated all aspects relevant from a (regional) case perspective.

Step 1 asks for the selection of a regional area in which dependencies and cascading effects will be identified and modelled. A regional case approach in itself demands of the user to let go of a discipline-specific perspective. The systems within that area are to be identified, as well as their characteristics, such as the geographical location of power supply stations, hospitals, etc. Vulnerabilities and outgoing effects of those systems are assessed.

In **step 2** geographical, functional and logical dependencies between systems are identified, such as the proximity of a school near a chemical plant (geographical) or the hospital depending on supply of drugs and thus on transportation in order to stay operational (functional). This step is a typical transdisciplinary step, looking at an area from an umbrella view and identifying links, relations, dependencies between all the systems located in the area. The information collected in step 1 and 2 is 'case- or incident-neutral' and purely area-related.

It is important to go through these steps before the case based approach starts because of our natural tendency to look at a problem, an accident, an incident, etc. from a problem-solving perspective. The validation session clearly demonstrated that incident managers' reflex is to go straight forward to the identification and consideration of possible solutions without having the patience to create a global picture.
Only after this inventory of information is done, an initiating event is selected in **step 3**. Following that, the risk conditions and outgoing effects of impacted systems are assessed.
In order to identify priorities for decision making, temporal aspects are defined in **step 4**: propagation time, endurance time, buffer time etc. (see before for the meaning of different notions related to time in footnote p. 15).
All this information regarding the possible evolution of the selected incident is assembled and visually represented in a timeline overview and a tree-view overview.
Step 5 assesses the impacts, based on five categories: human, social, economic, environmental and infrastructure. The impact is estimated per category and visually represented in a scorecard, thus giving a global overview of all possible impact.
In **step 6**, this is further put into perspective by comparing the impact per system combined with an estimation of the available timeframe to break the cascade, thus providing informed and visual support for the identification of key decision points.

5.2.3 The transdisciplinary character of the Incident Evolution Methodology and Tool

The added value of the IEM is that it provides for a structured approach to collect all relevant, monodisciplinary information and asks for the identification of links, relations, dependencies creating vulnerabilities, in order to get an integrated and holistic view on all case/incident relevant aspects to manage. Both the links and the global overview are exemplary of transdisciplinary thinking, different from a traditional multidisciplinary approach.
Without the support of a transdisciplinary methodology, it is difficult to obtain the same result, because of the large amount of information and because of the complexity once links and dependencies are identified. Without support is it difficult to keep the overview in mind. The step by step approach of the IEM ensures completeness of the required information and ensures the logical and chrono-logical putting into perspective of case-specific information in the building up of a comprehensive picture.

The Incident Evolution Tool – IET under development is an example of an transdisciplinary instrument guiding the users systematically through the six steps and providing visual support with the mapping, timeline view, tree view and scorecard.

Both the IEM and IET thus answer to one of the key challenges of incident management: gathering information from multiple sources, putting them into perspective, in a context which is highly complex, uncertain and where decisions need to be made under time pressure. It is designed to be generic and applicable to all kinds of incidents, including incidents with cascading effects, regardless of the originating event (natural, manmade accidental, manmade intentional). It is applicable to all levels of command and useful regardless of the number of actors involved, the level and type of coordination.

When used in the preparation and response phase, this methodology will improve the understanding of the evolution of an incident and lead to better informed decisions. The use of a transdisciplinary instrument will automatically lead to more awareness of the added value of transcending the boundaries of individual disciplines in multifacetted cases and thus encourage over time a transdisciplinary mentality. Without the need to touch upon existing structures, the current multidisciplinary bodies might transform in the longer run to truly transdisciplinary bodies.

The contribution of a transdisciplinary methodology such as the IEM is visually summarized in the following picture:

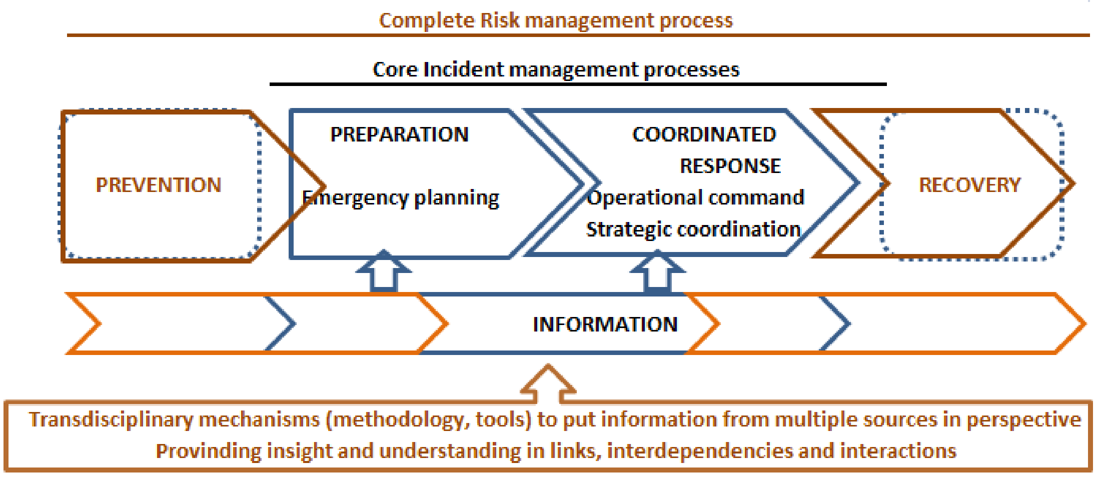

Figure 19 Contribution of transdisciplinary mechanisms to improve current incident management practices (Van Heuverswyn)

6 Conclusion on opportunities to improve incident management

The expected result from Task 1.3 was a flowchart for improved incident management.

This flowchart gives a visual summary and representation of the recommended transdisciplinary approach to improve current practices. The flowchart shows:

- the sequence and dependencies between consecutive phases of risk and incident management;
- the actors involved per phase, core first response and other, supporting disciplines. They belong to the 22 systems identified as possible impacted in case of cascading effects;
- the importance of a continuous information flow throughout the whole cycle;
- the added value of the support of a transdisciplinary instrument, such as the IET, to gather and treat all relevant information.

The first flowchart gives a transdisciplinary view on all relevant aspects.
For a more detailed view, it is broken down into partial flowcharts of two consecutive phases.

Flowcharts for improved incident management

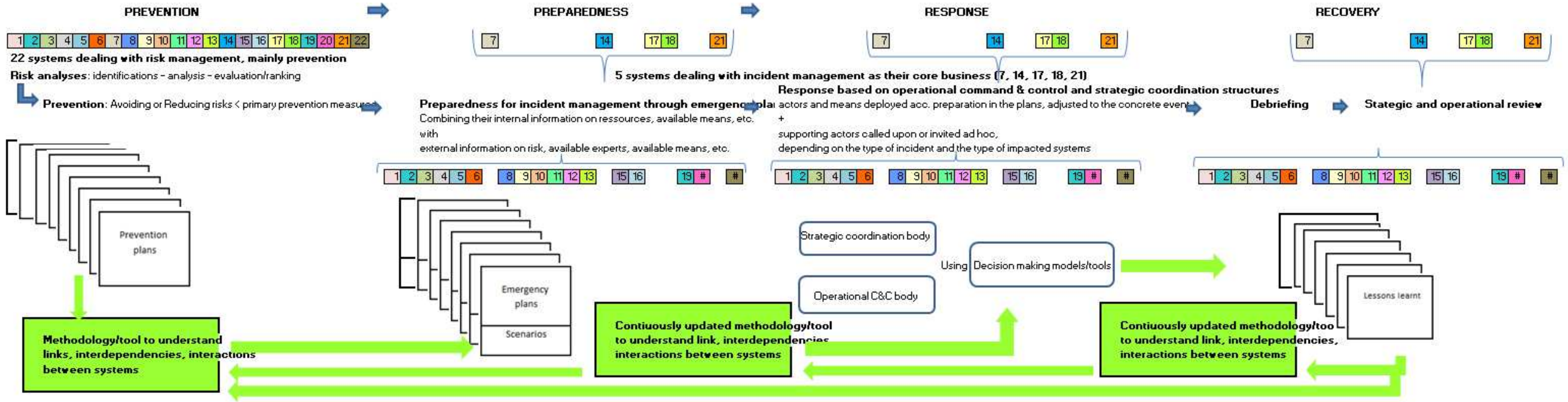

Figure 20 An integrated flowchart, demonstrating the added valueof a transdisciplinary approach and the contribution of the transdisciplinary methodology and tool, such as the IEM/T

Categories	N.	Prevention, incl. risk analysis	Preparedness, incl. planning	Response, operational and strategic	Recovery
Power Supply	1	Core business	Support	Support	Core business
Telecommunication	2	Core business	Support	Support	Core business
Water supply	3	Core business	Support	Support	Core business
Sewage	4	Core business	Support	Support	Core business
Oil and gas	5	Core business	Support	Support	Core business
District heating	6	Core business	Support	Support	Core business
Health care	7	Core business	Core business	Core business	Core business
Education	8	Core business	Support	Support	Core business
Road transportation	9	Core business	Support	Support	Core business
Rail transportation	10	Core business	Support	Support	Core business
Air transportation	11	Core business	Support	Support	Core business
Sea transportation	12	Core business	Support	Support	Core business
Agriculture	13	Core business	Support	Support	Core business
Business and industry	14	Core business	Core business	Core business	Core business
Media	15	Core business	Support	Support	Core business
Financial	16	Core business	Support	Support	Core business
Governmental	17	Core business	Core business	Core business	Core business
Emergency response	18	Core/support	Core business	Core business	Support
The public	19	Core business	Support	Support	Core business
Environment	20	Core business	Support	Support	Core business
Political	21	Core business	Core business	Core business	Core business
Food supply	22	Core business	Support	Support	Core business

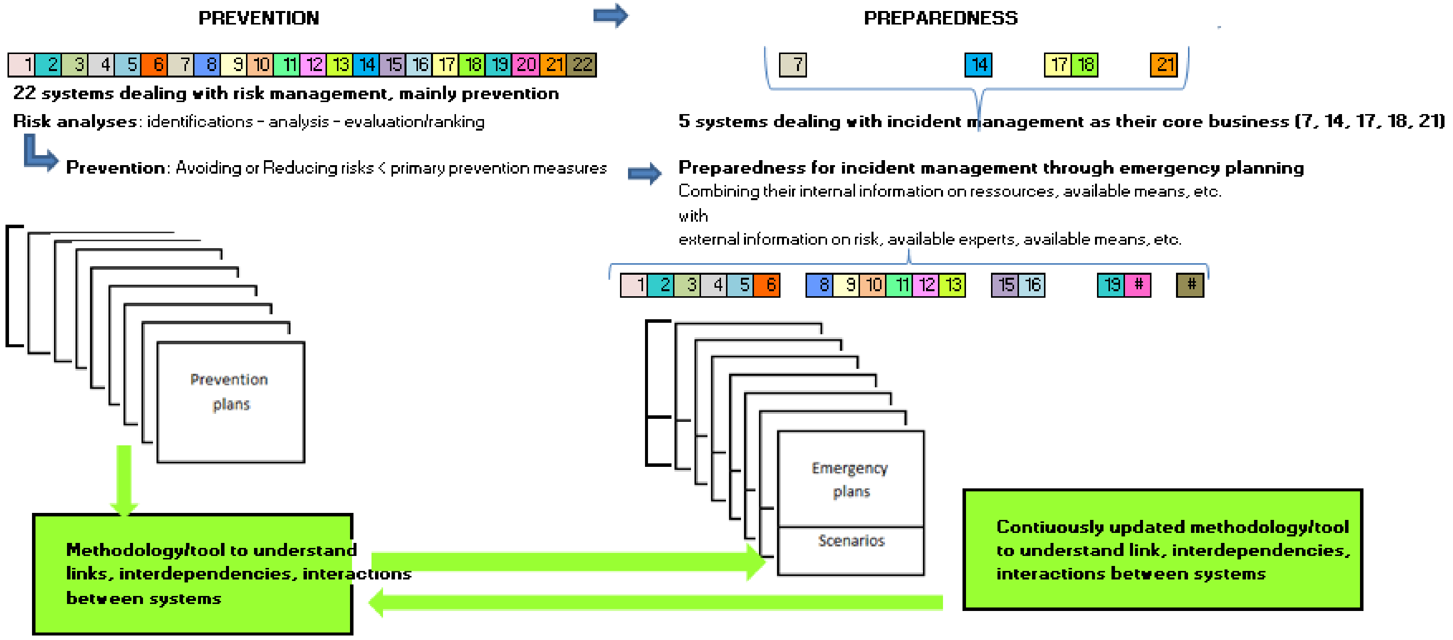

Figure 21 Flowchart detail - Link between Prevention and Preparedness

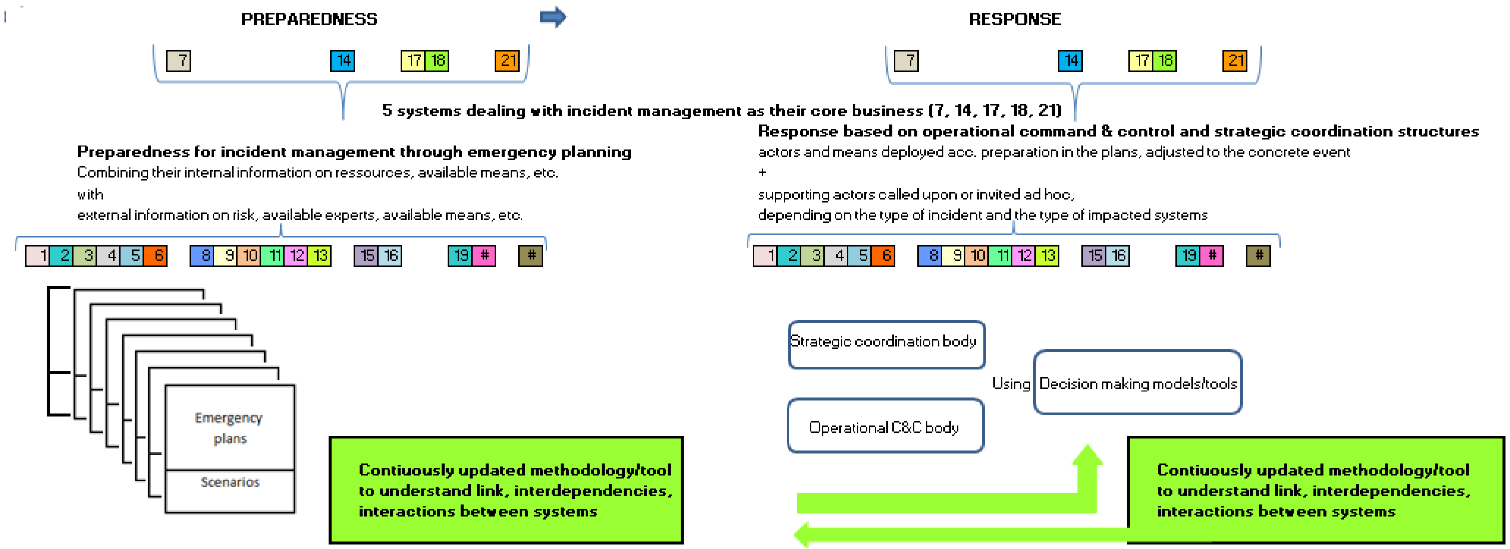

Figure 22 Flowchart detail - Link between Preparedness and Response

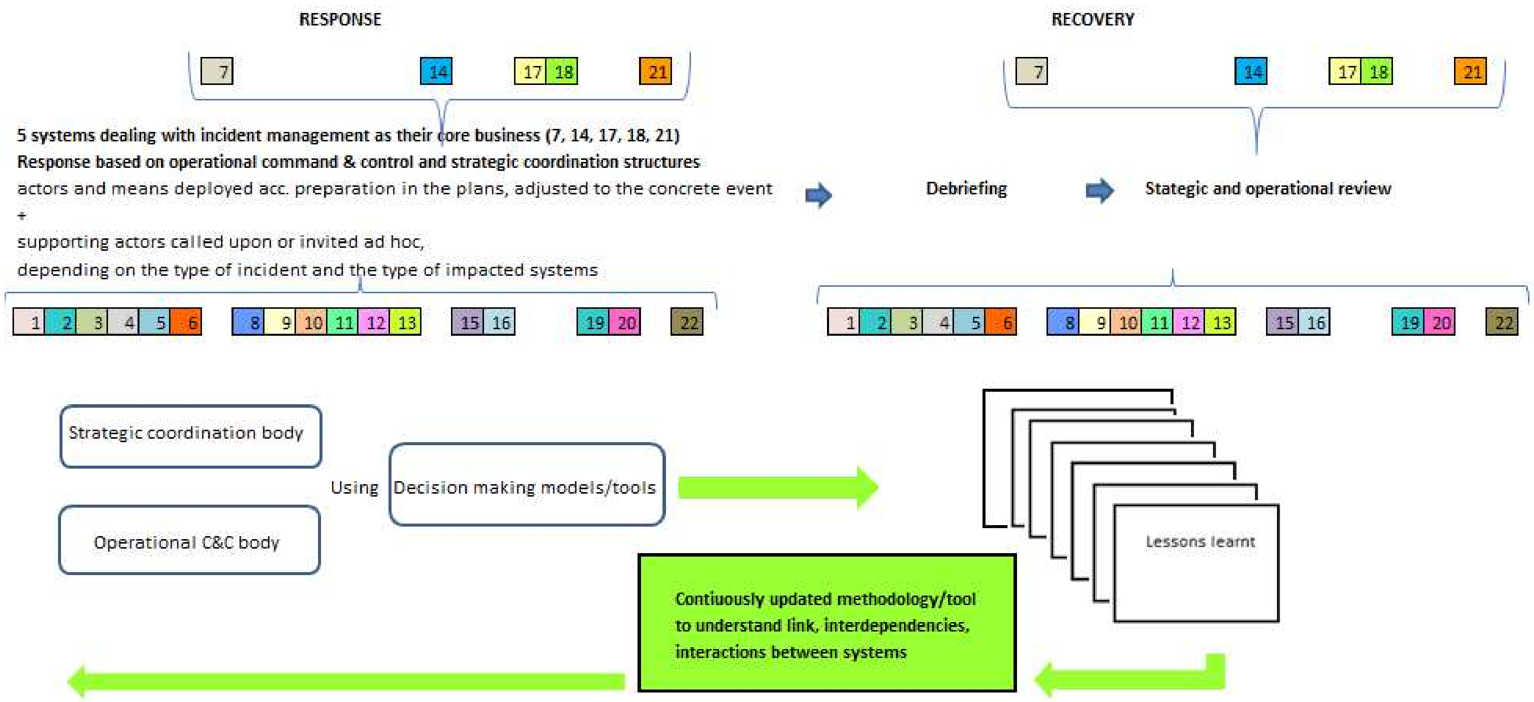

Figure 23 Flowchart detail - Link between Response and Recovery

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List figures

Figure 1Schematics of the dependencies between systems in case of cascading effects.......... 14
Figure 2Illustration of Buffer time, Propagation time, Endurance time and Time delay. 15
Figure 3 Core and supporting incident management processes – common practices.............. 19
Figure 4 Scenarios as an instrument for emergency planning for writing concrete procedures 25
Figure 5 Representation of the first response step, Analysis (Oefenbank Nederland) 26
Figure 6 Circular chart for multiple hierarchical command and control (Döbbeling, 2012)....... 27
Figure 7 Belgian IBOBBO model (Brugghemans et al, 2015) 28
Figure 8 Example of how to divide command and control structure into different levels, including a normative level 30
Figure 9 Common institutional structure of the organisation of civil security at national level 31
Figure 10 The Disaster Risk Management Cycle (DRMC) Diagram 33
Figure 11 ISO 22320:2011 distinguishes 3 phases of emergency management: before, during and after an incident. 33
Figure 12 FERMA 2003 35
Figure 13 The ISO 31000:2009 risk management processes in detail 35
Figure 14 Representation of Risk assessment as subprocess of Risk management based on ISO/IEC Guide 51:2014(E) 36
Figure 15 The link between Risk and Incident management processes 41
Figure 16 Schematic overview of fragmented power and process steps – Actors from 22 possibly impacted systems at three administrative levels dealing with the 4 phases of risk and incident management 42
Figure 17 Representation of the specific focus of a transdisciplinary approach (Van Heuverswyn, 2009) 44
Figure 18 Visual representation of mono-, multi, inter- and transdisciplinarity 45
Figure 19 Contribution of transdisciplinary mechanisms to improve current incident management practices.. 49
Figure 20 An integrated flowchart, demonstrating the added valueof a transdisciplinary approach and the contribution of the transdisciplinary methodology and tool, such as the IEM/T 51
Figure 21 Flowchart detail - Link between Prevention and Preparedness 52
Figure 22 Flowchart detail - Link between Preparedness and Response 53
Figure 23 Flowchart detail - Link between Response and Recovery 54

List tables

Table 1 Overview how common key characteristics of incident management relate to different types of events 17
Table 2 Overview of emergency plans in Belgium, the Netherlands, and the United Kingdom 20
Table 3 Levels of Incident Management Command 24
Table 4 Overview of response bodies for coordination in Belgium, the United Kingdom and France 24
Table 5 Overview of administrative levels with legal responsibility for incident management per country 31
Table 6 Common incident management phases (see full references (a, b, etc.) in CascEff D1.6) 34
Table 7 Core and supporting incident management actors in the 22 systems identified as possibly impacted by cascading effects 38
Table 8 Overview of a gradual multi-, inter- and transdisciplinary approach for improved incident management 47

Annex I – Table of correspondence midterm review D1.3

Areas to improve cf. midterm review	Changes, adaptations, additional research or argumentation
The focus on cascading effect, and the potentially necessary interaction, or iterative nature of the different phases is unclear	Revised D1.3 Chapter 3, Chapter 4 and Chapter 5.1.4
The Deliverable does not sufficiently clarify in how far the IET improves current practices	Revised D1.3: Chapter 5.2.2 - 5.2.3
The literature review (one of the research methods) is too autoreferential (too many references to CascEff Deliverables	See Bibliography and references in the revised D1.3
Definitions are not sufficiently in line with other CascEff Deliverables and are sometimes contradictory (e.g. incident management)	A CascEff glossary was developed and published as a new Deliverable, D1.6 (July 2016) in order to ensure a coherent use of definitions in all CascEff publications