Editor: Kathleen Van Heuverswyn[1]

Authors:

Abla-Mimi Edjossan-Sossou[2]
Anders Lönnermark[3]
Andrea Contini[4]
Bart Merci[5]
Clément Judek[2]
Cornelie van Hunnik[6]
David Lange[3]
Georgios Maragkos[5]
Koen Milis[1]
John Damen[7]
Romuald Salmon[8]
Ronald Ackermans[1]
Steven Van Campen[7]
Terry Considine[4]
Thierry Verdel[2]
Xavier Criel[6]

Report on scenarios to be elaborated for testing the incident evolution methodology

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[1] Campus Vesta, BE (CV)
[2] Université de Lorraine, FR (UL)
[3] SP Technical Research Institute of Sweden (SP)
[4] Northamptonshire Fire and Rescue Service, UK (NFRS)
[5] Universiteit Gent, BE (UGent)
[6] Safety Centre Europe, BE (SCE)
[7] XVR Simulations, NL (XVR)
[8] INERIS, FR

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Executive Summary

Scenarios are frequently used as an instrument in research projects. The scope, the type of story- or timelines, the level of detail and other characteristics are determined by the overall objective of the project, the stage of development they are used in and the specific purpose for their elaboration. This report clarifies the underlying methodology used for the selection and elaboration of the CascEff scenarios. For the sake of coherence, basic methodological guidelines on other, related aspects have been included in this report. They are to be further developed in subsequent tasks.

Scope and purpose – The aim of Task 1.4, as described in the Dow, is '*the identification of basic and representative originators leading to scenarios with cascading effects*'.

Design/Methodology/approach – The initial objective was extended to a more comprehensive methodological report on related aspects sharing the same purpose, which is testing the Incident Evolution Tool (IET). In doing so, more efficiency and a more coherent methodological approach on linked aspects was aimed at:

- The identification of basic and representative originators for the selection of scenarios with cascading effects (initial scope of Task 4.1);
- Derivation of starting point and methodology for development of multiple timeline development (to be elaborated in Task 5.1);
- Development of a methodology on how to create and use scenarios for testing the IET, including the definition of evaluation criteria for testing (scope of Task 5.2, resp. Task 4.3).

Input was found in previous CascEff Deliverables, ongoing Tasks, literature and national practices.

Findings – This report includes a coherent methodological approach, starting from the specific objective – testing and validation of the IET- and providing a basis for further development and elaboration of scenarios in Task 5.1 and the testing of the IET using the scenarios in Task 5.2.
Selection criteria
The set of criteria for the selection of scenarios was defined, taken into account the four criteria for qualitative and adequate scenarios, according to Walker (1995). The first two criteria relate to consistency and plausibility. The internal consistency and plausibility of the CascEff scenarios is assured by the fact that all scenarios are based on or inspired by real events. Consistency of the content between the CascEff scenarios has been guaranteed through the use of a template. Thirdly, scenarios need to be credible. The credibility of the CascEff scenarios is assured through the detailed analysis of interdependencies and impacted systems. This is briefly mentioned in this report and further developed in Task 5.1, where it is visualised with swim lanes. These are not arbitrary estimations, but based on the insights in cascading effects and impacted systems from WP2, which guarantees the credibility of the alternative timeline development. Fourthly, scenarios must be relevant, which relates to the purpose of the scenario. As the main purpose of the CascEff scenarios is the testing of the IET, the following criteria ensure their relevance, both individually and as globally as scenario set:

- Types of initiating events: the scenarios cover a variety of initiating events, such as man-made and natural landslide, different types of fire (industrial, tunnel, wildfire), a combination of a traffic and hazmat accident and a combination of extreme weather and disruption of power supplies;

- Secondary events/cascading effects: the scenarios cover different types of secondary events, effects and impacted systems. For some, the cascading effects are potential. In order to increase the representativity for testing, alternative timelines with more variety in secondary events, more cascading effects and more impacted systems are developed in 5.1;
- Impact and scale: all scenarios are considered as large scale incidents, with possible or real cascading effects. In the absence of uniform criteria to determine the scale, 'large scale' was justified based on national criteria from regulation or good practices, or specific criteria related to the type of incident;
- Cross border: some scenarios include real cross (national) border effects, for the other scenarios, the notion border was interpreted not only as national borders; internal, administrative borders or the fact that these scenarios could occur anywhere, also near an national border, were also considered useful;
- Multi-agency management: even if there are national differences in the way coordination is organised, in most scenarios the complexity of large scale incident management revealed to require the involvement of multiple organisations;
- Expertise of the partners: the type of incident falling within the scope of the expertise of the partners was considered useful, because of the availability of information and expertise (gold commanders involved in the incident belonging to the staff or the network of the partners);
- EU relevance: given the ambition of the IET, which is to provide support to the incident management, irrespective of the geographical location of the IET, the scenarios were chosen to be valuable in most European countries;
- Time span: the scenarios cover incidents for which the response phase varies between a few days and a few weeks.

Selected scenarios

The following scenarios have been selected:

The **Scheldt case** is based on a historical event in the industrial port of Antwerp (Belgium, July 5-9, 2013). Construction works created a man-made landside that caused a risk of explosion of damaged pipelines. In case of an explosion, a cascade of possible risks for the surroundings and considerable impact would have been probable.

The **Mont Blanc** tunnel fire is a historical scenario (24 March 1999) with real cascading effects that had identifiable cross border effects (Italy and France). The actual impacts due to the accident were very severe and had both a short and long term effect.

The **Festival case** is a fictitious scenario based on a combination of three real events (two incident types) with potential cascading effects, which could occur anywhere in Europe: (1) a hazmat transportation incident (Wetteren, Belgium, 2013; Ostedijck schip, Spain 2007), (2) the evacuation of an outdoor music festival (Pukkelpop, Belgium, 2007)

The **Séchilienne scenario** is not a past event but a potential scenario, which may lead to huge consequences. It concerns a potential ground movement of more than 3 million m3 in a village named Séchilienne.

The **Nut warehouse** blast scenario is based on a real industrial fire that happened in Northampton, UK (June 26, 2013) In this scenario, the political dimension is important due to the risk of environmental pollution and the possible impact on the local population.

The **Skatås wildfire** scenario is based on a real incident in the Skatås forest located around lakes Stora Delsön and Lilla Delsjön, east of the city of Gothenburg, on the west coast of Sweden (April 29, 2008). The actual consequences of the incident were limited, although possible cascading effects with considerable impact were probable (severe consequences for personnel safety, health, properties, infrastructure, businesses, societal services, transportation, etc.).

The **Power Blackout** scenario is fictive but the potential impacts are based on real-life large power outages in Europe and North America in recent years. It is a complex cross-border scenario, a combination of extreme weather conditions and a failure of a critical component causing an outage that affects two provinces in The Netherlands and after some time four provinces in Belgium.

The three 'best' scenarios, best compliant with the criteria and best fit for testing the IET will be selected in Task 5.2.

Evaluation criteria for testing

The following methodological steps were identified to define the evaluation criteria for testing: 1) refinement of the possible list of user requirements of D4.3. into a list of desirable user requirements; 2) selection of representative user requirements and scoring of each criterion. The representativity relates to the capacity to evaluate the functionality (does it function properly?) and intrinsic value (does it match the expectation to support improved incident management?) of the IET.

Methodological steps to elaborate a scenario

Key chronological steps in writing a scenario can be summarized from literature as: 1) scoping the scenario field; 2) identification of key factors; 3) analyzing key factors and their dependencies; 4) scenario script generation; 5) scenario transfer to paths.

Specific points of attention for qualitative scenarios require taking into account the need for a participatory process, goal-oriented writing and awareness for national differences.

Methodological steps to elaborate a test plan

The elaboration of scenarios is one of the stages of the elaboration of a test or exercise plan. The basics steps of such a plan have been identified in this report, as well as action points (input and needs) from the CascEff project for each step: Design and Development (preparation), Conduct (implementation), Evaluation (debriefing) and Improvement Action plan.

Exercise roles and responsibilities have been identified. Some relate directly to the organisation of the test/exercise, such as Exercise Director, an Exercise Project Team, Evaluators, Observers, etc. The key actors and supporting actors who will play/perform the scenario during the test have previously been identified (D1.3) as the Risk Owner, the Licensing Authority, the Competent Authority, the Incident Response Team, the Emergency Planning Services and the IET Trainer.

Other participants (volunteers, bit-part players) can complete the play in Operation based tests.

Multiple alternative timelines

Four starting points for alternative evolutions have been identified and are briefly explained in this report: 1) alternative decisions; 2) contextual, external factors; 3) impacted systems and their interdependencies; 4) the use of buffer time. They will be used for the multiple timeline development in Task 5.1.

Conclusions/Recommendations – This report provides selection criteria for the CascEff scenarios, a basic description of the selected scenarios and basic methodological guidance on related aspects, that need further development and implementation in consecutive CascEff Tasks:

- The 1.4 methodology for the elaboration of the scenarios (in concreto the multiple timeline development) will be completed and implemented in Task 5.1;

- The 1.4 methodology for the organisation of the tests of the IET will be completed and implemented in Task 5.2;
- The evaluation criteria for testing the IET will be defined in Task 4.3, following the 1.4 methodological steps.

A comprehensive overview of linked tasks and how they built on each other's results is included in the conclusions of this report.
The results of the all these linked tasks (1.4, 4.3, 5.1, 5.2) will inform the development of the incident evolution methodology, as well as and the architecture of the Incident Evolution Tool in Task 4.2.
Besides for the purpose of testing the IET, scenarios revealed to be useful as a working instrument during the project, such as for continuous improvement in understanding (possible) cascading effects, dependencies between multiple systems and/or modelling the physics (e.g. the Mont Blanc tunnel scenario). Scenarios are also used to demonstrate that cascading effects can appear on different scales and have different causes.

Nomenclature

Definitions cf. Deliverable 1.6, CascEff Definitions[9]

Buffer time - The time between the start of the incident management of the initiating event (in the originating system) and the time before a cascading effect occurs in a dependent system. (instrumental definition based on Yeomans and the notion 'Time Delay' cf. D2.3)

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.

Cascading Effects (Working definition) - An incident can be said to feature cascading effect when an initial impact in one system propagates to other system(s), leading to more severe consequences than those from the initially impacted system.

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 - A system that is negatively affected by either an initiating event or an originating system.

Event – A singular instance of a phenomenon negatively affecting a system.

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 four interrelated dimensions: technical, organisational, social, and economic.

Impacted system - a system which is negatively affected by either an initiating event or an originating system

Incident – A chain of events affecting multiple systems.

Incident Evolution Tool - An incident evolution tool (IET) is based on a methodology (the IET methodology) which relies on input from either 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

[9] Working document in progress, due as CascEff Deliverable 1.6, 30 June 2016

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 - Management of appropriate measures to deal with a (potential) situation characterised by (high) complexity, uncertainty and time pressure, that could lead to possible large scale damages and requires a specific organisation and coordination to ensure the restoration of the situation

Incident Management Tool - 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.

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.

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.

System (general definition cf. D2.1) - A regularly interacting or interdependent group of items forming a unified whole[10]

System (working definition cf. D4.3) - 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.

List of CascEff acronyms

CascEff - The European co-funded project in which this deliverable is part of

EEAB - External Expert Advisory Board

IET - Incident Evolution Tool

[10] http://www.merriam-webster.com/, search word: "system", retrieved 2014-11-26

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1 Introduction

The CascEff project aims to 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[11]. The present report constitutes the deliverable for Task 1.4, which consists of **scenario identification for testing the methodology**.

Scenarios are an important part of the CascEff project since they are used to test and evaluate the IET and its underlying methodology (Task 5.2). The scenarios are based on, or inspired by, past real incidents that are further developed. The main purpose for developing these scenarios is their use for testing the IET in the different phases of Emergency Management in Task 5.1. Only the three 'best' scenarios (the most comprehensive and representative) will be chosen for testing. The other scenarios are useful as a working instrument during the project, such as for continuous improvement in understanding (possible) cascading effects, dependencies between multiple systems and/or modelling the physics (e.g. the Mont Blanc tunnel scenario). Scenarios are also used to demonstrate that cascading effects can appear on different scales and have different causes.

The work carried out in WP2, where past events are analysed in order to understand the specific characteristics of cascading effects, provides an important basis for the scenario development in Task 1.4. Such insights about cascading effects also provide important input to the development of the IET in Task 4.2.

1.1 Objectives and scope of Task 1.4

1.1.1 Objectives and expected deliverable Task 1.4

The objectives of Task 1.4 are defined in the DoW as follows:

"Implementation of the methodology will require risk identification, scenario definition and multiple timeline development, based on existing incident command systems in Europe (e.g. CECIS, iCrisis, WIS, RIB, Nokeos, EmergencyCommandSystem and others identified in Task 1.1. and implemented in WP 4). This task will be to identify basic and representative originators leading to scenarios with cascading effects. These scenarios will be elaborated in WP5 using the incident evolution tool to be developed in WP4."

The expected deliverable cf. the DoW is a '*Report on scenarios to be elaborated for testing the incident evolution methodology*'. More concrete expectations were mentioned in the Consolidated Midterm Review Report (17 January 2016) and specifically the need for a more sound argumentation on the identification of selection criteria and re-application of the new criteria to a new scenario set, in order to assure:

- A requisite variety of scenarios;
- A clear focus on interesting and challenging cascading effects;

[11] CascEff Project (607665) Annex I DoW, Part A, p. 4 (4/10/2013)

- Coverage of all aspects stated in the DoW, including large scale scenarios.

For the identification of appropriate scenarios, the methodology needs to include a definition of scenario and an argumentation on cross border events (and cooperation), the geographical scale and malicious attacks. Moreover, first order cascading effects need to be demonstrated in every scenario.

For the first Report, the Task 1.4 Partners agreed (in consultation with the Partners involved in Task 5.1 and Task 5.2) to extend the scope of D1.4 to a full methodological report on the elaboration of scenarios (Task 5.2).
Instead of developing a methodology in three consecutive steps, first on 'originators' cf. the scope of Task 1.4; secondly, on the elaboration of the scenarios in Task 5.1 and thirdly on the use of these scenarios for validation in Task 5.2; the basic features of the methodological approach related to those three aspects are now covered in one single report (D1.4). The further development and concrete implementation of the methodological approach remains within the scope of Task 5.1 and Task 5.2. The main concern justifying this extension was to avoid a fragmented approach and to develop an overall coherent (basic) methodological approach for linked tasks. Accordingly, the extended deliverable D1.4 consists of two parts:

1. An argumentation on the selection criteria for the scenarios, how representative they are, and a brief description of the chosen scenarios.
2. A methodology for further elaboration of the scenarios to be used for validation in WP5. This part covers 1) evaluation criteria for testing, 2) guidelines for the elaboration of the scenarios as part of a test plan, 3) possible starting points on multiple timeline development.

The modifications following the Review Report concern mainly the first part of this Report, (Chapter Two). Chapter Three and Four have been updated to reflect these changes and to make this Deliverable congruent with other related tasks (see overview of links, Table 10). Links between Task 1.4 and other tasks are summarized in Table 1 and schematically illustrated in Figure 1.

Table 1 Link between Task 1.4 and other CascEff tasks

Input from other tasks	Use in Task 1.4
Task 1.3 – methodology for improved incident management	Input for Scenario description and multiple timeline development
WP 2 – historical case studies	WP2 terminology and insights in cascading effects to be taken into account
Task 4.2 – methodology for IET	Input for Scenario description
Task 4.3 – definition of IET architecture	The D4.3 list of possible user requirements serves as basis for the definition of evaluation criteria for the testing in Task 5.2.
Task 5.1 – identification and elaboration of scenarios	Defines the purpose of the scenarios
Task 5.2 - initial testing and feedback to WP 1-4	Defines the purpose of the scenarios, which is the validation of the IET

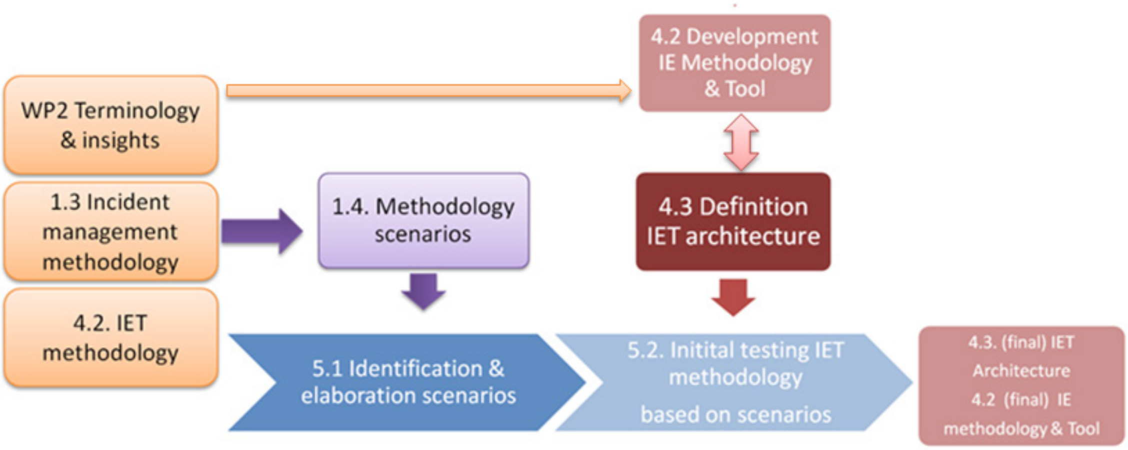

Figure 1 Overview of links between CascEff Tasks

1.2 Methodological approach

As mentioned in the previous section, this task includes:

1. An argumentation on the selection criteria for the scenarios, how representative they are, and a brief description of the chosen scenarios.
2. A methodology for further elaboration of the scenarios to be used for validation in WP5. This part covers 1) evaluation criteria for testing, 2) guidelines for the elaboration of the scenarios as part of a test plan, 3) possible starting points on multiple timeline development.

The methodological approach underpinning these parts are described below.

1.2.1 Methodology for the selection of scenarios

Selection criteria for scenarios will be defined, based on:

- Input from previous CascEff meetings, including suggestions from the EEAB;
- Input from previous CascEff Deliverables and ongoing Tasks;
- Task group discussions (Task 1.4 in consultation with all the partners from Task 5.1 and Task 5.2) to select a coherent set of criteria;
- Definitions and arguments from literature.

Expected output:

- Selection criteria for scenarios to test the incident evolution methodology.

1.2.2 Methodology for the elaboration of the scenarios

Evaluation criteria are identified and basic guidelines for the elaboration of scenarios are developed, based on:

- Input from other previous CascEff Deliverables and ongoing Tasks;

- A provisional comparative approach of a basic set of national practices and literature on guidance or templates on scripts for tests, exercises and demonstrations, aimed at providing a basis for further development in subsequent tasks;
- Selection of relevant methodological aspects serving the objective of this task which is to provide for a methodology for the elaboration of scenarios (Task 5.1) to be used for testing the incident evolution methodology (Task 5.2);
- Input for a list of originators and dependencies from where alternative timelines can be developed will be found in previous CascEff Deliverables.

The actual identification of possible alternative timelines and the development thereof is the scope of Task 5.1.

Expected output:

- A methodology for the definition of evaluation criteria for the testing in Task 5.2;
- Basic guidelines for the elaboration of test scenarios in Task 5.1 and a test script in Task 5.2;
- A list of originators and dependencies for alternative timeline development in Task 5.2.

1.3 Report outline

In **Chapter 2**, the revised methodology for the selection of scenarios is explained: the selection criteria are exhaustively commented. A brief description is given for each of the selected scenarios. Their compliance with the selection criteria is demonstrated for each scenario individually. A summarizing overview in included.

In **Chapter 3**, the methodology for the elaboration of the scenarios is explained, covering two aspects: 1) identification of evaluation criteria for testing, and 2) a testing plan, which includes guidance for the elaboration of the scenarios. Chapter 3 also gives an overview of possible originators and dependencies, identified in previous CascEff deliverables, which can serve as the basis for the identification and development of multiple alternative timelines.

In **Chapter 4** key conclusions are provided and a number of recommendations made for the implementation of this methodological approach in other CascEff Tasks.

2 Risk identification - Scenario definition and selection

2.1 Scenario definition

A comparative analysis of definitions and descriptions of scenarios (see overview in Annex I) was made in order to identify the scope, content and key characteristics of a suitable scenario. A first observation is that most definitions either focus on what a scenario is in terms of content, or define scenario by its purpose (i.e. its intended use).

In broad terms, a scenario can be described a story of possible future events, with some degree of uncertainty. The scenario can be based on real events, complemented with fictional story lines based on assumptions that are not necessarily predictive and thus differ from forecast and prognoses (Bishop et.al., 2007; Sidney and Schoeffler, 1955; Wack, 1985; Meristo, 1991, Vartia, 1994; Gausemeier et.al., 1995; Bartusik and Cabala, 1997).
Scenarios can be used for many different purposes, such as: to illustrate alternative solutions and identify potential problems (Bodker, 2000), to prevent certain effects (Laufer and Jung, 2010), to reduce uncertainty (Hansmann, 1983), to question existing assumptions (Vartia, 1994), to indicate thinkable futures (Scholz and Tietje, 1995) or desirable futures (Godet, 2000). They can also be used as a management tool to improve the quality of strategic decisions (Wilson 2000).
Few definitions include both aspects, content and purpose (Vartia, 1994) or aim at testing a tool in an incident or crisis management environment.
Only Walker (1994) covers all these aspect, therefore his definition and approach of key characteristics best fit the goal of this task. He defines a crisis management scenario (based on a more general definition suggested by Quade (1989)) as: "*a description of the conditions under which the crisis management system or crisis management policy to be designed, tested or evaluated is assumed to perform*" (Walker, 1994, p.1).

Walker distinguishes two relevant components: the context and the crisis. The context is "*the overall background or environment within which the specific crisis is to be considered. It is the state of the affected area at the time of the crisis*" (Walker, 1994, p. 2). This includes a specific timeframe or date stamp, demographics of a local population, geographical location, organisational relationships, availability of data etc. The context determines the framework into which a crisis is, or others might be embedded (for the purpose of the study).
Walker describes the second part, the crisis, as "*It includes the chain of (hypothetical) events that lead up to the crisis" or "the sequence of events to which the crisis management system must respond*" (Walker, 1994, p. 2). One context can thus embed different types of crises and within the crisis script, the chain of events can be altered, both leading to different scenarios (see further, multiple timeline development).

Walker identifies four criteria for scenarios to be adequate and qualitative: 1) consistency, 2) plausibility; 3) credibility and 4) relevance.

1) **Consistency** refers to the script not being self-contradictory (see also Van Asselt, 2001).
   For the CascEff scenarios, the **internal** consistency is assured by the fact that all scenarios are based on real events with fictional lines of development also inspired by real events. Consistency of the content **between** the CascEff scenarios has been guaranteed through the use of a template (see Annex II).

2) **Plausibility** means that the scenario needs to be likely to occur, i.e. it *might* happen (without necessarily being predictable). Extreme or worst case scenarios are not excluded, since some large scale historical incidents, such as the gas leak incident in Bophal, India in 1984 and the Chernobyl nuclear accident in 1986[12], were considered unthinkable before they happened. The plausibility of the CascEff scenarios derives from the real events upon which they are based or inspired. This is also taken into account in the multiple timelines developed in Task 5.1.
3) **Credibility** is closely linked to plausibility, according to Walker (1994). Circumstances, consecutive steps and any changes in them should be logical, and it is important to understand why they occur. In the CascEff scenarios, the credibility is raised through the detailed analysis of interdependencies and impacted systems. This is done in Task 5.1 and visualised with so called swim lanes. These are not arbitrary estimations, but based on the insights in cascading effects and impacted systems from WP2, which guarantees the credibility of the alternative timeline development.
4) **Relevance**. This criterion relates to the purpose of the scenario and is reflected in the CascEff selection criteria (see 2.3).

2.2 Development of selection criteria

Criteria for scenario identification and selection have been developed and refined as an ongoing process during the project, because of the evolving understanding about cascading effects, generated through the work of previous tasks.

There were several phases in the development of the selection criteria:

- Initial discussions on selection criteria and suggestions for some scenarios at the Revinge meeting in June 2014;
- Communication between the consortium partners on scenarios between June and October 2014;
- Selection of scenarios at the Campus Vesta meeting in October 2014;
- Elaboration of a template for basic information and a first understanding, see template in Annex II (January 2015);
- Evaluation of the selection, together with the EEAB, at the Paris meeting (March 2015);
- Decision to add the Wildfire case (SE) at the Paris meeting (March 2015) following a request from the EEAB;
- Decision to add the Black out scenario (NL) at the Ghent meeting (December 2015), following the discussions during the Midterm Review meeting.

Table 2 gives an overview of the needs and requirements, identified during meetings and discussions.

12 Other, more recent examples are the 9/11 terrorist attacks on New York City and Washington DC, the the 2004 tsunamis in Azia

Table 2 Input for scenario selection criteria

Input from	Criteria or aspects to take into account
DoW (updated version 29.09.2015)	- **Basic** and **representative originators** leading to scenarios with cascading effects (DoW Task 1.4); - **Potential impact** and **risk of escalation** (DoW Task 5.1); - Scenarios should **allow to test the IET** (DoW Task 5.2); - **Mix of real and fictional** events (DoW WP5); - Inclusion in the scenarios of **alternative cascading effects** based on different dependencies and actions (DoW WP5); - Scenarios consist of an **originator** (identified in Task 1.4) and a number of **different evolution timelines for testing** of the incident command methodology and tools (DoW WP5).
Revinge meeting June 2014, EEAB input (see D1.1)	- Incidents with **different contexts,** e.g. social vs technical; - A **variety** of cases; - Different **categories of cascading effects** involved; - Events with **single secondary impact** and with **multiple secondary impact;** - **Showing different ways to stop the course of event** depending on which systems are involved in the evolution.
Campus Vesta meeting October 2014 (see Minutes)	- **Mix of real and fictional** events; - Scenarios that fall within the scope of the **expertise of the consortium partners**, because of the availability of information and possible contribution of the organisations involved e.g. as test-participants (for obvious reasons of efficiency and required realism); - Real cases can be **developed into more interesting scenarios** by adding other aspects (discussion on the Mont Blanc tunnel).
INERIS meeting March 2015 (see Minutes)	- EEAB request to add a **wildfire scenario;** - Scenarios should address incidents **with different scales**: local, regional, national;
Discussions among the partners	- **Representativeness** of the scenarios can be obtained through **diversity**: scenarios should cover a variety of different characteristics: o different originators/risks involved; o different scale (small ⇔ large); o different time span (short ⇔ long response phase); o different actors and organisations involved (single ⇔ multi-agency), etc. - The **number of agencies involved** might be an interesting criteria to show that events with cascading effects do not per definition need a multi-agency incident management. - Scenarios and test set-ups should allow testing as **realistic** as possible.
Review meeting Ghent, December 2015	Aspects to consider for a requisite set of scenarios: **- Cross border events (and cooperation);** **- Geographical scale;** **- Malicious attacks;** **- Higher order cascading effects.**

2.3 Selected criteria

Selection criteria were defined based on the feedback from the aforementioned CascEff meetings and deliberations (see, Table 2). They can be broadly divided into two categories:

- **Criteria related to relevance**, covering requirements that all scenarios have to fulfil, in order to be appropriate for the purpose of testing the IET: such as initiating events of a different type and nature, a minimum of one first order cascading effect, etc.
- **Criteria related to representativeness**: the whole set of scenarios should cover a broad range of characteristics of incidents with cascading effects, and therefore can be considered representative for managing different types of event. These criteria are not to be seen as key aspects of (and thus a requirement to fulfil for) each individual scenario, it is the combination of them all that provides for a representative sample of events covered by the scenarios.

From these two broad sets of categories, more specific selection criteria can be identified. The selected scenarios needs to meet the demands on including a variety (or minimum level) in terms of:

- Type of the initiating (originating) event
- Secondary events/cascading effects
- Mix of real and fiction
- Impact and Scale
- Cross border effects
- Multi versus single agency management
- Expertise of the partners
- EU relevance
- Realistic
- Time span

Each of the selected criteria is justified and clarified in the following paragraphs.

2.3.1 Type of the initiating (originating) event

As described in WP2 (D2.3), the initiating event (initiator) is 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. The terminology adopted in WP2 is used here for consistency: 'initiating', rather than 'originating' event.

Considerations on a malicious act as initiating event:
A malicious event as initiating event, such as a terrorist attack, an intentional explosion, or a similar criminal act has been considered and discussed and was finally not included because of too much uncertainty about the possible impact on incident management.

The assumption is that such an event, leading to a cascading event of natural or manmade nature certainly has an impact on the number and type of organisations involved (justitial, forensic, intelligence, etc.) and on the actions to be taken (preservation of evidence, restrictions on information to the public and via social media, etc.). However, the assumption is that this impact concerns specific processes, additional to the incident response processes and will probably not alter (substantially) the incident management in terms of decision making and measures to be taken to deal with, to manage and control the incident, its impact and its consequences. There is indeed a bigger role to play by police and judicial forces (incl. forensics), and their handling of the situation will add an additional level of complexity (police, forensics, intelligence) that will rather occur in parallel, without affecting (substantially) the functioning of the coordinating incident management structure. Moreover, the type of information needed to manage the criminal part of the event is mainly sensitive information controlled by police and judicial forces and has so far not been considered to be included in the IET.

Confirmation of these assumptions has been sought in literature and in contacts with incident commanders and forensic experts. The latter confirm these assumptions, but no references could be found in literature, or in previous or ongoing national or European research projects. However, given the increasing occurrence of malicious events in Europe lately and the awareness of the increasing threat of such events in the future, the CascEff consortium is well aware of the importance to investigate this; thus two initiatives have been taken to take this into account in the further development of the IET:

- Contacts have been made with partners of the (EU funded) GIFT project, Generic Integrated Forensic Toolbox for CBRN incidents[13]. The exchange of scenarios, and participations of GIFT representatives in CascEff tests are considered in order to share experiences;
- End users from police forces, with a background in terrorism have been invited to the CascEff Focus group. So far, three experts have confirmed their participation in the Belgian Focus group.

2.3.2 First or higher order cascading effects

The potential impact and risk of escalation is covered by one or more secondary events, cf. the representation of the sequential order (D2.2). They are divided into first order and higher order cascading effects, cf. **Figure 3.1 in D2.2**.

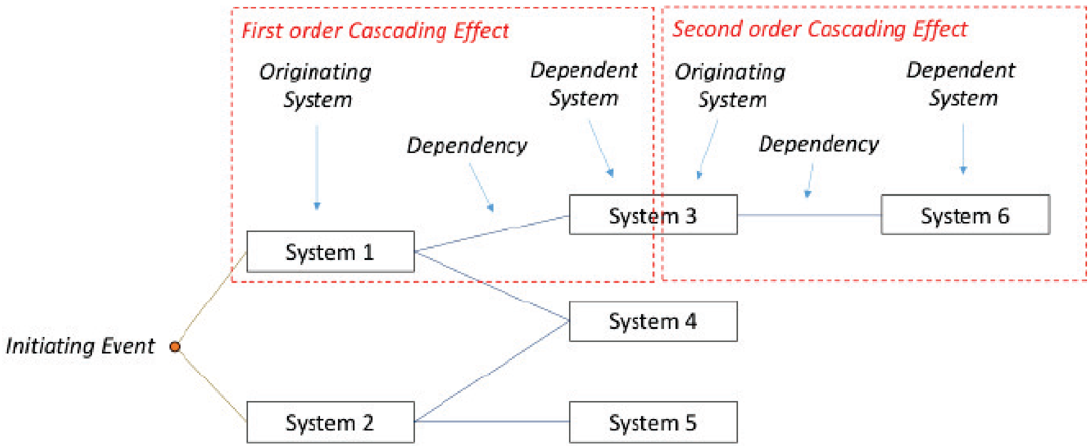

Figure 2 Conceptual model of the propagation of effects between systems in an incident that involves cascading effects

[13] See information on GIFT: https://giftforensics.eu/about/

The scenarios should at least include one first order cascading effect. The scenarios have been selected so that different categories of cascading effects (impacted systems) are covered. Where only one or few systems are initially concerned, this will be completed through the development of multiple timelines in Task 5.1. Higher order cascading effects covered by the scenarios are: explosion, mass evacuation, floods, environmental pollution. Second and third order cascading effects are internal safety risks, risk of explosion, industrial risks, contamination of water supply, etc.

Considerations on a malicious act as cascading effect:

The relevance of a malicious event as cascading event (first order cascading effect instead of initiating event as mentioned before) also has been considered, and after discussion, decided not to be included. The arguments differ from the argumentation on a malicious initiating event.

As a first order cascading effect, e.g. terrorists taking advantage of the chaos caused by the initiating event (e.g. during a storm, a black out etc.) to create more chaos and damages, this kind of scenario does not involve the same logical and physical system dependencies as for natural and man-made disasters. The dependencies and logics are mainly defined by the human factor interfering continuously and being able to affect and alter the evolution of the event in real time. This has so far not been the scope of the IET.

Human factors are studied and taken into account where it concerns the behaviour of the public in WP3, as part of the consequences of an incident, which is different from criminals causing and determining the evolution of an incident, with deliberately opposed actions. This has so far not been considered in the development of the IET.

As mentioned for the malicious initiating event, lessons learnt from the contacts with the GIFT partners and the feedback from Focus group members, will be taken into account in the further development of the IET, e.g. to indicate the boundaries, needs for further research and the possible scope for further developments if relevant.

Consideration on the exclusive/decisive importance of cascading effects:

The presence of cascading effects in the scenarios is important although the absence of real first order cascading effects in the basic scenario should not be a reason for excluding it as a large scale and thus useful scenario. The first reason is that scenarios will mainly, but not only, be used for testing the IET. Secondly, elaborating the scenarios has been a work instrument during the whole project to obtain more insight in the evolution of (possible) cascading events (such as in the Scheldt and Festival case) and for modelling (such as in the Mont Blanc case). The third reason is that the EEAB and incident commanders in the consortium explicitly and repeatedly stressed the importance of developing a tool that would not exclusively be applicable in very large scale (and thereby rare) cascading events, but should also be used for small(er) incidents with cascading effects characteristics or the potential threat of cascading effects.

The main focus (intended use of the IET) should remain on large scale and cascading events, because of the high level of complexity, without losing the possibility to use the tool for other large scale events and even for regular interventions of a certain complexity. The main motivations for keeping the scope of application sufficiently broad were 1) to maximise the potential use of the tool to support incident management decision-making; 2) the fact that a tool tailored on exceptional circumstances might be too exclusive; losing the benefit of creating a custom and culture of using such a tool as decision support.

2.3.3 Mix of real and fictional events

The selected scenarios should include a mix of real events, a fictional event inspired by a real event and a fictive combination of two real events.

Fictional information is added to the initial cases in the development of the multiple timelines in Taks 5.1, providing an opportunity to increase both the relevance and representativeness of the selected scenarios. A minimum link to a real event was considered as a requirement, because of the advantage of available information on the real chain of events and because of the possibility to consult the incident commanders involved.

2.3.4 Variety in terms of impact and Scale

Literature search was undertaken in order to find an objective reference to define the scale of an incident and a threshold for large scale. The results of that search revealed an immense variety of definitions, parameters and criteria (see Annex I). Differences occur due to different perspectives: geographically affected area and/or sufficiency of available means, number of victims/affected people, estimated or real consequences, administrative circumscriptions, etc. There is often even no unanimous set of criteria within one country. In Belgium for instance, the possible impact on society and the need for multiagency coordination are the parameters used to scale up from operational to strategic coordination and from municipal to provincial level[14]. A second, more elaborated set of criteria is used to define a national disaster (including geographical and/or economic and/or health and/or other impact)[15]. For specific types of disasters, specific criteria have been developed, such as for nuclear and radiological[16] and for black out scenarios[17].

Giving the distinction between natural and man-made disaster, the variety of types of disaster within each category (see Wirasinghe et. al., 2013 only for natural disasters), the number of possible impacted systems (cf. the 22 systems identified in WP2), it does not come as a surprise that not one unanimous set of parameters could be found.

In the absence of a uniform scale, the qualification of large scale or possible large scale of the CascEff scenarios has been made on an individual basis. For each scenario, the (possible of real) large scale character is clarified based either on national criteria of the place of the incident and/or scientific criteria related to the type of the incident.

[14] Royal Decree 16.02.2006, Emergency planning, *O.G.* 15.03.2006
[15] Royal Decree 31.01.2003, Crisis management at national level, *O.G.* 21.02.2003
[16] Royal Decree 17.10.2003, Nuclear and radiological emergency plan, *O.G.* 20.11.2003
[17] Royal Decree National emergency plan Electricity Black out, National Crisiscentrum, Ministry of Interior, 18.09.2012

2.3.5 Cross border effects

Cross border effects were taken into account explicitly in some scenarios, with an initiating event in one country and cascading effects in the neighbouring country.

Cross border was not considered solely as national borders; therefore not all scenarios include transnational borders. Two types of considerations are relevant here:

- Real scenarios with no transnational effects were included on the basis that they could conceivably occur in any country, irrespective of their proximity to an administrative or institutional border;
- Internal administrative borders have been considered as important as national borders, because in some countries, the organisation, methods etc. of incident command do differ significantly between jurisdictions. What is relevant in cross border situations is the additional level of complexity due to the involvement of multiple competent authorities, the issue of coordination and hierarchy and the operational challenge of interoperability or (in)compatibility of means and methods. This aspect is linked to the multi agency criteria.

2.3.6 Single- as well as multi-agency management

Cascading events do not necessarily require a multi-agency management. Multi-agency refers to the fact that a specific, ad hoc incident management coordination structure is installed. Ad hoc refers to the composition of the coordination structure, which varies in function of the type and characteristics of the event.

Partner discussions revealed that some primarily single-agency incidents, such as wildfires management by the Swedish fire brigade, can be complex and large scale, and might therefore be a good IET test case.

The number of organisations involved might be an indicator of the complexity of the situation. However a threshold number has not been considered relevant as a criterion. This criterion contributes to the representativeness of the scenarios.

2.3.7 Expertise of the partners

Events were chosen close to the expertise of the participating consortium partners because of the advantage of access to relevant information (including access to internal reports, not publicly available) and presumable contacts with the incident command team that managed the event.

2.3.8 EU relevance

In order to increase the relevance of the project results to a maximum of EU countries, scenarios representative and applicable to most countries have been selected.

2.3.9 Realistic

The consensus amongst the participating consortium partners was that this was an incident type with a realistic chance of occurrence or experienced by participants as realistic (i.e. immersed in the fictive incident, with accepted chance of occurrence and evolution and fitting their experience and achievement level).

Realistic scenarios meet the aforementioned criteria of plausibility and credibility as mentioned by Walker (1995) as quality criteria independent of the purpose of the scenario.

2.3.10 Variety in time span

The time span, short versus long, was included as a criterion related to representativeness. The time factor might be an indicator of the complexity of the situation and might also influence opportunities for alternative decisions (buffer time).

2.3.11 Other aspects taken into account

Allow testing of the IET

The criterion 'the scenario should allow to test the IET' is covered by other criteria, such as the real or possible impact/the real or probable occurrence of cascading effects. It is rather a point of concern and focus for the further development of the initial cases.

Different ways to stop the event

The criterion 'show different ways to stop the course of the event, depending on which systems are involved in the evolution' does not need to be a selection criterion, since the impact of a different decision can be shown for any case, any event and will be covered by the alternative multiple timeline development (see below).

Impacted systems and dependencies

Both aspects are not mentioned as a separate criterion, they are covered though by the criteria and those related to representativeness that aim at diversity: such as the initial event, first and following order cascading effects, the type of impact and scale, etc. Systems and dependencies will also be an important aspect of the multiple timeline development.

2.4 Brief description of the selected scenarios

In this section a brief description of the scenarios is given. For each scenario the following aspects are mentioned: the facts, possible impact, interdependencies, real impact, a justification of the inclusion as a CascEff scenario. Where relevant specific aspects are commented.

The initial template (January 2015) used as the basis of this description can be found in Annex II. The complete elaboration of the scenarios with a full description of all aspects is the scope of Task 5.1.

2.4.1 Scheldt case

The facts
The Scheldt case refers to a historical event in the industrial port of Antwerp (Belgium), from July 5-9, 2013. It was reported (to the dispatching) that the verge of a road nearby Total Refinery Antwerp had begun to lift up, with suspicion that this was due to a potential problem with underground pipelines.

The initial intervention type was 'smell of gas/gas discharge'. The first intervention team on the scene were fire and rescue services personnel, with standard material: two pump engines and a commando vehicle. Upon their arrival no leak was observed, the only damage visible was at ground level. As a precaution, the police was asked to close the Scheldt lane for all traffic. Thirty minutes later, the operational coordination phase was declared in light of the potential impact and the need to engage multiple services to address the issue. One hour later, the municipal coordination phase was declared, involving the Mayor and municipal services. The analysis of the situation showed that some pipelines had been moved from their original position, which put some of them under extreme pressure (because of the torsion).Seven pipelines, belonging to five different companies were impacted, containing: natural gas, crude oil, crude C4, nitrogen, hydrogen, butadiene and liquid hydrocarbon.

Possible impact
Potential impacts identified in the worst case scenarios included: 1) possible breach of (a) pipeline(s), inducing the risk of explosion; in which case there was the risk of fire spread to four tanks at house burning distance; 2) in parallel there was the risk for three refineries nearby to be cut off supplies, which might have caused an acute shut down, with all the safety risks involved for the plant and its vicinity, as well as supply shortage for the strategic fuel reserve in Belgium.

Interdependencies
Relevant interdependencies:

- Geographical: the proximity of the tanks, the proximity of the harbour of Antwerp, traffic hinder (marine & road), because of the location at the entrance of the harbour of Antwerp;
- Functional: supply lines involving plants in the harbour of Antwerp, lack of alternative supplies;
- Logical: the availability of expertise thanks to the proximity of the harbour of Antwerp,

Real impact
The nature of the actual impact was technical, organisational, social and economic. No human or environmental impact was observed.

Comment
The Scheldt case is based on a real event. Besides media coverage, no public reports are available on the facts, evolution and analysis of the event. The description used to elaborate a scenario is based on internal reports of the incident management team involved, especially internal reports of the Antwerp Fire Rescue Services.

Justification of inclusion as CascEff scenario
The Scheldt case has been a subject for much discussion between the consortium partners due to the fact that the cascading effects were hypothetical rather than actually realised during this incident. In this case, cascading effects were avoided by incident managers making the correct decisions. Because of multiple interdependencies and several possible (parallel) evolutions, as identified in the worst case scenario analysis, the Scheldt case forms a good basis for the elaboration of a scenario with multiple alternative timelines.

Criteria compliance and detailed justification

Type of the initiating event	Man-made landslide causing damage to a pipeline bed, creating the risk of explosion because of torsion on the pipelines.
Secondary events/cascading effects	This scenarios includes possible cascading effects. A scenario with real cascading effects is developed in Task 5.1 as one of the alternative timelines.
Mix of real and fiction	This basic scenario is based on real facts. Fictional timelines, including real cascading effects are developed in Task 5.1.
Impact and Scale	This is a large scale event with possible cascading effects. Cf. the Belgian regulations, this is a large scale event because of the threat of serious impact on society and because of the need to establish a strategic coordination body, involving the competent authority[18]. The provincial phase of emergency management was declared, involving the Governor. This was done more as a precautionary measure, in case cascading effects would have occurred and more means would have been required (because of the possible geographical impact, the number of possible victims, the material and human resources possibly required to control the incident, etc.) Through the development of multiple timelines in Task 5.1, the scale will be increased by real cascading effects.
Cross border effect	No actual national cross border effects occurred in the initial scenario. Because of the proximity of the harbour of Antwerp near to the Dutch border, in case of cascading effects, the impacted systems (emergency management, industry/economy, supply, nationality of victims (workers, civilians), etc. would have been located on both sides of the border. Moreover, this type of scenario could occur anywhere (near a national border).

[18] Royal Decree on Emergency and Intervention planning, 16.02.2006, O.G. 15.03.2006

Multi agency management	Because of the threat of cascading effects, this incident immediately engaged a multi agency management with alternately operational, municipal and provincial coordination. The operational phase involves different disciplines: fire services, police, specialised services, industry; during the municipal and provincial phase, an additional level of decision is installed, with the (strategic) coordination committee.
Expertise of the partners	Several experts attached to Campus Vesta were involved at different levels of command (gold - silver - bronze). They have been involved in the elaboration of the scenario and will be involved as end user, as member of the Belgian Focus Group, to participate in the testing and/or validation of the IET.
EU relevance	Given the wide spread use of pipelines across Europe, this scenario is relevant and representative for most other countries.
Realistic	This scenario is realistic as it is based on a real incident.
Time span	The crucial phase of incident management lasted 5 days. It took several weeks to restore the normal situation.
Further develop-ment	See D1.5: alternative timelines based on changing conditions are developed.

2.4.2 Mont Blanc

The facts

The Mont Blanc tunnel fire is a historic scenario that has been further extended to include other possible fictitious events (see below). The tunnel is one of Europe's longest road tunnels, located underneath the Mont Blanc mountain in the Alps, connecting Chamonix of France and Courmayeur of Italy via European route E25. The Mont Blanc tunnel facilitates both tourism and regional trade by allowing automobiles and Heavy Goods Vehicles (HGVs) to pass through this cross-border area; it is one of the major Trans-Alpine routes for transporting freight from Italy to northern Europe. The tunnel is a single-bore, two-lane tunnel that is 11.6 kilometres long, 8.6 meters wide and 6.0 meters high, having a 50-m² cross-section.

On the morning of 24 March 1999 a Belgian HGV with a refrigerated trailer entered the tunnel from the French side. The truck had traveled several kilometers inside the tunnel when oncoming vehicles noticed the first signs of smoke coming out of the truck. The driver eventually stopped at kilometer 6.7 in the France-Italy direction and left his vehicle that eventually caught fire. The fire quickly spread to the vehicles behind the truck. It is believed that the fast growth of the fire was due to the large fuel load of the HGV, which included 550 liters of diesel in the truck's fuel tank, 9 tons of margarine, 12 tons of flour and the shell of the refrigerated trailer which was made of a combustible isothermal foam. At the time of the fire, there was a weak airflow in the Italy-France direction, forcing the smoke and flame spread mainly in the direction of the French entrance. As a result, many vehicles stopped behind the truck were trapped and caught in the fire. Fire fighters were dispatched at both ends of the tunnel in order to suppress and control the fire. However, the intense heat and smoke filled the entire tunnel section, preventing emergency rescue and firefighting operations.

Two fictional scenarios have been identified and developed (See D5.1 for the full elaborated scenario). The first concerns a tunnel fire involving dangerous goods, such as explosives, toxic substances and/or radioactive material. The second a tunnel fire located in a populated area, e.g. underground tunnel within a city.

Possible impact

The possible severe impacts of the historic Mont Blanc tunnel fire accident, as well as its extended fictitious scenarios, include the loss of dozens of human lives, evacuation of a nearby town due to toxic danger, threat of the health of the citizens, environmental pollution, billions of collective damage and closing of a major route widely used for recreation and transporting purposes for years.

Interdependencies

- International accident between France and Italy with cross-border effects;
- Complexity in the decision-making processes due to the international character of the accident since France and Italy both operate half of the tunnel;
- Two interdependent key decision points, mostly at operational level, have to be taken in relation to the ventilation and evacuation of the tunnel. Expertise and organisational skills are important;
- Quick fire escalation and smoke production that makes the conditions and route close and inside the tunnel difficult for access by the fire fighters. Alternative strategies and fast response are essential in the first minutes of the accident to avoid further escalation;
- Evacuation of the tunnel and nearby city due to toxic danger. Close collaboration of the local authorities, the police and the fire service is essential;
- The location of the accident greatly affects thousands of people who aim to use the tunnel for tourism and regional trade purposes. Closing of the tunnel for years.

Real impact

The Mont Blanc tunnel fire resulted in a fire, which burned for approximately 53 hours reaching temperatures of 1000ºC and resulted in 39 human casualties, mainly the drivers trapped in the tunnel during the fire. Most of the drivers stayed in or near their vehicles and those who tried to escape could manage to make only 100 - 500 m before collapsing due to smoke. In addition to the huge human loss, 23 HGV, 11 cars, 1 motorcycle and 2 fire engines were also destroyed, making the Mont Blanc tunnel fire one of the worst road tunnel accidents ever recorded. In addition to the impacts mentioned above, the consideration of the fictitious scenarios will further result in the evacuation of nearby towns due to fire and/or toxic danger.

Comment

The official report of the accident was used for the development of the scenario.
Reference: Task Force for Technical Investigation of the 24 March 1999 Fire in the Mont Blanc Vehicular Tunnel - Report of 30 June 1999, Minister of the Interior, and Ministry of Equipment, Transportation and Housing (France), English translation, 1999.

Justification of inclusion as CascEff scenario

The Mont Blanc tunnel fire scenario is one of the selected scenarios that is based on a historic accident with real cascading effects that had identifiable cross border effects (Italy and France). The actual impacts due to the accident were very severe and had both a short and long term effect.

The extension of the real accident to two other possible fictitious scenarios also enhances the effect of cascading effects somewhat lacking in the original events of the Mont Blanc tunnel fire scenario. This provides the possibility for different scenario developments with possible severe cascading events.

Criteria compliance and detailed justification

Type of the initiating event	Fire in a Heavy Goods Vehicle (HGV) that eventually caused fire inside the tunnel.
Secondary events/cascading effects	This scenario includes possible cascading effects. A scenario with real cascading effects is developed in Task 5.1 as one of the alternative timelines.
Mix of real and fiction	This basic scenario is based on real facts. Fictional timelines, including real cascading effects are developed in Task 5.1.
Impact and Scale	The real scale of this historic event is medium scale with possible cascading effects. Medium scale because of the involvement of the competent authorities at provincial level (France and Italy) and the actual consequences following the accident (geographical impact, material losses, number of victims, economic and social impact). Through the development of multiple timelines in Task 5.1, the fictitious scenarios will involve more cascading effects.
Cross border effect	Clear cross-border effects between France and Italy. The closing of the tunnel for 3 years had direct consequences for both countries.
Multi agency management	Because of the location of the accident, this incident engaged immediately a multi-agency management with alternately operational and regional coordination between the two countries.
Expertise of the partners	Several members of Ghent University are experts on research related to combustion, fire and fire-safety. They have been involved in the elaboration and development of the fictitious scenarios based on the Mont blanc accident.
EU relevance	Given the existence of tunnels all over Europe, this scenario is relevant and representative.
Realistic	This is a real and historic accident. The developed fictitious scenarios (presented through different timelines in Task 5.1) are based on the real accident and are realistic.
Time span	Several days.
Further development	Through the development of multiple timelines in Task 5.1, the fictitious scenarios will involve more cascading effects.

2.4.3 Festival

The facts

This fictitious scenario is based on three existing scenarios (see justification paragraph below). A Friday afternoon in September. Warm, sunny weather. People shopping in the city, sitting outside on terraces. 65.000 youngsters partying at a music festival at the south border of the city. A trial of terrorists taking place at the courthouse nearby. A ship transporting 4000 ton Ammonium nitrate (NH4 NO3 , UN 2067) navigates on the Scheldt river. The captain notices white fumes coming from the hold. He is distracted, makes a navigation error and collides with a buoy near the quay next to the music festival. The cargo apparently is on fire and the captain calls marine traffic control for help. The wind blows white fumes towards the northern corner of the festival area. The festival attendees see the white smoke coming towards them. Some people start to move towards exits while others hold ground and want to listen to the concert.

The ship’s engine is overheating and catches fire. The fire causes oil to be spilled in the hold with a risk of the fire spreading to the hold. The cooling of the cargo is not successful (temperature has reached 200° C) and the self-sustained decomposition (SSD) process can no longer be stopped. There is an immediate danger of detonation of the Ammonium Nitrate. Because of the risk of an explosion the fire brigade decides to evacuate the entire festival area and all surrounding buildings in the vicinity of 2 km of the incident.

Possible impact

Explosion of the Ammonium Nitrate ship: thousands of casualties to be expected. Tens of thousands of victims with burns, crushes and cutting wounds due to the explosion, falling debris and shattered glass from buildings and cars. Consequential fires and injuries in the immediate vicinity and damage in an area of 1km around the explosion to buildings, roads and highway.

Security issues with terrorist prisoners at court house escaping: looting and violence following the disaster due to insufficient police resources to close down such a large area. Declaration of the highest terror alert level leading to military deployment. Close down of a significant part of the city and central highway between Gent and Antwerp for a long time.

Interdependencies

- Availability of sufficient egress routes: one evacuation route will be blocked by the smoke and alternative evacuation route blocked because of immediate threat of firework explosion in the egress route;
- Availability of traditional crisis communication channels towards the public: normal festival radio & TV communications are transmitted from the festival village, which needs to be evacuated;
- Complexity of decisions requires solid organisation, expertise and adequate capacity:
    - Immediate threat (ship fire);
    - High level of coordination between emergency response agencies (ship threat and large scale evacuation), festival organizers, local and port authorities, and regional agency for ship traffic control;
    - Organisation of shelter for evacuees;
    - Crisis communications towards festival attendees (evacuees and those who need to stay/shelter), residents in the area and the media;

    - Political responsibility/reputation of the city of Antwerp and its Mayor as images of the ship with white smoke over the city and the public from the festival spread like fire over social media.
- Geography of the area: vicinity of the city and highway infrastructure;
- Capacity to evacuate and shelter 150.000+ people in a short time frame. Including evacuation of convicted terrorists at courthouse;
- Traffic control: highway and tunnel underneath the river Scheldt need to be blocked and traffic turned around;
- Dilemma for the Incident Commander: decision to let the Ammonium Nitrate ship sink (and pollute the river for years and obstruct shipping for months) or try to tow the ship away with SSD reaction on-going or risk explosion causing fatalities amongst emergency responders.

Real impact

Large scale evacuation of an open air festival. Thousands of victims with breathing problems needing treatment. Panic in crowds, media pressure.

Justification of inclusion as CascEff scenario

This scenario is a combination of three events (two incident types) with potential cascading effects, which could occur anywhere in Europe: (1) a hazmat transportation incident, (2) the evacuation of an outdoor music festival. The scenario is based on the following three events:

- The hazmat train accident in Wetteren[19] (Belgium) in 2013 resulted in the evacuation of a village with 30 victims and 1 fatality.
- The Ostedijck schip[20] carrying 6000 tons NPK fertilizer started a SSD reaction near Estaca de Barres (Spain) in 2007. This fire lasted 11 days with a high explosion risk.
- The evacuation of a music festival due to severe weather (2007 Pukkelpop[21] Hasselt, Belgium) lead to 5 fatalities and > 300 victims.

These scenarios require coordination between multiple agencies and authorities leading to complex and long decision making processes. The usage of an IET in these types of scenarios could have a significant positive impact on the decision making process leading to less casualties and societal impact.

Criteria compliance and detailed justification

Type of the initiating event	Hazmat ship transport fire.
Secondary events/cascading effects	Explosion with mass casualties within 2kms and degradation of social infrastructure (e.g. healthcare, critical infrastructure)
Mix of real and fiction	Mix between three real life incidents: hazmat train accident in Wetteren (Belgium), fertilizer ship transport accident near Estaca De Barres (Spain) and Pukkelpop music festival evacuation with casualties due to bad weather.

[19] http://deredactie.be/cm/vrtnieuws.english/News/1.1620582

[20] http://edinburghfireresearch.blogspot.be/2010/12/fertilizer-fire-aboard-cargo-ship.html

[21] http://repository.disaster20.eu/sites/default/files/Peter%20Mertens%202012%2011%2005_How%20Pukkelpop%20stimulated%20SMEM_D2.0%20Birmingham.pdf

Impact and Scale	According to the Belgian regulations[22] on emergency planning, this scenario is considered a large scale incident due to the combination of the threat of considerable impact and the need for multi-agency coordination, including the competent authority at provincial level.
	• Geographical: severe impact on rural area and marine transport within the 1km zone.
	    • Physical: several hundreds of mortalities and thousands of injured when ship explodes.
	    • Technical: destruction of critical infrastructure including telecommunications, hospital capacity, electricity, road infrastructure
	• Economic: Road transportation between NL/D and F/UK disrupted due to demolition by explosion. Operational impact on companies as workforce is impacted directly or indirectly as victims of the incident.
	• Organizational: incident requires also post-incident coordination between multiple authorities, transport sector, city planning, … Discussions on liability will impact legislation and risk planning for both public and private sectors.
	• Social: impact on local and international community due to number of fatalities, victims and international exposure of the festival. This incident might impact local and international regulations for transport of dangerous goods and the location of festival areas.

Cross border effect	Cross border effects at political level and victim care given the international public usually present at large scale music festivals.
Multi agency management	Complex decision making given the number of stakeholders involved and the political and environmental impact of the decisions. This incident requires high level of coordination between responders, competent authorities, Port Authority, Marine Rescue and Coordination Centre & festival organizers.
Expertise of the partners	SCE and involved emergency response agencies of city of Antwerp (through KCCE).
EU relevance	Festivals are organised in every country. Often next to transport infrastructure such as rivers/canals and public rail/roads, also used for hazmat transportation.
Realistic	Given prior historic incidents, the actual routes of NPK ship transport and the use of a location of a real festival this scenario is realistic. In the past 10 years in Europe a significant number of fatalities have been registered during festival and hazmat transport incidents .
Time span	Depending on cascading effects time span can range from days to months.
Further development	Through the development of multiple timelines in Task 5.1, the fictitious scenarios will involve more cascading effects.

[22] Royal Decree 16.02.2006, Emergency planning, *O.G.* 15.03.2006

2.4.4 Séchilienne

The facts

The Séchilienne scenario is not a past event but a potential scenario, which may lead to huge consequences. It concerns a potential ground movement of more than 3 million m^3 in a village named Séchilienne. It may produce the following sequence of events: landslide over a road and a river; creation of a natural dam over the river; creation of a lake behind the dam; dam rupture; flooding of the valley downstream (several villages concerned); flooding of a big chemical plant located downstream; potential industrial accidents due to the flooding.

Possible impact

The event may induce several types of impacts:

- Technical: damage on a road, then damages due to a flooding to downstream villages and a large chemical factory;
- Organisational: loss of road communication (lost access to famous skiing stations, lost access for emergency services, congestion in traffic road for tourists going to or coming back from skiing stations);
- Social: loss of work hours at the factory and for people unable to access to their work area;
- Human: there could be directly injured people due to the landslide and to the subsequent flooding itself. Then there could be injured people due to a toxic release in the chemical factory;
- Economic: economic losses due to the landslide itself (cost of removal, cost to repair the road, cost of the flooding, then economic loss for skiing stations or for impacted industries).
- Environmental: losses due to the flooding (all along the river), toxic release in air or in water.

Interdependencies

The main interdependencies concern the transportation system which may be affected by the landslide and which may, in return, affect many other systems such as access to some villages, access to major skiing stations, supply chain of several companies.

Real impact

Not relevant for this scenario.

Comment

Séchilienne landslide is presently monitored by INERIS so that we have continuous and live information about the movements going on. Moreover, an expert group has produced several reports about the intensity that the landslide may reach and which consequences it may have.

Justification of inclusion as CascEff scenario

The scenario remains a future upcoming event. It is well considered since the 1980’s, this is why it is studied and non-stop monitored. INERIS is one of the organisations in charge of controlling the stability of the mountain.

This scenario implies several types of hazards, starting from the landslide followed by a succession of potential hazards and therefore risks for the population, the economy and the environment. Indeed, the landslide is supposed to create a stone-dam in the valley closing the National road (important way towards Italy) and blocking the river stream, which will make a lake upstream. When the pressure will be too strong on the dam, it will collapse and this will generate severe floods downstream threatening industrial plants and the agglomeration of Grenoble. This complex situation will involve many stakeholders from different organisations (public and private) and will induce a multi scale commandment from municipalities until regional and even national scales.

Criteria compliance and detailed justification

Type of the initiating event	Landslide over a road and a river situated below the mountain.
Secondary events/cascading effects	This event may generate an impediment of the traffic (in both directions) on the road and a stone-jam on the river holding back an important quantity of water. The natural dam created over the river could then collapse at any time flooding the valley downstream (several municipalities are concerned); flooding a big chemical plant located downstream with potential industrial accidents due to the flooding.
Mix of real and fiction	This scenario is not real; it remains a future upcoming event with a realistic chance to occur. Fictional timelines, including real cascading effects are developed in Task 5.1.
Impact and Scale	The scenario could be considered large scale because of the involvement of many stakeholders from different organisations (public and private) and will induce a multi scale commandment from municipalities until regional and even national scales. Through the development of multiple timelines in Task 5.1, the scale could be enlarged to cross-border effects because of transportation problems and international skiing stations which may be affected.
Cross border effect	This scenario has potential cross-border effects because the impacted road is an important way towards Italy and famous skiing stations. Thus, some systems located in Italy could be affected as well as international organisations.
Multi agency management	Because of possible cascading effects, this event could engage a multi agency management with operational (industrial plant), municipal and departmental coordination at each level.
Expertise of the partners	UL is specialized in risk analysis related to ground movement as Séchilienne is. UL has been also involved in the elaboration of Séchilienne scenario and has some experience in simulating a crisis situation using iCrisis tool.
EU relevance	Many places in Europe are concerned with slope stability problems over transportation infrastructures, especially in mountainous regions.
Realistic	This scenario is not based on a real event but it has been identified as a realistic case by the group of national experts who has studied this case for the French government. Nevertheless, many works have been carried out on field to minimize the consequence of such a scenario. Therefore, it is not entirely realistic anymore.
Time span	The collapse event itself may be preceded by some days of ground movements recorded by the installed monitoring system. The collapse itself should take few minutes. Then the duration for rescue operations may take several days and recovering from several weeks to several months due to the amount of material to remove from the place.

Further development	The development of the scenario will be based on a detailed description of all systems implemented in the area concerned by the potential consequences of the Séchilienne landslide. Therefore, many potential timelines of cascading effects can be identified involving a wide scope of systems.

2.4.5 Nut warehouse blast

The facts

The Nut warehouse blast scenario is based on a real industrial fire that happened in Northampton, UK. On 26th June 2013 at 3.24, the Pre-Determined Attendance (PDA) units were sent to the scene. After a first dynamic situation assessment, a set of eight pumps were sent to the incident location. The main building of the warehouse was completely on fire. It was storing nuts from India. Due to the type of fire, the tactical approach of the incident was offensive. Shortly after, the fire brigade ran out of water. The use of a local pond as a recycling system for the contaminated water was avoided in order to preserve fish species. After the discovery that the pond was part of an old industrial complex and was built to contain polluted water in case of a spill, it was safely used as receiver of contaminated water. The fire was extinguished using slow burning techniques and the incident was closed after 3 weeks.

Possible impact

This scenario could lead to different types of impacts:

- Business and industry: direct effects on businesses and premises close to the incident; indirect effects on businesses in case of water contamination;
- Environment: large quantity of contaminated air and water spread in the environment;
- Political: bad decisions and a possible contamination of the water supply could lead to a refusal of the authority from the population;
- Water supply: contaminated water with pollutants could stop the production of fresh and drink water and consequently have an effect on the whole society.

Interdependencies

The air and the water supply contamination could be interdependent of a systematic failure of other systems that are relying on people. Following a report of Public Health England, it has been argued that the decision-making process during the emergency could have a significant impact on the recovery and restoration phase (PHE 2015).

Real impact

The initial 'cascading effect' was the water run off endangering the Koi Carp which then presented a potential reputational risk to NFRS. A critical decision was made to cease using fire fighting water to extinguish the fire and instead, take a defensive stance and allow to burn. This then presented the cascading effect of a large smoke plume travelling across the county with the potential for causing health risks to the population including vulnerable sections of the community. The smoke also caused major roads to be closed and traffic to be diverted. By ceasing fire fighting to limit danger to 'alien species' fish this caused other more serious social, political and economic effects. After approximately one day, it was identified that the real risk was not the fish but the water course being contaminated, which would affect the water supply and present serious risk to native wildlife.

The plume was limited and without any evident harm for the population. The decision to block the sewage system lead to a limited polluted area and did not involve other systems such as drink water supply. The Environment Agency had to intervene on the pond area only. The decontamination process had to proceed slowly to avoid possible negative consequences.

Comment

This was a unique incident that required public health investigation and environmental data analysis. Additionally, more knowledge of the industrial area, specifically the nearby pond designed to capture polluted water in the case of chemical spills, would have resulted in a faster resolution of the incident.

Justification of inclusion as CascEff scenario

The interesting part of this scenario is that the timeline, management and decision-making processes are crucial in the real development of the situation. A miscalculation of priorities could lead to catastrophic consequences. Another aspect that is important in this scenario is related to political consequences due to environmental pollution that could possibly affect the local population.

Criteria compliance and detailed justification

Type of the initiating event	Industrial fire.
Secondary events/cascading effects	This scenario includes a series of possible cascading events, which in reality have been successfully avoided. An environmental pollution disaster could have occurred, including contaminated drinking water, as well as considerable crises in Business and Industry and politically. This has been confirmed by an official report.
Mix of real and fiction	This scenario is based on a real event, fictional timelines are developed in Task 5.1.
Impact and Scale	The actual impact was local and rather limited. The possible impact could have been qualified as a large scale disaster, as was confirmed in an official report.
Cross border effect	There were no cross border effects. This type of scenario could occur anywhere near internal, administrative or national borders.
Multi agency management	This scenario required a multi-agency coordinated intervention.
Expertise of the partners	NFRS staff was involved in the incident command team.
EU relevance	An industrial fire with serious and realistic threat of an environmental disaster and other large scale consequences could occur in many other European countries.
Realistic	This scenario is based on a real event and thus realistic.
Time span	The whole duration of the real incident covered three weeks.
Further development	Alternative timelines including more second order effects are developed in Task 5.1.

2.4.6 Skatås wildfire

The facts

The Skatås forest is located around lakes Stora Delsön and Lilla Delsjön, east of the city of Gothenburg, on the west coast of Sweden. The two lakes and the surrounding forest are a popular destination for locals and tourists for water sports such as fishing, canoeing and kayaking, as well as hiking, running, mountain biking, picnicking and sunbathing. The lakes are a part of the potable water supply for the city of Gothenburg and act as a reservoir for the city. South of the two lakes is the Riksväg 27 highway, which runs from the city out to the airport and then east towards the city of Borås. The Riksväg 27 is an important commuter and transportation highway for the region. The initial event was a forest fire, which was started by children who were playing with fire.

The wind speed on the day (29th of April in 2008) of the incident was 15 m/s and the wind direction was SSE. The weather on the day of the incident was sunny and 15 ºC. Before the event, there had been a generally dry climate for a few weeks contributing to the low moisture content of the fuel and rapid fire spread. The initial impact was a forest fire, which spread throughout the forested area.

There is a telecommunications mast near to the location of the fires ignition. This includes a small office amongst other buildings as well as a mast which is 300m high. The mast is anchored to the ground with steel cables, which also have hydraulic dampers. Although the area around the telecommunications mast is secure, the vegetation does continue throughout the compound. The fire spread rapidly and uncontrolled to north of the telecommunications tower.

At 12.30, approximately 40 min after the first appliance arrived at the scene (11:51:36), the rescue leader went up in a police helicopter to get a better overview of the incident. Police helicopters were used throughout the incident to monitor the spread of the fire. The fire was under control on the same day. However, small fires continued to burn locally and efforts continued to extinguish them. At approximately 11:00 the following day (the 30th of April) rain started to fall, which helped with the remaining extinguishing and cooling efforts. The fire and rescue service stayed on site with their equipment until the next morning (the 1st of May). The total incident response time was 72 hours 22 minutes.

Possible impact

Possible consequences include:

- Injuries to members of the public;
- Contamination of the drinking water supply;
- Ccological damage;
- Interruption to usability of the Riksväg 27 highway;
- Damage to the Riksväg 27 highway;
- Damage to the telecommunications mast and interruption of or reduced telecommunications service;
- Evacuation of the hospital as a result of smoke spread over the urban area, interruption to provision of medical care as a result of reduced number of hospital beds and surgical theatres;
- Damage to power lines and interruption to power supply to some neighbourhoods;
- Social consequences including reduced access, delays in collecting children from day care or returning home from school or work;
- Evacuation of residential areas;

- Spread of the fire to the wildland urban interface and subsequent damage to property.

All of these possible consequences were prevented by either the actions of the fire and rescue service or the conditions (wind conditions) on the day. There was reportedly great concern for the staff of the telecommunications tower as well as the safety of the buildings around the telecommunications mast. This was because of the risk for fire to affect the cables of the mast, potentially leading to collapse. Operations to protect the cable stays for the mast were negatively affected as a result of shortages of water.

Interdependencies

The following geographical interdependencies exist in the possible chain of events and impact of the system:

- Between the forest and the telecommunications mast;
- Between the forest and the public, who may have been using the area for recreation;
- Between the forest and the hospital;
- Between the forest and the city of Gothenburg;
- Between the forest and the electrical cables buried underground;
- Between the forest and the lakes Stora Delsjön and Lilla Delsjön;
- Between the forest and the Riksväg 27 highway (or other roads).

The following physical interdependencies exist in the possible chain of events and impact of the system:

- Between the lakes Stora Delsjön, Lilla Delsjön and the city of Gothenburg;
- Between the electrical cables buried underground in the forest and the city of Gothenburg;
- Between the Riksväg 27 highway and Landvetter airport;
- Between the Riksväg 27 highway and commuter towns and cities;
- Between other roads and the community in the city of Gothenburg.

The following logical interdependencies exist in the possible chain of events and impact of the system:

- Between the power lines buried underground and infrastructure in the city of Gothenburg;
- Between the telecommunications mast and infrastructure in the city of Gothenburg.

Real impact

The actual consequences of the incident were limited. 2.88 km2 of the forested area was affected by the fire, and one fire fighter was injured. There was no interruption of services in the hospital or the telecommunications mast, however workers at the telecommunications mast were evacuated and the hospital did close external ventilation and made plans for evacuation. Personnel at the hospital began to make plans to close the hospital if needed and made a priority list of critical operations and patients that may need to be moved etc. The Prehospital Catastrophic Medical Center (PKMC) made the decision not to send patients in ambulances to this hospital.

Comment

During the calendar year of 2014, there were two wildfires with similar characteristics in Sweden, albeit with very different outcomes. These will be compared in CascEff and used for the further development of the wildfire scenario.

Justification of inclusion as CascEff scenario

Many wildfires have occurred in Europe and in the rest of the world during recent years. These fires are often very difficult to control and extinguish. This can have severe consequences for personnel safety, health, properties, infrastructure, businesses, societal services, transportation, etc.

The CascEff External Expert Advisory Board (EEAB) specifically requested that the project incorporate a wildfire scenario. The Skatås forest fire was selected as the wildfire scenario mainly for two reasons: 1) SP having good contacts with and having employed a former incident commander of the Gothenburg fire and rescue services gave good bases for describing the conditions of the incident and 2) the locations of the incident with the city of Gothenburg and important infrastructure and drinking water supply nearby give many dependencies and possible impacts.

Criteria compliance and detailed justification

Type of the initiating event	Children playing with fire.
Secondary events/cascading effects	The real incident did not result in severe cascading effects since the involved personnel managed to control the incident. However, the risk for cascading effects affected the actions and plans were taken to avoid cascading effects. This included: the tactics dependent on the avoiding run-off water to reach the lakes (fresh water reservoirs); the protection of the telecommunication mast; preparatory measures taken at and in relation to the hospital. Cascading effects are elaborated on in D5.1.
Mix of real and fiction	The scenario is based on a real incident, occurring at the same location. In the elaboration of the timelines, also the development and results of other wildfires have been taken into account.
Impact and Scale	The scale of the real incident can be considered to be medium, but the experience from the large wildfire in Västmanland in Sweden 2014 (and other wildfires around the world) show how large the consequences can be. Furthermore the proximity to Gothenburg city and to important infrastructure could have resulted in large-scale cascading effects and consequences.
Cross border effect	The real incident did not have cross border effects, but the Västmanland in Sweden 2014 had regional cross border effects, proving clear issues regarding responsibilities, decisions making, resources, etc. This is typical for wildfires where the spread can be quick, cover a large area and suddenly change both character and direction when the wind conditions change.
Multi agency management	The involved organisations were fire brigade, local police, prehospital catastrophic medical center (PKMC) ambulances, owners of the communication tower, local authorities for the Skatås natural park, and safety and security personnel from the Gothenburg municipality.
Expertise of the partners	SP having good contacts with and having employed a former incident commander of the Gothenburg fire and rescue services gave good bases for describing the conditions of the incident. SP also have personnel being involved in research project on wildfires.

EU relevance	Wildfires cause problems all over the world, so also within EU. The selection of a wildfire scenario was a specific request by the EEAB. There are also ongoing studies on the issue whether climate effects will increase the probability and severity of wildfires in the future.
Realistic	The scenario is based on a real incident. Furthermore, the development of multiple timelines is based on experiences from real incident
Time span	3 days.
Further development	The multiple timelines described in D5.1 include 1) the effects of a change in the wind direction on the real incident described above and 2) the possible consequences if a fire similar to the wildfire in Västmanland (Sweden) 2014 would have occurred in the Skatås region (again with another wind direction).

2.4.7 Black out scenario (by XVR)

The facts

The Power Blackout scenario is fictive but the potential impacts are based on real-life large power outages in Europe and North America in recent years. It is a complex cross-border scenario with an initiating event in The Netherlands and as a result a cascading event in Belgium. It's plausible, by means that the location of the initiating event (station called Kreekrak) earlier is reported as possible weak spot in the power distribution in South West Netherlands. Relevant in this cross border situation is the additional level of complexity due to the involvement of multiple competent authorities, the issue of coordination and hierarchy and the operational challenge of interoperability or (in)compatibility of means and methods.

In this particular case, a combination of winter weather and a failure of a critical component caused an outage that affects two provinces in The Netherlands and after some time four provinces in Belgium. Due to the severe winter weather, quick repairs take more time than normal, causing further escalating effects in the power distribution system and creating more challenges to deal with heating problems, the traffic, food supply etc. The failures ultimately lead to the separation of the Dutch system from the Belgium system.

Ultimately, the blackout lasted from December 28 (1630hr) until December 31 (0430hr). The first intervention team on the scene was personnel from a Dutch power infrastructure company, they failed to start up the facility. The affected Safety region started the Coordinated Regional Incident-Management Procedure (because of the circumstances GRIP 3, see further). After two hours resulting in a GRIP 5 status because the neighbor province also became affected with the outage of power supply.

Due to the affected people in the area (nearly 1 million), as well the severe weather conditions (code Red) and the alarming messages from both safety regions, the Dutch government announce the highest GRIP level (State). At 21:00, as a result from the first breakdown two 380kV-circuits to Geertruidenberg and to Zandvliet break down. The power distribution station Zandvliet, located in Belgium, comes to a halt.

Two provinces in the Netherlands are at this time affected, namely Zeeland and the western part of Noord Brabant. In Belgium, four provinces are affected at this time, namely West and

East Flanders, Flemish Brabant and Antwerp. In total approx. five million Dutch and Belgian people are affected by the black-out. A first restart of Zandvliet fails at this time. The national emergency plan for a major power outage is effective and announced by the Belgian Government.

Possible impact
A regional blackout lasting more than several days (>48hr) could be considered as a "worst case" scenario. Most back-up and security systems will fail after a longer period without electric power, leading to an almost complete failure of most critical infrastructures. Hence, the prolonged black-out, especially in combination with the severe winter weather, causes severe cascading effects in multiple systems.

Interdependencies
Relevant interdependencies:

- Geographical: cross border power outage system dependency, severe hinder at airports and marine ports in the direct area, after some time distribution stop of kerosene pipelines in the Amsterdam, Rotterdam and Antwerp area (ARA area);
- Physical: health effects due to heating problems, food and water supply after some time, healthcare organizations struggle with their operationality;
- Technical: security systems are breaking down, ATM services comes to a stop as well gas stations, telecom etc.;
- Economic: distribution and transportation of food and goods due to the weather conditions, some industries finally coming to a stop due to the blackout;
- Organizational: complexity due to the involvement of multiple competent authorities, the issue of coordination and hierarchy and the operational challenge of interoperability or (in)compatibility of means and methods;
- Social: public sector is severely affected.

Real impact
The nature of the actual impact was geographical, physical, technical, economic, organizational and social.

Comment
This fictive scenario is complex by its nature of multiple system dependencies and broad dimensions of impact.

Criteria compliance and detailed justification
The extension of this fictive scenario enhances the effect of multiple cascading effects. The potential impacts are based on real-life large power outages. Because of multiple interdependencies the scenario forms a good basis for the elaboration of a scenario with multiple timeline developments.

Criteria compliance and detailed justification

Type of the initiating event	A critical component at a power distribution station caused a power outage in the South West Netherlands.
Secondary events/cascading effects	A total blackout in several provinces in The Netherlands and Belgium occurred creating multiple cascading effects.

Mix of real and fiction	This scenario is fictive but the potential impacts are based on real-life large power outages.
Impact and Scale	This is a large scale incident with multiple cascading effects. As a power outage incident occurs with a possible impact as now described its classified by both governments as a vital infrastructure incident class A . That means there is to be expected that it has an economic impact of 50 billion euro plus and/or a decrease of ca. 5.0 % in real income and/or psychical consequences, like more than 10.000 people killed, seriously injured or chronically ill. Furthermore, social welfare problems are expected to more than 1 million people like emotional problems or serious surviving issues.
Cross border effect	This scenario has severe cross border effects.
Multi agency management	The involvement of multiple competent authorities, the issue of coordination and hierarchy and the operational challenge of interoperability or (in)compatibility of means and methods, makes it very complex.
Expertise of the partners	Several members of XVR Simulation are experts related to crises- and disaster issues. One is also a former incident commander and has a master degree in this field.
EU relevance	Given the magnitude and dimensions this scenario and the fact that this could occur in most European countries, this scenario is relevant and representative.
Realistic	This scenario is based on former real incidents with similar dimensions of impact. Complexity is of a higher level because of multiple agencies in different countries who has to deal with the incident.
Time span	The crucial phase of incident management took 60 hours. For some aspects, it took several weeks to restore the normal situation.
Further development	Multiple timelines are being developed in Task 5.1. In order to use this scenario for testing, a discussion is needed at what deeper level we have to describe the affected systems and the following dependencies.

2.5 Representativity of the scenarios

The following table gives an overview of the compliance of the selected scenarios with the final selection criteria, and shows the representativity of the whole scenario set

Table 3 Criteria compliance by scenario

Criteria	Scheldt case	Mont blanc	Festival	Séchilienne	Nut ware-house blast	SkatåS wildfire	Black out
Nature of Initiating event[23]	Man-made Land-slide	Tunnel fire	Ship Fire	Landslide	Industrial fire	Wildfire	Critical component failure at a power distribution station
Type of initiating event	Accidental	Accidental	Accidental	Natural hazard	Accidental	Accidental	Accidental
Secondary events: first order cascading effect	Risk of explosion	Risk for a mega-fire	Risk of explosion	River flow and road transportation interruption	Environmental disaster and public health risks	Risk for polluting drinking-water reservoir; smoke affecting the city (especially hospital); risk for telecommunication; nearby infrastructure (highway, airport)	Power outage followed by a total black out
Secondary events: other cascading effects (second, third … order)	Other explosions (Occupational) Safety risks	(Occupational) Health risks	Health & Safety risks Traffic impediment Socio-economical	Flooding (2nd), Pollution (3rd), Industrial accident (3rd), Toxic release (4st), … + many people and goods transportation	Contamination of water supply Business and Industry Political and (psycho-) social impact	Risk for affecting municipal services as water supply, healthcare. Risk for effects on transportation and communication in the	Geographical area and number of people affected, cross border and cross system impact, socio-demographic impact

[23] WP2 Terminology

				problems all-over the area leading to disruption in education, economical activities, etc…		region	
Real/ fictional	Real event	Real event	Fictional, combination of 3 real events	Fictional but based on real data	Real event	Real event, with risks for cascading effects based on both real and fictional events.	Fictional but potential
Large scale impact	Geographical, Industrial, Economic, Social	Geographical Economic, Social	Geographical Economic, (psycho-)Social	Geographical, Industrial, Economic, Social	Environmental, Industrial, Economic, Social, Health	Geographical Technical Economic Social	Geographical Physical Technical Economic Organisational Social
Cross border effects	NL-BE	FR-IT	Any border	Internal borders	Internal borders	Internal borders	NL-BE
Multi/Single Agency	Multi	Multi	Multi	Multi	Multi	Multi	Single
Expertise of the partners	Campus Vesta BE	Ghent University BE	SCE, KCCE BE	UL and INERIS FR	NFRS UK	SP SE	XVR Simulation NL
EU Relevance	Every country	Every country	Every country	Every country	Most countries	Most countries	Every country
Time span	5 days – several weeks	several days /weeks	2 days- several months	1 week minimum	Several weeks	3 days	60 hours – several weeks
Realistic	✓	✓	✓	✓	✓	✓	✓

3 Methodological basis for the elaboration of test scenarios

3.1 Methodological approach

The aim of this section is to provide methodological guidance for the elaboration of the scenarios. Chronologic steps and recommended methodological aspects have been identified from a combination of national practices, previous CascEff Tasks and Deliverables, literature and discussions amongst the partners. Aspects that were considered relevant are those that match the purpose of this methodology, which is to test the intermediate[24] Incident Evolution Tool.

The guidance developed hereafter relates to the following items:

1. A methodology for the definition of evaluation criteria for testing cf. the objectives of Task 5.2;
2. Guidance to be used for the further elaboration of the scenarios in Task 5.1 and the organisation of the tests in Task 5.2;
3. Possible starting points for the development of multiple alternative timelines in Task 5.1.

3.2 Testing objectives and evaluation criteria for testing

3.2.1 Definition of testing objectives and evaluation criteria

The objective of the testing in Task 5.2 is to evaluate the IET and its underlying methodology, at the stage of development mid 2016 (timing Task 5.2). The overall objective can be split up in two concrete sub objectives:

1. Testing the functionality of the IET: does it work, does it function properly?
2. Testing the intrinsic value of the IET: does it match the expectation to support improved incident management?

Criteria are needed to evaluate during the tests whether these two objectives are met. The evaluation and feedback of the tests will be an important input for the further development of the IET, which is to be done in Task 4.2.

Inspiration for those criteria can be found in Deliverable 4.3 'Initial Structure for implementation of the IET', which defines the basic architecture for the IET. As part thereof, Deliverable 4.3 lists a series of user requirements related to functional, non-functional and technical aspects. The actual list of D4.3 user requirements, as included in Annex III, is a provisional list with *possible* user requirements. It can thus not be used as such, it provides a mere basis.

[24] IET version available at the time of the tests in the course of 2016

In the following months this list will be subject for discussion in order to select the final IET user requirements. They will constitute the design criteria for the further development of the IET. This will be done in three steps:

- Discussion amongst the consortium partners and adoption of a list of specific, appropriate requirements;
- Feedback from the EEAB;
- Adoption by the consortium partners of the final list.

The definitive selection and adoption will probably be finalized shortly before the first test sessions are held.

An intermediate step might be considered in case the final list of user requirements is still long. For reasons of efficiency, successful testing does not necessarily requires validation of every single characteristic of the IET, it might be more efficient to extract from the complete list a set of high level representative and not-overlapping evaluation criteria (i.e. high level user requirements).

The criteria are then scored by each observer and each test participant individually on a ++, +, -, -- scale, forming so called individual Harris profiles (New Product Profile Chart, Harris, 1961; Roozenburg and Eekels,1998). All evaluators can also define specific fixes needed, which are to be prioritized according to the software development MoSCoW method, i.e. distinguishing between Must have, Should have, Could have, Would like to have or Won't have this time) (DSN Atern Handbook) These individual scorings are stored for later statistical evaluation.

Table 4 User requirement evaluation example

Input from user requirements	⇨ **Evaluation criteria for observation**				
		++	**+**	**-**	**--**
F1[25] Support emergency planning and response	EC1[26]: IET supports emergency planning – opinion of the participants EC2: IET supports incident response - opinion of the participants				

In a group session following the individual scoring, the criteria and everyone's scores are discussed and combined into a joint Harris profile per group. Also possible fixes can be discussed and further detailed, re-prioritized or discarded. It is advised to consider different groups for test-participants and observers/evaluators, since both will have experienced the incident and test differently and may have different backgrounds.

[25] Functional requirement 1
[26] Evaluation criterion 1

A second more thorough evaluation is to be done by a small committee of Consortium Partners on these individual and joint Harris profiles and suggested fixes and other observations made:

- **Step 1: statistical qualitative evaluation** of individual scoring on criteria (% of participants fully agree, % agree, % disagree, % fully disagree) and compare this with the joint profiles made later. Discuss possible differences.
- **Step 2: A weighted evaluation** by giving the criteria weights, i.e. most important characteristic have a higher weight; and setting a minimal overall score and a minimum per criteria. Comparing the scoring values with the minima set gives an overall pass/fail and a pass/fail per high-level user requirements. A sensitivity analysis is to be made on the weighted criteria method (i.e. changing the weights ±20% - ±50%) to exclude overly powerful criteria and reviewing statistical relevance.
- **Step 3: Review of the full list** of D4.3 user requirements to retrieve any missing fixes needed and (re-)prioritize the complete list of (suggested) fixes following the MoSCoW method. The review should also consider impact of the implementation of the requirements on project budget and time when evaluating the final selection of the user requirements for the IET.

This evaluation methodology is a combination of the well accepted MoSCoW prioritization method (DSN Atern Handbook), trade-off methodologies as described in product development literature (Roozenburg and Eekels, 1998) and systems engineering methodologies (INCOSE, 2012).

The evaluation of the IET will be done by a combination of observations made during running the test-scenarios and by feedback from the test participants. As a result, input for the further development of the final IET will include:

- Satisfying characteristics;
- Aspects needing improvement;
- Characteristics that might not satisfy at all and need redesign;
- Missing aspects that need to be covered.

The last three categories will form the basis for an action plan for improvement (see also below, as part of the testing methodology).

3.2.2 Analysing objectives and evaluation criteria for testing

The testing objectives can be summarized as follows:

1. Testing the functionality of the IET: does it work, does it function properly?
2. Testing the intrinsic value of the IET: does it match the expectation to support improved incident management?

The methodological steps to define the evaluation criteria for testing can be summarized as follows:

- Final selection of the user requirements for the IET (scope Task 4.3)
    - Discussed and decided by all partners involved;
    - Feedback from the EEAB;
    - Final adoption by all the partners involved.

- Selection of representative[27] (high profile) user requirements as evaluation criteria for the testing in Task 5.2. (scope of Task 5.2):
    - Selection of the criteria;
    - Scoring of the criteria;
    - Use of the criteria during the tests in Task 5.2.
- Feedback of the test results will provide input for Task 4.2, for the further development of the final IET.

3.3 Guidance for scenario writing (Task 5.1) and test plan (Task 5.2)

3.3.1 Clarification on the approach

Guidelines for the elaboration of the scenarios and the organisation of tests for validation are dealt with together in this subtask, because of their obvious relation, as the main purpose for the scenarios in this project is their use for testing.

In general, exercises, tests, simulations and similar activities include scenarios as an important part of the test plan. Inspiration to develop guidance for the CascEff project has therefore been gathered from sources that relate to optimal scenario writing as well to successful crisis management tests and exercises. From the comparison of these guidelines and recommendations and their evaluation in the light of our purpose - testing the IET – relevant aspects are bundled and put into perspective in the basic guidelines provided in the following paragraphs.

Although there are numerous variations on how to conduct a scenario-based exercise or test, comparison quickly shows that there are a lot of variations on the same theme. That is, all have a certain number of key elements in common. The differences mostly relate to the specific purpose of the guidelines, methodology or manual:

- Scenario writing for scenarios used for *training* purposes, where the focus is on testing the knowledge of the participants (as covered by E. Borglund and L-M Öberg (2015));
- Scenario writing for scenarios used for *testing* new technology, equipment, etc., where the focus is on the technical aspect, the functioning of the tested technology or equipment as well as on process related aspects, such as the contribution to incident management decision making, operations or other aspects (as covered by J. Lundberg, R. Granlund and A. Fredäng (2012)) ;
- Guidelines for a performant exercise *program*, which scope is much broader than managing a single exercise activity or project and includes more structural long term aspects such as support from the general direction and management, steering committee or other body, a feedback loop for continuous improvement for more efficient and effective organisation of exercises, etc. (as covered by ISO 22398 ; Campus Vesta Roadmap for multidisciplinary exercises ; HSEEP/FEMA Exercise Methodology, Exercise Methodology Province of Antwerp ; e-Semble Guidelines[28] - Norel, 2010, Van Campen, 2015).

[27] Representative = not the whole list but a selection of criteria that allow to evaluate the effectiveness and efficiency of the IET developed so far

[28] based on the national Education, Training and Exercise guidelines of the IFV, formerly known as the NIFV (NIFV, 2008 and 2009) and a research report by TNO (Van Berlo, 1999)

None of the methodologies, guidelines or manuals reviewed by the consortium could be used as such due to the very specific objectives and context for the scenarios in the CascEff project. As discussed above, a combination of relevant aspects was made, combining generic aspects, common to all sources, and only those specific aspects that are relevant in the context of the specific purpose of this project, which is not to develop a overall methodology for performant exercises but a methodology for the elaboration of CascEff scenarios to be used in exercises to test the intermediate version of IET.

As represented in the following figures, the context determining the scope and purpose of the scenario is not the exercise program management but the CascEff project. Input for scenario and exercise design comes from the CascEff objectives and feedback and lessons learnt from the exercises should in return benefit ongoing and subsequent CascEff Tasks. CascEff evaluators and observers ensure the link.

HSEEP/FEMA Exercice cycle **CascEff variant of the cycle**

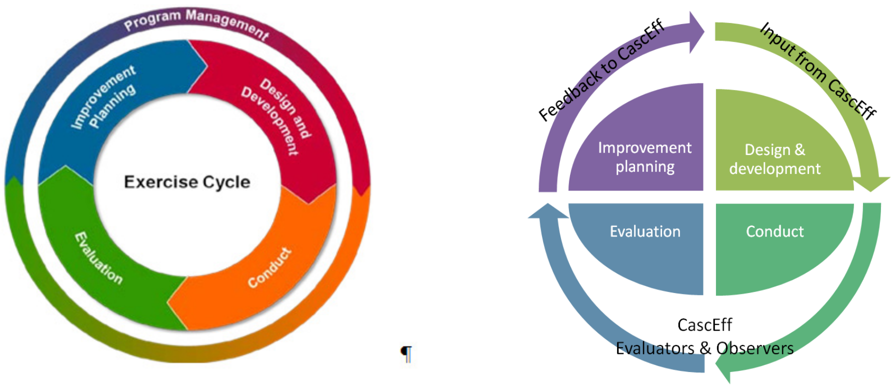

Figure 3 The HSEEP/FEMA and CascEff Exercise cycles

3.3.2 Scenario writing

Wilson and Ralston (2006) provide a comprehensive and detailed process for developing and using scenarios. This involves eighteen steps (see table 5 below). Each step in this process is a critical point of adding value and exposing mental models and assumptions during the scenario project. These 18 steps are divided in four general phases of scenario planning, namely, (a) "*getting started, (b) laying the environmental analysis foundation, (c) creating the scenarios, and (d) moving from scenarios to a decision*".

- Steps 1-6 are related to starting up the scenario project, and these steps are meant to define the scope of the project and assemble the scenario project team;
- Steps 7-10 are concerned with exploring the internal and external environments and putting these together in a cohesive picture;
- Steps 11-14 focus on developing the scenarios themselves, based on all of the work done in the previous steps;
- The final phase includes steps 15-18, they cover the use of the scenarios to examine current strategies and decisions.

Wilson and Ralston provide a detailed roadmap through each of these steps with specific instructions and practitioner tips.

Table 5 Step-by-Step Approach to developing and using scenarios
(Wilson and Ralston, 2006, p.25)

Step 1: Develop the case for scenarios Step 2: Gain executive understanding, support and participation Step 3: Define the decision focus Step 4: Design the process Step 5: Select the facilitator Step 6: Form the scenario team Step 7: Gather available data, views and projections Step 9: Identify the critical forces and drivers	Step 10: Conduct focused research on key issues, forces and drivers Step 11: Assess the importance and uncertainty of forces and drivers Step 12: Identify key "axes of uncertainty" Step 13: Select scenario logics to cover the "envelope of uncertainty" Step 14: Write the story lines for the scenarios Step 15: Rehearse the future with scenarios Step 16: Get to the decision recommendations Step 17: Identify signposts to monitor Step 18: Communicate the results to the organization

Wilson and Ralstons' roadmap only focuses on one of the two aspects this task wants to cover, namely optimal scenario writing. Their context and discipline are also different, in the sense that they aim at a conceptual model for elaborating scenarios as a strategic management tool to anticipate future evolutions, rather than decision making based on forecasting. Even if the starting point and angle are different, their roadmap is relevant for incident management scenarios, as shown by Moats et al (2008) who picked up this step by step plan for crisis management training.

From their guidelines and all others covered by the comparative analysis, the elaboration of scenarios is situated somewhere in the middle of the test plan. As a consequence, several steps recommended by Wilson and Ralston become irrelevant in the roadmap for the elaboration of scenarios, since these steps and corresponding aspects are defined as part of the test plan, this is, as part of the preparation and planning of the exercise. Again, there interrelation is shown.

The main steps in scenario writing can be summarized by analogy with Wessberg (VTT User Manual):

1. **Scoping the scenario field**: definition of the purpose, identification of problems to be addressed, focus of the scenario, theme, etc.;
2. **Identification of key factors**, such as key decision factors, drivers and barriers;
3. **Analyzing key factors and their dependencies**: ranking the driving forces on the basis of their significance and degree of uncertainty and identifying logics to deal with uncertainty;
4. **Scenario script generation**: writing the story line as a coherent and realistic scenario;
5. **Scenario transfer to paths**: linking the scenario to the initial purpose and communicate to the parties involved.

Besides chronological steps, the following areas of attention for scenario writing were identified from literature:

- Create scenarios that are **trustworthy and plausible** (E. Borglund and L-M Öberg, 2015);
- **Participatory process**: involve both the actors/players and the exercise organisation team in the writing process of the scenario (E. Borglund and L-M Öberg, 2015);

- **Goal-orientation**: the goal of the activity where the scenario is used for, should be constantly beared in mind (E. Borglund and L-M Öberg, 2015), e.g. to determine the level of complexity (do not make it more complex than necessary to obtain the goal);
- **National differences**: if several countries are involved, national differences related to incident management should be taken into account in the scenario script (E. Borglund and L-M Öberg, 2015).

The main axes of scenario writing related to content, as identified in literature are:

- Selection of a **theme** and corresponding **events in a Major Event List**;
- Selection of **incidents**;
- Selection of **actions**;
- Identification of the **roles and functions** of the participants.

Although further development is required and planned in Task 5.1, these 4 axes are already available or being prepared for the CascEff scenarios:

- The **theme** and corresponding events have been selected, discussed and refined from the start of the CascEff project in a participatory process, in collaboration between the consortium partners and the EEAB. Seven scenarios have been selected, as commented in detail in Chapter 2.
- The selection of **incidents** is partly based on the real facts for those scenarios that are based on real events and will partly be further developed in the multiple alternative timelines in Task 5.1.
- The selection of **actions** in the CascEff scenarios is based on the multiple timeline development and on the use cases as described in D4.3. cf. the wording of D4.3. "*use cases are made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal*". The D4.3 use cases have been developed for four distinct phases in Incident management: Planning, Preparation, Response, Recovery. They describe in detail all actions performed by a specific actor/function in a specific setting.
- **Relevant roles and functions**, specifically concerned by the IET, have also been previously identified, in D1.3. More detailed information about these roles is given in section 3.3.4.2 below.

3.3.3 Exercise methodology

As the aforementioned Figure 3 of the HSEEP/FEMA exercise cycle shows, most methodologies distinguish 4 exercise process phases :

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

Hereafter a short description is given of the consecutive steps in each phase, complemented with specific CascEff input already available. Needs for further development in Task 5.1 and Task 5.2 are listed.

I. Design and development

The design and development phase includes :

- Identify the exercise **goal** (training, testing/validation, etc.) ;
- Set **SMART**[29] **exercise objectives** and define corresponding **performance/evaluation criteria;**
- Appoint the **Exercise director** and an **Exercise project team** (coordinator, operators, evaluators);
- Develop the **exercise scenario** and **prepare all content** e.g. build the scenario in XVR and/or iCrisis (see above : theme, incidents, actions, target group participants);
- Create **exercise documentation** (test script for the key actors, evaluation template for the evaluators, etc);
- Define the **type of activity** : test, simulation, discussion-based or operations-based exercise, etc. and prepare for a **test plan/exercise script** accordingly (cf. NIFV template). Elaborate the test plan in parallel to the course of actions in the scenario:
    - Choice of location;
    - Appropriate infrastructure;
    - Required staff (exercise operators the day of the exercise, key actors and supporting actors, etc.);
    - Preparation of the required resources and logistic plan;
    - Catering;
    - Etc.
- Establish a **communication strategy.**

CascEff input and needs for Design and development:

- The goal is determined by the aim of Task 5.2 : testing the IET;
- The objectives are twofold:
    - Testing the functioning of the IET;
    - Testing the intrinsic value of the IET, evaluation of the contribution of the IET for improved incident management;
- These objectives need to be made SMART;
- Evaluation criteria will be defined cf. the methodology aforementioned, in 3.2.2;
- The exercise director and project team will be appointed in Task 5.2;
- Scenarios are elaborated in Task 5.1;
- Exercise documentation needs to be elaborated in Task 5.2;
- The preparation of a test plan and communication strategy will be done in Task 5.2, including the decision on the type of activity. Preparation of the location, logistic needs, required resources etc. will follow from the definitive scenarios. The preparation and planning will be done in Task 5.2 for each scenario individually.

II. Conduct

The Conduct phase consists of:

- **Start up briefing** by the exercise coordinator: briefing of the exercise operators, key actors and supporting actors and distribution of documents;
- **Roll out** of the test script and scenario;
- Termination of the exercise.

[29] **S**pecific (and Simple), **M**easurable, **A**chievable (and Accountable), **R**elevant (and Realistic), **T**ime-bound (and Task-oriented)

CascEff needs for Conduct:
All aspects related to Conduct need to be prepared in Task 5.2.

III. Evaluation

The Evaluation phase consists of:

- **Post exercise debriefing**: feedback from the evaluators is gathered, shared and discussed in one or more debriefing sessions;
- **Consultation of stakeholders**: results of the debriefing can be shared with stakeholders.

CascEff input and needs for Evaluation:
A methodology for evaluation (based on scoring of the evaluation criteria) has been developed in 3.2.1. Preparation for the briefing, concrete roll out and debriefing will be done in Task 5.2. Relevant stakeholders in the CascEff project are other consortium partners than those involved in Task 5.1 and 5.2 and the EEAB.

IV. Improvement Action Plan

The last phase collects relevant information and prepares the follow up.

- Improvement action plan: lessons learnt from the exercise need to be the subject of an action plan with actions, guidelines and/or recommendations for improvement.

CascEff needs for Improvement Action Plan:
The CascEff Improvement Action plan will be part of Task 5.2 to make sure that lessons learnt are put forward to Task 4.2 for the final development of the IET.

3.3.4 Roles: exercise roles and scenario roles

Most methodologies list a number of roles and define their responsibilities. It is often a mix of functions responsible for the organisation of the exercise and functions, playing a role in the scenario as participants. In this report, a formal distinction is made between those two categories, because the exercises roles are more generic, applicable to all exercises, independent of the scenario, whereas the scenario roles are specific and can be made concrete for CascEff, based on input from D 1.3.

3.3.4.1 Exercise roles

The following generic exercise roles were identified:

Table 6 Exercise Roles and Responsibilities

Role	Responsibility
Exercise director or manager	Has the overall responsibility for all aspects related to the organisation of the exercise. Has a clear mandate to do so. Manages and supervises the exercise team and the whole process.
Exercise (project) team	Depending on the complexity of the exercise, recurrent functions in the exercise team are: the exercise coordinator, operators, facilitators, evaluators, observers, (safety) controllers, etc.
Exercise coordinator	The person responsible for the concrete planning, conducting and evaluating exercise activities and for the cooperation between internal and external entities.
Evaluator(s)	Persons who observe and evaluate the exercise without taking an active part in it. They are chosen for their specific expertise related to the theme and the goals of the exercise. They use evaluation documents or templates to document their observations and feedback.
Observer(s)	Have a similar but more narrow role than evaluators. Their task is to observe and share their observations, without interpretation or evaluation.
(Lead evaluator)	(If there are many evaluators, assigned for specific aspects of the exercise, a lead evaluator can be appointed. He is in charge of collecting all the feedback and their integration into a global evaluation.)
Exercise Operators	Operators are in charge of operational aspects of the organisation of the exercise. They play an important role in the logistic preparation of the exercise.
Safety controller	The person in charge of occupational safety and health matters, the day of the exercise and in the preparation phase.

The distribution and assignment of these roles in the CascEff project belongs to the scope of Task 5.2.

3.3.4.2 Scenario roles

Scenario roles are different from the exercise roles in that they do not actively participate in the organisation of the exercise.

Table 7 Scenario Roles and Responsibilities

Role	Responsibilities
Participants	Persons who participate actively in the exercise as players in the scenario. They can be key actor or supporting actor.
Key actors	Persons playing an active role in the prevention, response and/or recovery actions presented in the scenario. They initiate actions and by doing so determine the actual course of actions the day of the exercise. They participate in Discussion-based as well Operation-based exercises.
Supporting actors	Mostly volunteers, simulating a specific role in Operation-based exercises and contribute to a realistic scenario (victims, neighbours, people passing by, etc.).

In order to determine the required scenario roles and their appropriate profile, for each of the selected CascEff scenarios, the decision will have to be made whether to organise a Discussion-based or Operation-based exercise (or combination of both for separate alternative timelines).

- Discussion-based (or functional or Command post or Table Top) exercises are single or multi-agency activities designed to evaluate capabilities and multiple functions using a simulated response (simulated deployment of resources and staff);
- Operation-based or full scale exercises are single agency or multi-agency/multi-jurisdictional activities involving actual deployment of resources in a coordinated response, as if the real incident had occurred (mobilization of units, personnel and equipment in a realistic environment).

Generic CascEff roles have already been defined in D1.3., as shown in the following table.

Table 8 Roles in Incident Management

Role	Description
Risk Owner	The party that creates the risk, e.g. industry, festival organizer, building owner. In case there is no private risk owner the Competent Authority is the risk owner: e.g. municipality or province for natural reserves, county for rivers, etc.
Licensing Authority	Government body in charge of providing the Risk owner a license (environmental permit, building permit, license to operate, etc.).
Competent Authority	Authority liable from a legal perspective.
Incident Response Team (Rescue Services)	All public agencies involved in incident response: fire rescue services, police, healthcare department, civil defence, etc.
Emergency Planning Services	Organization(s) in charge of developing external emergency plans for the authorities and Rescue Services
IET Trainer	Internal or external learning provider.

3.3.4.3 Further development

Timing

Besides the action points mentioned in the above description, two specific aspects needs to be considered from the start:

- A comprehensive and concrete timing, indicating specific milestones and deadlines throughout the whole process.

  At least 2 planning conference types should be scheduled for all exercises:

  - **Concepts and Objectives Conference** to define schedule and location for all exercises and exercise project team, type, scope, scenarios and objectives per exercise;
  - **Mid-Term Planning Conference** to evaluate progress of the individual exercises and resolve any issues that might be raised by an individual exercise project team.

  Per individual exercise, timing and planning need to include:

  - **Initial Planning Conferences** to settle any logistical or organizational issues and perform site walk down (only for operations-based exercise);
  - **Master scenario Event List conference** for the scenario developers to align injects for exercise conduct;
  - **Final Planning Conference.**

  .

- **Documentation needs to be prepared in advance. Minimum documents are:**
  - Master Exercise Document including exercise goals and objectives, Exercise Project Team composition, Exercise Plan, Logistics and budgets;
  - A to do list;
  - A test plan, including Major Event list (Task 5.2);
  - A communication plan (Task 5.2);
  - Instructions for key actors and supporting actors (Task 5.2);
  - Exercise Evaluation template (Task 5.2);
  - Safety instructions, related to the location and specific for the exercise (Task 5.2);
  - After Action Report templates (Task 5.2);
  - Improvement Action Plan templates (Task 5.2).

3.4 Multiple timeline development

An important part of the elaboration of scenarios consists of the development of multiple timelines in order to test the IET. This requires to add fictional information to the initial cases, showing possible alternative impact of different factors on the evolution of the event and the management thereof.

This is specific to the CascEff project and therefore no methodological input can be found in existing literature and practices. Several previous CascEff Deliverables show the following possible triggers or starting points for alternative evolutions, either originators or dependencies:

- **Alternative decisions** by the incident command team, as shown in the D1.3. flowcharts because they indicate crucial decision points, including points where the IET supports the decision making;
- **Contextual, external factors** that influence the event: changing circumstances, changing conditions, new factors of physical, human, political, nature etc.;
- **Impacted systems and their interdependencies**
- Use of **buffer time.**

In this report, for the sake of completeness in providing an overall methodological report we only mention the categories of aspects at this stage identified as possible originators or dependencies offering an opportunity for the identification and elaboration of alternative evolutions. Without developing each of these possible starting points – this is the scope of Task 5.1 – some clarification on each category is given in the following paragraphs.

3.4.1 Alternative decisions based on the flowcharts

The D1.3. Flowcharts not only indicate the flow of consecutive steps, they also indicate where the IET contributes to the incident management process. In order to test both the functionality and intrinsic value of the IET, comparing alternative decisions, taken with or without the use of the IET, might provide useful lessons.

Risk Assessment

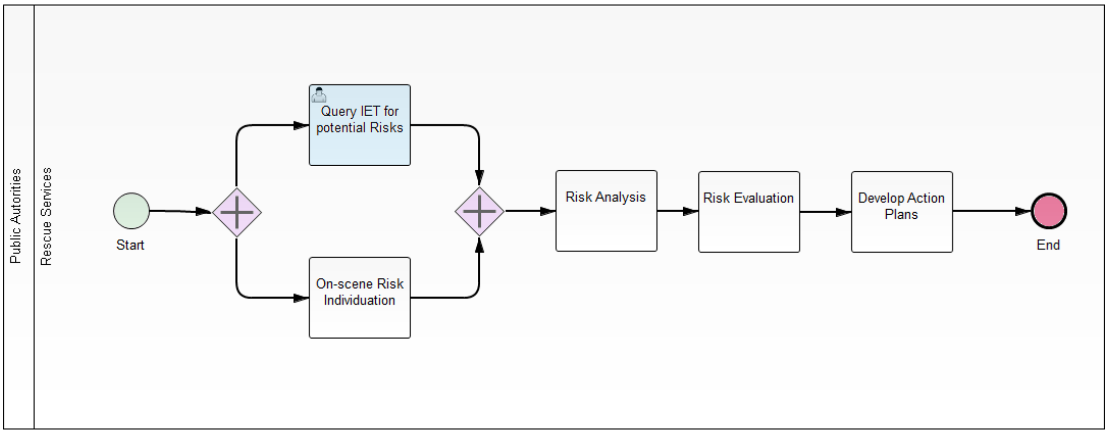

Figure 4 Risk Assessment flowchart

Description of Risk Assessment:

- Rescue services perform risk assessments by carrying out two fundamental operations:
    - On scene risk evaluation;
    - Query the IET for potential risks of cascading effects;
- After individuating the contingent risks, rescue services execute risk analysis, evaluation and the development of an action plan.

Situational Awareness

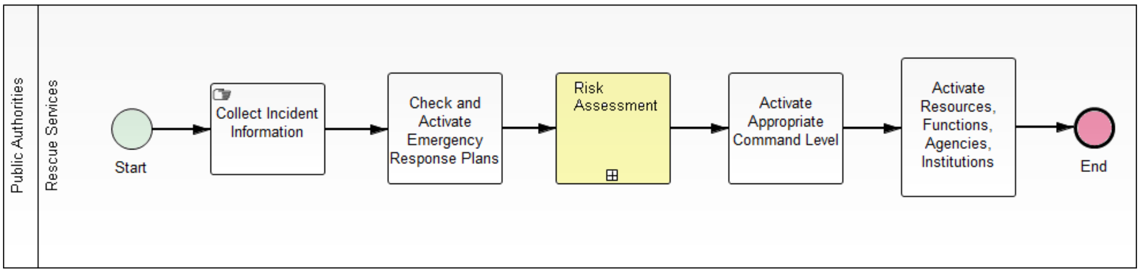

Figure 5 Situational Awareness flowchart

Description of Situational Awareness:

- Emergency services perform an initial situation awareness, collecting information and checking and activate emergency response plans and procedures;
- They successively perform a risk assessment;
- After having a clear operational picture, the appropriate level of command has to be activated;
- Resources, functions, agencies and institutions can be activated following the procedures established in the emergency response plans.

Joint decision-making

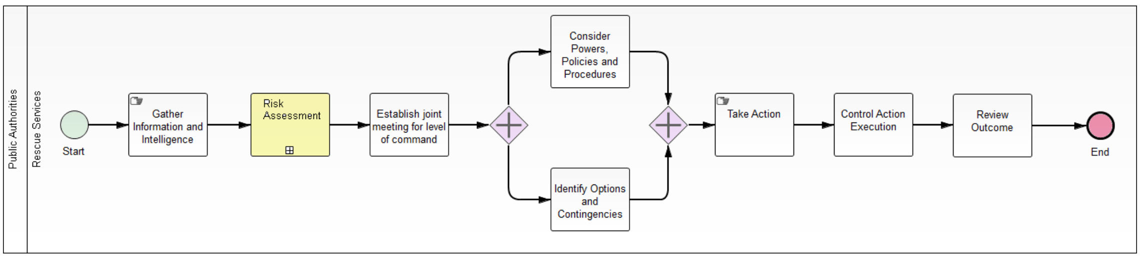

Figure 6 Joint decision-making flowchart

Description of Joint decision-making:

- Emergency services need to acquire continuously updated information;
- They now perform a dynamic risk assessment;
- After having an updated common operational picture, they convene for a joint meeting at the right command level:
    - To make a decision, emergency services need to consider powers, policies and procedures;
    - and identify options and contingencies.
- When this decisional process is done, emergency services can take action, control the execution and review the outcomes of the decisions made.

3.4.2 Contextual, external factors

Alternative timelines for testing the IET can also be developed based on different contextual factors, such as the categories describing dependency conditions as identified in Task 2.1. (CascEff D2.1)

Table 9 Categories describing dependency conditions

Categories	Description/example of possible values
Weather conditions	Cold, Warm, Rain, Snow, Windy
Timing	Time of year, Time of week, Time of day
Type of location	Urban, Rural, Metropolitan, Coast
Initial event type	Natural Accidental, Intentional
Operational state	Above normal capacity, Reduced capacity

Any change in those conditions will affect the event and can thus be a starting point for a new alternative timeline. Examples include:

- Changing weather conditions from dry to rain;
- Incident takes place August 30, (in some EU countries) a holiday period, September 1, school starts with more traffic, presence of children to take into account, etc.;
- The incident starts in urban areas and due to evacuation spreads to rural surroundings;
- The event starts as a natural event, and is exploited intentionally.

3.4.3 Interdependencies and impacted systems

As mentioned before (in the Mont Blanc case), interesting cases can be made more interesting by adding extra affected systems to the scenario. This is also a way to increase the representativeness of the scenarios, by paying attention that a variety of impacted systems and interdependencies is covered by all scenarios.

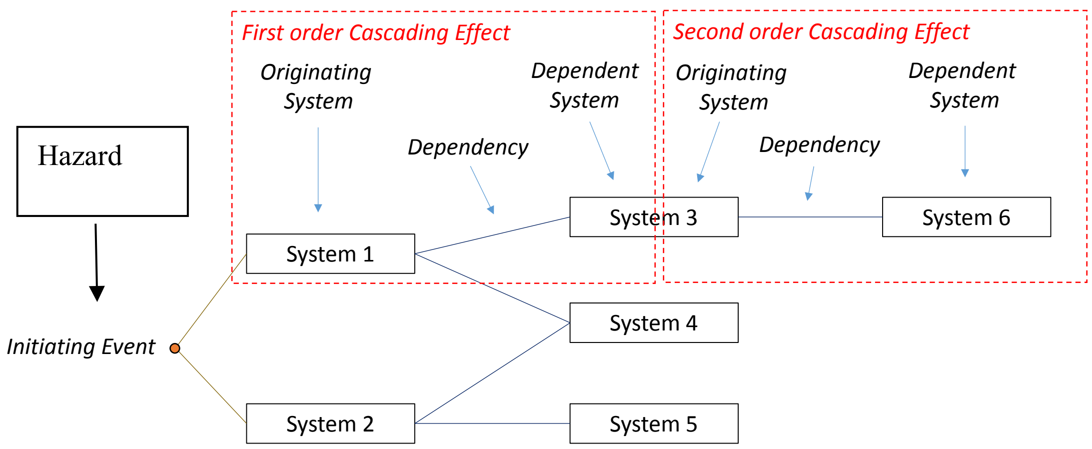

Figure 7 Conceptual model of the propagation of effects between systems in an incident with cascading effects

A list of potentially affected systems was previously developed in Task 2.1. (D2.1).

Categories	N.	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

3.4.4 Buffer time

"Buffer time" is defined as *"the time between the start of the incident management of the initiating event (in the originating system) and the time before a cascading effect occurs in a dependent system"*. This is an instrumental definition, based on the notion of a "buffer" in project and risk management[1] (Yeomans, 2011) and the notion of "Time delay", referred to in D2.3 as "*the time between when a system is affected and when either the system it depends upon is firstly affected or the start of the initiating event*".

By weighing the buffer time against the time necessary to implement certain mitigation strategies, buffer time will guide the incident commander in determining priorities amongst alternative decisions. Buffer time will not be a standalone starting point for alternative evolutions, but needs to be considered jointly with the previously mentioned categories of originators and dependencies.

4 Conclusions and recommendations

Because of the interrelation between several CascEff Task, in particular between Task 1.4 and Task 4.3, Task 5.1 and Task 5.2, the initial scope of this report was extended from the identification of basic and representative originators leading to scenarios with cascading effects to a more global methodological report on all relevant aspects of writing scenarios for the purpose of testing the IET and its underlying methodology.

4.1 General findings and conclusions

Without developing in detail all specific aspects of relevance, a basic, nevertheless coherent, methodological guidance has been developed, covering:

1) The choice of representative scenarios, based on selection criteria;
2) Methodological steps to identify evaluation criteria for testing;
3) Basic guidance on the elaboration of the scenarios as part of the test plan;
4) Identification of starting points for multiple timeline development.

All aspects developed in this report built further on the results of previous and ongoing CascEff tasks and will serve in turn as the basis for further development in other tasks.

Seven scenarios have been selected that comply with the selection criteria as defined in this report. The selection criteria are:

- Type of the initiating (originating) event
- Secondary events/cascading effects
- Mix of real and fiction
- Impact and Scale
- Cross border effects
- Multi versus single agency management
- Expertise of the partners
- EU relevance
- Realistic
- Time span

Each of the selected criteria is justified and clarified in this report. For each scenario individually, the compliance with these criteria is explained.

The selected scenarios are:
The **Scheldt case,** based on a historical event in the industrial port of Antwerp (Belgium, July 5-9, 2013). Construction works created a man-made landside that caused a risk of explosion of damaged pipelines. In case of an explosion, a cascade of possible risks for the surroundings and considerable impact would have been probable.
The **Mont Blanc** tunnel fire, a historical scenario (24 March 1999) with real cascading effects that had identifiable cross border effects (Italy and France). The actual impacts due to the accident were very severe and had both a short and long term effect.
The **Festival case,** a fictitious scenario based on a combination of three real events (two incident types) with potential cascading effects, which could occur anywhere in Europe: (1) a hazmat transportation incident (Wetteren, Belgium, 2013; Ostedijck schip, Spain 2007), (2) the evacuation of an outdoor music festival (Pukkelpop, Belgium, 2007).

The **Séchilienne** scenario, this is not a past event but a potential scenario, which may lead to huge consequences. It concerns a potential ground movement of more than 3 million m3 in a village named Séchilienne.

The **Nut warehouse blast** scenario, based on a real industrial fire that happened in Northampton, UK (June 26, 2013) In this scenario, the political dimension is important due to the risk of environmental pollution and the possible impact on the local population.

The **Skatås wildfire scenario,** based on a incident in the Skatås forest located around lakes Stora Delsön and Lilla Delsjön, east of the city of Gothenburg, on the west coast of Sweden (April 29, 2008). The actual consequences of the incident were limited, although possible cascading effects with considerable impact were probable (severe consequences for personnel safety, health, properties, infrastructure, businesses, societal services, transportation, etc.).

The **Power Blackout** scenario, a fictive case but the potential impacts are based on real-life large power outages in Europe and North America in recent years. It is a complex cross-border scenario, a combination of winter weather and a failure of a critical component causing an outage that affects two provinces in The Netherlands and after some time four provinces in Belgium.

For each scenario, a brief description, based on a template, was included in this report. The three 'best' scenarios, best compliant with the criteria and best fit for testing the IET will be selected in Task 5.2.

4.2 Recommendations for other tasks

Other methodological aspects covered in this report are summarized in Table 10.

The full elaboration of the scenarios, including multiple timeline development is the scope of Task 5.1. The full elaboration of a test plan is the scope of Task 5.2. The selection of evaluation criteria for testing needs to be done in two steps:

- From the D4.3 list of possible user requirements, definitive design criteria need to be selected. This belongs to the scope of Task 4.3;
- From the definitive design criteria, a set of representative evaluation criteria for testing needs to be selected in Task 5.2.

Table 10 Summary of follow up in other CascEff tasks

1.4 methodological guidance	Further development in other tasks
- Chronological steps to select the final IET user requirements (design criteria) - Methodology for defining representative (high profile) user requirements as evaluation criteria for testing the IET, incl. scoring, weighing	- Selection of final IET user requirements in Task 4.3 - Selection of evaluation criteria, incl. scoring and weighing in Task 5.2 - Elaboration of an evaluation template for the evaluators/observers participating in the tests in Task 5.2
- Basic chronological steps in scenario writing, areas of attention and main axes for content - Starting points for multiple timeline development	- Further development and implementation in Task 5.1/5.2, a.o.: o Preparation of content: theme, incidents, actions, identification and assignment of scenario roles and functions o Multiple timeline development
- Basic chronological steps in organising tests/exercises	- Further development and implementation in Task 5.2, a.o.: o Making objectives SMART o Appointing exercise team (Director, coordinator, …), distribution and assignment of exercise roles o Decision on the type of the exercise (discussion- or operations-based) o Elaborate a test plan, incl. concrete timing o Create exercise documentation, incl. templates o Prepare exercise logistics o Establish a communication strategy o Preparation and roll out of the Exercise Conduct phase o Preparation and Organization of planning conferences, briefings and debriefings - Make sure that the lessons learnt are included in an Improvement Action Plan and forwarded to Task 4.3 and Task 4.2.

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CascEff (2016) Deliverable 1.6 “Definitions”

CascEff (2015) Deliverable 2.1 “*Method to study cascading effects*”

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All CascEff reports are available at:

http://www.casceff.eu/en/publications/Sidor/default.aspx

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Annex I – Overview of relevant definitions

In this Annex, an overview of definitions from literature is listed. This overview shows the great variety of definitions and descriptions of emergency management terminology. Instrumental definitions used in the CascEff project are based on a comparative analysis (recurrent key features and differences) of the listed definitions.

Scenario

- "A product that describes some possible future state and/or that tells the story about how such a state might come about. The former are referred to as end state or even day in the life scenarios; the latter are chain (of events) scenarios or future histories."[30]
- "A story with no way to confirm its validity or nature as a certain degree of evidence."[31]
- "A fictitious organization in order to prevent any confounding effects of pre-crisis reputation."[32]
- "A description of the development of the object of the analysis in alternative framework conditions".[33]
- "Scenarios can be used to reduce uncertainty by making the future structured into predetermined and uncertain elements".[34]
- "A holistic script about the future, which defines the working environment of a company based on different assumptions and describes the paths from present to the future" and "possible, but not necessarily probable views of the future."[35]
- "Scenarios are descriptions of a future situation and the development respectively the description of the way which leads from the present into the future."[36]
- "Scenarios are used to describe that part of the organisations' environment for which projections are difficult or even impossible. Scenarios give the possibility to prepare for alternative and uncertain future options without knowing anything about the probability of the possible outcomes. This makes the scenarios different from forecasts. Effective scenarios are distinct, logical and they are different enough from each other so that they are able to describe the central changing factors of the future and place questions on existing assumptions".[37]
- "A description of a complex future situation that occurrence cannot be predicted for sure as well as the presentation of the development that could lead from the present to the future."[38]
- "In contrary to prognoses, scenarios do not try to predict the future. Scenarios do more try to 'throw light on' thinkable future possibilities."[39]
- "One possible picture of future conditions of the object and its environment; above mentioned conditions are described by characteristics of the results of given sequences of events (situations) and factors which disturb the natural run (evolution) of these sequences."[40]

[30] Peter Bishop, Andy Hines and Terry Collins, 2007. "The current state of scenario development: an overview of techniques", Foresight, Vol. 9, Issue 1, pp. 5-25

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- "Scenarios are used to present and situate solutions, to illustrate alternative solutions, to identify potential problems".[41]
- "Scenarios are a management tool used to improve the quality of executive decision making and help executives make better, more resilient strategic decisions".[42]
- "A scenario is simply a means to represent a future reality in order to shed light on current action in view of possible and desirable futures".[43]
- "Consistent scenarios are scenarios of which the underlying assumptions, preferences and choices are transparent and consistent among different sectors, problems and scales".[44]
- "Scenarios contain: (1) actors, (2) background information on the actors and assumptions about their environment, (3) actors, goals or objectives, and (4) sequences of actions and events".[45]

Large scale incident

- "Large-scale accidents could result in potential radiation exposure of hundreds of thousands of people."[46]
- "Large-scale incidents are characterized by a large number of social media messages as well as a wide geographic and/or temporal coverage. In contrast, small-scale incidents, such as car crashes or fires, usually have a small number of social media messages and only narrow geographic and temporal coverage".[47]
- According to Eide et al. (2012): in large-scale emergency management, an activity characterized by constantly changing task demands, collaboration within and between emergency response agencies is essential. Efficient collaboration during emergency response in large-scale incidents requires a clear understanding of roles, responsibilities, and tasks among the involved actors; simple sharing of relevant information; and a common and shared understanding of the situation at hand.[48]
- "Large-scale incidents invariably require the involvement of groups of individuals, health-care facilities, and agencies responding from one or more geographic or governmental jurisdictions".[49]
- "Large-scale incidents that threaten the lives of many people, create tremendous damage, and pose significant challenges to timely recovery efforts."[50]
- "Small rural areas generally follow informal agreements, where it is understood that large-scale incidents will require all available resources from several community fire departments, and that each department sustains its own resources when providing aid".[51]

[41] S. Bodker, 2000. "Scenarios in user-centred design - setting the stage for reflection and action". Interacting with Computers. Vol. 13, Issue 1, pp. 61-75.

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- Incident: "an occurrence, natural or manmade, that requires a response to protect life or property". The term incident is used to refer to incidents in which FEMA is involved, generally in support of and in partnership with State, territorial, tribal, and local governments. Incidents may be types in order to make decisions about resource requirements. Incident types are based on the following five levels of complexity: (FEMA)

Type 5	• The incident can be handled with one or two single resources with up to six personnel. • Command and General Staff positions (other than the Incident Commander) are not activated. • No written Incident Action Plan (IAP) is required. • The incident is contained within the first operational period and often within an hour to a few hours after resources arrive on scene. • Examples include a vehicle fire, an injured person, or a police traffic stop.
Type 4	1. Command staff and general staff functions are activated only if needed. 2. Several resources are required to mitigate the incident, including a Task Force or Strike Team. 3. The incident is usually limited to one operational period in the control phase. 4. The agency administrator may have briefings, and ensure the complexity analysis and delegation of authority are updated. 5. No written Incident Action Plan (IAP) is required but a documented operational briefing will be completed for all incoming resources. 6. The role of the agency administrator includes operational plans including objectives and priorities.
Type 3	1. When capabilities exceed initial attack, the appropriate ICS positions should be added to match the complexity of the incident. 2. Some or all of the Command and General Staff positions may be activated, as well as Division/Group Supervisor and/or Unit Leader level positions. 3. A Type 3 Incident Management Team (IMT) or incident command organization manages initial action incidents with a significant number of resources, an extended attack incident until containment/control is achieved, or an expanding incident until transition to a Type 1 or 2 IMT. 4. The incident may extend into multiple operational periods. 5. A written IAP may be required for each operational period.
Type 2	1. This type of incident extends beyond the capabilities for local control and is expected to go into multiple operational periods. A Type 2 incident may require the response of resources out of area, including regional and/or national resources, to effectively manage the operations, command, and general staffing. 2. Most or all of the Command and General Staff positions are filled. 3. A written IAP is required for each operational period. 4. Many of the functional units are needed and staffed. 5. Operations personnel normally do not exceed 200 per operational period and total incident personnel do not exceed 500 (guidelines only). 6. The agency administrator is responsible for the incident complexity analysis, agency administrator briefings, and the written delegation of authority.
Type 1	• This type of incident is the most complex, requiring national resources to safely and effectively manage and operate. • All Command and General Staff positions are activated. • Operations personnel often exceed 500 per operational period and total personnel will usually exceed 1,000. • Branches need to be established. • The agency administrator will have briefings, and ensure that the complexity analysis and delegation of authority are updated. • Use of resource advisors at the incident base is recommended. • There is a high impact on the local jurisdiction, requiring additional staff for office administrative and support functions.

Cascading incident

- "Cascading incidents, where one error or mistake leads to another, culminating in disaster."[52]

Domino incident

- "An incident which starts in one item may affect nearby items."[53]
- "Incidents in which a fire or explosion at one plant initiates another hazardous incident at another plant, and so on, leading to a "leapfrog" effect resulting in damage far more widespread than was caused by the initial incident."[54]

Domino effects

- "Domino effects can be defined as accidents in which a primary unwanted event propagates within a system ("temporally"), or/and to nearby systems ("spatially"), sequentially or simultaneously, triggering one or more secondary unwanted events, in turn possibly triggering further (higher order) unwanted events, resulting in overall consequences more severe than those of the primary event."[55]
- "A domino effect can be defined as a cascade of events in which the consequences of a previous accident are increased by following one(s), spatially as well as temporally, leading to a major accident. Internal domino effects occur inside the boundaries of the plant where the domino accident originates. External domino accidents are characterized by the involvement of two or more plants. Remark that the definition of what constitutes a domino effect provided by the Seveso II Directive (96/82/EC) is limited to external domino effects."[56]
- Article 8 of the Seveso II Directive uses the term domino effects to denote the existence of "establishments or groups of establishments where the likelihood and the possibility or consequences of a major accident may be increased because of the location and the proximity of such establishments, and their inventories of dangerous substances".[57]
- "A factor to take account of the hazard that can occur if leakage of a hazardous material can lead to the escalation of the incident, e.g. a small leak which fires and damages by flame impingement a larger pipe or vessel with subsequent spillage of a large inventory of hazardous material".[58]
- "A loss of containment of a plant item which results from a serious incident on a nearby plant unit".[59]
- "The effects of major accidents on other plants on the site or nearby sites".[60]
- "A cascade of events in which the consequences of a previous accident are increased by following one(s), spatially as well as temporally, leading to a major accident".[61]

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[60] Health and Safety Commission, 1984. "The Control of Major Hazards". Third Report of the HSC Advisory Committee on Major Hazards, HMSO.

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- A domino event is defined "as a loss of containment incident on a major hazard installation which had resulted either directly or indirectly from a loss of containment incident at an adjacent or nearby major hazard installation".[62]
- "The occurence of a cascading chain of events when the fire, explosion, missile projection, etc., generated by an accident in one process unit causes secundary accidents in other units is a likely scenario in many major industrial plants and has the potential for catastrophic consequences".[63]
- "An incident which starts in one item, and may affect nearby items by thermal, blast or fragment impact, causing an increase in consequence severity or in failure frequencies". [64]
- "That a domino accidental event will be considered as an accident in which a primary event propagates to nearby equipment, triggering one or more secondary events resulting in overall consequences more severe than those of the primary event".[65]
- "Four different parameters are used to unambiguously identify the character of the domino effect under consideration:
    - Character 1: Internal: happening inside the boundaries of the plant where the domino accident orginates. External: happening outside the boundaries of the plant where the domino accident originates, as a direct or an indirect result.
    - Character 2: Direct: happening as a direct consequence of the previous domino event. Indirect: happening as an indirect consequence of a preceding domino event, not being the previous one.
    - Character 3: Temporal: happening within the same area as the preceding event, but with a delay. Spatial: happening outside the area where the preceding event took place, with or without a delay.
    - Character 4: Serial: happening as a consequent link of the only accident chain caused by the preceding event. Parallel: happening as one of the several simultaneous consequent links of accident chains caused by the preceding event".[66]

Criteria to define scale and large scale

Number of organizations involved in the response

- "For a smaller incident, a single organization might respond, and its maximum capacity would be defined by the resources of that one agency and the plan for how they are to be used. For a larger incident, the plan might involve unified command of multiple local organizations plus local or regional mutual aid. In that case, the nature of the system would be very different, and its maximum response capacity significantly larger."[67]
- "Large-scale incidents will involve many organisations and communities."[68]

[62] J. Gledhill and I. Lines, 1998. "Development of methods to assess the significance of domino effects from major hazard sites". CR Report 183, Health and Safety Executive.

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Annex II - Initial Template Scenario Description

1 **Name** of the scenario

2. **Place** of the scenario

3. Overall **type** of the initial event and type of the impact

4. **Description of the initial system** including more details on the initial event

5. Description of the course of events

6. **Description of cascading effects**, types of dependencies, systems involved after the spread from the initial system

- Interdependencies in the chain of events:
    - Geographical interdependency
    - Physical interdependency
    - Logical interdependency
- Interdependencies relevant for the impact of the incident:
    - Physical interdependency
    - Logical interdependency

7. Real **consequences** and possible consequences

8. Is the scenario **local, regional, national or intern**ational? Are there cross border effects?

9. Description of the different **organisations involved** and the relation between them

10. Is the scenario based on a **historic event?** If yes, please give references or information on where more detailed information can be found or obtained

11. Are there **similar real events** that are not exactly the same, but could be of interest?

12. If the scenario is based on a historic event, does the selected scenario differ in any sense from the historic event? If yes, in what way?

Impact

Describe the effect (usually negative on a system either from an initiating event or, where systems are dependent, through a system dependency. The impact may be measured in one or several of the six impact categories:

1. **Technical** impact (encompasses the damage and loss of technical components, physical assets, etc.)
2. **Organisational** impact (relates to the organisations and institutions that manage the systems; encompassing impacts in terms of organisational capacity, coordination, and information management, etc.)
3. **Social** impact (encompasses impacts on community such as political and civil unrest)
4. **Human** impact (encompasses impact on the population, such as health-issues, well-being, casualties and injuries)
5. **Economic** impact (encompasses impacts in terms of both direct and indirect economic losses)
6. **Environmental** impact (encompasses the effects on natural resources, flora, fauna)

Annex III – Complete D4.3 list of possible user requirements

This is the full list of all possible functional, non-functional and technical user requirements as listed in Chapter 3 of D4.3 'Initial Structure for implementation of the incident evolution tool (IET)'

It should be noted that this list is an unfiltered list. It will further be reduced to a list of accepted user requirements by the consortium partners before January 2016.

1. Functional Requirements

Functional requirements describe what the IET will need to do from a user perspective once it is operational.

N°	Requirement	Relevant Use Case
F1	Support emergency planning and response.	All
	Improve the understanding of the dynamics of cascading effects through:	
F2	Insight in originators, dependencies, consequences	All
F3	Account for gaps in decision making	All
F4	Raise (shared) situational awareness	All
F5	The concept of a Common Operational Picture (COP)	All
F6	Provide a holistic view over all possible scenarios.	All
F7	Distinguish between the evolution of the incident (in order to break the cascade) and the consequences (manage recovery) of the cascading effects.	All
F8	Support verification of existing plans.	Planning-01
F9	Training exercises (D 1.1, p. 6) – real case training modules. (D 1.2, p. 15 – Pre-incident challenges of cascading effects)	Preparation
F10	Understanding of interdependencies, e.g. relating effects to root cause.	All
F11	Evaluate incident management beyond obvious causes to also include opaque root causes on different system levels.	Recovery-01
F12	Manage the complexity of achieving a holistic view over all possible scenarios.	All
F13	Predict as much as possible in advance (planning) during pre-incident stage, to avoid occurrence of cascading effects.	Planning
F14	Advise the user on possible scenarios. (D 1.1, p. 6)	All
F15	Allow dynamic description of the way that effects from specific scenario propagate.	
F16	Predict (possible/perceptive rather than deterministic) cause - effect chains (incl. indicator of uncertainty).	All
F17	Assess infrastructure and social vulnerability from a system perspective	All
F18	Model and illustrate the linkages between infrastructures	Planning
F19	Assessing the severity and importance of observed effects. (D 1.1, p. 6)	Preparation Planning
F20	Predict risk in terms of (singe/multiple) secondary and tertiary effects. (D 1.1, p. 6,7 + D 1.2, p. 15 –Challenges of cascading effects during an incident)	All
F21	Understanding of interdependencies, e.g. relating effects to root cause. (D 1.2, p. 15 –Challenges of cascading effects during an incident)	All

N°	Requirement	Relevant Use Case
F22	Monitor assumptions in the decision making process and adjust for errors. (D 1.2, p. 15 –Challenges of cascading effects during an incident)	All
F23	Evaluate incident management beyond obvious causes to also include opaque root causes on different system levels. (D 1.2, p. 15 – Challenges of cascading effects during an incident)	Response Recovery
F24	Quantify societal aspects of the effects of the incident and incident management. (D 1.2, p. 15 – Challenges of cascading effects during an incident)	All
F25	Providing real time support as the situation is evolving. (D 4.1, p. 6)	Preparation Planning Response
F26	Integrate information from different sources/agencies to avoid misunderstandings, avoid ignoring key data and avoid uncoordinated activities. (D 1.2, p. 15 – Challenges of cascading effects during an incident)	All
F27	Provide a common situational awareness to different agencies and organisations involved in response to emergency situations	Preparation Planning Response
F28	Multi-hazards tool: 1 tool for natural, human and technological hazards/incidents (D 4.1, p. 17)	All
F29	Because completeness is probably too ambitious, the tool should include a combination of (rough) estimates + warning messages (be aware of …….) (D 4.1, p. 18)	All
F30	Refine and compile information from scattered and specialized systems such GIS, data bases, plans, computer models, remote detections systems, social media etc..... In hindsight it often shows that all data was available but misinterpreted, uncorrelated or to complex to interpret quickly. (e.g. GIS, data basis, plans, computer models, remote detection systems, social media, etc. – very often, post-event analysis of disasters show that all data to avoid the tragedy was available but misinterpreted, uncorrelated, … and people could not interpret them quickly and make correct and effective decisions, (D 1.2, p. 16 – Challenges of cascading effects after an incident)	All

2. Non-Functional Requirements

2.1 Development time non-functional requirements

Maintainability – The IET will be released as an open-source application to be used in pilot environments. It is however important that the development methodology and tools support a framework which is maintainable in the open source community. This includes aspects such as:

- Modularity: use of separate modules to facilitate change management with minimal impact on other system components;
- Reusability: application of software modules in multiple parts of the system;
- Analysability: facilitate the analysis of the impact of planned changes on the system;
- Modifiability: facilitate effective and efficient changes without compromising software quality;
- Testability: support test plans to validate the compliance of the software to requirements.

Portability – Given the diversity of users and technology platforms the IET should support users using different hardware and software platforms including desktop or laptop computers and tablets. Given the users working in the field and in offices, it is considered by the consortium partners that smartphones do not provide sufficient screen estate for the IET to work optimally. Requirements include:

- Adaptability: ability to adapt to new hardware/software or other operational user environments;
- Installability: easy to install on client computers without requiring assistance of IT experts;
- Co-Existence: ability to run IET on a client computer next to other IMT and other emergency management applications.

2.2 Run-time non-functional requirements

Functional suitability – Comply to the functional user requirements as listed in paragraph 1 above.

Performance Efficiency – The degree to which the IET can support multiple users whilst providing each user an acceptable usage experience.

- Time Behaviour: The response time of the IET. Although this is most critical in the emergency response phase users tend to abandon products that don't give an 'instance response' experience;
- Resource Utilization: The required hardware and software resources should not increase linearly by the number of active users on the system. It is expected that the choice for a centralized model will put greater demands on the system given the expected number of concurrent users;
- Capacity: The IET should be able to run in an environment which is considered within the norm for IMT and GIS applications.

Compatibility – the degree to which the IET can co-exist and exchange information with other products on the same system.
This includes:

- Co-existence: the IET client software should be able to share the same hardware platform as other IMT's or other 3rd party applications it needs to share information with.
- Interoperability: Support of data exchange with existing IMTs (bi-directional) and existing 3rd party databases including:
  - GIS: e.g. compatibility with INSPIRE Directive and data format [69]
  - Risk Databases: Fire Weather, risk analysis according to Seveso-III Directive, natural hazard maps, …
  - Asset Databases: Infrastructure (pipelines, waterways, roads & utilities), vulnerable objects (schools, hospitals, elderly homes, …) , buildings, …
  - Population Data: demographics per geographic area;
  - Land use: Corine Land cover dataset[70].
- Scalability: The user should be able to use the IET for smaller incidents as well as disaster situations. This includes support for cross border incidents. Cross border incidents also put specific localization requirements on the tool in terms of:
  - Multi-language support
  - Use of different metric systems
  - Use of different GIS geo-reference systems.

In cross-border incidents it is also important to consider whether the IET would be a decentralized or centralized model. A centralized model would have one IET instance for the whole of Europe whereas a

[69] Infrastructure for Spatial Information in the European Community (INSPIRE) geo portal [online] available from <http://inspire-geoportal.ec.europa.eu> [21 June 2015]

[70] European Environment Agency "Corine Land Cover 2006 raster data" [online] available from <http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-3> [21 June 2015]

decentralized model would allow each member state to install and manage its own IET. Aspects of data ownership, system maintenance and data exchange between instances need to be considered with the objective of achieving a broad acceptance of the IET with respect for local incident management models.

Usability – The user should be able to use the IET effectively and efficiently to his/her satisfaction.

- Appropriateness recognisability: the users should easily recognize what IET function should be selected to achieve their objectives.
- Learnability: the user should be able to achieve certain learning objectives through the use of IET.
- Operability/usability: the IET should be easy to use by the target user.
- User interface aesthetics: the user interface should be attractive and provide a satisfying experience to the user.
- Accessibility: The tool should be useable by the intended target users in context of the emergency management phase in which the IET is used. i.e. in an office for the planning phase, a classroom for the preparation phases and an on-scene command post for the response phase.

Reliability – any tool to be used in crisis situations should be reliable in mission critical circumstances. In order to achieve this goal, the IET must be resilient. This translates into the following quality requirements:

- Maturity: ability to operate in crisis circumstances (e.g. power outages, lack of telecom coverage, bandwidth congestion, …).
- Availability: the IET should be useable online and offline during the response phase of an emergency in order to cope with any type of crisis situation (incl. power and telecom outages).
- Fault Tolerance: Ability of the IET to work according to design despite hard- or software errors.
- Recoverability: in case of service interruption the IET should be able to recover from where the user left of before the interruption.

Security – As the IET will contain sensitive risk and incident data the application should provide basic security measures to assure proper authorization, access control, data confidentiality and integrity protection as well as accountability and non-repudiation of transactions.

3. Technical Requirements

Technical requirements include all technology related requirements such as data exchange standards and client platform requirements. The IET consists of a server component running in a datacentre on the internet and a client component running on the users' local device.

3.1 Operating System platform requirements

From the non-functional requirements we can conclude that the client component of IET should be able to run both in a browser environment and on a tablet as an app or a HTML5 application. T4.3 will further examine technical requirements and possibilities to support the functional and non-functional requirements for the final architecture in D4.4.

Given the usage at the incident site during the response phase, rugged laptops and tablets should be supported next to desktops and laptops in office and training environments. In this environment the mainstream operating system is still Window. Android tablets and iPads are becoming more pervasive given their relative cheap price-tag. It is recommended to use the latest versions of operating systems as older versions might become obsolete by the time IET is market ready. This means that IET should focus on Windows 8.1 and above, Android 5 and IOS 8 and above.

The server environment should adopt a cloud based approach and run on mainstream virtual machine environments (VMWare, Hyper-V, Windows Server 2012 and above, Linux) provided this can be combined with client data caching for offline usage in response phase. This should provide the IET user with some of the non-functional requirements such as capacity, scalability and reliability. Particular security requirements should be carefully considered when examining potential cloud environments.

3.2 Database requirements

The IET server should be able to store local data as well as interface with external databases containing the data listed in 2.1 Compatibility. Local databases should use standard open databases used in cloud environments.
The local database should store IET internal data as well as any data that is lacking from external systems and which the user has entered into the IET.

The idea of using cloud-based approach for the development of the IET needs some prerequisites, which are:

- database should be hosted by an accessible server on the web
- the server provides access from the application server to the database through a direct access to the data management
- standardisation of the data format (time information, location information, physical data, etc.) so that the data are readable by all IET users.

External data access is needed to support both legacy applications as well as linked open data sources. From the IMT's discussed in D4.1 only a few support data exchange with outside applications.
In D4.3 the data exchange with external data sources and applications is further discussed.

3.3 Application requirements

In accordance with the DoW the IET will be an open source tool and follow open source standards[2]:

"The Incident Evolution Tool will be launched through the project website as an open source tool including training material to allow easy input to existing incident management systems throughout Europe."[3]

The IET should support end user access both through an IMT as well as be used as a standalone application. Moreover given the resilience requirement in D4.3, the client must be able to deal with offline mode when invoking IET as a standalone application. Hence it is expected that information from the IET server should be cached on the local devices and cache needs to be updated regularly. When caching data, it is not recommended that the IET client would cache raw data from the 3rd party applications in order to avoid any potential Intellectual Property Rights.

The IET should use Web Services to link with 3rd party applications such as IMT's and other 3rd party applications as per functional requirements documented in the Use Cases. Both legacy architectures such as SOAP[4] and JSON[5] and more modern architectures such as REST[6] will be considered in the Data Exchange Standard selection.

[1] "*Buffer is defined as non working time added between two activities to account for identified risks*."
[2] Open Source initiative, [online] available from <http://opensource.org/osd> [21 June 2015]
[3] CascEff DoW 1.1.2.2 p 8
[4] W3C April 27, 2007 "SOAP version 1.2 Part1 : A messaging Framework (Second Edition)" [online] available from < http://www.w3.org/TR/soap12-part1> [21 June 2015]
[5] JavaScript Object Notation (JSON): 2000 [online] available from <http://json.org/> [21 June 2015]
[6] Representational State Transfer (REST): Chapter 5 of Doctoral Thesis of R. T. Fielding, 2000 "Architectural Styles and the Design of Network-based Software Architectures", Doctoral Thesis of R. T. Fielding, 2000 [online] available from <http://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm> [21 June 2015]