

Anders Lönnermark<sup>1</sup>  
David Lange<sup>1</sup>

## Project vision and approach



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| Coordinator:        | Anders Lönnermark at SP Sveriges Tekniska Forskningsinstitut (SP Technical Research Institute of Sweden) |
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<sup>1</sup> SP Technical Research Institute of Sweden (SP)

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## Executive Summary

The FP7 project CascEff (“Modelling of dependencies and cascading effects for emergency management in crisis situations”) started April 1, 2014. The project aims to address a growing societal challenge arising as a result of a societal risk picture which is evolving as systems, infrastructures and communities become more closely related and interdependent. This report summarizes the societal challenge which the project is addressing; the project goals and vision; the approach which the project consortium has taken in tackling the challenges and in trying to achieve the projects goals to reach this vision; and finally the expected impact of the project.

The main goal of CascEff is to improve our understanding of cascading effects in crisis situations through the identification of initiators, dependencies and key decision points. Seven different target groups have been identified: First responders, other authorities, critical infrastructure providers, teaching and training organisations, research organisations, members of the public, and the commercial sector.

The aims of the project are reached by focusing on and studying different issues:

- incident management practices
- opportunities for improved management of incidents with cascading effects
- methodology for analysis of incidents with cascading effects
- characterization of cascading effects, including originators, dependencies and key decision points, by reviewing previous incidents
- human factors and influences which affect both response and reaction to large-scale incidents
- how media is used by decision makers and incident managers to inform the public
- the possible use of social media
- the use of incident management tools and incident evolution tools

The derived knowledge is used to develop an incident evolution tool (CascEff IET). The IET will provide additional information to the incident commanders beyond the knowledge available from experience alone by making it possible to evaluate the impact of alternative options for response strategy, based upon an understanding of system dependencies and the risk for cascading events. This additional information will supplement the experience of the incident commander and will provide additional information upon which to base his/her actions.

Being a summary, this report does not describe all detailed results derived in CascEff. However, in the description of the project structure and approach there are references to the relevant deliverables. All deliverables from the project are also listed at the end of this report.



# 1 Introduction

The project “Modelling of dependencies and cascading effects for emergency management in crisis situations” (CascEff for short) started on the 1<sup>st</sup> of April 2014. It is a project funded under the European Union’s 7<sup>th</sup> framework programme for research (FP7). This document is intended to introduce the reader to the various aspects of the project. It first of all describes the societal challenge which the project is addressing, then introduces the reader to the project goals and vision. After this, the reader is introduced to the approach which the project consortium has taken in tackling the challenges and in trying to achieve the projects goals to reach this vision. Finally the impact of the project is described.

As mentioned, this document is intended as a ‘primer’ to the overall project. We anticipate that it will help the reader to put the rest of the projects deliverables into the context of the overall project, helping them to understand and identify which of the projects outcomes are useful for them.



## 2 Societal challenge

The project aims to address a growing societal challenge arising as a result of a societal risk picture which is evolving as systems, infrastructures and communities become more closely related and interdependent. Interdependencies at first glance may appear to be relatively superficial from the perspective of emergency response (for example: a temporary power cut affects the level of comfort of individuals in society), however higher degrees of interdependencies may result in a significantly higher impact of a relatively minor incident than may be expected (for example: a power cut affects telecommunications facilities which help to manage hydroelectric facilities or distribution centres remotely: without the telecommunications facilities efforts to restore power are hampered which prevents restoration of telecommunications which in turn leads to difficulties in coordinating response). These higher degrees of interdependencies lead to an increasingly complex incident.

These so-called cascading effects in crisis situations significantly challenge both emergency preparedness and response to man-made threats and natural hazards. An escalating incident can quickly become extremely difficult for emergency services to handle. In particular complex systems which lack adequate response and recovery capacity and planning to certain initiators will be prone to cascading effects occurring in dependent systems.

This means that initially small incidents can ultimately have large and quickly escalating consequences with respect to life, property and the environment and for both infrastructure and the general public, affecting an extended geographical area and potentially extending across borders. In these instances, to prevent these escalating consequences, the incident management needs to be as efficient as possible and built on up to date information and a detailed understanding of the environment in which the incident is occurring.



## 3 Project objectives and vision

The projects overall objective may be described as: CascEff will improve our understanding of cascading effects in crisis situations through the identification of initiators, dependencies and key decision points. These will be developed in the methodological framework of an Incident Evolution Tool (IET) which will enable improved decision support, contributing to the reduction of collateral damages and other unfortunate consequences associated with large crises. Use of the Incident Evolution Tool will be validated through its implementation into different incident management and training platforms representing different end users in the project (e.g. NoKeos, iCrisis, WIS and XVR). A roadmap for similar implementation in other incident management and training platforms throughout Europe will be defined to allow broad acceptance of the Incident Evolution Tool.

### 3.1 Objectives

In order to achieve this overall objective, we have set ourselves 4 objectives, which are outlined below.

#### 3.1.1 Objective 1 - Better understanding of the cascading effect in crisis situations

CascEff will improve our understanding of cascading effects in crisis situations by the identification of initiators, dependencies and key decision points in complex systems. The methodology developed will be generally applicable to allow its use both in scenarios studied explicitly within the project and others

#### 3.1.2 Objective 2 - Develop an Incident Evolution Tool (IET) for predicting past, present and future crisis evolution leading to cascading effects

CascEff will implement the understanding of initiators, dependencies and key decision points gained through Objective 1 in an Incident Evolution Tool. The Incident Evolution Tool methodology is being developed in close cooperation with end-users – first responders, emergency managers, decision makers. Further, the finished tool will be suitable for foresight concerning future incident management and resource needs based on an increasing complex society.

#### 3.1.3 Objective 3 - Identification of human activities in the crisis

CascEff will explore the impact of human activities in a crisis, specifically in relation to emergency responder tactics and crisis communication, e.g. forced evacuation and the public as active detection in crisis development (through Twitter and other social media).

#### 3.1.4 Objective 4 - Improved incident management for present and future threats

The Incident Evolution Tool will support improved incident management throughout Europe by providing an open methodology for understanding and modelling cascading effects in an emerging incident. The tool will be useful in all stages of incident management including: pre-incident planning, incident management, debriefing and training, and foresight. The IET will be designed to support cross border operations taking into account a wide European perspective. The Incident Evolution Tool will be available as a generalised methodology for implementation into different national incident management frameworks or tools.



## 3.2 Vision

The projects work may most easily be thought of in two halves, the first half relating to incident management and the other half relating to incident evolution. This division has led to the development within the project of a software tool referred to above as the IET (Incident Evolution Tool). In this section we provide an overall project vision, as well as a summary description of the vision of the IET.

### 3.2.1 Project vision

Increased understanding of cascading effects, by studying previous incident, system dependencies, decision-making, human behaviour, the role of media, etc., incident management during incident with cascading effects will be improved. The vision with regards to incident management is to develop a methodology for improved incident management in incidents with cascading effects through better understanding of cross border collaboration and the provision and incorporation of foresight tools in the incident command process. These foresight tools, incorporated in the incident management methodology, will be used by incident commanders to inform their decision-making process, leading to reduced consequences and preventing cascading effects.

The information is provided via the CascEff IET and is of pertinence during all stages of crisis management: Planning, Mitigation, Preparation, Response and Recovery. The IET will allow the incident commander to identify key points in which the cascade could be broken, and on consequences of cascading effects which should enable prioritization of decisions and resources.

As a result of the additional information available during planning and preparation, following the identification of potential cascading effects, proper capacity planning can be performed such as calling in pre-defined emergency management capabilities, involving pre-defined experts, verifying tactical assumptions, considering evacuation, etc. By identifying cascading effects during incident response planning, collaboration with key actors and collaborative response activities can also be planned

In the recovery phase the additional information should enable analysis and explanation of the cascading effects and thereby ensure that lessons are identified as well as learned and implemented.

### 3.2.2 IET vision

The CascEff IET software is a solution for predicting the cascading effects which could develop in a crisis situation and which could lead to the propagation of the effects of an incident from one system to another. The solution is based on a methodology to register different features of systems and the relationship between systems and calculate dependencies between those systems based on vulnerabilities and outgoing effects. A user inputs the information about individual systems and an initiating incident, the software then calculates the possible propagation of this incident and displays this in one of several possible graphical formats: a fault tree type visualization; a map with indicators of the propagation which evolve over time; a swimlane type illustration; and a bubble / node type illustration.



In addition to the evolution of the incident depicted in these ways, the IET also displays and reports the consequences of the incident in terms of direct economic loss, environmental impact, and impact on society. Links illustrated in the visualisations can be deactivated by the user to evaluate the impact of different emergency response actions on the overall consequences of the incident and to input to the decision making process.

Different users can contribute to the data base and the incident can be limited by the user to a specific region / area by means of what we call a “case”. This allows different incidents and scenarios to be run on the same set of systems in the database depending on current needs. The IET links with other incident management tools by exchanging data as well as by sharing results of the cascading effects calculation. It should also be possible in the future to linked one IET with other IET’s held in, e.g., neighbouring countries or municipalities to contribute to successful cross-border collaboration and response actions.

This information about cascading effects in different situations is useful for emergency responders to reduce the overall impact of an incident; to evaluate the effect of changes to the infrastructure in a region; or for training/debrief purposes to provide various ‘what if’ scenarios.

### **3.3 Target end users**

When discussing the target end users, we differentiate between the end users of the projects results and the end users of the developed IET. Some stakeholders have an interest in large parts of the information and knowledge derived within CascEff, e.g. persons responsible for education, development and strategic processes within first responder organization, while some groups may have an interest in specific parts of the research (e.g. other researchers) or the IET itself (potential users, persons responsible for tools (e.g. incident management tools), developers of incident management tools, etc). In most cases there will probably be a mixture.

There are therefore seven types of stakeholder groups, which may be targeted by the results of the project, with a different motivation for targeting these types of groups. The groups which have been identified are not exclusive and there are, naturally, many organisations both within the project and outside of the project who fall into more than one of these groups.

In the following table, we have tried to identify which parts of the project are likely to be of most interest to these different groups.



|                                    | <b>Foreground knowledge created</b> | <b>Incident management</b> | <b>The IET</b> |
|------------------------------------|-------------------------------------|----------------------------|----------------|
| Research organisations             | x                                   |                            |                |
| Teaching or training organisations | x                                   | x                          | x              |
| First responders                   |                                     | x                          | x              |
| Members of the public              |                                     | x                          |                |
| The commercial sector              |                                     |                            | x              |
| Critical infrastructure providers  |                                     |                            | x              |
| Other authorities                  | x                                   | x                          | x              |

The different stakeholder groups are described further in the Dissemination plan (D6.1). In D6.1 also some other potential stakeholders are mentioned. These include other relevant EU projects and the CasCEff External Expert Advisory Board (EEAB).



## 4 Project structure and approach

The project has been divided into seven work packages, structured to address the objectives above.

Work package 1 is the packaging for the rest of the project, it will result in the conceptual incident management framework into which all of the other project results are intended to fit. It addresses both legal and ethical issues when responding to large scale crises as well as the use of the IET and how it can enhance incident response.

- 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 projects Incident Evolution Tool. As noted above, the intention is that by improving the quantity and quality of information provided to an incident commander that he will be better able to take informed decisions regarding mobilisation of resources and public communication / interaction.
  - A workshop was held with the CascEff external expert advisory board (EEAB) at an early stage to discuss their interpretation of cascading effects and their needs to respond to these types of incidents. A report of this workshop is given in the CascEff deliverable D1.1.
  - Deliverable D1.2 reports on a wider review of incident management methods in crises, and details incident management practices, how agencies respond to incidents with cascading effects and how they handle cross border and inter agency collaboration. This information is gathered from a series of interviews and questionnaires, which were distributed by the consortium to different actors.
  - A first proposed methodology for improved incident management in crises accounting for the information available from the proposed IET is presented in Deliverable D1.3 of the project. This deliverable addresses also the IETs use during different stages of incident management. This is based primarily on practices in different countries reported in deliverables D1.1 and D1.2 and in deliverable D3.1 and deliverable D3.2. The methodologies are presented in flowcharts.
  - Deliverable D1.4 describes the scenarios which are to be used for the evaluation of the incident evolution tool, as well as for testing its use in the improve incident management methodology. In this instance 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. This deliverable has very close links with deliverable D5.1.
  - Deliverable D1.5 will be an elaboration of Deliverable D1.3. It will present an improved methodology for incident management using the IET, and accounting for the feedback, which is received by the projects consortium following the exercises, which are planned for work package 5.
  - Deliverable D1.6 is the projects glossary. It has evolved over the first two years of the project, and includes terms agreed upon by the projects general assembly and which are intended to help with the understanding of the projects reports. To understand and agree on the terminology used has been identified in discussions with other projects and stakeholder as one of the



most difficult and important issues. Therefore, D.1.6 can be of use as such also outside the project.

Work packages 2 and 3 developed important foreground knowledge about the evolution of incidents involving cascading effects.

- In work package 2, we identified originators and dependencies for cascading effects in previous incidents. A detailed review of the responses taken and the impact of 40 separate incidents was undertaken. Each of the incidents reviewed resulted in either a significant cross-border impact or significant loss of life or infrastructure and had immediate and lasting repercussions not only for those who were involved but also the wider community. During the review of these incidents, we identified the nature of the dependencies as well as the nature of the impacts.
  - Deliverable D2.1 describes a conceptual method for studying incidents with cascading effects. This is the first step towards studying previous incidents and is employed in the analysis of selected incidents which are reported on in Deliverable D2.2. In total 16 different incidents are studied in D2.2 in detail to test the methodology.
  - Deliverable D2.3 is an extension of the work presented in D2.1 and in D2.2. Based on past incident reports from 40 separate disasters, this deliverable describes a database was created, which outlines the dependencies between different systems. Originator and dependency pairings are identified, as well as buffer times and various other features of these dependencies and cascading effects. The outcome of this report is important background knowledge needed for the development of the IET.
  - Deliverable D2.4 is a study of cloud monitoring needs for crisis situations, i.e. using cloud-based resources to connect with remote sensors and analyse data to foresee risks for cascading effects.
  - Deliverable D2.5 is a report on physics in large-scale incidents. It is based on a series of simulations carried out using numerical and analytical tools and identifies the usefulness of these tools for studying or for predicting cascading effects. Some of these tools could later be incorporated in the IET; however computational power limits the use of numerical tools for real time modelling or prediction.
  - Finally, in work package 2, Deliverable D2.6 is a report of loss and consequence modelling in cascading effects and details how information about potential losses could be included in the IET to increase the dimensionality of information provided to incident commanders to aid in their decision making.
- In work package 3 we studied the human factors and influences which affect both response and reaction to large scale incidents. This included a review of the tactics which are employed by first responders and comprised also studies of evacuation of large areas carried out in addition to the models of physical effects in WP2 to study crowd movement and large scale evacuation. It also describes the use and role of media in both the response and development of an incident through interviews and focus groups held with the public and first responders with experience of dealing with large-scale incidents. With regards to the media, we also considered how media is used by decision makers and incident managers to inform the public as to what is currently happening and the evolution of an incident. We studied how crises are



presented in the media as well as how people react to the information in media (both the general public and those involved in the work with the incident), including also possibilities for the use of social media.

- Deliverable D3.1 reviews tactical first responder operations in large-scale crises. The report presents a review of the decision making process in large-scale crises and presents a flowchart of the process, which first responders may take, identifying where the IET could contribute to this process. Deliverable D3.2 is the foundation for the work, which is presented in deliverable D3.1.
- Deliverable D3.2 deals with the issue of decision-making in emergencies with cascading effects. In order to examine this, information is taken from academic literature, interviews and case studies and analyzed with respect to the DoW. This includes data on response organizations in Sweden, The United Kingdom, Norway, Belgium, The Netherlands and France, research on several models of decision-making including associated social and organizational factors, case studies of the 2014 mudslide in Oso, USA, the 2005 bombings in London, UK and the 2014 forest fire in Västmanland, Sweden.
- Members of the public and the role of crisis management in communicating the evolution of an incident to them are discussed in deliverable D3.3. As well as discussing how decisions should be taken with regards to informing the public, it also discusses how the public are likely to respond to and act upon this information. This is important input to the IET and to the incident management methodology developed in WP1.
- Deliverable D3.4 builds on the work of deliverable D3.3 and discusses the role of the media in communicating this information.

In work packages 4 and 5 we address the development, testing and validation of the incident evolution tool.

- In work package 4 we are developing a methodology for predicting narratives of incidents with cascading effects and implementing this in an incident evolution tool. The incident evolution tool will use the models identified in work package 2 and the information and models from work package 3 as well as the methodology, which is developed for identifying originators and dependencies. The incident evolution tool is being tested on some of the events, which are studied in work package 2.
  - Deliverable D4.1 is a review of existing tools. The project consortium carried out a survey of existing incident evolution tools and incident management support tools to identify how these are used by incident commanders at present and to identify any gaps in these tools which the CascEff IET can fill.
  - Deliverable D4.3 is a first version of a proposed structure for the CascEff IET. It addresses the feedback and requirements of the EEAB, which were provided at our first workshop and reported on in D1.1. It has been the basis of the ongoing development work within the project.

Finally, the project will rely upon a number of simulated exercises in response to incidents. These simulated exercises (performed in work package 5) will employ the incident command methodology developed in work package 1 and which relies upon incident evolutions (narratives) as developed in work package 4 and tools from work package 2 and human interaction from work package 3. This work package will compare the incident command



methodology in response to real cases, such as those studied in work package 2 as well as test the methodology in response to a number of imaginary cases.

- Deliverable D5.1 is a detailed description of the scenarios, which will be used for testing the IET. It is based on the scenarios described in D1.4, however with additional possible timelines described.



## 5 Impact

### 5.1 Crisis management

The work performed in CascEff will significantly improve the possibility for incident commanders to manage complex emerging incidents by improving our understanding of initiators, dependencies and key decision points and the development of an Incident Evolution Tool. This will introduce additional information and decision support into the incident management process. The Incident Evolution Tool will provide additional information to the incident commanders beyond the knowledge available from experience alone by making it possible to evaluate the impact of alternative options for response strategy, based upon an understanding of system dependencies and the risk for cascading events. This additional information will supplement the experience of the incident commander and will provide additional information upon which to base his/her actions.

Understanding of cascading effects and the impact of and on crisis management, including the role and influence of different groups and their actions, will lead to improved management of incidents involving cascading effects. The combined results of the project will lead to an improved incident management as such, but will also have a large focus on how the CascEff IET can be used efficiently when managing incidents with cascading effects.

Information on possible cascading effects is needed during all stages of an incident: Planning, Preparation, Response and Recovery. The experience from the CascEff EEAB supports the expression by Dwight D. Eisenhower (somewhat differently expressed): “Plans seldom survive, but planning is everything”; flexible emergency response requires thorough preparations.

As a result of the use of the IET in planning and preparation, following the identification of potential cascading effects incident managers will be able to carry out proper capacity planning and make arrangements in advance for pre-defined emergency management capabilities, for example involving pre-defined experts, verified tactical assumptions, mass evacuation, etc.

In the response phase, the main use of the IET can be to show the links between systems and the risk for cascading effects. It can visualize the probable paths of the incident and thereby also key points for decisions and intervention. The results can also enable prioritization of decisions and resources.

In the recovery (and post-incident) phase the IET should enable analysis and explanation of the cascading effects and thereby ensure that lessons are identified as well as learned and implemented.

### 5.2 Scientific impact

Several different fields have been studied in CascEff to identify parts that can influence the development of cascading effects and how to intervene in an efficient way. Examples of such studies are:

- Present incident management praxis, including challenges (e.g. in-group bias, legal issues, ethical issues, cross-border effects)
- The use of incident management tools and incident evolution tools



- Methodology for analyzing incident with cascading effects
- Characteristics of cascading effects, including originators and dependencies between different systems
- The influence of human behavior
- Decision making during incidents with cascading effects
- Modelling, both of components of an incident and of the cascading effects

Many of the results from these studies have been published scientifically and can also form the basis for further studies, either of the separate subjects or as interdisciplinary studies.

### **5.3 Societal impact**

The results from the project and the knowledge about cascading effects can be used to mitigate cascading effects or its consequences by taking the risks into account at an early stage. This could mean specific mitigation action for different systems, but could also lead to changes in e.g. organisations and communication before and during an incident to limit risks and consequences. The IET could help to make information on cascading effects more objective, and support the alignment of the vision of different partners with different goals, different experience, different skills, etc. The results from the IET should enable prioritization of decisions and resources.

By use of the IET it could be possible to reduce probability and consequence of cascading effects through proper risk planning and preparation. Cascading effects can be managed in advance by e.g. verifying existing plans, training exercises, and strengthening the safety culture.

The IET should give information on cascading effects, both on originators and dependencies to identify key points in which the cascade could be broken, and on consequences which would serve the purpose of managing the recovery.



## 6 Conclusions

The main goal of CascEff is to improve our understanding and mitigate the consequences of cascading effects in crisis situations through the identification of initiators, dependencies and key decision points.

The derived knowledge is used to develop an incident evolution tool (CascEff IET). The IET will provide additional information to the incident commanders beyond the knowledge available from experience alone by introducing a number of alternative options for response strategy, based upon an understanding of system dependencies and the risk for cascading events. This additional information will supplement the experience of the incident commander and will provide additional information upon which to base his actions. The improved knowledge on cascading effects in combination with the developed IET will lead to improved management of incident involving cascading effects

Seven different target groups have been identified: First responders, other authorities, critical infrastructure providers, teaching and training organisations, research organisations, members of the public, and the commercial sector.

The aims of the project are reached by focusing on and studying different issues:

- incident management practices
- opportunities for improved management of incidents with cascading effects
- methodology for analysis of incidents with cascading effects
- characterization of cascading effects, including originators, dependencies and key decision points, by reviewing previous incidents
- human factors and influences which affect both response and reaction to large-scale incidents
- how media is used by decision makers and incident managers to inform the public
- the possible use of social media
- the use of incident management tools and incident evolution tools



## 7 List of deliverables

Below all the deliverables published so far in CascEff are listed. Some of the deliverables are available in revised versions and therefore the date for the most recent version is also included for each deliverable. It is also indicated which of the deliverables are public. Those are available to download from the CascEff web site: [www.casceff.eu](http://www.casceff.eu).

- D1.1, "A summary of the EEAB workshop 18-19 June 2014" (Sept. 16, 2014)
- D1.2, "Report of incident management in crisis" (Dec. 31, 2014), Public
- D1.3, "A flowchart of the methodology for improved incident management in crisis" (April 15, 2016)
- D1.4, "Report on scenarios to be elaborated for testing the incident evolution methodology" (April 15, 2016), Public
- D1.6, "CascEff Glossary and Definitions" (June 30, 2016), Public
- D2.1, "Method to study cascading effects" (Dec. 19, 2014), Public
- D2.2, "Review of previous incidents with cascading effects" (March 31, 2015), Public
- D2.3, "Cascading effects in past events – A database structured around originators and dependencies" (June 30, 2015)
- D2.4, "Report on technical needs for integrating the e.cenaris platform for cloud monitoring of hazards in crisis situations" (March 29, 2016), Public
- D2.5, "Modelling of physics in cascading effects" (Sept. 30, 2015), Public
- D2.6, "Losses and consequences of large scale incidents with cascading effects" (July 31, 2015), Public
- D3.1, "Modelling of response to emergencies with cascading effects" (April 15, 2016), Public
- D3.2, "Decision-making and human behavior in emergencies with cascading effects" (April 15, 2016), Public
- D3.3, "A strategy for communication between key agencies and members of the public during crisis situations" (May 4, 2016), Public
- D3.4, "A report on the role of the media in the information flows that emerge during crisis situations" (May 31, 2016), Public
- D4.1, "Identification of capabilities of existing tools" (Dec. 15, 2016)
- D4.3, "Initial Structure for implementation of the incident evolution tool (IET)" (June 30, 2015)
- D5.1, "Detailed description of selected scenarios" (April 15, 2016)
- D6.1, "CascEff Dissemination plan v3" (April 15, 2016)
- D6.2, "Project Website" (June 30, 2014), Public
- D6.3, "Project Leaflet" (Sept. 29, 2014), Public
- D7.1, "CascEff Progress report M1-M11" (March 13, 2015)
- D7.2, "CascEff Progress report M1-M27" (June 30, 2016)

