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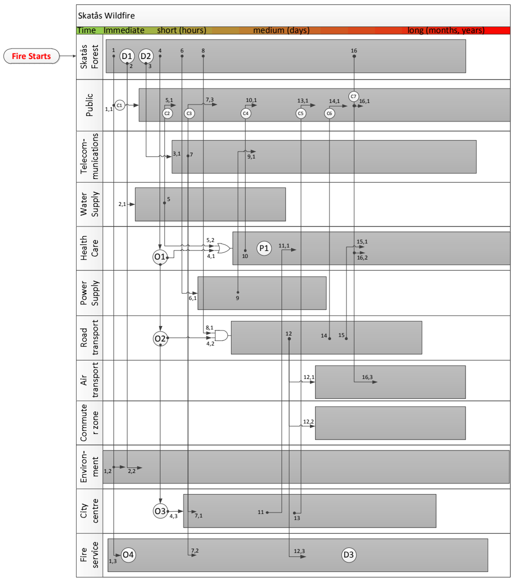
Detailed description of selected scenarios



Deliverable Number: D5.1 v2 (Public version July 29, 2017)
Date: April 15, 2016
Due Date (according to DoW): October 31, 2015
Dissemination level: PU
Reviewed by: Interim review

Grant Agreement No:	607665
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Project acronym:	CascEff
Project title:	Modelling of dependencies and cascading effects for emergency management in crisis situations

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Table of Content

Executive Summary

Topic and purpose
The ultimate goal of the CascEff project is the development of the CascEff IET. To prove the functionality and usability of the IET it needs to be tested and validated in some way. However, it is not obvious against what such a tool should be validated. For this purpose a number of scenarios were selected in the project. This specific task was performed within WP1 of the project and presented in D1.4, while the elaboration of the scenarios and descriptions in more detail is part of this D5.1. The scenarios were selected according to a number of criteria, e.g. type of initiating event, type of higher order dependencies and events, scale of impact, cross border effects, type of response, experience of the consortium, need for modelling, etc. The elaboration of the selected scenarios is described in this report.

Findings and conclusions
Seven scenarios were selected and summarized in D1.4:

1. Scheldt (local landslide)
2. Mont Blanc tunnel fire (an international incident with cross-border effects)
3. Festival (evacuation due to fire and release of toxic gases)
4. Séchilienne (large landslide)
5. Nut warehouse blast (Industrial fire)
6. Skatås wildfire
7. Black out scenario

Most of the scenarios are based on real incidents (no 1, 2, 5, 6). One (no 3) is a mixture of incidents and some added ideas while no 4 and no 7 are fictional but based on knowledge about a real incident and analysis of the specific region for the scenario.

In the report the selected scenarios are described in detail and especially the following information is presented for each scenario:

- Name and location of the scenario
- Type of initial event and initial system affected
- Course of events
- Dependencies and cascading effects
- Actual and possible consequences
- Geographical extension and types of organisations involved
- Relation to historic incidents

The plan is to test the IET together with existing tools (e.g. incident management or information handling tools). To be useful for such validation sessions, the scenarios need to be described in a way where dependencies, different options, key decision points, buffer times, etc. are presented and described. Therefore, a format (based on different existing formats) for visualizing this information in a figure was developed and used for each scenario. In this way both the main scenario and other developed timelines could be presented. The visualization has a so called swim-lane structure where the different affected systems each constitute one swim lane and the key points and impact of one system on another is shown together with decisions, options, processes and suggested communication. This helps both the understanding of the scenarios and the creation of the validation sessions with the existing tools.

Limitations

The developed timelines for the different scenarios should be seen as plausible examples. It is not an exhaustive list and the timelines do not contain all possible details. The scenarios and timelines will be even further developed in connection with the planning and preparation of the specific validation sessions for the IET

Nomenclature

Abbreviations

AT	Alternative timeline
ATMB	Autoroutes et Tunnel du Mont Blanc
CC	Coordination committee
CEREMA	centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement
COGIC	Centre opérationnel de gestion interministérielle des crises
CP-OPS	Command Post – Operations
Cx	Communication point x
Dir CP-OPS	Director Command Post-Operations
DIR Med	Medical director
DIR Pol	Police Director
Dir Log	Logistics Director
Dir Info	Information Director
DoW	Description of Work
Dx	Decision point x
EA	Environment Agency
HGV	Heavy Goods Vehicle
IC	Incident Commander
IET	Incident Evolution Tool
NPK	Nitrogen, Phosphorus, Potassium
Ox	OR (Option) point x
PKMC	Prehospital catastrophic medical centre
Px	Procedure point x
SITMB	Societa Italiana del Trafono di Monte Bianco
SMEs	Small and medium-sized enterprises
SSD	Self-sustaining decomposition
VMA	Important public announcement (Viktigt Meddelande till Allmänheten)
WUI	Wildland-Urban interface

1 Introduction

CascEff aims to improve our understanding of cascading effects in crisis situations through the identification of initiating events, 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.

This deliverable (D5.1) presents the key findings from Task 5.1, which focused on the **identification and development of scenarios** for the Incident Evolution Tool. The objective of this task according to Description of Work (DoW) is given in Section 1.1.

1.1 Objectives and scope of Task 5.1

According to the DoW:
"This task will select a number of representative historical scenarios from those which are studied in task 2.2 for further development and implementation into a software environment using the methodologies developed in Task 1.3 and Task 4.2. This will require the identification and definition of originators and alternative dependencies based on the potential actions taken at the key decision points.

Actions taken at the time of the incident will be included in the scenario definitions, as well as new developments in tactical response.

Additionally, originators and dependencies of potential incidents will be identified and implemented in the incident management environment in the same way.

Scenarios will be selected based on their potential impact and risk of escalation.
Typical scenarios may include, but are not limited to: multifunctional building, e.g. transport terminal/hub, combined hotel/conference centre/ shopping mall; major ports and industrial areas; high rise or iconic buildings; sink holes; highways and critical infrastructure.

The scenarios will be created using the XVR Simulation Platform which allows the development of highly realistic multi-actor first responder exercises, the iCrisis platform and others as relevant within the project."

This task relates to several of the other work packages and tasks. The ultimate goal of the CascEff project is the development of the CascEff IET. To prove the functionality and usability of the IET it needs to be tested and validated in some way. However, it is not obvious against what such a tool should be validated. For this purpose a number of scenarios were selected in the project. This specific task was performed within WP1 of the project and presented in D1.4, while the elaboration of the scenarios and descriptions in more detail is part of this D5.1 (Task 5.1). The scenarios were selected according to a number of criteria, e.g. type of initiating event, type of higher order dependencies and events, scale of impact, cross border effects, type of response, experience of the consortium, need for modelling, etc. The selection of scenarios is to a large extent done with the historical events studied in Task 2.2 and 2.3 as a point of departure.

When describing an incident or scenario, the involved systems and types of systems need to be described. An extensive work on this was done in WP2 and some of the conclusions from that work regarding different types of systems, subsystems, initiating events and dependencies are presented in Chapter 3.The results from the work on analysis of different real incident in WP2 and WP3 have also been used during the work with the scenarios. There is also a link to WP4, in both directions, when it comes to how to understand and describe dependencies and cascading effects during an incident.

1.2 Definitions

CascEff has created a lexicon of key terms in order to ensure that they are understood and used in the same way. Although this was not a task in the DoW, it was an issue that was identified during discussions between the project partners and those involved in other research projects. For CascEff, the common definitions have been collated in a document[1], some of which are presented below.

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.*

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

Events, system and dependency

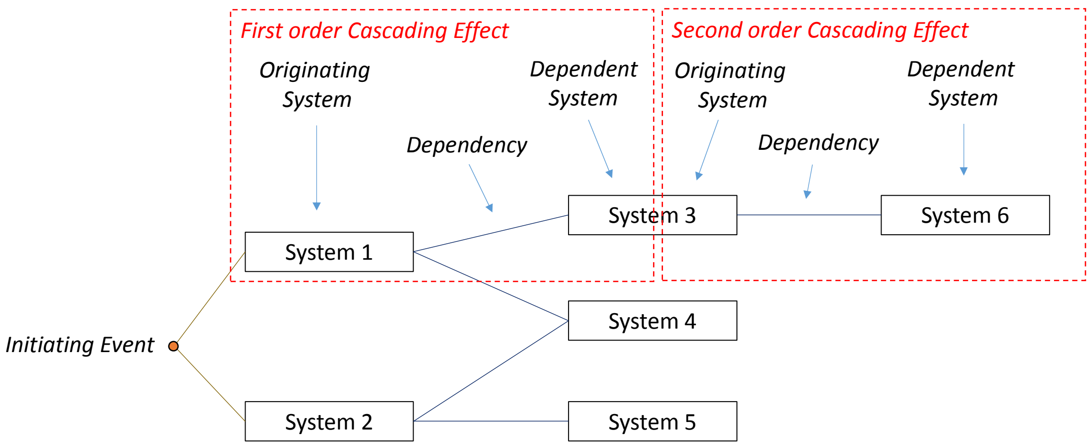

Figure 1.1 Schematics of the dependencies between systems in case of cascading effects.

[1] Lönnermark, A. et al., "CascEff glossary and definitions", D1.6 (To be published).

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.

Originating system – a system in which a failure propagates to another system.

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

Dependency: a mechanism whereby a state change in one system can affect the state of another system. Note that this definition differs from the way the concept "dependency" is used in the DoW. The use of the concept "dependency" in the DoW corresponds to what we refer to as "impacted system" (see definition above).

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

Dependency type– In the CascEff project, three types of dependencies are included. A *physical dependency* occurs when the state of different types of systems are dependent on the output(s) of another. A *geographic dependency* occurs when systems are located in one region and where changes in the local environment can create state changes in all of them. A *logical dependency* occurs when a state change in one system results in a state change in another, without any of the other dependencies occurring.

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

Incident – a chain of events affecting multiple systems either in series or spreading in parallel.

Incident Evolution Tool

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

Incident Management Tool

An **Incident Management Tool** (or Incident Management System) is a toolbox from which an incident commander can select a tool to assist them in the management of an incident (Cote, 2003). This tool can be used for different purposes e.g. and during different phases of the incident management cycle: pre-planning, response, debriefing, and training.

Our IET should be compatible with existing Incident Management tools. It will be one component of the toolbox from which an incident commander (IC) selects their tool(s) to manage incidents. The CascEff project sets out to illustrate how information presented to the IC by the IET can help the IC make better informed decisions about their response strategy e.g. allocation of capital resources (e.g. equipment), personnel, and knowledge.

Cascade order

Cascade order: the number of stages in a propagation from a directly impacted system to one that is impacted indirectly (e.g. an event propagating from one originating system to one dependent system represents a first order cascading effect, while the event would be referred to as a second order cascading effect if the same event would further propagate to yet another system). See Figure 1.1.

Impacts

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

- The physical dimension refers primarily to the physical properties of systems; technical impact describes the damage and loss of function of technical systems.
- Organizational impact relates to the organizations and institutions responsible for managing the physical components of the system(s). This domain encompasses impact to systems in terms of organizational capacity, planning, training, leadership, experience, and information management.
- The social dimension of impact refers to the population and community characteristics of social groups that are vulnerable to hazards and disasters.
- Economic impact refers to the impact in terms of both direct and indirect economic losses resulting from disasters.
- Environmental impact refers to the effects on ecosystems and natural resources

Key decision points represent opportunities to affect the links between the originating system and the dependent system(s), where an intervention might prevent cascading effects from occurring after the event.

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

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

Buffer time: The time between the start of an incident in the originating system and before a cascading effect occurs in a dependent system.

Scenario: the collection of systems which could be affected as a result of a specific initiating event, indicating also the nature of the interdependencies and the time at which the different dependencies take effect. It contains details of cascading effects both real (when based on a historical incident) and possible, as well as external conditions, first responder actions, procedural actions, and communication opportunities.

Timeline: illustrates the impact on the systems which could arise in the event of one set of different external conditions, first responder actions, etc. occurred or are taken. It is based on a scenario and describes one possible progression of events and outcome from a scenario.

2 Descriptions of the selected base scenarios

Seven different scenarios were selected for the validation of the CascEff IET. The scenarios were also used as a basis for discussions between the partners on cascading effects, as well as the analyses of various incidents (see WP2). The selection criteria for the seven CascEff scenarios were articulated in D1.4.

The seven selected scenarios are summarized in Table 2.1 and are described in more detail in separate sections below.

Table 2.1 Summary of the CascEff scenarios.

	Scheldt	Mont blanc tunnel fire	Festival	Séchilienne	Nut ware-house blast	Skatås wildfire	Blackout
No	1	2	3	4	5	6	7
Initiating event	Land-slide	Tunnel fire	Ship collision with fire and release of toxic gases	Landslide	Industrial fire	Wildfire	Power outage (component failure)
Type of initiating event	Accidental	Accidental	Accidental	Natural	Accidental	Accidental/Natural	Accidental (technical)
Real/ fictional	Real event	Real event	Mix of real and fictional	Fictional	Real event	Real event	Fictional
Scale of impact	Local	Regional	Regional	Regional	Local	Regional	International
Country	BE	FR/IT	BE	FR	UK	SE	BE/NL
Time span	5 days	Response several days; closed 3 years	8h - Several days	Response: 1-3 days	3 weeks	Several days	2-3 days

In order to facilitate a comparison of the scenarios themselves and of the results from activities using the scenarios some basic information is needed for each scenario. At least the following information was gathered:

1 **Name** of the scenario
2. **Location** of the scenario
3. **Type** of initial event and 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 (Geographical, Physical, Logical), systems involved after the spread from the initial system
7. Actual **consequences** and possible consequences
8. Is the scenario **local, regional, national or international**? 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?**
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?

The scenario descriptions below are structured according to the list above, with the exception of questions 11 and 12, which have been included in the section on historic events (10).

Most of the scenarios are based on real incidents (no 1, 2, 5, and 6). One (no 3) is a mixture of incidents and some added ideas while no 4 is fictional but based on knowledge about real incident and analysis of the specific region for the scenario.

In the subsections below, the seven selected scenarios are described in detail.

2.1 Scheldt

2.1.1 Location of the scenario

Antwerp, Belgium - Industrial Port, July 5-9, 2013

2.1.2 Overall type of the initial event and type of the impact

A pipeline bed was damaged by a landslide, caused by construction works, creating a possible risk of pipeline(s) explosion.

2.1.3 Description of the initial system including more details on the initial event

The context of the event:

The Sigmaplan involves a series of construction projects along tidal rivers in order to better protect the Flanders region against floods. One of the projects aims to reinforce the Scheldt dikes through elevation. The responsible (master) builder is Waterways and See Channel Ltd.
Large amounts of sand were stockpiled near the construction site. The weight of this sand lifted up the verge of a nearby road, under which lay several underground pipelines. The landslide partly dislodged the pipelines from their original place, creating a torsion which put the pipelines under pressure, causing the risk of explosion.

Figure 2.1 Verge of the Scheldt lane affected by the landslide.

Figure 2.2 Sigma construction works creating a landslide.

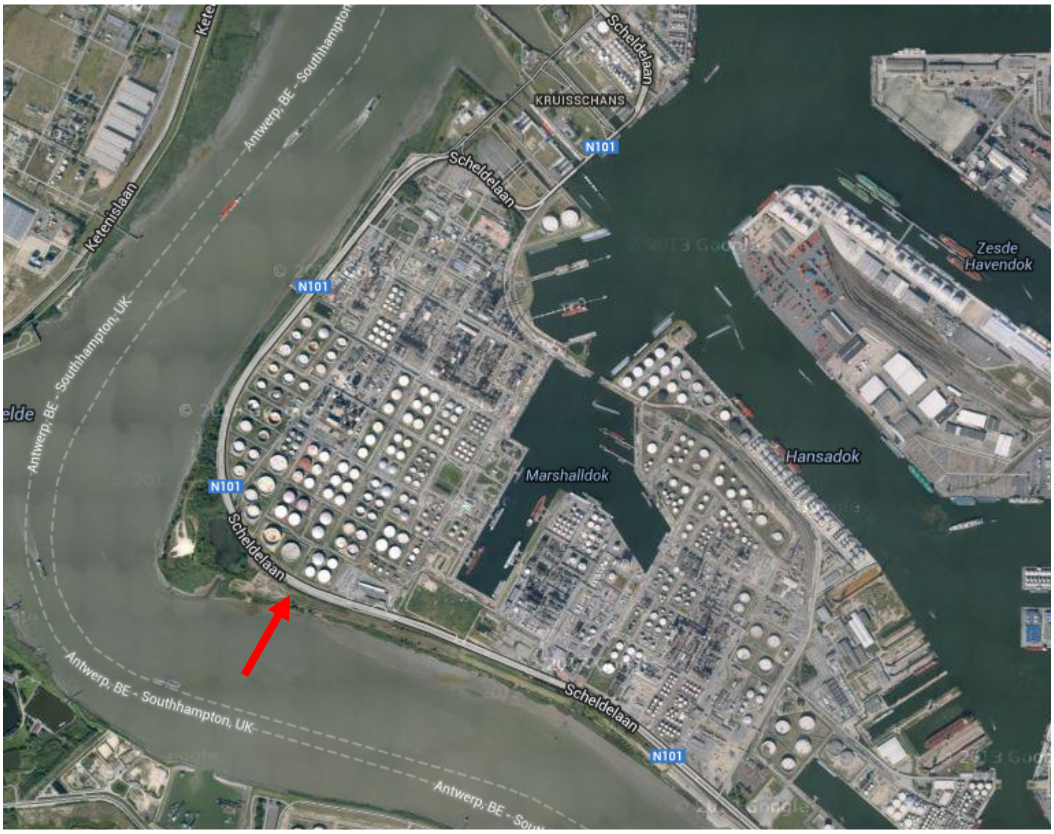

Figure 2.3 Scheldtlaan, affected area.

Figure 2.4 Scheldt lane affected area, tanks at house burning distance.

Initial situation and information:

July 5

17h03 Initial information via the 112 dispatching: the lifting up of the verge of the road nearby Total refinery Antwerp, with possible impact on the underground pipelines
Intervention type: 'smell of gas / gas discharge'.

17h14 First intervention team on the scene are firemen, with standard material: 2 pump engines + commando vehicle. They only observe visible damage at ground level, no leak is observed.
Police is asked to close the Scheldt lane for all traffic (cars + cyclists).

17h47 The operational coordination phase is declared because of multiple services concerned (*see below*, *Organizations involved*) and the possible impact (*see below, Possible impact*).

2.1.4 Description of the course of events

The operational coordination phase

July 5

17h47 The operational coordination phase is declared because of multiple services concerned and the possible impact

Services concerned:

- Initial firemen (Discipline 1)
- 2 extra officers (firemen)
- Representatives of the 4 other disciplines (*see below*, *Organizations involved*):
    - Medical (Discipline 2)
    - Police (Discipline 3)
    - Logistics (Discipline 4)
    - Information (Discipline 5)
- The 2 Advisors Hazardous materials from the province of Antwerp are summoned
- Representatives of the pipeline owners, of surrounding companies (including those relying on the pipelines for supplies) are informed and invited
- The building contractors

A mobile Command Post is installed

Actions (and available information)

- The **online pipeline atlas** of the FPS Interior (Ministry of Interior) is consulted in order to list the pipelines concerned. 7 different pipelines are identified, belonging to 5 different companies
    - 5 in use: Natural gas, Crude oil, Crude C4, Nitrogen, Hydrogen
    - 2 not in use: Butadiene, Liquid hydrocarbon
    - Other tubes (not of immediate concern): 1 power line (150 KVa) and telecom lines
- **Photo's** (at ground level) show the gravity of the situation
- **Tables of calculations of impact distances** are consulted
    - ⇨ Worst case scenarios are identified (*see below*, *Worst case scenarios*)

Possible impact:

- Possible breach of pipelines => risk of explosion
- Risk of flash over to 4 tanks at house-burning distance
- Risk for 3 refineries nearby being cut off of supplies => an acute shut down could have caused safety risks at the plant (and possible damage in the vicinity)

=> An exclusion perimeter[2] of 500 m and isolation perimeter[3] of 1000 m are installed
=> From that follows the decision to redirect all shipping traffic on the Scheldt via locks and docks

Municipal coordination

July 5

18h51 Decision to scale up to municipal coordination, which adds a level of decision making, presided by the Mayor. Decision to establish a crisis centre (Coordination Committee) at the Antwerp Fire Service Post Noord.

19h07 First formal deliberation in the CP-OPS (Command Post – Operations)

19h19 After deliberation between the pipeline owners and their clients, it is decided to put some of the pipelines out of service under supervision.
It takes all night to secure all the pipelines.

Actions taken:
Relieving/blowing of the pressure, blocking and bleeding of parts of the pipelines. Not all the pipelines can be put out of service because the processes relying on them are critical. Putting them out of service could have caused a dangerous situation in the refineries where this would have induced a shut down.

20h20 Extra firefighting devices and equipment are requested as part of the preparations for incident escalation:
1 pump engine, 2 foam vehicles, 2 dry powder vehicles, 1 lift, 1 hose vehicle. The Civil Protection adds extra industrial firefighting equipment such as foam trailers and pumps/fire hoses with a capacity of 22 000 L/min.
Other services join the CC during the evening: Waterways and Seechannel, SeeScheldt, Dredging International.

July 6

9h00 Dredging International start excavations to free the pipelines from external pressure.

July 6-July 9

In the next days the following activities took place at an impacted zone of 110 m length:

Actions taken:

- Removal of the sand that caused the landslide and excavations frees the pipelines from the external pressure.
- Extra command container for the meetings of the technical teams (coordination of contractors).
- Contacts with owners of other pipes: sewage system, electricity (high voltage cable), cable television, …
- Excavation of 5 provisional trenches to determine how far the pipelines has been removed from their original position – removal of the bicycle path – uncovering the impacted pipelines
- Construction of an additional dam on one side (for stability) – priority for the securing of the crude oil pipeline (because the only supply line that has no alternative) – piercing of 4 holes for regular analysis of the pipelines – placing of panels (dam function).

[2] The exclusion perimeter (= legal obligation) indicates the zone where only relief workers are allowed, approved by the DIR CP-OPS

[3] The isolation perimeter is (= legal obligation) the zone where logistic support for the relief operations is organised, where people who work and live there are allowed, if approved by the DIR CP-OPS and following his directives

- Sunday night (7/7) the perimeters are reduced to 100m (exclusion) and 200 m (isolation).

Figure 2.5 Repair works to secure the pipelines and restore the bed.

July 9
21h21 Municipal coordination phase formally ends.

July 10
16h31 The operational coordination – coordinated by the fire department of Antwerp – goes on until Wednesday 16h31.
During the day, a safety coordinator for (mobile and temporary) construction sites was appointed to supervise the ongoing work of the contractors.

July 11
6h30 Only on Thursday at 6h30, the Scheldt lane is reopened partially for regular traffic.

Ongoing actions

During all these activities, several experts were present for regular controls (magnetic, ultrasonic – firemen), analysis of the stability of the pipelines (mechanical engineers) and the bed (land surveyor), technical analyses (AIB Vinçotte). Industrial firefighting equipment and staff were permanently stand by.

2.1.5 Cascading effects, dependencies and systems involved

Worst case scenarios identified:

Table 2.2 Consequences and dependencies.

Initial event	Possible consequence 1	Possible consequence 2	Possible consequence 3
Pipeline bed damaged	4 tanks (+/- 20 mil. m^3) at house burning distance	Supply of 3 refineries nearby is threatened	- Internal safety at the plant ↪ Environmental - …
	= Consecutive	= could be simultaneous to 1 or consecutive	Gravity of the risks depends on whether a gradual or acute shut down is required
	Geographical dependency	Physical dependency	Physical dependency

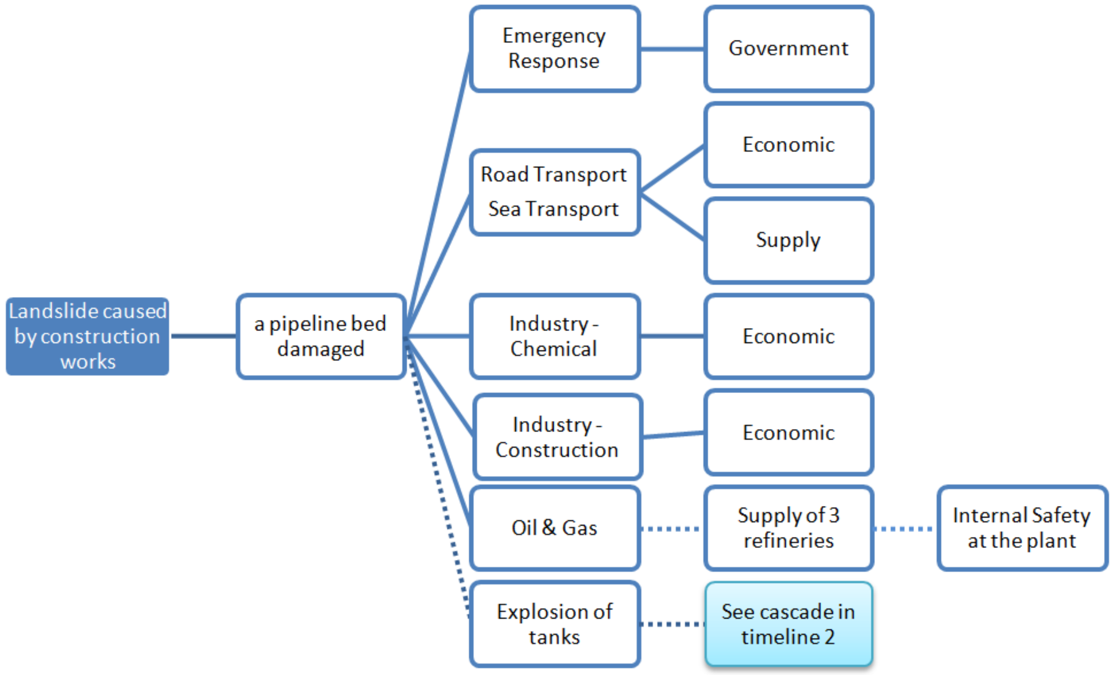

Figure 2.6 Overview of real (full line) and possible (dotted line) impacted systems.

The impact may be measured in one or several of the six impact categories:

- **Technical impact** (*encompasses the damage and loss of technical components, physical assets, etc.*)
    - Damage to the road and bicycle path
    - Damage to the pipelines and the bed
- **Organizational impact** (*relates to the organizations and institutions that manage the systems; encompassing impacts in terms of organizational capacity, coordination, and information management, etc.*)
    - Involvement of personnel and staff of all the actors concerned
- **Social impact** (*encompasses impacts on community such as political and civil unrest*)
    - Reduced and hindered mobility in the Antwerp Harbor
- **Human impact** (*encompasses impact on the population, such as health-issues, well-being, casualties and injuries*)
    - None

- **Economic impact** (*encompasses impacts in terms of both direct and indirect economic losses*)
    - Costs related to the abovementioned consequences
- **Environmental impact** (*encompasses the effects on natural resources, flora, fauna*)
    - **None**

2.1.6 Actual consequences and possible consequences

Actual consequences

- Road and shipping traffic/mobility of local residents and businesses hindered (and associated indirect costs of such disruption)
- The industrial, chemical sector nearby was affected in several ways:
    - Some because of the geographical proximity and their facilities, infrastructure and workers at risk in case of an explosion
    - Some because of the physical dependency of supply from the pipelines

  ⇨ This in turn caused economic loss/costs because of the need to take measures to be prepared, such as looking for alternative supplies, preparing for a shut down in a worst case scenario, etc.
- The continuation of the Sigma construction works were delayed and the construction and other workers were deployed to perform the works to secure the pipelines and to restore the damaged bed
- The Oil & Gas sector was affected because some pipelines had to be put out of service
- At first, emergency response was coordinated at operational level. Very soon the situation revealed to be serious enough to engage the responsible authority, in this case, the Mayor
- Economic costs, as second order impact, consist of:
    - Cost of staff and material/equipment involved in the incident management: the 5 disciplines, contractors, experts
    - Cost of the work to repair the bed, the pipelines in it
    - Delay of the Sigma works
    - Delay caused by the interruption of the supplies by the impacted pipelines
    - Industrial processes reduced or even stopped

Possible consequences

The initial event would have produced considerable other consequences in the case of explosion of one of the damaged pipelines (the dotted line in the figure), such as:

- extra fires
- cascade of explosions and fires
- extensive damage to the nearby facilities
- (long term) problematic access to the industries in Antwerp harbour because of important access roads in the vicinity of the incident

2.1.7 Geographical extension and cross border effects

Thanks to the efficient approach (quick gathering of information and expertise for a reliable assessment of the situation and estimation of the appropriate actions), the impact of the initiating event remained local. In case of cascading escalation, the impact would have been regional. There was never a risk of cross border effects.

2.1.8 Different organisations involved and the relation between them

Traditionally, five functional disciplines are involved in the case of a major incident.
Two coordination/command structures are put in place when the definition of an emergency situation applies (Royal Decree 16.02.2006):

An emergency situation *is "every event that causes or could cause a damaging impact on society (serious disturbance of public safety, a serious threat to live or the human health or important material assets) requiring the coordination of disciplines to eliminate the threat or to limit the damaging consequences. "*

The (by definition multidisciplinary) operational coordination (CP – OPS) is ensured by five Directors appointed for each Discipline and chaired by a Dir CP-OPS (according to the type of incident).
Administrative coordination is ensured by the Coordination Committee – CC, chaired by the competent authority (Mayor, Governor or Minister) and comprised of a representative of each Discipline, the civil servant responsible for emergency planning and a number of invited experts.

In 2013, the police and fire service were directly accountable to the Mayor. Between the five disciplines there is no hierarchical neither a contractual relation. They coordinate their operations according to the decisions made in the CC and the directives decided in the CP-OPS.

Organizations involved in the Scheldt scenario are summarized in Table 2.3.

Table 2.3 Organizations involved in the Scheldt scenario.

Disciplines	Actors CP-OPS		CC
D1 - Relief operations	Mainly firemen, 2 Advisors Hazardous materials	DIR CP-OPS	Repres.
D2 - Medical	Ambulance and medical team	DIR Med	Repres.
D3 Police	Local Police, Harbor Police	DIR Pol	Repres.
D4 Logistics	Civil protection	Dir Log	Repres.
D5 Information	Civil servant responsible for information and communication	Dir Info	Mayor
Other	Civil servant responsible for emergency planning		
	Representative Operator Tanks Representative Operator Total Experts: mechanical engineers, land surveyor, AIB Vincotte (certified organisation for technical control) Master Builder, Waterways and See Channel Ltd Building contractors		
Informed	The province Governmental Crisis Center		Repres.

2.1.9 Information on the historic event the scenario is based on and on similar events

The scenario is based on a historic event, starting July 5, 2013.

Publicly, only press articles are available[4, 5, 6, 7]. The intervention report of the Antwerp fire service, in charge of the incident command of the event, has been consulted for the reproduction of the facts and actions in this scenario. The report is confidential and not publicly available.

The initial event was similar to the Gellingen case in Belgium: explosion of a pipeline of natural gas at an industrial site[8]. In case the event would have escalating to neighbouring tanks, this scenario would have been similar to the Buncefield scenario[9].

- Similarities with Gellingen:
    - Scheldt case and Gellingen started with damaged pipelines.
- Differences compared to Gellingen
    - In the Scheldt case the incident management started in a phase of acute threat of explosion, whereas in Gellingen, the incident management started with the explosion and the almost immediate cascading effects on the surrounding industrial site
    - One of the lessons learnt from Gellingen was the need to dispose of plans indicating underground pipelines and tubes. In the Scheldt case that information was available.

- Similarities with Buncefield:
    - (risk of) Tank explosion
- Differences compared to Buncefield
    - The tanks were threatened, no real fire/explosion in Antwerp
    - In Buncefield 1 single tank was concerned, in the Scheldt case 4 tanks were at risk

[4] Het Laatste Nieuws: http://www.hln.be/hln/nl/957/Binnenland/article/detail/1664385/2013/07/05/Rampenplan-in-Antwerpse-haven-na-grondverzakking.dhtml

[5] De Standaard: http://www.standaard.be/cnt/dmf20130709_00652283

[6] Het Nieuwsblad: http://www.nieuwsblad.be/cnt/dmf20130705_00648750

[7] Totaaltrans (website for the transportation and logistic sector): http://www.totaaltrans.nl/grondverzakking-in-antwerpse-haven-risicos-voor-pijpleidingen/

[8] "High pressure Gaspipeline disaster: Perspective of fire brigade", 30 July 2004, http://www.safety-sc.com/en/862_Gellingen%20gas%20disaster.pdf

[9] "Buncefield: Why did it happen?", COMAH, 02/11, http://www.hse.gov.uk/comah/buncefield/buncefield-report.pdf.

2.2 Mont Blanc tunnel fire

2.2.1 Location of the scenario

The Mont Blanc tunnel (Figure 2.7), one of Europe's longest road tunnels, located underneath the Mont Blanc mountain in the Alps and connects Chamonix of France and Courmayeur of Italy.

(a) (b)

Figure 2.7 Entrance of the Mont Blanc tunnel on the (a) French side and (b) Italian side.

2.2.2 Overall type of the initial event and type of the impact

Fire scenario where the fire started in a single heavy goods vehicle (HGV) within the tunnel.

2.2.3 Description of the initial system including more details on the initial event

The Mont Blanc tunnel is a single-bore, two-lane tunnel which is 11.6 km long, 8.6 m wide and 6.0 m high, as well as having a 50 m² cross-section[10]. The entrance elevation on the French side is 1274 m and 1381 m in Italy, with a maximum of 1395 m near the centre, a maximum difference of 121 m. The horse-shoe shaped profile of the tunnel (Figure 2.8) has a 7 m wide roadway with two 0.8 m walkways on each side and a clearance height of 4.5 m. Every 300 m, there are vehicle rest areas (Garages), 3.15 m wide by 30 m long, situated on alternating sides of the roadway and numbered from 1 to 36 in the France-Italy direction.

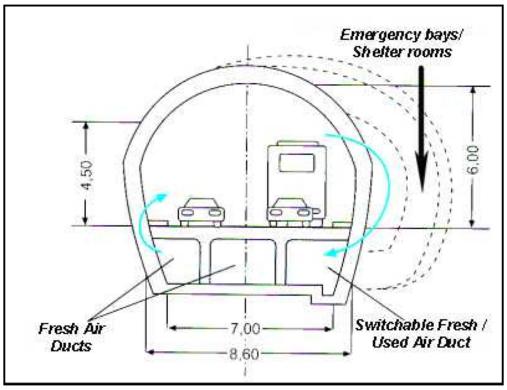

Figure 2.8 Cross-sectional area of the Mont Blanc tunnel.

[10] "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.

On the morning of 24 March 1999, a Belgian heavy goods vehicle (HGV) with a refrigerated trailer entered the tunnel from the French side. It had travelled several kilometers inside the tunnel when oncoming vehicles noticed the first signs of smoke coming out of the truck. The driver eventually stopped at 6.7 km into the tunnel and left his vehicle close to Garage 21 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 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. The result was a mega fire, which burned for approximately 53 hours reaching temperatures of 1000 °C.

2.2.4 Description of the course of events

A detailed chronology of the events that occurred during the tunnel fire is presented in Table 2.4, however, a full description and more details about the 1999 Mont Blanc tunnel fire are given in the public investigation report[10] of the accident.

Table 2.4 Chronology of the 1999 Mont Blanc tunnel fire[11].

Time	Time after alarm (min)	Chronology of the incident
10:46	-6	A truck stopped at French toll plaza.
10:52	0	An opacimeter in rest area 18 detected smoke from the HGV and raised alarm.
10:53	+1	The HGV stopped at the location 6500 m away from French portal. A French tunnel operator realized that a fire had happened.
10:54	+2	An Italian tunnel operator received a call from lay-by 22 (about 300 m away from the incident).
10:55	+3	The French and Italian regulators closed the toll. An ATMB agent enters the tunnel and is stopped shortly after rest area 18 (about 750 m from the originally-caught-fire truck).
10:57	+5	ATMB light fire engine entered the tunnel with 4 men from French portal. There was an alarm from lay-by 21 (use of a fire alarm push button).
10:57 ~ 11:01	+5 ~ +9	The employees of Italian toll companies entered the tunnel.
10:58	+6	There was an alarm showing the lifting of a fire extinguisher from rest area 21. The French tunnel control centre alerted the public rescue services.
10:59	+7	ATMB rescue vehicle with 2 men entered the tunnel from French portal.
11:02	+10	The fire rescue vehicle of Chamonix left its base. The Italian tunnel

[11] Kim, H.K., Lönnermark, A., Ingason, H., "Effective firefighting operations in road tunnels", SP Technical research institute of Sweden, SP Report 2010:10, 2010.

		control centre alerted the Courmayeur (Italian) fire brigade.
11:04	+12	The first Italian firefighting vehicle of Courmayeur left its station.
11:05	+13	A French patrolman came within some 10m of the HGV on fire from Italian portal.
11:08	+16	ATMB light fire engine could not advance further after 5400 m due to smoke. They went into shelter located at lay-by 17 (5100 m away from the French portal).
11:09	+17	ATMB rescue vehicle was blocked by the smoke after 5100 m. They went into the shelter located at lay-by 17.
11:10	+18	The first high power fire engine on Chamonix (French) reached the tunnel portal.
11:11	+19	The first Italian fire engine entered the tunnel.
11:16	+24	The Italian firemen were stopped by smoke at lay0-by 22 (about 300 m away from the incident). They had to retreat to lay-by 24 (900 m away from the vehicle) with another 2 Italian firemen and wait rescuers for about 3 hours.
11:15 – 11:18	+23-26	The French fire engine was stopped by dense smoke at 3700 m of the French portal. The firefighter had to escape to lay-by 12 (3600 m away from the French portal) and wait for rescuers for 5 h.
11:32 – 11:36	+40-44	A second French fire engine entered the tunnel to rescue trapped French firemen. However, rescuers failed to reach lay-by 12 and were forced to stay at lay-by 5 (1500 m from the French portal).
12:55	+2h 3	A rescue operation started from the French side.
13:04	+2h 12	The Specialized Rescue Plan for the tunnel was activated on the French side.
About 14:16	+3h 24	5 Italian firefighters were evacuated through the ventilation duct.
15:00	+4h 8	The 5 Italian firefighters were evacuated.
18:35	+7h 43	All the trapped fire and rescue teams from the French side were rescued.
+53 h		The fire was extinguished.

2.2.5 Cascading effects, dependencies and systems involved

Despite the interesting elements within the Mont Blanc tunnel scenario (e.g. historic event with cross-border effects), in its original formulation, it lacks of high level of interdependencies and of higher order cascading effects. For this reason, the Mont Blanc tunnel fire accident will serve as a basis for further development. The original scenario will be extended to account for more dependencies between systems.

2.2.6 Actual consequences and possible consequences

The 1999 Mont Blanc tunnel fire resulted both in human casualties and long-term economic and social disruptions due to its ensuing closure for 3 years that impacted an area with a radius of over 300 km in central Europe from a traffic congestion point of view. A brief overview of the impacts caused by the Mont Blanc tunnel fire is presented below:

1. Technical: Damage to the tunnel infrastructure, material losses, legal costs and liabilities). The cost of the repair and renovation of the Mont Blanc tunnel was approximately 350 million

euros[12]. In addition to the huge human loss, 23 HGV, 11 cars, 1 motorcycle and 2 fire engines were also destroyed[10], making the Mont Blanc tunnel fire one of the worst road tunnel accidents ever recorded.

2. Organizational: The fire accident resulted in a closer collaboration of ATMB and SITMB and the introduction of a third control and command centre.

3. Social: Increased traffic congestion due to the tunnel's closure for three years, undergoing repair and safety improvement works, after the severe infrastructure damages it had sustained due to the fire (Figure 2.9), only to re-open in 2002.

4. Human: 39 fatalities.

5. Economic: The estimates of the effects on the local Italian economy around the area of the Mont Blanc Tunnel were estimated at €1.75 billion[13].

6. Environmental: High pollution levels in the valley surrounding the Mont Blanc tunnel.

Figure 2.9 Aftermath of the Mont Blanc tunnel fire (1999).

2.2.7 Geographical extension and cross border effects

The scenario is a historic and international event (France and Italy) with clear cross-border effects (during the evolution of the accident and after it due to traffic congestion following the tunnel's closure).

[12] Dix, A, "The Fatal Burnley Tunnel Crashes, Melbourne, Victoria, Australia, Incident – 23 March 2007, 2011". (http://www.arnolddix.com/wp-content/uploads/2013/01/Dix-Report-Burnley.pdf)

[13] "Tunnel fire protection for tunnel structures & services", Promat, 2008. (https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB0QFjAAahUKEwjTnO-_nOLIAhUC8XIKHXxWDzs&url=http%3A%2F%2Fwww.promat-tunnel.com%2Fdownloads%2Fget%2Fen%2Fdef78d67-8ac7-43fa-943e-5ede00cc648e&usg=AFQjCNFkH3zozRjNP2U9O9uQ07np50rXyw&sig2=ERF73jKS0S15itOCWW-UbA&cad=rja)

2.2.8 Different organisations involved and the relation between them

The tunnel is managed by two public companies (organizations), ATMB (Autoroutes et Tunnel du Mont Blanc) in France and SITMB (Societa Italiana del Trafono di Monte Bianco) in Italy, each responsible for approximately half of the tunnel length.

Both the tunnel operating companies along with Italian and French fire-fighters, policemen, emergency response teams and local authorities were involved during the accident.

2.2.9 Information on the historic event the scenario is based on and on similar events

The scenario is based on a historic event. Detailed information and references about the event can be found in deliverable D2.5 and in the public investigation report [10] of the accident.

Similar road tunnel accidents have occurred in the past and are summarized in Table 2.5. Even though the causes and consequences of every accident differ, these events are relevant to our study.

Table 2.5 List of important road tunnel fires.

Year	Tunnel	Country	Tunnel length (m)	Fire duration	People	Vehicles	Structure
1949	Holland	USA	2,550	4	66 injured	10 trucks, 13 cars	Serious
1978	Velsen	Nederlands	770	1h 20min	5 dead, 5 injured	4 trucks, 2 cars	Serious
1979	Nihonzaka	Japan	2,045	159	7 dead, 2 injured	127 trucks, 46 cars	Serious
1982	Caldecott	USA	1,028	2h 40 min	7 dead, 2 injured	3 trucks, 1 bus, 4 cars	Serious
1983	Pecorila Galleria	Italy	662	-	9 dead, 22 injured	10 cars	Limited
1993	Serra Ripoli	Italy	442	2h 30 min	4 dead, 4 injured	5 trucks, 11 cars	Limited
1995	Pfander	Austria	6719	1h	3 dead, 4 injured	1 truck, 1 van, 1 car	Serious
1999	Mont Blanc	France/Italy	11,600	53h	39 dead	23 trucks, 11 cars, 1 motorcycle, 2 fire engines	Serious (closed for 3 years)
1999	Tauren	Austria	6,401	15h	12 dead, 49 injured	14 trucks, 26 cars	Serious (closed for 3 months)
2001	St. Gottard	Switzerland	16,900	Over 2 days	11 dead	2 trucks, 23 vehicles	Serious
2003	Baregg	Switzerland	1,390	-	2 dead, 21 injured	4 trucks, 3 fire engines	Serious
2006	Viamala	Switzerland	760	-	9 dead, 6 injured	1 bus, 2 cars	-

2.3 Festival

This scenario is a mixture between several incident and some added ideas.

2.3.1 Location of the scenario

An outdoor dance festival situated to the south of a residential suburb of Antwerp, the river Scheldt and main road transport infrastructure (highway, tunnel and secondary roads). The 65.000 festival attendees are typically aged between 16 and 35 years old.

Figure 2.10 Top: Location of the festival (red area), Bottom: Pictures of the festival crowd.

2.3.2 Overall type of the initial event and type of the impact

The initial event was a ship collision with fire and release of toxic gases threatening the life and health of the festival attendees. The different potential consequences, sorted per type of impact, are presented in Table 2.6.

Table 2.6 Potential consequences.

Technical:	Quayside infrastructure, vicinity of buildings (palace of justice) and highways + tunnels in effect area.
Organizational:	Complex coordination of local authorities, fire brigade, health workers, police, port authorities and government environmental agency. Evacuation of potentially 60.000 – 100.000 people.
Social:	Panic in crowds, social unrest when people realize such hazardous materials are stored and transported so close to a city of approximately 500,000 people. Should the product detonate serious damage would be caused in a big part of the city with thousands of casualties.
Human:	Thousands of people suffering from chest pain and acute breathing problems, panic in crowds.
Economic:	Blockage of the river traffic.
Environmental:	Impact on the river fauna and flora when Ammonium nitrate dissolves in water: algae will flourish due to this pollutant.

2.3.3 Description of the initial system including more details on the initial event

A warm, sunny Friday afternoon in September sees people shopping in the city, sitting outside on terraces in bars and restaurants. 65.000 revellers are at a music festival just south of the city. At the same time, a trial of suspected terrorists is taking place at the local courthouse. 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 refuse to move and continue to enjoy the live music at the festival.

A ship transporting 4000 tons Ammonium nitrate (NH_4NO_3, UN 2067) approaches the festival site via the nearby river Scheldt. 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 catches fire (seemingly through a self-sustained decomposition, SSD) and the captain calls marine traffic control for help.

2.3.4 Description of the course of events

The fire brigade orders preventive evacuation of the production village, which is in the effect zone of the ship fire. According to the evacuation simulation in T3.3 this evacuation is expected to take 10 minutes from the initial alarm signal.

The fire brigade uses thermal cameras and measure the temperature of the cargo is at 180 ºC. They decide to use lances to cool the cargo with water. Cooling is expected to take up to 10 days. The fire brigade carefully monitors the cargo temperature during this cooling to measure the effectiveness of the cooling.

Figure 2.11 Situation map of the initial incident.

2.3.5 Cascading effects, dependencies and systems involved

The ship’s engine overheats and catches fire. The fire causes oil to be spilt in the ship's hold with a risk of the fire spreading to the hold. Efforts to cool the cargo are unsuccessful (temperature has reached 200 °C) and the self-sustained decomposition process cannot be stopped. There is an immediate danger of detonation of the Ammonium Nitrate.

Due to the risk of an explosion the fire and rescue services decides to evacuate the entire festival site, as well as all buildings within two kilometres of the incident.

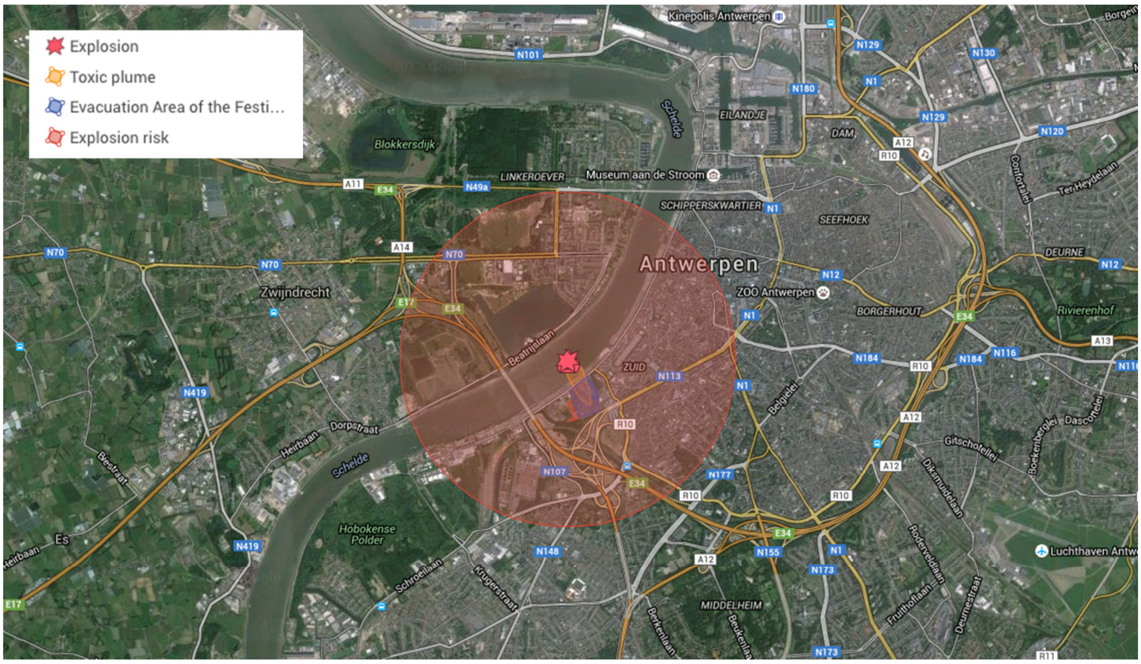

Figure 2.12 Situation map of cascading effect indicating blast area with potential fatalities.

System dependencies

- Availability of adequate egress routes: one evacuation route is blocked by the smoke and an alternative evacuation route is inaccessible due to the immediate threat of firework explosion in the egress route.
- Availability of traditional crisis communication channels towards the public: routine festival radio & TV messages 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), risk of panic and consideration of time & resources needed should incident escalate (terrorist attack);
  - High level of coordination between emergency response agencies (ship threat & large scale evacuation), festival organizers, local & port authorities and regional agency for ship traffic control;
  - Organisation of shelter and accommodation for evacuees;
  - Crisis communications between IC, relevant emergency managers and 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.
- Traffic control: Highway and tunnel underneath the river Scheldt need to be sealed off and traffic rerouted away from the incident.
- Dilemma for the Incident Commander: either let the Ammonium Nitrate ship sink (and pollute the river for years and obstruct shipping for months or try to tow ship away with SSD reaction on-going risk of explosion and possible fatalities amongst emergency responders and wider population.

2.3.6 Actual consequences and possible consequences

Actual

Large scale evacuation of an open air festival. Thousands of victims with breathing problems needing treatment. Media clamour for information and speculation about incident.

Potential

- Explosion of Ammonium Nitrate ship.
- Thousands of casualties anticipated as a result of explosion(s). Tens of thousands of victims with burns, superficial and more serious injuries e.g. 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 evacuation of prisoners at court house.
- Looting and violence following the disaster due to insufficient police resources to close down such a large area. Involvement of the military to support evacuation, sheltering and security control.
- Closure of a significant part of the city and central highway between Gent and Antwerp for a long time period.

2.3.7 Geographical extension and cross border effects

Initial scenario would be local. With escalation scenario immediate impact would be regional. Cross border effects due to traffic restrictions for ships that need to travel from the Netherlands to upstream the river Scheldt. Road transport disruption as this part of the highway is the most congested highway in Belgium on the crossroad of the Netherlands, France and the UK. Impact on industrial activity in the port will be severe and might lead to companies shifting economic and production activities abroad.

2.3.8 Different organisations involved and the relation between them

See the description of the civil aid services in the Scheldt scenario. In addition for this scenario the following organisations would be involved:

- Regional: Flemish Ministry of Waterways
- Governor of the Province of Antwerp
- Port Authorities of Antwerp
- Experts from the private industry: Belintra (BASF) for expertise on the hazmat and emergency response procedures
- Team-D5: the social media monitoring team of the ministry of interiors
- Ministry of Defence

2.3.9 Information on the historic event the scenario is based on and on similar events

The scenario is a combination of three historic incidents with some modifications:

- 2007 - Pukkelpop Hasselt (Belgium): evacuation of music festival due to severe weather, tent collapse with 5 fatalities and > 300 victims[14].

[14] Mertens, P., "How thunderstorms at Pukkelpop 2011 stimulated Belgium's use of social media for disaster response", For Disaster 2.0, ibz Intérieur Binnenlandse Zaken, 05.11.2012, http://repository.disaster20.eu/sites/default/files/Peter%20Mertens%202012%2011%2005_How%20Pukkelpop%20stimulated%20SMEM_D2.0%20Birmingham.pdf.

- 2013 - Wetteren (Belgium): hazmat train accident near a village leading to the total evacuation of the village for days with over 30 victims and 1 fatality[15].
- 2007 - Ostedijck near Estaca de Barres (Spain): ship carrying 6000 ton NPK fertilizer with an SSD reaction resulting in 11 days of fire[16].

Next to the above scenario's other incidents relating to evacuation problems at festivals and other Ammonium Nitrate incidents or other hazmat transport incidents near residential areas are relevant, e.g.:

- 2010 - Love Parade, Duisburg (Germany)[17]
- 2000 – Roskilde (Denmark) and other historical festivals disasters are available[18]
- 2013 - West Fertilizer Company explosion, West, Texas (US)[19]
- 1947 – Port of Texas City, US http://en.wikipedia.org/wiki/Texas_City_disaster
- An overview of incidents involving Ammonium Nitrate is available [20]

Some identified differences between the selected scenario and the historic events are:

- The originating incident from Wetteren was a train accident with acrylonitrile wagons on fire releasing toxic gasses in the air as well as through the sewage system of the village.
- The Pukkelpop evacuation was due to severe weather (storm) and a tent collapsing.
- The Ostendijck ship incident was offshore but illustrates the duration and extent of the effects of Ammonium Nitrate SSD (high risk component of NPK fertilizer).

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

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

[17] http://en.wikipedia.org/wiki/Love_Parade_disaster.

[18] http://matadornetwork.com/nights/10-deadliest-concert-disasters-of-the-last-50-years/

[19] http://en.wikipedia.org/wiki/West_Fertilizer_Company_explosion

[20] http://en.wikipedia.org/wiki/Ammonium_nitrate_disasters

2.4 Séchilienne

The Séchilienne scenario a fictional scenario. It is the worst expected scenario that has a very low probability after many studies and much work has been done at the site to prevent most of the effects. The following scenario does not take all of this work into account.

2.4.1 Location of the scenario

Southeast part of France, a city called Séchilienne

2.4.2 Overall type of the initial event and type of the impact

Initial event: Landslide over a road and a river while the river is already very high after a long period of heavy rains. The landslide may create a dam over the river, then generate a lake, then the dam could break and generate flooding downstream.

2.4.3 Description of the initial system including more details on the initial event

It had been raining for several days and the Romanche river reached a critical level. Moreover, some movements have been recorded within the Ruines de Séchilienne (movable part of the mountain). Suddenly, a huge part of the mountain slid down and covered the road and river at the bottom.

Type of impacts:

- technical: damage on a road, then damage due to flooding in the downstream villages, small industries, and a large industrial zone.
- organizational: loss of road communication (lost access to famous skiing stations, lost access for emergency services, congestion on road for tourists going to or coming back from skiing stations).
- social: loss of work hours in industries and for people unable to access to their work area.
- human: there could be people injured directly by the landslide and to the subsequent flooding. There could also be injured people due to fires, blasts or toxic releases in some factories.
- economic: losses due to the landslide itself (cost of removal, cost to repair the road, cost of the flood damage), then economic loss for skiing stations and for impacted industries).
- environmental: losses due to the flooding (all along the river), toxic release affecting air, water and soil.

Figure 2.13 and Figure 2.14 show the area around the Séchilienne landslide. Most of the assets are visible in Figure 2.13, specifically the road to skiing stations, the Romanche river, several municipalities concerned (Séchilienne upstream, and Vizile and Jarrie downstream). The main industrial zone (chemical factories) is located at Jarrie along the Romanche river. Other assets are shown in Figure 2.14 together with the potentially flooded area.

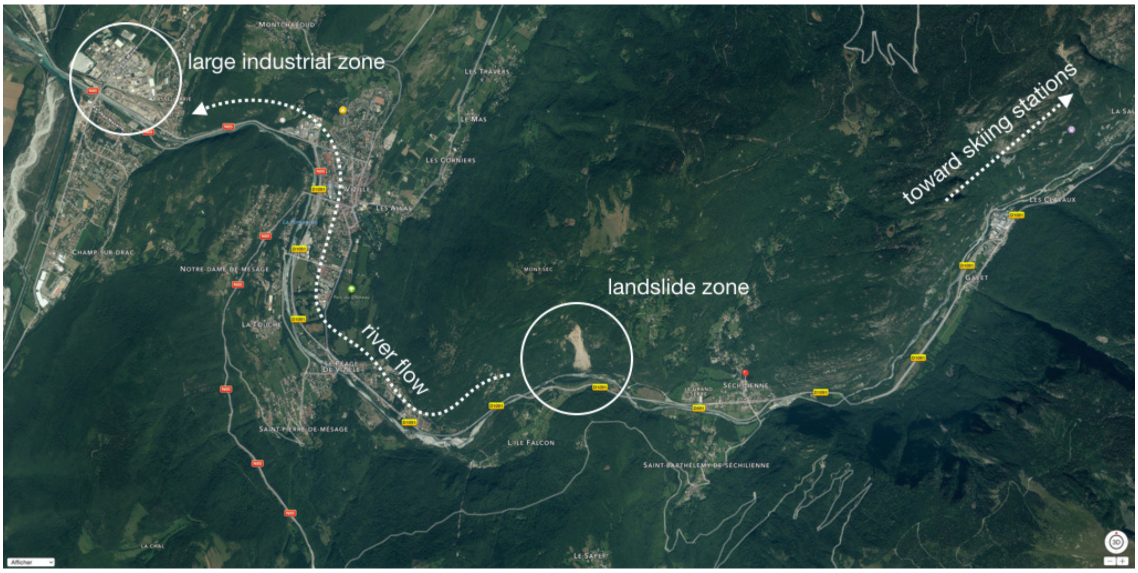

Figure 2.13 Big picture of the area around the Sechilienne landslide area.

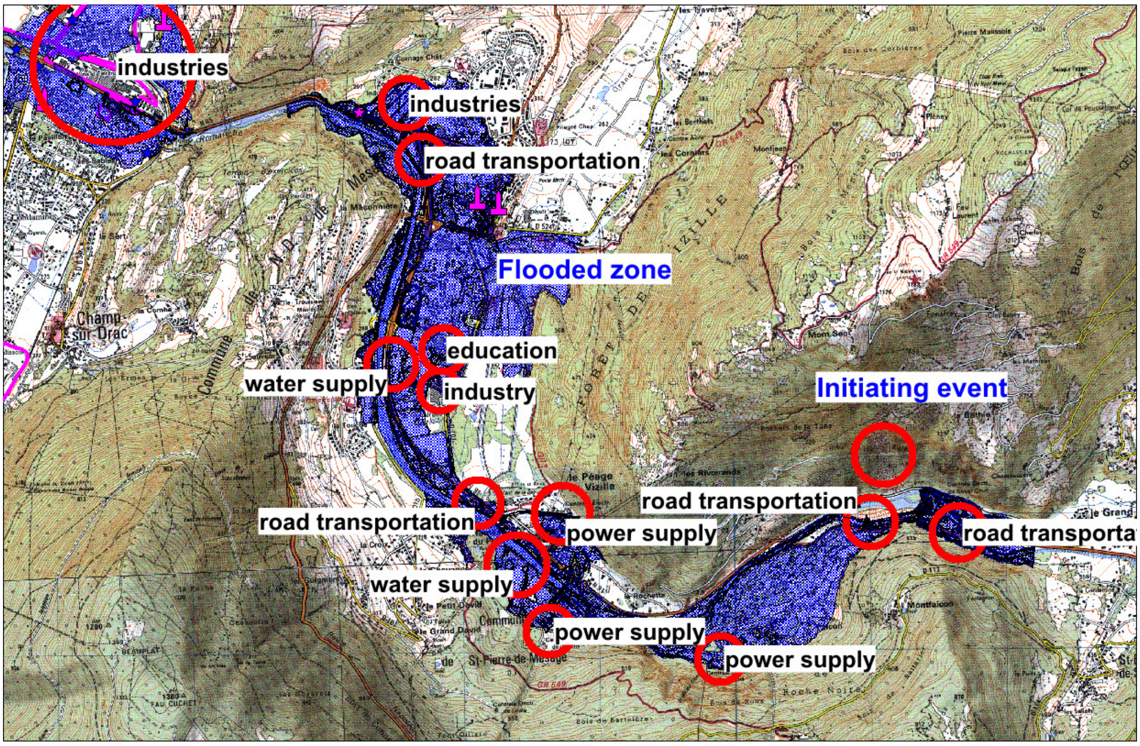

Figure 2.14 Detailed view of the main assets exposed to a flood after the Séchilienne landslide and dam rupture.

The Séchilienne landslide is now well known and several instruments were installed to record the movement of the mountain. INERIS is monitoring some of these measurements. They show that the mountain is moving significantly, especially after rainy periods. An increase of movement was noticed in the recent period with displacements of more than 3 m/year at some parts of the mountain. Several collapses have already occurred in the area such as shown in Figure 2.15.

Figure 2.15 On 24/01/2004 a 200-ton rock fall occurred on road RN91 (now called RD 1091), which blocked this national road for more than 24 hours and imposed traffic deviation, while many people were travelling to ski stations (pictures from L. Cassagne, Irma[21]).

2.4.4 Description of the course of events

- Technical authorities record high movements over the alarm threshold. They inform the Prefecture about it;
- a part of the mountain (around 3 million m^3) suddenly collapses over the river (a thickness of 16m is observed at the river, 5m at the road);
- a lake is created behind the dam formed by the landslide
- a second landslide may create an accidental wave
- the dam breaks
- a flood occurs downstream reaching Vizille and Jarrie villages
- it reached several SME companies and a commercial area (Vizille) as well as a major industrial site at at Jarrie.

2.4.5 Cascading effects, dependencies and systems involved

Most of the expected consequences are the result of a flooding caused by the rupture of the dam which may have been created by the landslide over the river. All activities located in the flooded zone may be impacted.

The main system to be impacted is the road transportation system because there is no alternative road to access to some part of this region. As a result, public systems, several SMEs (Industry systems), and education system may be affected as well as emergency and health care systems due to the traffic cuts. If the dam created by the landslide breaks, a flood can affect downstream assets. Then the downstream public system will be affected (flooded houses), transportation system will be affected, some accidents may appear in industries (fires, blasts, pollution or toxic releases) depending on their level of protection and the efficiency of their protecting measures. Water supply may be interrupted or water be polluted. Some hydraulic power supply units may also be interrupted If such industrial accidents occur, it may have consequences on other industrial facilities, on the public systems and so on.

[21] http://www.irma-grenoble.com/05documentation/04dossiers_PJ.php?id_PJ=216&id_DT=1&PHPSESSID=8f476d36cbaa8d852bbd534014cd84a3

2.4.6 Actual consequences and possible consequences

In the case of an accidental collapse of a landslide over an inhabited area with traffic and eventually river passing through the valley consequent effects can be listed as such:

- Short-term (immediate) effects:
  - human casualties
  - economic impact (damages in the road, river arrangement, habitations and industrial infrastructures).
- Long-term effects:
  - socioeconomic impact (limited access to a main traffic axe, reorganization of industrial and inhabited areas)
  - ecologic impact (high-pollution levels in the valley downstream to the landslide area).

2.4.7 Geographical extension and cross border effects

This scenario is local/regional. To some extent it can be considered as national and international because of the touristic activity which will be affected. No direct cross border effects

2.4.8 Different organisations involved and the relation between them

- Seven Local communities directly concerned (Séchilienne, Saint- Barthélémy-de-Séchilienne, Vizille, Saint-Pierre-de-Mésage, Notre- Dame-de-Mésage, Jarrie et Champ-sur-Drac). They are concerned with the safety of people and protection of assets on their territory. They have to provide assistance such as opening of rooms for the grouping of evacuees, food and water supply to inhabitants.
- Regional authority (Prefecture) is in charge of relief operations all over the impacted area. It has to coordinate all emergency services involved.
- Ministry of Interior through the COGIC (Center for Crisis Management at a national Level). Will be informed and may provide assistance in emergency management.
- Local and regional emergency services (fire brigade, hospitals).
- CEREMA, which is a regional expert center depending on the Ministry of Ecology, in charge of the monitoring of the landslide and to raise alarm in case of significant signs of movements.
- Expert group dedicated to this landslide
- INERIS as a national expert also involved in the monitoring of the landslide
- Local communities directly concerned if impacted.
- Several factories and companies directly concerned in case of flooding
- Skiing stations potentially impacted in case of communication disruption

All these organizations have plans to operate together in case of accident.

2.4.9 Information on the historic event the scenario is based on and on similar events

This scenario is not based on an historic event but has been suggested by a group of expert as a possible scenario. After mitigation works been carried out on site, the probability of this scenario has been significantly reduced.

There are several historic events involving landslides such as the Malpasset Accident (1059), south of France, which was ignited by a dam collapse and induce more than 400 killed people

40 km away at Frejus city. In Italy, the accident of the Vajont dam in 1963, was due to a landslide in an artificial lake behind a dam. Two waves of 25 million m^3 each submerged the dam and killed around 2000 people.

This is not a real incident scenario, but the worst expected one with a very low probability after many studied have been carried out and many works having been carried out at the place to prevent most of the effects. The following scenario is not taking all these works into account.

2.5 Nut warehouse blast

2.5.1 Location of the scenario

Weedeon Bec, Northamptonshire, England, in an industrial park near a highly populated area.

2.5.2 Overall type of the initial event and type of the impact

This was a large industrial fire. Run-off from firefighting water contaminated with peanuts oil threatened to contaminate a major water supply plant. An aggressive strategy against the fire required a high volume of water that could not be found nearby. Containment of the fire water run-off involved using a local pond with ornamental fish in it. Initially the pond was not used due to fear of damaging the fish. The pond was used after it was discovered that it was originally constructed to contain industrial spills.

2.5.3 Description of the initial system including more details on the initial event

On 26th June 2013 at 3.21, a witness called 999 to require the Fire Brigade. Flames were spotted coming from a nearby industrial estate. The warehouse was storing peanuts from India to be used as bird food and was and unusual experience for NFRS due to the fuel (peanut oil) and potential cascading effects on public health and environmental damage.

Figure 2.16 The warehouse after the fire.

2.5.4 Description of the course of events

Early in the incident it was found that the firefighting water run-off was entering a pond that contained Koi Carp (an alien fish species). This was in fact a balancing pond that was a planning requirement for the industrial estate to be built. The balancing pond was required to contain any effluent leaving the site that would and would prevent the effluent from entering the water course and contaminating the drinking water supply for a large city population.

2.5.5 Cascading effects, dependencies and systems involved

The initial cascading effects were thought to be the water run-off endangering the fish, which presented a potential reputational risk to NFRS. A critical decision was made to cease using firefighting water to extinguish the fire and instead take a defensive stance and allow to the fire to burn. This decision presented the cascading effect of a large smoke plume travelling across the county with the potential for causing health risks to the population, especially the vulnerable inhabitants of the community. The smoke also caused major roads to be closed and traffic diverted. By ceasing offensive firefighting operations to limit danger to the fish in the pond, other more serious social, political and economic effects could have occurred. After approximately one day, it was established 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.

2.5.6 Actual consequences and possible consequences

The potential consequences were as described above. The actual consequences were reputational (political/social), involving NFRS and other agencies, and also impacting the capacity of these services to respond to other incidents.

2.5.7 Geographical extension and cross border effects

The scenario was local but fed into national agencies.

2.5.8 Different organisations involved and the relation between them

All of the following agencies were either involved with the emergency or consequence management, either as a responder or as an enforcing authority: fire and rescue, police, Environment Agency (EA), local authorities (County and District Councils), water company, gas supply company, electricity supply company, and Public Health England.

2.5.9 Information on the historic event the scenario is based on and on similar events

The Nut warehouse blast scenario is based on a real industrial fire that happened in Northampton, UK. More information from a media point of view can be found on the Internet. A full story coverage was held by BBC for a month period, due to environmental consequences. Also local newspapers followed it, publishing updates and official communications.

2.6 The Skatås wildfire

2.6.1 Location of the scenario

The Skatås forest is located in a natural park around lakes Stora Delsjön and Lilla Delsjön east of the city of Gothenburg on the west coast of Sweden. Skatås natural park is very popular for hiking and training (running tracks). See
Figure 2.17 for a vicinity map of the site.

2.6.2 Overall type of the initial event and type of the impact

Children were playing with matches and ignited a forest fire. The weather had been warm, dry, and windy for several weeks prior to the event so the conditions were favourable for ignition of a fire that spread quickly. The direct impact of the fire was in the form of flames, heat and smoke affecting the fire and rescue responders and smoke blowing into residential areas of Gothenburg, including a large hospital.

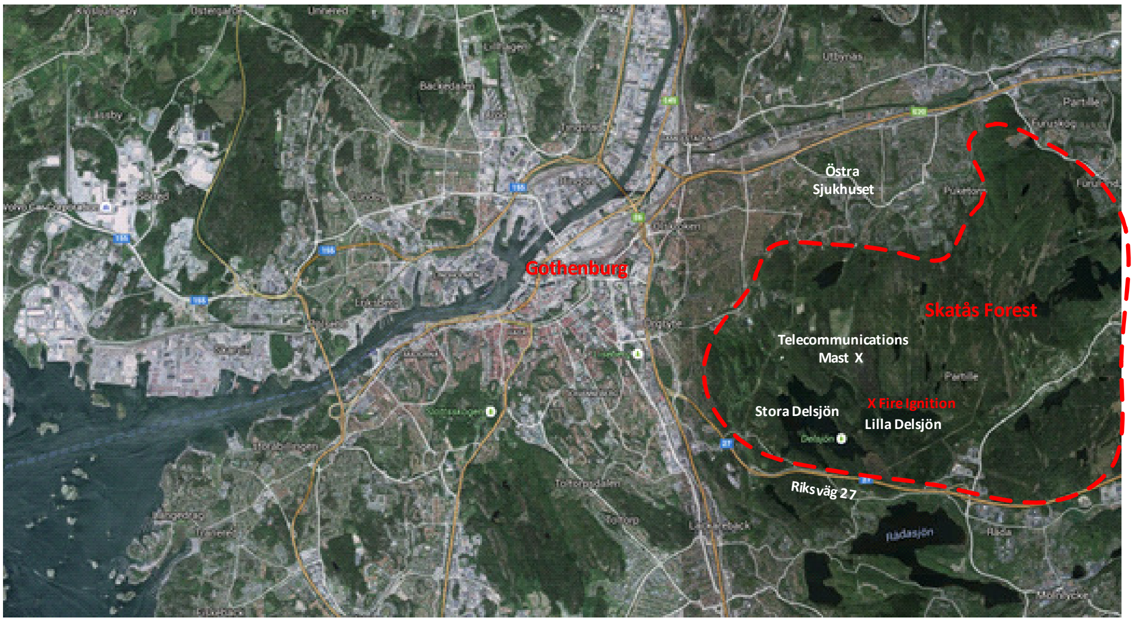

Figure 2.17 The Skatås forest to the east of the city of Gothenburg and around the lakes Stora and Lilla Delsjön.

2.6.3 Description of the initial system including more details on the initial event

The wind speed on the day of the incident was 15 m/s and the wind direction was from the south-southeast. 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 low moisture content of the fuel and rapid fire spread. The fire spread rapidly in the direction towards critical infrastructure (a nearby communication mast for radio, telephone and television was directly in the path of the fire), a large hospital, residential areas, and Gothenburg city.

2.6.4 Description of the course of events

Due to the weather conditions and availability of dry forest fuels the fire spread rapidly in a northerly direction towards the communication tower and Gothenburg city. Not far from the forest there are residential areas and one of the largest hospitals in the city. A few hours after the fire started the residential area and the hospital is inundated with smoke. The lakes near the starting point of the fire are reservoirs for drinking water for the residents of Gothenburg; therefore care was needed to avoid contaminating the water with run-off from firefighting operations.

Firefighting water was taken from local hydrants and the supply of water brought by the fire and rescue service and also from Delsjön, and Härlandsjön, which are lakes at the northern boundary of the fire area. Operations to protect the cable stays supporting the telecommunications tower were negatively affected as a result of shortages of water. There was great concern for the staff of the telecommunications tower as well as the safety of the buildings around the telecommunications tower because of the risk for fire to affect the cables supporting the tower, potentially leading to collapse. Inspection of the stays after the incident revealed, however, that they were only moderately heated.

During the incident, police went through the forest on motorcycles, using the dirt roads, to evacuate members of the public who were in the area. The emergency radio communication system was not working properly so communication was managed by telephone and by direct contact between the incident commander and the rescue crews as he moved throughout the area.

Two fire breaks were built to obstruct the northern (leading) edge of the fire, which successfully contained the fire until it was extinguished.

The following timeline includes only the events of interest to this project. When times are given they have been rounded to the nearest 5 minutes. The total incident response time was 72 hours 22 minutes.

- 11:25 The first call to emergency services was made.
- 11:25 to 16:00 The fire spread rapidly and uncontrolled to north of the telecommunications tower, which is indicated in
- Figure 2.17.
- 11:50 Fire and rescue, police, and ambulance have arrived at the scene.
- 12:20 Emergency responders focus on protecting the telecommunications tower.
- 12:20Telecommunications personnel turn off equipment and evacuate the premises.
- 12:30 Police helicopters were used throughout the incident to monitor the spread of the fire.
- 13:20 Instructions for closing windows, doors and ventilation were given directly to the security people working at the hospital located downwind of the fire.
- 13:30 The incident commander sent out a public announcement (VMA) with information that the fire had broken out and that smoke was traveling towards the urban area. The notice included instructions for people to stay inside and close windows, doors and ventilation.
- 13:45 Prehospital catastrophic medical centre (PKMC) decided not to send patients in ambulances to this hospital. In addition to this, 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.
- Reinforcing units were assigned the task of establishing a boundary line north of the fire.
- 16:00 Fire spread contained.

- Same day- The fire controlled. However, small fires continued to burn locally and efforts continued to extinguish them.
- 11:00 the following day (the 30th of April)- rain fell and helped with the remaining extinguishing and cooling efforts.
- April 30 to May 1 The fire and rescue service stayed on site with their equipment.
- May 1 to May 2 The Gothenburg parks department inspected the area in the evening and again in the morning.
- May 3 to May 5 The fire and rescue service left their hoses in place until after the weekend.

2.6.5 Cascading effects, dependencies and systems involved

The decision to avoid fighting the fire near the lakes, which could be contaminated due to polluted firefighting water, was made early in the response. The initial focus was twofold: evacuating civilians from the fire area, and protecting the communication tower. If the hydraulic systems for the supporting cables for the tower were compromised by the fire, it could fall and damage other structures and possibly harm people. Also, communication would be impaired if the tower no longer functioned.

Residential areas and a large hospital were inundated with smoke and were in the path of the spreading fire. The hospital chose to divert ambulances to other hospitals (which impacted the other hospitals as well as travel time for people using the ambulances), close the ventilation system and get ready to evacuate some or all of the patients. Residents in the affected areas were advised to close their windows, doors, and ventilation and to stay inside.

2.6.6 Actual consequences and possible consequences

The real consequences of the incident were limited. 2.88 km^2 of the forested area were affected by the fire and one fire fighter was injured. There was no interruption to service in the hospital or the telecommunication tower, however workers at the telecommunication tower were evacuated and the hospital did close external ventilation and made plans for evacuation.

Actual Consequences:

- Civilians from Skatås natural park were evacuated.
- Staff from the communication tower were evacuated.
- One fire fighter was hurt by smoke and flames.
- Ambulances were diverted to other hospitals.
- The hospital ventilation system was closed.
- The hospital prepared to evacuate patients.
- Residents in the affected areas closed their doors, windows, and ventilation and stayed indoors.

Possible consequences:

- The drinking water is contaminated.
- The communication tower collapses, damaging several other structures and harming people.
- Communication is impaired due to the collapse of the communication tower.
- The hospital must evacuate some or all of the patients.
- The residential areas downwind of the fire must be evacuated.
- The fire spreads to the buildings in the city, possibly including the hospital and homes that were evacuated.

- The fire disrupts road traffic, which impairs mutual aid coming from other fire and rescue brigades.
- The disrupted road traffic inhibits access to the airport, which affects air transport of both people and goods.
- The fire disrupts rail traffic, affecting rail transport of people and goods.

2.6.7 Geographical extension and cross border effects

This event was local with regional cross border effects due to the service area of the large hospital.

2.6.8 Different organisations involved and the relation between them

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.

These organisations cooperate with each other at the scene of the event and also through support staff. The fire brigade routinely requests aerial support from the police for enhanced situational awareness.

2.6.9 Information on the historic event the scenario is based on and similar events

This scenario is based on a real event taking place on April 29, 2008. The event described above was relatively small and was contained before it caused serious problems, but there were many opportunities for impacting other systems.

Historically, there are many wildfires every year in most parts of the world that start in forests but spread to threaten the built environment. These fires are called wildland-urban interface (WUI) fires. Sometimes WUI fires can become quite large and destroy many structures and cause human casualties. The following text describes some scenarios that are potentially associated with WUI fires, but did not occur during the Skatås Wildfire.

The *Witch Fire* (also called the Witch Creek Fire) started in a canyon in the San Diego, California area on October 21, 2007. The cause of the fire was sparks from an arcing electric line. The *Guejito Fire* started about 12 hours later, also from electrical lines. The high wind caused electric lines to either arc amongst themselves in one case and blew conductive material into the wires in the other case. These two fires converged on the community of Rancho Bernardo about 2 hours after ignition of the Guejito Fire 10 km away. Flying embers from the fire front arrived at the community about an hour before the fire. The relative humidity and wind speed in the area were 30 – 40 % and 35 – 70 km/h, respectively, at the start of the fires and the humidity dropped to around 8 % and the wind increased in excess of 90 km/h later[22]. The terrain through which these fires burned prior to encountering the community is very rugged and difficult to defend. There were 274 homes in the community most affected by the fires, and 245 homes within the fire perimeter. 74 homes were completely destroyed and 16 were partly damaged. Forces from the San Diego fire department, police, and homeowners prepared for the arrival of the fires at the community that was directly in its path, most of the

[22] Maranghides, A., Mell, W., "A Case Study of a Community Affected by the Witch and Guejito Fires", National Institute of Standards and Technology, NIST Technical Note 1635, pp. 60, 2009.

residents were evacuated from the area. Other San Diego fire fighters were sent to the Guejito fire. This real scenario illustrates the hazard of responding to simultaneous fires that are caused by the weather conditions.

The *California Rim Fire* started on August 17, 2013 in the Stanislaus National Forest north of Yosemite National Park and east of the San Francisco Bay Area in California. A total of 2573 hectares was consumed. Over 5000 fire fighters worked to contain the fire. There were no fatalities (but 10 injuries) and 112 buildings were destroyed, including 11 residences. The fire was contained after 9 weeks, and took over a year before declared "out"[23]. There were numerous factors that contributed to the severity and thus the consequences of this fire. First, policies were in place that encouraged quick suppression of small fires, thus allowing build-up of fuel on the forest floor. Second, drought conditions and higher than normal temperatures had been in place for several years (and still exist today). And third, the wind kept changing direction, which caused firefighting efforts to be largely reactive. Thousands of people were temporarily evacuated, a major highway that crosses the Sierra Nevada mountain range was closed, smoke caused poor air conditions in Reno, Nevada and Lake Tahoe during the first week (outdoor events were cancelled and children were sent home from school). A State of Emergency was declared by California for San Fransisco after 6 days, due in part to closure of two hydroelectric power plants and because the fire burned within 1.6 km of Hetch Hetchy reservoir, which provides 85 % of San Francisco's water. Water was moved to downstream reservoirs as a precaution.

The *Cedar Creek Fire* near San Diego, California, started on October 25, 2003. It was driven by Santa Ana winds and burned 280,278 acres (2803 hectares) 2,820 buildings (including 2,232 homes) and killed 15 people including one firefighter before being contained on November 3. At that time is was largest of 15 major fires burning in the San Diego area; the combined fires are referred to as the "*2003 Fire Siege*" that strained firefighting resources far beyond their capacity[24]. After containment the Cedar Fire continued to burn within its perimeter for a little over a month, until it was 100 % controlled on December 5. The fire started in the Cleveland National Forest and response was quick but failed to control it, in part because air resources were minutes from dropping their load on the fire but were turned back because the policy at that time did not allow flying within 30 minutes before sunset[25]. During the night the fire killed 12 people, burned 39 homes, and spread 50 km. It continued to spread over the next 8 days before containment. Very strong Santa Ana winds caused fire to spread to the west; when winds died the fire turned and spread easterly, destroying another 500 homes. Major highways were closed. A fire company was trapped. One firefighter died and three others were injured. The fire forced the evacuation of the main air traffic control facility for arriving and departing aircraft in the San Diego and Los Angeles areas, shutting down all commercial and general aviation in the region and disrupting air traffic across the United States.

[23] See http://inciweb.nwcg.gov/incident/3660/ for details.

[24] Blackwell, J. A., Tuttle, A., "California Fire Siege 2003: The Story, Multi-Agency Coordinating System (MACS) group, pp. 99, 2004.

[25] The 2003 San Diego County Fire Siege Fire Safety Review, pp. 58, 2003. This report documents issues, findings, and recommendations from a stakeholder workshop held on November 20, 2003.

2.7 Power blackout scenario

This scenario describes a power blackout in the Netherlands and in Belgium. This cross-border scenario is fictive, but the potential impacts are based on real-life large power outages in Europe and North-America in recent years. [26]

2.7.1 Location of the scenario:

A combination of severe winter weather and a failure of a critical component at power distribution station Kreekrak in the Netherlands causes this station to break down (see Figure 2.18). As a result, after some time, the power distribution station Zandvliet in Belgium also breaks down[27]. These two power distribution stations connect the Dutch power grid with the Belgian power grid. This results in a severe black-out in the south-west part of The Netherlands and the north-west part of Belgium.

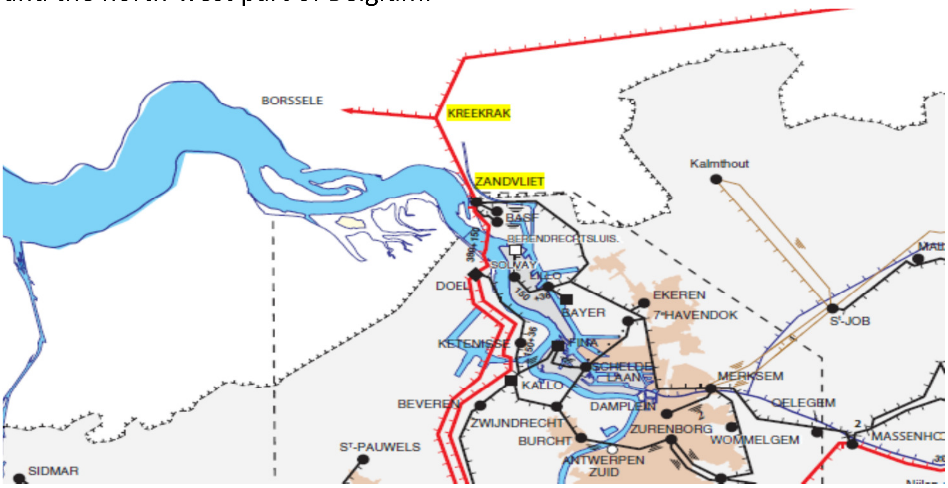

Figure 2.18 The 380 kV power grid around transmission stations Kreekrak and Zandvliet, north of Antwerp, Belgium.

2.7.2 Overall type of the initial event and type of the impact

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 and food supply etc. The failures ultimately lead to the separation of the Dutch system from the Belgian system.

Over the last 10 years, a big investment has been made by power distribution companies and governments in the region to make the power infrastructure severely storm proof. As a result it is less likely that large wind gusts knock over power masts, but "dancing of wires" is observed from time to time at Dutch and Belgian power lines, especially in case of ice storms.

A regional blackout lasting more than several days (>48 h) 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[28]. Hence,

[26] Magazine nationale veiligheid en crisisbeheersing 2015 - nr.3

[27] 2010-2016 Kwaliteits- en Capaciteitsplan tabel 3

[28] Power Blackout Risks Risk Management Options Emerging Risk Initiative – Position Paper

the prolonged black-out, especially in combination with the severe winter weather, causes severe cascading effects in multiple systems. See chapters 2.7.4 and 2.7.5 for a complete overview of the course of events and all affected systems.

2.7.3 Description of the initial system including more details on the initial event

A blackout is the total loss of power to an area and is the most severe form of power outage that can occur. Blackouts which result from or result in power stations tripping are particularly difficult to recover from quickly[29]. Deliverable D2.3 provides a generic overview of which other systems can be affected by cascading effects from a failing power system.

In this scenario a failure in a critical component causes the power distribution station Kreekrak in the Netherlands to break down. It affects after some time the Belgian power station Zandvliet. In general, outages may last from a few minutes to a few days depending on the nature of the blackout and the configuration of the electrical network. In this scenario, it will take 2½ days to re-establish electricity to the provinces affected.

It can be stated that the power supply system is highly relevant when it comes to cascading effects. Out of all the pairs of originators and dependencies, the power supply system is the most frequent originating system. It is also one of the systems that will get hit the first by initiating events, such as storms, earthquakes, flooding, fires or internal failures[30]. Another characteristic of failures in the power supply system is that it will affect dependent systems rapidly, with an average of 4 hours in the studied cases.

The power supply system has the potential to affect most systems, but there are five systems that have been found more likely: the public, business and industry, telecommunications, health care and water supply, in that order. Few or none of the effects have been reported with regards to district heating, air and sea transportation, environment, political or food supply[31].

2.7.4 Description of the course of events

This chapter describes the scenario in chronological order. Although the weather is not the initiating effect of further cascading effects, this chapter starts with describing the weather change, because of its big influence on the course of events and greatly increases the effects in affecting systems once the power outage occurs. Furthermore, this winter weather already affects the road networks and general life even before the black-out occurs.

When this scenario is played out in an IET test-session in WP5, the course of events - once the blackout has started and the strategic command structure in both The Netherlands and Belgium is set up (i.e. the targeted users of the IET) - is subject to change, because these events are partly dependant on decisions made/not made by the test-participants.

Tuesday, December 27th, time 15.31, temp: +4 degrees C., wind West, Visibility 3-5 km

Warning for extreme weather is announced by the Dutch and Belgian Meteorological Institute. A very low pressure area is approaching from the West. It will bring heavy snowfall on Wednesday.

[29] According to the Belgian Royal Decree 18.09.2012 a loss of 2000MW is the benchmark for a black out on Belgian territory

[30] CascEff Case studies

[31] CascEff Case studies

Time 17.00

The Dutch meteorological Institute[32] announces code yellow for the Dutch coast region because of the expected heavy snowfall in the night to Wednesday. This will stay on for several days. The Royal meteorological Institute[33] of Belgium announces code yellow for the Flanders region.

Code yellow: The general public should be aware that bad, dangerous weather is likely (i.e. chance > 60%) to occur within 48 hours.

Wednesday, December 28th, time 08.00, temp: -2 degrees C., wind West, Visibility poor

The weather is getting worse. The temperature is below 0 degrees C. Heavy snowfall has arrived in the Western part of both countries, only major roads are expected to be passable.

The Dutch meteorological Institute announces code red for the provinces Zeeland and Noord Brabant.

Code red: Extreme weather conditions will occur within 12 hours with great societal impact and/or big safety risks; the general public must take action to avoid risks like stay indoors.

The Belgian Meteorological Institute gives a severe weather warning for the Flanders and Antwerp area.

Military air bases are closing down due to the severe weather and visibility conditions.

In the Netherlands, Amsterdam (Schiphol) - and in Belgium Brussels International (Zaventem) airports have at this time only one runway available for arriving and departing airplanes.

Time 16.30

In the Netherlands there is chaos on the main roads, there is a traffic jam with a total of 800 kilometres around 16.00. In the Antwerp region some traffic road incidents occur because of the heavy snowfall. Traffic in this region comes to a halt.

Around 16.30, it's already dark, a failure in a critical component causes the power distribution station Kreekrak in the Netherlands to break down.

Additional information about TenneT and the weak-spot Kreekrak:

> *The power connection Borssele (where the only Nuclear Power plant in The Netherlands is situated) and Zandvliet (Belgium) as well Borssele and Geertruidenberg (multiple power plants situated) is known by the Dutch authorities and the power infrastructure company TenneT as a fragile power connection if it fails and breaks down. Planned is that in 2017 these connections are 'failsafe', assuring that if one connection fails, another connection can completely take over. Currently, the impact of a failure in 380 kV connections can result in escalating failures within the grid[34]. Very high energy transport will seek its way over the grid and possible into 150kV connections, not designed to withstand these high energy peaks.*
>
> *The Dutch company TenneT[35] transmits electricity via the high-voltage grid in the Netherlands and large parts of Germany. They connect producers to the regional grids which supply*

[32] Dutch meteorological Institute / Koninklijk Nederlands Meterorologisch Instituut (KNMI) and http://www.knmi.nl/kennis-en-datacentrum/uitleg/knmi-waarschuwingen

[33] Royal meteorological Institute / Koninklijk Meterorologisch Instituut (KMI)

[34] Quality- and Capacity document, Tennet 2013 (Kwaliteits- en Capaciteitsdocument).

[35] www.tennet.eu

electricity to consumers. (See for definitions within the power system Figure 2.19 and for TenneT's infrastructure Figure 2.20). All systems dependant on electrical power in the Netherlands and these parts of Germany are thus dependant on the functioning of TenneT's power infrastructure. Note that Germany is not directly impacted in this scenario.

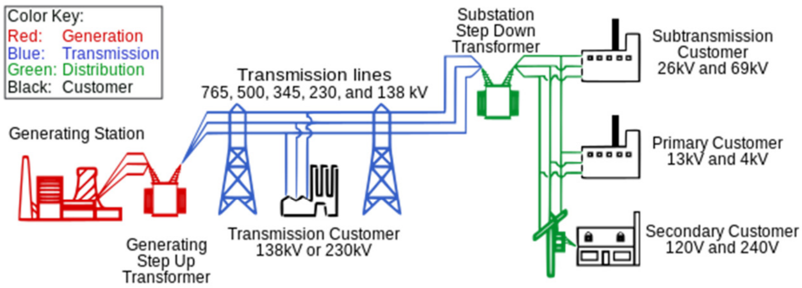

Figure 2.19 Diagram of an electric power system.

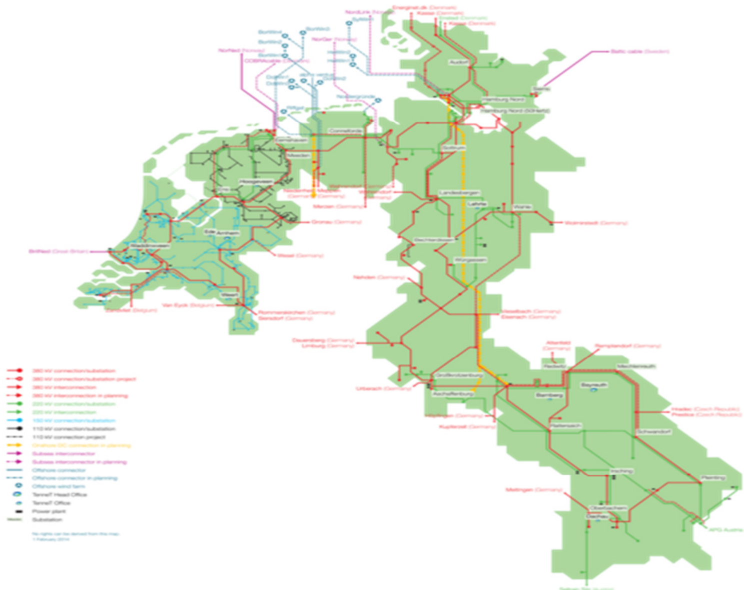

Figure 2.20 Map of Tennet's power distribution system in the Netherlands and parts of Germany.

Time 16.50

Around 16.50 TenneT fails to restart remotely the power station Kreekrak. They monitor that the province Zeeland suffers from the outage. A team is under way but suffers from the heavy snowfall on the roads. They are expected to arrive at 18.30. It's not possible to fly in by helicopter because of the poor visibility. TenneT informs the safety region Zeeland of the present situation.

Time 17.00

The safety region Zeeland (number 19 on the map in Figure 2.21) announces the GRIP 3 procedure (Coordinated Regional Incident-Management Procedure runs form GRIP 1 to 5 and even the highest Governmental level GRIP State)[36].

GRIP 3 means: Threatened well-being of (large groups of) the population within a wider affected area.

It requires that a regional operational team of all emergency services will be formed in the affected safety region in this case in the city Middelburg. Team members stand on 2 hours' notice.

Time 18.30

Short term effects already occur.

People suffer directly with heating problems, because almost all Dutch heating systems are installed in all individual buildings and work on natural gas (non-affected system) and electrical power (affected system). The outside temperature is minus 6 °C. Telecommunications in the area are also severely affected by the black-out. Most communication lines in the affected province are out, with internet access being the most important affected system. Internal communications in and amongst governmental, defence and emergency services via the emergency net is working properly, but communications to and from the general public and with other organisations is severely disrupted. There are reports from the western part of the adjacent province Noord-Brabant that people also suffer from the outage.

The regional operational team in Zeeland is operational and gets the report from TenneT that a team of specialists has arrived at the incident site Kreekrak. First observation shows that some transformers have blown up.

Time 18.50

The safety region Midden en West Brabant (number 20 in Figure 2.21) also announces the GRIP 3 procedure. After consulting TenneT about the current situation, GRIP 5 (because multiple regions are now affected) is announced in Zeeland and Midden en West Brabant.

Grip 5 means: Provincial Coordination Centres have to become operational as well as the National Crises Centre[37]***.***

This NCC is located at the Ministry of Safety and Justice in The Hague. NCC alarms departmental Crises Centres (DCC). This means that the ministries directly involved also have to become operational. Team members stand on 2 hours' notice.

[36] See also chapter 5 GRIP procedure

[37] www.nctv.nl

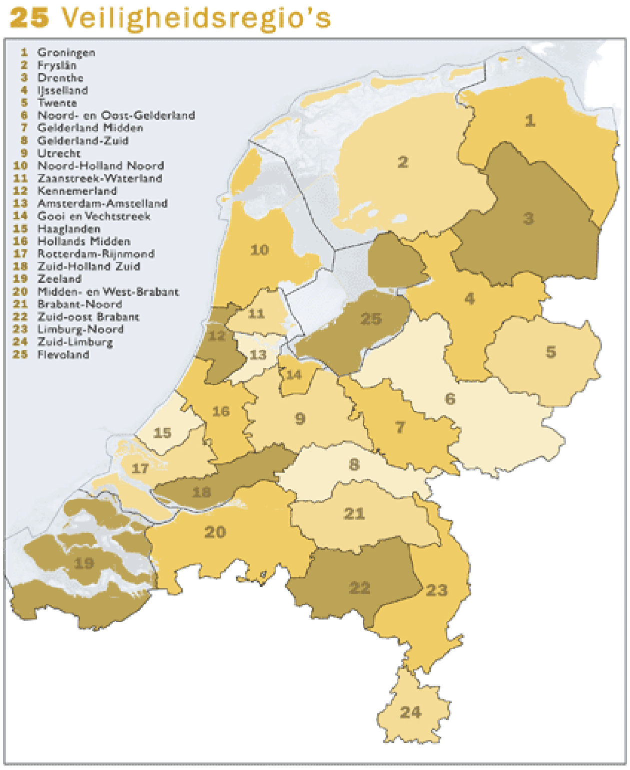

Figure 2.21 The 25 Safety Regions in the Netherlands.

Time 20.45

The Operational- and Crises Centres at provincial and governmental level in the Netherlands are fully operational. First Situational Reports (Sitreps) are rapidly coming in. There is some knowledge that the incident will take 24 hours and probably more to recover from. 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). The expected cascading effects can be huge and can create a major disaster; the government has to take general control. At this moment the National Coordination Centre has the general coordination and the Ministerial Commission for Crises Management takes the general command.

Time 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. Some transformers at this station experienced a sustained load that exceeded the capacity it was designed for (i.e. stated on the nameplate of the transformer station) and broke down.

Additional information about Zandvliet and Elia:

> *The Belgian power distribution station Zandvliet is the interconnection between the south of the Netherlands and the north of Belgium. It's directly above the main harbour of Belgium and the heavy industry around the city Antwerp (see also Figure 2.18). When station Zandvliet is out, the harbour, all industries and off course the general public in the entire province of Antwerp will be affected.*

> *The Company Elia[38] operates the high-voltage (30 kV to 380 kV) electricity transmission system in Belgium. The Dutch and Belgian power grid are part of an interconnected network throughout the whole of Europe.*

Time 21.15
Decision has been made in the Antwerp region to immediately scale up to provincial level, which appoints the Governor as responsible authority and adds a level of decision making to the municipalities concerned. The strategic crises centre, the Coordination Committee which includes the competent authorities, is established at the Antwerp Fire Service Post Noord.

When the evening continues, power outages in large parts of Northern Belgium and Southern Netherlands occur.

Time 22.00
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. 5 million Dutch and Belgian people are affected by the black-out. See Section 2.7.5 for a complete list of affected systems.

Elia, Belgium's electricity transmission system operator is with several teams present at the Zandvliet site. The first restart fails at this time.

The national emergency plan for a major power outage is effective and announced by the Belgian Government[39].

[38] www.elia.be

[39] National Electricity Emergency plan (Nationaal Noodplan Elektriciteitspanne van Grote Omvang, 18.09.2012)

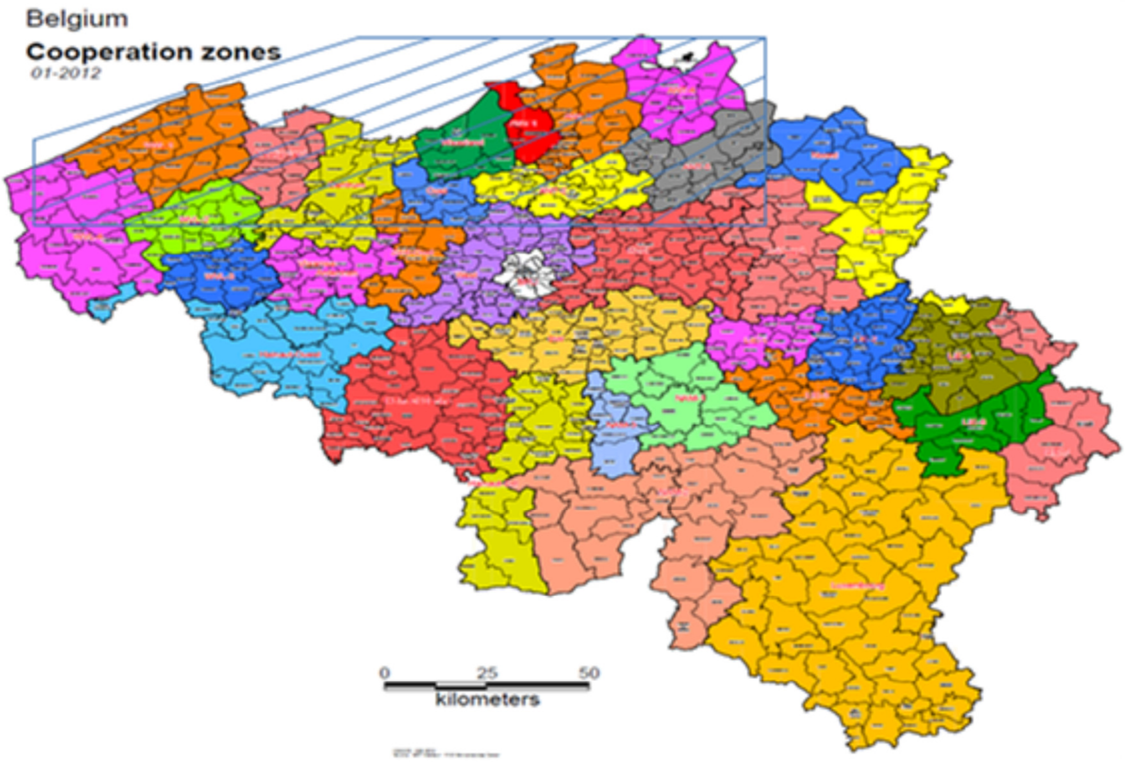

Figure 2.22 Cooperation (safety) zones in Belgium, the outlined zone is the affected blackout area.

Time 23.30
In Belgium, coordination structures are put in place at national level: a National Crises Centre[40] becomes operational, led by the Minister of Interior and composed of a management cell, an evaluation cell and an information cell. The provincial Coordination committees remain active.

[40] www.crisiscentrum.be

Both countries are now communicating at Governmental level. Exchange of information is ensured through the Governmental Crisis centrum (i.e. a permanent body). The Belgian Brussels International Airport (Zaventem) is closing down. Snow removal trucks are unable to keep the runway and taxiways operational.

Military airports are active, but no flights can be done due to the poor visibility. This block out the option of aerial emergency operations in the regions affected.

After 28 December 23.30
Events after this time are mostly dependent on decisions taken by the governmental and provincial/regional command centers. Note that some of these decisions are probably taken before 28 Dec 23:30 (e.g. evacuation). These decisions are a vital part of the test-session in which this scenario is played out.

Decisions are expected to be taken on the following topics (not in order of priority):

- Communications with the general public;
- Food & water supply;
- Alternative heating solutions;
- Healthcare;
- General emergency operations;
- National and regional security;
- General road and supply lines (to facilitate the above);
- Emergency services and military resource capacity (and using that of non-affected regions and other helpful entities);
- Recovery of the power system as soon as possible;
- Recovery in the other affected systems.

2.7.5 Cascading effects, dependencies and systems involved

In both countries it is decided at Governmental level that a power outage as described in the previous chapter is a vital infrastructure disaster. There is to be expected that it has an economic impact of 50 billion euro plus; a decrease of ca. 5.0 % in real income; psychical consequences, like more than 10.000 people killed, seriously injured or chronical ill. Social welfare problems are expected to more than 1 million people like emotional problems or serious surviving issues[41].

In this case, the failure in the power supply system constitutes the Initiating event that affect the Originating system Power supply. Through dependencies, a number of other systems are affected, i.e. cascading effects take place. These include propagation of effects to the systems Air transportation, Telecommunications, the Public, etc. (see next paragraph for complete list of affected system). Furthermore, the outage also escalates further in the Belgian power system causing effects in other Belgian systems as well. The severe winter weather aggravates the situation, by worsening the effects in systems (e.g. all electrical systems AND the essential heating system in houses affected) and making emergency and restore operations more difficult and time consuming (e.g. road network also affected by heavy snowfall). Taken together, all these effects are obviously greater than the effects to the root impacts and from the fact that multiple systems are affected there are also multiple stakeholders involved.

<u>Affected systems</u>

Note that only the affected systems in this scenario are described in this paragraph. The educational system is usually affected by a black-out, but for instance because of the Christmas holiday in this scenario the educational system can be described as not affected.

General public:

All inhabitants, residents, workers and other persons present in the large area being affected by the black-out already are experiencing severe winter weather when the black-out strikes. Due to heavy snowfall their mobility is severely hindered. Furthermore, the number of injuries is increased, putting an extra demand on the Healthcare sector (see also this affected system). In this case, the most important and almost direct affect to the general public due to power outage is the lack of heating. Due to the low temperature and high wind speeds, this quickly leads to extra health problems.

Healthcare:

The temperature affects directly the influenced people; achievability of hospitals due to the heavy snowfall is very poor, while amount of injuries and illnesses is increased. When the power fails, hospitals switch over to emergency generators and activate their own emergency plans (i.e. close operating theaters, try to move IC patients, cancel day-treatments and more). Successful implementation of the hospital's internal emergency plans is hampered due to the severe winter weather, which actually brings more patients to the emergency wards and a reduction in available staff (due to road network blockages and the personnel directly affected by the black-out and telecoms failures as well). Emergency generators work for max 48 hours, forcing hospitals in the affected area to close down once it is known that the blackout will last longer than these 48 hours. This is of course dependable on the probability of supply of extra

[41] See for Belgium, the estimation of the Impact by the Plan Bureau (2004): http://www.plan.be/admin/uploaded/200605091448107.WP0418nl.pdf

gasoline. At this stage, the amount of people with healthcare problems due to lack of heating will be considerable.

Telecommunication:

Access to the internet, electronic banking, GPS issues, automatic registration of patients in Hospitals, and automatic business processes are affected. The (mobile) telephone net is out. The National emergency nets in both countries are functioning but are overloaded. These nets will keep functioning in this scenario.

Traditional media is severely affected within the affected area. The recent hostage incident at the Dutch NOS news station on 29 January 2015, shows there is no full proof back-up plan at hand for a national crisis coordination media channel.[42] Since both the Dutch and Belgian media organizations are located outside the affected area, they are expected to keep functioning, but have no means to directly contact affected people. Social media will not function in the affected area due to the black-out. However, directly outside the affected area it is expected that social media will be heavily used and could be used to coordinate support operations.

During large-scale, sustained power failures, the problem is that the ability of emergency managers to communicate important life/safety information to the public is greatly hindered. To begin to identify potential solutions to this important problem, it is useful to identify three key problem areas related to public communications during severe power outages[43].

Area Number 1: Fragile Communication Channels. During emergency responses that include major power outages, emergency managers frequently find many communication channels on which they normally rely on are not usable. For example, television stations may be airing news coverage, but households without power cannot view the broadcast. Emergency managers can post useful information on the locality's website or send it by email, but households without power do not have access to the Internet. Incoming calls to the dispatching are problematic. These centers are very difficult to reach.

Area Number 2: Mismatched Information. In times of crisis, people have a need for hyper-local information. Mainstream media is often focused on larger, more sensational aspects of the overall crisis, at a time when individuals have very specific needs for information on where to get local help for critical items such as water, food, shelter or medication.

Area Number 3: Infrastructure Collapse. When infrastructure has been destroyed and normal communication methods are disabled, emergency managers will struggle to communicate vital information with the public. For example, a city's Town Hall and Emergency Operations Center may have backup generator power, but what if Town Hall and the entire downtown area have been washed away by a severe storm or leveled by terrorists? During severe power outages, emergency managers face these three core issues as they work to fulfill a core mission objective: sharing critical information with the public.

Public Policy and security issues:

Streetlight, traffic lights, elevators, trains, metro trains and street cars fail to a stop in the affected provinces. Automated production, distribution and assimilation of nuclear material are facing severe problems. Despite the outage the Belgian nuclear power sites at Doel and the Dutch nuclear site at Borssele are safely shutting down. Normally emergency power systems are functioning 48 hours, after this time the regional automated embankments and industrial control systems are immediately affected.

[42] http://nos.nl/artikel/2016195-korte-gijzeling-bij-nos.html

[43] Thesis, HIGH-TECH, LOW-TECH, NO-TECH: COMMUNICATIONS STRATEGIES DURING BLACKOUTS by Diana Sun Solymossy

After 48hours, the Belgian nuclear power sites at Doel and the Dutch nuclear site at Borssele have come to a final and safe stop. More than 1 million people suffer directly of the power outage and the consequential lack of heating. They have become shelter in community centers, churches and army barracks. Social welfare problems are a big issue at this stage. General and reserve forces are distributing food and water, since normal shops and cash machines do not function anymore because of the black-out.

Prison system:
In some, mostly older prisons all electronic functions will collapse in due time[44].

Public Administration:
Availability of data out of the national's base administrations is not possible. Governmental agencies are facing huge problems because of dysfunctional data systems.

Finance:
Banks have their own emergency procedures and back up plans and facilities. This sector will be less affected than the public sector. Nevertheless within the EU cascading financial effects are happening in due time.

Transport sector:
The cities Amsterdam, Rotterdam and Antwerp (ARA)[45] form together an important oil- and petrochemical cluster with several connections throughout Europe. In Rotterdam there are five refineries with a distillation capacity of 58 billion tons. It is connected by oil pipelines with five refineries near Antwerp, Vlissingen and two refineries in Germany. Rotterdam is also part of the Central European Pipeline System (CEPS) of NATO. It connects to military and civil airports.

The pumps of the kerosene- and oil pipe lines are facing power disturbances. Aircraft handling at the airports in the affected regions are coming to a stop. The military Air Bases in the affected area are closed due to the weather condition. Harbor activities in the Westerschelde area (Antwerp-Vlissingen) are also affected. Only the essential traffic systems keep functioning for 48 hours in emergency power.

Most companies and agencies thought they had better backup than they did. They did not understand the fragility/vulnerability of their technology. Most thought they had better backup power than they in fact had[46].

Seveso-factories & other industries:
It is unknown to the Dutch and Belgian Government which effect a total blackout can have on these institutions. There are form led structures and procedures but the precise impact of a total black-out is unknown. There might be acute shut downs creating risks on site and for the environment.

[44] Noodplanningsgids Elektriciteitspanne

[45] https://nl.wikipedia.org/wiki/ARA-gebied

[46] EFFECTS OF CATASTROPHIC EVENTS ON TRANSPORTATION SYSTEM MANAGEMENT AND OPERATIONS
August 2003 Northeast Blackout New York City

Agricultural sector:
Electricity is vital for this sector. Big agricultural institutions have alternative supply of electricity. But expected is that a blackout generates waste of products and massive death of animals. It takes only minutes for animals to die after a total black out due to lack of heating or somewhat later by lack of water and food supply.

Emergency services and military capacity (BEL & NLD):
Achievability of security forces, the Police, ambulance, Fire Department, Army personnel etc. can be severely disturbed by the weather and because of the holidays. Between Christmas and New Year's Day most people are on a leave and spent their holidays abroad or with family.

Food supply:
Shops will be forced to close because of falling out of electronic payment, scanning of products, failing electronic doors and security systems, etc. Food distribution will stop. Citizens having a minimal stock will be in shortage of daily necessary provisions.

Water supply:
The water supply system is dependable on electricity and falls out between 2 and 8h. To start it up again after a stop of >2 days it takes 1-2 days to disinfect all water pipelines.

2.7.6 Actual consequences and possible consequences

For this scenario the primary power infrastructures of the province Zeeland and the Antwerp region is selected as main systems being impacted. This failure of vital infrastructure in its turn triggers a lot of cascading effects in other systems. The reason to select this part of the Belgian and Dutch critical power infrastructure is because:

- It is categorized as vital infrastructure of class A in both countries[47], with a large spread of (potential) severe cascading effects
- The power station at Kreekrak is a known critical but weak link in the power infrastructure between Netherlands and Belgium[48]
- A severe black-out occurred in North-Holland on 27 march 2015 due to the failure of a similar 380 kV power station at Diemen (region Amsterdam)[49]
- The region is centrally located between two of the largest ports and industrial areas in Europe, thereby having great economic impact

As initiator, a failure in a critical component is chosen and severe winter weather is selected, because it is very realistic according to TenneT and Belgian government documentation – especially with the current climate changes.

Besides the chosen initiator, power fluctuations remain also as a likely reason for failures within the power distribution system. These fluctuations can be caused by change of and imbalances within supply and demand (e.g. due to cold weather and holiday season), high wind speeds ("dancing of wires") and simple failures of small parts. The severe winter

[47] Magazine nationale veiligheid en crisisbeheersing 2015 - nr.3

[48] Kwaliteits- en Capaciteitsdocument, Tennet 2013

[49] http://www.nu.nl/binnenland/4019658/grote-stroomstoring-treft-noord-holland.html, 27-03-2015

conditions in this scenario further hamper quick fixes of the power distribution system, thereby greatly increasing and escalating the damages within the system in a relative small time period. [50]

The scenario is timed in the days between Christmas and New Year, as during these days a lot of people are on the move (or would like to be) causing different demands on the road and power networks. Furthermore, since during these days a lot of people are on leave, this greatly increases complexity in resource management within emergency services and the governmental and defence organisations of both countries.

2.7.7 Geographical extension and cross-border effects

This scenario is defined as a very large-scale incident with cascading effects, because of:

- the geographical space and amount of people affected,
- cross-border and cross-system effects and consequences, spanning regions of 2 countries,
- the duration of the scenario (multiple days),
- Socio-demographic impact.

Two provinces in the Netherlands are 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. 5 million Dutch and Belgian people are affected by the black-out.

This scenario is classified by both governments as a vital infrastructure incident class A[51]. 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 chronical ill. Furthermore, social welfare problems are expected to more than 1 million people like emotional problems or serious surviving issues[52]. The two countries have their own command structure and IMTs involved and thus a large number of agencies are involved, including the national commands and operational coordination centres of both countries. Due to cold weather and heavy snowfall health effects are directly considerable in both countries.

2.7.8 Different organisations involved and the relation between them

In Belgium[53] emergency management with (possible) cascading effects requires per definition an interagency cooperation and coordination. At Governmental level is decided that the outage has become a vital infrastructure disaster. The National Crisis Centre located under responsibility of the Minister of Interior is therefore in charge.

[50] Kwaliteits- en Capaciteitsdocument, Tennet 2013

[51] Dutch classification based on EU criteria, Magazine nationale veiligheid en crisisbeheersing 2015 - nr.3

[52] ESRIF final report page 69 – 87 critical infrastructure (European Security Research and Innovation Agenda).

The terminology Gold, Silver, Bronze for strategic, tactical and operational command is not commonly used in Belgium. Table 2.7 describes the corresponding levels of command in Belgium. Each discipline involved in emergency management keeps its own command and control structure and follows its own internal decision making model.

Table 2.7 Levels of command in Belgium.

BE terminology	Corresponding responsible body	Presided /led by	Location	Levels of command	
Strategical coordination	Coordination Committee	Mayor or Governor or Minister	Determined in the emergency plans	Gold	Strategical
Operational coordination	Command Post Operations CP-Ops	Director appointed (function of the type of emergency)	On site/on the scene	Silver	Tactical
Operational execution	The 5 (functional) Disciplines	Officer or doctor or civil servant in charge	On site/on the scene	Bronze	Operational

As far as crisis management is concerned in Belgium, three administrative/political levels are involved depending on the magnitude of the incident.
Municipal level – responsibility of the Mayor
Provincial level – responsibility of the provincial Governor
Federal level – responsibility of the Minister of Interior.

The national coordination structure as described in the national emergency plan is shown in Figure 2.23.

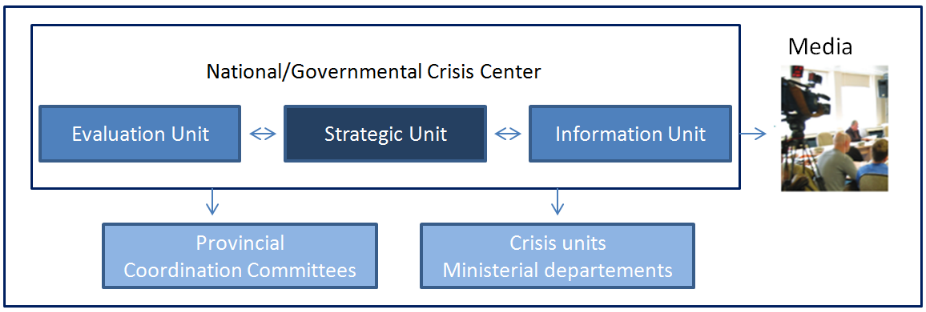

Figure 2.23 National coordination structure in Belgium.

In The Netherlands emergency management with (possible) cascading effects requires per definition an interagency cooperation and coordination. At Governmental level is decided that the outage has become a vital infrastructure disaster. The National Crisis Centre (NCC) located under responsibility of the Minister of Home Affairs is in charge in this scenario.

Emergency management starts with the GRIP procedure (Coordinated Regional Incident-Management Procedure). It runs form GRIP 1 to 5 and even the highest Governmental level, called GRIP State (see Table 2.8). In The Netherlands are 25 Safety Regions divided over 12 provinces.

Table 2.8 Simplified table of GRIP procedure[54].

GRIP PHASE	AFFECTED AREA	BODY	PRESIDED/ LED BY	Responsible authority	Advisory to the responsible authority
GRIP 0	Source-suppression. Day-to-day routine operations, no special coordination necessary.		Crew commander	mayor	
GRIP 1	Source-suppression. Incident of limited proportions, harmonisation necessary between the various emergency services.	COPI/ A coordination team consisting of duty officers of the involved services is set up	Leading officer COPI	mayor	Leading officer COPI
GRIP 2	Source- and effect suppression. Incident with a definite effect on the surrounding area.	ROT/operational team	Regional Operational leader	mayor	Regional Operational leader
GRIP 3	Threatened well-being of (large groups of) the population within a wider affected area.	ROT/regional operational team	Regional Operational leader	mayor	Regional Operational leader GBT/ Municipal advisory team
GRIP 4	One safety region	ROT/regional operational team	Regional Operational leader	Chairman Safety region	Regional Operational leader RBT/Regional Advisory team
GRIP 5	multiple safety regions	ROT's/ regional operational teams	Regional Operational leaders	Chairman Safety regions	Regional Operational leaders RBT/Regional Advisory teams
GRIP STATE	Guidance by state required to preserve national security	As in GRIP 5	As in GRIP 5	Ministers Minister of Home Affairs	DCC/Departmental coordination centre MBT/Ministerial Advisory team NCC/National coordination centre

The test-session, for which this scenario is developed, will be aimed at using the IET by staff of the Belgian National Coordination Centre (NCC) and the Dutch National Coordination Centre (NCC). These centres are selected as main participants (i.e. persons using the IET) because in this kind of cross-border crises these centres are the main national managers of the crisis management information streams.

[54] Nationaal Handboek Crisisbesluitvorming/National handbook Crisesmanagement

In command structure terms, these NCC centres will be positioned between national command on one side (i.e. ministerial level) and the Belgian provinces and cooperation zones and Dutch safety regions on the other side. As such, they must liaise and interpret information and advices from the provinces, zones and regions up to super-strategic level and communicate decisions and information vice versa down. They also have their own responsibility to acquire extra information, combine the information streams, predict (near-) future scenarios and provide advices to both sides (i.e. up and down the command chain).
With their positions and responsibilities, the NCC centres will have a strategic task in information management and thus in actively using the IET. The information managers on provincial and regional level are already included as main test participants in other test-sessions.

2.7.9 Information on the historic event the scenario is based on and similar events

The scenario is fictional, but there are a number of power real outage incidents in The Netherlands[55], Belgium and other countries applicable as references/examples:

27 March 2015	North-Netherlands: power outage due to failure in transmission station, causing Schiphol airport to close down for a couple of hours.
12-15 December 2007	The Netherlands: Bommelerwaard power outage due to Apache helicopter crash in power lines.
25-28 November 2005	The Netherlands: Haaksbergen power outage lasting several days during winter weather conditions.
04 November 2006	Europe: a routine disconnection of a high-voltage line over the river Rhine and lack of communication between Transition System Operators creates a cascading effect resulting in splitting the ENTSO-E net in three parts. Just in time activation of emergency procedures prevents a black-out in West Europe. 15 million people were affected for 2 hours.
14 August 2003	Canada + USA: black-out in parts of North-East and Mid-West US and Ontario due to lack of effective response to imbalance.
28 September 2003	Italy: power outage due to failures in power grid between Italy and Switzerland
23 September 2003	Sweden and eastern Denmark: power outage due to component failures outside the scope of normal system design and security standards.
5 January 1998	Canada: An ice storm causes massive damage to the power infrastructure resulting in a total black-out in Québec, Ontario and Brunswick, affecting 4 million people
4 August 1982	Belgium: a large part of the country loses power due to an exploding alternator.

[55] NCTV Magazine, 2015 nr 3

3 Initiating events and dependencies

In the development of the different scenarios, both in the way the actual events and dependencies are described and how to take into account other possible timelines and consequences, results and conclusions from other parts of CascEff have been used. In this section some of those are summarized.

In WP2, 74 different incidents were identified as likely to be interesting to analyse with the developed method for analysing incidents with cascading effects. These incidents were from different parts of the world and some even affected more than one country.

For the 74 incidents the initiating event was identified and reported. These initiating events can be grouped as presented in Table 3.1.

Table 3.1 Summary of the initiating event in the 74 incidents studied in WP2.

Initiating event	Number	Comments	Related to scenario
Avalanche	1		
Blackout	6		
Cable rupture	3		
Cold snap	1		
Contaminated water supply	1		Skatås; Qualty Nuts
Cyber attack	1		
Dam rupture	2		Séchilienne
Earthquake	4		
Explosion	2		Antwerp
Fire	7	Fire (6) + Tunnel fire (1) + Wildfire (2)	Mont Blanc; Skatås; Antwerp; Quality Nuts
Flooding	7		Séchilienne
Fuel shortage	2		Antwerp?
Heat wave	2		
Hurricane; Tornado; Storm	6	(2+1+3)	
Ice storm	1		
IT event	3		
Landslide	4		Séchilienne
Pipeline rupture	1		
Power outage	5		
Sabotage	1		
Solar storm	1		
Strike	1		
Terrorism	2		
Water drought	1		
Water pipe rupture	2		
Water shortage	1		
Volcano eruption	3		

During incidents there may be many dependencies between different systems, however not all of these lead to cascading effects. It is important to understand the different dependencies and how different systems are influenced to be able to model the development of an incident.

In the same way it is important to be able to describe the dependencies to be able to develop relevant scenarios for testing the CascEff IET.

The Mont Blanc Tunnel fire (1999) was analysed in WP2. In Figure 3.1 the impacted systems, cascade order and dependency impact from originating to impacted system are illustrated graphically.

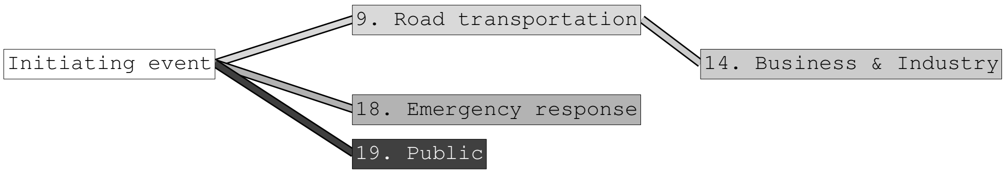

Figure 3.1 Impacted systems, cascade order and dependency impact from originating to impacted system during the Mont Blanc tunnel fire scenario. Grey scale (white 0 % and black 100 %) is used to illustrate system impact level (system boxes) and dependency impact level (dependency line).

The different systems and subsystems used for the methodology development and incident analyses in WP2 were summarized in D2.3. They are presented in Table 3.2

Table 3.2 Predefined system and sub-system categories (from WP2).

Number	System name	Sub-system name
1	Power supply	Not specified
		Production
		Local distribution
		Sub-transmission
		Transmission
		Raw material supply
2	Telecommunication	Not specified
		Telephone landline
		Telephone mobile
		Internet
		Radio-communication
		Satellite/GNSS
		Postal system
3	Water supply	Not specified
		Water treatment plants
		Distribution
		Infiltration areas
4	Sewage	Not specified
		Waste water
		Storm water
		Combined Waste/Storm
5	Oil and gas	Not specified
		Production
		Distribution
		Refining
6	District heating	Not specified
		Production plants
		Distribution
		Raw material supply
7	Health care	Not specified
		Primary care
		Medicine and material supply
		Child care
		Disabled persons
		Elderly care
		Psychiatry
		Social services
		Disease control
		Hospitals
8	Education	Not specified
		Primary school
		Secondary school
		University
		Research
9	Road transportation	Not specified
		National network
		Regional network

		Local network
		Bridges
		Tunnels
		Road traffic
10	Rail transportation	Not specified
		Railway stations
		Railway network
		Subway
		Trains
		Trams
		Train control
		Rail yards
11	Air transportation	Not specified
		Airports
		Flight control
		Airplane traffic
12	Maritime transportation[a)]	Not specified
		Ports
		Cargo traffic
		Passenger traffic
13	Agriculture	Not specified
		Crops
		Cattle
		Forest
		Fishing
		Plantations
		Diary
14	Business and industry	Not specified
		Raw material
		Construction
		Manufacturing
		Service sector
		Retail
		Import
		Export
		Hotel & Restaurant
		Tourism
15	Media	Not specified
		Newspaper
		Social media
		TV
		Radio
		Web-based information
16	Financial	Not specified
		Central banking system
		Credit card
		Financial transactions
		Stock exchange
		Cash availability

		Insurance
		Currency exchange
17	Governmental	Not specified
		Border control & immigration
		Court system
		Prosecutors office
		Customs
		Correctional system
		Pension systems
		Waste treatment
		Embassies & Consulates
		Local
		Regional
18	Emergency response	Not specified
		Emergency health care
		Police
		Rescue services
		Call centres
		Coast guard
		Defences forces
		National guard
19	Public	Not specified
20	Environment	Not specified
		Flora
		Fauna
		Lakes
		Ocean
		Forests
		Rivers
		Deserts
		Mountains
21	Political	Not specified
		Local level
		Regional level
		National level
22	Food supply	Not specified
		Distribution
		Processing
		Control
		Primary production

a) In WP2 this was defined as "Sea transportation", but was here broadened to "Maritime transportation" to include also e.g. transport on rivers.

4 Multiple timelines and visualization of the scenarios

4.1 Introduction

In this section we draw a distinction between a timeline and scenario. A scenario is here defined as the collection of systems which could be affected as a result of an initiating event. It is based on the different dependencies which exist between the affected systems and the nature of the events. It contains details of cascading effects both real and theoretical, as well as external conditions, first responder actions, procedural actions, and communication opportunities. A timeline, conversely, illustrates the impact on the systems which could arise in the event of one set of different external conditions, first responder actions, etc. occurred or taken.

A timeline therefore is one of many possible evolutions of an incident with time, and is dependent on many factors which may differ from day to day and based on the actions of those involved. A scenario contains all possible timelines and shows the opportunities for improving the situation and reducing the impact of an incident by, for example, shifting the course of events to a timeline with less severe consequences.

The basic scenarios, which are presented elsewhere in the CascEff project, and which are based on historical incidents or potential worst case scenarios which the project team are aware of are here elaborated on and developed to complete the scenario description. This is done by methodically exploring the consequences of the initiating event affecting the initial system, and the impact of these consequences on dependent systems. This process is repeated for all dependent systems, using information from the historical scenarios as well as the results from other deliverables in the CascEff project, specifically those of deliverables D2.1, D2.2 and D2.3.

In order to identify opportunities for breaking the course or chain of events or affecting the outcome of the incidents, we relied on the incident reports from the actual events; as well as the results of, e.g. deliverable D3.1 and D3.2.

The end results, presented here for all of the CascEff scenarios, are by no means exhaustive. However they illustrate the scenarios developed in such a way that they can be used to develop multiple different timelines resulting from an initiating event and which can be used for developing the CascEff IET and implementing the scenarios in existing tools within the project. The elaborated scenarios also help with understanding the dependencies and possible cascading effects. They are also of valuable help for the further development of the scenarios in relation to the tools to be used for the validation of the IET.

This chapter first of all describes how to develop the individual scenarios, providing also a key to the illustrations which are used. All of the CascEff scenarios are then illustrated using the methodology described. For each of the scenarios, some of the different timelines are described in a narrative form to accompany the different scenario visualisations.

4.2 Methodology for developing the scenarios

The diagrams for visualisation of the scenarios are based on swimlanes, but incorporate also Boolean logic gates, as well as notation specific to the process. In order to create the scenario visualisations the following procedure is followed.

1. Prepare a swimlane diagram which includes all possible affected systems. The initiating event and the first originating system is normally included at the top.
2. Starting with the first affected system as originator, move systematically down the swimlanes asking, if the first system is damaged, will the system in this swimlane be affected? If so, indicate this with an arrow from the originators swimlane to the dependent systems swimlane.
    a. If the dependency is dependent on a decision, indicate this on the arrow.
    b. If the dependency is dependent on external conditions (e.g. wind), indicate this in the middle of the arrow.
    c. If action can be taken within a system to limit the impact, indicate this with a procedure.
    d. If communication with the public will affect the severity of the outcome indicate this on the appropriate swimlane.
3. The time line shown at the top of the example is approximate. This indicates the duration of the incident approximately according to immediate effects, short, medium and long term effects.
4. The horizontal length of the connectors can be used to represent approximately buffer time.
5. The duration of the negative effects on the system can be indicated by the 'length' of the box indicating that the system is affected.
6. The nodes at the tail of the arrows indicate that some impact threshold has been exceeded which triggers the cascade to an additional system. At the moment we do not indicate this threshold or the severity, this will be added when we combine the information from modelling, experience, etc. to the IET.
7. Once all dependencies of all systems on the first system as the originator have been checked, move to the second system assuming this is the originator and check all other systems for dependency.
8. Continue adding arrows, decisions, external conditions, etc. moving through all systems as orignators and checking the others for dependency.

Using the method described above the scenarios can be elaborated in such a way that all cascading effects and key decision points can be shown. In order to develop the multiple timelines, the different decisions, external conditions etc. should be changed systematically in order to create all possible outcomes.

In the following sections we use the legends shown in Figure 4.1 to illustrate the elaborated scenarios. Logical AND means that all the dependencies linked to a system needs to be realized for the system to be affected, while a logical OR means that it is enough that one of the dependencies linked to a system is realized for the system to be affected.

For some of the scenarios, the figure and the table with description of different events during the incident are accompanied by a longer text describing more in detail some other possible timelines. This is included to increase even further the understanding of the possible cascading effects and how these are affected by conditions, decisions, etc.

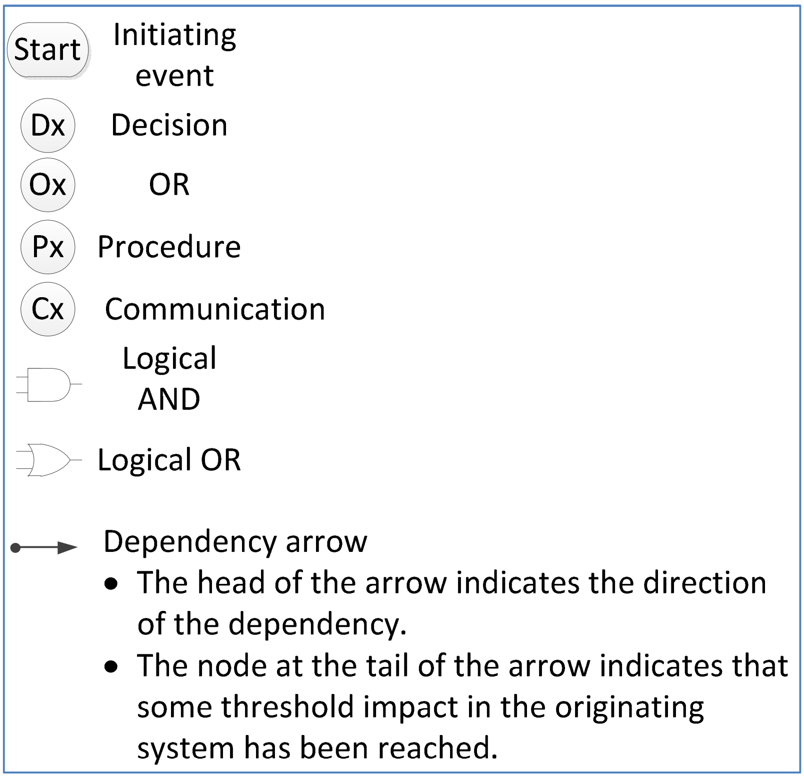

Figure 4.1 Description of symbols used in visualization figures.

4.3 Scheldt

The original Scheldt scenario involved mainly *possible* cascading effects, as the decisions taken by the incident command team succeeded in avoiding escalation of the initial event. For the purpose of testing the IET, the elaboration of the scenario, based on alternative timelines, includes different triggers, which add additional chains of effects. In Figure 4.2 the Scheldt scenario is visualized with multiple timelines. The numbered symbols are explained in Figure 4.3, while numbered dependencies in Figure 4.2 are described in Table 4.1.

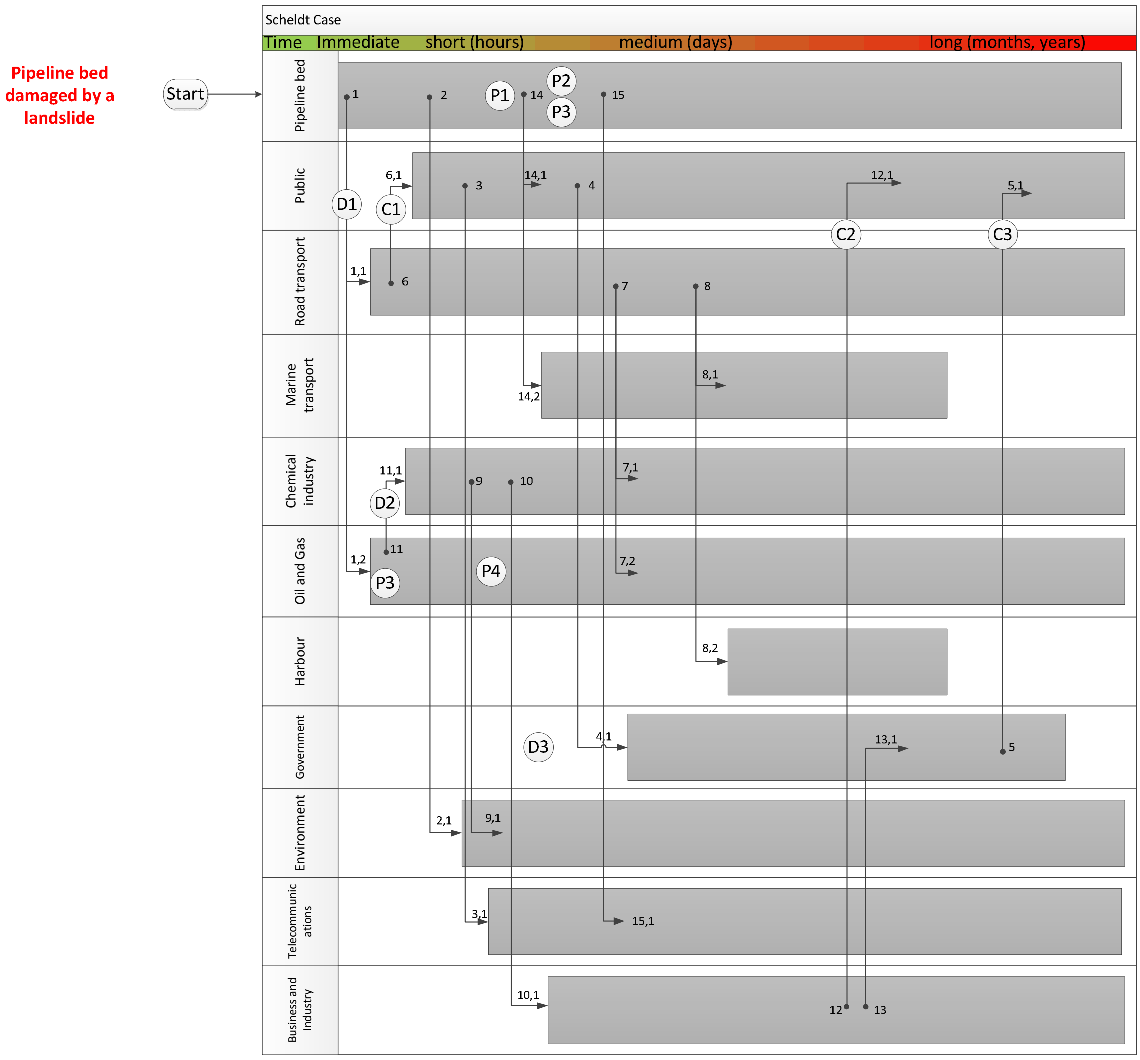

Figure 4.2 Scenario visualisation showing multiple timelines in the Scheldt scenario.

D1	Close Scheldt road for all traffic (cars plus cyclists)
D2	Inform and invite representatives of the pipeline owners, of surrounding companies (including those relying on the pipelines for supplies)
D3	Scale up from operational to municipal coordination
P1	Set up exclusion perimeter and isolation perimeter (perimeter of 500 m and isolation perimeter of 1000 m)
P2	Involve contractors, ask them to free the pipelines from external pressure
P3	Summon hazardous materials advisors
P4	Put some of the pipelines out of service under supervision
C1	Communicate rerouting of traffic to the public
C2	Communicate progress of recovery to the public
C3	Communicate future planning activities and recovery process to the public

Figure 4.3 Description of decisions, options, processes and communication in Figure 4.2.

Table 4.1 Description of dependencies shown in Figure 4.2.

Originator	Dependency
1 – Pipeline bed	1,1 – Geographic dependency of the road adjacent to the pipeline bed on the pipeline bed 1,2 – Logical dependency of the oil and gas supply on the pipeline bed
2 – Pipeline bed	2,1 – Environmental impact as a result of pipeline damage
3 – Public affected by road closures	3,1 – Increase demand on telecommunications infrastructure
4 – Workers unable to return home from work, collect children, rerouted	4,1 – Government affected by public dissatisfaction
5 – Lasting impact on local government	5,1 – Prolonged impact on publics satisfaction with government
6 – Interruption to road usability and rerouting of traffic	6,1 – Public affected by rerouting of traffic
7 – Continued interruption to road usability	7,1 – Interruption to logistics for chemical industry 7,2 – Interruption to logistics for Oil and Gas supply
8 – Prolonged interruption to road usability	8,1 – Need to identify alternative logistics solutions increases demand on marine transport 8,2 – Need to identify alternative logistics solutions increases demand on port and harbour facilities
9 – Physical damage at chemical facilities	9,1 – environmental damage as a result of escalating problems at chemical industry
10 – interruption and reduced activity at chemical industry	10,1 – impact to other businesses and industry
11 - interruption to Oil and Gas supply	11,1 – Logical dependency between Oil and Gas supply and supplied industries
12 – Impact to business and industry	12,1 – Public affected by, e.g. reduced productivity or demand
13 – Impact to business and industry	13,1 – Government affected by economic problems
14 – Exclusion zone set up around incident	14,1 – Exclusion zone affects public activities, access and mobility 14,2 – Exclusion zone affects marine transportation routing
15 – Damage to pipelines as a result of blast or increasing external load	15,1 – Damage to telecommunication pipelines adjacent to the damaged pipelines

For the Scheldt scenario three alternative timelines are explicitly described. Three different alternative timelines (AT) for the Scheldt scenario are:

AT1: Explosion as a cascading effect
An explosion happens, once the work to repair the damaged pipeline bed has started.
This is a change in contextual, external factors, altering the type of ***the main incident to manage***, which is a cascading effect of the initial event, and which will impact:

- the incident management decisions;
- the type and number of the impacted systems and the systems impact;
- the buffer time.

AT2: Different time period
AT2 is a variation on AT1. The event is moved in time, and takes place at the last day before the official holidays. This is mandatory holiday period for the construction sector, a lot of other sectors align their holidays. As the dispatching is informed around 17 h, workers are leaving and are not to be supposed returning for the next three weeks.
This is a change is contextual/external factors, altering the time/period of time when the event occurs, which will impact:

- the incident management decisions;
- the impacted systems and the systems impact;
- the buffer time.

AT3: Explosion as initial event
AT3 is a variation on AT1. Instead of an explosion as a cascading effect of the initial event – the landslide, the incident starts with an explosion as an immediate (quasi simultaneous) consequence of the landslide (and the torsion on the pipelines).
This is a change in contextual, external factors, altering the type of ***the main and initial incident to be managed***, which will induce a different cascade, mainly a different order of cascading effects, and which will impact:

- the incident management decisions;
- the type, number and order of the impacted systems (compared to AT1) and the systems impact, especially the severity of the impact;
- the buffer time.

Each of these AT's is described more in detail and visualised in the following paragraphs.

4.3.1 AT1: Explosion as a cascading effect

Short description AT1
The main alternative factor:
In the initial scenario, the work to repair the damaged bed, incl. securing the damaged pipelines, putting some out of order, etc. started about 16 h (day 2) after the fire service arrived at the incident scene. At that moment, the area has been secured as much as possible thanks to the blocking of road and sea traffic, and the 'buffer time' has allowed to collect the necessary information to assess the situation (content of the pipelines, contact with the owners, etc.) and to identify the appropriate measures to be taken, the means to execute them, etc. Shortly after the start of the repair works, an explosion takes place in the damaged bed.

Altered dependencies and impacted systems:

The following **first order** impacted systems of the initial scenario remain:

- Emergency response;
- Road and Sea Transport;
- Chemical industry;
- Construction Sector;
- Oil & Gas.

As well as the **second order** impacted systems:

- Government (dependency Emergency response)
- Economic (dependency Road/Sea Transport; Chemical Industry, Construction Sector)
- Supply (dependency on Road/Sea Transport)

Some of the first order impacted systems will be more impacted:

- Emergency response: will need reinforcement: more staff, different staff, more material and equipment
- Government: might require scaling up to a provincial coordination phase depending on the required reinforcement means
- Chemical industry: the threat of explosion of the 4 tanks at house burning distance increases, with a specific cascade of effects
- In case of third order explosion/fires:
    - ⇨ possible victims – Health
    - ⇨ impact on the Emergency response => Government
    - ⇨ possibly Environmental damage
    - ⇨ increased Media attention => increased Public concern
- Construction Sector: will encounter much longer delays for the Sigma works
- Oil & Gas: supply from the concerned pipelines will stop abruptly, creating a new chain of cascading effects:
    - Industry: Acute shut down of one or more plants
        - ⇨ Impact on the internal safety measures
        - ⇨ Impact on the production = Economic
        - ⇨ Impact on other industries because of delays in production and supply = Industry, Economic

More impacted systems will occur in second order:

- Health care: there will probably be victims amongst the workers, urgent medical care will have to intervene to bring them to the nearest or appropriate hospital(s);
- Media: because of the scale of the incident and the victims, media attention will be certain (whereas in the initial scenario, there was hardly any interest of the media)

Other third order impacted systems:

- Because of media attention, the public will be concerned
- Other industries (than those in the vicinity) might be affected

Impact duration and impact on the decisions:

- 'Buffer time' is abruptly reduced to 0, because immediate interventions are necessary
- Controlling the situation will become suddenly much more complex and will take more time to manage (controlling the situation and the consequences);
- Controlling the fire and the consequences of the explosion will require additional means and efforts (compared to the initial scenario) and will delay the restoration of the damaged pipeline bed.
    - This will impact the duration of the road and sea traffic blocking
    - This will impact the supply of the surrounding plants
- Restoration works in itself will take much longer (restoring damaged pipeline bed and restoring the damage of the explosion and consecutive fires);
- Possibly restoration of environmental damage, which might require long term efforts.

Systems consequences:

Technical More and other equipment and material will be required, at different locations/belonging to different owners: the emergency responders, private actors such as the owners of the 4 tanks, the owners/staff of the refinery, the companies at the construction site, etc.

Organisation Much more partners will be actively involved:

- More response teams/more disciplines: fire services, police, urgent medical care, logistics, specialised services
- More authorities might be concerned: besides the Mayor, the Governor (Province) might be involved
- Media attention and concern of the Public will additionally have to be managed
- Private actors will have to deploy their own means (internal safety plan), coordination and alignment of their efforts will be needed

Human

- Medical care for the victims
- Psychological care for relatives
- Psychological impact on the public

Economic

- Much more 'entities' begin concerned, economic losses will be much more substantial
- The sum of the financial costs for all the parties concerned will equally be substantial

Environment

- The explosion(s) might create the risk of pollution of soil and water

4.3.2 AT2: Different time period

Short description AT2

The main alternative factor:

The initial scenario started July 5th. In Belgium there is an official and mandatory summer holiday period of 3 weeks for the construction sector. A lot of other sectors align their summer holidays to that period. The changing factor in this scenario is the start of the scenario, which is the landslide, moved to the last working day before the holiday period. As the 112 dispatching is informed at 17 h, workers are leaving the work place and are not supposed to return for the next three weeks. This means that workers and staff of the company, responsible for the main cause of the incident are not available and might already have left the country by the time the impact of the landslide becomes clear. Other staff, such as civil servants from competent authorities, specialised services, private companies' staff might not be available.

Altered dependencies and impacted systems:

The following **first order** impacted systems of the initial scenario remain:

- Emergency response;
- Road and Sea Transport;
- Chemical industry;
- Construction Sector;
- Oil & Gas.

As well as the **second order** impacted systems:

- Government (dependency Emergency response)
- Economic (dependency Road/Sea Transport; Chemical Industry, Construction Sector)
- Supply (dependency on Road/Sea Transport)

Some of the first order impacted systems will be more impacted:

- Emergency response: will have to deal with a shortage of staff to start the necessary works, which might require additional measures to keep the area safe and secure
- Government: will need to requisite personnel
- Chemical industry: will face a longer period and increased threat of explosion of the 4 tanks at house burning distance (with a specific cascade of third order effects , see AT1: Health, Environment, Media, Public additionally impacted)
- Oil & Gas: it might take longer to secure the pipelines and thus create additional risks,

Increased risk of environmental damage might occur as a second order impacted system

Impact duration and impact on the decisions:

- 'Buffer time' will be longer because there is an additional step to take, requisition of appropriate staff
- Controlling the situation might become more complex because there might be additional measures to take to keep the area safe and secure – risks might increase because of longer torsion on the pipelines;
  - This will impact the duration of the road and sea traffic blocking
  - This will impact the supply of the surrounding plants
- Restoration works in itself will take much longer;
- Increased risk of environmental damage.

Systems consequences:

Technical The lack of available staff might also involve lack of available means. An additional step in the incident management is to find and requisite workers and material.

Organisation The organisation becomes more complex:

- Because of the need for an additional step, getting the necessary staff and material to the incident scene
- Requisition by the competent authority will be necessary
- The additional steps delays the implementation of the necessary

	measures, which might need additional, intermediate measures to secure the area and to deal with an increased risk of explosion for a longer period. • Traffic might be blocked for a longer period, which might attract Media attention, which will have to be additionally managed • Private actors will have to be stand by for a longer period to secure the internal safety of their plant, while also working with reduced staff in the holiday period.
Human	
Economic	• Any delay in dealing with the incident will cause reduced production for the plants nearby the incident scene, with a cascade of effects for (the supply of) their client • Any delay will raise the financial costs of the whole operation for all the parties concerned
Environment	• increased risk of pollution of soil and water

4.3.3 AT3: Explosion as initial event

Short description AT3

The main alternative factor:
AT3 is a variation on AT1. Instead of an explosion as a cascading effect of the initial event – the landslide, the incident starts with an explosion as an immediate and direct consequence of the landslide (and the torsion on the pipelines). This is a change in contextual, external factors, altering the type of ***the main and initial incident to be managed.*** In the initial scenario, there was a buffer time. Several hours were needed and available to assess the situation and to decide on the necessary works to repair the damaged bed, incl. securing the damaged pipelines. This buffer time is now reduced to 0, which alters not only the impacted systems but also their order of occurrence.

Altered dependencies and impacted systems:

The following **first order** impacted systems of the initial scenario remain:
- Emergency response: fire services and others called at the scene at the same time;
- Road and Sea Transport;
- Chemical industry;
- Construction Sector;
- Oil & Gas.

As well as these **second order** impacted systems:
- Economic (dependency Road/Sea Transport; Chemical Industry, Construction Sector)
- Supply (dependency on Road/Sea Transport)

Additional **first order** impacted systems:
- Government becomes a first order impact system, because the 112 dispatching will alert the competent authority.

- Health becomes a first order impacted system, because victims are likely to occur among the construction workers, drivers on the Scheldt lane. Urgent medical care will have to intervene to bring them to the nearest or appropriate hospital

Most of the **first order** impacted systems will be more impacted:

- Emergency response: will need full deployment in terms of staff, material and equipment. Emergency response will have to deal with the explosion and the threat for the vicinity
- Government: might require scaling up to a provincial coordination phase depending on the required reinforcement means
- Chemical industry: the threat of explosion of the 4 tanks at houseburning distance is very realistic, with a specific cascade of effects:
  In case of third order explosion/fires
    - ⇨ possible victims – Health
    - ⇨ impact on the Emergency response => Government
    - ⇨ possibly Environmental damage
    - ⇨ increased Media attention => increased Public concern
- Construction Sector: will encounter much longer delays for the Sigma works
- Oil & Gas: supply from the concerned pipelines will stop abruptly, creating a new chain of cascading effects:
    - Industry: Acute shut down of one or more plants
        - ⇨ Impact on the internal safety measures
        - ⇨ Impact on the production => Economic
        - ⇨ Impact on other industries because of delays in production and supply => Industry, Economic

As in AT1, more impacted systems (compared to the initial scenario) will occur in **second order**:

- Media: because of the scale of the incident and the victims, media attention will be certain (whereas in the initial scenario, there was hardly any interest of the media)

Other **third order** impacted systems:

- Because of media attention, the Public will be concerned
- Other industries (than those in the vicinity) might be affected

Impact duration and impact on the decisions:

- The most important altered impact is that the 'Buffer time' is abruptly reduced to 0, because immediate interventions are necessary
- Controlling the situation will become suddenly much more complex and will take more time to manage (controlling the situation and the consequences);
- Controlling the fire and the consequences of the explosion will require substantial means and efforts (compared to the initial scenario) and will delay the restoration of the damaged pipeline bed.
    - This will impact the duration of the road and sea traffic blocking
    - This will impact the supply of the surrounding plants

- Restoration works in itself will take much longer (restoring damaged pipeline bed and restoring the damage of the explosion and consecutive fires);
- Possibly restoration of environmental damage, which might require long term efforts.

Systems consequences:

Technical Substantial equipment and material will be required, at different locations/belonging to different owners: the emergency responders, private actors such as the owners of the 4 tanks, the owners/staff of the refinery, the companies at the construction site, etc.

Organisation Much more partners will be actively involved:

- The 4 operational disciplines will be called at the scene immediately: fire services, police, urgent medical care, logistics, specialised services
- More authorities might be concerned: besides the Mayor, the Governor (Province) might be involved
- Media attention and concern of the Public will additionally have to be managed
- Private actors will have to deploy their own means (internal safety plan), coordination and alignment of their efforts will be needed

Human

- Medical care for the victims
- Psychological care for relatives
- Psychological impact on the public

Economic

- Much more ‘entities’ begin concerned, economic losses will be much more substantial
- The sum of the financial costs for all the parties concerned will equally be substantial

Environment

- Increased risk of pollution of soil and water

4.4 Mont Blanc

The scenario is based on the historic Mont Blanc tunnel fire accident (1999). To see the effect of other conditions and/or decisions, the original scenario has been further expanded to account for other possible cascading effects.

Accounting for alternate evolutions of the scenario, the driver of the Heavy Good Vehicle (HGV) now abandons his vehicle very close to one of the tunnel’s portals, e.g. the French exit (approximately 50 m away from the portal) due to heavy smoke coming out of his truck engine. The French operating company notices the incident and in cooperation with the Italian operating company close the entrances to the tunnel. There is now a queue of vehicles forming behind the stopped HGV, towards the French side, which is slowly burning, emitting heavy smoke. There is also a number of HGV’s waiting for the check control on the French portal. Within these HGV’s there are some carrying dangerous goods, e.g. explosive substances (Class 1), toxic substances (Class 6.1) and/or radioactive material (Class 7). On the opposite side (towards the Italian exit) there are also stopped vehicles in front of the burning HGV. Within a few minutes, the fire in the stopped HGV has grown up in size that quickly spreads from one vehicle to another as in the real accident. As the fire spreads from one vehicle to another it eventually reaches outside of the French entrance. There is now eminent danger that the flames will spread towards the stopped HGV’s carrying dangerous materials resulting in a release of toxic and radioactive materials in the atmosphere and that the forest might catch fire due to intense heat radiation. Both these threats pose serious dangers for the people living in the towns nearby the tunnel portals. Based on the work performed in D1.4, the possible triggers or starting points for alternative evolutions, either originators or dependencies, within the scenario are the ventilation direction inside the tunnel (alternative decisions) and where the driver stops the Heavy Good Vehicle (external factors).

The visualization of the Mont Blanc scenario is shown in Figure 4.4, with explanation of the numbered symbols in Figure 4.1. The numbered dependencies in Figure 4.4 are explained in Table 4.2.

The Initiating event (HGV fire within the tunnel) will affect the “Road transportation” (geographical dependency), and “Public” (geographical dependency) systems almost immediately (within 5-10 m) and the “Environment” system (after approximately 1 h). The “Road transportation” system will then affect “Public” (logical dependency) within a few minutes.

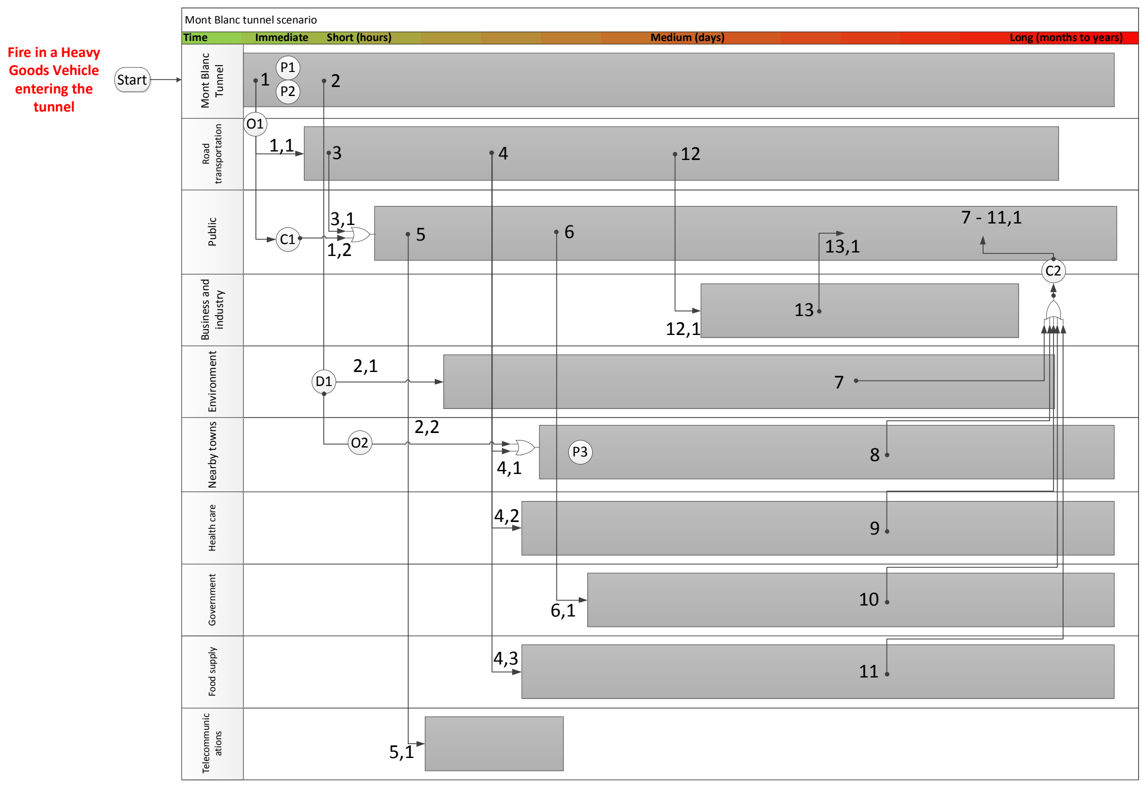

Figure 4.4 Scenario visualisation showing multiple timelines in the Mont Blanc scenario.

- D1 Tunnel ventilation direction towards the portal which is closest to the fire
- O1 HGV stops close enough to the tunnel portal that the fire can be fought
- O2 HGV carrying hazardous goods
- P1 French first responders respond to the accident
- P2 Italian first responders respond to the accident
- P3 Initiate evacuation of nearby towns
- C1 Inform public about the incident and encourage them to seek alternative routes or not make the journey
- C2 Inform public about the long lasting effects of the incident

Figure 4.5 Description of decisions, options, processes and communication in Figure 4.4.

Table 4.2 Description of dependencies shown in Figure 4.4.

Originator	Dependency
1 – Tunnel	1,1 - Logical dependency of road transportation on the state of the tunnel 1,2 - Logical dependency of the public on the state of the tunnel 1,3 – Depndency of the emergency response capacity in France on the tunnel fire 1,4 – Depndency of the emergency response capacity in Italy on the tunnel fire
2 – Tunnel, fire not extinguished early	2,1 – Environmental impact from a prolonged fire incident 2,2 – Need for evacuation of nearby towns in the event that the fire effluent is hazardous
3 – Road transportation	3,1 – Impact of reduced mobility on the public
4 – Long lasting impact to road transportation	4,1 – impact of long lasting road transportation interruption to nearby towns 4,2 – Impact of interruption to transportation on health care (supply chains, worker and patient transport) 4,3 – Impact of interruption to transportation on food supply chains
5 – Impact on the public	5,1 – Increased reliance and load on telecommunications infrastructure
6 –Prolonged impact on the public	6,1 – Impact on local government
7 – Lasting environmental impact	7,1 – Prolonged impact on publics wellbeing
8 – Lasting impact on nearby towns	8,1 – Prolonged impact on willingness of public to stay in the town – possible reduced population
9 – Lasting impact on health care	9,1 – Prolonged impact on the ability to provide essential health care services to the public, or need to find alternative supply routes
10 – Lasting impact on local government	10,1 – Prolonged impact on publics satisfaction with government
11 – Lasting impact on food supply	11,1 – Prolonged impact on the availability of essential or luxury food stuffs – need to find alternative supply routes
12 – Reduced availability of supply routes	12,1- impact on dependent businesses
13 – Reduced output from local businesses	13,1 – impact on public from reduced demand for products and workers

4.5 Festival

4.5.1 Base scenario

The response strategy is aimed at cooling the cargo and monitoring the effectiveness of the cooling through thermal camera's. Maximum duration of the fire is expected to be 10 days. Toxic fumes are put down through water spraying below wind and the population in the effect zone is evacuated. The population will start using their cell phones to call and reach out on social media resulting in overloading GSM masts in the vicinity of the festival. Images are picked up by the media increasing the public pressure on government to improve safety measures for transport of such dangerous goods next to a densely populated area. Although Ammonium Nitrate is not harmful to the environment contaminated fire water will increase algae growth in the sewer systems if not properly contained. This is expected to have moderate impact on water purification systems and no impact on human health.
Due to the proximity of the ship to the roads all traffic within 600 m will be diverted causing traffic jams for the duration of the incident.

In Figure 4.6 the Festival scenario is visually presented with multiple timelines. Definitions and description of decisions, options, processes and communication are given in Figure 4.7, while the dependencies are described in Table 4.3.

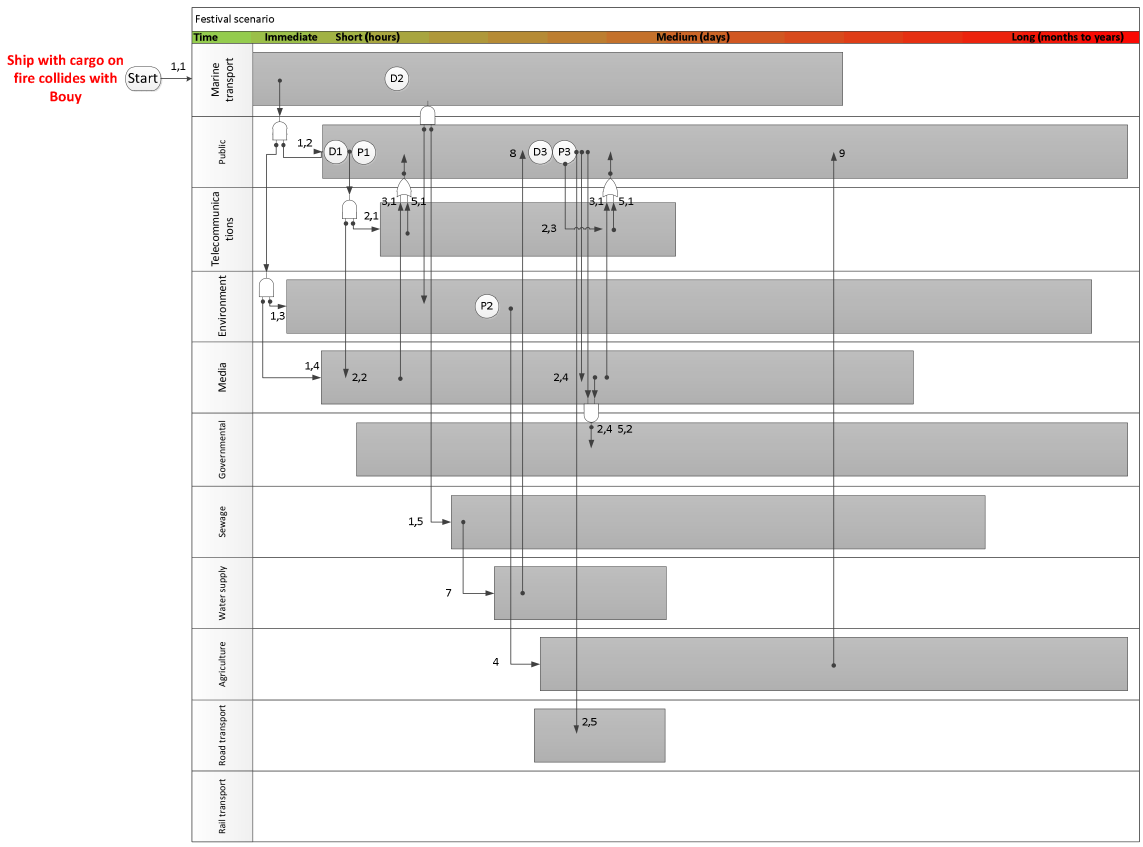

Figure 4.6 Scenario visualisation showing multiple timelines in the Festival scenario.

Table 4.3 Explanations of the dependencies in Figure 4.6.

Originator	Dependency
1 – Marine Transport – River Scheldt	1,1 - Blockage of ship traffic on the river Scheldt and North Sea for all marine traffic heading south of Antwerp. Fire lasting up to 11 days. 1,2 - Public health threat to nearby population and festival attendees due to toxic fumes 1,3 - Air pollution due to toxic fumes. Use of water curtains to limit spread of toxic fumes results in threat of water pollution due to fire water getting into the river. 1.4 - Traditional and social media coverage 1.5 – Firefighting tactics leading to some water pollution in the sewer system
2 – Public – Festival attendees, population working or living in city of Antwerp	2.1 - Overload of GSM networks due to attendees calling and messaging on social media. 2.2 - crisis spreading on social media 2.3 – telecom networks overloading because of mass evacuation 2.4 – media crisis due to mass evacuation 2.5 – media pressure causing impact on policies for ADR transports by water 2.6 – evacuation causing congestion of roads
3 – Telecommunications	3.1 – overload of GSM networks creating relatives to come to incident to collect family
4 – Environment	4 – polluted water causing change in river fauna and flora due to increased algae growth. Food chain impact.
5 – Media	5 – News, photos and videos on (social) media causing increased public attention and potentially people in neighbouring areas that want to evacuate or come and help. 5.2 – Media pressure on government to change policy on ADR transports and question civil security
6 – Governmental	
7 – Sewage	7 – polluted sewer water which is not contained entering the water supply through water purification system
8 – Water Supply	8 – contaminated water entering the food chain
9 – Agriculture	9 – Contaminated food threatening public health

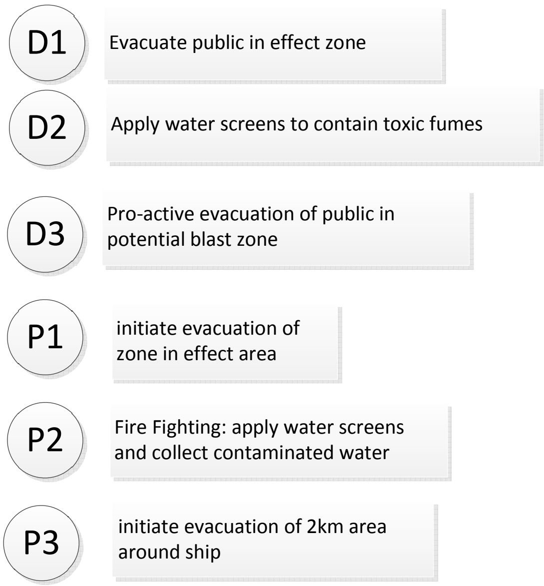

Figure 4.7 Description of decisions, options, processes and communication in Figure 4.6.

4.5.2 Alternative timeline 1: Sinking the ship

As the temperature of the cargo cannot be reduced through cooling the firefighting strategy becomes sinking the ship and evacuation the public within 2km of the ship. The ship will cause oil pollution and increased growth of algae in the river Scheldt. The ship wreckage will obstructs marine traffic on the river until the ship is salvaged.

4.5.3 Alternative timeline 2: Explosion of the ship

If cooling or sinking is not successful, the ship will explode. The explosion will be somewhat reduced due to the river but will damage all infrastructure (roads, buildings, highway, rail tracks, pipelines, utilities) and cause thousands of victims if the evacuation is not successful. Vital infrastructure loss will take months to years to rebuild and nearby hospitals will be impacted due to the flood of victims. Structural stability of quay, underground, buildings, river tunnel will all need to be verified. Demolition and reconstruction expected. Recovery estimated to take years. Political impact will be significant at all levels. The regulator might have to issue more stringent regulation which will have impact on businesses in the Port and other industrial zones.

4.6 Séchilienne

Figure 4.8 and Table 4.4 provides a description of some possible timelines regarding the Séchilienne scenario, where the system description has been a little simplified compared to Figure 2.14 map. This simplification concerns the Industry system, the Water Supply system and the Power Supply system which gather several units having similar sensibilities or potential impacts. Definitions and description of decisions, options, processes and communication are given in Figure 4.9.

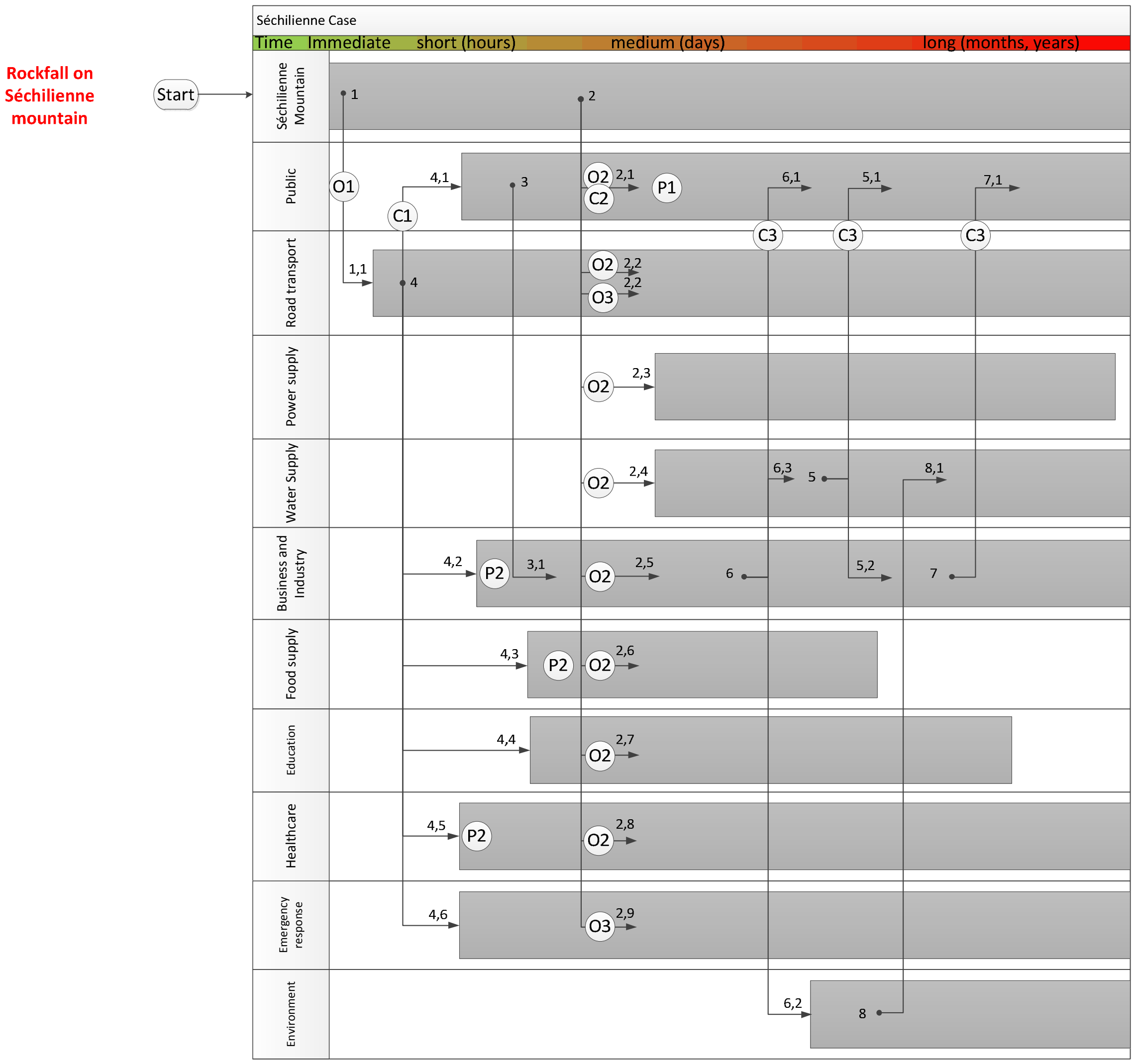

Figure 4.8 Scenario visualisation showing multiple timelines in the Séchilienne scenario.

O1 Rockfall lands on road

O2 Secondary rockfall falls on Dam causing damage

O3 Secondary rockfall falls in same area as first rockfall, risking harm to first responders

P1 Involve contractors, ask them to free the pipelines from external pressure

P2 Summon hazardous materials advisors

C1 Inform public about road closure and encourage alternative route if possible

C2 Inform public about imminent flooding

C3 Inform public about long term effects and recovery plans

Figure 4.9 Description of decisions, options, processes and communication in Figure 4.8.

Table 4.4 Explanations of the dependencies in Figure 4.8.

Originator	Dependency
1 – Landslide on mountain	1,1 – landslide falls on road interrupting traffic flow
2 – Damn rupture after rockfall	2,1 - Possible injuries to members of the public 2,2 - Roads are submerged and damaged 2,3 – Damage to hydroelectric power supply 2,4 – Damage to potable water supply 2,5 - Some industries/factories are damaged 2,6 - Food shops or commercial centres are damaged 2,7 - Education facilities are damaged 2,8 - Health care operations (movement of ambulances and doctors) are limited or delayed, possible damage to facilities 2,9 - Emergency operations (movement of rescue teams) are limited or delayed
3 – Mobility of public reduced	3,1 – Some workers unable to commute to work
4 – Interruption to traffic flow	4,1 - The movement capabilities of the population is limited 4,2 – Logistics operations are affected 4,3 - Food supply and distribution is negatively impacted 4,4 – Inability for teachers and students to travel to and from schools 4,5 – Capacity for movement of patients, hospital staff, and medical supplies is reduced 4,6 - Emergency operations (movement of rescue teams) are limited or delayed
5 – Pollution to potable water supply	5,1 – Public have no more access to potable water 5,2 - Some industries/factories can not use water anymore in their process
6 - Blast/Fire/Toxic Release as a result of damage to industries	6,1 – Injuries and long lasting health effects on members of the public 6,2 - Pollutants are released 6,3 - River is polluted
7 – Closure of some industries as a result of damage	7,1 – increased unemployment
8 – River / water table is polluted	8,1 – Potable water supply stopped because of polluted water

4.7 Nut warehouse blast

In Figure 4.10 the Festival scenario is visually presented with multiple timelines. Definitions and description of decisions, options, processes and communication are given in Figure 4.11, while the dependencies are described in Table 4.5.

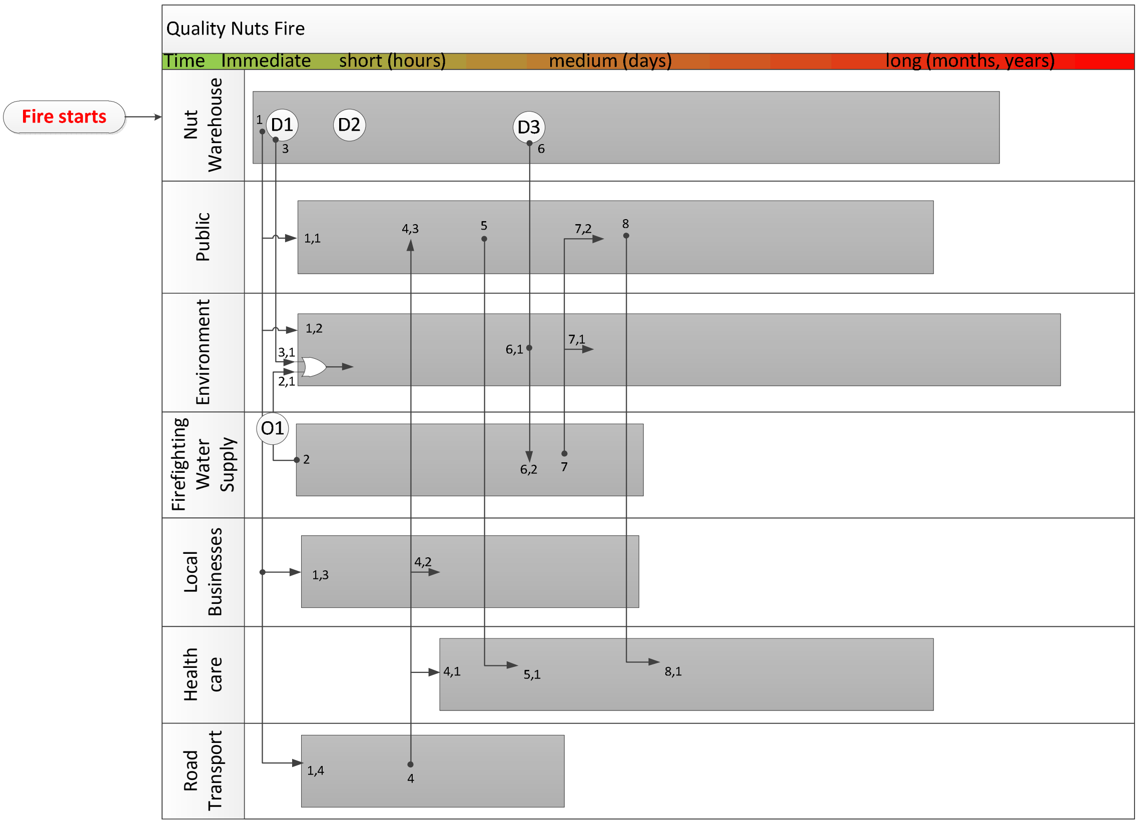

Figure 4.10 Scenario visualisation showing multiple timelines in the Nut warehouse blast scenario.

D1	Offensive fire fighting
D2	Defensive fire fighting
D3	Use holding pond
O1	Insufficient firefighting water

Figure 4.11 Description of decisions and options in Figure 4.10.

Table 4.5 Description of dependencies shown in Figure 4.10

Originator	Dependency
1 – Nut warehouse, fire starts	1,1 - Public is affected by threat to life and property damage. 1,2 – The environment is damaged by fire effluent. 1,3 – Local businesses are threatened by fire and smoke. 1,4 – Smoke causes roads to be closed.
2 – Firefighting water supply insufficient	2,1 – Environment is contaminated by fire water run-off
3 – Nut warehouse, offensive firefighting strategy requires much water	3,1 – Fish and other wildlife in pond are killed.
4 – Road transport impacted by smoke	4,1 – Ambulance activities are affected by road closures and traffic conditions. 4,2 - Local businesses can't get/make deliveries. 4,3 – Public travel on roads near fire is impaired by closures and traffic conditions.
5 – Public health impacted by smoke	5,1 – Health care facilities stressed by influx of people with smoke exposure problems.
6 – Environment, no use of holding pond	6,1 – Water from firefighting operations contaminates the watershed area. The drinking water supply requires special treatment.
7 – Water supply is contaminated	7,1 – The environment is contaminated. 7,2 – The public must find alternative sources of drinking water.
8 – Public becomes ill from contaminated water	8,1 - Health care facilities stressed by influx of people with illnesses from drinking bad water.

4.8 The Skatås wildfire

The Skatås fire scenario with multiple timelines is shown in Figure 4.12. Critical points have been identified in the base case scenario timeline where deviations may occur to produce a different set of outcomes from different choices (multiple timelines). The critical *decision* points in the timelines are denoted as D1, D2 and D3. Likewise, influences outside the control of the emergency responders, such as changes in wind direction, may cause changes in the timeline and thus the outcome of the event. These *outside* influences are denoted O1, O2, O3 and O4. Procedural actions taken by systems affected by the initiating event may also contribute to deviations from the base case scenario. In this study P1 represents a *procedural* action.

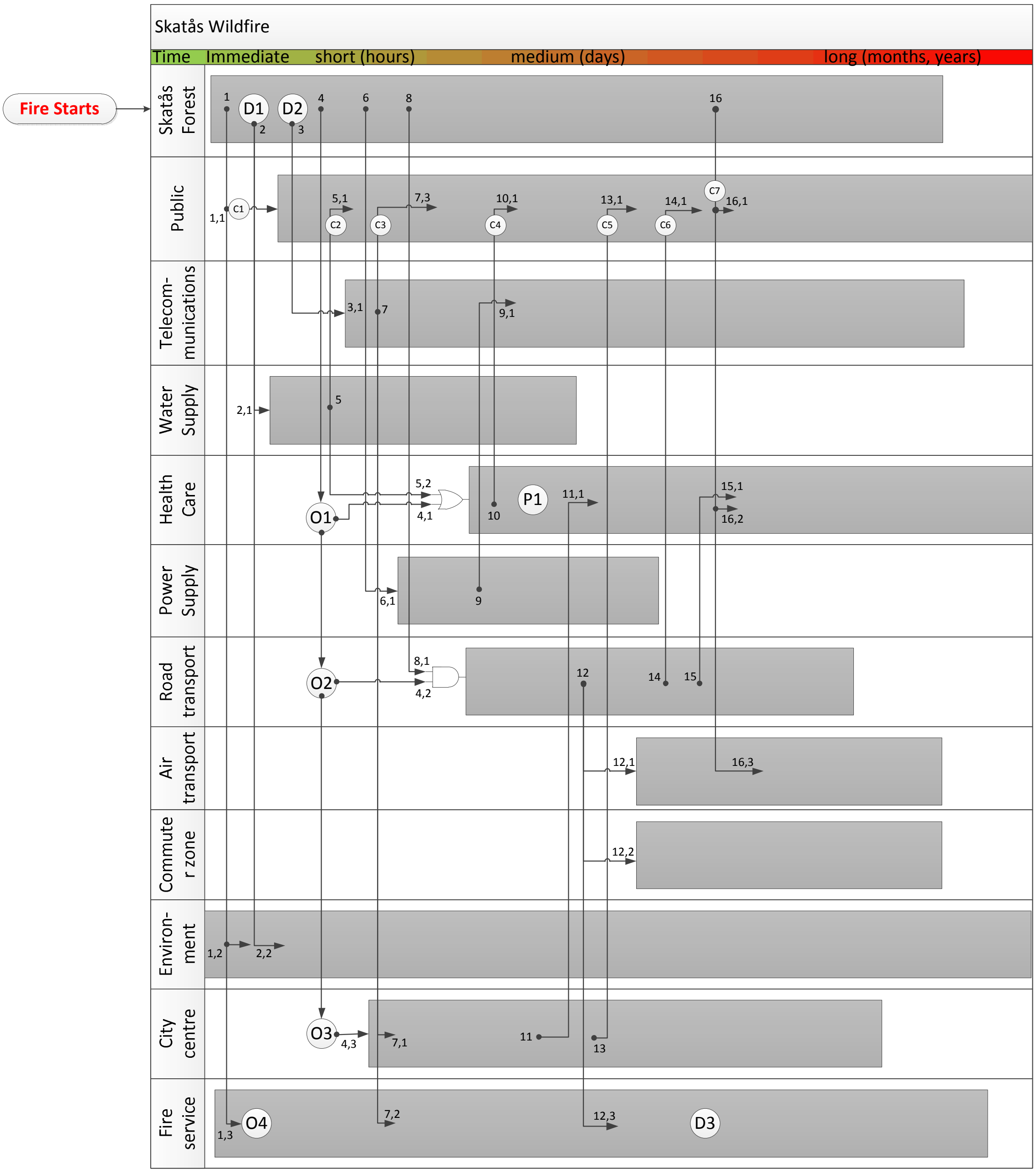

Figure 4.12 Scenario visualisation showing multiple timelines in the wildfire scenario.

The total number of possible timelines resulting from the six critical points identified for the base case is far too large to allow discussion of them all here; therefore a select few will be discussed in detail in the following text.

The small numbers in the figure above indicate points in the timeline when dependencies between systems occur. The key to these numbers is explained in Figure 4.13. The different dependencies are described in Table 4.6.

D1	Fight fire later to avoid risk of fire water run-off into the lake	C1	Inform public of need to evacuate forest and surrounding area
D2	Protect the tele-comm tower	C2	Inform public of contamination of water
D3	Call for reinforcements from military and/or other countries	C3	Inform public of reduced telecommunications facilities
O1	Wind direction North	C4	Inform public of health care provisions
O2	Wind direction East	C5	Inform public of affects to city centre
O3	Wind direction South	C6	Inform public of road transport arrangements
O4	Wind direction West	C7	Inform public of spreading fire and need to evacuate a large area
P1	Initiate emergency procedures in hospital		

Figure 4.13 Description of decisions, options, processes and communication in Figure 4.12.

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Table 4.6 Description of dependencies shown in Figure 4.12.

Originator	Dependency
1 – Skatås forest, fire starts	1,1 - Public is affected by threat to life and property damage. 1,2 – The environment is damaged by the fire. 1,3 – Reduced capacity of fire and rescue services in Gothenburg during a high fire hazard time.
2 – Skatås forest, immediate fire fighting	2,1 – Potential contamination of water supply 2,2 – The environment around the lakes is damaged by the fire.
3 – Skatås Forest, do not protect telecommunications tower	3,1 – Telecommunications are impaired.
4 – Skatås forest, wind from north	4,1 – Contaminated drinking water stresses health care systems. 4,2 – Fire causes closure of major road. 4,3 – Fire impacts central Gothenburg.
5 – Water supply, contaminated lakes	5,1 – Public has reduced supply of drinking water. 5,2 – Contaminated drinking water stresses health care systems.
6 – Skatås forest, underground electric cables disturbed	6,1 – Power supply is stressed.
7 – Telecommunications tower is compromised	7,1 – Central Gothenburg has reduced radio and television services. 7,2 – The fire and rescue services have reduced ability to communicate and coordinate their operations. 7,3 – The public has reduced radio and television services.
8 – Skatås forest, wind from east	8,1 – Fire causes closure of major road.
9 – Power supply, underground electric cables disturbed	9,1 – Telecommunications tower is unable to provide service.
10 – Health care, hospital is impacted by fire	10,1 – Public has reduced health care services.
11 – City centre, impacted by fire	11,1 – Large concentration of public require health care for exposure to smoke and fire.
12 – Road transport is affected by fire	12,1 – Access to airport is delayed or closed. 12,2 – Commute traffic is delayed. 12,3 – Fire and rescue services cannot reach their positions to fight the fire.
13 – City centre, roads closed	13,1 – People are stranded in the city centre, unable to return home.
14 – Road transport, wind from east	14,1 – People are stranded away from their homes and possibly their family members.
15 – Road transport, ambulance service impaired	15,1 – Ambulance service is impaired due to closed or congested roads.
16 - Skatås forest, fire very large near airport	16,1 – Many people are evacuated and displaced for extended time. 16,2 – Many fire-related health problems overwhelm health care services. 16,3 – Airport is closed.

For the Skatås wildfire scenario, two separate timelines are explicitly described below to show the effect of different alternative condition.

4.8.1 Alternative timeline 1

This timeline is indicated in Figure 4.12 as a no for D1, a yes for D2 and a yes for O2. The wind changes direction after 3 hours, blowing directly toward the Gothenburg city centre (toward the west) as shown in Figure 4.14, and increases in strength. The hospital to the north of the fire ignition point is no longer threatened after the wind changes so P1 is a no in this timeline.

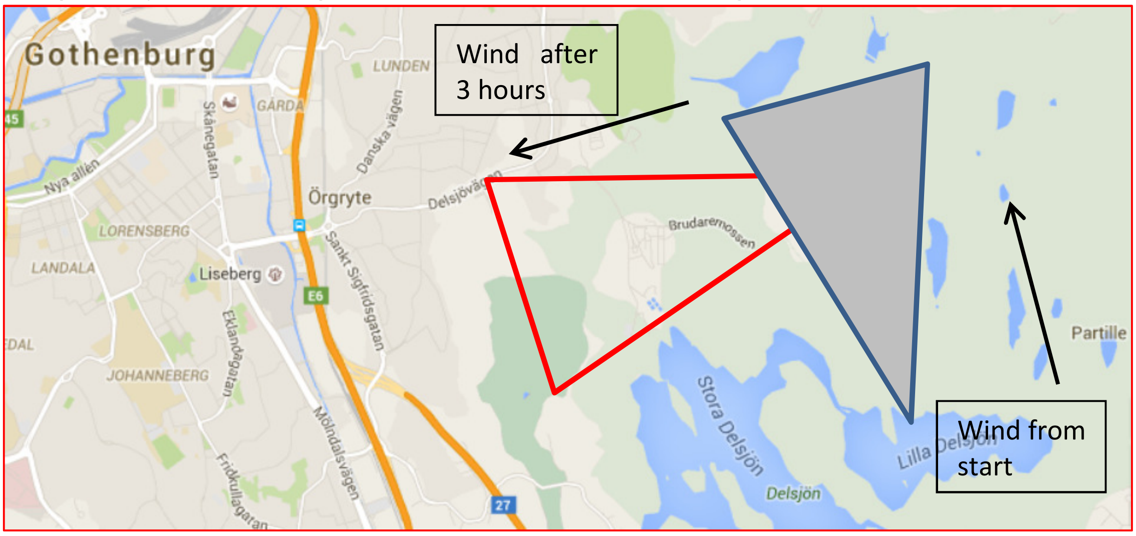


Figure 4.14 The wind changes direction and strength in Timeline 1.

The decision D1 was made to fight the fire immediately, rather than letting it burn away from the lake, which risks contamination of the drinking water supply. This is a deviation from the base case. The decision D2 to protection the telecommunications tower is the same as the base case, however, when the wind causes the fire to change direction heavy smoke impacts large parts of the city and causes problems with road and rail transport. Spontaneous evacuation of residents in the threatened areas exacerbates the traffic problem. Some of the emergency response vehicles are trapped in the traffic and detained from arriving at the fire site, which allows it to grow much stronger. A housing complex with a fitness centre and many clubhouses is destroyed. Another fire has started elsewhere and there are several other minor ongoing events so staff and resources are strained to their limits, making it difficult for the public to get emergency help.

The cascading effects in this timeline are:

- Public: Spontaneous evacuation, difficulty getting emergency help, blocked roadways resulting in problems going to/from work and collecting children. Heavy smoke causes people to feel ill.
- Fire and Rescue Service: blocked roadways prevent or delay access to fire site, allowing the fire to grow stronger, and preventing or delaying assistance to the public. Not enough staff and resources to respond adequately to all events.
- Transport: Major roads and railways are shut down. This also affects access to the airport, which is the second largest airport in Sweden.
- Economic: Businesses must shut down until the traffic clears and people can come back to work and goods can be transported.
- Water Supply: It is possible that fire water run-off has contaminated the lakes in Skatås natural park, endangering the drinking water for Gothenburg.
- Health Care: Ambulances cannot operate effectively in blocked traffic. People require medical attention for exposure to smoke from the fire.

4.8.2 Alternative timeline 2

This timeline is indicated in Figure 4.12 as the effects occurring due to the outside factor O4. This timeline starts the same way as the base case, with delayed firefighting to avoid contamination of the lakes and protection of the telecommunications tower. The date and time that the fire starts has been changed to July 31, 2014 at 13:30 to reflect a similarity to the *Sala Fire* in Västmanland, Sweden. The Sala Fire was one of the largest forest fires in Swedish history and had many cascading effects so this timeline will approximately follow the Sala Fire sequence of events. In this timeline the wind is blowing strongly from the west, as shown in Figure 4.15. As with the Skatås Wildfire, the weather has been unusually warm and dry for several weeks. For this reason there are delays in the response to the fire due to other weather-related emergencies so a reduced level of staff and resources from the fire and rescue service, police, and ambulance does not arrive until the fire has developed into a larger than expected fire. When they arrive, they encounter many coughing people coming from the jogging track around the fire who report that there are other people on the tracks that are having difficulty getting out of the heavy smoke. The rescue unit's first task is to get the people out of the area and prevent others from entering.

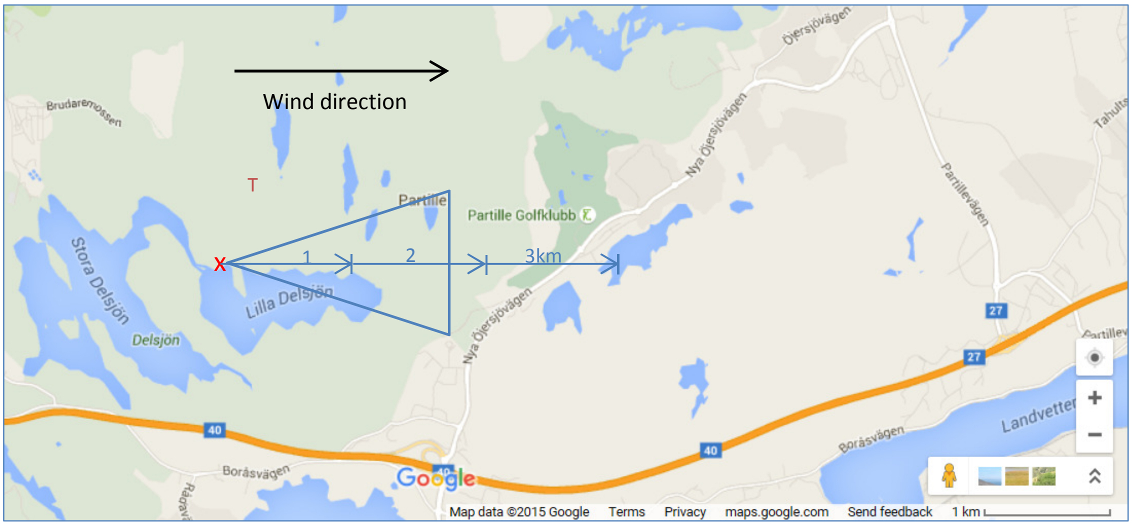


Figure 4.15 Map showing the beginning stages of the fire.

Traffic congestion builds as the fire develops and emergency responders have difficulties getting into position with their equipment. Reinforcing units did not arrive until 15:45, almost an hour after the alarm is received. By this time the fire is burning strongly and is much bigger. The west wind pushes the fire front toward the Partille golf course. The decision to evacuate residents in the path of the fire was made at 18:00. Some additional reinforcement arrives during the evening. Around 30 fire fighters work through the night to prevent the fire from spreading beyond a major roadway but it jumps the roadway and continues to burn out of control.

The next morning (August 1) a request is made to use military helicopters to fight the fire but none are available during the day, although this might change in the evening. In the afternoon a request for help is made to the Swedish Civil Contingencies Agency and the Home Guard. By the evening the fire has spread further west into an area of about 4 km × 5 km and 70 – 80 people are fighting it.

On the morning of August 2 a decision was made to close a large section of the major highway R40. Military helicopters are available for firefighting. Fire and rescue services from neighboring municipalities arrive as reinforcements. In the evening volunteer groups in the two largest cities in the area (Gothenburg and Borås) are alerted and asked for resources.

On August 3 a unified command center and a crisis management organization are established and many of the participating organizations begin to coordinate their activities. Communication with the public is made through a website and the emergency information officer network is activated. Meanwhile, the fire continues to jump all fire breaks and burns uncontrolled. Additional evacuations are necessary. The Landvetter airport (second largest in Sweden) is being affected by smoke.

On the morning of August 4 the Coast Guard flies over the area with an infrared camera. The Landvetter airport makes the decision to close. Reports of civilians trapped in the fire are received. Requests to other countries for water bombers are made. The fire continues to spread, causing further evacuations.

On August 5 the national emergency response organization takes over command of the fire from local fire and rescue services and appoints a new incident commander.

On August 6 water bombers from other countries begin to assist in the firefighting effort.

The cascading effects in this timeline are:

- Public: Spontaneous and forced evacuation, difficulty getting emergency help, blocked roadways resulting in problems going to/from work and collecting children. Heavy smoke causes people to feel ill. In some cases people were trapped by the fire. Facilities must be made available for evacuees.
- Fire and Rescue Service: blocked roadways prevent or delay access to fire site, allowing the fire to grow stronger, and preventing or delaying assistance to the public. Not enough staff and resources to respond adequately to all events. As the fire grew, new channels for requesting and managing reinforcements were needed.
- Transport: Major roads, railways, and an airport are shut down. This also affects air traffic across Europe.
- Economic: Businesses must shut down until the traffic clears and people can come back to work and goods can be transported.
- Health Care: People require medical attention for exposure to smoke from the fire.

4.9 Black out scenario

The diagram on the next page provides a schematic overview of the affected systems, the originators and effects (numbered “On” and “n.n”, with n being consecutive numbers) and communications (“Cn”), procedures (“Pn”) and decisions (“Dn”) to be made/taken. Furthermore, the activated command levels in both affected countries are visualized by orange lines in the diagram.

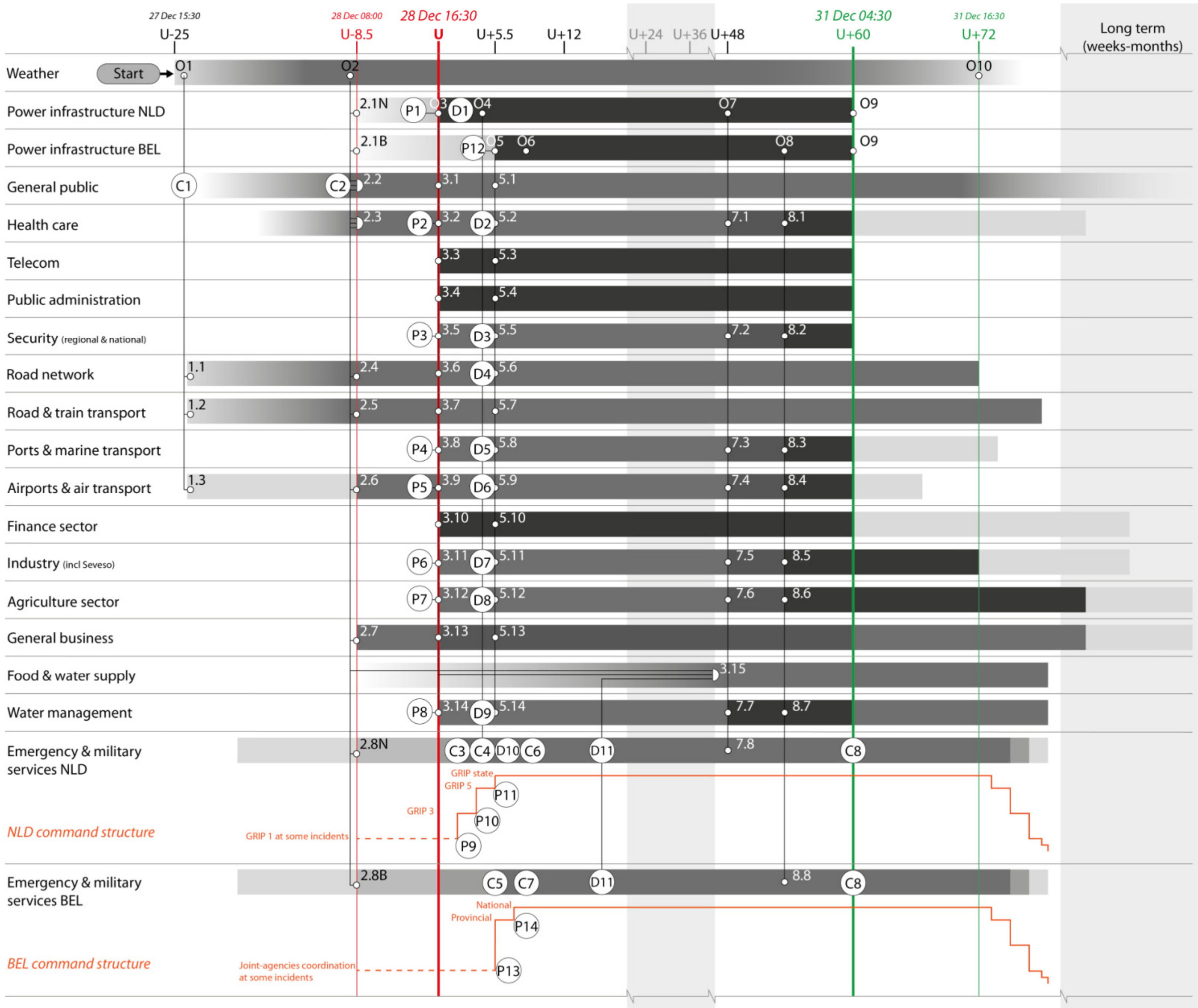
The test scenario, and thus the scenario injects with information regarding every affected system, will be further expanded in Deliverable 5.2. By further detailing the scenario, also the

exact moment in time for the test to start will be determined. This start moment will lay around hour "U": the moment the black-out starts in the province Zeeland.
The list of systems stated in the swim lanes overview is based on the 22 systems defined in D2.3, but has some deviations from this list:

- Weather is added since it greatly aggravates effects in the systems (e.g. failure of heating systems) and because it already affects eight systems before the power outage at hour U.
- The power systems of Belgium and the Netherlands are split to provide more clarity in the overview and because they are managed by two different companies (i.e. Elia in Belgium and TenneT in the Netherlands)
- The original "water supply" and "food supply" is combined in "water and food supply" to show its link with general business. "Water management" is included as separate system because of the elaborate semi-governmental water sector in the Netherlands and Belgium because these sectors both provides drinking water and manages the water levels in sub-sea-level and other water-prone areas.
- The Oil and gas system is included in the transport sectors, since in this scenario only the fuel supply is affected.
- District heating is left out, since this is very uncommon in the affected regions in this scenario (each Dutch and Belgian home and other building mostly has its own heating system, usually working on natural gas or oil).
- The education system is left out, because of the Christmas holidays in which this scenario is placed.
- Business and Industry is split in general business (with its link to water and food supply) and other industries (inclusive Seveso companies, which have an increased risk profile).
- The media system is left out, because the (traditional) media hotspots of both countries are located around Amsterdam and Brussels, which are regions not directly affected by the black-out. Further traditional and social media effects of the black-out are included in the general public swim lane.
- The Belgium and Dutch emergency services and military apparatus are split per country to provide more clarity and include the Political system.
  Furthermore, the command structure is indicated in these systems to provide extra information and to visually map the command processes over time.

Definition of times

- U: moment of first power outage (28 December 2016 - 16:30);
- U-: minus hours before the first power outage;
- U+: hours after the first power outage.



27 Dec 15:30
U-25
28 Dec 08:00
U-8.5
28 Dec 16:30
U
U+5.5
U+12
U+24
U+36
U+48
31 Dec 04:30
U+60
31 Dec 16:30
U+72
Long term (weeks-months)
Weather
Start
Power infrastructure NLD
Power infrastructure BEL
General public
Health care
Telecom
Public administration
Security (regional & national)
Road network
Road & train transport
Ports & marine transport
Airports & air transport
Finance sector
Industry (incl Seveso)
Agriculture sector
General business
Food & water supply
Water management
Emergency & military services NLD
NLD command structure
GRIP state
GRIP 5
GRIP 3
GRIP 1 at some incidents
Emergency & military services BEL
BEL command structure
National
Provincial
Joint-agencies coordination at some incidents

Table 4.7 Description of dependencies

Originator	Dependency
1. Severe weather warning (U-25)	1.1 Impact of reduced mobility for the public 1.2 Impact of reduced mobility for the transport sector 1.3 Impact airport operations affected airports/airbases
2. heavy snowfall/ inability to clear roads etc (U-8.5)	2.1 Dependency on power sector 2.2 Dependency on public sector 2.3 Dependency on health sector 2.4 Dependency on road network 2.5 Dependency on transport sector 2.6 Dependency on airports 2.7 Dependency on general business 2.8 Dependency on emergency services
3. power distribution station Kreekrak in the Netherlands breaks down (U)	3.1 Dependency on affected public sector 3.2 Dependency on health sector (hospitals and other medical organizations affected area, hospitals have 48 hrs. emergency power) 3.3 Dependency on telecom sector (overload of GSM networks) 3.4 Dependency on public administration 3.5 Dependency on security issues (streetlamps/traffic lights etc) 3.6 Dependency on road and rail network (fueling stations etc) 3.7 Dependency on road transport in the affected area 3.8 Dependency on affected harbors 3.9 Dependency on affected airports 3.10 Dependency on ATM machines 3.11 Dependency on industries (some have 48 hrs emergency power) 3.12 Dependency on the affected agricultural sector 3.13 Dependency on the general businesses 3.14 Dependency on water management (sector has 48 hrs. emergency power) 3.15 +48 hr: water and food has run out at most homes. Based on O2, D11 and P10 alternative water & food supply is set up.
4. total blackout recognized in The Netherlands (U+4)	prolonged impact on sectors and institutions mentioned under 3
5. power distribution station Zandvliet in Belgium breaks down (U+5,5)	5.1 Dependency on affected public sector 5.2 Dependency on health sector (hospitals and other medical organizations affected area, hospitals have 48 hrs. emergency power) 5.3 Dependency on telecom sector(overload of GSM networks) 5.4 Dependency on public administration 5.5 Dependency on security issues (streetlamps/traffic lights etc) 5.6 Dependency on road and rail network (fueling stations etc) 5.7 Dependency on road transport in the affected area 5.8 Dependency on affected harbors 5.9 Dependency on affected airports 5.10 Dependency on ATM machines 5.11 Dependency on industries (some have 48 hrs emergency power) 5.12 Dependency on the affected agricultural sector 5.13 Dependency on the general businesses 5.14 Dependency on water management (sector has 48 hrs.

	emergency power
6. total blackout recognized in Belgium (U+9)	prolonged impact on sectors and institutions mentioned under 5
7. lasting impact in the Netherlands (U+48)	7.1 Emergency power comes to a stop in the health sector 7.2 Emergency power comes to a stop in the security sector (Nuclear power plants) 7.3 Emergency power comes to a stop affected harbors 7.4 Emergency power comes to a stop affected airports 7.5 Emergency power comes to a stop affected industries 7.6 Emergency power comes to a stop affected agricultural sector 7.7 Emergency power comes to a stop affected water management sector 7.8 Emergency power comes to a stop affected emergency sector
8. lasting impact in Belgium (U+54)	8.1 Emergency power comes to a stop in the health sector 8.2 Emergency power comes to a stop in the security sector (Nuclear power plants) 8.3 Emergency power comes to a stop affected harbors 8.4 Emergency power comes to a stop affected airports 8.5 Emergency power comes to a stop affected industries 8.6 Emergency power comes to a stop affected agricultural sector 8.7 Emergency power comes to a stop affected water management sector 8.8 Emergency power comes to a stop affected emergency sector
9. Resuming power (U+60)	Both power companies are able to resume power in the affected areas
10. Aftermath Phase (U+72)	

Table 4.8 Description of communications.

C1 (U-23)	**Communication in both countries to the public and institutions, severe weather warning code yellow (highest warning level is code red)**
C2 (U-10)	Communication in both countries to the public and institutions, severe weather warning code red
C3 (U+2)	Communication to the public and institutions (NL), power outage has occurred in province Zeeland, solving time unknown at this moment Communication within safety region (NL), Upscale to Coordinated Regional Incident-Management Procedure GRIP 3 (procedure runs from GRIP 1 to 5 and even the highest Governmental level GRIP State)
C4 (U+4)	Communication to the public and institutions (NL), power outage will probably last for hours perhaps a day, affected area now increased to western part of province Noord Brabant (Northern Brabant). Communication within now affected safety regions (NL), Upscale to Coordinated Regional Incident-Management Procedure GRIP 5. Provincial and Governmental institutions are on general alert.
C5 (U+5,5)	Communication to the public and institutions (B), power outage has occurred in large parts of North Western part of Belgium; especially the Antwerp area is severely affected. Communication within the provinces West- en Oost Vlaanderen (West- and East Flanders) and Antwerp. Municipal and Provincial level are getting operational.
C6 (U+6)	Communication from the National Coordination Centre (NL) GRIP State is announced
C7 (U+7)	Communication from the National Coordination Centre (B) the strategic unit is operational and in control
C8 (until U+60)	Communication to the public and institutions in both countries about the current situation. Recognized is that communication is severely disturbed in the affected areas.

Table 4.9 Description of procedures.

P1 (U)	**Initiating power outage procedure (TenneT power company)**
P2 (U)	Initiating emergency power procedure hospitals and other medical facilities
P3 (U)	Initiating security measures
P4 (U)	Initiating emergency power at harbor facilities especially harbor traffic control
P5 (U)	Initiating emergency power at airports especially air traffic control
P6 (U)	Initiating emergency power at industrial facilities especially SEVESO companies
P7 (U)	Initiating emergency power at agricultural facilities and damage control for those not equipped with emergency power
P8 (U)	Initiating emergency power water management facilities
P9 (U+2)	Initiating Coordinated Regional Incident-Management Procedure GRIP 3
P10 (U+4)	Initiating Coordinated Regional Incident-Management Procedure GRIP 5
P11 (U+6)	Initiating Coordinated Regional Incident-Management Procedure GRIP state
P12 (U+5,5)	Initiating power outage procedure (Elia power company)
P13 (U+5,5)	Initiating Coordination Centers at Provincial and cooperation zones level (B)
P14 (U+7)	Initiating command and control to Government level (B)

Table 4.10 Description of decisions.

D1 (U+2)	**The power company is not able to remotely start the power station. Decision is made to scale up and inform the affected safety region.**
D2 (U+4)	Call for reinforcement personnel at health institutions
D3 (U+4)	Call for reinforcement personnel for security measures
D4 (U+4)	Call for reinforcement personnel for snow removal main roads
D5 (U+4)	Harbor facilities are safely closing down
D6 (U+4)	Decision is made to stop aircraft handling at the airports in the affected regions. The military Air Bases in the affected area are closed due to the weather condition.
D7 (U+4)	Decisions are made to safely close Seveso companies conform their procedures
D8 (U+4)	Preparation measures are taken for damage control agricultural sector
D9 (U+4)	Preparation measures are taken for pollution control water management sector
D10 (U+4)	Call for reinforcement emergency- and military personnel Decision to mobilize military personnel
D11 (U+15)	Decision to set-up alternative means of communication and food & water supplies
D12 (U+60)	Decision to decontaminate water supply pipelines
D13 (U+72)	Decision to scale down the Coordinated Regional Incident-Management Procedure in The Netherlands Decision to scale down from strategic-to municipality level in Belgium Decision to demobilize military personnel

5 How to use the scenarios in existing tools

The elaborated scenarios described in Chapter 4 will be used together with some existing tools for the validation of the CascEff IET. Below descriptions of tools that are planned to be used together with the IET to validate the functionality and usability of the IET. This includes also description of how the scenarios can be used together with the tools for this validation. To some extent there are also descriptions on how the scenarios needs to be further developed in other parts of WP5.

5.1 XVR

5.1.1 Presentation of the tool

XVR is a 3D Virtual Reality Simulation, allowing for the creation of virtual scenarios by Instructors, and allows Students to walk around in those scenarios from a first person or parrot view.

XVR is built around the view of an Instructor being in control of the situation at all times. Nothing progresses automatically based on computer calculation, unless the Instructor has built such an option within the scenario. This allows for containment of learning goals and a focus on the interaction with the Students playing in the scenario.

As easy as one can build a scenario in XVR, one can adjust or change the scenario on the fly while training. This allows Instructors to really play into what Students decide to do. You call in an extra fire truck, no worries, It can be placed and driving up in mere seconds. You ask bystanders to leave the scene, no worries, in mere seconds the bystanders can walk to the designated safe area.

The XVR Library of objects holds over 2000 different object found on scene. Ranging from various persons of many ages and ethnic groups to vehicles damaged both from normal or from emergency response organisations to objects used in response or affected by incidents to the actual incident visualisation objects like fire, smoke, leaks, waterjets, and many, many more.

XVR can be used in a myriad of training setups from classroom education to team training to individual one-on-one training. Being able to visualise the scene, situation training can be performed at various levels of organisations from first arrival to an incident to team commander to disaster coordinator to mayors visiting an incident location.

The physical requirements of XVR are dependent on the training setup, but usually consist of One XVR Server, with good graphical specifications, laptop or desktop and one or more XVR Client machine(s). They are connected by a network, preferably wired, to allow for multi machine training setups.

XVR is enabled with an SDK allowing other programs to tie into the functions of XVR. Either getting information back form things happening or providing things to XVR to do with the scenario. This Link requires technical knowhow and programming on the connectors part, but it can be utilized to enhance or tie in multiple systems.

Given XVR provides a visual reference of the virtually created scenario to walk around in, the immersion of students is much higher than in a table top or role-play setting. It allows for more natural learning of procedures and communication, and by such methods XVR provides an excellent compatibility with other tools such as iCrisis and Nokeos.

For videos of XVR in use, and more information, please see, http://www.xvrsim.com

5.1.2 Proposition for using the scenarios

XVR is a 3D Virtual Reality Simulation, and as such could be used in all the CascEff scenarios to portrait a visual representation of the effects and cascades that are happening on scene. It even allows for partaking parties to walk around in such a scenario getting a real life feel for the situation.

The exact usage will of course depend on the scenario chosen, as XVR has not all the real world locations from the scenarios available. But a general geological representative should be present and could be used as basis for the visualisation. Allowing XVR to adapt to any scenario one can think of.

The main goal for utilising XVR would be to build a scenario with all the possible cascades and the visualisation of their effects. And then play out a scenario where the participants will see the incident situation and the resulting cascades.

Required for this would be at the minimum an XVR Server machine, and per participating group that has its own first person view of the simulated scenario a XVR Client machine. An Instructor that leads the scenario will need to trigger, or cue in a technical assistant, the cascade visualisations within XVR.

A thorough description of the physical start situation of a scenario and the triggers and effects that occur in that scenario are required to be able to build them into the XVR Scenario. Especially those that result in visible changes are keys to building a fitting simulation.

Besides a life training play in XVR, it can also be used to make still photos or screen capture videos of situations created within a scenario. That can be used in the setup of other tools to provide or link together the situational visualisations.

5.1.3 Requirements of the scenario description to utilize XVR

To make the best use of XVR in the scenarios descriptions of those scenarios need to incorporate a thorough description of the situation and changes that occur. Especially those that are visible as XVR needs to have those build in to be as accurate to the scenario as possible. To achieve this please use the following steps:

1) Go through all scenarios and state in generic terms how the incident looks at the start of the test-session:
    a. emergency service units (vehicles & crew):
        i. What is available
        ii. where on scene
        iii. at which time
        iv. how much was in total available.
    b. The non-emergency situation:
        i. civilians
        ii. cars traffic

iii. Regular situation(before incident)

2) Determine per swim lane if something needs to visually change in the virtual XVR incident (e.g. the wind turns, so the smoke plume turns. A fire starts. Responders do this or that. Cars are swept away by floods.)

   If a visual change is needed, we call this an "XVR Event". Write down all the XVR Event in the scenario.

   Then add what they chance and when it should be activated (e.g. manually by exercise staff when a certain IM decision is made, or automatically X min after another Event)

   Example:
   XEvent #3: Police come to the crime scene
   trigger: When Student calls in backup
   Effect: The police stationed nearby (maximum of 4) will go to the location of the student. They will park their cars correctly and then walk over to the Student to report in.

3) Check all time-lines whether all required changes have an XVR Events that is described. Events are mostly bound to decision moments or procedures activated.

   Note that most probably 1 XVR Event can be re-used in multiple timelines. In this case please note down where to reuse what.

   Example:
   XEvent #6: Police come to the crime scene again
   trigger: when the civilians nearby call the police
   effect: Same as XEvent #3.

Even if there might be cases where it can be uncertain whether it is possible to visualize something specific in XVR or not, it should still be described. It is better to over specify and later realize that something is not needed, than to not write it down and later realize were missing a Key part of a scenario.

5.2 iCrisis

5.2.1 Presentation of the tool

iCrisis is a web-based simulation system, which allows facilitators of the simulation session to animate and analyse virtual crisis management situations dedicated to private or public decision-makers. iCrisis simulations are not Master vs Players but Players vs Players based, where collaborative creativity is emphasized. Players form decision groups of people who virtually attempt to face a crisis situation whose evolution relies on an open-scenario driven by an animation team. iCrisis belongs to the virtual full scale simulation category. It only concerns crisis units at a strategic level and does not rely on computer modelling.

An iCrisis simulation (Figure 5.1) involves several crisis units (usually three) that are physically separated, an animation team and a "media office". As long as these parameters are considered, then any configuration (number and type of crisis units etc.) is possible regarding the context of the scenario (type of disaster and country etc.). For instance, based on the

French risk management organisation, the crisis units generally consist of a Prefecture command post (regional scale of governance), a Municipality command post (city scale of governance) and a Company command post that are connected together by exchanging messages via the internet. Groups exchange messages between themselves, the animation team exchanges messages with all groups and also receives copies of all messages transferred through the iCrisis software.
iCrisis software also provides several statistical analyses about the messages exchanged between the groups as well as a description of the dynamics of these exchanges.

By its flexibility, the iCrisis simulation approach is highly compatible with the use of tools such as XVR and Nokeos. Regarding our CascEff IET, we think that its best use would be as a stand-alone tool beside iCrisis. Integration is possible but has no much interest in doing it since iCrisis is not an IMT but a support tool for communication.

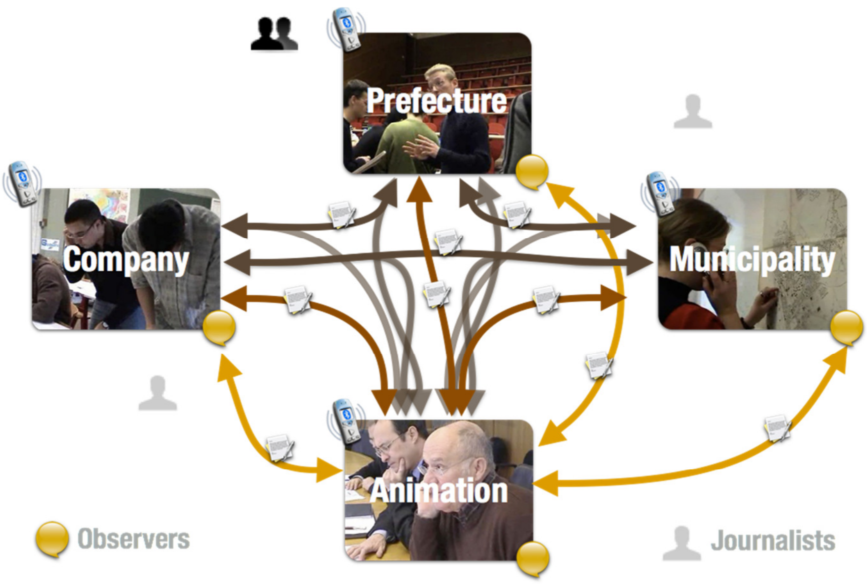


Figure 5.1 iCrisis organisation

5.2.2 Proposition for using the scenarios

An iCrisis simulation requires at least two groups plus the animation team group. These groups represent different **strategic** management scales, for example: a company, a municipality, an emergency and rescue service. But there is no fixed configuration for the groups. iCrisis is flexible enough to adapt to all six scenarios developed within the CascEff project.

In the iCrisis simulation approach, the animation team injects step-by-step parts of scenario regarding the prepared story line. Practically speaking, the animation group provides to the other groups a description of the field events (including emergency progress and results) so that they can define and adapt their response strategy. Moreover, the animation group also plays all external roles which may interfere with the situation (politicians, experts, involved stakeholders).

5.3 NoKeos

5.3.1 Presentation of the tool

NoKeos Incident Manager is a Crisis Information Management System and IMT designed by incident commanders and responders to support organisations throughout the 4 incident management phases: planning, preparation, response and recovery. Incidents are dynamic events that require a coordinated intervention of multiple parties based on shared situational awareness.

Information is often available but insufficiently structured and too static to be able to fulfil the requirements for real-time emergency management and to assure long-term knowledge management.

For an IMT to be effective, it needs to actively support the relief organisations in doing the right things at the right time during the course of an incident.

Although the evolution of incidents is highly unpredictable, the emergency response is always characterised by similar decision support structures. A lot of procedures, parameters and boundary conditions have a recurring pattern. These patterns can be pro-actively designed and embedded in a software environment for consultation during incidents. Through training and lessons learned from past incidents, these patterns can be further optimised and refined.

Figure 5.2 Screenshot of Nokeos dashboard and GIS map.

5.3.2 Proposition for using the scenarios

Nokeos can be used as an existing IMT during some of the exercises of Task 5.2. The scenario's will be defined in Nokeos using the relevant national incident command structure per relevant scenario and relevant incident parameters and an OpenStreet GIS map. The IET will then be invoked by the incident command staff from within NoKeos and feedback from the IET would be returned to Nokeos such as the selected IET timeline and related GIS objects. This will enable testing of the IET - IMT interface as defined in Task 4.3.

6 Conclusions

The ultimate goal of the CascEff project is the development of the CascEff IET. To prove the functionality and usability of the IET it needs to be tested and validated in some way. For this validation six CascEff scenarios have been selected. The seven scenarios are:

1. Scheldt (local landslide)
2. Mont Blanc tunnel fire (an international incident with cross-border effects)
3. Festival (evacuation due to fire and release of toxic gases)
4. Séchilienne (large landslide)
5. Nut ware-house blast (Industrial fire)
6. Skatås wildfire
7. Black out scenario

Most of the scenarios are based on real incidents (no 1, 2, 5, 6). One (no 3) is a mixture of incidents and some added ideas while no 4 and no 7 are fictional but based on knowledge about real incident and analysis of the specific region for the scenario. The selection of scenarios was performed within Task 1.4 (presented in D1.4). However, in this report (D5.1) the selected scenarios are described in more detail, especially the following information is presented for each scenario:

- Name and location of the scenario
- Type of initial event and initial system affected
- Course of events
- Dependencies and cascading effects
- Actual and possible consequences
- Geographical extension and types of organisations involved
- Relation to historic incidents

The plan is to test the IET together with existing tools (e.g. incident management or information handling tools). To be useful for such validation sessions, the scenarios need to be described in a way that dependencies, different option, key decision points, buffer times, etc. are presented and described. Therefore, a format (based on different existing formats) for visualizing this information in a figure was developed and used for each scenario. In this way both the main scenario and other possible timelines could be presented. This helps both the understanding of the scenarios and the creation of the validation sessions with the existing tools. This report presents both these visual representations and a description on how the scenarios later in the project can be used together with the existing tools. This includes some instructions on how the scenarios can be further developed in the future to suit the continued work with the validation of the IET within CascEff.

Appendix 1

Visualization of the Scheldt scenario

Start – Initiating event

Dx – Decision

Ox – Option

Px – Procedure

Cx – Communication

Logical AND

Logical OR

Dependency arrow
- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

D1 – Close Scheldt road for all traffic (cars plus cyclists)

D2 – Inform and invite representatives of the pipeline owners, of surrounding companies (including those relying on the pipelines for supplies)

D3 – Scale up from operational to municipal coordination

P1 – Set up exclusion perimeter and isolation perimeter (perimeter of 500 m and isolation perimeter of 1000 m)

P2 – Involve contractors, ask them to free the pipelines from external pressure

P3 – Summon hazardous materials advisors

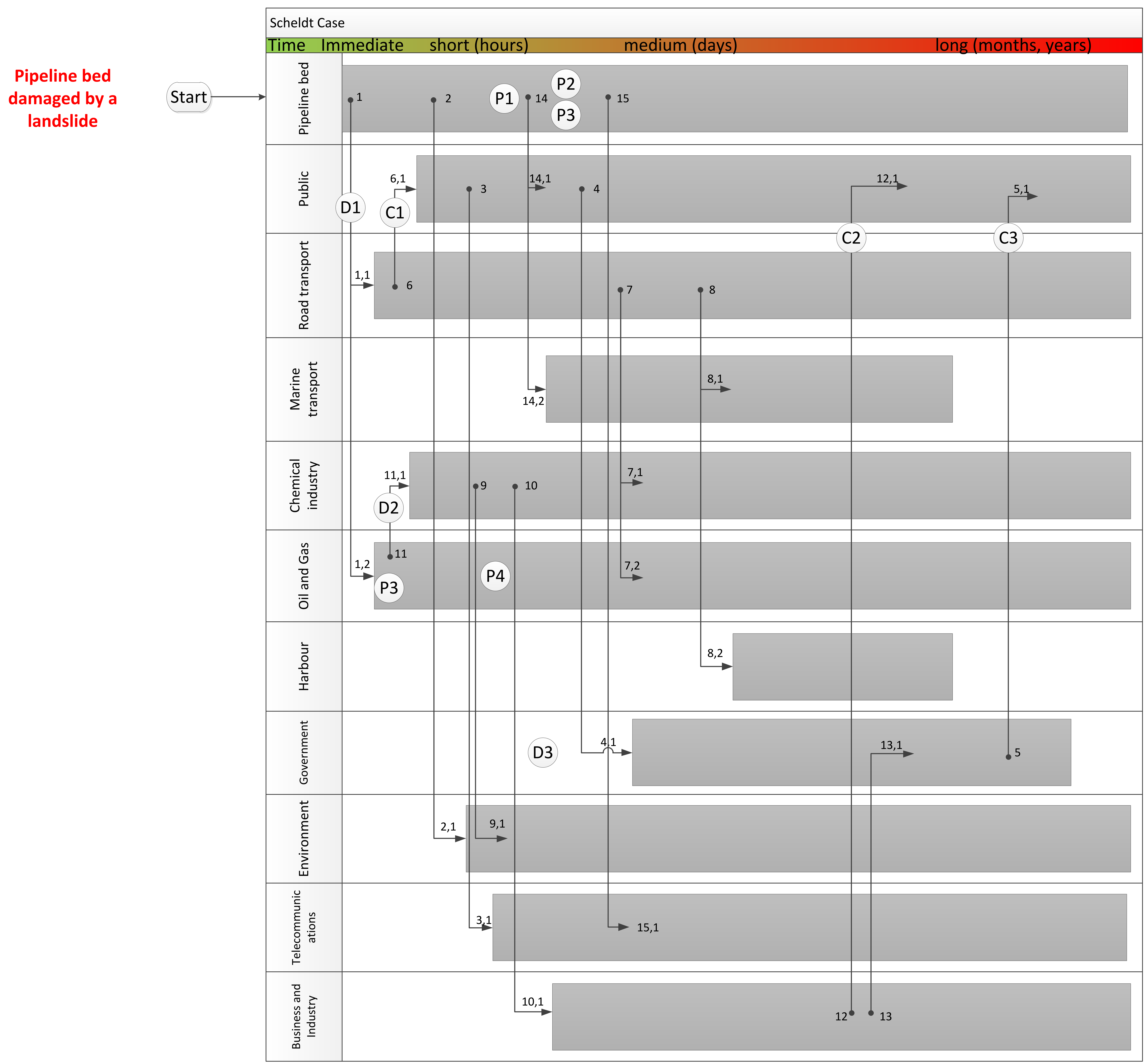
P4 – Put some of the pipelines out of service under supervision

C1 – Communicate rerouting of traffic to the public

C2 – Communicate progress of recovery to the public

C3 – Communicate future planning activities and recovery process to the public

Originator	Dependency
1 – Pipeline bed	1,1 – Geographic dependency of the road adjacent to the pipeline bed on the pipeline bed 1,2 – Logical dependency of the oil and gas supply on the pipeline bed
2 – Pipeline bed	2,1 – Environmental impact as a result of pipeline damage
3 – Public affected by road closures	3,1 – Increase demand on telecommunications infrastructure
4 – Workers unable to return home from work, collect children, rerouted	4,1 – Government affected by public dissatisfaction
5 – Lasting impact on local government	5,1 – Prolonged impact on publics satisfaction with government
6 – Interruption to road usability and rerouting of traffic	6,1 – Public affected by rerouting of traffic
7 – Continued interruption to road usability	7,1 – Interruption to logistics for chemical industry 7,2 – Interruption to logistics for Oil and Gas supply
8 – Prolonged interruption to road usability	8,1 – Need to identify alternative logistics solutions increases demand on marine transport 8,2 – Need to identify alternative logistics solutions increases demand on port and harbour facilities
9 – Physical damage at chemical facilities	9,1 – environmental damage as a result of escalating problems at chemical industry
10 – interruption and reduced activity at chemical industry	10,1 – impact to other businesses and industry
11 - interruption to Oil and Gas supply	11,1 – Logical dependency between Oil and Gas supply and supplied industries
12 – Impact to business and industry	12,1 – Public affected by, e.g. reduced productivity or demand
13 – Impact to business and industry	13,1 – Government affected by economic problems
14 – Exclusion zone set up around incident	14,1 – Exclusion zone affects public activities, access and mobility 14,2 – Exclusion zone affects marine transportation routing
15 – Damage to pipelines as a result of blast or increasing external load	15,1 – Damage to telecommunication pipelines adjacent to the damaged pipelines



Appendix 2

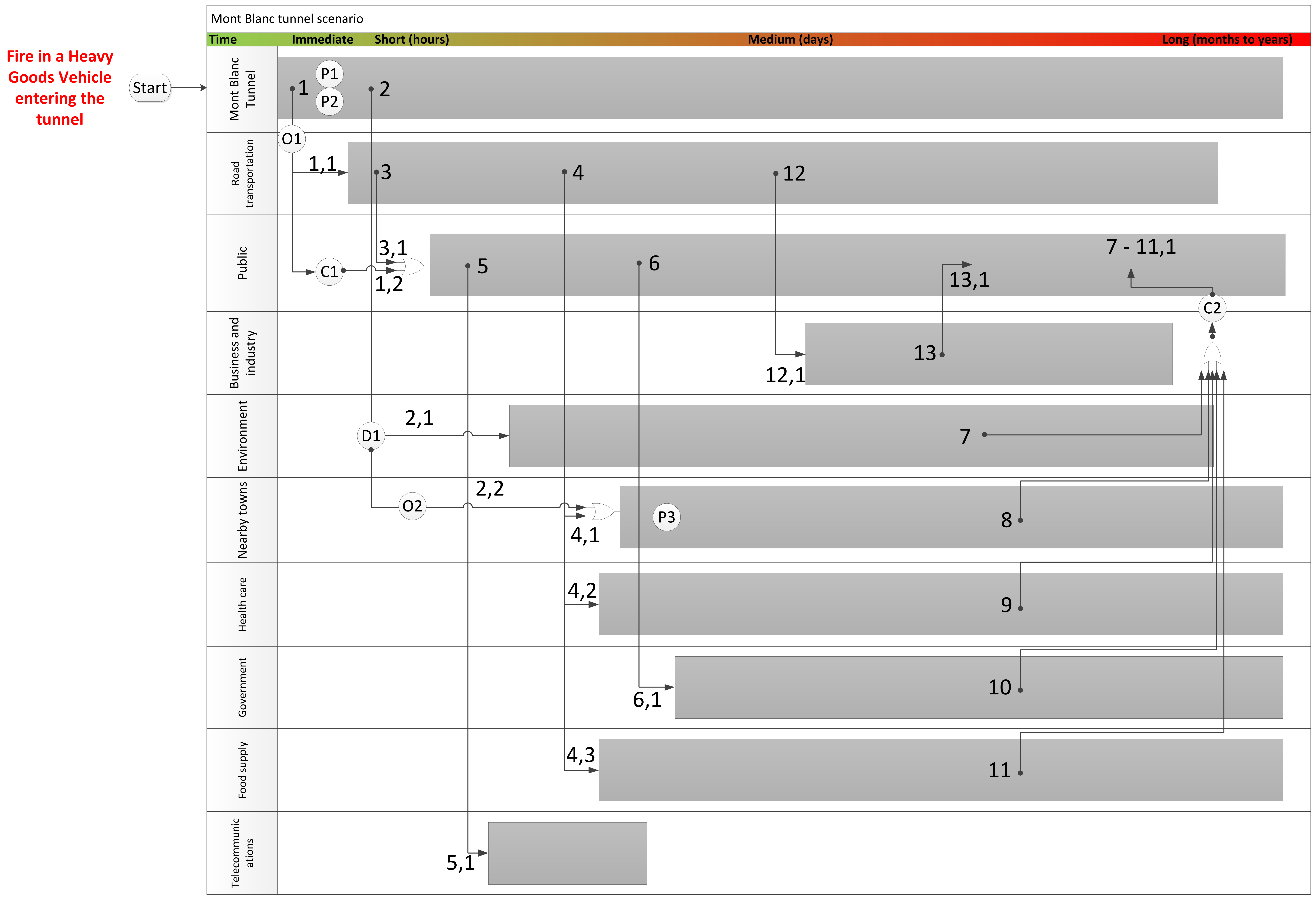
Visualization of the Mont Blanc tunnel fire scenario

Start – Initiating event
Dx – Decision
Ox – OR
Px – Procedure
Cx – Communication
Logical AND
Logical OR

Dependency arrow
- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

D1 – Tunnel ventilation direction towards the portal which is closest to the fire
O1 – HGV stops close enough to the tunnel portal that the fire can be fought
O2 – HGV carrying hazardous goods
P1 – French first responders respond to the accident
P2 – Italian first responders respond to the accident
P3 – Initiate evacuation of nearby towns
C1 – Inform public about the incident and encourage them to seek alternative routes or not make the journey
C2 – Inform public about the long lasting effects of the incident

Originator	Dependency
1 – Tunnel	1,1 - Logical dependency of road transportation on the state of the tunnel 1,2 - Logical dependency of the public on the state of the tunnel 1,3 – Depndency of the emergency response capacity in France on the tunnel fire 1,4 – Depndency of the emergency response capacity in Italy on the tunnel fire
2 – Tunnel, fire not extinguished early	2,1 – Environmental impact from a prolonged fire incident 2,2 – Need for evacuation of nearby towns in the event that the fire effluent is hazardous
3 – Road transportation	3,1 – Impact of reduced mobility on the public
4 – Long lasting impact to road transportation	4,1 – impact of long lasting road transportation interruption to nearby towns 4,2 – Impact of interruption to transportation on health care (supply chains, worker and patient transport) 4,3 – Impact of interruption to transportation on food supply chains
5 – Impact on the public	5,1 – Increased reliance and load on telecommunications infrastructure
6 –Prolonged impact on the public	6,1 – Impact on local government
7 – Lasting environmental impact	7,1 – Prolonged impact on publics wellbeing
8 – Lasting impact on nearby towns	8,1 – Prolonged impact on willingness of public to stay in the town – possible reduced population
9 – Lasting impact on health care	9,1 – Prolonged impact on the ability to provide essential health care services to the public, or need to find alternative supply routes
10 – Lasting impact on local government	10,1 – Prolonged impact on publics satisfaction with government
11 – Lasting impact on food supply	11,1 – Prolonged impact on the availability of essential or luxury food stuffs – need to find alternative supply routes
12 – Reduced availability of supply routes	12,1- impact on dependent businesses
13 – Reduced output from local businesses	13,1 – impact on public from reduced demand for products and workers



Appendix 3

Visualization of the Festival scenario

Start – Initiating event

Dx – Decision

Ox – OR

Px – Procedure

Cx – Communication

Logical AND

Logical OR

Dependency arrow
- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

D1 – Evacuate public in effect zone

D2 – Apply water screens to contain toxic fumes

D3 – Pro-active evacuation of public in potential blast zone

P1 – initiate evacuation of zone in effect area

P2 – Fire Fighting: apply water screens and collect contaminated water

P3 – initiate evacuation of 2km area around ship

Originator	Dependency
1 – Marine Transport – River Scheldt	1,1 - Blockage of ship traffic on the river Scheldt and North Sea for all marine traffic heading south of Antwerp. Fire lasting up to 11 days. 1,2 - Public health threat to nearby population and festival attendees due to toxic fumes 1,3 - Air pollution due to toxic fumes. Use of water curtains to limit spread of toxic fumes results in threat of water pollution due to fire water getting into the river. 1.4 - Traditional and social media coverage 1.5 – Fire fighting tactics leading to some water pollution in the sewer system
2 – Public – Festival attendees, population working or living in city of Antwerp	2.1 - Overload of GSM networks due to attendees calling and messaging on social media. 2.2 - crisis spreading on social media 2.3 – telecom networks overloading because of mass evacuation 2.4 – media crisis due to mass evacuation 2.5 – media pressure causing impact on policies for ADR transports by water 2.6 – evacuation causing congestion of roads
3 – Telecommunications	3.1 – overload of GSM networks creating relatives to come to incident to collect family
4 – Environment	4 – polluted water causing change in river fauna and flora due to increased algae growth. Food chain impact.
5 – Media	5 – News, photo’s and video’s on (social) media causing increased public attention and potentially people in neighbouring areas that want to evacuate or come and help. 5.2 – Media pressure on government to change policy on ADR transports and question civil security
6 – Governmental	
7 – Sewage	7 – polluted sewer water which is not contained entering the water supply through water purification system
8 – Water Supply	8 – contaminated water entering the food chain
9 – Agriculture	9 – Contaminated food threatening public health

Appendix 4

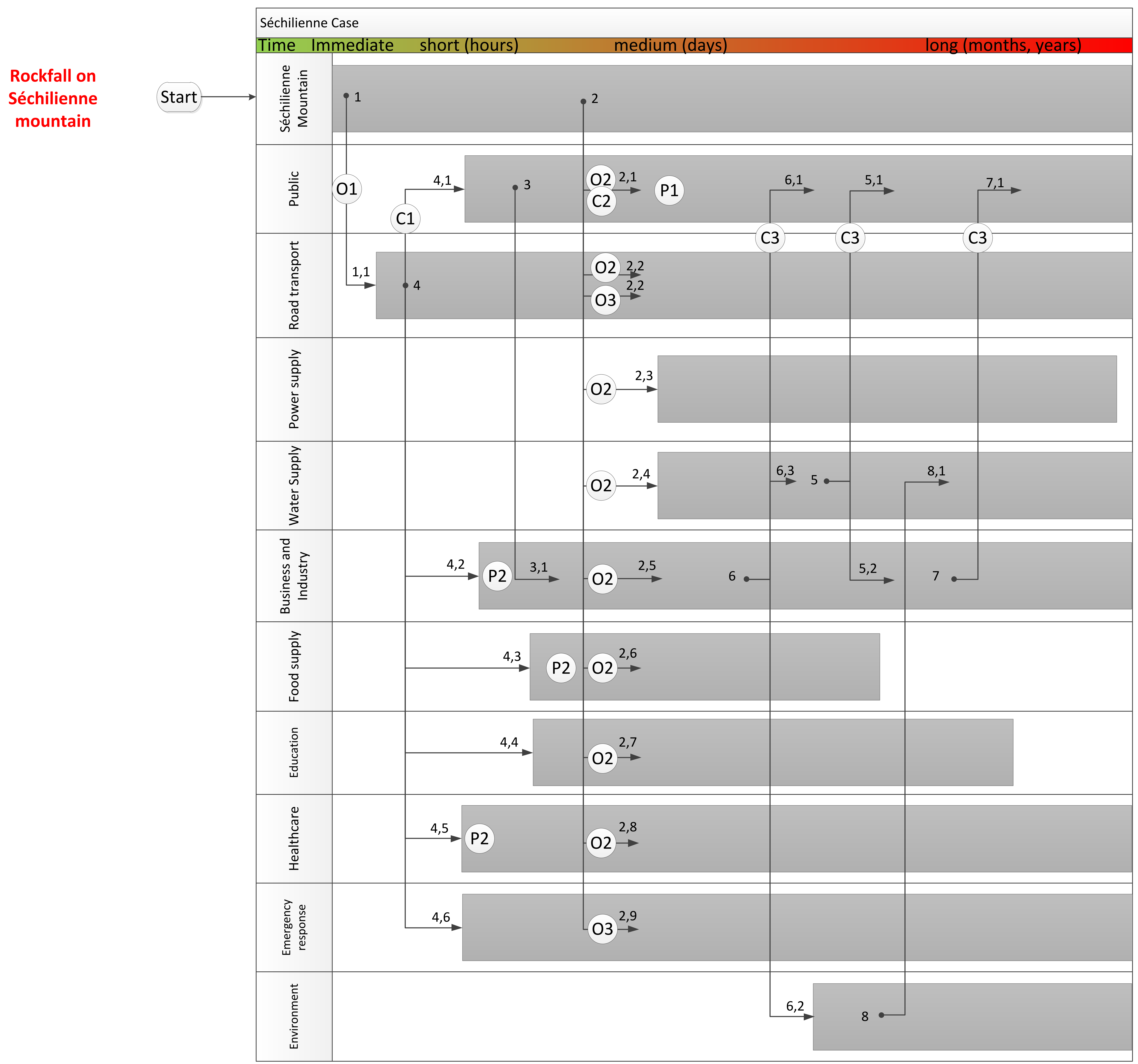
Visualization of the Séchilienne scenario

Start Initiating event
Dx Decision
Ox Option
Px Procedure
Cx Communication
Logical AND
Logical OR

Dependency arrow
- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

O1 Rockfall lands on road
O2 Secondary rockfall falls on Dam causing damage
O3 Secondary rockfall falls in same area as first rockfall, risking harm to first responders
P1 Involve contractors, ask them to free the pipelines from external pressure
P2 Summon hazardous materials advisors
C1 Inform public about road closure and encourage alternative route if possible
C2 Inform public about imminent flooding
C3 Inform public about long term effects and recovery plans

Originator	Dependency
1 – Landslide on mountain	1,1 – landslide falls on road interrupting traffic flow
2 – Damn rupture after rockfall	2,1 - Possible injuries to members of the public 2,2 – Roads are submerged and damaged 2,3 – Damage to hydroelectric power supply 2,4 – Damage to potable water supply 2,5 - Some industries/factories are damaged 2,6 - Food shops or commercial centres are damaged 2,7 - Education facilities are damaged 2,8 - Health care operations (movement of ambulances and doctors) are limited or delayed, possible damage to facilities 2,9 - Emergency operations (movement of rescue teams) are limited or delayed
3 – Mobility of public reduced	3,1 – Some workers unable to commute to work
4 – Interruption to traffic flow	4,1 - The movement capabilities of the population is limited 4,2 – Logistics operations are affected 4,3 - Food supply and distribution is negatively impacted 4,4 – Inability for teachers and students to travel to and from schools 4,5 – Capacity for movement of patients, hospital staff, and medical supplies is reduced 4,6 - Emergency operations (movement of rescue teams) are limited or delayed
5 – Pollution to potable water supply	5,1 – Public have no more access to potable water 5,2 - Some industries/factories can not use water anymore in their process
6 - Blast/Fire/Toxic Release as a result of damage to industries	6,1 – Injuries and long lasting health effects on members of the public 6,2 - Pollutants are released 6,3 - River is polluted
7 – Closure of some industries as a result of damage	7,1 – increased unemployment
8 – River / water table is polluted	8,1 – Potable water supply stopped because of polluted water



Appendix 5

Visualization of the Nut warehouse blast scenario

Start/End

Dx Decision

Ox Outside factor

Px Procedure

Logical AND

Logical OR

Dependency arrow

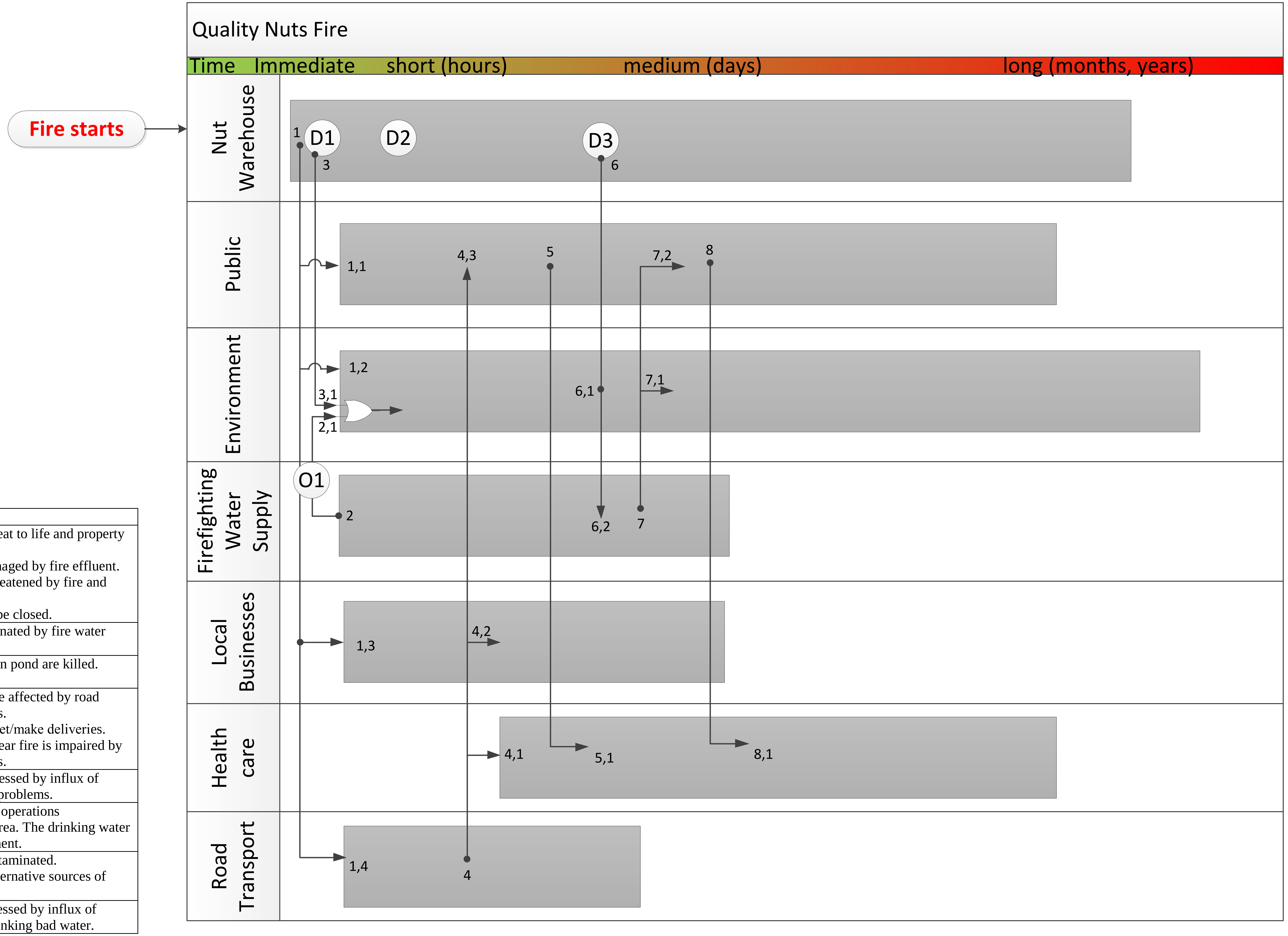
- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

D1 Offensive fire fighting

D2 Defensive fire fighting

D3 Use holding pond

O1 Insufficient firefighting water



Originator	Dependency
1 – Nut warehouse, fire starts	1,1 - Public is affected by threat to life and property damage. 1,2 – The environment is damaged by fire effluent. 1,3 – Local businesses are threatened by fire and smoke. 1,4 – Smoke causes roads to be closed.
2 – Firefighting water supply insufficient	2,1 – Environment is contaminated by fire water run-off
3 – Nut warehouse, offensive firefighting strategy requires much water	3,1 – Fish and other wildlife in pond are killed.
4 – Road transport impacted by smoke	4,1 – Ambulance activities are affected by road closures and traffic conditions. 4,2 - Local businesses can't get/make deliveries. 4,3 – Public travel on roads near fire is impaired by closures and traffic conditions.
5 – Public health impacted by smoke	5,1 – Health care facilities stressed by influx of people with smoke exposure problems.
6 – Environment, no use of holding pond	6,1 – Water from firefighting operations contaminates the watershed area. The drinking water supply requires special treatment.
7 – Water supply is contaminated	7,1 – The environment is contaminated. 7,2 – The public must find alternative sources of drinking water.
8 – Public becomes ill from contaminated water	8,1 - Health care facilities stressed by influx of people with illnesses from drinking bad water.

Appendix 6

Visualization of the Skatås wildfire scenario

Start/End

Dx Decision

Ox Outside factor

Px Procedure

Logical AND

Logical OR

Dependency arrow

- The head of the arrow indicates the direction of the dependency.
- The node at the tail of the arrow indicates that some threshold impact in the originating system has been reached.

D1 Fight fire later to avoid risk of fire water run-off into the lake

D2 Protect the tele-comm tower

D3 Call for reinforcements from military and/or other countries

O1 Wind direction North

O2 Wind direction East

O3 Wind direction South

O4 Wind direction West

P1 Initiate emergency procedures in hospital

C1 Inform public of need to evacuate forest and surrounding area

C2 Inform public of contamination of water

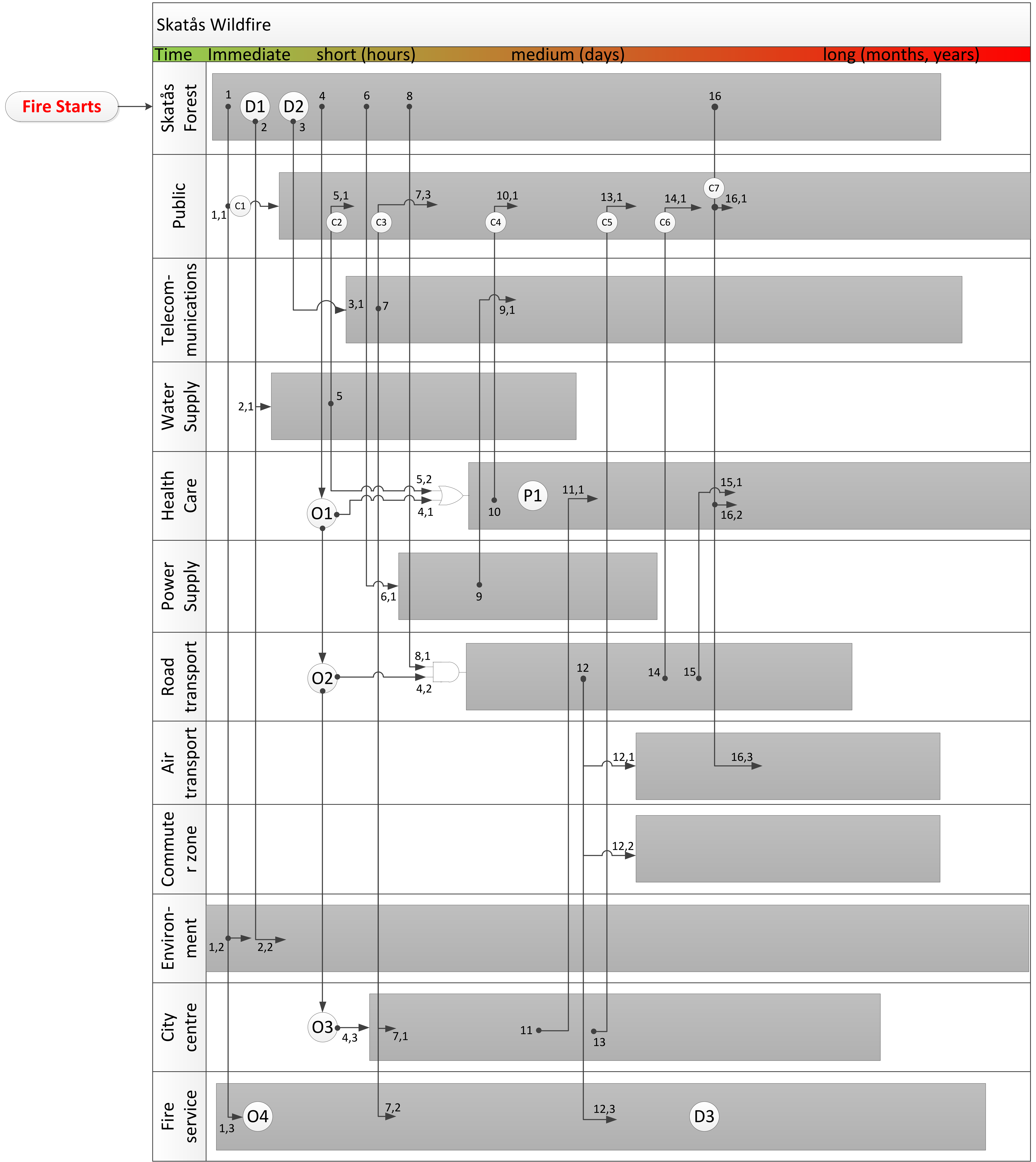
C3 Inform public of reduced telecommunications facilities

C4 Inform public of health care provisions

C5 Inform public of affects to city centre

C6 Inform public of road transport arrangements

C7 Inform public of spreading fire and need to evacuate a large area



Originator	Dependency
1 – Skatås forest, fire starts	1,1 - Public is affected by threat to life and property damage. 1,2 – The environment is damaged by the fire. 1,3 – Reduced capacity of fire and rescue services in Gothenburg during a high fire hazard time.
2 – Skatås forest, immediate fire fighting	2,1 – Potential contamination of water supply 2,2 – The environment around the lakes is damaged by the fire.
3 – Skatås Forest, do not protect telecommunications tower	3,1 – Telecommunications are impaired.
4 – Skatås forest, wind from north	4,1 – Contaminated drinking water stresses health care systems. 4,2 – Fire causes closure of major road. 4,3 – Fire impacts central Gothenburg.
5 – Water supply, contaminated lakes	5,1 – Public has reduced supply of drinking water. 5,2 – Contaminated drinking water stresses health care systems.
6 – Skatås forest, underground electric cables disturbed	6,1 – Power supply is stressed.
7 – Telecommunications tower is compromised	7,1 – Central Gothenburg has reduced radio and television services. 7,2 – The fire and rescue services have reduced ability to communicate and coordinate their operations. 7,3 – The public has reduced radio and television services.
8 – Skatås forest, wind from east	8,1 – Fire causes closure of major road.
9 – Power supply, underground electric cables disturbed	9,1 – Telecommunications tower is unable to provide service.
10 – Health care, hospital is impacted by fire	10,1 – Public has reduced health care services.
11 – City centre, impacted by fire	11,1 – Large concentration of public require health care for exposure to smoke and fire.
12 – Road transport is affected by fire	12,1 – Access to airport is delayed or closed. 12,2 – Commute traffic is delayed. 12,3 – Fire and rescue services cannot reach their positions to fight the fire.
13 – City centre, roads closed	13,1 – People are stranded in the city centre, unable to return home.
14 – Road transport, wind from east	14,1 – People are stranded away from their homes and possibly their family members.
15 – Road transport, ambulance service impaired	15,1 – Ambulance service is impaired due to closed or congested roads.
16 - Skatås forest, fire very large near airport	16,1 – Many people are evacuated and displaced for extended time. 16,2 – Many fire-related health problems overwhelm health care services. 16,3 – Airport is closed.

Appendix 7

Visualization of the Power blackout scenario

Originator	Dependency
1. Severe weather warning (U-25)	1.1 Impact of reduced mobility for the public 1.2 Impact of reduced mobility for the transport sector 1.3 Impact airport operations affected airports/airbases
2. heavy snowfall/ inability to clear roads etc (U-8.5)	2.1 Dependency on power sector 2.2 Dependency on public sector 2.3 Dependency on health sector 2.4 Dependency on road network 2.5 Dependency on transport sector 2.6 Dependency on airports 2.7 Dependency on general business 2.8 Dependency on emergency services
3. power distribution station Kreekrak in the Netherlands breaks down (U)	3.1 Dependency on affected public sector 3.2 Dependency on health sector (hospitals and other medical organizations affected area, hospitals have 48 hrs. emergency power) 3.3 Dependency on telecom sector (overload of GSM networks) 3.4 Dependency on public administration 3.5 Dependency on security issues (streetlamps/traffic lights etc) 3.6 Dependency on road and rail network (fueling stations etc) 3.7 Dependency on road transport in the affected area 3.8 Dependency on affected harbors 3.9 Dependency on affected airports 3.10 Dependency on ATM machines 3.11 Dependency on industries (some have 48 hrs emergency power) 3.12 Dependency on the affected agricultural sector 3.13 Dependency on the general businesses 3.14 Dependency on water management (sector has 48 hrs. emergency power) 3.15 +48 hr: water and food has run out at most homes. Based on O2, D11 and P10 alternative water & food supply is set up.
4. total blackout recognized in The Netherlands (U+4)	prolonged impact on sectors and institutions mentioned under 3
5. power distribution station Zandvliet in Belgium breaks down (U+5,5)	5.1 Dependency on affected public sector 5.2 Dependency on health sector (hospitals and other medical organizations affected area, hospitals have 48 hrs. emergency power) 5.3 Dependency on telecom sector(overload of GSM networks) 5.4 Dependency on public administration 5.5 Dependency on security issues (streetlamps/traffic lights etc) 5.6 Dependency on road and rail network (fueling stations etc) 5.7 Dependency on road transport in the affected area 5.8 Dependency on affected harbors 5.9 Dependency on affected airports 5.10 Dependency on ATM machines 5.11 Dependency on industries (some have 48 hrs emergency power) 5.12 Dependency on the affected agricultural sector 5.13 Dependency on the general businesses 5.14 Dependency on water management (sector has 48 hrs. emergency power
6. total blackout recognized in Belgium (U+9)	prolonged impact on sectors and institutions mentioned under 5

7. lasting impact in the Netherlands (U+48)	7.1 Emergency power comes to a stop in the health sector 7.2 Emergency power comes to a stop in the security sector (Nuclear power plants) 7.3 Emergency power comes to a stop affected harbors 7.4 Emergency power comes to a stop affected airports 7.5 Emergency power comes to a stop affected industries 7.6 Emergency power comes to a stop affected agricultural sector 7.7 Emergency power comes to a stop affected water management sector 7.8 Emergency power comes to a stop affected emergency sector
8. lasting impact in Belgium (U+54)	8.1 Emergency power comes to a stop in the health sector 8.2 Emergency power comes to a stop in the security sector (Nuclear power plants) 8.3 Emergency power comes to a stop affected harbors 8.4 Emergency power comes to a stop affected airports 8.5 Emergency power comes to a stop affected industries 8.6 Emergency power comes to a stop affected agricultural sector 8.7 Emergency power comes to a stop affected water management sector 8.8 Emergency power comes to a stop affected emergency sector
9. Resuming power (U+60)	Both power companies are able to resume power in the affected areas
10. Aftermath Phase (U+72)